Baking problems solved

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1

Problem solving – a guide

‘You can’t solve a problem with the same type of thinking that caused it’

Einstein

Problems that show as unexpected variations in bakery product quality do occur from time to time. Often considerable time, effort and money are required to identify the causes and solutions concerned. Unexpected quality variations are not the exclusive province of any particular size of manufacturing unit: they can occur in both large and small bakeries. Nor are they exclusive to the production bakery: even the best-controlled test bakery or laboratory can experience unexpected fluctuations in product quality.

There is no magic to problem solving. It is normally achieved through critical observation, structured thought processes and access to suitable sources of information. In this chapter we offer a guide to some of the methods that might be employed when trying to solve bakery-related problems. In doing so we must recognise that baking is a complex mixture of ingredient and process interactions so that the solutions to our problems may not always be instant in nature.

1.1 How to problem solve

Successful problem solving usually requires a methodical approach. It is perfectly possible to stumble quickly on the required solution by chance but more often than not a haphazard approach to problem solving is wasteful of time, resources and money. Not all problems are solved using exactly the same
2 Baking problems solved

approach but the critical elements of the problem solving process are largely common.

In problem solving we normally move from the problem to the cause and finally to the corrective action. However, we must recognise that on many occasions the manifestation of a particular problem does not necessarily have a unique and identifiable cause and so there may be other intermediate steps to take into account in determining the real cause of the problem. This situation can be described schematically as follows:

Problem → primary cause → contributing factors → corrective action

Or in more simple terms as:

What is seen → why → because of . . . → corrective action

The basic process becomes apparent if we consider two examples of problems in bread making; the first low bread volume and the second collapse of the sides of an open top pan loaf, often referred to as ‘keyholing’.

Low bread volume
Externally we observe that the bread is smaller than we expect and this may also have led to a paler crust colour because of the poorer heat transfer to the dough surface. Internally the cell structure may be more open than usual.

Since bread volume is a consequence of expansion of the dough by carbon dioxide gas from yeast fermentation and the retention of that gas within the dough matrix (Cauvain, 1998) there are two potential primary causes of this problem – lack of gas production and lack of gas retention. To separate the two we will need more observations, and an important one will be whether the rate of expansion of the dough in the prover and oven was normal or slower than usual. If the latter was the case then the primary cause of the problem is likely to be lack of gas production and potential contributing factors may include the following:

• yeast activity or level too low;
• lack of yeast substrate (food);
• dough temperature too low;
• proving temperature too low;
• proving time too short;
• salt level too high;
• proving temperature/time/yeast combination incorrect.

On the other hand if the proving had been at a normal rate and there was a lack of oven spring then this would lead us to recognise that the problem would be lack of gas retention. In this case the list of potential reasons for the problem includes:
• improver level too low;
• incorrect improver;
• combination of improver and flour too weak for process;
• enzymic activity too low;
• energy input during mixing too low;
• mixing time too short;
• dough temperature too low.

Note that the ‘dough temperature’ too low appears in both lists because of its effect on yeast activity and the effectiveness of the functional ingredients in the improver.

Keyholing
Externally we observe there is a loss of bread shape but only at the sides of the product. Internally we may see the formation of dark-coloured, dense seams, often referred to as cores. The centre crumb may be more open than we normally expect for the product concerned.

Why has this happened? Clearly we have no problems with gas production since there is no evidence for slow proving and the bread had good volume. We have clearly retained the carbon dioxide gas produced, otherwise the bread would have low volume as described above. In this case the excessive centre crumb expansion leads us to the view that in fact the gas retention is excessive.

Thus, the primary cause of the problem is excessive gas retention arising from a number of potential individual causes or combinations. The contributing factors may include:

• improver level too high;
• incorrect improver;
• combination of improver and flour too strong for process;
• enzymic activity too high;
• energy input during mixing too high;
• mixing time too long.

From the foregoing examples we can see that observation and reasoning are key elements in problem solving. The former can be readily systematised while the latter will rely heavily on the availability of suitable information to use as the basis for comparisons. The potential sources of such information are discussed below.

It is interesting to consider the process by which one might set about identifying the particular cause of a problem, such as the keyholing (excessive gas retention) of bread discussed above. The most likely mental process is one associated with probability achieved by matching the pattern of observations with ones previously experienced and remembered. When we recognise a general similarity between observation and stored image we are likely to explore in more detail the factors most likely to contribute to the pattern we observe.
One potential analogy for how we problem solve is that of a tree. The main line of observation is via the central trunk with the potential to explore branches at many points. In the case of our bread problem if we fail to identify the cause of the problem from our first consideration then we will close down that line of reasoning, go back to the main theme (the trunk) and then set off on another branch of investigation. Our route through the branches of our reasoning tree is complex and occasionally we may jump from branch to branch rather than going back to the trunk before continuing our investigation.

The length of time that we take to identify the cause and the corrective actions needed varies considerably from occasion to occasion and from individual to individual, and is more likely to be related to our accumulated knowledge and experiences rather than logical reasoning. Our abilities to recognise and match subtle patterns are probably so intuitive that we are seldom aware of them.

1.2 The record

It is common for the manufacture of bakery products to be based on some starting formulation and formal method of processing the ingredients into the finished product. This will require some form of recorded details of the ingredients to use, their quantities, equipment, process settings and timings involved. Consult any standard recipe or baking book for food preparation and you will find such details recorded for use by others. In almost all modern bakeries a formal production record will be set up for each of the product types and used by the manufacturing operatives to prepare the various items.

Invaluable in problem solving is the formal record of what was actually carried out on a particular occasion. While many operatives will keep to the prescribed formulation and processing recipe, small variations about a given value can occur and lack of information of what the actual values were for a given mix makes problem solving more difficult. It is normal for standard production specifications to allow a degree of tolerance for weights and operating conditions. For example, a temperature specification for a cake batter may be stated as $20 \pm 2 ^\circ C$. However, such a specification allows for replicate batters to be $18$ or $22 ^\circ C$ and a $4 ^\circ C$ variation coupled with other small changes may have a larger effect of final product quality than normally considered.

A formal record of production can encompass many aspects including the following:

- Any variations in the source of the raw materials. For example, changes in flour or whole egg batches, or a new supplier of a particular ingredient.
- Changes in analytical data even where these are still within acceptable limits because the cumulative effect of small changes in a number of individual parameters can have a large effect on final product quality.
- The actual quantities of ingredients used compared with the standard values. For example, in breadmaking it is common to adjust the water level added in
order to maintain a standard dough rheology for subsequent processing. In other cases deliberate changes from the standard formulation may have been introduced in order to compensate for some process change. For example, in bread dough the yeast level may be adjusted to compensate for a change in prover temperature so that final proving times do not vary.

- The processing conditions, such as mixing times, energies, ingredients and batter or dough temperatures. Once again the values may fall within acceptable ranges but still have a cumulative effect.
- Process equipment settings which may vary according to ‘operator preference’ or because of other variations in other factors. For example, an unavoidably higher laminated paste temperature may result in greater damage to the laminated structure which may require a compensatory adjustment to roll gap settings during sheeting.
- Process timings, such as baking or cooling times.
- Changes in packaging materials.

The record may be simplified by using the standard recipe as a pro forma against which to record variations. Such techniques have been commonly used to record dough divider weights (see Fig. 1) and can be readily adapted for any aspect of bakery production. The record may be on paper or by input to suitable computer-based programs.

In addition to the recipe and process records it is very important to have a formal record of finished product quality. Once again it will be common to have some form of product specification with appropriate tolerances against which to make an assessment. Such techniques are commonly the province of the Quality Control Department. The degree of detail recorded will vary.

<table>
<thead>
<tr>
<th>Product unit weight (g)</th>
<th>Dough temperature (°C)</th>
<th>Time to divider</th>
<th>Dough consistency* S/SS/N/SF/F*</th>
<th>Divider setting</th>
</tr>
</thead>
</table>

* Dough consistency codes:
  S = softer than normal
  SS = slightly softer than normal
  N = normal consistency
  SF = slightly firmer than normal
  F = firmer than normal

Fig. 1  Example of divider record sheet.
6 Baking problems solved

For use in problem solving the formal product specification or quality control record may require some adaptation and enlargement since small, but commonly accepted, variations may hold the vital clue to the cause of a particular problem. In both the quality control and problem solving contexts relevant data on the finished product may include the following:

- **Product size based on height or volume.** Devices for measuring product dimensions may be used off- or on-line. They may be as simple as using a rule to measure loaf height or measuring product volume by seed displacement in a suitable apparatus (Cauvain, 1998).
- **Shape may be assessed subjectively and compared with an accepted standard.** The introduction of image analysis offers new opportunities for recording product shape.
- **The external appearance of the product and the recording of any special features that may be present or indeed the absence of expected features, e.g. lack of oven spring in bread.**
- **Surface blemishes, their size and location on the product.**
- **The coloration of all surfaces.** Descriptive techniques, comparison with standard colour charts, e.g. Munsell or tristimulus instruments (Anderson, 1995) may be used. Deviations from the norm should be clearly noted.
- **The appearance of the internal structure, if there is one.** Most baked products have some form of internal structure that is an intrinsic component of product quality. Assessment of that internal structure may be subjective and describe the size, numbers and distributions of the cells which go to make the internal structure. Cell structures may be unevenly distributed in the product cross-section or form a ‘pattern’ that is characteristic of such products. Deviations from the norm may be noted. Image analysis offers new opportunities for objectively assessing internal cell structures but has yet to be fully exploited in the baking industry.
- **The internal colour may be assessed using techniques described above for surface colour.**
- **The physical characteristics that contribute to eating quality may be assessed subjectively with ad hoc or trained panels.** Alternatively some form of objective test designed to mimic aspect of taste panel assessments may be employed, e.g. texture profile analysis (Cauvain, 1991).
- **Product odour and flavour may be assessed subjectively on an ad hoc basis or with trained panels.** The development of the so-called ‘electronic nose’ may offer a more objective measure but has yet to approach human sensitivity.

Whatever details are considered to be appropriate for the record it is important to have a standardised format for recording the details. This usually takes the form of a standardised record sheet, paper or electronic, with blank spaces in which to enter the appropriate data or comments. Where a product attribute cannot be measured, an attribute ‘scoring’ system might be used to provide a more objective basis for analysis of the problem. Any number of scoring systems may be employed. One example is given in Fig. 2 and others are given in the literature (e.g. Kulp, 1991; Bent, 1997a).
1.3 The analysis

If a standard record sheet is available then the initial analysis can be as simple as considering whether the recorded data deviate from the process specification and in what direction. The effects of any changes can then be compared with existing knowledge bases (in whatever form) in order to provide the basis of a diagnosis. Sadly few bakery problems are solved with such a simplistic approach.

Almost all bakery processes include an element of elapsed time, e.g. proving, baking and lamination, which must be taken into account when analysing the causes of problems. Many larger bakery operations involve continuous

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**Fig. 2** Example of product scoring sheet.

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**Table:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
<th>Score</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recipe code</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date manufactured</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Date evaluated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluated by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product weight (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product height (mm or max. 10)</td>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Volume (cm³ or max. 10)</td>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>External appearance</td>
<td>Uniformity of shape (10 max.)</td>
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<td>Collapsed Peaked</td>
</tr>
<tr>
<td></td>
<td>Crust break (5 max.)</td>
<td></td>
<td>Even Uneven</td>
</tr>
<tr>
<td></td>
<td>Crust colour (5 max.)</td>
<td></td>
<td>Dark Light</td>
</tr>
<tr>
<td>Internal appearance</td>
<td>Crumb cell structure (max. 10)</td>
<td></td>
<td>Open Close</td>
</tr>
<tr>
<td></td>
<td>Crumb uniformity (max. 10)</td>
<td></td>
<td>Even Uneven</td>
</tr>
<tr>
<td></td>
<td>Crumb colour (max. 5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensory qualities</td>
<td>Aroma (max. 5)</td>
<td></td>
<td>Off-odour</td>
</tr>
<tr>
<td></td>
<td>Flavour (max. 10)</td>
<td></td>
<td>Off-flavour</td>
</tr>
<tr>
<td></td>
<td>Crumb firmness/softness/crispiness (max. 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eating qualities (max. 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total score (max. 100)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional comments</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
production, even though they are batch fed and this adds a further complication to take into account in the analysis.

An example from our own experiences is that of a plant manufacturing baked puff pastry shells where deviations in the product dimensions were identified at the end of the baking process. In this instance the plant had to run continuously in order to be efficient and not compromise product quality (i.e. no gaps in the pastry sheet or the oven). The operation was batch fed from the mixer so that the relationship between a given mix batch and the product leaving the oven had to be established first. When this was done it then became possible to identify the contribution that any variation in the mix batch contributed to the problem.

After establishing this relationship it became clear that batch to batch variation was not the prime cause of the problem observed since simple plots of dough properties ex mixer (e.g. temperature or rheology) did not correlate with variations in product quality even when the elapsed time element had been taken into account. The solution to this particular problem lay in a plot of changes in product character with time (see Fig. 3), which upon analysis showed that the variation was more regular than first thought. At first glance it appeared to be the well-known ‘shift change effect’ and to some extent that was true: not, in this case, because of the operator effect but because each new shift started with a new batch of re-work to add to the virgin paste. As the re-work aged the effects on baked product character diminished. In this example a simple trend analysis provide the basis for the solution of the problem.

One analysis technique that has started to be applied to cereal science and technology is ‘root cause analysis’ (Stauffer, 2000). Not all bakery problems are likely to be potential subjects for this type of analysis since a key element in this technique is the brainstorming session. Brainstorming usually implies that more

![Fig. 3 Effect of scrap on lift in laminated products.](image-url)
than one person is involved and all too often many of us confront bakery
problems alone or against a timescale that is insufficient to gather together the
necessary team of experts. In manufacturing processes based on batch
production, stopping the line until the problem is solved is an option; however,
for many bakery processes anything other than a short-term stoppage is seldom
an option. However, if the problem is a persistent one or of a catastrophic nature
then root cause analysis can be a suitable technique to apply.

1.4 Modelling techniques

The application of statistical methods of analysis is common in many areas of
food manufacture. They can be used in problem solving and quality
optimisation, though in the manufacturing environment modelling methods
tend to be confined to the plotting of trends using simple graphs as discussed in
the example above for a laminated product. More sophisticated statistical and
modelling techniques can play their part in helping to build up the information
base on what the critical ingredient and process factors are which determine
changes in product quality. Once identified these critical factors can be logged
and matched with problems when they occur.

To develop such predictive models it will be necessary to carry out
experiments in the test bakery or trials on the plant. While trials on the plant are
preferred they can be wasteful of raw materials, energy and time so that the most
common practice is to carry out evaluations in the test bakery and ‘translate’ the
results to the plant. It is very important to establish any clear changes that are
relevant when translating test bakery results to a plant environment. A simple
example encountered by the authors was the development of a sponge cake
recipe in a test bakery using a planetary-style mixer while the plant used a
continuous mixer to prepare the same recipe batter. In this case it is necessary to
remember that less carbon dioxide gas will be lost during continuous mixing
than with a planetary mixer so that baking powder levels should be adjusted
downwards to compensate for this difference. A typical adjustment would be to
reduce the baking powder level for a continuous mixer to be about 75% of that
used on a planetary mixer in order to keep sponge cake volume constant
(Cauvain and Cyster, 1996).

There are a number of examples of modelling techniques which might be
applied to bakery products. Street (1991) provides a review of suitable
techniques that may be applied to baked products and there are many examples
in the scientific and technical literature. The concept behind the development of
such mathematical models is that a relatively limited number of experiments
may be used to build models that can be used to predict changes in bakery
product quality as a consequence of changes in combinations of ingredients and
processes.

Once a predictive model has been established then the information can be used
for problem solving. For example, suppose that we show by experimentation how
loaf volume varies as a result of an interaction between the level of ascorbic acid in the dough and mixing time. At some later stage we may encounter a problem with low bread volume and then we would be able to use the output from our model to help decide whether the problem was associated with the level of added ascorbic acid or mixing time, or both. Furthermore we might use our model to show which changes were most likely to restore our bread volume to its original level.

Baking is a complex food process with many ingredient and process interactions. These interactions lead to complicated models that are often difficult to apply. For example, for a given set of mixing conditions we would observe that bread volume increases with increasing levels of ascorbic acid reaching a maximum and thereafter there will be little change in volume for increasing additions of ascorbic acid. This occurs because the oxidation effect of ascorbic acid is limited by the availability of oxygen from the air incorporated during dough mixing. The availability of oxygen is affected by yeast activity, so that yeast level becomes an influencing factor. Both yeast and ascorbic acid activity are temperature sensitive and proceed at a greater rate when the temperature increases. Dough temperature is a function in part of ingredient temperatures and in part the energy imparted to the dough during mixing. Energy transfer in turn is related to the mixing time. So, too, is gas occlusion to a lesser degree because during mixing an equilibrium point is reached when the entrainment process is balanced by the disentrainment process. This equilibrium may occur before the end of the mixing time.

So for the given example while we set out to study the effects of the level of ascorbic acid and mixing time we must also ensure that we measure:

- ingredient temperatures;
- final dough temperature;
- gas occlusion in the dough;
- energy transferred to the dough.

This is necessary because we cannot independently control some of the properties concerned, e.g. mixing time, energy and dough temperature. Whenever we do work during mixing we must expect there to be a temperature rise. This relationship also holds true if a water jacket has been fitted to the mixer and in this case we must remember that the water temperature in the jacket will also rise.

There tends to be greater variability in product quality for products manufactured on a plant than one sees in many test bakery environments. This process ‘noise’ in the data can mask some of the critical issues that control product quality and therefore weaken the value of any models which have been developed. There are a number of statistical techniques that can be used to help separate such noise from underlying effects, trends and relationships. In many manufacturing processes the specified product characteristics can be achieved by many different combinations of formulation and process conditions. Taguchi methods use experiments to search systematically and efficiently for combina-
tions of ‘control’ factors that minimise product variability in the face of variations in ‘noise factors’ such as ambient temperature. Taguchi methodology has been applied to the manufacture of bakery products, in particular in a study of the factors that affect the quality of puff pastry (DTI, 1993).

1.5 The information sources
Few of the problems that we may encounter in the manufacture of bakery products are likely to be so unusual that they have not been encountered and recorded before. Even where an apparently new problem arises, access to suitable information sources often reveals a problem and solution so similar that it can be readily adapted to our particular needs. For example, most of the problems that we are likely to encounter in the production of cakes with heat-treated cakeflours will have similar solutions to those that would apply if we were using chlorinated cakeflours. Even though it may be the first time that we have used a heat-treated flour we therefore have a suitable base for identifying the solution to our problem.

The availability of suitable information is a fundamental tool for our ability to problem solve successfully. Traditionally such information sources could be classified as personal and written. More recently computer-based sources have become increasingly available in forms that would not be classified as an electronic equivalent of the written word.

Personal
Even in today’s fast-moving electronic age there is no substitute for personal experience which builds one’s own portable information source. However, few of us will spend long enough in positions that allow the systematic build-up of the appropriate knowledge through ‘trial and error’ studies. Aspects of problem solving may be taught in our years of academic study but these are seldom detailed enough to provide us with the comprehensive information base required.

Personal contacts with experts and consultants can be used to supplement the individual information base. Contact with other professional bakers and professional baking organisations is invaluable because it allows access to a wider range of experiences. Thus membership of professional bodies such as the British Society of Baking, the American Society of Baking and the Australian Society of Baking, which are linked with one another, has benefits in developing one’s own knowledge base.

Written
The scientific and technical literature provides the most obvious source for written material which aids in problem solving. Starting a collection of ‘useful’
articles and some form of index is very helpful in establishing your own information base. Included in the written form are pictorial libraries of faults and associated text related to their identified causes. Such libraries may be built for oneself or may be purchased from a suitable source.

Over the years many of the ‘rules’ related to problem solving in baking have been summarised and published (e.g. Street, 1991; Bent, 1997b). These generally take the form of lists of faults and associated causes. In many ways such rules are of limited value because they seldom consider or assign a likelihood value and so one must use one’s own judgement as to which of the causes to investigate first. Such lists tend to deal only with the most common problems and seldom consider interactions between ingredients or ingredients and processing. Also the causes of faults are given equal weighting; thus there is no expression as to whether a particular cause is more likely than another.

**Knowledge (computer)-based systems**

Computing technology offers a special opportunity to help with problem solving. In particular reason-based programs, commonly known as ‘expert systems’, can be used in fault diagnosis and linked with corrective action. The Flour Milling and Baking Research Association at Chorleywood was the pioneer in applying such technology to the baking industry. Lately the work has continued in the Campden and Chorleywood Food Research Association.

Expert, or knowledge-based systems as they are now commonly referred to, can combine facts and rules to solve problems. The ‘rules’ can take several forms including mathematical models, ‘rules of thumb’ and ‘intuitive’ rules. The latter may well take the form of ‘if I increase the level of ingredient X then property Y in the product will change in a positive direction’. Such rules may not quantify the degree of change, only the direction.

Knowledge-based systems can contain many rules which should be capable of validation. They should not contain opinion but rather concentrate on facts. Such systems can perform a fault diagnosis within a few minutes and are capable of considering large information bases very quickly. They can consider many interactions and are often written to provide degrees of likelihood in the answers so that prioritising corrective actions is possible. Images and text can be integrated and displayed to provide pictorial display of product characteristics. In some cases it may be possible to diagnose faults with a knowledge-based system based solely on images run using touch-screen computing technology (Young, 1998a).

Unlike humans, knowledge-based systems never forget and always consider all the necessary information. However, they are not perfect because they rely on human programming and so are only as good as the information they contain. Nevertheless they can play an important role in aiding problem solving and offer a significant advantage over the classical written fault diagnosis text lists.

Knowledge-based systems have been applied for problem solving in the production of bread (Young, 1998a), cake (Petryszak et al., 1995; Young et al., 1996),
1998) and biscuits. In addition to their application for problem solving they may be used in product development (Young, 1997), process optimisation, e.g. retarding (Young and Cauvain, 1994; Young, 1998b), and for training (Young, 1998a).

The ‘Web’
The development of new information highways such as the World Wide Web has increased the range of options available for information and contacts to help with problem solving. There are many sites that can be accessed that may provide information but it is important to try to ensure that the information received has some validity and credibility. It is therefore best to deal with reputable and well-known sources. A number of professional bodies associated with baking offer their problem solving services to members.

Developments in web-based technologies will considerably increase the availability of computer-based tools such as knowledge-based systems. Already work is underway to provide access to such programs on an on-line basis, linked with the transfer of appropriate baking technology (Young, 1999).

1.6 Some key ingredient and process factors affecting product quality

Bread
Volume:
• flour protein quantity;
• flour grade colour/ash/bran level;
• improver level – oxidants, emulsifiers, fats, enzyme-active materials;
• improver composition – oxidants, emulsifiers, fats, enzyme-active materials;
• yeast level;
• dough development – energy/time;
• dough temperature;
• prover conditions – time/temperature/humidity;
• oven conditions – temperature.

Crust colour:
• sugar levels;
• improver level;
• improver type;
• dough enzymic activity;
• fermentation conditions – time/temperature/yeast level.

Crumb cell structure:
• flour properties – protein quantity;
14 Baking problems solved

- improver level – oxidants, emulsifiers, fats, enzyme-active materials;
- improver composition – oxidants, emulsifiers, fats, enzyme-active materials;
- yeast level;
- dough development – energy/time;
- dough temperature;
- dough moulding.

Crumb colour:
- flour grade colour/ash/bran level;
- crumb cell structure;
- dough moulding.

Crumb softness:
- volume;
- cell structure;
- ingredients – emulsifiers, enzyme-active materials;
- moisture content;
- baking conditions – time;
- storage conditions – temperature/time.

Cakes and sponges

Volume:
- recipe balance;
- baking powder level;
- emulsifier level;
- mechanical aeration;
- baking conditions – temperature.

Crust colour:
- recipe balance – sugars, milk products;
- baking – conditions temperature.

Crumb cell structure:
- mixing time;
- mechanical aeration;
- recipe balance;
- baking powder level.

Crumb colour:
- Ingredients, e.g. egg level.

Crumb softness:
- volume;
• moisture content;
• cell structure;
• baking condition – time;
• storage conditions – time/temperature.

**Pastries**

**Shape:**

• recipe balance;
• mixing conditions – time/energy;
• process conditions – resting periods.

**Fragility:**

• recipe balance;
• mixing conditions.

**Eating qualities:**

• recipe balance;
• moisture content;
• moisture migration;
• storage conditions – time/temperature.

**Laminated products**

**Shape:**

• recipe balance – fat level;
• mixing conditions – time/energy;
• process conditions – resting periods;
• lamination conditions – numbers of layers, temperature.

**Lift:**

• recipe balance – fat level and type;
• mixing conditions – time/energy;
• production method – English/French/Scotch;
• process conditions – temperature, resting periods.

**Eating qualities:**

• recipe balance – fat level;
• fat type;
• moisture content;
• moisture migration.
1.7 Conclusions

Many of us will be faced with the need to solve problems in the bakery. Some will be minor and some extensive in nature, but they will all be important. To a large extent identification of the cause of the problem will be based on sound observation and the application of appropriate knowledge in a systematic manner. As bakers we have to deal with a mixture of complex ingredients and their many interactions with one another and the production processes we use. For practical bakers many of the causes of problems are ‘hidden’, for example, a change in flour properties is seldom obvious until a defective product leaves the oven.

There is always a need to find the ‘quick’ solution and traditionally this was based on training and experience. Today’s bakers seem to get little of the former and are seldom given the time to obtain the latter. Modern information technologies can go some considerable way in providing suitable problem solving tools for the modern baker. There is no single unique source that can provide all of the necessary solutions to bakery problems but keen observation, a methodical approach and good information sources will almost always help identify cause and solution.

1.8 References

MUNSELL, A.H. (no date) Munsell System of Colour Notation, Macbeth, Baltimore, USA.


Useful web addresses
American Society of Baking – www.asbe.org
British Society of Baking – www.bsb.org.uk
Campden & Chorleywood Food Research Association – www.campden.co.uk
2.1 What effects will variations in flour protein content have on baked product quality? How is the property measured?

The protein content of flour is probably the single most important property of wheat flour. Perhaps more correctly we should refer to wheat proteins since there is more than one type of protein present. The scheme established by Osborne (1907) is most commonly used for the groups of proteins in wheat, which comprise:

- albumins, soluble in distilled water;
- globulins, soluble in dilute salt solutions;
- prolamines, soluble in 70% aqueous ethanol;
- glutelins, soluble in dilute acid.

The two most important groups for bread and fermented goods are the prolamines and the glutelins. They contain the gluten-forming proteins that give wheat flour its almost unique ability to form a dough capable of retaining gas and increasing in volume under the influence of heat and carbon dioxide gas released by yeast fermentation. The properties of wheat gluten were recognised as long ago as 1729 (Bailey, 1941).

Gliadin and glutentin are the two wheat protein components that give wheat gluten its special properties. These can best be appreciated by making a dough of flour and water and hand kneading it under running water. As time proceeds a milky-white liquid is washed out: this is the starch and other insoluble components. Eventually all that is left is a grey, light brown mass with an extensible but also an elastic character. This is the gluten and its gas retention properties can be shown by placing the mass of gluten in the oven and watching it swell. The quantity of gluten that can be extracted varies with the protein content of the flour.
Bread and other fermented product volumes are directly related to the quantity of protein present: the higher the protein content of the flour, the greater the product volume. This positive relationship has been reported by a large number of observers for many different breadmaking processes and products (e.g. Cauvain et al., 1985). Thus in answer to the question, variation in protein content will result in potential variations in bread and fermented product volume. They will also affect the lift obtained with laminated products but will have no significant effect on the volume of other baked products, though variations in protein content may affect other product attributes, e.g. eating quality in cakes.

Protein absorbs water, 1.3 g of water for each 1 g protein (Stauffer, 1998), and so variations in protein also affect flour water absorption.

Wheat proteins contain nitrogen, and protein measurement methods are based on that basic measurement. For many years the standard ‘wet chemistry’ method was the Kjeldahl (AACC Method 46-10, 1995). The method involves the acid digestion of the flour using sulphuric acid in the presence of a catalyst. The Kjeldahl nitrogen value so determined is converted to protein using a factor; for wheat this involves multiplying by 5.7. More recently Kjeldahl protein determination has been replaced by the Dumas method based on combustion in the presence of oxygen (AACC Method 46-30, 1995).

Flour protein is also commonly measured using near infrared reflectance (NIR) technology (CCFRA, 1991). This provides a fast and simple to use method which can also be applied to on-line processes in the flour mill. However, it should be noted that NIR protein is calibrated against an accepted ‘chemical’ method since it does not represent a fundamental measurement of protein.

References
2.2 There are many references to protein and gluten quality in the technical literature: how important are these properties for bread and other baked products?

As discussed in the previous question flour protein content is probably the most important of all flour analyses because of its relationship with gluten quantity. In gluten washing experiments with different flours not only do we observe different quantities of gluten but for the same gluten mass from two different flours we may observe that the rheological character (i.e. the way it stretches and deforms) of the gluten varies.

The variations in gluten ‘quality’ from different flours are important in many aspects of baking. In particular they directly affect the way in which flours will behave when subjected to the stresses and strains of processing. The key qualities that we need to consider are:

- resistance to deformation;
- elasticity;
- extensibility;
- stickiness.

Gluten has all of these properties and is described as a viscoelastic material; that is, its behaviour can be described by considering both viscous and elastic properties.

In the production of bread and fermented goods we are seeking to preserve the gas bubble structure that has been created during mixing and to obtain a considerable degree of expansion during proving and baking. We therefore seek to have a gluten which has low resistance to deformation, minimal elasticity and maximum extensibility. Bread and other fermented doughs generally only experience problems with stickiness when they are subjected to shear, e.g. as in moulding.

The sheeting of doughs as for the production of laminated products, pastries, crackers and biscuits also requires that we have an extensible but not elastic gluten. However, since recipe water levels in such products are lower than used in breadmaking the gluten tends to have a more elastic nature. To overcome this it is common to use resting periods during processing to allow the gluten to become softer and less elastic. It is not so easy to use resting periods with fermented products because of gas production by the yeast.

In batter-type products, such as cakes, gluten quality is considerably less important, mainly because it cannot form in the initial mixing stages because the low viscosity of the system makes the transfer of sufficient energy and therefore gluten development difficult.
2.3 I have seen that there are several different methods to assess flour protein quality. Which one gives the most meaningful results?

There are indeed many ways to assess the quality of protein present in flour. Since they are all related to some aspect of baking performance they will all give meaningful results but because they all have a different basis for assessment then it can be very difficult to compare data from one test to another. The other common problem encountered is that almost without exception the methods are not based on the same formulation, mixing or processing conditions that are now in common use in baking. Indeed the basis of many of the flour quality tests originate from the days when breadmaking using bulk fermentation was the norm. Today, no-time doughmaking processes dominate and so this means that the outputs from flour quality tests need a degree of ‘expert’ interpretation in order to obtain the most meaningful results. Over a period of time experts can readily extrapolate from protein quality data to end product quality and so comparison between flours can be readily achieved.

Some of the protein quality tests commonly used are given below:

**Farinograph**
This test is based on mixing a flour and water dough under prescribed conditions. It is commonly used in the determination of flour water absorption. Evaluation of the mixing curve can supply data on protein quality using the parameters dough development time, dough stability and degree of softening.

**Extensograph**
In this test a flour–water–salt dough is mixed using the Farinograph. The resultant dough is moulded and rested under prescribed conditions. After resting, the dough pieces are stretched over two set pins by a moving hook. The test mimics the stretching of the dough in a craft baker’s hands. The resistance to extension and extensibility to the point of the dough snapping are measured. The piece may be re-moulded, rested again and re-tested.

**Alveograph/Consistograph**
In the Alveograph test the water level added to the flour is fixed and after mixing the dough is extruded and shaped. After a resting period the dough is clamped over a metal ring and inflated by air pressure. The resistance of the dough to expansion and the point of rupture are recorded. Typically a curve is produced, the area of which is related to flour strength. The weakness of the Alveograph was the fixed dough water content which has now been replaced with an optimised water level in the Consistograph test but otherwise the procedure is similar.
Roberts/Dobraszczyk dough inflation
This device can be fitted to standard texture analysis machines. The dough is prepared under standard conditions and air pressure is used to inflate a bubble to the point of rupture. There are some similarities to the Consistograph.

Fundamental dough rheology measurements
A number of devices and methods are based on small-scale deformation of dough between two oscillating plates. The data can be related to fundamental rheological measurements but because dough is viscoelastic and deformation forces are so low, the relationship between such measurements and dough behaviour remains as tenuous as with other tests.

Large-scale deformation testing
A number of tests have been developed by workers seeking to mimic the behaviour of dough under normal bakery conditions more closely. The tests tend to be product (e.g. Telloke, 1991) or project specific (e.g. Cauvain et al., 1992) and not in common use as standard methods.

References

Further reading
2.4 We have been using a flour ‘fortified’ with dry gluten for breadmaking. The bread is satisfactory when made on a high-speed mixer but less so when we use a low-speed mixer. What is ‘dry gluten’ and can you explain why we get different results when we change mixers?

Dry gluten is obtained by washing out the starch from a wheat flour dough (McDermott, 1986). The rubbery mass left is known as gluten which is then carefully dried using controlled procedures which are designed to retain the maximum ‘vitality’ of the gluten, i.e. its ability to form gluten after hydration and dough mixing. Typically the protein content of the dry gluten will be in the region of 70–75% dry matter. Dry gluten absorbs about 1.5 times its own weight of water when it is used in breadmaking. The addition of dry gluten may be used to boost the level of the natural flour protein to improve the gas retention properties of the dough. It may be added to the flour in the mill or it may be added as a dry ingredient in the bakery. Dry gluten does not usually require pre-hydration before dough mixing.

The input of energy during dough mixing is an essential part of the development of a gluten structure capable of retaining gas during baking. Different mixers impart different levels of energy to the dough for a given mixing time and so are more or less effective at developing a gluten structure. High-speed mixers impart higher energy levels to the dough during mixing than low-speed mixers. This difference remains true even when the dough mixing time with low-speed mixers is lengthened. This is because the low speed of mixing results in a low rate of energy transfer.

Gluten development, as manifested by improved gas retention, is known to be linked with the rate of energy input to the dough with faster rates of energy input improving dough gas retention for many flours (Cauvain, 1998). This effect is especially true for gluten-fortified flours and it appears that mixers at low speeds are less able to make full use of dry gluten additions. However, the full reasons for the difference are not completely understood.

References
2.5 What is the Falling Number of a flour and how is it measured? What values should we specify for our flour miller?

The Falling Number of a flour is related to the level of cereal α-amylase which is present. The production of cereal α-amylase is encouraged within the wheat grains if their moisture content is sufficiently high in the last few weeks before harvesting. Such conditions are most likely to happen if the period concerned is particularly wet.

The full name for the test is the Hagberg Falling Number test and it was originally developed in Sweden. It takes its name from the basis of the test. A flour–water suspension is heated within a tube held in a boiling water bath. The mixture is stirred for 60 s to ensure uniformity of the mixture. At the end of the stirring period the stirrer is brought to a predetermined point at the top of the tube, released and the time taken for the stirrer to fall through the mixture to a lower fixed point in the test tube is measured. The time taken for the stirrer to fall down the tube is known as the Falling Number.

The test is based on the action of the cereal α-amylase on the starch present in the flour. The temperature in the test is designed to give maximum enzymic activity in the flour–water mixture and quickly changes according to the level of cereal α-amylase present; the higher the cereal α-amylase level, the quicker the flour–water paste thins, the faster the stirrer falls and therefore the lower the Falling Number.

The higher the cereal α-amylase level, the greater the formation of dextrins during breadmaking and so the more likely that there could be problems with bread slicing. In bulk fermentation high cereal α-amylase levels will lead to dough softening.

The Falling Number includes the 60 s stirring time so that the lowest theoretical number is 60. In practice Falling Numbers over 250 are suitable for most breadmaking processes. As well as having too much cereal α-amylase activity it is possible to have too little and Falling Numbers above 350 indicate that the flour should be supplemented with a form of amylase (see 4.5). We suggest you specify that your Falling Number lies between 250 and 280, though the actual level you require will be specific to your products and processes.
2.6 What is damaged starch in flour? How is it damaged and how is it measured? What is its importance in baking?

Starch granules in flour have a flattened, roughly spherical shape which is sometimes described as lenticular. They range in size from about 10 to 50 μm. Each starch granule has a surface or skin.

Within the developing wheat grains the starch granules are embedded in a protein matrix in the endosperm. During the flour milling process the endosperm is fragmented by the action of the milling’s rolls or stones. Some of the starch granules are exposed to high pressures during the milling process and their surfaces may be become mechanically ruptured or damaged. The damage to starch granules typically occurs during the reduction (smooth rolls) stage of roller milling. Here the gaps and speed differentials between the rolls may be adjusted to give more or less starch damage according to the requirements for the final flour.

Damaged starch is susceptible to attack by α-amylase (see 4.4) and this action provides the basis for the different methods that have been and continue to be used for the measurement of the damaged starch level in flours. A long-standing method based on the enzymic hydrolysis of starch was that devised by Farrand (1964) and for many years the level of damaged starch in flours was referred to in Farrand Units (FU). More recently the most important methods of measuring damaged starch are:

- the Megazyme method based on a two-stage enzymic assay (Gibson et al., 1992);
- the AACC method (Donelson and Yamazaki, 1968; AACC, 1995) based on digestion of the damaged starch by fungal α-amylase with the value expressed as a percentage.

The importance of damaged starch is mainly for breadmaking. Damaged starch absorbs twice its own weight of water in contrast with undamaged starch which only absorbs around 40% of its weight. This high water-absorbing capacity means that the damaged starch may account for about 16% of the total flour water absorption, a value similar to that for the protein itself (Stauffer, 1998). The contribution that damaged starch makes to flour water absorption has made it an essential element of flour specifications.

The upper limits for starch damage are not well defined or understood. The link between damaged starch and α-amylase activity is an important one since excessive amylase activity leads to dextrin formation and the release of water into the dough which, in turn, causes softening. Breadmaking processes employing periods of bulk fermentation are more likely to experience such problems than most no-time systems.

Very high levels of starch damage may lead to loss of bread quality, including a more open (larger average size) cell structure and greying of the crumb colour. Farrand (1964) observed such quality losses and related the starch damage and flour protein levels. His premise that the damaged starch level
should not exceed protein$^2$ divided by 6 is no longer relevant but the principle
that the higher the flour protein, the higher the starch damage that can be
accommodated remains a relevant ‘rule of thumb’.

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2.7 We find that we often have to adjust the water level we add to our flours in order to achieve a standard dough consistency. What are the factors that cause the water absorption capacity of flour to vary?

The water absorption capacity of a flour depends on a number of different flour properties, including the following:

- The flour moisture content – the lower the moisture content, the higher the water absorption.
- The flour protein content – the higher the protein content, the higher the water absorption.
- The level of added dry gluten in the flour – dry gluten absorbs about 1.5 times its own weight of water so that if it has been used to supplement the protein level in the flour the water absorption may be somewhat higher than expected from indigenous protein levels.
- The flour damaged starch level – the higher the level of damaged starch, the higher the water absorption (see 2.6).
- The flour pentosan level – the higher the pentosan level, the higher the water absorption.
- The bran content – the higher the bran content, the higher the water absorption. This is one reason why more water must be added to wholemeal flours than to white flours.

In addition the level of enzymic activity in the flour may affect the apparent flour water absorption because of softening that may occur, especially during any periods that the dough stands in bulk.

A number of workers have studied the factors that may affect flour water absorption (Farrand, 1964) and several have derived equations to predict water absorption from measured flour properties (e.g. Cauvain et al., 1985).

Other reasons why the added water level may vary include the following:

- Variations in partial vacuum levels in the Chorleywood Bread Process (CBP); lower mixer headspace pressures result in doughs that are ‘drier’ to the touch.
- Variations in dough final temperature since the viscosity of dough increases when the temperature goes down.

References

2.8 Why is flour particle size important in cakemaking?

White flour that is used in cakemaking is composed mainly of endosperm fragments that have been separated from the surrounding bran during the milling process. The maximum particle size is fixed by the screen sizes in the plansifters in the mill but typically falls around 150 μm. If we were to examine a straight run white flour we would find some fragments of the original protein matrix (less than 15 μm), some starch granules freed from the protein matrix (up to 45 μm), with the remainder being endosperm fragments of varying sizes.

In cakemaking the wheat starch plays a significant role in forming the cake structure as it controls the batter viscosity during heating and helps retain the expanding gases, carbon dioxide (from the baking powder), air (trapped during mixing) and steam (from the added water). This is particularly true for the so-called high ratio flours which may undergo further treatment with heat or chlorine gas in order to enhance their cakemaking properties.

Many of the key processes in cakemaking depend on the surface activity of many materials and so increasing the surface area of the available starch becomes important in aiding stability of the batter. The separation of the starch granules from the protein matrix can be readily achieved by re-grinding and/or air classification. The aim of re-grinding is to free the starch granules from the surrounding protein and lower the maximum particle size of the flour, typically to less than 90 μm.

Air classification enables fractionation of the flour into components with narrow particle size ranges using air currents. Two or three fractions may be separated using this milling technique. Typically the cut-off points in the air classifiers are set to deliver fractions as follows:

- Less than 15 μm, comprising fragments of free wedge protein and small starch granules. The protein content will be very high, typically more than 20%.
- Between 15 and 45 μm, comprising mainly starch granules and smaller fragments of endosperm. The protein content will be low, typically around 8%.
- Greater than 45 μm, comprising the large fragments of endosperm. The protein content is usually close to that of the base flour, typically around 10%.

Cauvain and Muir (1974) provided a comprehensive study of the effects of changing the particle size of cakeflours and show that treated flours without particle size reduction yielded cakes that collapsed during baking and had a dense cell structure (Fig. 4). Progressive reduction of the maximum particle size decreased the degree of collapse in the cake. They considered that the maximum particle size for cakeflours should be 90 μm. They also showed that the application of heat treatment or chlorination to the flour could be carried out before or after particle size reduction, which emphasises the importance of flour particle size in cakemaking. Cauvain and Hodge (1977) showed that a
significant proportion of larger particles in cakeflours could also be responsible for collapse in sponge cakes.

References
2.9 What is heat-treated flour and how can it be used?

The modification of wheat to produce heat-treated flour or the direct heat treatment of flour may be used to achieve a number of different changes in the final flour properties. We can broadly classify the type of heat treatment as wet (steam) or dry.

Steam treatment of wheat is commonly used to inactivate the enzymes present so that the subsequent flour may be used as a thickening agent, for example in the production of soups. Without inactivation any cereal α-amylase that is present would act on the damaged starch and the subsequent release of water would cause thinning of the soup.

Steam treatment of both wheat and flour may be used to induce a degree of gelatinisation in wheat flour which helps with its potential function as a thickening agent. Steam treatment may also have a small reducing effect on the numbers of viable microorganisms present in the flour but the treatment is usually insufficient to sterilise the material.

Dry heat treatment of wheat and flour has a long history. In the earlier years of the 20th century it was used to modify the extensibility of gluten from some wheat varieties (Kent-Jones, 1926) but such uses are no longer in common practice. The main application of dry heat treatment to wheat and flour is in the preparation of high ratio cakeflours as an alternative to chlorination (see 2.10). A number of patents were developed that established the necessary heating conditions required to achieve the necessary modification of flour properties (Doe and Russo, 1968; Cauvain et al., 1976). The cakes illustrated in Fig. 5(a) use an untreated flour (left) and a flour from a heat-treated semolina (right), while the graph (Fig. 5(b)) shows the effect of the relationship between oven (heat) temperature and heating time (Cauvain et al., 1976). Treatment temperatures normally exceed 100°C, rising to around 140°C as the treatment temperature increases the residence time required to achieve the modification decreases from several hours to a few minutes.

The mechanism of the improving effect from dry heat treatment is not clear but is likely to be associated with some modification of the surface properties of the starch present in the final flour. At the end of the treatment process the flour

![Fig. 5](image)

**Fig. 5** Effect of flour heat treatment on cake quality.
is very dry and it is clear that the loss of moisture is associated with achievement of the necessary changes in the flour (Cauvain et al., 1979), but the low moisture content of the flour is not part of the mechanism of improvement. When the dry flour is rehydrated considerable heat is given off – known as heat of hydration – and unless compensatory steps are taken, this may lead to undesirable increases in cake batter temperatures and premature release of carbon dioxide gas.

References


2.10 What is chlorinated flour and how is it used?

The treatment of flour with chlorine gas was first identified in the 1920s and was used for the modification of the cakemaking properties of flours for many years in the UK, the USA, Australia, New Zealand, South Africa and many other countries. The use of chlorination for cake flour treatment was withdrawn from the UK in 2000 (The Miscellaneous Food Additive (Amendment) Regulations, 1999). It remains permitted in many other countries.

Chlorine treatment of flour permits the raising of recipe sugar and liquid levels to make the so-called high-ratio cake (i.e. a recipe in which the added sugar and water levels both exceed the flour weight). The principal benefit of the high-ratio cake recipe is that product moisture levels can be increased without adversely affecting the mould-free shelf-life of the product. The higher moisture level confers a more tender eating quality to the final product. If the flour has not been chlorinated and used with a high-ratio recipe then the cake structure will collapse, with loss of crumb structure, the formation of dense, dark coloured streaks and the product eating quality becomes pasty (Fig. 6).

Chlorine treatment of flour is achieved by mixing and blending the gas through the flour. Typical levels of treatment lie between 1200 and 2500 ppm chlorine based on flour weight. The higher levels are commonly used to treat flour intended for the manufacture of fruited cakes. The gaseous treatment has a number of effects on flour quality but only a small proportion of the gas used actually confers the beneficial effects to the flour. In summary the chlorine gas is used as follows:

- Around 50% of the level used is absorbed by the flour lipids (typically around 2% of the flour mass) but appears to play no significant part in the improving action.
- Around 25% denatures the flour proteins (i.e. prevents the formation of gluten) but plays no major role in the cake-improving effect.
- The remaining 25% or so reacts with the starch granules and this is the main cake-improving effect. It appears that the chlorine reacts with the proteins associated with the starch granules and makes them more hydrophobic. There is also evidence that chlorine treatment increases the exudation of amylose.

![Fig. 6 Effect of chlorination on cake quality.](image)
from within the starch granules (Telloke, 1986) but that there is no change in the gelatinisation temperature of the starch (Cauvain et al., 1977).

• The action of chlorine is to bleach the flour pigments so that a whiter flour and brighter product crumb colour result.

• The flour pH is lowered and commonly used as a crude measure of the level of chlorination achieved. More accurate assessment of the level of chlorine treatment requires the use of a chloride meter.

In the UK and elsewhere the heat treatment of flours for cake making has replaced chlorination (see 2.9).

References


2.11 We have two supplies of wholemeal (wholewheat) flour: one is described as ‘stoneground’ and the other comes from a roller mill. Why is the bread we obtain from the stoneground flour often smaller in volume?

The fundamental difference between roller-milled and stoneground wholemeal flours is related to the size distribution of the particles that form the flour. These particles come from the bran, germ and endosperm components of the wheat grain. Overall roller-milled wholemeal flours tend to have a greater proportion of endosperm released as white flour compared with stoneground flours.

While stoneground flours may be milled to coarser or finer average particle sizes it is difficult to provide flours in which the particle size distributions of the bran and endosperm (white flour components) differ. In bread baking the particle size of the bran can have an important effect on bread quality, with larger bran particles being less deleterious to bread volume than fine ones (Cauvain, 1987). Collins and Hook (1991) studied the effects of the particle size distribution of roller-milled and stoneground wholemeal flours on bread quality and found that loaf volume increased with increasing fineness of the endosperm particles.

Thus there may be more than one reason why you are experiencing the loss of volume with the stoneground and so you should measure the particle size distribution of the flour concerned. While coarser bran particles are desirable, coarser endosperm particles are not.

In order to overcome the loss of product volume with the stoneground flour you may wish to consider using a high-protein flour or making adjustments to your formulation or improver level if you use one.

References

2.12 Some wholemeal flour we have had in stock for a while has passed its use-by date. Can we still use it?

The quality of all flours changes with storage time; in some cases the changes may be advantageous and in others detrimental. Wholemeal flour has a higher lipid content than white flours and is more prone to problems associated with rancidity. The low moisture content and water activity of wholemeal flour will ensure that microbial spoilage is unlikely to occur. There is a potential for rancidity from enzyme-catalysed changes in the flour oil and this is a key factor in limiting its shelf-life. The other point to consider is the potential for insect infestation. We recommend that you do not use the wholemeal flour in question and try to implement more strict control on your flour stocks to avoid a similar problem in future.

Most of the studies in the long-term storage changes in flour have used white flours. As storage time increases, the breadmaking potential of white flours changes and a progressive loss of volume in the final product is likely. Such changes take place slowly and appear to be associated with changes in the flour lipid composition and in particular with the release of free fatty acids (Bell et al., 1980). The loss of volume may be overcome with the addition of extra fat or some other form of lipid, e.g. emulsifiers (Bell et al., 1976, 1980). The restoration of the breadmaking potential of white flours through the addition of a suitable lipid, e.g. higher levels of breadmaking fat or a suitable emulsifier, could be achieved with white flours even after they had been stored for 48 months (Collins et al., 1992).

Historically, long-term storage of flours has been used to enhance the baking performance of flours. This appears to be in contradiction to the findings described above, but it should noted that there has been a fundamental change in breadmaking processes in the last 100 years with a move from bulk fermentation to no-time dough systems. With the latter breadmaking systems, the role of fat in assisting gas retention is more critical and this may account for the apparent reversal of the storage effects.

The cakemaking qualities of flours are also considered to improve with long-term storage and some natural bleaching appears to occur.

References
2.13 What are the active components in self-raising flour?

Self-raising flours contain sodium bicarbonate and a suitable food grade acid. When used in baking the bicarbonate and acid react to generate carbon dioxide gas. Self-raising flours are most commonly sold through the retail trade and find greatest use in the domestic market. They may be used in smaller bakeries as an alternative to separate additions of plain flour and baking powder.

The level of added baking powder is usually governed by a form of regulation that specifies the volume of carbon dioxide gas that is evolved at the point of final use. Since there may be a small degree of reaction between the active components and loss of carbon dioxide gas during the relatively long storage periods for such flours, the rates of addition to the fresh flour will be somewhat higher than required by legislation. For example, the UK Bread and Flour Regulations (1996) specifies that self-raising flour should yield not less than 0.4% of available carbon dioxide but commonly rates of addition will deliver around 0.8% when freshly prepared. The latter level equates to 1.56% of the flour weight being sodium bicarbonate.

A number of different food acids may be used in the production of self-raising flour. They include:

- acid calcium phosphate (ACP), monocalcium phosphate (MCP);
- sodium acid pyrophosphate (SAPP);
- sodium aluminium phosphate (SALP);
- cream of tartar, potassium hydrogen tartrate;
- glucono-delta lactone.

Each acid component will be added according to its neutralising power with sodium bicarbonate (Thacker, 1997). The rate at which carbon dioxide gas is released depends on the type of acid being used. Sometimes a mixture of two acids may be used to provide a so-called ‘double-acting’ baking powder which provides for both early and late carbon dioxide release.

References


2.14 What are ‘organic’ flours, how do they differ from other flours and what will be the differences to the baked product?

The term ‘organic’ refers to the manner in which the wheat has been farmed and turned into bread and flour. Organic farming uses more traditional methods of treating the land during the farming cycle and in particular does not use ‘artificial’ fertilisers and restricts applications of pesticides, insecticides or herbicides. Organic wheats will be segregated and milled separately from other types.

In principle any breadmaking wheat types may be used in the production of organic wheat flour. However, since the farming process relies totally on the application of natural fertilisers there is a tendency for the protein of many wheat varieties to be lower than that which could be obtained with non-organic farming methods. Currently the UK production of organic wheats is too low to sustain the market requirements and much of the wheat is imported. Large quantities of organic wheat come from North America where the fertility of the soil and the larger growing areas have not necessitated the use of the more intensive farming methods seen in the UK.

The lower protein of some organic flours may present a potential problem for the production of bread of similar volume to that typically seen with non-organic flours. The other ingredients that may be added to manufacture organic bread are closely specified and many must also come from organic sources, e.g. dried gluten which could be used to boost bread volume. You should consult the Soil Association or similar body for advice. In the event that you wish to make organic bread you will need to obtain the necessary accreditation from a specified body.

In summary you should not expect organic baked products to be substantially different from non-organic ones. However, you may need to make some adjustments to your formulations in order to maintain product quality.
3

Fats

3.1 What are the critical properties of fats for making bread, cakes and pastries?

To answer this question it is first necessary to be clear about the definition of a fat. In the bakery this is usually the term given to a material that is a blend of liquid oils and solid fats from different sources, usually vegetable in origin. Podmore (1997) provides a comprehensive review of the nature and structure of fats. The basic building blocks of fats are the fatty acids, of which there are three. The fatty acids of the triglyceride may be the same as one another or different. All natural oils and fats are mixtures of glycerides and the properties of the individual fats and oils depend on the quantity and distribution of the different glycerides that may be present.

Since fat properties are related to the glycerides present a detailed knowledge of the composition of a compound fat can be useful. This is commonly obtained using gas chromatography (GC) or high-performance liquid chromatography (HPLC). However, such analytical techniques require expensive and specialised equipment that is not within the scope of many laboratories. The fatty acid composition is related to other more readily measurable properties of fats and oils.

A readily known measurement is the iodine value which measures the proportion of double carbon bonds in the fat and indicates the degree of saturation present. In some fatty acids adjacent carbon atoms in the chain may be joined by a double bond so that fewer hydrogen atoms are attached than theoretically possible and so they are called ‘unsaturated’. In ‘saturated’ fats two bonds form between two carbon atoms in the chain while the two remaining bonds are formed with two individual hydrogen atoms.
Traditionally the ‘slip’ or ‘melting point’ of a fat was used to characterise its performance in baking. However, since many commercial fats are compound mixtures of triglycerides the melting point is often spread over a wide range of temperatures and so has limited value. It is now more common to refer to the Solid Fat Index (SFI) of a fat which considers the proportion of a compound fat which is solid at a given temperature.

Fat SFIs are commonly measured using nuclear magnetic resonance (NMR) and sometimes NMR values for fat are quoted rather than the SFI. Whichever nomenclature is used the temperature at which the measurement is made should be quoted, e.g. NMR\(_{20}\) indicates the percentage of solid fat present at 20°C (see Fig. 7).

In the past measures of fat firmness using cone penetrometry have been used to indicate the characteristics of given fats, e.g. ‘C’ values (Haighton, 1959). The firmness of a fat at a given temperature is strongly influenced by the proportion of oil to solid; however, this is not the only relevant property of fat to be considered. Solid fats may exist in different crystalline forms depending on their temperature history in production and use. The size of the fat crystals also affects their functionality. Small crystals have a larger surface area relative to large ones and so are more able to retain large quantities of liquid oil within the crystal matrix. The crystalline form of a fat is not usually assessed or measured even though it may affect the fat performance.

**Fig. 7** Examples of fat solid fat index profiles.
References
3.2 Our bread doughs prove satisfactorily but they do not rise in the oven. On some occasions they may even collapse and blisters may form on the dough surface in the corners of the pans. What is the cause of these problems?

A lack of oven spring or collapse of the dough in the oven usually signifies a lack of gas retention in the dough. This may arise for a number of different reasons but your comment on the formation of blister on the dough surface in the corner of the pans strongly suggests that your problem comes from a lack of fat or other suitable lipid (e.g. emulsifier) in your improver or bread formulation. The problem can be too low a level or an inappropriate character of the ingredient.

In modern, no-time breadmaking systems, e.g. the Chorleywood Breadmaking Process (CBP), the addition of a fat or emulsifier is important in ensuring adequate gas retention in the dough (Cauvain, 1998). It has been known for quite some time that it is only the solid portion of the fat that can affect dough gas retention and in no-time doughmaking processes it is important that a proportion of any added fat should remain as solid in the dough at the end of final proving. Since typically final proving is carried out at around 40–45°C, the fat melting point must be above 45°C.

The necessary level of solid fat to achieve the required effect at 45°C can be quite small and values as low as 0.02% flour weight have been quoted. However, it is known that the minimum level of fat required varies with flours. In general higher levels of fat appear to be required with stronger white flours and a general recommendation of 0.7% of a compound bakery shortening was the original blanket recommendation in the CBP because this ensured that a sufficiently high level of solid fat remained in the dough at the end of proving.

Improved gas retention with wholemeal and brown flours requires considerably higher levels of added fat than white flours. Cauvain (1998) provides an example for wholemeal bread made by the CBP where maximum bread volume was obtained when added fat levels reached 4% of the flour weight. It is also known that the loss of gas retention which comes from prolonged storage of flour can be compensated with the addition of high levels of a suitable fat.

It is most likely that the fat confers improved gas retention in bread dough by helping to control gas bubble size and stability. Composite bakery shortenings are a mixture of oil and solid fat at dough temperatures but it is only the solid fat portion that can play the necessary gas bubble stabilising role. The molecules of the solid fat portion align themselves at the interface of the gas bubble and the liquid dough phase and play a part in determining the size of the gas bubbles as well as their stability. As the temperature rises in the dough some of the fat molecules melt and lose their ability to stabilise the gas bubbles. Eventually all the fat melts and other materials, principally the gluten, are left to maintain gas bubble stability. A key role for fat may be the prevention of coalescence of gas bubbles in the dough in the early stages of baking.
Emulsifiers are commonly used to replace fat in bread doughs on the basis that they can be used at lower levels. In simplistic terms they may be considered as specialised fats with a high melting point. They play a similar role to fats in stabilising gas bubbles in the dough. However, their melting profile is quite different from that of fats in that they remain solid to much higher temperatures in the dough, typically around 60 °C.

The blisters observed on the dough are gas bubbles that have become excessively expanded but are unstable. When the dough reaches the oven the gluten network is unable to cope with the gas bubble expansion and individual bubbles become over-expanded, perforate and collapse. Collectively they lead to total dough collapse. The addition of a suitable level of a high melting point fat should overcome this problem.

Reference
### 3.3 What is the role of fat in the manufacture of puff pastry?

In the manufacture of puff pastry, fat may be added to the paste in two ways: as part of the base dough formulation and as fat layers formed between two adjacent dough layers. The latter is by far the more important of the two uses and contributes most to the formation of the characteristic layered structure and flaky eating character.

It is not common to add aerating agents to puff pastry yet considerable expansion of the structure occurs as the dough layers are forced apart during baking. The pressure for the expansion comes from the water present in the dough layers as it turns to steam. As the steam tries to escape to the atmosphere, the melting fat acts as a barrier to its progress and the dough layers move apart (Cauvain and Young, 2000).

In order to obtain maximum pastry lift it is important that the fat layers remain separate and discrete from the dough layers for as long as possible, so careful attention should be paid to the processing temperature for the paste. For example, butter has a low solid fat index at 20°C and pastes made with all butter benefit from processing at temperatures around 12–14°C, which gives workable fat layers but ones that will not be so brittle as to break during sheeting.

Since the aeration mechanism involves the fat it is reasonable to assume that the characteristics of the fat play a part in the degree of lift during baking. Telloke (1991) showed that the pastry lift depended on the following fat characters:

- The level of added fat, with higher fat levels giving greater lift.
- The solid fat index, with higher SFI giving greater lift.
- The firmness of the fat at point of use, with greater firmness giving greater lift.
- The crystalline form, with smaller crystal size giving greater lift.

While pastry lift benefits from a higher solid fat index there may be some loss of eating qualities as fats with very high melting points tend to give a greasy mouth-feel and ‘palette cling’. The addition of fat to the base dough has a small adverse effect on pastry lift and gives a more tender eating quality to the final product.

The impedance of steam by the fat layers also plays a part in the aeration of Danish pastries and croissant, though in these cases lift is affected by the activity of the yeast which contributes to the expansion of the dough layers (Cauvain and Telloke, 1993).

**References**


3.4 What is the optimum level of fat to use in the production of puff pastry?

The level of fat that is used in the manufacture of puff pastry depends on a number of factors including the degree of lift and flakiness of eat that you are seeking in the baked product. Puff pastry and other laminated products are characterised by the formation of a relatively thin dough sheet, part of which is covered with fat and subjected to a series of folding and further sheeting steps, with the objective of forming alternate and discrete layers of fat and dough.

Traditionally there are three types of puff pastry characterised by the level of laminating fat used in the formulation. They are commonly designated as **full**, **three-quarter** and **half** puff in which the laminating fat is used at an equal weight to the flour, $\frac{3}{4}$ and $\frac{1}{2}$ respectively. The level of laminating fat has a direct effect on the thickness of the fat layer in the laminated paste and thus a direct impact of the degree of separation of the dough layers. The higher the level of laminating fat, the greater the pastry lift but also the greater the pastry shrinkage (Telloke, 1991). With an increase in laminating fat levels the baked pastries became more tender eating.

There is no absolute optimum level of fat for use in the manufacture of puff pastry, the choice depends on a number of different criteria which may be required in the final product, such as lift, eating quality and flavour. The level of laminating fat is also linked with the number of laminations (folds or turns) given to the paste. In general the lower the laminating fat level, the lower will be the number of laminations required to achieve maximum lift or optimum quality. Telloke (1991) suggested that optimum quality with half paste came with 128 theoretical fat layers (see 8.3) while with full paste the optimum was achieved with 256.

The base dough may also have a small addition of fat (5%) which confers a more tender eating quality to the baked product but does decrease pastry lift. Because of the latter effect we recommend that you avoid using levels of added dough fat greater than 10% of the flour weight.

Similar effects of changing fat levels may be observed in the production of Danish pastry and croissant, though the numbers of laminations are fewer than with puff pastry and the maximum laminating fat level lies around 65% of the flour weight (Cauvain and Telloke, 1993).

References
3.5 Our puff pastry fails to rise sufficiently even though we believe that we are using the correct level of fat. Are we using the correct type of fat?

The lift in laminated products can be affected by two properties of the laminating fat: the solid fat index and the size of the crystals in the solid fat portion, and the degree of work softening of the fat during preparation for use.

The laminating fat plays a significant role in the aeration mechanism in puff pastry by impeding the movement of steam from the dough layers to the surrounding atmosphere (see 8.1). Solid fat layers form a greater barrier than liquid ones and so the proportion of laminating fat that remains solid as the pastry begins to bake is an important characteristic. We can measure the solid fat to liquid oil ratio in a given fat using a number of techniques, for example NMR. The SFI represents the proportion of fat that is solid in the mixture at a given temperature. Such measurements are typically made at three of four different temperatures to establish the solid fat profile.

The higher the solid fat index, the greater the puff pastry lift will be (see Figure 8) but the increase in solid fat may lead to an unacceptable change in eating characteristics (Telloke, 1991). It is particularly important that the proportion of solid fat at 40°C is restricted because it does not melt in the mouth and confers an unpleasant waxy eating quality commonly described as ‘palate cling’. We suggest that any laminating fat you use should not have more than 5% solid fat at 40°C.

Reference
3.6 What is the role of fat in cakemaking?

The main function of fat in cakemaking is to assist with the incorporation of air into the batter during mixing. It also affects the air bubble size in the batter and the bubble stability during before and during the early stages of baking.

Cake batters are essentially a ‘foam’, that is a system in which air bubbles are trapped and held in an aqueous phase. Foam systems are characterised by the fact that all the air bubbles are separated from one another by a thin film of stabilising material. During baking the foam changes to a sponge (in the generic sense), that is a system in which all of the air cells are interconnected and vapours and liquids can move through the matrix. The moment at which the foam in a cake batter makes the conversion to a sponge has much to do with the recipe formulation (Cauvain and Young, 2000) and the stability of the air bubbles while the temperature is rising makes a major contribution to final cake volume.

The protective film that forms around the gas bubbles may come from a number of sources. Fat can contribute to the protective films in the batter foam. Telloke (1984) used light microscopy to show that fat crystals in high ratio cake batters were located at the interfacial film between the air bubbles and the sucrose solution. The crystalline form of the solid portion of the fat is important in determining the functionality of the fat in cakemaking, of the three fat polymorphs encountered the volume of air which could be incorporated into the batter. Telloke (1984) showed that it was greatest with the β, less with the α and least with the β form.

As the batter temperature rises in the oven the solid fat turns to liquid oil and the natural buoyancy of the air bubbles causes them to try to move upwards and escape. The longer the bubbles are retained in the batter the greater the cake volume will be. This means the fat must have a high melting point. However, dispersion of the solid fat crystals is important if they are to be effective and a liquid oil component is necessary to achieve ready dispersion.

Fats and oils contribute to the soft and tender eating properties required for cakes. In part this benefit comes from the effect on batter aeration and in part from the lubricating effect that fat has in the mouth.

References
3.7 We are making ‘all-butter’ cakes but find that after baking they lack volume and have a firm eating character. Why is this and is there any way to improve the cake quality?

Butter is often chosen in cakemaking because of its quality attributes related to flavour and mouthfeel, and its potential marketing value through the association with ‘naturalness’ and ‘quality’. However, while a ‘natural’ product, butter can be the subject of natural quality variations and has characteristics that are not always best suited to cakemaking.

Butter is a mixture of butter oils, water and salt. The level of water must not exceed 16% and salt levels do not exceed 2% of the total butter weight. Thus if butter is used to replace an oil or bakery shortening then the level of addition should be increased to about 1.2 times the recipe shortening level. A weight for weight replacement of shortening with butter will therefore result in a lower fat level in the recipe which will reduce batter aeration and cake volume. Butter oils and butterfats are available which can be used on a one for one replacement basis because they do not contain water (Rajah, 1997).

Generally the ability of butter to contribute to batter aeration and thus cake volume is inferior to bakery shortenings or cake margarines. This is because the SFI at 20°C for butter is lower than that generally recommended for use in cakemaking; typically around 24% of a fat should be solid at 20°C. Butter SFIs at 20°C vary according to the butter’s source, in part because of differences and changes in feeding habits of the cows.

The tempering of butter can improve its functionality in cakemaking. We suggest that you hold the butter between 28 and 30°C for 18–20 h before use. This tempering period permits a beneficial increase in the crystal size of the solid fractions in the butter. You should ensure that full equilibration of temperature has taken place because often the slabs of butter may be stored on a pallet or in a large block which slows down the rate of heat penetration to the centre of the stack.

Considerable improvements in cake volume, softness and eating quality can be obtained by adding a low level of glycerol monostearate (GMS) to the batter. GMS is more effective than butter at stabilising the foam structure of a cake batter. We suggest the addition of a level of 1% (GMS solids) of the total batter weight. The GMS should be in the alpha form and may be added as a stabilised gel.

Reference
3.8 We have been using oil in the production of our sponge cakes but we wish to change to using butter. How can we do this?

There are two courses of action open to you: either melt the butter and add it as a warm oil or add it in the solid form.

The practice of melting fats to incorporate them into sponge batters has been known for some time. The traditional ‘butter sponge’ utilises a basic sponge recipe to which the melted butter is added after all of the other ingredients at the end of the mixing process. The butter should be heated only until it is just liquid, otherwise the hot oil may increase the batter temperature high enough to cause a premature reaction of the baking powder. You may find some benefit in using a little more baking powder in the formulation to compensate for any losses that may occur. If you are not already doing so you may find some advantage in the addition of a suitable emulsifier to the formulation.

If you are going to use the butter in the solid form we certainly recommend the addition of an emulsifier to the formulation otherwise you will not achieve the product volume that you are seeking. You may experience some difficulty in dispersing the butter and so it may be better to use an all-in mixing method. You may also wish to adjust the baking powder level in the formulation.

If you wish to make any claim regarding the use the term ‘butter’ as part of the baked product descriptor you will need to ensure that the level of added butter conforms to the following Code of Practice in the UK:

- At least 5% butterfat for the claim ‘contains’.
- 100% for the claim ‘made with butter’ or the descriptor ‘butter sponge’.
3.9 We wish to produce a softer eating sponge cake and have been trying to add fat or oil but cannot get the quality we are seeking. Is the addition of fat to sponge batters possible and what do we need to do to achieve the quality we are seeking?

In a traditional sponge recipe composed of flour, sugar and egg the mixing action of the whisk draws small air bubbles into the batter during mixing. The egg proteins, principally the lipoproteins, align themselves at the interface of the air bubbles with the aqueous phase. At the interface they provide stability to the air bubbles and prevent them from rising to the batter surface and escaping to the atmosphere.

This bubble stabilisation of the batter ‘foam’ is particularly important in the early stages of baking when the increase in temperature increases the tendency of the air bubbles to rise. Later, during baking, the solid part of the foam begins to set, the gas bubbles begin to burst and the gases diffuse out leaving behind a sponge structure (here the term ‘sponge’ is used in the generic sense, referring to a structure in which the individual cells are interconnected and gases and liquids may diffuse through the matrix).

When oils or solid fats are added to a traditional sponge batter they inhibit the inclusion of air into the batter and displace the egg proteins at the gas bubble/aqueous phase interface. This change allows many of the gas bubbles to escape from the batter, especially during baking when any solid fat is turning to liquid oil. The result is that the mechanical aeration is much reduced and the resultant cake volume is small. For these reasons many traditional methods of producing sponge cakes encourage the scalding of the mixing bowl to remove any traces of fat before the start of mixing.

Oils or fats may be added to sponge cakes to improve the eating quality by carefully blending them into the batter towards the end of mixing. In the case of fats which are solid at bakery temperature it is advisable to heat the fat until it is liquid.

Alternatively you can add an emulsifier, such as GMS, to the sponge formulation to take over the main air bubble stabilising role from the egg proteins. The level of addition needs to be sufficiently high to ensure that bubble stability is maintained during baking up to the point of conversion from foam to sponge (Cauvain and Cyster, 1996). Oils are more suitable for the production of enriched sponges though the addition of solid fat is possible but sponge cake volume and texture are less satisfactory (Cauvain and Cyster, 1977).

References
3.10 We are making a non-dairy cream cake and find that after some days a ‘soggy’ layer forms at the interface of the cake and the cream. We have balanced the water activity of the cake and cream but still see the problem and so we believe that this comes from fat migration from the cream. Are we correct?

There are two possible causes for the formation of a soggy layer at the interface of the cake and cream: one is related to moisture migration and the other as you correctly assume comes from fat migration. Both moisture and fat migration can occur and so we must consider that your problem may be related to a combination of the two effects. However, since you have balanced water component activities we can assume that most of the seepage comes from the migration of fat.

The mobility of a composite fat or shortening depends on its oil content at any given temperature since only the liquid component can flow downwards under the influence of gravity. Thus, we would expect that the problem would be worse when using fats with lower solids contents. To minimise the problem we suggest that you use a fat with a higher solids fat content provided that this does not give you problems with aeration of the fat during whipping or an unacceptably greasy mouthfeel.

Fat seepage is affected by the product storage temperature (see Fig. 9). The higher the storage temperature, the greater the proportion of a given fat that is
liquid and so the greater the risk of seepage. Variations in storage humidity on the other hand have very little effect on fat seepage though small increases have been observed as the storage humidity increases (Cauvain and Young, 2000).

Fat seepage is affected by the degree to which the cream has been aerated with seepage being greater as the cream specific volume increases (Cauvain and Young, 2000). You may wish to limit your cream specific volume or reduce your overall fat content.

Reference
4

Improvers

4.1 What are bread improvers and why are they used?

The term ‘bread improver’ is used to embrace a wide range of materials that can be added to wheat flour and dough in order to improve some aspect of dough behaviour and final bread quality. The use of the term is common and most often applied to the addition of several ingredients at low levels blended with a ‘carrier’, a material that may or may not have functional properties but that aids dispersion and provides a more conveniently handled composite material. The formulation of bread improvers will be influenced by legislative control over the list of permitted ingredients that may be used in breadmaking.

Alternative names for bread improvers that may be encountered in the baking industry include:

- **Dough conditioners**, a specific reference to the fact that the material addition changes dough rheology.
- **Processing aids**, that implies a similar function to dough conditioners.
- **Oxidising agents**, that implies a more specific role concerned with the formation of the gluten network in the dough.
- **Additives**, more commonly applied to specific ingredients.
- **Concentrates**, similar to an improver but with a greater range of ingredients present (e.g. fat, sugar and salt) and commonly used at higher rates of addition.

Almost any material added to a flour and water dough will have some improving effect. For example, the addition of yeast improves the lightness and palatability of bread, while salt changes the handling properties of wheat flour doughs and the flavour of the baked bread. However, the term bread improver is
now commonly restricted to materials that are typically added at much lower levels of addition than yeast or salt with the intention of improving gas production or gas retention in the dough, retaining bread crumb softness and obtaining a whiter crumb colour.

Some of the more common ingredients used in bread improvers are noted below. The classification used is arbitrary since the complex actions of most materials in breadmaking means that they might be classified in more than one group. For example, the addition of many enzyme preparations brings about changes in dough rheology that makes it easier to process doughs but also results in improved oven spring, a manifestation of improved gas retention.

- Aids to dough processing: enzyme-active preparations, e.g. malt flour, fungal \(\alpha\)-amylase.
- Aids to gas production: yeast foods, such as ammonium chloride.
- Aids to gas retention: oxidising agents, such as ascorbic acid and potassium bromate.
- Aids to bread softness: e.g. glycerol monostearate (GMS).
- Aids to improving crumb colour: soya (soy) flour.

Further reading
4.2 What are the functions of ascorbic acid in breadmaking?

Ascorbic acid (AA) is commonly known as vitamin C and is present in large quantities in many green vegetables and fruits. It is an essential component in the diet. Its use in breadmaking was recognised many years ago with a UK patent (BP 455,221) from 1936. It is a commonly used oxidant (improver, additive) and in many cases (e.g. within the European Union) it is the only one permitted for use in breadmaking.

In breadmaking it is used to improve dough gas retention through its effect on the gluten structure. In terms of its chemistry AA is a reducing agent (and sometimes referred to as an anti-oxidant) but during dough mixing it is readily converted to dehydroascorbic acid (DHA) (see Fig. 10) in the presence of oxygen and ascorbic oxidase enzyme (Collins, 1994). The oxygen for the conversion comes from the gas bubbles incorporated during dough mixing and the conversion is enabled by the ascorbic oxidase enzyme, which occurs naturally in wheat flour.

The chemistry of the AA oxidation process in dough mixing is complex (Williams and Pullen, 1998) but probably involves the oxidation of the $\text{—S—H}$ (sulphydryl) groups of gluten-forming proteins and the formation of $\text{—S—S—}$ (disulphide) bonds. The net result of the AA effect is to improve the ability of the dough to retain gas (as seen by increased oven spring) and to yield bread with a finer (smaller average cell size) crumb cell structure. These changes also result in bread crumb that is softer to the touch yet has the resiliency to recover much of its original shape after compression. This helps to convey the impression of improved freshness to the consumer.

The dependency on oxygen for the AA to DHA conversion means that the quantities of air incorporated during dough mixing play a significant role in promoting oxidation. This means that AA-assisted oxidation varies with mixer type because of the ability of different mixers to occlude different quantities of air (Marsh, 1998). Some mixing regimes have been developed that increase the total quantity of air occluded during mixing so that greater AA-assisted oxidation can be achieved; two examples are mixing in an oxygen-enriched atmosphere (Chamberlain, 1979) and the use of the so-called ‘pressure-vacuum’

\[ \text{Ascorbic acid (AA)} \]

\[ \text{Oxidase enzyme (from flour)} \]

\[ \text{Oxygen (from air during mixing)} \]

\[ \text{DEHYDROASCORBIC ACID (DHA)} \]

Fig. 10  Ascorbic acid changes in dough.
mixer (Cauvain, 1994). There has been a tendency to consider that it is not possible to ‘over-treat’ with AA because of the limiting effect associated with oxygen availability. With the advent of the pressure-vacuum mixer such statements should be viewed with caution.

The oxidising effect of AA is mainly limited to the dough mixing period because bakers’ yeast will remove any oxygen remaining in the air bubbles by the end of mixing or soon after its completion (Chamberlain, 1979). Thus, in the dough that leaves the mixer the gaseous mixture of nitrogen (from the air) and carbon dioxide (from yeast fermentation) that remains provides an environment in that AA can act as a reducing agent. If AA is used in doughmaking processes with extended periods of fermentation then the opportunity exists for the reducing effect of AA to weaken the gluten structure with subsequent loss of gas retention in the dough. Ascorbic acid is thus best suited to no-time doughmaking systems.

The action of AA during mixing also brings about changes in the rheology of the dough, making it more resistant to deformation (Cauvain et al., 1992) by comparison with doughs treated with an addition of potassium bromate. Potassium bromate does not exert its full effect until the dough reaches the late stages of proving and the early stages of baking.

References
4.3 We have heard that soya flour is added in breadmaking to make the bread whiter. Is this true, and if so how does it work?

Full-fat, enzyme active soya flour has commonly been used as a functional ingredient (improver) in breadmaking since the 1930s. It is often described as a ‘carrier’ for other functional ingredients, e.g. oxidants, to facilitate the addition of the small quantities that are commonly used but it does contribute functionality of its own. The soya bean contains a high percentage of natural oil and has a distinctive ‘beany’ flavour that can be unpleasant if used at high levels of addition but not at the 1 or 2% level normally used with bread improvers.

Soya flour has three basic functions: it gives a white bread crumb, it contributes to gas retention through oxidation and it increases the level of water that needs to be added to the dough. The first two functions are caused by the actions of the natural enzyme systems that are present and so it is important that the enzyme-active form of soya flour is used.

Soya flour is rich in the enzyme lipoxygenase, that plays a major role in its bleaching action. With the help of the enzyme the intermediate oxidation compounds formed during dough mixing transfer oxygen from the atmosphere to bleach the yellow-coloured carotinoid pigments present in the flour. By this mechanism the flour is bleached and the bread crumb becomes whiter. The greater the availability of oxygen, the greater the bleaching effect.

The oxidation effect appears to come from freeing bound lipids from specific sections of the gluten proteins, thereby allowing the proteins to become hydrophilic and helping to form the viscoelastic surface of the air bubbles in the dough (Frazier et al., 1973).

Soya flour and its derivatives have found other uses in baking, for example as an egg replacer and in ‘gluten-free’ breads (Cauvain, 1998).

References


4.4 We are using a bread improver that contains enzyme-active malt flour and find that doughs are becoming too soft and that the sidewalls of loaves collapse inwards to give a ‘keyhole’ shape. Is the malt flour to blame?

The ‘keyhole’ shape that you describe (see Fig. 11) occurs because you are adding too much cereal α-amylase to your dough via the addition of malt flour. In addition to the dough softening and the loss of shape you may also observe some dark, dense patches in the crumb near to the areas of collapse. These are often referred to as ‘bone’ by bakers and derive from the same source, namely the excess of cereal α-amylase.

Malted wheat or barley flours are good sources of enzymic activity that can be used to improve gas retention in the dough. This improvement in dough gas retention comes from the high level of cereal α-amylase present but because of continued yeast action in the oven the centre of the dough piece continues to expand for a considerable period after the outer crusts have formed. This expanding centre crumb then compresses more crumb against the crust, squeezes the air out of the cells and that causes the dark colour. You can see this effect if you squeeze a portion of normal crumb firmly between your fingers.

The excessive expansion of the centre crumb lowers the density to such an extent that as the bread cools and the effects of external pressure are manifest,

![Fig. 11](image)

**Fig. 11** Keyholing in bread.
the loaf is unable to support itself and it collapses. This will be exacerbated when the loaf is handled, such as during slicing.

The softening of the dough you observed is most probably due to the presence of proteolytic enzymes which are also present in the malt flour. Malting encourages and raises levels of all of the enzymes present in the grain. The proteolytic enzymes weaken the protein structure, causing it to lose its rigidity and become soft. The $\alpha$-amylase also contributes to the dough softening through the breakdown of the starch from the flour and the subsequent release of ‘free’ water into the dough.

Dough softening because of enzymic action is usually a much greater problem when using doughmaking processes with a period of bulk fermentation because the length of time available for enzymic action is considerable. In no-time doughs, dough softening may not be obvious but the ‘keyhole’ effect can be readily observed when high levels of malt flour are used.
4.5 We understand that an enzyme called $\alpha$-amylase can be added to flour or dough to improve bread quality but that there are several different forms. We have tried several and get different effects on bread softness. Which one(s) should be used?

The $\alpha$-amylases are a group of enzymes that facilitate the breaking down of the hydrated starch granules, both amylose and amylopectin, in flour doughs to shorter chained, unbranched molecules known as dextrins. This action creates sites for any $\beta$-amylase present to convert the starch to individual maltose molecules. Wheat flours usually contain sufficient $\beta$-amylase but levels of $\alpha$-amylase vary and in many cases may be so low that the starch to maltose conversion is limited (see 2.5).

Maltose is fermented by bakers’ yeast to provide carbon dioxide gas in the dough and thus a key role for $\alpha$-amylase is to support gas production. While this was the original reason behind the addition of sources of $\alpha$-amylase to wheat flour doughs, in many cases its addition also leads to improvements in gas retention, bread volume and softness (Cauvain and Chamberlain, 1988) and this has now become the main reason for its addition.

The traditional source of $\alpha$-amylase for breadmaking was from malted barley or wheat flour but today it is more common to use amylases derived from the fermentation of microscopic fungi (Aspergillus oryzae) or a bacterial source. The main difference between the amylases lies with their heat stabilities (Williams and Pullen, 1998). The more heat stable the amylase, the greater the breakdown of the starch during baking. In general terms fungal $\alpha$-amylase is inactivated before cereal (malt) which, in turn, is inactivated before bacterial. The so-called maltogenic amylases are derived from modified bacterial sources and have a profile more similar to that of the fungal source.

The heat stability of the amylase source (see Fig. 12) is important in providing a balance between good and bad effects in baking. In the dough the amylase attacks the damaged starch granules and breaks down the starch molecules. As heating proceeds, especially during baking, the swelling and later gelatinising starch provides a larger quantity of available substrate for the amylase enzymes that are now working at a faster rate because of the higher temperature. The positive benefits are the improvements in gas retention through a more extensible gluten network while the disadvantages are related to the formation of sticky dextrins (see also 6.2).

To maximise the benefits you should use the fungal source. The maltogenic form can be used because of its greater anti-staling effect which gives softer bread. However, if used at too high a level you may find difficulties in slicing the bread because of its enhanced initial softness. Avoid using the traditional bacterial form as this may survive the baking process and lead to unwanted liquefaction of the product crumb during storage.
Fig. 12 Effect of temperature on α-amylase activity.

References

4.6 Why are emulsifiers used in bread improvers? How do we decide which one we should be using?

Emulsifiers are used in bread improvers for a number of different reasons including:

- to help control gas bubble size;
- to improve gas retention;
- to improve dough stability;
- to improve crumb softness.

Each of the emulsifiers permitted for use in breadmaking contributes something to all of the above dough and bread properties to greater or lesser degrees depending on the particular emulsifier.

The most commonly used emulsifiers and their likely contribution to dough character and bread quality are as follows:

- **Diacetylated tartaric acid esters of mono- and diglycerides of fatty acids (DATA esters, DATEM)** are thought to reduce the average gas bubble size in bread doughs, which leads to a finer cell structure. They are known to improve dough gas retention, which contributes to improved bread volume and crumb softness. Levels of use are usually up to 0.3% flour weight in a variety of bread and fermented products.

- **Sodium steoryl-2-lactylate (SSL)** improves dough gas retention, bread volume and crumb softness but weight for weight is less effective than DATA esters. It is commonly preferred in the production of sweeter fermented products, e.g. buns and doughnuts.

- **Glycerol mono-stearate (GMS)** is best used in the hydrated form but can be added as a powder. It does not greatly contribute to dough gas retention of bread volume but does act as a crumb softener through its proven anti-staling effect.

- **Lecithins** are a group of naturally occurring, complex phospholipids commonly derived from soya. They are used in baguette and other crusty breads to improve dough gas retention to a degree and contribute to crust formation.

Since no single emulsifier will equally perform all of the tasks required in breadmaking it becomes a case of choosing a given emulsifier to fit with the main product and process requirements. A blend of emulsifiers could be used. Price may also influence your final choice.

**Further reading**

4.7 What is L-cysteine hydrochloride and what is it used for in bread improvers?

Cysteine is a naturally occurring amino acid that, because of its sulphydryl group (\(-S-H\)), is able to act as a reducing agent on the disulphide (\(-S-S-\)) bonds present in the gluten structure of wheat flour doughs. It is most commonly used in the hydrochloride form to improve its solubility.

It came into common use in breadmaking in the 1960s when it was a key component of the breadmaking process known as Activated Dough Development (ADD) (Cauvain, 1998). In ADD L-cysteine hydrochloride was combined with potassium bromate and ascorbic acid to give an improver capable of delivering both chemical reduction and oxidation processes during doughmaking. ADD was designed to allow bakers to obtain the benefits of making no-time doughs without the need for the high-speed mixers associated with the Chorleywood Breadmaking Process (CBP). ADD remained very popular with smaller bakers until superseded by the use of spiral mixers (Cauvain, 1998).

In some ways the chemical reduction of gluten disulphide bonds by L-cysteine hydrochloride can be equated to the mechanical disruption of such bonds in the CBP. This view has led to the consideration that one of the benefits derived from the use of L-cysteine hydrochloride is that work levels can be reduced in the CBP.

More certain is that the reducing effects of L-cysteine hydrochloride beneficially modify dough rheology and improve its processing. For example, its addition to so-called ‘bucky’ doughs in the USA (i.e. doughs having high resistance and lacking extensibility) improves dough moulding, and in the CBP ‘steaks and swirls’ in the crumb may be reduced, but not eliminated (Williams and Pullen, 1998).

Additions of L-cysteine hydrochloride may be made to fermented products that are sheeted, e.g. pizza base, and to laminated and short pastry to reduce dough and product shrinkage.

References


5.1 Is it true that yeast requires oxygen before it can work correctly?

As long ago as 1875, Louis Pasteur showed that fermentation could take place in the complete absence of oxygen. He also showed that the presence of oxygen inhibited fermentation but increased yeast growth and respiration. Pasteur’s observation that ‘fermentation is life without air’ is a well-known quotation in food science.

If oxygen is introduced in increasing quantities into a fermenting sugar solution, fermentation slows down and respiration takes over. The process can be described chemically as follows:

\[
\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 6\text{CO}_2
\]

Glucose + oxygen → water + carbon dioxide

In practice the theoretical respiration equation is never realised because much of the carbon dioxide that is liberated combines with other materials to form yeast cell substance. The yeast manufacturer makes use of the effect of oxygen by blowing large volumes of air through the fermenter to discourage fermentation and so maximise the yield of yeast.

Some confusion about the relationship between yeast and oxygen may arise because of the well-known effect of yeast scavenging oxygen molecules from a bread dough during mixing (Chamberlain, 1979). The importance of this observation is that it explains why the effect of ascorbic acid as an oxidising agent is limited to the mixer in breadmaking (see 6.9).
Reference
5.2 How does bakers’ yeast produce carbon dioxide in breadmaking?

Yeast produces carbon dioxide gas in breadmaking by fermenting the sugars that are present in the ingredients or the formulation. The basic reaction is represented in the following manner:

\[ C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 \]

Glucose  ethyl alcohol  + carbon dioxide

You will notice a significant difference in the reaction compared with that given in the previous question. In particular fermentation yields the production of ethyl alcohol whereas respiration does not. The fermentation process does not require the presence of oxygen.

The yeast cell contains large numbers of enzymes which are required for the fermentation and respiration. These enzymes are held within the cell, provided the cell wall remains intact. About 14 different enzymes are involved in the fermentation process.

When a dough is made the yeast first feeds on the naturally occurring sugars in the flour (glucose and sucrose). As these are used up the enzyme complex begins to provide more sugars by breaking down other flour components. The damaged starch is important in this context because of its conversion ultimately to maltose. This is why we are concerned with the enzymic activity and damaged starch levels in the flour that we use (see 2.5 and 2.6). If we cannot provide a substrate (food) for the yeast it will stop working and carbon dioxide production will cease. When the CBP was introduced in the 1960s the type of bakers’ yeast then used was unable to provide carbon dioxide gas in the critical early stages of baking and it became necessary for the yeast strain to be changed (Williams and Pullen, 1998). Though the precise nature of the changes is not public knowledge it undoubtedly was related to the enzyme activity within the yeast cell.

In modern no-time breadmaking processes we are concerned only with the production of carbon dioxide by the yeast. Respiration and growth are not required. Indeed the conditions within a bread dough formulation and the timescales concerned are unlikely to be suitable for either process to take place to any significant degree.

Reference

5.3 We have been advised to store our compressed yeast in the refrigerator but our dough temperature is much higher: is this the correct thing to do?

The advice that you have been given is absolutely correct. Once compressed yeast has been prepared it should be kept under refrigerated conditions (4 °C) until it is required for doughmaking. Storing yeast at higher than refrigerated temperatures results in the progressive loss of its gas production potential. Williams and Pullen (1998) showed how dough proving times were increased when compressed yeast was stored at 10 and 15 ºC. By the time that the yeast had been held for 14 days at 15 ºC the proving time required for the dough had doubled (see Fig. 13). Storing compressed yeast at dough temperatures would be a disaster!

It is therefore very important that the yeast is stored under the best possible conditions. Storing at 4 ºC reduces the potential for unwanted activity within the block (see 5.4). The compressed yeast is usually transported under refrigerated conditions and on delivery should be moved as quickly as possible to storage at a similar storage temperature. The blocks should be left in the refrigerator as late as possible before use. Once dispersed into the dough the cells soon warm and produce carbon dioxide.

Variations in gassing activity will show as variations in proving volume for a given time. If you are not able to adjust the proving time to compensate for this variation (few bakeries can) then you will get variations in bread volume and problems with product shape, e.g. ragged breaks from under-proving.

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**Fig. 13** Effect of storage temperature on yeast activity.
Reference
5.4 What are the causes of the dark brown patches we sometimes see on compressed bakers’ yeast? Do they have any effect on baked product quality?

The brown patches are autolysis and comprise dead yeast cells. They usually come from having kept the yeast too long or at too high a storage temperature (see 5.3). There is no food available for the yeast cells in the compressed block. Storage at around 4°C limits the activity of the cells but if the temperature rises sufficiently then oxidation processes begin and the cells break down. This means that there will be a loss of gassing activity when the yeast comes to be used in the dough.

In addition to the loss of gassing potential the contents of the affected cells may leak out of the ruptured membranes. The yeast cells contain a suite of enzymes and other chemicals. The release of proteolytic enzymes and glutathione (a reducing agent) are bad news for breadmaking because both materials will attack the gluten structure of the dough and weaken it. Subsequently the affected doughs will exhibit a lack of gas retention, i.e. a loss of volume and a more open cell structure. In more severe cases the doughs may become sticky and difficult to process.

We suggest that wherever possible you do not use the affected yeast and that you check the settings and efficiency of your refrigerator.
5.5 We have recently been experiencing ‘weeping’ from our non-dairy cream formulation. This shows itself as a ‘soggy’ layer where the cream is in contact with the cake. How can the problem be cured?

In order to solve this problem we first have to decide its origins. There are three possibilities: fat or moisture migration, or both.

Fat migration can occur when the oil fraction of the cream filling is too large because it does not remain trapped within the cream structure and sinks into the cake layer below under the influence of gravity. In order to decide the oil to solid fat ratio you will have to consider a number of factors including:

- the product storage temperature – the higher the storage temperature, the higher the SFI needs to be;
- the eating qualities of the cream – the softer the eating character, the greater the liquid oil fraction will have to be.

Fat migration is not influenced by storage humidity. To reduce fat separation you may find some advantage in adding a suitable emulsifier to the cream formulation, e.g. lecithin or glycerol monostearate, or a stabiliser such as gelatine.

Moisture migration occurs when the water activity of the cream is not in equilibrium with that of the cake. The causes and cures for moisture migration have been reviewed by Cauvain and Young (2000). Your problem is associated with moisture migration by diffusion: where two materials are in direct contact with unequal water activities the moisture moves from the wetter to the drier component. The main solution to the problem of moisture migration is to balance the component water activities and reduce the driving force for change. This will require a reformulation of cream or cake, or both. You should have the component water activities measured and reformulate to reduce any differential. Adjusting salt or sugar levels can be advantageous, or additions of glycerol may be used. Placing a moisture-proof barrier between the two components is possible but difficult given the porous nature of cakes.

Moisture migration is also strongly influenced by the storage temperature, with migration being reduced as the temperature is lowered. Unlike fat migration, moisture migration is affected by storage humidity with migration moving at a faster rate when there is a greater difference between the component and storage humidities.

Reference

5.6 The chocolate fondant on our cream éclairs falls off the top of the casing and gathers on the tray underneath as a sticky syrup. What causes this and how can we prevent it?

The chocolate fondant contains undissolved sugar particles which tend to make it hygroscopic, that is likely to absorb water. As more water is taken up by the fondant then the fondant becomes more liquid and likely to flow. If you are putting the fondant on to the curved top of the éclair shell then it can readily flow down the sides.

The water that causes this problem will derive from the other components of the éclair. Usually the source will be the cream which has a very high water activity (equilibrium relative humidity, ERH) and the moisture readily diffuses through the porous and dry choux shell. The moisture that gathers at the shell–fondant interface acts like a lubricant and helps the fondant flow.

This is not an easy problem to eliminate because of the diverse nature of the three components in the composite product. Some points to consider are as follows:

• The fondant will always contain undissolved sugar and therefore have hygroscopic properties. However, these may be reduced to some extent by replacing some of the sucrose with a glucose syrup, adjusting the water as necessary.
• Adding a small quantity of fat to the fondant, say 5–6%.
• Lowering the ERH of the cream in order to reduce the driving force for moisture migration. The options may be limited though sucrose or even glycerol additions may help.
• A change to a slightly more permeable packing may help by allowing some loss of moisture to the external atmosphere, but beware that this may lead to the whole product drying out too quickly.
• Try icing the base of the éclair shell because this is usually flat.
• Look carefully at the tray in which you stand the éclairs. If the éclair does not stand level in the tray then there is always a potential for the fondant to flow.
5.7 When we changed our supply of bun spice in our hot cross buns we experienced problems with slow gassing in the prover and flowing of the buns during baking. What can we do to avoid these problems?

Many spices have an adverse effect on yeast and will inhibit gas production. The higher the concentration of the spice, the greater will be the effect. It appears that the change from one spice supply to another has resulted in the inadvertent addition of a more concentrated form to the dough, which is the equivalent of a higher spice level even though the weight of added spice has remained constant. Alternatively the new spice formulation you are using may have a concentration of one or more spices which have a significant effect on gas production.

The problem you describe can occur whether you are using a liquid or dry spice. Try to make sure that the yeast and the spice are kept separate for as long as possible in the mixing process. In the case of a liquid spice and some mixing operations you may be able to hold the liquid spice until after the yeast has been fully dispersed.

The flowing that you see almost certainly comes about because of the same problem. Direct contact between the spice and the yeast may have caused disruption of the yeast cells with subsequent leakage of the proteolytic enzymes and glutathione which both weaken the gluten network in the dough. If sulphur dioxide or sodium metabisulphite have been used as preservatives in the spice, residues of these chemicals can act as reducing agents and weaken dough structures.

If the problem persists after you have taken suitable precautions during mixing or after adjusting the levels of addition you might try using less spice in the dough and more in the glaze for the products to maintain product flavour.
5.8 We are making a fruited bun product and from time to time experience problems with the product flowing out during proving and baking. What is the cause and how can it be remedied?

There are a number of possible reasons for your product flowing during proving and baking. They include the following:

- Too much water in the dough. This may come from incorrect levels of addition or from the fruit if you have been soaking it.
- The presence of the reducing agent glutathione arising from the disruption of yeast cells that have not been stored correctly (see 5.3).
- Too much humidity in the prover which causes solubilisation of the proteins in the dough.
- Residual sulphur dioxide in the dried fruit.

Since the problem is associated with a fruited product we suggest that you thoroughly wash and dry the fruit before using it. If the problem persists then you should look for a processing cause, such as excess humidity in the prover.
5.9 We wish to use milk powder in our fermented goods and have heard that it is advisable to use a heat-treated form. Why is this?

The use of fully heat-treated milk or milk powder products is essential if you are to avoid losses in product volume. In the case of liquid milk typical heat-treatment conditions would require raising the temperature to around 80°C and holding it at that temperature for some 30 minutes before cooling and use. If dried milk powders are to be used it is important that they have been subjected to a similar temperature to that given above (Collins et al., 1970).

Similar problems with loss of volume can occur if inadequately treated milk powder is used in the production of sponge goods. On some occasions a collapse of the cake structure and the formation of a ‘core’ (an area of coarse, dark coloured cell structure) may occur.

The adverse effects of inadequately treated milk arise because the globulin proteins normally present have not been denatured. The normal pasteurisation process applied to milk does not denature the globulins which can interfere with the stability of the gas bubbles in the proving dough or baking cake.

The suitability of a milk powder for baking can be assessed with a small-scale baking test or by employing the Swortfiguer cloud test (Swortfiguer, 1958). A clear or slightly cloudy solution at the end of the test indicates that the milk powder has been adequately treated.

References
SWORTFIGUER, M.J. (1958) Is there a simple method by which we may determine whether a sample of non fat dry milk has received proper treatment?, Baker’s Digest, October, 78.
5.10 Does the addition of mould inhibitors have any significant effects on baked product quality?

The most obvious effect of mould inhibitors will be on the smell and flavour of the product. This may be particularly noticeable if the product is heated, as in the case of preparing toast from bread slices with an inhibitor in the formulation.

Even if there is no effect on flavour we can expect there to be some effect on yeast activity in fermented products. Yeasts are a class of microorganism and so will be affected in a similar manner to moulds, namely that their activity is inhibited. In the case of bakers’ yeast the lower activity will show as slower gas production in the dough which may lead to under-proving and lack of oven spring in the resultant bread. Any such loss of activity is usually overcome by raising the added yeast level in compensation. In cake and other confectionery products the presence of mould inhibitors has no effect on gas production from the baking powder reaction.

It is worth noting that while not a direct effect on baked product quality, the mould-free shelf-life of the product is extended through the use of mould inhibitors. The effect of some mould inhibitors is enhanced when the pH of the product is lowered so that the increase in mould-free shelf-life becomes more dramatic. This is certainly the case with the mould inhibitor potassium sorbate when used in the manufacture of cakes (Cauvain and Young, 2000)

Reference

5.11 What are the functions of salt in baking?

Common salt, more correctly sodium chloride, provides a number of functions in baked products:

• It contributes to product flavour, e.g. in bread.
• It lowers product water activity and therefore extends product shelf-life (Cauvain and Young, 2000).
• It inhibits yeast activity and so can be used to control fermentation in breadmaking (Williams and Pullen, 1998).
• It modifies dough rheology in breadmaking, making the dough less sticky.
• It contributes to the formation of bread crust colour, especially in longer fermentation systems.

Salt levels will vary in baked products according to the functional needs. In general, salt levels have fallen gradually in foods because of concerns over high levels of sodium in many diets.

Although potassium chloride will have similar functional effects in baking, if used to replace sodium chloride on an equal weight basis it confers a largely unacceptable bitter taste to the final product.

References


5.12 What are the correct proportions of acid and alkali to use in baking powders?

The principal alkali used in baking powders is sodium bicarbonate and it is this ingredient that supplies the carbon dioxide gas which inflates powder-raised goods such as cakes and sponges.

In order for the gas to be evolved at the most suitable time during baking a food acid is added to the formulation. Sodium bicarbonate will release carbon dioxide by thermal decomposition at 90°C but this is far too late to be of use because at that temperature the structure of the product is effectively set and unable to expand any further. A number of suitable acids are available, each having a different rate of reaction with the sodium bicarbonate and each leaving a different residual salt in the baked product. Both properties are important, the first because it affects the overall expansion of the product and the latter because it affects the flavour.

The correct proportion of acid to sodium bicarbonate varies according to the chemistry of the acid. The correct proportion of acid to sodium bicarbonate is normally considered to be that which takes the reaction to completion and is referred to as the *neutralising value*. For commonly used acids the appropriate proportions for 1 part of sodium bicarbonate are:

- mono (acid) calcium phosphate (MCP, ACP) – 1.25;
- tartaric acid – 0.9;
- sodium acid pyrophosphate (SAPP) – 1.33;
- cream powder (SAPP on a neutral powder base) – 2.0;
- sodium aluminium phosphate (SALP) – 1.0;
- cream of tartar (potassium hydrogen tartrate) – 2.2;
- glucono-delta-lactone (GDL) – 2.12;

Some baking acids are available in different grades which control their rate of reaction with sodium bicarbonate.
5.13 Why is sodium bicarbonate frequently used alone or in excess to the normal baking powder for the production of ginger products?

The idea of using an excess of sodium bicarbonate in ginger products is no doubt based on traditional practices and any explanation would be speculative. Despite its traditional basis the practice does have a practical advantage. Under the influence of moisture and heat, carbon dioxide is liberated from any sodium bicarbonate left after the normal acid–base reaction and sodium carbonate remains as a residue. The carbonate is alkaline and will react with sugars, particularly invert sugar to form complex carbon compounds that are brown in colour. In this way the excess of sodium bicarbonate aids the formation of the dark brown colour that characterises ginger products.

If you look closely at the cut surface of baked ginger cakes you may see that the colour is more intense toward the base and sides of the cross-section. These are the areas that are baked first and so have been held for a longer time at the oven temperature and the browning reaction has proceeded further than the more moist centre areas of the cake.

The residual sodium carbonate has a characteristic ‘washing soda’ taste which is why we normally seek to neutralise the sodium bicarbonate in most baked products. However, the strong flavour of ginger will commonly mask the carbonate after-taste.
5.14 We are using walnuts in our gateau buttercream filling and find that it turns black. It does not appear to be mould. What is the cause of this discoloration?

You are quite right that the problem is not one of mould growth. The most likely cause is a reaction of the tannin in the walnut pieces with any traces of iron that may be present in the cream, perhaps picked up from the mixing utensils that you have used. The colour may take several days to appear. Sometimes the colour may be purple rather than black, depending on the product pH.

We suggest that you use stainless steel utensils and particularly avoid using any iron utensils that are scratched or damaged. You should also try to ensure that any cut cake surfaces do not come into contact with iron surfaces.
5.15 What is the role of emulsifier in the production of sponge cake products?

The key role for the emulsifier added to sponge cake batters is to assist in the incorporation and stabilising of the air bubbles mixed into the cake batter. The most common emulsifier used in sponge cakemaking is glycerol monostearate (GMS), though polyglycerol esters are also used. In both cases the emulsifier can be considered as a molecule which has a hydrophobic (water-hating) head and a hydrophilic (water-loving) tail. Thus when the emulsifier is used in a cake batter the hydrophobic head aligns itself at the interface of the liquid and air phases while the hydrophilic tail is located in the liquid phase. These actions confer stability to the air bubbles incorporated during mixing.

Sponge cakes may be made without any emulsifier and in this case the egg proteins play the bubble stabilising role. However, if any fat or oil is present in the formulation then the egg proteins cannot maintain gas bubble stability during baking and the cake may exhibit collapse and core formation (see 10.33). To overcome this problem when using fat or oil it is necessary to add an emulsifier. In this case the emulsifier takes over the gas bubble stabilising role of the egg proteins. It is important to ensure that sufficient emulsifier is added to maintain gas bubble stability in both the cold batter and during baking. Cauvain and Cyster (1996) showed how core formation was made worse when a low level of GMS was added to the batter but was eliminated as the level progressively increased (see Fig. 14).

Gas bubble size and therefore sponge cake cell structure is directly affected by the level of emulsifier. Cauvain and Cyster (1996) studied the effects of GMS

![Fig. 14 Effect of level of emulsifier on bubble size in sponge cake batter.](image-url)
and found that the minimum gas bubble size, and therefore finest cell structure, was obtained at about 0.6% batter weight with their formulation. Increasing the level of added GMS had no effect on gas bubble size but at 1.5% batter weight the cake was unacceptable, having a loose crust, many surface blisters and a very close cell structure. This can be interpreted as over-stabilisation of the batter with a layer of GMS so thick around the gas bubbles that they were unable to rupture (i.e. convert from foam to sponge) at the correct moment during baking.

The volume of gas that can be incorporated into the batter is also related to the level of emulsifier used. The higher the level of emulsifier, the greater the volume of air that can be incorporated and so the lower the batter relative density can be achieved. This in turn can lead to greater product volume provided that sufficient emulsifier is present to ensure bubble stability during baking.

In order to ensure that the emulsifier is effective as a bubble stabiliser it is important to use it in its most appropriate form. In the case of GMS there are a number of different forms in which it can exist, depending on its concentration in water and the temperature of the preparation. Krog and Larsen (1968) studied the phase diagram for GMS and water and showed that the most effective form for cakemaking occurred over a limited range of concentrations and temperatures. The most appropriate form is often called the ‘alpha gel’ form. Commonly cake emulsifiers are used in a ready-prepared gel form and may contain a ‘co-emulsifier’ to prevent GMS reversion when the mixture is cooled.

References
6.1 We are producing a range of pan breads, some baked in a rack oven and others in a deck oven, and find that there are large indents or cavities in the base of many of the loaves. What is the cause of this effect and how can it be overcome?

When the pans enter the oven, dough expands to touch all the sides of the pan. As the temperature continues to rise the dough piece can no longer expand outwards because of the pan sides and so starts to grow upwards.

Even though there is some friction between the side of the pan and the expanding dough, the dough will continue to move upwards until the conditions against the pan sides are suitable for the formation of the side and bottom crust of the loaf. This normally happens fairly quickly because of the heat conductivity of the metal pans. As the crust begins to set, steam that has been lost begins to diffuse up the side of the pans and is lost to the atmosphere.

The centre of the dough continues to expand after the bottom crust has formed so that dough becomes compressed against the sides of the forming loaf. In some cases this extra compression causes a strong seal to form between the baking dough and the pan so that pockets of steam become trapped between the forming crusts and the pan. The steam pressure can become so great that areas of the dough may be forced away from the pan sides and the cavities or large dents that you see are formed (see Fig. 15).

The simplest solution to the problem is to use pans with small holes drilled at the angle where the base of the pan joins the sides walls. It is usually only necessary for there to be three holes, each 1 to 2 mm in diameter, down each of the two longer sides. Alternatively there can be up to six holes around the circumference of a round pan.
A number of other aspects may contribute to the problem. For example:

- using pans that are too small for the mass of dough being used (i.e. over-scaling, or simply having the wrong size of pan);
- having too much bottom heat in the oven, such as might be the case in the deck oven;
- packing the pans too closely together which slows down the rate of heat transfer and sets the bottom crust before the side crusts; this may be the case in your deck oven.

Tight-fitting lids may also contribute to this problem and in some extreme cases lidded loaves have been known literally to blow apart.

It is somewhat ironic that one sees this particular problem only when the dough has good gas retention. Although weakening the dough gas retention (e.g. by using less mixing or a lower dough temperature) is seen as a means to solve the problem it should be avoided because of the loss of other desirable bread properties, e.g. volume and crumb softness.

Fig. 15 Example of ‘pan-lock’ in bread.
6.2 We are experiencing a problem with the sides of sandwich loaves caving in. Sometimes the lid also shows the same problem, though to a lesser degree. Is the problem associated with overbaking?

It is true that when the baking time for bread is extended that the sides may tend to cave-in. However, this is not the cause of your particular problem which lies more with the gas retention properties of the dough than the baking conditions.

The early stages of baking are associated with expansion of the dough before the yeast is inactivated. As indicated in the previous question when the dough reaches the sides of the pan, the crust begins to form and expansion stops. However, because dough is a poor conductor of heat, expansion of the dough centre continues for some time after the side crusts have formed. This results in compression of dough layers against the side crusts. In some cases the expansion of the dough centre can be considerable so that if we were to measure the crumb density at various points in a slice cross-section we would find that the centre crumb was considerably less dense than at the sides. This lower crumb density results in a centre less able to cope with the changes in internal and external pressures during cooling and the sides pull inwards.

The most common cause of the problem is changes associated with an increase in dough gas retention. These may come from a number of sources, including:

- the flour being too strong for the breadmaking process being used;
- too high an improver level or too ‘strong’ an improver;
- excessive enzymic activity.

Other contributing factors may come from faster proving from raised yeast levels, or normal proving times with lower dough and prover temperatures and higher yeast levels. Long, slow baking may also contribute to this problem.

This problem is often seen as a sign of ‘weakness’ in the dough but in fact it is the reverse. See also 4.4.
6.3 We are producing hearth-style (oven-bottom) breads, baguettes and French sticks and are experiencing problems with ragged cracks appearing along the sides of the loaves. What are the likely causes of this problem?

The problem that you describe suggests that your doughs are under-proved before they enter the oven. The main function of proving is to expand the dough bubble structure using carbon dioxide gas generated from yeast fermentation. It is common to try to achieve around 85-90% of your required final product volume in the prover, leaving the remaining 10% or so to come from oven spring during baking.

The crust forms quickly on oven-bottom breads because they are not shielded from the heat of the oven by the sides of any pans. The surfaces quickly become dehydrated and inflexible but as with all breads there will be continued expansion of the centre of the dough. If the dough is under-proved then the potential for crumb expansion is considerable and the forces generated begin to crack the already rigid crust along any lines of weakness (see Fig. 16).

During proving changes take place in the dough rheology which make it more extensible and less elastic and less resistant to deformation. Such changes depend more on time than on temperature. By making the dough more extensible it is better able to withstand the considerable stresses and strain experienced by the dough during the early stages of baking and so expansion is more even. Even expansion of the dough is most often seen as uniform oven spring.

Fig. 16 Example of ragged crust break with bread.
We suggest that you look closely at final proving time and the yeast level that you are using. Times less than 40 min, especially with higher yeast levels, are likely to lead to problems with under-proved doughs. We also suggest that you look at other factors, such as the following:

- The weight of the dough pieces – high dough piece weights are more likely to lead to this problem.
- Dough temperature – low dough temperatures, especially with high yeast levels, are more likely to lead to this problem.
- Under-fermentation if you are using a breadmaking process that relies on bulk fermentation to develop the dough.
6.4 We have noticed the development of a ‘fruity’ odour in our breads after they have been stored. The problem is particularly noticeable with our wholemeal products. What is the cause of this problem and are there any remedies we can apply to prevent its occurrence?

The odour that you are describing comes from a problem that bakers refer to as ‘rope’. The problem gets its name from the fact that in the later stages of development the crumb will become soft and sticky and when cut surfaces of the loaf are slowly pulled apart, thin strands or ‘ropes’ can be seen stretching from one surface to the other.

The problem comes from contamination of your product by a bacterium, *Bacillus subtilis*, which occurs naturally in the soil. Rope bacteria are commonly present on the outer parts of vegetables and grains. Wheat may become contaminated with rope-forming spores in the field and these may pass through the flour milling system into the flour. Wholemeal flours may have higher numbers of rope spores present than white flours because the spores are mostly associated with the outer bran layers. The crease in wheat makes it a difficult task for the miller to remove rope spores.

The rope-forming spores can readily survive the bread-baking process. The water activity of the crust surfaces is normally low enough to slow down bacterial growth after baking, but the conditions in the loaf centre, with a water activity of 0.9 to 0.95, are well suited to the development of rope. The length of time taken for the problem to be manifest depends on the level of contamination and the conditions of storage (particularly the temperature), the heavier the contamination and the warmer the conditions, the faster will be rope developments.

Since the source of the problem is natural the strategy should be to contain the problem rather than eliminate it. This may be achieved using one or more of the following tactics:

- Do not allow any stale bread or bakery returns into the same area as fresh production. Stale bread can be an extra source of contamination because some rope development may have already occurred.
- Minimise areas where dust and breadcrumbs may collect.
- Try to reduce the risk of airborne contamination from outside the bakery.
- Add to the dough either propionic acid at 0.1% flour weight, calcium propionate at 0.2% flour weight, or 1 l of 12.5% acetic acid solution (vinegar) per 100 kg flour as rope inhibitors (check local regulations concerning permitted additions and levels). These act by lowering dough pH and making the conditions less suitable for rope development. You may have to increase yeast levels slightly because they will also slow down gas production.
6.5 When viewing the crumb appearance of our sliced bread we notice the appearance of dark streaks and patches that have a coarser cell structure and firmer texture than the rest of the crumb. Is this a problem with uneven mixing?

Since the mixing process is solely responsible for the incorporation of the gas bubbles which eventually become the breadcrumb cell structure, with no-time doughs it is perfectly reasonable to assume that mixing can be responsible for variations in crumb cell structure you observe. Unless you have a grossly inefficient mixer or your doughs are grossly undermixing, whether too little energy or too short a time, this is probably not the main cause of your problem.

In general, the larger the size of the cell in the crumb, the deeper it is and the darker will be the shadow that it casts when viewed in oblique lighting (see Fig. 17). When doughs leave the mixer the gas bubbles that become cell structure are the smallest size that they can be. During the journey to the oven carbon dioxide gas from yeast fermentation inflates the bubbles and makes them larger. The size to which the gas bubbles can grow is limited by the ability of the gluten film surrounding them to stretch without rupturing. In the event that the gluten film ruptures, small gas bubbles may coalesce (join together) to form larger ones. The displaced gluten film may well contribute to improving the strength of the remaining larger bubble. Thicker cell walls also contribute to darker crumb colour.

Bursting and coalescence gas bubbles in the dough may occur if the surrounding material is unable to maintain bubble stability during processing, especially in those operations that place the dough under stresses and strains, e.g. dividing and moulding. We would suggest that your problem arises because your dough lacks the necessary bubble stability and is being broken down by the
moulding actions. This lack of bubble stability may come from a number of sources, including:

- using a flour that is too weak for the breadmaking process being employed;
- under-developing the dough, e.g. too little energy or mixing time too short;
- not using a suitable improver with a no-time dough, e.g. one that lacks hard fat or an emulsifier;
- too little water in the dough – tight doughs are more susceptible to moulder damage than soft ones (Cauvain and Young, 2000);
- using cold doughs, which yield stiff and under-developed doughs;
- insufficient first proving, which gives a dough that is not sufficiently relaxed for final moulding;
- incorrect moulder settings, essentially excessive pressure at any moulding stage. The dark patches may form characteristics patterns, which can indicate their point of origin in moulding.

Other possible causes for variations in crumb cell structure of the type that you describe may come from the inclusion of old, fermented dough during the later stages of mixing or accidentally during moulding and processing, or from skinning of the dough pieces before moulding.

Reference
6.6 Periodically we observe the formation of large holes in the crumb of our pan breads and suspect that the adjustment to the pressure board on our final moulder is faulty. Can you confirm our suspicions?

You are correct in assuming that your pressure board settings play a part in the formation of the large holes that you see in your breads but it may not simply be a case of finding the correct settings on the moulder to eliminate the problem. There is a strong interaction between the dough and the moulder performance and you must bear in mind that a moulder is inanimate and can therefore only react to the material that it receives.

In the previous question we considered how the stability of gas bubbles was affected by dough development and the stresses and strains introduced by moulding. Even in doughs with optimised development, damage to the gas bubble structure may occur during moulding. Large gas bubbles formed from the coalescence of smaller ones have a lower internal pressure than the smaller ones around them. This lower internal pressure means that the carbon dioxide gas generated from yeast fermentation is more likely to diffuse into the large gas bubbles rather than the smaller ones. In consequence the large gas bubbles may continue to grow to such an extent that they may form holes in the final crumb.

A key to avoiding this type of problem is to ensure that the dough rheology is optimised by the time of moulding (Cauvain, 1998). In order to minimise stresses and strains during processing you need a dough that lacks resistance to moulding and is not elastic. Such ‘relaxed’ doughs come from ensuring full development with optimised water levels. Cold doughs should be avoided and sufficient first proving should be given to lower dough resistance to deformation. You need a dough that is extensible and this comes from optimising gluten formation.

A common response to the problem you describe is to ‘tighten’ the mould by increasing the pressure exerted during moulding. In many cases increasing moulding pressure leads to greater damage to the structure and is more likely to exacerbate the problem than cure it. The pressure board setting should just be enough to deliver the shape of dough piece you require and nothing more. In some types of moulders the pressure board length is too short to achieve the required dough size without subjecting the dough to considerable pressure during the final stages of moulding. The aim of moulding should be to shape the dough piece but preserve the gas bubbles intact. This approach is best seen in the production of baguettes where a very soft dough and gentle moulding allows the retention of large gas bubbles in the dough to deliver the characteristic open cell structure (Collins, 1978).

Other factors that may influence the formation of holes in the crumb include any skinning of the dough that may occur before moulding, the use of hot pans and excessive bottom heat in the oven. In the latter case the holes that form may well occur towards the bottom of the loaf and may have a ‘triangular’ shape.
References
6.7 What is the function of four-piecing or cross-panning in breadmaking?

Four-piecing (see Fig. 18) is a technique commonly used in the production of sandwich-style breads where a fine (small average cell size) and uniform cell structure is required. In essence it consists of moulding a dough piece to a long cylindrical shape under the pressure board and then cutting the piece as it exits the board into four pieces of equal size or weight. The four pieces are turned through 90° and gathered together before being placed in the pan.

During sheeting some of the gas bubbles present in the dough are elongated in the direction of the dough movement through the moulder. After curling, the cells maintain their elongated shape because the viscoelastic properties of dough and the curling process itself prevent the bubbles from assuming a spherical shape. In single piece bread the cells formed from these bubbles are cut through their short sides in the product and the cell walls cast a significant shadow, thus giving the crumb a dull, grey colour.

In four-piecing, turning the pieces through 90° means that the cells are cut through their long axis and the shallow cells that remain will cast less of a shadow. This means that the crumb from four-pieced bread will be seen as brighter when viewed under similar lighting conditions as single piece bread. In addition to the improvement in crumb appearance there is an improvement in crumb softness and a small but helpful improvement in crumb resilience. The latter helps with the slicing and eating properties of such breads.

While there is an improvement in cell uniformity within the individual pieces there can be greater slice to slice variation along the length of the loaf. This is especially true for the areas where two pieces meet and so it is important to ensure that the four pieces are as equal as possible and uniformly placed in the pan.

Eight-pieced loaves are known and a similar technique is ‘cross-panning’ or ‘cross-graining’.

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Fig. 18 Four-piecing of bread doughs.
6.8 Can you explain the role of energy in the Chorleywood Bread Process?

The transfer of mechanical energy to the dough during mixing with the Chorleywood Bread Process (CBP) is an essential component in the development of a dough with specific rheological properties and the necessary gas retention to produce a loaf of optimum volume and crumb cell structure (Cauvain, 1998). When first introduced the ‘optimum’ work input level for the CBP was reported as 11 W h/kg dough in the mixer but later work has shown that the optimum total work input varies with the type of flour being used, see Fig. 19 (Cauvain, 1998; Gould, 1998).

The role of energy in the CBP has still to be fully explained. It is very likely that the high-energy inputs are capable of mechanically breaking the disulphide (—S—S—) bonds holding the original protein configurations. In this way mechanical energy can be likened to the effects of natural (enzymic) or chemical reduction. This may explain in part why the addition of a chemical reducing agent such as L-cysteine hydrochloride is considered to reduce the energy required for dough development.

Chamberlain (1998) – one of the co-inventors of the CBP – considered that only about 5% of the available energy was required to break the disulphide bonds. A significant part of the energy input during CBP dough mixing will be taken up with the mixing of the ingredients and breaking weaker bonds. In breaking the disulphide bonds energy may well play a role in opening potential sites for oxidation. The CBP may therefore be considered as a redox-type process, in this case a combination of mechanical reduction and chemical oxidation rather than a purely chemical one.

As we consider the role of energy in the CBP we must recognise that a fundamental difference between CBP-compatible and other mixer types is the rate at which energy is delivered. You can increase the total energy imparted to doughs by lengthening the mixing time but the effect on bread quality is not as good as if the same total energy is delivered at a faster rate. In the original CBP the delivery of energy was needed within two to five minutes of mixing and the same premise holds true today, even when flours that require more than the original 11 W h/kg are used.

In addition to noting the rate effect we should also recognise that the input of energy to the dough is manifest as a significant temperature rise and that the provision of suitable quantities of chilled water are required. It may even be necessary to employ a cooling jacket of some form so that final dough temperatures can be maintained at acceptable levels, typically around 30°C.
Fig. 19  Effect of work input: (a) 5; (b) 8; and (c) 11 Wh/kg dough.

References
6.9 We are using the Chorleywood Bread Process to develop our doughs and apply a partial vacuum during mixing to produce a fine and uniform cell structure in the baked loaf. Sometimes we observe that the cell structure becomes more open even though the vacuum pump is still working. What is the cause of this problem?

The application of partial vacuum (typically 0.5 bar) during dough mixing with the CBP is used to produce a fine (smaller average cell size) and more uniform cell structure in the final baked loaf (Cauvain, 1998a). It does this by shrinking the size of the gas bubbles present in the dough. At the same time it reduces the total quantity of gas in the dough (Marsh, 1998) which gives improved divider weight control and yields a dough that feels ‘drier’ to the touch. The latter effect has allowed users of the CBP to increase the added water content at dough mixing to deliver a dough consistency similar to that obtained with bulk fermented doughs with lower water contents (Cauvain, 1998a).

The process of dough expansion depends on the presence of nitrogen gas bubbles in the dough, because the oxygen in the air bubbles originally incorporated during mixing is lost because of yeast action (Chamberlain, 1979). The nitrogen gas bubbles provide the sites into which the carbon dioxide gas generated by yeast fermentation can diffuse. This nucleating role is critical since carbon dioxide itself cannot form a gas bubble in bread dough (Baker and Mize, 1941). Without sufficient nitrogen gas bubbles being present in the dough you cannot form a ‘normal’ bread cell structure.

The numbers of gas bubble nuclei in the dough are considerably reduced as the mixer headspace pressure falls closer to 0 bar. In practice most vacuum pumps fitted to CBP-type mixers are designed to run around 0.5 bar because lower pressures tend to give coarser and more open cell structures. We suggest that you discuss the operation of your vacuum pump with your engineers and equipment suppliers. Though rare, it does appear that the source of the problem is that the pump at times is operating at pressures much lower than 0.5 bar.

In addition to the coarse open cell structure a characteristic of this problem is that there is extensive blistering of the crust which also has a waxy, greasy or oily appearance, somewhat similar to that seen on retarded pan breads (Cauvain, 1998b).

References


6.10 We are using spiral mixers for our bread doughs. What is the best mixing time to use?

There is no simple answer to this question because it depends in part on the type of spiral mixer you are using, your product range and the product quality you are seeking. Most spiral mixers have two operating speeds: a slow one mainly used to disperse the ingredients and a faster one used to develop the dough.

Spiral mixers typically operate at lower speeds than CBP-compatible mixers and thus in a given mixing time cannot impart as much energy to the dough. The actual transfer of energy to the dough with spiral mixers depends to a large extent on the configuration of the mixing blade, and those designs that have more than one mixing blade will transfer a greater quantity of energy to the dough in a given time. Thus, for a given mixing time we will expect to see differences in those aspects of bread quality that are related to dough gas retention, such as volume and softness, and to a lesser extent fineness of cell structure. We can expect that the greater the energy transfer, the larger the bread volume and the softer the crumb.

For any given spiral mixer increasing the mixing time will increase the total energy transferred to the dough. The longer the mixing time, especially on second speed, the greater the total energy and the larger the bread volume. However, since spiral mixers operate at lower speeds than CBP-compatible mixers we cannot expect to achieve the same total energy levels that are possible with the CBP.

To determine your optimum mixing time we suggest that you carry out a series of trials in which you start with your existing mixing times, if you have them, and raise the second speed mixing time by 2 minutes for successive doughs. If you do not have an established second speed mixing time start at, say, 6 minutes, use 8 for the next dough, and so on. You will probably find that you need not go beyond 14 minutes.

It is important to have the same final dough temperature at the end of mixing so that you can make a true comparison. The longer the mixing time, the greater the transfer of energy and so the greater the temperature rise in the dough. This can be compensated for by lowering the water temperature that you use in doughmaking. Each 1°C that the dough temperature requires adjustment by will require at least 2°C change in water temperature.

It is also important that any trials are carried out with the same dough mass in the bowl because energy transfer with spiral mixers depends on the degree of interaction between dough and spiral beater. For a given mixing time this interaction increases as the mass of dough goes down, within limits, and vice versa.

When you have completed your trials you will probably see that bread volume increases as mixing time increases, reaches a maximum at about 10 or 12 minutes and then begins to fall slightly. This will indicate the optimum mixing time for your particular spiral mixer. The same time can be used for a range of different bread types, assuming that maximum bread volume and crumb softness are your aims.
6.11 Why is it necessary to control the temperature of bread doughs?

The control of final dough temperature to a constant value is essential to ensure consistency of product quality whatever the breadmaking process that is being used because almost all of the chemical and biochemical processes involved in breadmaking are temperature-sensitive. In addition many of the physical properties of dough that influence its processing are directly affected by changes in temperature.

The most obvious of the processes in breadmaking that is temperature-sensitive is gas production by the yeast and variations in dough temperature will be reflected in variations in proving volume, even in a controlled prover environment. In many bakeries variations in proving volume cannot be compensated for by changing proving time and so variations in bread volume and quality would follow. Yeast activity increases as the temperature increase, reaching a maximum at about 43°C.

A complex series of enzymic actions takes place in fermenting dough and all of these are temperature-sensitive. As with yeast, enzymic activity increases as the temperature rises though the temperature varies at which maximum activity occurs according to the particular enzyme. In breadmaking processes that employ significant periods of bulk fermentation as part of the development stage, variations in dough temperature will have a profound effect on bread quality.

Even the chemical reactions, such as ascorbic acid-assisted oxidation, are affected by temperature. Lower temperatures give less oxidation and hence yield doughs with a reduced ability to retain gas in the oven.

If the temperature of the dough at the end of mixing is raised then the rheology of the dough will change; it becomes less viscous and easier to deform. In turn this results in less moulder damage. However, if the dough temperature is raised too high, then it becomes too soft to process. If the dough temperature falls, then the dough becomes stiffer and moulder damage will increase.

The choice of dough temperature to use is closely linked with the breadmaking process being used, with higher dough temperatures being used with no-time doughs than those that will experience bulk fermentation or significant processing times.
6.12 We have been experiencing some variation in crust colour on our bread products. What causes bread crust colour and why should it vary?

The crust colour in bread is principally formed by Maillard-type reactions involving reducing sugars and amino compounds (free amino acids and terminal amino-groups in soluble proteins). For colour formation you need both factors to be present in appropriate amounts.

A small amount of the main reducing sugar, maltose, may be present in the flour but in fermentation, proving and the early stages of baking the alpha- and beta-catalysed hydrolysis of the starch in the flour increases the amount present. Amylases are slow to attack intact starch, so the main source of starch for hydrolysis is the damaged starch. Thus, the balance of enzymic activity and flour starch damage becomes important for correct crust formation.

Other sugars that may contribute to colour formation are glucose and fructose, sucrose or lactose if non-fat milk solids are present in the recipe. Caramelisation may also occur, even in the absence of Maillard-type reactions but it occurs at much higher temperatures, usually above 155°C.

The variations in colour that you are experiencing may therefore come from a number of sources. Assuming that the baking conditions are not to blame then the most likely causes are variations in damaged starch levels in the flour or enzymic activity, whether in the flour or from the improver. You may want to have these checked.

Remember that enzymic activity is temperature sensitive so that variations in dough temperature may contribute to variations in crust colour. Processing delays may cause darker than usual crust colours because of the longer time available for enzyme action. Even retarded doughs can show problems of dark crust colours because of enzyme activity in the dough. If you are using a fermentation process to develop your dough you should check that the bulk time is being carefully controlled.

There are generally adequate amounts of naturally occurring amino compounds in bread flour, but if you continue to get pale crusts then an addition of non-fat milk solids or an ammonium salt will help. Reducing a dark crust is harder to achieve because it requires the removal of material that may already be in the flour or improver.
6.13 Why is the surface of some bread doughs cut before baking?

Many types of breads, especially crusty forms, have a distinctive pattern of cuts showing on the baked surface. These cuts are usually made when the dough leaves the prover and before it enters the oven.

The most obvious reason for the cuts is to provide a distinctive surface pattern which distinguishes one loaf from another. The characteristic patterns will have originated many years ago and has now become so enshrined in the product character that they have become part of the authenticity of a particular product and part of consumer perception of product quality. If it has been cut like a bloomer and baked like a bloomer then at first glance in a display of other breads it meets customer expectations of a bloomer and customers will be attracted to it.

Probably surface cuts were first used for quite different reasons. While dough proves, its rheology begins to change and in particular it becomes less elastic. If doughs enter the oven under-proved the elastic nature of the dough prevents uniform expansion. Cutting the surface of dough pieces creates points of weakness which can be exploited by the expanding dough so that cutting can be used to produce controlled oven spring. A rule of thumb is that if doughs are not fully proved you cut deeply, while if doughs are over-proved you make the cuts shallow.

There is a common tendency to worry about cutting doughs deeply because they may collapse and fail to rise in the oven. The main cause of such collapse is not usually the cutting (unless the doughs are over-proved) but rather that the doughs lack gas retention. Doughs that have been fully developed can be cut quite deeply and even if they collapse after cutting they will regain their correct size and shape in the oven.

Bread doughs bake by receiving heat through their surfaces. Because dough is a poor conductor of heat, one way to speed up heat transfer is to increase the surface area available for heating by cutting the dough. This increase in surface area also helps with flavour development in the product because cutting often increases the proportion of crust relative to that of the crumb. Since much of the bread flavour comes from the crust, the greater the proportion of crust, the more flavoursome the product.

Cutting should always be carried out with a clean, sharp knife and should follow the traditional pattern closely. Each bread type will have its own distinctive pattern and method of making the incisions and without the right procedure then you will not get the authentic product.
6.14 What are the best conditions to use for proving bread dough?

The main purpose of the proving stage in baking is to expand the dough piece and modify its rheology to obtain further expansion and structure development in the oven. To achieve this we need to generate carbon dioxide gas from yeast fermentation. So our first consideration is to provide the best possible conditions for yeast activity. Yeast will produce carbon dioxide gas over a range of temperatures running from around 0 °C. As the temperature rises gas production increases reaching a maximum at around 43 °C. By the time that the temperature has reached 55 °C all yeast activity has ceased and the cells are dead.

Usually we seek to achieve around 90% of our required product volume in the proved dough, leaving the last 10% or so to come from oven spring. The time that it takes for this point to be reached in the prover depends mainly on the proving temperature and the level of yeast, that is present in the dough. The greater the quantity of yeast, the shorter will be the proving time to a given volume. Thus, if our sole criterion for deciding on proving conditions is to leave the dough in the prover for as short a time as possible then we would choose a high yeast level and a temperature around 40–43 °C, and to a large extent this is the norm in most bakeries.

The other issue we have to consider is the relatively poor conductivity of heat by dough. The dough commonly enters the prover at a lower temperature than the air in the prover. As proving proceeds, the outer layers quickly warm while the dough centre remains cooler. If the yeast level is very high the outer layers will quickly become over-proved and lose their gas retention properties. Large temperature differentials in a dough piece by the end of proving tend to give poorer product quality, showing as lack of volume and uneven cell structure.

The other condition that we must pay attention to is the relative humidity of the air surrounding the dough. The dough relative humidity lies around 90–95% and so there is considerable potential for surface evaporation unless we take steps to raise the prover humidity. Typically we raise this to around 85% to minimise surface evaporation or skinning.

In summary the best proving conditions to use are the ones that are most 'dough-friendly'. This would suggest temperatures similar to those that we achieve in doughmaking but this would give extended proving times unless we raise yeast levels to such an extent that we may incur unacceptable flavour changes or unnecessary high ingredient costs. The practical compromise suggests temperatures from 35 to 40 °C with appropriate humidity control.

Further reading
6.15 Can we freeze our unproved dough pieces and store them for later use?

The freezing and storing of unproved bread and other fermented doughs is perfectly possible but does require some attention to all aspects of dough production, processing and subsequent use on defrosting. The following guidelines highlight some of the most important areas:

- Use a no-time doughmaking process as periods of fermentation before freezing have an adverse effect on bread quality.
- Use ingredients and a dough formulation that give good products by scratch production. Freezing and thawing cannot improve product quality.
- Raise your recipe yeast level to compensate for the loss of gas production from yeast cells that are killed during the freezing and storage. Or use a yeast strain with a greater tolerance to freezing.
- Freeze the dough as quickly as possible after moulding to minimise gas production.
- You may need to adjust product dimensions before freezing as doughs may sometimes spread during freezing and fail to fit the pans when you take them out for thawing.
- Use a blast freezer but avoid air temperature less than −30°C because of adverse effects on product quality.
- Ensure that products are fully frozen, with a core temperature of at least −10°C, before passing to storage to minimise quality losses.
- Expect progressive loss of final product volume as frozen storage time increases so compensate with increased proving times.
- Thaw the products using low temperatures and long times to minimise temperature differentials between the dough centre and its surface when it reaches the end of proving.
- Select carefully the products that you wish to make with frozen dough. Products with small diameters such as rolls and baguettes will be more successful than thicker products such as pan breads.

Further reading


6.16 What happens when dough bakes?

In simple terms when dough enters the oven it expands and loses moisture, the crust darkens and the dough sets (Fig. 20). Behind this simple description are a great many different physical and chemical changes, which are summarised as follows:

- Gas production by the yeast continues as the dough temperature rises in the early stages of baking. When all of the dough exceeds $43^\circ C$ the rate of gas production falls and eventually ceases by $55^\circ C$. While the dough surface is rapidly heated and yeast activity ceases there the poor heat conductivity of dough means that the centre continues to produce carbon dioxide gas for some time after the crust has formed. The force that is created by the expanding centre means that tin dough springs upwards, creating oven spring.
- The dough is also being expanded by steam pressure and the expansion of trapped gases.

![Fig. 20 Changes in bread dough during baking.](image-url)
In order for the dough to continue to expand during baking it must be able to retain the gas that is being released. The stresses placed on the dough during the early stages of baking are much greater than those placed on it during proving and it is only in the oven that doughs that truly lack the correct gas retention properties are exposed. Commonly, lack of gas retention is seen as lack of oven spring or in more extreme cases as collapse.

The dough loses moisture with increasing baking time. The moisture losses are greatest from the crust and this encourages the formation of a crisp eating, crusty layer.

The Maillard reactions begin to develop the crust colour.

The starch begins to swell and gelatinise. At this time more of it becomes susceptible to the action of any $\alpha$-amylase enzymes present and the breakdown to sticky dextrins and maltose is accelerated by the higher temperatures.

In the dough the gas bubbles present are separated from one another by a thin protective film. Since they are not connected with one another they are commonly described as a ‘foam’. As baking proceeds, the loss of water makes the gluten protective film become more rigid and the pressures within the gas bubbles rupture the protective films. The foam in the dough is converted to a sponge, that is a system in which all the cells are open and interconnected. At this time the volume of the baking loaf falls slightly as the internal and external gas pressures are equalised.

Moisture continues to be lost while the product remains in the oven.

All of the necessary changes from dough to baked product are usually achieved by the time that the product centre reaches a temperature between 92 and 96°C.

Further reading
6.17 Why do crusty breads go soft when they are wrapped?

When crusty products leave the oven the moisture content of the crust is much lower than that of the centre crumb. Typical values can be as widely apart as 12 and 42% respectively. From the moment of leaving the oven this moisture differential provides a driving force for moisture migration from the crumb centre to the crust. This moisture migration continues as the product begins to cool and carries on during subsequent storage. Eventually the crust moisture content rises to a level at which the product is no longer crisp or crusty.

The rate and extent to which the moisture migrates from the crumb to the crust depend on several different factors, including the storage temperature. The lower the storage temperature, the lower the rate of moisture migration, but note that the rate of non-moisture related firming will increase (see 6.18).

The usual process for the movement of moisture in crusty bread is from crumb to crust as nature tries to achieve moisture equilibrium between the two components. The moisture content of the crumb falls and that of the crust rises. If the product is unwrapped then the crust generally loses moisture to the surrounding atmosphere provided that the atmosphere relative humidity is lower than that of the loaf. In practice this is mostly the case and air draughts sweeping across the product surface carry the moisture away. This lost moisture is replaced by more migrating from the crumb and the whole product dehydrates and loses consumer appeal.

To prevent this dehydration bread is wrapped in a suitable protective film but if crusty bread is put in a moisture-impermeable film (e.g. a polyethylene bag) then the moisture that would have been swept away remains and the bread quickly comes to equilibrium with the atmosphere in the wrapper. The result is that crustiness is quickly lost. The alternative is to use a semi-permeable film to let some of the migrating moisture escape through the holes in the wrappers and help keep crust crispness for a longer time. Commonly perforated films are used for the purpose, the size and distribution of the perforations being used to control the rate of moisture loss.

A common cause of loss of crust crispness, even when perforated films are used, comes from wrapping bread too warm. In many bakeries bread freshness is only equated with the product being hot, and staff may be encouraged to wrap the product while still warm. This practice has three main disadvantages:

1. Moisture will be lost from the warm bread and condense within the wrapper. The moisture will be re-absorbed by the product crust and so in the case of crusty breads it encourages softening of the crust.
2. The loss of crust crispness leaves the bread susceptible to crushing on the shelf and in the shopping basket.
3. Condensation encourages the localised raising of product water activity and so encourages the growth of moulds.
Further reading

6.18 We have been comparing our bread with that of our competitors and find that the crumb of our bread is firmer. Why?

There are a number of reasons why we can have differences in breadcrumb softness; some are related to the ingredients used while others are directly affected by the processing methods. The first element to look at is whether there are any differences in the moisture content of the crumb of the breads concerned: the higher the crumb moisture content, the softer the bread will appear to be (Cauvain and Young, 2000).

Bread softness is directly related to bread volume and the greater the volume of the bread, the softer it will be. Even when breads have the same volume we may still see differences in softness which are related to the density distribution in the crumb cross-section. If we want to make the crumb of pan breads softer then one possibility is to create greater expansion of the centre crumb to lower its density and resistance to compression. We can do this by increasing the gas retention in the dough using ingredients such as oxidants, fat, enzymes and emulsifiers, or by improving dough development during mixing.

However, producing a crumb that is less resistant to compression is only part of the answer to making fresher bread. We also need to make a crumb that will largely recover its original shape after the squeeze test. This again can be achieved by improving dough gas retention. In particular we would want to create a fine (small average cell size) crumb cell structure with thin cell walls. This can best be achieved by creating a gas bubble structure in the dough which consists of many small bubbles and expanding them uniformly without excessive damage to the dough during moulding.

All bread goes firmer during storage, even if moisture is not lost from the crumb. This firming process is the one most often referred to as ‘staling’ and is largely associated with the recrystallisation (retrogradation) of the starch in the bread (Pateras, 1998). A number of factors will influence the rate at which bread stales including the following:

- The storage temperature – bread staling increases as the temperature of storage falls, reaching a maximum at about 4 °C. Check the temperatures in your despatch and storage areas and see if they can be made warmer but watch out for greater microbial spoilage.
- The presence of emulsifiers in the formulation. Some emulsifiers work to improve crumb softness by improving dough gas retention or through reducing gas bubble size in the dough. Additions of GMS can be used to slow the starch retrogradation process but it is important that the GMS is added in its active alpha form, commonly as a hydrated gel.
- Maltogenic amylases can be added to the dough and these also affect starch retrogradation. In this case the bread will not only start softer but firm at a lower rate.
You should also look at your oven baking conditions. Generally softer bread is obtained if you can bake at a higher temperature for a shorter time but of course there are limitations. Also check your cooling process and whether you can shorten the time being taken. The shortest possible cooling time will be dictated by the temperature at which you can slice or wrap your product. You do not want to encourage condensation in the wrapper, which can encourage mould growth.

References
6.19 We have been deep-freezing bread products and experience a number of problems with different products. With crusty products we observe that the crust falls off, but with some other products we find that longer periods of storage lead to the formation of white, translucent patches in the crumb which are very hard eating. Are the problems related to the performance of our freezer?

The first of your problems is commonly referred to as ‘shelling’, that is the loss of the crust from frozen fermented items which may occur during storage but more commonly manifests itself when the product is defrosted. Similar problems may be observed with some part-baked, frozen products.

When all bread products leave the oven the moisture content of the crust region is much lower than that of the crumb. This differential in moisture content is much greater in crusty products than with many other types of bread, e.g. sandwich breads, and is an integral part of the character of the product. The difference in moisture content between crust and crumb is partly responsible for their differences in texture, with the low moisture crust having a harder, more rigid character than the higher moisture content soft crumb. The difference in moisture content also means that the salt concentration is higher in the crust region than in the centre crumb, which will lower the temperature at which ice forms in these regions.

The combination of different freezing points and structural architecture means that the crust and crumb will expand and contract at different rates. The stress that this places on the interface between the two regions may become so great that they become separated from one another. This phenomenon will occur under almost any freezing condition so it is unlikely that your freezer performance is directly to blame for the problem. You will have to accept that you are unlikely to freeze crusty products successfully because the only solution is to allow equilibration of moisture before freezing, but then the product would not be crusty anyway!

Your second problem could well be related to your freezer performance and is a phenomenon known as ‘freezer burn’ (Cauvain and Young, 2000). It comes from the loss of water from different regions of your product during frozen storage. It has been estimated that about 30% of the water in bread remains unfrozen in bread, even at $-20^\circ$C. This ‘free’ water may leave the product and enter the freezer or pack atmosphere where it eventually shows as ‘frost’. The hard, translucent patches that you see are areas of crumb that have become dehydrated in the freezer.

The condition is exacerbated by any periods when the freezer has been allowed to warm to temperatures above the freezing point of the product. The higher temperatures accelerate moisture losses and the slow re-freezing that follows also contributes to the problem. We suggest that you look at your freezer performance and in particular any changes in conditions during the defrost cycle. Also look closely at your operating procedures and try to minimise the
opening and closing of the freezer. This is a common cause of the problem because the cold air is lost and replaced by warmer air which raises the temperature of the products nearest to the door or lid.

Reference
7

Fermented products

7.1 What steps could be taken to prevent round doughnuts shrinking or collapsing within a few minutes of leaving the fryer?

The collapse of doughnuts after they leave the fryer is associated with the transition of the dough from a ‘foam’ to a ‘sponge’ (in the generic not specific cakemaking sense). In foams the gas bubbles or cells are separated from one another by a stabilising film of one form or another, e.g. protein, fat, emulsifier, while in a sponge the cells are interconnected and gases and liquids can readily pass through the matrix (see Fig. 21).

In the oven most baked products undergo the transition from foam to sponge and the gas contained within the individual cells diffuses out of the product into the surrounding atmosphere. The transition occurs at different parts of the dough piece at different times, depending on the heat transfer rate. Before conversion the pressure inside the air bubbles is greater than that of the surrounding atmosphere and this contributes to inflation of the product. At the moment of conversion from foam to sponge there is an equalisation of the gas pressure with

![Diagram showing transition from foam to sponge](image)

**Fig. 21** Transition from foam to sponge during baking.
that in the surrounding atmosphere and this is seen as a slight shrinking of the volume of the baked product just before the end of baking.

The addition of some ingredients can delay the conversion of the foam to a sponge to a later time during the baking process. Sugar, in the form of sucrose, delays the gelatinisation of the wheat starch and subsequently the temperature at which the foam to sponge conversion is made. In some formulations the transition may not take place within the centre of the product before baking is completed. As a consequence the foam remains intact and as the temperature within the cells falls so does the internal pressure. At some point the external pressure on the product becomes greater than the internal pressure of the cells and the product shrinks. This is the collapse and wrinkling of the product that you see.

To avoid the problem you should reduce the sugar level in the formulation or reduce the ability of the dough to retain gas. It is well known that a mechanical shock delivered to many such products can be used to eliminate the problem, so simply banging the trays as you remove them from the fryer can reduce or even eliminate this problem.
7.2 The fermented doughnuts we are making tend to be quite greasy to eat. How can we reduce this problem?

During the frying process the heat expands the air bubbles trapped within the dough, carbon dioxide gas is evolved from the last of the yeast activity and steam is given off. While all this is happening, the pressure within the dough piece is greater than that of the surrounding atmosphere and the greater internal pressure prevents the absorption of oil. Once the transition from foam in the dough to sponge is made (see 7.1) the pressure within the dough becomes equal to that outside the dough and it is only after this point that oil can penetrate the product.

In fact, much of the oil absorption that one sees with doughnuts occurs after the product has left the fryer. In particular any pools of oil that remain on the draining wires in contact with the final product provide easy access for the oil below the product surface. You should try to find a means of shaking off as much excess oils as possible before leaving the doughnuts to stand. In some cases tapping or banging of the trays can be employed and this may also help avoid problems of collapse and wrinkling (see 7.9).

Other means of reducing oil absorption in doughnuts include:

- adding a low level of a cellulose-based material to the formulation (up 0.3% flour weight);
- maximising the added water content of the dough as this will help to increase the steam pressure during frying;
- ensuring that the frying temperature of the oil does not fall too low. Typically it should be about 180°C. Too low an oil temperature reduces the heat input and lengthens the time that the doughnut spends in the fat after the foam has converted to a sponge, thereby increasing the time for oil penetration.
7.3 When we retard our rolls before proving and baking we sometimes see a dark mark on the base immediately after baking and cooling. We see similar problems with our retarded doughnuts. Is this mould because the products have been left to cool on the trays before wrapping? We use silicon paper to bake on; does this aggravate the problem?

It is unlikely that that problem is one associated with mould growth because you observe it so soon after baking. It is most unlikely that mould colonies would grow large enough to see in such a short time in spite of the high temperatures of the baked product.

The dark spots are almost certainly caused by a chemical reaction between the dough pieces and any source of iron they have been in contact with. The most obvious source will be the baking sheets used to hold the products in the retarder. The close contact between the base of the dough pieces and the iron tray ensures that the relative humidity in the area of contact remains high. The dough is slightly acid, commonly pH around 5.5, and this accelerates the reaction with the iron to form iron compounds which are dark in colour. The chemical composition of these compounds is similar to those involved in the rusting processes associated with iron.

You should avoid using trays that are damaged, scratched or showing signs of rust. An alternative may be to change to using aluminium trays. The reaction can be so strong that it is known to take place through the silicon paper that you are using.

The doughnut wires that you are using may be tin-coated iron/steel and the coating may have worn sufficiently in places to expose the underlying source of iron for the chemical reaction to occur. You can get these re-tinned or change to an alternative metal form.
We are retarding our roll and stick doughs overnight but find that the products baked from them are covered with many small, white, almost translucent spots on the surface. We do not get the same problem with our scratch production using the same recipe. Can you give an explanation for their appearance and advise on how to get rid of them?

The formation of small, white, almost translucent spots on the surface of retarded products is not uncommon (see Fig. 22). The principal reason for the problem is excessive gas production in the retarding phase, especially if the dough lacks good gas retention.

Gas production continues in dough after it enters the retarder. The rate of gas produced is directly related to the temperature of the retarder: the lower the retarder temperature, the lower the rate of gas production. In fact the production of carbon dioxide gas has been shown to continue in dough even when stored at $-5^\circ$C in the retarder (Cauvain, 1998). The release of carbon dioxide gas over the long storage period begins to inflate the small gas bubbles in the dough. When viewed under a low-power microscope, the larger gas bubbles held just underneath the top surface of the dough piece where white spots form appear to have water droplets hanging under their upper surface. This ‘free’ water may act as a diluent for the colour-forming components. These normally contribute to crust colour and so on baking those particular bubbles appear white against a darker background. There has yet to be a full explanation for white spot formation on retarded products. However, the important role of moisture is indicated by the fact that white spots cannot occur on retarded products that have skinned.

Elimination of the white spots can be achieved in a number of different ways including:

Fig. 22  White spots on retarded products.
• ensuring that the dough has good gas retention, e.g. correctly mixed;
• by not using a low dough temperature;
• by reducing yeast level to minimise gas production in the early stages of retarding;
• by using as low a retarding temperature as possible without freezing the dough piece;
• by avoiding delays between product make-up and loading the retarder.

Reference
7.5 We have problems with our retarded teacakes which have large holes underneath the top crust. We do not experience the same problem with scratch made products. Why is this?

Even though you are not experiencing a problem with your scratch production one of the possible causes of your problem may come from the shaping processes. In particular the pressure applied during the pinning process may be causing some damage to the dough bubble structure underneath the upper surface of the dough. The dough pieces spend a long time in the retarder and this extended period of gas production may tend to exaggerate the problem.

Some of the causes of damage to the gas bubble structure in the dough derive from the initial dough mixing and processing. For example, if the dough is stiff or cold then pinning pressures need to be higher to achieve the required shape and size. There is often a temptation to make doughs for the retarder at a lower temperature to help control gas production. However, this is to the detriment of dough development and yields a dough less able to withstand the stresses and strains applied during processing. It is better to use lower yeast levels to control gas production in the dough destined for the retarder.

The appearance of holes underneath the top crust of the retarded product can also be made worse if any skinning of the dough piece has taken place in the retarding stage. There is always some loss of moisture from the dough piece surface during retarding but if this is too great the upper surface of the piece loses flexibility. When the piece moves into the proving cycle the increased evolution of carbon dioxide in the dough increases the internal stresses within the piece. This may exploit any areas of weakness such as those arising from moulder damage. Since skinning is less likely to occur with the scratch product the upper surface remains more flexible and better able to cope with the internal stresses and strains.

Further reading
7.6 We have been receiving complaints that our small fermented products, such as rolls, teacakes and baps, are staling too quickly. How can we improve the product softness?

There are several different ways to improve the softness of products. They can be grouped under the headings of improving volume, raising moisture content, using functional ingredients and storage.

**Improving volume**
In general larger-volumed products will have a softer crumb. This is because the resistance of the crumb to compression, whether by the fingers or in the mouth, is reduced. You will also need to ensure that the dough has been fully developed before baking as this gives a degree of resilience to the crumb which is important for the overall quality of the product. Rolls that show no resiliency after compression while definitely appearing soft lack the chewiness associated with fermented products. The better the dough development and gas retention in the dough, the larger the product volume. Better dough development often comes from extending dough mixing times (see 6.10).

**Raising moisture content**
The higher the moisture content in the final product, the softer it will be. You should look to maximise the water addition to the dough, since this will also help dough development. Try also to bake less water out in the oven, since the final moisture content is more affected by the length of time that the product spends in the oven so there are advantages to raising the baking temperature and reducing the baking time. Some of the moisture from the crumb will migrate to the drier crust in order to achieve equilibrium. Keeping the crust thin means that less water is needed to achieve equilibrium (Cauvain and Young, 2000).

**Using functional ingredients**
There are a number of functional ingredients that may be used to improve crumb softness including fat (mainly through improved gas retention), emulsifiers such as DATA esters and SSL (Williams and Pullen, 1998). GMS forms complexes with the starch and so has a true anti-staling effect in fermented products (Pateras, 1998). Additions of enzyme-active materials are also useful. For example, the so-called maltogenic or intermediate thermal stability enzymes have a beneficial anti-staling effect while fungal α-amylase can be used to increase product volume (Cauvain and Chamberlain, 1988).
Storage
It is important to wrap your products as quickly as possible after cooling in a moisture-impermeable film to minimise moisture losses. You should also be careful where you store the products because bread staling proceeds faster as the temperature falls (Pateras, 1998). So avoid storage areas where the ambient temperature falls below about 15°C.

References
7.7 We have been experiencing difficulties with the production of our bread rolls. The finished rolls have poor volume with large holes in the crumb. What measures might we take to eliminate these faults?

Your problem with small volume may come from a number of sources, all associated with a lack of gas retention in the dough. The specific volume (volume per unit mass) of rolls is normally expected to be greater than that of bread and so it is necessary to increase the gas-retaining abilities of the dough. You can achieve this in a number of ways including the following:

- Using a better quality (stronger) flour. It is common practice to use a higher grade of flour for bread than for rolls.
- Raising the level of the improver that you are using. Often bread improvers are used at 1% flour weight and this may be increased to 2% for rolls.
- Change to a more powerful improver, that is one that will give improved gas retention in the dough.
- Ensure that the dough is fully developed during the mixing cycle. This may entail raising work input in the CBP or mixing longer with other breadmaking systems (see 6.8 and 6.10).
- Raise the dough temperature to aid dough development. If excessive gas production before moulding becomes a problem simply reduce the yeast level.

The holes that you observe are most likely to come from damage to the gas bubble structure during moulding. There are a number of reasons why this damage might occur including the following:

- The level of water in the dough is too low (Cauvain and Young, 2000) so that moulding pressures have to be increased in order to achieve the required shape.
- The dough is insufficiently relaxed because the resting time between moulding stages is too short.
- The dough temperature is too low giving a more viscous (stiff) dough similar to having too low a water level.

Reference

7.8 Our fruit breads rise very slowly in the prover and fail to rise any further in the oven. We make some unfruited products with the same formulation and they are satisfactory in all respects. Why?

Since the problem is associated only with fruited products then we must look to the fruit for the cause. You appear to have a problem with both gas production – the slow proof – and gas retention – the failure to rise in the oven.

Bakers’ yeast is a microorganism and as such its activity, that is its ability to produce carbon dioxide gas, can be inhibited by a number of naturally occurring materials. Dried fruits do contain such anti-microbial agents, which is part of the reason that fruited cakes take longer to grow mould. While the fruit pieces are intact the effect of these agents is small but when the fruit skins are broken they are more able to exert their inhibitory effect. The concentration of sugars in dried fruit is high and breaking the fruit skins releases these sugars into the aqueous phase of the dough where the increased concentration also slows down gas production by the bakers’ yeast.

To avoid these effects we suggest that you examine the mixing process and ensure that the fruit is added as late as possible consistent with achieving a thorough blending of the fruit into the dough. This will minimise the breakage of the fruit skins. You may also wish to examine the mixing speed and mixing action that you are using for the fruit addition.

You may need to increase the water level that you are using to make the dough for your fruited products. This is because the addition of the dry fruit will absorb some of the dough water and produce a stiffer dough. This may lead to difficulties with fruit dispersion and the inclination to mix longer than necessary. If you can we suggest that you avoid the practice of making a plain dough, and then taking off part for your plain products and adding fruit to the remainder. You will get much better results by making a dedicated fruited dough.

Ideally the temperature of the fruit that you use should be the same as that of your dough otherwise the fruit addition will give you a lower temperature and lower yeast activity.

Some dried fruits may be treated with sulphur dioxide to help maintain their quality for long periods of time. When the fruit is added to the dough such treatment may result in the formation of reducing agents that will adversely affect dough gas retention. This will be seen as a lack of oven spring, though in severe cases the effects may be seen in the prover as well. If you suspect that this is the cause of your problem we recommend that you wash and drain the fruit before use. This normally solves the problem. If you wash the fruit remember to adjust the added water level to compensate for the wetter fruit.
7.9 Our fruited buns frequently collapse when they leave the oven. We have tried baking them for longer but this does not cure the problem. Our fruited loaves made with the same dough do not have the problem. Why?

The cause of this problem is essentially the same as that described for the doughnuts (see 7.1), namely that the transition of the dough from a ‘foam’ to a ‘sponge’ (in the generic not specific cakemaking sense) is not occurring in the oven and the gases within the individual bubbles or cells are not diffusing out of the product into the surrounding atmosphere. During cooling the external pressure becomes greater than the pressure within the intact bubbles and the product shrinks and collapses and the crust wrinkles. No amount of extra baking will cure the problem. To avoid the problem you should reduce the sugar level in the formulation or reduce the ability of the dough to retain gas.

It is well known that a mechanical shock delivered to many such products can be used to eliminate the product, so simply banging the trays as you remove them from the oven can reduce or even eliminate this problem. Some bakers have developed the habit of dropping trays on the floor but this should be done with caution to avoid personal injury or damage to equipment. If the mechanical shock is too violent then it is possible to crack the crust surface of the product since it lacks the necessary flexibility to withstand the mechanical stresses.

You are less likely to see the problem with the dough baked in pans because the standard procedure when you take the products out of the oven is to give the pans a sharp knock in order to release the product from the pan for cooling. This depanning action delivers the required mechanical shock necessary for the disruption of the gas cells.
7.10 When we cut open bread rolls and hamburger buns that have been stored in the deep freeze for a period of time we observe a white ring just inside the crust which has a hard eating character. Where does this problem come from?

The phenomenon that you have observed is commonly referred to as ‘freezer burn’ and arises from the movement of water within and from the product while still in the deep freeze. It was reported by Pence et al. (1958) who examined the whitened areas of products exhibiting the phenomenon and observed that they had a greater number of tiny voids associated with starch granules. These voids were linked with ice crystals that had sublimated from within the starch granules, causing a greater opacity of the crumb and the whitened appearance. The change in the crumb texture from this effect also causes the crumb to have a harsh, dry eating quality arising from the lower moisture content. However, the effect does not come exclusively from the loss of moisture since the attempts to restore the crumb properties are unsuccessful unless substantial ‘re-wetting’ of the crumb is applied.

Even though the product has been stored in a deep freeze running at about −20°C not all of the aqueous phase in the product is ‘frozen’. This arises because of freeze-concentration effects and the presence of soluble materials like salt and sugar. As water turns to ice crystals the concentration of the remaining aqueous phase increases and its ‘freezing point’ becomes lower (Cauvain and Young, 2000). Eventually the concentration may become so low that the solution will not freeze even at −20°C.

Any increase in the product temperature during storage will enable some of the ‘unfrozen’ water present to diffuse from the product into the surrounding atmosphere. This clearly happens with many frozen products since it is not uncommon to find ‘snow’ or ice within the wrapping material. The longer the product is held in the storage freezer then the greater is the accumulation of snow as the product progressively dehydrates.

After the product has warmed in the storage freezer any subsequent refreezing will take place very slowly from the surface inwards. This creates an interesting effect because the centre of the product often remains frozen, the surface begins to freeze quite quickly, while a few millimetres under the surface freezes slowly. The end result is the formation of the white areas of freezer burn which commonly reflect the outer shape of the product.

The problem can be minimised by paying attention to a few simple ‘housekeeping’ rules:

• Do not store the product for very long periods of time.
• Check the actual storage temperature over a period of running time. The set temperature in the deep freeze is nominal and the thermostat will allow some degree of fluctuation around the set point.
• Ensure that your storage freezer is regularly serviced and have the conditions of any automatic defrost cycles checked.
As much as possible avoid actions that allow the freezer temperature to rise excessively. For example, keep doors closed as much as possible and minimise loading and unloading times as much as possible.

References
8

Laminated products

8.1 What causes puff pastry to rise during baking?

Most of the lift in puff pastry comes from the water vapour generated from the water held in the dough layers which when converted to steam becomes trapped in the melting fat between the dough layers (see Fig. 23). The thickness of the dough layers changes little during baking and makes no significant contribution to pastry lift.

Expansion of the paste can occur only if the dough layers are separate and discrete from the fat layers. Any strong bridges between the dough layers, such as may be caused when adjacent layers are crushed together in sheeting, restrict

Fig. 23 Mechanism for puff pastry lift.
the rise that can be obtained. However, if no crushing occurs then the baked pastry may be so flaky that it falls apart after baking.

Most of the expansion of puff pastry occurs in the first half of the baking time but more water must be driven off before the pastry is set firm enough to stand without collapsing (Cauvain and Young, 2000).

Many factors contribute to the degree of puff pastry lift and some of these are discussed in other questions below.

Reference
8.2 Why do we get a less regular lift in our puff pastry when we use the Scotch method compared with the English or French?

The so-called Scotch method of producing puff pastry differs fundamentally from the English or French in that the laminating fat is added at the dough-making stage rather than later in the process. To achieve this the laminating fat is usually cut into small cubes, with sides of about 20 mm, and added to the mixing bowl along with the other ingredients. After mixing, the paste will be sheeted and laminated in a similar manner to paste prepared by the other two methods.

Telloke (1991) used light microscopy and dye-stained laminating fat to study the layer formation in puff pastry and showed that the distribution of laminating fat between dough layers was less structured in paste made with the Scotch than with the English or French methods. This is hardly surprising since we would expect that the initial mixing of dough ingredients and laminating fat would effectively prevent the formation of separate and discrete dough and fat layers.

Variations in pastry lift with the Scotch method are common because of the lack of uniformity in the paste, and the overall pastry lift will be less than might be obtained with the English or French methods. Because of the variation in pastry lift it is not common practice to use Scotch method paste, for products such as vol-au-vent rings or other shape-sensitive products. Scotch method paste does find use within products such as the British sausage roll where a flaky eating character but restricted lift is required of the paste. Often the number of laminations given to Scotch method paste will be increased beyond that seen with English or French methods in order to help distribute the fat lumps as evenly as possible within the paste structure.

A benefit of using the Scotch method is that because discrete dough layers are not a feature of the method long paste relaxation times can be avoided and so it provides a more rapid means of making puff pastry products.

Reference

8.3 We are experiencing a problem with our puff pastry, which fails to lift and shows no sign of layering on baking. Why is this?

The layered structure in puff pastry relies on the formation of discrete and separated layers of fat and dough. The mechanism by which puff pastry rises relies on this separation as described above (see 8.1) and any number of ingredient, recipe or processing changes may cause the problem.

We suggest that you examine the following:

- The solid fat content of the fat that you are using since fats with low contents can result in poor lift.
- The number of laminations you are giving the paste. Too many laminations cause the fat layers to rupture and allow the broken dough layers to stick together and reduce lift.
- The application of any docking mechanisms because excess pressure or large numbers of docking holes can pin dough layers together and restrict expansion.
- Your oven temperature, as higher temperatures encourage lift. You should bake at around 230°C.

You can increase pastry lift by using a stronger flour, provided sufficient rest is given to achieve the optimum dough rheology during processing and before baking. Low levels of an oxidising agent, e.g. ascorbic acid, may help but you should note the comments on pastry shrinkage (see 8.2 and 8.5).
8.4 What are the purposes of the resting periods in the production of laminated products?

The rheology of the base dough is very important to the formation of the discrete dough and fat layers in the manufacture of laminated products. The successive sheeting and lamination stages during manufacture continue to change the dough rheology because of the work that is imparted, especially by the sheeting rolls. The overall effect of the work is to increase the dough elasticity and to reduce its extensibility and this may lead to tearing or breakdown of the individual dough layers. The holes that form in the dough sheet provide a ready escape route for the steam generated during baking and this restricts the pastry lift that can be obtained.

If a dough is left to rest after mixing or some other form of work its rheological character changes with time. In particular its character becomes less elastic and more extensible and the effects of subsequent sheeting are less severe. Thus, a key role for the resting period is to modify the dough rheology so as to preserve the separation of dough and fat layers so important to the formation of laminated product structure.

The degree of change in dough rheology is influenced by temperature and varies with different flours. Strong flours, that is ones high in protein or with strongly elastic glutens, require longer periods of relaxation than weaker ones to achieve the necessary rheological changes for optimum product quality. This change in rheological properties with resting time is linked with the natural reducing agents (glutathione) and enzymic activities in the flour.

In the case of strong flours, some resting time is required to achieve optimum pastry production while with weaker flours less resting time is desirable. While weaker flours are more suited to rapid processing they are less tolerant to plant delays. These observations allow us to conclude that weak flours are more suited to rapid processing methods but will not be tolerant to plant delays.
8.5 We have been experiencing some problems with excessive shrinking of our puff pastry products. What are the probable causes?

Some shrinkage of puff pastry during baking is inevitable, though it can be minimised. It is also important to recognise that in most cases puff pastry lift and shrinkage are linked with greater lift, often leading to greater shrinkage and vice versa.

Causes of excessive shrinkage may come from a number of recipe and processing sources, including the following:

- The flour is too strong for the processing methods being used. Strong flours require longer resting periods than weak flours in order for the dough rheology to become optimised for sheeting and laminating.
- Oxidants, such as ascorbic acid, may be present in the flour or dough formulation.
- The pH of the dough is too low because of the addition of acidic materials (see 8.6).
- The sugar level, if present, is too high.
- The level of recycled trimmings in the paste is too high. This is especially the case if the trimmings are added at the sheeting stage rather than in the mixer.
- Insufficient relaxation of the paste during the processing stages whatever the flour strength. This often applies to the stage after cutting out and before the product enters the oven.

Shrinkage may be overcome to some degree through the addition of a reducing agent, such as sodium metabisulphite or L-cysteine hydrochloride, or a proteolytic enzyme.

However, since such materials remain relatively active in the paste the effect in recycled trimmings may lead to excessive softening of the paste. We recommend that you try to reduce shrinkage by other means before considering the addition of such materials.
8.6 Why are acids sometimes added to puff pastry?

The acidification of doughs was commonly seen as a means to ‘strengthen’ the flour gluten, making it more pliable and extensible, which, in turn, would lead to extra pastry lift. While it is certainly true that puff pastry lift is increased by the addition of a suitable food-grade acid (see Fig. 24), there is also a tendency for pastry shrinkage to increase. With high levels of acid addition shape-critical products (e.g. vol-au-vent rings) may expand excessively and non-uniformly in the oven and may topple over during baking.

The optimum level of acid addition varies according to the type of acid and the flour being used. Variations in pastry shrinkage from the addition of a given level of acid to a range of flours are usually greater than variations in pastry lift. The reasons for the variations are not clear but are most likely to come from variations in the natural buffering effects of different flours (i.e. variations in paste pH) and the rheology of the gluten.

Where possible greater pastry lift should be sought through other means (see 8.3) rather than through the addition of an acid to the dough.
8.7 How should we handle the trimmings we get during the production of puff pastry shapes?

The production of trimmings from the manufacture of many puff pastry shapes is inevitable and it is perfectly acceptable to recycle them provided a few simple rules are followed. The trimmings contain naturally occurring microflora which become active in the paste and during any standing periods before reuse. The changes brought about by microflora include:

- lowering of the pH of the trimmings;
- softening of the trimmings because of proteolytic enzyme activity;
- the development of musty and off-odours;
- the growth of unsightly microbial colonies which can cause paste discoloration.

In the case of Danish pastry and croissant the presence of bakers’ yeast in the dough will also influence the effects of trimmings on product quality. All the above microbial activities are temperature- and time-dependent and proceed faster at higher temperatures and become more pronounced with longer times.

To use trimmings successfully we suggest the following guidelines:

- Recycle trimmings by adding them to the mixer rather than trying to add them at the sheeting stage. Addition at the mixing stage ensures their uniform dispersion and should avoid problems with uneven layering and shrinkage.
- Keep all trimmings at refrigerated temperatures (4°C) until required for use to minimise microbial activity.
- Allow a reasonable length of time for the trimmings to warm before reuse to avoid adversely affecting dough or paste temperatures.
- Every three or four days stop using trimmings to avoid excessive build-up of microbial activity in the paste.
8.8 We are experiencing a problem with the discoloration of unbaked puff pastry stored under refrigerated conditions. Sometimes black spots appear on the surface. Why does this happen and how can it be avoided?

The discoloration and dark spots that you see comes from enzyme-assisted oxidation of the polyphenols naturally present in the flour. These polyphenols are associated with the bran particles that come through from the milling process for white flour. The greater the level of bran present in the flour, the greater will be the number of black spots, and the larger the bran particle size, the larger the spot.

While enzymic activity is reduced as the storage temperature is lowered there is still sufficient activity at refrigerated temperatures for the problem to be manifest because of the long storage time involved. One possible way to avoid the problem would be to lower the storage temperature even further, perhaps even low enough to freeze the paste. However, using this approach you will have to ensure that the paste is sufficiently defrosted for subsequent processing.

Other means of minimising the problem include:

- excluding oxygen such as by storing the paste in gas-tight film;
- adding ascorbic acid, though this may adversely affect pastry lift and shrinkage (see 8.6);
- adding citric acid at low levels, i.e. up to 0.2% flour weight, but this too may adversely affect pastry lift and shrinkage, and flavour (see 8.6).

The easiest and most reliable solution is to change to a white flour with a lower level of bran present (e.g. lower grade colour figure or lower ash).

The addition of low levels (5–15 ppm) of glucose oxidase is claimed to prevent the formation of spots and general discoloration of fermented and non-fermented doughs after freezing and thawing (Unilever, 1992).

Reference

8.9 We wish to make croissant with the moulded ends joining to form a circle but find that they open up during baking. How can we overcome this problem?

During sheeting and processing the rheology of the paste changes because of the work that is done on the laminated dough. After work doughs tend to become more elastic and less extensible in character. The relaxation periods that commonly follow sheeting and laminating allow the paste to ‘relax’, that is become less elastic and more extensible. In a simple shape, such as a vol-au-vent ring or a square, the elastic component of paste rheology manifests itself as an eccentricity of shape, i.e. one side or radius shrinks more than the other. Thus it is not uncommon for a round vol-au-vent ring to become oval or a square shape to become rectangular.

In more complicated shapes, such as croissant, other changes may be observed when the dough is too elastic and these may include the opening-out of the circular shape. Increased paste elasticity may be overcome in a number of different ways including:

![Diagram](attachment:image.png)

Fig. 25 Effect of direction of cutting on croissant quality.
higher water levels in the base dough;
- a weaker flour;
- longer resting periods after sheeting and lamination, especially if strong
  flours are used;
- a suitable resting period after the formation of the circle and before the
  croissant enters the oven. This usually occurs in the prover.

The complicated shape of a croissant and the manner in which it is cut from
the paste sheet can play a very important role in controlling shape. Towards the
end of processing much of the roller action on the paste is in one direction, that
is in the direction of travel on the plant. The apex of the triangular shape
required for croissant before it is rolled up may be cut either in the direction of
travel or at right angles to it (see Fig. 25). In the latter case the stresses within the
curled piece can often lead to the problem you describe. If you cannot change
the direction of the cut we recommend that you employ a cross-pining roller,
that is one that moves at right angles to the travel of the plant to even out the
stresses.
8.10 Why should croissant and Danish pastry doughs be given less lamination than puff pastry?

A key difference between puff pastry and Danish pastries and croissant is the presence of bakers’ yeast in the latter two products. The yeast plays a significant part in the aeration of the paste during proving and baking but also disrupts the integrity of the dough and fat layers in the paste. In order to counteract this disruption of the dough layers and retain a degree of flakiness in the eating quality of the product it is necessary to keep the dough and fat layers thicker than would be normal with puff pastry.

Telloke (1991) suggested that optimum lamination for puff pastry occurred with about 100 to 130 theoretical fat layers, while Cauvain and Telloke (1993) suggested that the optimum for Danish pastry and croissant was between 18 and 32.

The aerating effect of yeast places a significant strain on the gluten network in the dough during proving. Higher yeast levels and longer proving times are likely to cause greater rupturing. It is important to ensure that the gluten network in the dough has good extensibility otherwise the baked products will lack volume and definition. This may require an increase in the strength of the flour used.

References


Further reading
9

Short pastry

9.1 Why does our pork pie pastry go soft during storage and what can we do to make our pastry crisper?

The softening of pork pie pastry (and the pastry of many other composite products) arises because of the migration of water from the moist filling to the dry pastry. The driving force for this migration is the difference in the component water activities. Cauvain and Young (2000) give typical water activities for savoury pie components as pastry 0.24, jelly 0.99 and filling 0.98.

Key factors that influence the rate at which water moves between components in savoury pies and the rate at which the pastry softens include the following:

• The storage temperature (Butcher and Hodge, 1984); the lower the temperature, the slower the rate of moisture migration.
• The absolute difference in water activities between the components; the greater the difference, the faster the moisture migration.

Fat also migrates during the manufacture of pies but most of this occurs in the oven when all of the solid fat has turned to oil and is therefore mobile. At ambient or lower temperatures the solid component of the fat cannot move within the pastry matrix. In the past, part of the softening of pie pastry has been attributed to fat migration but if this occurs it is a minor contributor to pastry softening. In fact the migration of oil into the base pastry under the influence of gravity in the oven probably contributes to keeping the base pastry from softening. The oil fills many of the microscopic voids formed in manufacture in the base paste and probably acts as a waterproofing agent so preventing the ingress of significant quantities of water.
As discussed above the main cause of lack of pastry crispness is associated with the movement of water from the moist filling to the drier pastry. The most common way to reduce this problem is to manipulate component water activities to reduce the ERH differential. However, in the case of savoury pastry reformulation of filling and pastry tends to be a limited option so that other means of maintaining pastry crispness must be sought.

One way of achieving a crisper pastry is to increase the initial crispness of the pastry so that even though it softens at the same rate, the crispness at any given storage time will be greater than normal.

In summary the opportunities for improving pastry crispness are:

- lower the temperature to slow the rate of moisture migration;
- reduce the absolute difference in water activities between the components;
- use the hot paste method which gives an initially crisper pastry;
- increase the protein content of the flour used in the manufacture of the paste;
- cool the pies thoroughly before adding the jelly.

References
9.2 We are producing unbaked meat pies but find that the short pastry lid cracks on freezing. The cracks become larger when the product thaws and during baking the filling may boil out, leaving an unsightly blemish on the surface. Why is this and what can we do about it?

In the freezer the fat in the unbaked pastry contracts by about 10% in volume whereas the aqueous phase expands. This differential in expansion causes stresses to build up in the paste which may exploit any microscopic weaknesses in the paste, turning them into visible cracks. The movement of air across the unbaked product during the freezing operation removes a small amount of moisture from the surface until ice is formed. This drying out of the paste also exacerbates the problem.

The level of gluten formation in short pastry is relatively modest compared with that developed in puff paste or bread doughs. This means that the gluten lacks any significant degree of extensibility and so during sheeting or blocking there is a tendency for the gluten network in the paste to become ruptured, if not visibly then certainly at the microscopic level. The cracks formed are most obvious on the lid because they are readily visible but almost certainly occur in other parts of the product.

In addition to being extensible the gluten network should not be elastic since this increases the stress on the paste. Increased elasticity is most likely to come from overmixing of the paste. The use of a stronger flour may have some advantage in reducing the problem.

Robb (1985) suggested a number of practical remedies for the problem. They included:

• increasing the paste water content;
• reducing the fat content;
• keeping paste mixing times to a minimum consistent with forming an homogeneous paste;
• blast freezing the pies and trying to minimise moisture losses during storage;
• keeping the proportion of trimmings in the lid pastry to a minimum.

Incorporating trimmings into the base paste whenever possible.

With some products where the paste fits tightly around the filling, for example sausage rolls and Cornish pasties, there may be some advantage in lowering the filling moisture content to reduce the degree of any physical expansion.

Reference
9.3 Our baked pastries and quiches are baked in individual foils. Why do they have small indents in the base, which project upwards and are pale in colour?

This problem has a similar cause to that described for fermented products in pans (see 6.2), namely that steam is trapped between the pastry and the foil case during baking and since it cannot escape then pressure builds up in some areas and forces the pastry upwards. Since the pastry has not coloured it is likely that this event has occurred early in the baking process.

In the case of the pastry the blocking process itself helps to create the impermeable seal necessary for the steam to remain trapped. It may be that some of the indent is created as the die withdraws, though even hand-blocked products have been known to show the problem.

The most obvious solution to your problem is to use foils with small perforations in the base. However, you should look closely at the location of the holes which should be at the lowest point of the foil, or if the foil concerned has more than one low point then holes should be present in each of the low areas. Even though the holes are small in size, typically, 1 mm, the pressure generated by the hot gases will still allow the steam to diffuse through them.

If the problem persists you should look at your baking conditions. The problem is always exacerbated by baking at high temperatures for short times and with high bottom heat. If you suspect that this is the case then try reducing the temperature and increasing the baking time.

Allowing the pastry case to rest after blocking and before filling and baking can also reduce the problem.
9.4 How can we make the sweet pastry that we use with our apple pies crisper eating?

The cause of sweetened short pastry softening is the same as that discussed for savoury pastry, namely that it is because of movement of moisture from the moist filling to the drier pastry. In contrast to the situation in a savoury product there are many more potential ways to extend the crispness of sweetened pastry products because of the greater potential for recipe reformulation.

Potential ways of keeping your pastry crisper include the following (Robb, 1991):

- Lowering the storage temperature.
- Reducing the differential in ERH between pastry and filling through reformulation. This can include the addition of sugar to the pastry or filling, or the addition of humectants such as glycerol to the filling.
- Omitting baking powder from the pastry formulation.
- Ensuring that any stabiliser in the filling has had sufficient time to become effective. Some stabilisers may require several hours to achieve optimum control over water activity.

Another possibility is to include a barrier between the pastry and the filling. Any such barrier must be edible and should not significantly change the product character. Cauvain (1995) provided some examples of suitable moisture barriers (see Fig. 26):

- A protein solution – egg albumen – sprayed on the pastry before depositing the filling.

![Fig. 26 Effect of barrier on short pastry crispness.](image_url)
• A gum solution – carboxy methyl cellulose – sprayed on the pastry before depositing the filling.
• A rice paper disc placed on the pastry before depositing the filling.

References

Further reading
9.5 From time to time we experience problems with the sheeting of our short paste; in particular it cracks or fails to remain cohesive. Why does this happen?

Gluten formation in short pastry doughs is not normally considered necessary. Traditional multistage methods of dough mixing were evolved to try to minimise the potential for gluten formation by ‘waterproofing’ the flour proteins with fat. While the degree of gluten formation required in the manufacture of short pastry is considerably less than is required in breadmaking, some is desirable so that the paste units or sheets remain intact during the forming and sheeting processes, otherwise cracks may form on the surface of the pastry. In extreme cases the crack may extend through the pastry sheet, causing it to break into two separate pieces.

Too much gluten formation in short pastry commonly leads to problems associated with shrinkage during sheeting, blocking, forming and during baking. Getting the balance between too little – lack of cohesion – and too much – excessive shrinkage – requires careful control of recipe and mixing conditions.

As might be expected the level of water used in the recipe plays a major role in determining the rheological properties of the final paste (Cauvain and Young, 2000). Too little and the paste will not form a cohesive sheet, too much and the paste will be too soft to process. The final paste rheology is also affected by the added fat level and to a degree fat and water are interchangeable in their effect on paste firmness: more fat gives a softer paste which can be offset by reducing the added water level. However, fat and water have completely opposite effects on gluten formation with fat inhibiting gluten formation and water promoting it.

Taylor (1984) studied the effect of mixing method for the manufacture of puff pastry and found that cracking of short pastry was more influenced by the length of the mixing time than the mixing method used. Short pastes mixed on a high-speed mixer tended to be more friable and prone to cracking because of the short mixing times employed. These findings confirm the need to develop a limited degree of gluten in the paste in order to minimise cracking of the sheets.

We suggest that you first investigate the effects of increasing mixing time. You may notice a small increase in paste temperature which can be readily compensated for by lowering the water temperature. If you still have the problem when you have optimised mixing time then we suggest you try raising the added water level.

References

9.6  We are having difficulty in blocking out savoury pie paste in foils. There is a tendency for the dough to stick to the block, causing the base of the foil case to become misshapen. We do not have the same problem with our sweetened paste. Why?

The problem is most likely to be associated with the temperature of the block that you are using. In particular you are more likely to experience the problem when the block temperature is low, for example, at the beginning of the run or on cold mornings.

Soft pastes will exacerbate the problem so you will find an advantage in restricting the added water or fat levels, or both. The addition of sugar without changing the water level increases the solids to liquid ratio in the recipe, in effect producing a firmer dough.
9.7 Why is the hot water method preferred for the production of savoury pastry but not for sweetened pastry?

The use of hot/boiling water in the production of the savoury paste is known to increase the crispness of the resulting paste during storage (see Fig. 27) (see 9.1). The reasons why this should be are not clear. Adding the boiling water to the flour may cause limited gelatinisation of the starch present but there is no direct evidence that this contributes to the formation of a crisper paste. The high temperature may inhibit the activity of the amylase in the flour and reduce any potential effect on the gelatinising starch. Since many savoury pie pastes will stand for a period of time after mixing or blocking, the limitation of any enzymic activity may be very important.

The high temperature resulting from the addition of the hot water will melt the solid fat. This may aid its dispersion into the microscopic voids created during mixing. These voids carry through to the baked product and provide a route for water to move through as it migrates from the filling. If the voids are filled with fat then there is less opportunity for the movement of water as shown by the observation that the base paste of pies does not soften during storage (see 9.1).

If the hot water method is used in sweetened pastry production it tends to produce a soft and sticky paste which will be difficult to block.

![Graph showing the effect of hot and cold pastry making methods on pastry crispness during storage.](image-url)
9.8 Why does the filling of baked custards sometimes have a watery appearance in the cold product?

The formation of a stable gel in the filling of baked custards depends on achieving the correct conditions during baking. It is important to prevent the temperature of the filling going too high. The stability of the gel depends on the ability of the egg proteins (the albumen), and any starches or stabilisers present in the formulation to hold the water within their structures. The problem that you are seeing comes from breakdown of the gel and is often referred to as syneresis (see 13.3).

Under the influence of sufficient heat the egg proteins will coagulate and in doing so their spatial configuration changes in a way that reduces their ability to hold large quantities of water within the three-dimensional protein structure formed during mixing. As this water is ‘lost’ from the coagulated protein structure it needs to be taken up by the other custard components otherwise it will be released from the gel. The quantity of the released water that will be mopped up by the other components will be limited.

Most commonly this problem arises from baking the product for too long. The long baking time allows a greater input of heat into the filling and raises its temperature far higher than that of the coagulation temperature of the albumen. The baking time should be reduced and the baking temperature may have to be raised to ensure that the paste is fully baked. Raising the baking temperature will have less effect on raising the filling temperature than prolonging the baking time.

A common sign that the filling is boiling is that the top of the custard will become rounded in the oven.

If adjusting the baking conditions does not cure the problem then consider raising the egg or stabiliser level in the filling formulation.
9.9 How do we avoid ‘boil-out’ of our pie fillings?

The boiling-out of pie fillings is most readily controlled by adjusting the baking conditions you are using. Commonly we bake our products to colour but the rate at which we achieve the required colour depends to a large extent on the choice of baking temperature. Boil-out of the filling, however, will depend mostly on the length of the baking time. The longer the product spends in the oven, the higher the filling temperature will become and the greater the chances of boil-out. We suggest that you consider increasing the oven temperature and shorten the baking time.

If the crust colour of sweetened pastry becomes too dark then you may need to reduce the level of sugar used. If you are using glucose or another reducing sugar you may need to replace part or all of it with sucrose.

Alternatively consider lowering the ERH of the filling by adjusting the soluble solids of the filling formulation. The level of soluble solids in pie fillings controls the boiling point of the liquid in the filling; the higher the soluble solids content, the higher the boiling point (Cauvain and Young, 2000). You can therefore raise the boiling point by increasing the level of soluble solids. In the case of sweet fillings this may be through the addition of extra sugars. To avoid the filling becoming too sweet, you can use glucose rather than sucrose, since the former is less sweet on a weight for weight basis. Remember that if you use a glucose syrup then you must balance the water addition to compensate for that present in the syrup otherwise the filling ERH may not fall.

Reference

9.10 We wish to reuse pastry trimmings but find that sometimes we experience a ‘soapy’ taste in the final product. Can you suggest a cause for the flavour and how best to reuse the trimmings to avoid this and any other potential problems?

The ‘soapy’ taste undoubtedly comes from the trimmings that you have been reusing. Soap is formed when some of the fat in the paste splits into glycerol and fatty acids, the latter combines with any alkaline material present to form soap. The fat splitting will be caused by microorganisms present in and on the trimmings. Contamination of the paste during processing is difficult to avoid because the microorganisms concerned will be in the bakery atmosphere, coming from external and internal sources. You should keep the trimmings as free from contamination as possible, especially sweeping clear any dusting flour which you may have used during their processing.

Since the problem is linked with microbial contamination you can expect that the problem becomes more prevalent when the bakery temperature is higher than usual. Usually you can control the growth of microorganisms present in the trimmings using low temperatures. We suggest that you transfer any trimmings at regular intervals into refrigerated storage, around 4 °C and try to use them within 24 hours of production. It is helpful to store the trimmings in thin sheets rather than in a large bulk because it will take some time for the centre of a large mass of trimmings to cool and during that period microbial activity may be sufficient to initiate an adverse reaction.

We recommend that you add the trimmings at the mixing stage to ensure that they are uniformly distributed throughout the paste sheet when it is processed. You should either allow the trimmings to warm before adding them to the mixer or compensate for the lower paste temperature by raising the added water temperature. Establish a production schedule that allows the trimmings to be used in strict rotation, otherwise you may still encounter problems. Limit the storage time of trimmings to about 24 hours. Periodically, say every 3 to 4 days, it is advisable to have a break in production which allows you to start with virgin paste to avoid progressively increasing the level of microbial activity in the paste.
10

Cake and sponges

10.1 What is the flour-batter method of cakemaking?

The flour-batter method of cakemaking is based on two separate stages of air incorporation which are later combined before mixing is completed. It involves splitting the flour into two portions, the first to be creamed with the fats and the second portion retained to be mixed into the batter at a later stage. At the same time as the flour and fat are being mixed, the eggs and sugar are whisked together using a second machine to form a foam (as when making sponge cakes).

Typically the fats are creamed with an equal weight (or slightly less) of flour until a creamy mixture is obtained. About 400 g flour to 450 g fat (14 oz flour to 1 lb fat) is recommended. The egg is whisked with its own weight of sugar. This whisking need not be as thorough as for sponge cakes and aeration should not go too far or the cakes will be too light. About five or six minutes on second or fast speed with a planetary mixer is usually adequate. There is a greater possibility of getting a batter too light when using this method than when making cakes by the sugar-batter method (see 10.2) as in the latter case the presence of fat when the eggs are beaten in will prevent too much air being incorporated into the batter.

When the egg/sugar foam is ready it is added to the flour and fat batter while the machine is running at a moderate speed. The foam may be added in small portions – usually in four or five parts, each portion being beaten in before the next portion is added. Alternatively it may be run in as a continuous stream. When both batters are mixed any remaining flour can be mixed in, either by hand or at the slowest machine speed.

For fruited cakes the fruit is added when the flour is almost mixed in. Any minor ingredients such as essences or colours should be added to the fat and
flour while beating. If milk is added then this should be done at the time of adding the second portion of flour. Where the weight of sugar is greater than the weight of eggs, the extra sugar should be dissolved in the milk along with colours and salt (if used). This gives a better distribution of the colour throughout the cake batter.

If glycerine is used in flour-batter cakes, this may be added either to the sponge or to the flour batter, usually the latter before the two are mixed together. When milk powder is used instead of liquid milk, the necessary quantity of powder is added along with the second portion of flour, while the necessary amount of moisture in the form of water is added and the batter is mixed as before.

This method enables the eggs to be added far more quickly and with far less possibility for curdling of the batter. In the sugar-batter method adding the eggs too quickly can result in curdling (see 10.15). Another advantage of this method is that by semi-foaming the eggs with the sugar, a more even texture is imparted to the cake. Since most of the flour has been creamed with the fats, there is relatively little of it to be amalgamated at the critical moment in cakemaking after all the eggs are in and so the potential for toughening of the batter by overworking is reduced.
10.2 What is the sugar-batter method of cakemaking?

With this cakemaking method a batter is formed based on an emulsion of oil in water with air bubbles trapped in the fat phase. The other ingredients are dissolved or dispersed in the water phase.

The fats and sugar are creamed together until the mixture is light. Usually this takes about 10 minutes but does depend on the temperature and creaming qualities of the fat and the type of mixer used. Most commercial bakers mix the batter to a fixed specific gravity (see 13.4). The liquid egg is then added in four or five portions over a period of five to seven minutes with creaming of the mixture between additions to prevent the batter curdling. Egg, and the other ingredients, should be at the correct temperature (21°C/70°F is considered optimum) as this will also assist in avoiding curdling of the batter. Curdling (see 10.15) arises as a result of the breakdown of the emulsion when the fat separates out from the aqueous phase.

Once all the eggs have been creamed in, the batter should have a smooth, velvety look and texture. Flavouring can then be added followed by sifted flour and other powders and any additional milk or water. These are gently mixed into the batter. Any fruit should be added when clearing the batter (i.e. the last stages of mixing to ensure that there are no unmixed ingredients remaining). It is not advisable to mix the fruit with the flour as some flour may stick to the fruit and could cause the formation of larger holes in the baked cake.

It is important in all cakemaking processes to have correct temperatures and mixing conditions to ensure consistent product quality.
10.3 When making fruit cakes we find that the fruit settles to the bottom of the cake after baking. Why is this and what can we do about it?

The settling or sinking of fruit in cakes is connected with the viscosity and density of the batter during the early stages of baking. If the initial viscosity decrease during baking is too great, the fruit, being of higher density than the batter, will sink while the latter is still in a semi-liquid state – rather like a stone would sink in water. The denser or the larger the pieces of fruit, e.g. cherries, the greater their potential for sinking.

To prevent the fruit, whether it be cherries, sultanas or other particulate materials, e.g. chocolate chips, from sinking, the batter viscosity in the early stages of baking must be increased. There are various ways in which this problem can be overcome, such as recipe changes, using high-protein cake flour, the additions of hydrocolloids such as cellulose gums, decreasing the batter pH or processing changes, e.g. by adjusting baking conditions.

In high ratio recipes the batters are always more fluid than traditional types of batters by the end of mixing. However, the use of chlorinated or heat-treated flours will give a more viscous batter than untreated flours during baking. In such fruit cakes it is common to add tartaric acid or some other acid in excess of that found in baking powder. Lowering the batter pH is probably the most effective remedy to the problem since the extra acidity increases the contribution to batter viscosity of the proteins present in the flour, egg and other raw materials. The levels of addition are small, typically 0.2 to 0.3% tartaric acid based on flour weight is added.

Another remedy involves ensuring that the batter does not remain in a fluid state for too long. In some cases baking at a slightly higher temperature reduces the time that the batter viscosity is at its lowest. Reducing the baking powder, particularly for larger units or slab cakes, will reduce the batter aeration during the slower baking conditions normally required for these large sizes of cake and so keeps the batter more viscous for longer periods.

Eggs also have an effect on the viscosity of the batter. The addition of too much egg can cause the batter density to become too low. Generally frozen egg once thawed is a more viscous product than freshly broken shell egg. The addition of too much raising agent can have the same effect on lowering batter density.

The fruit itself should not escape scrutiny. Washed but not properly dried fruit will have a tendency to sink. The extra water associated with the fruit will cause the batter to be less viscous and add to the potential for the fruit to sink. In more traditional cakemaking the dried fruit can be dressed with the recipe flour (not extra flour) in order to coat the fruit and help prevent its downward movement by providing a ‘granular’ coating. The mixture should be added at the end of mixing after the flour has been added to the batter.

Older recipe books show that bakers have added a small quantity of ground almonds to the mixing. During baking this will have sufficient binding and
swelling effect to counteract the force of gravity acting on the fruit. However, this can add to the costs of the recipe and may cause other problems, e.g. in the safety of the product when marketing for people with nut allergies. Additions of other starches, e.g. cornflour, should be avoided because they have different gelatinisation characteristics from wheat starch and may lower batter viscosity at the critical moment during baking.

Another cause of sinking fruit is using too weak a flour, that is one with a low protein content. Most flour suppliers will have a slightly higher protein flour (typically around 11–12%) which can be used for fruit cakemaking. If you are making lower-ratio cakes then you can use a good-quality bread flour.
10.4 Can we freeze cake batters and what happens to them during storage?

Cake batters can be frozen successfully and frozen cake batters may be purchased in order to give customers choice without incurring the wastage that might occur with scratch production where demand is less predictable. For those purchasing frozen cake batters the advantages include:

- no storage or handling of raw materials (apart from that for product decoration);
- no ingredient weighing or mixing on site;
- specialist centralised production improves the chances of optimal product quality;
- improved ability to meet peak demands for a variety of cake products.

Cake batters can be frozen and stored for up to about two or three months before any substantial quality losses are encountered. Cake batters do not freeze until temperatures between \(-12\) and \(-20^\circ\text{C}\) \((11\text{ and }6^\circ\text{F})\). The temperature will vary depending upon the level of dissolved salts and sugars because their presence depresses the freezing point of the free water in the batter (Cauvain and Young, 2000). The high sugar concentration in most dried fruits will further depress the freezing temperature of fruit cake batters. The time taken to freeze the batter will be shorter at lower air temperatures and higher air velocities in the freezer.

Care should be taken not to expose the frozen batter to temperatures above its freezing point between production, distribution and storage since unplanned thawing can lead to deformation of the batter in the container. Some loss of volume will occur with cakes produced from batters that have been deep frozen and stored at \(-20^\circ\text{C}\) or below for six months (Screen, 1988). This loss of volume will be progressive with increasing storage time. A long storage time will also lead to a firmer and less tender crumb in the baked product. However, with care, the product should still have acceptable volume, crumb texture and taste when baked. The crust of the cake may have a marbled appearance owing to the batter drying out during storage, causing localised excess sugar at the surface of the cake.

The frozen batters should be removed from the deep freeze and can either be given a short defrosting period, or baked immediately from frozen. The defrosting method has no significant effect on cake quality though a slight surface discoloration may occur when product is baked from frozen but this may not be a disadvantage if the cake is to be decorated. Baking conditions should be as normal but if baking from frozen, a longer baking time may be required.

References


10.5 When we add fresh fruits such as blackcurrants to our cake batters we sometimes find that they fail to keep their colour during baking and often discolour the batter adjacent to the fruit. Can you offer an explanation and a solution to the problem?

This problem occurs because the natural colouring agents in the blackcurrants and many other fruits (see 12.29) are pH-sensitive. This means that they will change colour as the pH changes. For example, anthocyanin, a major colouring component of blackcurrants and other red fruits, will change in colour from red to pink to violet as the pH progressively increases. Blue and violet colours are most likely to occur when the pH is 7.0 or above. To overcome the problem try making the batter slightly more acidic by adding up to 0.6% tartaric acid based on flour weight. This should maintain the basic colour of the fruit without adversely affecting other cake qualities.

The leaking of the colour into the surrounding batter comes from damage to the fruit skins during mixing and depositing. This is difficult to avoid but you should keep the handling of fruit in the batter to a minimum. You may try the addition of frozen fruits as this may help to avoid rupturing the fruit skin. Blueberries have a tougher skin and so are less sensitive to mechanical handling than blackcurrants. However, they are just as sensitive to pH changes.
10.6 Why do cakes go mouldy?

Mould growth is the visible sign that the product has been contaminated with mould spores in an environment suitable for their growth. Such spores can be present in the batter but are effectively killed in the baking process. However, as there are many spores in the atmosphere it is likely that spores settle upon cake surfaces during the cooling and packing processes and if the conditions are favourable they will grow, thus spoiling the product.

The moulds that grow on cakes need water and oxygen to thrive. Ingredients in the cake can ‘lock up’ water so that it is no longer available for use by the moulds. A measure of the amount of water held by the ingredients is the equilibrium relative humidity, ERH. This is sometimes referred to as the ‘water activity’. ERH is measured on a scale of 0 to 100%, water activity on a scale 0 to 1.0. The higher the ERH, the greater the potential for mould growth will be. Cake products usually have an ERH in the range 75–85%. The ERH of a product is different from its moisture content and while the moisture content is a good indicator of the product’s eating characteristics, it is the ERH that governs mould growth.

The rate at which the moulds grow is also dependent on the temperature of storage and the level of contamination. In general terms the higher the storage temperature (up to around 33°C), the faster the mould growth. For example, with an ERH of 86%, the cake would have a mould-free shelf-life of about 10 days for a storage temperature of 21°C (70°F) and of about 7 days if stored at 27°C (80°F).

It is possible to measure the ERH of a cake product. Representative samples of the product are carefully prepared and can be measured using a water activity meter. Alternatively the product ERH can be calculated from recipe ingredient and baking data. There is software, ERH CALC™ (CCFRA, 1999), which can be used to calculate the ERH of the product from its ingredient data and moisture loss during baking, cooling and storage. It can then be used to determine the mould-free shelf-life of the cake. Such software is invaluable to product development teams in assessing the ‘use by’ date required by retailers.

Some ingredients have the ability to hold on to water better than others. For example, salt and glycerine are very effective and additions can prevent some of the water in the recipe from being used by the moulds. Increasing sugar content or reducing water content can also extend shelf-life provided the eating characteristics desired are still maintained.

It is important to provide the product post-baking with as clean an atmosphere as possible to reduce the potential for spore contamination. The following suggestions may reduce such contamination:

- After de-tinning allow products to cool without removing any lining paper. All surfaces in contact with the cake should be clean, dry and free from flour dust. Preferably cooling should not take place in the bakery but in a temperature-controlled area.
If the product is to be cut or decorated ensure that all utensils used are clean and dry and wrap immediately after further processing.

Store the product in a cool place before dispatch.

Reference

Further reading


10.7 In the light of the previous question, why do heavily fruited cakes go mouldy more slowly?

Vine fruits used in heavily fruited products, such as Christmas cakes, Christmas puddings and Dundee cake, have natural mould-inhibiting properties. This is partly as a result of the high natural sugars present in the fruit and this property lowers the ERH of the product and so extends the shelf-life. Also there are traces of natural preservatives in the fruit skins that, while not changing the batter ERH, will improve the product mould-free shelf-life.

Care must be taken, however, with products such as these that the cake or pudding is cooled properly before packing in order to ensure that there is no localised condensation on the surface. Localised condensation provides areas high in moisture and, while the overall ERH of the product may be adequate to ensure the desired mould-free shelf-life, on these localised areas the relative humidity and moisture content can be high enough to allow mould growth at a faster rate.

In Christmas pudding production, the steaming process actually adds moisture to the product rather than removes it as in conventional baking. An allowance must be made for this extra moisture in the final product when determining its ERH and desired shelf-life. Usually Christmas puddings have an ERH below 80% and a moisture content between 25 and 28%. On storage the space in the container above the pudding can become saturated (owing to the evaporation of moisture from the product). If storage conditions fluctuate grossly then moisture can condense and fall onto the product surface either by spot condensation on the packaging film or on the sides of the container. The local atmosphere then becomes favourable to mould growth. If the pudding basins are not adequately filled with the pudding mixture, water enters while they are still boiling and remains to a much greater extent than if the basins/containers had been well filled and tightly sealed before boiling. When the puddings are boiling the water must not be allowed to cease boiling since if the temperature falls, the puddings are inclined to contract, and water might enter between the container and the outside of the pudding. After steaming the puddings should be cooled with the top surfaces exposed to permit drying out without risk of condensation and allowed to dry for 24–48 hours before packing.

Further reading

10.8 Why are we getting mould between our cakes and the board on which they sit?

Mould spores are always present in a bakery, particularly where there may be poor hygiene or an excess of flour dust. Moulds in flour dust are destroyed during baking. The board itself may not be the source of contamination though this cannot be discounted. The cake may have picked up the mould spores post-baking, for example, from a surface in the bakery on which there was flour dust. If the spores are picked up and the cake is subsequently iced they are sealed by placing the cake on the board. The humid conditions created in those circumstances provide the appropriate conditions for the mould spores to germinate.

This problem only occurs with cakes of high ERH. Usually there is a certain amount of air trapped between the board and the cake and if the relative humidity of the localised trapped air is below 75%, mould growth will not take place despite contamination. This can be achieved by painting the base of the cake with a concentrated sugar solution (thus lowering the RH) before putting it on the base board – the basis of the tradition of painting on a fruit purée onto the surface of cakes. A practical, low-cost solution is to raise a fondant to boiling point and paint it over the base of the cake. The syrup is largely absorbed and helps to act as an adhesive.

Eventually moisture migration will take place between the cake crust and crumb, and the whole cake will come into equilibrium. The desired localised reduction in ERH near the base is maintained for a long time to prevent mould growth. Similarly the top surface of a sponge, which may have become contaminated from mould spores in the atmosphere and which is subsequently iced, can exhibit mould growth of this nature.

It is very difficult to eliminate contamination of this type, but it can be reduced by placing the cakes on a clean dust-free surface and covering them with, for example, greaseproof paper prior to packing. The boards should be stored in a dry place and protected from contamination by dust.

Further reading

10.9 We are experiencing mould growth on the surface of our iced Christmas cakes. This is the first time we have had this problem. Why has it happened?

Christmas and celebration cakes need to be stored with care to avoid mould growth on their surface. This mould growth is caused by localised areas of high moisture on the surface of the iced cake. These localised high-moisture areas can often form because of the presence of undissolved sugar crystals in the icing which makes it hygroscopic. If cakes are stored in a container before they are completely cool, condensation can fall from the surfaces of the container or wrapping material onto the cake, forming an area of high moisture. Such areas are good breeding grounds for mould.

A good way to avoid this problem is to cool the cakes completely and then to wrap them in greaseproof paper before placing them in tins with a few holes for ventilation. The tins should then be stored in a cool, dry place. The cakes should not lose too much moisture during storage because the average ERH will be low and so limit evaporative losses. See also 10.8 and 10.25.
10.10 We are experiencing a ‘musty’, off-odour developing in our cakes, even though we store them in a deep freeze. Why?

Because of their high sugar content cakes are susceptible to picking up both moisture and odours from the surrounding atmosphere. Care should be taken to keep the areas and surfaces of all containers clean and free from other materials that might impart odours into the atmosphere. In the case of a deep freeze, it is important that any stagnant water accumulating in the drip tray near the evaporator is regularly flushed out with clean water. Such stagnant water provides a breeding ground for moulds and bacteria which can produce odours that are readily absorbed by the cakes.
10.11 When we take our cup cakes from the oven we find that the paper cases they were baked in fall off. How do we avoid this problem?

The tendency for cakes to shrink when baked is the most usual cause of paper cases becoming detached. The shrinkage generally results from the recipe having too high a liquid level. On cooling, the pressure of the steam formed and maintained within the cake while in the oven is reduced and the cake shrinks under normal atmospheric pressure. Because the cases are rigid, they hold their shape and the result is that the cake shrinks away from the case.

This same problem is sometimes found in pound cakes baked in hoops or paper bands. The steam within the cake cannot readily escape from the sides as it does from the surface and so the cake remains softer here. Underbaking or sweating during cooling can also contribute to the fault. Sometimes these cakes have an uncooked core near the bottom.

The remedy is to reduce the liquids in the recipe or by increasing the proportions of baking powder and sugars.
10.12 Why do our Genoese cake sheets tend to lack volume and have cores in the crumb?

Poor volume seen with very close grain and the development of seams or cores in the crumb suggests inadequate chemical aeration in the batter. It may be that the sodium bicarbonate was omitted or the wrong balance of raising agents was used. Check that sodium bicarbonate is included when weighing the other ingredients. Often preparing a composite baking powder for general use or purchasing a ready-made baking powder will avoid any errors in preparation. To improve the general quality of the Genoese sheet we suggest, as a trial, you increase the proportion of aerating agents to determine the level best suited to your recipe.

Genoese sheets sometimes have an uneven surface giving problems with uniform volume. This unevenness can be the result of poor mixing and scraping down of the batter. We suggest the following procedure on adding the eggs should be followed:

1. Add half of the eggs over 1 minute. Scrape down.
2. Add remaining eggs over 1 minute. Scrape down.
3. Mix for a further 3 minutes.

All mixing should be done on slow speed. Make sure that, on scraping down, that the job is done properly.

Have a look at your mixer and examine the gap between the beater and the bottom of the bowl. This should be as small as possible to avoid areas of undermixed batter that may then find their way into the sheet when deposited. If you think that the gap is too large you may need to replace your beater or even your mixing bowl.
10.13 Sometimes our Madeira cake has a poor (coarse) texture. How can we improve it?

Madeira cakes are characterised by their uniform and fine texture (cell structure). If the texture is coarse, the addition of a suitable emulsifier can help rectify the problem. The emulsifier will help to reduce the overall size of the gas bubbles incorporated into the batter and improve their stability during baking. A number of emulsifier preparations are available. They come in gel and powdered forms; we suggest that you consult your ingredients’ supplier.

The powdered form is used in the formulation of dry cake mixes. A proportion of such emulsifiers consists of a carrier, usually skimmed milk powder. If this is the case then you should make allowance by reducing the level of milk powder in the recipe otherwise the cake may be too brown because of the Maillard reaction and the lactose in the milk powder. You should have no such problems if you use a gel emulsifier but you will need to adjust the recipe water addition to compensate for the inclusion of some water in the gel.

A suitable usage level for powdered emulsifier would be between 5 and 10% of flour weight; you should reduce the milk powder level by about half of your normal level of addition in your recipe to avoid the potential for darkening. In the case of a gel emulsifier around 2.5% flour weight should be suitable.
10.14 Our small Madeira cakes often shrink excessively during cooling. How can we avoid this?

All cakes shrink a little on cooling. However, excessive shrinking on cooling occurs because the intact gas cells in the texture contract. During baking the gas cells forming the foam in the batter expand as they are filled with the steam and gas produced by the raising agents. Because of the high quantity of sugars in the batter the gelatinisation temperature of the cell wall material is delayed and the structure does not ‘set’ until the temperature reaches the high 80s °C. The flexibility of the cell wall material allows the cells to expand until they burst or perforate, converting the foam to a sponge structure and allowing the gases to permeate throughout the cake. This all happens at a microscopic level. If this setting does not take place, even though the cake is considered baked because it has achieved the necessary appearance and colour, then on cooling the pressure inside each cell falls and under the weight of the cake and atmospheric pressure the cells shrink. This causes the whole cake to shrink.

This problem can be remedied as follows:

• Give the tins a substantial jolt as they leave the oven, causing the cells to ‘burst’ and the pressures to equalise. This can be achieved by allowing the pans to drop from one conveyor to another near the start of the cooling process.
• Increase the level of baking powder in the recipe, or change to a slower acting powder. This should help to break down the cell walls as the cake sets during baking, so leaving the minimum number of intact cells in the crumb.
10.15 Why do cake batters made by the sugar-batter method sometimes have a curdled appearance? Does this affect final cake quality?

Curdled batters are usually the fault of carelessness or haste during preparation of the ingredients or mixing. If all the ingredients in the batter are at a similar temperature they will amalgamate to form a thick, smooth cream. However, if the eggs are added too quickly, causing the butter or fat particles to separate from the water in the mixture, breaking down the emulsion, the mixture will become curdled. It will also happen if the butter or margarine, which contain water as well as fat, is used in a hard rather than a soft condition and then well creamed with the sugar to a whitened, smooth cream before any eggs are added. This problem may well be evident in the case of rich recipes, e.g. Madeiras containing a great percentage of eggs, particularly if the eggs are watery or if poor-quality frozen eggs are used.

Care should be taken to get the batter and eggs at a suitable temperature and the eggs should be added slowly. Each portion of egg should be adequately beaten in before the next quantity is added.

Batter can be prevented from curdling by:

• ensuring all ingredients are at the correct mixing temperature, typically 20–22°C (70°F);
• adding a small quantity of flour at the first signs of curdling;
• using a high-ratio shortening containing an emulsifier.

If the recipe includes a high ratio of sugar and liquid to flour, it is essential that a high-ratio短ening, or an emulsifier in conjunction with plain shortening, is used.

Generally curdling will not significantly affect the final cake quality, provided the recipe is properly balanced. This is because any water that separates out during curdling is later reabsorbed when the flour is added.
We are experiencing seepage of jam in our frozen fresh cream gateaux when they are thawed. Can we avoid this?

Seepage of this nature is caused by the formation of surface water through syneresis within the cream and jam as a result of the crystallisation or aggregation of polymers. It is commonly found with products that undergo freezing and then thawing. Surface water forms because of the breakdown of the cream foam and subsequent release of water. In the case of jam seepage, the jam is basically a coloured sugar solution containing fruit and the colour is unlikely to be held fast. Once a coloured solution has formed it can diffuse into the cream.

The problem is sometimes encountered where frozen products are partially thawed and then refrozen as might be experienced with refrigerated transport. This temperature cycling impairs cream stability and as a consequence the jam spreads out. If the temperature cycling in transport reaches above \(-5\,^\circ\text{C} (23\,^\circ\text{F})\) then seepage is more likely to occur. We would not expect to see such temperature changes in a well-managed and monitored distribution chain, except for some boxes on the outside of stacks or pallets. The cardboard sealed box and the air between it and the gateau does present a reasonable barrier to heat transfer. Also a stack of frozen gateaux should behave as a reasonable cold sink.

The solution to the problem is to avoid periods of intermediate defrosting. Where such periods do occur, the temperature the gateaux reach should be kept as low as possible.

Further reading


10.17 What are the causes of the small, white speckles we sometimes see on the crust of our cakes?

White speckles on the crust of cakes are most commonly due to sugar that has recrystallised. They are sometimes referred to as ‘sugar spots’. Sugar spotting on the crust of cakes is caused by the recrystallisation of sugars that were previously in solution in the batter. During the baking process, the reduction of moisture content particularly near the surface of the cake can result in the sugar coming out of solution and forming the spots on the surface.

Any changes in recipe resulting in a reduction of moisture content or excessive sugar, thereby increasing the ratio of sugar to water, may give rise to sugar spot formation. For example, the change from butter or other fat containing a proportion of water to a white fat containing no water can be enough to precipitate the problem. Similar results may occur if any water-containing ingredients are replaced by forms containing no water.

Other factors that might cause sugar spotting on cakes include the following:

- Increased granularity of sugar, which may prevent it dissolving properly at the batter stage. As a precaution, the sugar can be dissolved in the water added to the batch before mixing. This is easily done when using a flour batter or blending mixing method. When a sugar-batter mixing method is employed, sugar in excess of the weight of fat may be dissolved in the liquid portion before addition. With all-in mixing methods pre-dissolution of coarse sugar is essential to avoid this problem.
- Baking at a lower than normal temperature or baking in an oven with too low humidity may prove detrimental.
- Allowing the deposited batter to stand for too long a period in the bakery atmosphere before baking may cause surface drying and subsequent sugar spotting. If using a travelling oven, a much shorter standing time is required because of the hot air passing over the cakes at the entrance to the oven. In such ovens the problem can be overcome by applying, by hand or automatically an ‘atomised’ spray of water over the cakes while they are on the oven sole and as they pass into the oven.
- In Madeira cakes where a ring of batter (a sugar ring) may have overflowed the wrapper and become loose, a slight reduction in scaling weight or increasing the height of the paper band used would help to prevent overflowing and hence the localised sugar spotting.
10.18 Why are we getting an orange discolouration of the crumb of our fruit cakes?

Fruits, for example cherries, used in cakes may contain permitted colouring dyes. Many such colours are soluble at different pHs (usually above pH 4.0). When the discoloration occurs in the crumb surrounding the cherries it is caused by the colour from the fruit ‘bleeding’ into the crumb.

If the cherries are added at a later stage in mixing, the discoloration will be far less pronounced. If they are washed and drained before use and introduced at a late stage then the bleeding should cease.

In summary:

• Use good quality fruit in your products. Preferably use whole, unbroken fruit.
• Where the problem occurs wash the fruit with water slightly acidified by citric acid and drain thoroughly.
• Check with your supplier which dyes (and their solubility level) are used in the fruit so that the problem can be avoided.

See also 10.5
Our sultana cakes are collapsing. What can we do to remedy this problem?

Sultana cakes can tend to shrink or sink slightly at the top. This is sometimes accompanied by a slightly open crumb cell structure (grain). This is caused when the batter has been over-aerated during mixing, thus making the specific density of the batter too high to support the denser fruit, particularly nearer the centre.

This may be countered by increasing the amount of liquid in the recipe, if the flour content is adequate, or by reducing either the sugar content or the amount of aerating agent. The first and last of these actions usually brings about an improvement. It is also preferable to have the egg content slightly higher than the total fat content as egg adds strength to the cake structure. Where milk is replacing eggs, a simple method for calculating the baking powder requirement is to assume that 560 ml (1 pint) milk requires 28 g (1 oz) baking powder. See also 10.3.
10.20 We are getting large holes in the crumb of our fruited slab cake?

Large and unsightly holes in fruit cake can be caused by any of the following reasons:

• If damp fruit is used, localised steam is formed around the fruit during baking, especially near the centre of the individual berries where it is less able to escape quickly. The top of the cake becomes baked and so the localised steam is trapped and it produces holes in the crumb as the pressure builds up. All fruit should be thoroughly dried after washing to remedy this problem.

• In spreading Genoese and large fruit slabs, air may be entrapped during depositing or, while spreading batter by hand or with a wet palate knife, part of it may be folded over, again entrapping air and so causing holes.

• Low carbon dioxide levels, either because there is too little baking powder or because the baking powder has reacted too quickly.

• Occasionally over-mixing of the batter, especially when adding the fruit, can cause the problem. In this case the holes may run vertically or at an angle rather than horizontally.

See also 10.29.
10.21 Why do cakes sometimes sink in the middle?

Many of the faults that occur in cakemaking are a result of the ingredients in the recipe not being ‘balanced’ for the type, size and shape being made. This balancing of ingredient ratios is important to ensure the correct aeration and structure for the baked product. Whether the collapse occurs during baking or after baking is an important clue as to why the problem is occurring.

In the case of the sunken top the following ingredient effects are relevant:

• The sugar level may be too high. The late gelatinisation of the starch means that the transition from foam to sponge does not occur before the end of baking (see 10.30).
• The fat level may be too high.
• The baking powder level may be too high.

You may need to rebalance your recipe to eliminate this problem.

There are other reasons why a cake might sink in the middle. If a cake is removed from the oven before it is thoroughly baked it will drop in its centre. The centre of a cake is the last portion to bake so that if the product is removed from its source of heat when it is still fluid the crust will be unsupported and the cake sinks.

If the cakes are knocked or moved about while they are baking and before they have become properly set there could be a premature release of gases which can cause the cakes to sink in the centre (Fig. 28).

![Fig. 28 Collapse in cakes.](image)
10.22 Our fruited cakes are fine to eat soon after production but tend to become drier eating after a few days. Why?

Fruited cakes are a multicomponent product comprising two phases: the cake crumb and the dried fruit. Even though the two components are in intimate contact from mixing through to baked product, equilibration of moisture does not necessarily occur. In many cases after baking there is a significant difference in cake crumb and fruit particle moisture content with the dried fruit continuing to absorb moisture from the cake crumb. Experimental data (Cauvain and Young, 2000) has shown that up to four days may be required for equilibrium to be achieved. This lack of moisture equilibrium is most likely to be the reason for the dry eating cake crumb that you are observing.

One way to overcome your problem is to raise the moisture content of your fruit by washing and draining it before use (see Fig. 29). However, note that this will raise the overall moisture content of the cake and may decrease its mould-free shelf-life.

There are several ways off preventing crumbling with fruit cakes:

- Use flour of medium strength (10–11% protein) instead of high-ratio cake flour.
- The proportion of fat used should be less than the egg content by approximately 10% (based on flour as 100%).
- Where the ratio of sugar to liquid is high, the cake crumb tends to be more fragile. For a fruit cake this ratio should be lower than 115% flour weight.

**Fig. 29** Effect of fruit on cake moisture during storage.
• When the proportion of egg in the total liquid is low, the cake structure is weak and has a tendency to crumble on cutting. Egg should make up about 50% of the total liquids to prevent this.
• Emulsifier should be kept to a minimum.
• Avoid high levels of raising agents as these can increase crumb fragility.
• Wash fruit and dry well before use. Dusty or unclean fruit may produce a ‘drag’ effect during cutting.
• Mixing must be controlled to ensure constant batter aeration and emulsification. Under-mixing and also over-aeration of batters can cause a crumbly end-product.
• Batter depositing and baking should not be delayed after mixing.

Reference
10.23 Our cake quality varies when we change from one type of oven to another, even when the ovens register the same temperature. Why?

Ovens, even those of the same make and model, vary in their ability to deliver heat to the product. The temperature setting indicated on dials or displays are indications of the actual air temperature rather than a measure of the heat available for baking.

During baking heat is transferred to the product in one of three ways:

- Convection, the transfer of heat in fluids, achieved by the colder fluid carrying away heat from a hotter surface which sets up convection currents.
- Conduction, the passage of heat through a medium, from hot to cool regions, the heat being passed on from molecule to molecule, e.g. hot pan to cooler bread dough.
- Radiation, the transfer of heat from hot surfaces without the need for a transferring medium, e.g. the heat we receive from the sun.

Ovens used in bakeries use all three heat transfer mechanisms though the balance between the three varies with oven type. For example, in a deck oven conducted and radiant heat dominate, while in a rack oven convection and to a lesser extent radiation dominate.

The thermostat fitted to an oven senses and controls the temperature of the oven by calling for more or less heat accordingly. Occasionally this may be at fault and may not be working accurately or may be controlling the temperature at a point that does not coincide with the position of the cakes in the oven. For specific temperature settings in your oven it is advisable to bake the products at several different temperatures to find the ideal settings for your oven. You should try to make sure that the oven has a reasonably similar load for each trial otherwise you will get variable results. Try adjusting temperatures in 5 °C steps, above and below your current settings, so as to avoid making products that would not be acceptable for sale.

It would be wise to check that a consistent temperature is being delivered for consecutive bakes in case you have a problem with burners or heating elements. You may find that the oven is not fully recovering its heat load between bakes of successive batches. If this is the case you should consult your equipment supplier. On the other hand it may be that the time between bakes is so long that ‘flash’ heat builds up in the oven. This is associated with the radiant heating component in the oven and often leads to burning of the product crust. Since most products are baked to a particular colour and shape, the temptation in these circumstances is to lower the oven temperature for the next bake. You should avoid this if possible. If you are about to use an oven that has been standing empty but heating for a period of time and you suspect there may be problems with flash heat, we suggest that you inject a burst of steam into the chamber. The evaporation of the water will remove some of the excess heat and readily escapes when you open the oven door or damper. If you use the latter remember
to close it again when you load the product into the oven otherwise you could end up drying the product out unnecessarily.

Variations in oven humidity can also lead to variability for some products. For example, Swiss rolls benefit from humidity in the oven as the water vapour keeps the crust moist and so aids the rolling process post-baking.

While your problem is associated with cakes you might like to note that the same rules will apply to almost all baked products.
We are encountering an intermittent fault with our round high-ratio cakes in that a shiny ring with a pitted appearance is seen on the cake surface. What factors are likely to give rise to this fault?

This fault is caused by the batter viscosity being too low during the early stages of baking. As the product is heated the viscosity of the batter helps to trap the gases produced by the raising agents. If the batter is too fluid, i.e. low in viscosity, then the structure, which is not set, allows gases to escape and these burst through the forming crust, leaving behind the pitted surface appearance.

The shine on the ring suggests that the sugar level in the recipe is too high. High levels of sugar delay the gelatinisation of the starch and so the batter is kept fluid for longer.

An increase in viscosity can be achieved in any of the following ways:

- Reduce the water content of the batter.
- Increase the flour-damaged starch. Damaged starch will hold more water, thus making the batter more viscous.
- Extend the mixing time but avoid over-mixing.
- Reduce the recipe sugar level.
10.25 How important is the temperature of cakes at the point of wrapping?

Cakes can be wrapped at either high temperatures or completely cooled. In either case the important point is to ensure that no localised condensation occurs on the surface of the product which might result in mould growth during storage. The equilibrium relative humidity of the product should remain at the level required to achieve the desired mould-free shelf-life (see 10.9).

If a cake requires no filling, coating or other finishing after baking there is no reason why it should not be wrapped direct from the oven at a temperature of about 88–93 °C (190–200°F). Obviously there may be some difficulties involved in wrapping at these high temperatures, such as damage to a fragile product and control of condensation as the product cools. Provided the wrapping material is in reasonably close contact with the product, condensation soon disappears even when a moisture-impermeable film is used.

Materials for wrapping at high temperatures should be chosen with care. Materials such as polythene would be unsuitable, but most grades of cellulose film do not appear adversely affected by hot wrapping.

If products are to be cooled and then wrapped care must be taken during the cooling process. Rapid cooling can be achieved with suitably high air velocities. However, if drying out of the product is to be prevented, the relative humidity in the cooler must be carefully controlled. The relative humidity can be controlled only if the air temperature is closely regulated since relative humidity changes rapidly with a small change in air temperature at a given moisture vapour content.

If refrigeration is used both temperature and relative humidity can be controlled satisfactorily with an air temperature of, say, 16 °C (60 °F) and about 80–85% relative humidity. To prevent the product drying out the relative humidity should be close to the equilibrium humidity of the product (typically 80–85% for cakes) so that moisture is not encouraged to move from the product. The high relative humidity in a refrigerated system means that large cooling plates are required to prevent condensation of moisture onto the cooling coils.

Without refrigeration, relative humidity can be controlled using water spray type humidifiers. In this case close control is more difficult especially if the air temperature (around 21 °C, 70 °F) is subject to fluctuations.

The moisture loss from flour confectionery products during cooling may be a critical factor in determining their mould-free shelf-life and eating qualities. If controlled cooling conditions are used it is possible that an increase in the moisture content of the product could occur with a resulting reduction in the shelf-life. It is advisable to make careful checks on moisture content when setting up the cooling system and recipes may need adjustment to decrease the ERH of the product.

Under controlled cooling conditions, it is important that any air blown over the product is clean and thorough filtering of air drawn from outside is desirable. Cooling times are dependent on the size and thermal conductivity of the product.
It is pointless using high air velocities with large products, where cooling time is controlled mainly by the time taken for heat to be conducted from the centre of the product to the outside.

See also 10.6, 10.8 and 10.9.

Further reading
**10.26 We have a shrinkage problem with the parkin cake we produce. How do we eliminate it?**

Shrinkage of parkin cake is usually due to an excess of liquid or to an abnormally low proportion of egg. For this type of cake the proportion of liquid should lie between 25 and 60% of the total flour weight (inc. oatmeal) and the egg between 5 and 20% flour weight.

**Sample recipe**

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<th>Ingredient</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>500</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>500</td>
</tr>
<tr>
<td>Baking powder</td>
<td>15</td>
</tr>
<tr>
<td>Ground powder</td>
<td>15</td>
</tr>
<tr>
<td>Margarine</td>
<td>350</td>
</tr>
<tr>
<td>Golden syrup</td>
<td>560</td>
</tr>
<tr>
<td>Brown sugar</td>
<td>570</td>
</tr>
<tr>
<td>Eggs</td>
<td>200</td>
</tr>
<tr>
<td>Milk</td>
<td>375</td>
</tr>
</tbody>
</table>
10.27 What precautions should we take when freezing flour confectionery products?

The greatest benefits to be gained from freezing cakes and other flour confectionery products is a delay in the staling process, provided the products are adequately protected against moisture loss and microbial spoilage.

Before freezing all products should be cooled to ambient temperature (typically 20–25 °C, 70–77 °F) in order to maintain the efficiency of the freezing process. The most efficient and economical freezing temperature is −20 °C (−5 °F). However, cryogenic freezing systems using liquid nitrogen or carbon dioxide have led to the use of much lower temperatures, −171 °C (−275 °F) for liquid nitrogen and −100 °C (−158 °F) for liquid carbon dioxide. Fans operating in such equipment aid heat transfer.

It is advisable to use a specially produced moisture-proof film that has increased flexibility and is resistant to cracking. Wrapping the products before freezing will help reduce evaporative losses but does increase the length of time taken for the product to become frozen.

Storage times for frozen products vary but can be many weeks at −20 °C (−5 °F). Remember that if products are stacked in frozen storage then the temperature of the product may vary according to its position in the stack and in some cases may be unacceptably high with subsequent defrosting.

The thawing time for frozen confectionery depends on the unit size and thawing conditions available. A 285 g (10 oz) sized plain slab cake can take up to 6 h standing at 21 °C (70 °F) before the internal temperature reaches 21 °C but such a cake would be edible within 4 h. If the same cake was thawed at 38 °C (100 °F) an internal temperature of 21 °C would be reached within 1.75 h. Dry eating products may occur if the thawing rate is too slow because of excessive moisture losses.

Condensation can occur during thawing and depends largely on the thawing temperature, which controls the time during which the surface temperature of the product remains below the dew point of the atmosphere in the packaging. The higher the thawing temperature, the more quickly is the condensation removed and the less likely it is to affect the product.
10.28 We would like to improve the quality of our slab cake. How important is batter temperature in this context?

In order to produce an optimum product the temperature of the ingredients and the resulting batter should be such that it allows thorough amalgamation and good aeration from each of the components. A batter temperature maintained at 21 ± 2 °C (70 ± 3 °F) is recommended.

There is little rise in temperature of cake batters during their short mixing times and so there is no need to provide for chilled water or egg. Ingredients that are too cold, e.g. frozen egg and cold milk, cause a tightening of the batter and a partial ‘setting’ of the fats. The latter effect is seen as ‘curdling’ of the batter (see 10.15).

It is also important that the batter temperature does not increase too much so that the fats melt and allow the batter to lose aeration. Higher batter temperatures will also increase the chemical reaction of leavening agents, resulting in a loss of aeration from this source.

By keeping materials at an even temperature, better aeration and a more thorough dispersion and hydration of ingredients will result in a cake with better appearance, volume and texture when baked.
10.29 Why should the whole of the batter for one slab be placed in the tin in one piece rather than bit by bit?

If the batter is placed in stages into the tin, there is a chance that a quantity of air can be trapped between the various deposits and this may result in large, unsightly holes in the slab when it is baked and cut. It is therefore better that the batter deposit is placed in the tin in one piece to ensure an even texture in the baked product.

Similar problems may be encountered filling sponge moulds and here there is also a chance of trapping a bubble of air at the top where the mould is small. One trick used to fill such moulds to avoid entrapping large bubbles is to fill a long funnel and allow the batter to flow slowly into the bottom of the mould.

See also 10.20.
10.30 What happens to the batter when cakes enter the oven and how can you tell when a cake is baked?

Converting a fluid batter to the desired eating characteristics in the end product is the result of getting both the temperature and timings correct during baking. The ‘foam’ structure (discrete cells) of the batter is converted to a ‘sponge’ structure (inter-connected cells) in the baked product. Baking is a process of heat gain and moisture loss.

Even before the cake enters the oven, the condition of the oven is important. Any build-up of ‘flash’ heat should be dissipated so that the cake receives an even bake. Once the cake is in the oven, the heat starts to melt the fats. This first occurs on the outside of the cake and gradually extends to the inner portions. At the same time the air cells begin to expand and if raising agents are present carbon dioxide is released to inflate the cells. This begins slowly at first from the outside and gradually extends to the interior of the batter. The temperature of the cake continues to rise and some of the starch cells are gelatinised while the cake is still in a molten state. The cake continues to rise until the structure is set by the gelatinising starch and the outside of the cake colours to give a cake of the required size and appearance. The continued expansion of the cells along with the gelatinisation of the starch causes the foam cells of the batter to become ruptured to form the inter-connected cells of the final structure.

If the cakes are small and the oven is hot, a skin forms quickly on the top and rapidly colours as the moisture in the vicinity of the surface is converted to steam, leaving the sugary portion of the batter to reach a temperature where the sugars caramelize. Although this skin forms quickly it will not have sufficient strength to prevent the interior of cake expanding (especially where there is a high proportion of baking powder). The pressure eventually exceeds the strength of the top. The top is the weakest portion of the cake as the sides and bottom are often supported by the tin or hoop. The batter forces its way through the forming crust and a rounded or bold head is formed. This is small at first but grows as baking continues. The fluid batter has moisture driven off before it too takes on colour.

In larger cakes the top skin takes longer to form as in these cases the oven is cooler (to allow for a more even bake and to prevent the outside being burnt before the inside is baked). Also the humidity in the oven is higher (e.g. when the oven is full of products), and because larger cakes usually contain a higher proportion of eggs than milk they give up their moisture at a lower rate. Eggs coagulate at the boiling point of water and retain a good deal of the water that would otherwise have been driven off as steam. If the recipe is correctly balanced, the bursting through the centre top is less pronounced.

The temperature at which the structure is set depends on the sucrose concentration in the batter. The higher the sucrose concentration, the higher the gelatinisation temperature and the longer the batter will remain fluid during baking. To test whether a cake is baked the centre top is less pronounced. The surface just springs back when lightly pressed. If the surface just springs back it shows that the centre of the batter (the last portion to set) is baked.
If the oven temperature is too low, aeration proceeds as usual but the cake is slower at drying and setting on the outside so that the top skin will be longer in forming. The fluid batter will rise evenly all over the surface and a flat-topped cake will result. Another manifestation of too low a temperature in baking is a discoloured crumb, particularly in the lower portion of the cake, and the cake will also be dry eating. The low temperatures result in the cake taking longer to set but at the same time drying out. As the drying out continues the sucrose concentration in the unset portions of the cake becomes higher and will begin to caramelise. The coloured crust becomes thicker and the longer the cake remains in the oven, the more the discoloration of the crumb extends into the body of the cake. The upper part of the cake has been in contact with the steam inside the oven, and the damp atmosphere will have kept the cake moist and, to some extent, will have prevented the development of excessive dryness. The lower crumb, however, not in contact with the steam, becomes dry and then discoloured.

Deciding the temperature at which to bake one particular kind of cake is complicated. The ingredients, their quality and quantity, and the size of the cake along with the type of results expected all need to be considered. Some ‘rules of thumb’ for deciding on the baking temperature are:

- the greater the difference between the proportion of flour to butter and eggs used, the hotter the oven should be;
- the higher the proportion of fats, the cooler the oven should be;
- the larger the cake, the lower the temperature should be;
- the faster the heat input, the more rapid the moisture loss.

Further reading
10.31 What are the advantages of having the oven filled when baking slab or other cakes?

The advantages of having an oven filled with product come from the humidity and heat transfer. Once cakes are placed in the oven their temperature rises and eventually the moisture in the product reaches boiling point and steam is given off. If the oven is full of product then the volume of steam will be fairly large for a given volume of oven capacity. The humidity in the oven will be high and will act on the surface of the cake, keeping it moist. As each cake is in close proximity to its neighbour, the side crusts will be kept thin and pale in colour. The hardening or drying of the final crusts on the top and sides will be delayed, enabling the cake to reach full growth before it is set.

If the crust has become set before full growth has been achieved, the inside of the cake will burst through the prematurely formed crust and form a break or crack across the slab. In some cases this break may be desired, e.g. in muffins. The atmosphere in the oven is less humid and so the product crust sets and dries before the cake has risen fully.

For slab cakes a break on the surface is not desirable and so aim for a full oven, with the oven door remaining closed for the whole baking period. Where this is not possible, a humid atmosphere should be created in the oven by placing tins of water in the oven with the product.
10.32 Why do we add extra acid to make white cake batters?

If the sodium bicarbonate element of the raising agent is not completely neutralised by the acid component then the excess bicarbonate will cause some degree of caramelisation of the sugars during baking. Indeed this occurs in all cakes but because the crumb of many cakes is tinted yellow either with egg yolks or egg colour the slight degree of discoloration largely passes unnoticed.

In the case of a white cake where no egg yolk is present the slightest discoloration would be noticed. To prevent this therefore, additional acid – cream powder or cream of tartar – is added to make sure that all the bicarbonate of soda is neutralised.
10.33 We have been experiencing problems with collapse of our sponge sandwiches which leaves the product with a depression forming on the top of the cake and an area of coarse cell structure in the crumb. What causes this problem?

The area of coarse cell structure that you have observed in your collapsed sponge cake is often referred to as ‘core’ formation. Sometimes this might be observed in the crumb even though the top of the cake has not collapsed.

The primary cause of your problem is instability of the air bubbles in the batter. When the sponge batter reaches the oven and the gas bubbles begin to expand it is important that they do not coalesce until the right moment in the later part of the baking process. To remain separate from one another the stabilising film must stretch as the air bubbles expand under the influence of heat and because of the carbon dioxide gas that is diffusing into them as the result of the accelerating baking powder reaction. If the stabilising material is not able to stretch sufficiently then it ruptures, allowing adjacent gas bubbles to coalesce and form larger ones – the coarse component of the cell structure. At the same time the displaced stabilising material will join with other materials to form areas devoid of air cells – the thick cell wall material which also looks darker in colour.

While there is only one primary cause there are many contributing factors, including the following:

- The presence of traces of fat or oil in a non-emulsified sponge recipe. Ensure that all traces of fat or oil are removed from the mixing bowl and whisk by using boiling water to wash the utensils.
- Too little emulsifier in an emulsified sponge recipe. Try increasing the level to about 0.75% of the batter weight (see 5.15).
- Too much baking powder in the formulation (see Fig. 30). Reduce the baking powder level and if the cake lacks volume increase the mixing time to lower the batter relative density or increase the emulsifier level.
- Batter relative density too low, especially with low levels of emulsifier. While the batter may be stable at low temperatures it is during the baking that bubble stability is most important.
- The particle size of the flour being too large (Cauvain and Hodge, 1977).

One factor known to contribute to this problem is the presence of ‘anti-foaming’ agents such as silicones. Even levels as low as 2 ppm have been shown to induce core formation in sponge cakes. The effective level depends to some extent on the level of emulsifier present but 5 ppm silicon will destabilise most sponge cake batters. Traces of silicone may come from a number of different sources, including the following:

- Barrier creams used for hands.
- Vegetable oil.
- Sugar.
- Flour, most likely from the wheat.
• Skimmed milk powder.

If you suspect that an ingredient may have become contaminated with silicon you should discuss the problem with your supplier.

Reference

Further reading
10.34 We are having problems with the bottom crust of our sponge cake products becoming detached after baking. We also notice that the corners of the product become rounded and the texture close. Why do these problems occur?

The problem comes from a lack of carbon dioxide in the formulation either because you are adding too little baking powder or because too much has been lost before the product reached the oven, or you are mixing the batter for too long.

In most cakes, but especially with sponges, getting a fine cell structure and light texture in the baked product requires the evolution of baking powder in the oven to inflate the air bubbles that have been incorporated during mixing. Even though the air bubbles expand under the influence of heat in the oven their degree of expansion is limited by Charles’s Law, i.e. to \( \frac{1}{273} \) of their volume for each 1 kelvin (for practical purposes 1 K = 1 °C). The evolution of carbon dioxide provides increases in gas volumes far in excess of that obtained purely from the temperature effect.

As the sponge batter expands during heating its relative density changes and this affects the heat transfer rate into the batter. Batters with high relative densities, i.e. low gas volumes, bake faster than those with low relative densities, because the gases involved act like an insulating material. Thus the more gas that is evolved during baking the slower the heat transfer rate and this leads to a more uniform expansion of the batter.

Steam is also generated during the baking process. This requires that the temperature in the product exceeds 100 °C. The presence of dissolved sugars raises the boiling point of the aqueous phase in sponge (Cauvain and Young, 2000) but the crust still sets fairly early in the baking process. The quantities of steam progressively evolved from the batter as the heat penetrates to the centre build up pressure under the top crust and detach it from the rest of the product. There is also a build up of steam at the angle of the base of the pan and its side, which prevents the batter flowing into that area. The rounding of this area of the product is often referred to as ‘chamfering’.

The rate at which carbon dioxide gas is evolved depends on the rate of reaction between the acid component and the sodium bicarbonate. This can be regulated either by changing the acid type or its particle size. In the latter case larger particles are slower to react.

We suggest that you first investigate the effect of raising the level of the baking powder that you are using. This usually solves the problem. If it persists then you are probably using an acid that is too fast acting and we suggest that you change to a slower one. A rough guide for choosing a suitable acid is:

- fast acting acids – acid calcium phosphate (mono-calcium phosphate), tartaric acid and cream of tartar (potassium hydrogen tartrate).
- slow acting acids – sodium acid pyrophosphate and sodium acid aluminium phosphate.
The baking powder reaction rate can also be controlled by using an acid or sodium bicarbonate with a larger particle size; however, you must ensure that unreacted components are not left behind in the baked product as this can lead to flavour problems.

If you mix the batter for too long then the carbon dioxide gas evolved during the mixing process may escape from the batter rather than diffusing into the air bubbles. Cauvain and Cyster (1996) showed that this could happen even when using an apparently ‘slow’ acting acid such as sodium acid pyrophosphate.

References
When making sponge drops we find that the last ones to be deposited are not as good as the first ones. Why is this?

Once a batter has been mixed changes in its properties occur with time. The nature of these changes varies according to the manner in which the batter is treated and the length of time that elapses before it is deposited. The main change is related to the stability of the air bubbles in the batter and the evolution of carbon dioxide gas from the baking powder in the formulation.

Once mixing starts, the acid in the baking powder begins to dissolve and react with the sodium bicarbonate present. The rate of the reaction depends on the type and nature of the acid and the temperature of the batter. The reaction proceeds more rapidly at higher temperatures whatever the acid being used. Some time after the baking powder reaction has begun the carbon dioxide gas diffuses into the air bubbles in the batter and they begin to inflate. Some may become so large that they can rise in the batter and escape at its surface. The stabiliser in the batter (e.g. emulsifiers) helps prevent this from occurring.

As the batter standing time before depositing increases, more carbon dioxide is evolved and eventually some of it can escape from the batter. If too much of the carbon dioxide is lost the batter relative density begins to increase, that is the batter becomes less well aerated and the sponge drops in volume. The length of time that has to elapse before this situation is reached depends on the particular baking acid being used but can occur with all acids. The potential for ‘de-aeration’ of the batter increases if the batter is agitated or subjected to shear. The longer that the batter stands, the greater will be the potential de-aeration effect from any agitation.

We suggest that you examine the length of time that the batter stands and see if this can be shortened. This may require the production of smaller batches mixed more frequently. Avoid excessive agitation of the batter once prepared, e.g. try to minimise the degree of scraping down of hoppers because this incorporates ‘old’ batter which contains less gas. Alternatively, consider using a slower-acting acid in your baking powder.
10.36 From time to time we experience problems with Swiss rolls cracking on rolling. What causes the problem?

The two most important characteristics of a Swiss roll sheet are that it should have a uniform thickness after baking and should be sufficiently flexible to withstand the rolling process. Control of a number of different recipe and process factors are therefore important if you are to avoid problems with the rolls cracking. We suggest that you look closely at the following aspects.

• The thickness of sheet after baking, since both increases and decreases in thickness may cause cracking. Thinner sheets are particularly prone to cracking. Pay attention to any changes in sheet thickness that may have arisen from changes in batter density, lower or higher, from changes in mixing times or from different levels of air injection in continuous mixers.

• Since baking powder action makes a significant contribution to roll thickness you may wish to examine the level that you use. The rate at which the carbon dioxide is released varies according to the type of acid that is being used and you may wish to check that you are using the same acid each time. There is some release of carbon dioxide gas while the batter stands before depositing and so any significant variation in batter standing time can have an effect on final product volume.

• You should check your deposit weight control to ensure that there are no significant variations. Remember that the deposit weight for a given unit area with Swiss roll batter is low and so even small variations may have a significant effect.

• Avoid unnecessary drying of the roll during baking. This may come from longer baking times, higher baking temperatures or higher air velocities in some types of oven. Variations in batter formulation and aeration will also have an effect on the final roll moisture content. Remember that a thinner deposit will bake to a lower moisture for a given set of baking conditions.
10.37 What causes sponge sandwiches to assume a peaked shape during baking?

There are a number of different reasons why this problem should occur but a particularly common one is associated with the conditions in the oven during baking. Often the condition is caused by too rapid a heat transfer to the batter. In all baked products heat is transferred from the surface to the centre and in the case of round products much of the heat transfer is along the radii from outer edges to centre. In the case of round sponges the surface area is large relative to its thickness so that a small portion of batter in the centre is the last to bake and the considerable expansion forces present exploit the radial effect and force the sponge to peak.

The most obvious sources of too rapid a rate of heat transfer are as follows:

- Too high a baking temperature in the oven. Robb (1987) showed that sponge cake peaking was entirely dependent on baking temperature and independent of baking time. The solution is to lower the baking temperature but you may also have to increase the baking time in order to remove sufficient water from the product.

- Excessive top heat, particularly in deck ovens. The high radiant heat component in such cases acts like too high a baking temperature. In such cases the ‘baking temperature’ may appear to be satisfactory. If you cannot balance the heat components in your oven steaming the chamber before you are ready to bake is a good way of removing excess radiant heat.

- In the case of ovens that bake by forced air convection too high an air velocity can cause the product to peak. Cauvain and Screen (1988) showed that high air velocities in forced convection ovens increased sponge cake peaking even when the temperature was ‘normal’.

Other possible reasons for the problem include the following:

- Over-treatment of the flour, either from excessive chlorine treatment (see 2.10) or excessive heat treatment (see 2.9). In the latter case you might also expect that the flour has a ‘burnt’ odour which may carry through to the product. If you suspect that this may be the cause we suggest you discuss the problem with your flour supplier.

- A lack of carbon dioxide gas because the baking powder level is too low or because the rate of reaction has been too fast and much of the carbon dioxide gas has been lost before the batter reaches the oven.

- Insufficient mixing so that there are too few gas bubble nuclei present in the batter for carbon dioxide inflation.

References


10.38 How do we convert a plain sponge recipe to a chocolate form?

The use of the term ‘chocolate’ to describe a cake varies a little around the world and is often regulated in some way. For example, in the UK chocolate can be used as a cake descriptor only if the final product contains not less than 3% dry, non-fat cocoa solids (LAJAC, 1963). This is usually achieved through the addition of cocoa powder and when calculating the level to use in a recipe allowance must be made for variations in moisture (usually around 5%) and fat (commonly between 10 and 20%).

The calculation is quite straightforward, as shown by the following example:

- Cocoa powder contains 5% moisture and 15% fat.
- The required dry, non-fat solids are 3%.
- The mass of cake crumb after baking is 100 kg.

The quantity required is given by

\[
\frac{3 \times 100}{100 - 5 - 15} = 3.75 \text{ kg}
\]

It is wise to increase the level of added cocoa powder slightly so that any variations in cocoa composition or cake moisture content are taken into account. Thus in the above example the level of cocoa powder could be increased to 4 kg.

The addition of cocoa powder should be considered as ‘flour’ for the purposes of recipe balance. It is common practice to add extra water along with the cocoa powder (Cauvain and Cyster, 1996). For the example given above the addition of 2 kg extra water would be recommended. Without this extra water addition the batter would be very viscous and may become difficult to process in the normal manner.

Even with the addition of extra water chocolate cakes tend to be more dry eating than the equivalent plain form. It helps to increase added oil or fat levels slightly, or to add glycerol. There may also be some loss of volume in chocolate sponge; this can usually be compensated for by slightly raising the added emulsifier or baking powder levels.

Often chocolate batters may contain an excess of sodium bicarbonate to yield alkaline cake which helps enhance the chocolate colour in the final product.

References

LAJAC (1963) Baking Industry Committee and the Local Authorities Joint Advisory Committee (LAJAC) on Food Standards (1963).
11

Biscuits

11.1 What is ‘vol’ and what is its function in biscuit doughs?

Vol is a baker’s term that is applied to ammonium carbonate. It is used as an aerating agent and does not require the addition of an acid in order to evolve carbon dioxide. It also differs from other aerating agents in that it evolves almost no gas in the cold and decomposes under the influence of heat to yield three gases: ammonia, carbon dioxide and water vapour (steam).

The evolution of ammonia restricts the use of vol. Ammonia is readily soluble in the liquid phase and will remain in the product if sufficient water remains after baking. This is the case with cakes where the use of vol will leave an unpleasant ammonia taste and smell. In biscuits, however, the degree of heat input required to drive off almost all of the water ensures that the majority of the ammonia is also driven off so that the effect on taste and flavour is not detectable.

There are a number of reasons why vol has been used in the baking industry:

- The volume yield of gases is considerable for a given weight of material.
- The complete decomposition and the absence of an aerating acid means that there are no salts left in the product that may yield unacceptable flavours.
- The minimal release of gas in the cold permits the mixing of large batches of dough and extended processing times without significant change in paste density or loss of aeration before baking.
11.2 From time to time we have noticed a white discoloration on the surface of our all-butter shortbread. Why does this occur?

The discoloration that you have observed is the phenomenon commonly referred to as ‘fat bloom’. It is the formation of small crystals of fat on the surface of the biscuit and occurs mainly as the result of temperature cycling during storage, that is periods of warmth and cold such as may occur in unheated locations subject to the effects of ambient temperature fluctuation.

Fat crystals may exist in a number of different forms (see 3.1). Since their size may be as small as 5 μm only agglomerates of fat crystals can be seen with the naked eye. The formation of crystal agglomerates is encouraged by rapid cooling, such as might be experienced when the products are quickly chilled after baking. Similar conditions may occur if a warm product is placed into a chilled environment. A similar problem may be seen with chocolates that have become too warm in periods of hot weather and then placed in a refrigerator to cool.

To minimise the problem you should examine your cooling technique and try to cool more slowly, or eliminate forced air cooling. Also consider whether you can pack in a warmer environment. You should record the typical storage temperature history of the product, looking for any fluctuating periods of warmth and cold and eliminate, or at least minimise, these.

If none of these considerations is relevant you might tackle the problem by introducing a small portion (say about 5%) of a low melting point butterfat fraction or oil into the product. This will help to reduce the tendency for the fat to recrystallise.
11.3 We produce biscuits containing powdered fructose which we cream with the fat and sucrose before adding the other ingredients. Recently we have seen the appearance of brown spots on the product. What causes this effect?

The most likely cause of your problem is associated with the creaming of the fat and the sugars. It is likely that some of the fructose that you are adding has become so coated with fat that it cannot dissolve in the limited amount of water that is available in the biscuit dough. This leads to excessive browning during baking.

To avoid the problem you could dissolve the powdered fructose in the dough water before mixing. Or you could change to a fructose syrup, remembering to re-balance the sugar solids and water content of the recipe.

Similar brown or dark spots may arise if you are using very large crystals of sucrose which do not dissolve completely and lead to the problem sometimes described as ‘sugar burn’.

Dark spots may also originate from undissolved aerating acids in the mix. For example, acid calcium phosphate is sparingly soluble and can hydrolyse on the surface of baked goods to give free phosphoric acid. The acid can carbonise carbohydrates during baking, giving rise to dark spots where the phosphate is concentrated. Often the problem is alleviated by changing to a finer form of the acid concerned so that there is better dispersion. Should the dark spots still form they are usually too small to be detected by eye.
11.4 Our chocolate-coated wafer biscuits are prone to cracking. Why does this happen and how can we avoid the problem?

The most likely cause of your problem is the absorption of water by the wafer and its subsequent expansion. We suggest that you look closely at the quality of your enrobing practices because any uncoated areas or even pin-prick holes in the coating provide access points for water from the atmosphere.

The moisture content of wafers is very low in order that they will have a crisp eating quality. The ERH of the wafer is also very low and much lower than the relative humidity of most atmospheric conditions. This means that the natural driving force is for water from the atmosphere to condense on exposed wafer surfaces where it will be absorbed and diffuse through the sheet. As the moisture level rises the wafer will begin to expand and exert so much pressure on the inelastic chocolate coating that the latter will split. Barron (1977) showed that for each 1% increase in moisture, wafer sheets expanded by between 0.33 and 0.42% of the original dimension.

The time taken for the cracks to become manifest will vary according to the completeness of the coating and the initial wafer moisture content. The relative humidity of the surrounding atmosphere will also affect the rate of wafer expansion: the higher the relative humidity, the greater the relative humidity differential and the faster the transfer of moisture. One way to limit this effect is to ensure that the wrapping of the final product is tight and so has a minimum volume of air around the product.

Reference
11.5 We are experiencing intermittent problems with gluten formation in our wafer batter. What causes this problem?

Gluten development is undesirable in wafer batters because it can lead to blockages in pipes or nozzles of batter distribution systems. This can lead to uneven distribution of batter on the plates and the incomplete formation of wafer sheets.

Gluten formation depends on three main factors: the presence of protein in the flour, the hydration of that protein from the addition of water and the input of energy during mixing. In batter systems the ratio of water to flour solids is usually high enough to lower batter viscosity to such an extent that gluten formation should not occur (Cauvain and Young, 2000). However, wafer batters are often pumped and recirculated through holding tanks to prevent separation of the solids while they are standing and this may cause shear in a number of areas of the pipework. Shear leads to work and subsequently gluten formation.

Since the recirculation of wafer batters is a practical expedient then the ingredient specification or batter formulation will have to be changed to alleviate the problem. Lowering the overall protein content of the flour used is the most obvious way of reducing the potential for gluten formation. This may be achieved by using weaker or softer milling wheats. Alternatively you could use a low-protein, starch-rich fraction from an air-classified flour. Typically this would equate to particles in the range 15 to 40 μm.

Alternatively you could replace a portion of your standard flour with a heat-treated flour. Heat treatment denatures the protein and restricts its gluten-forming potential (see 2.9) but will affect water absorption, and an increase in the water addition will be necessary in order to maintain a standard batter viscosity. Another way to reduce gluten formation would be to replace a portion of the standard flour with wheat or some other suitable starch.

Lowering the protein content of the flour used in your batters may have an adverse effect on the wafer strength, making them more fragile and so more prone to physical damage.

Reference
11.6 A batch of our biscuits containing oatmeal has developed a ‘soapy’ after-taste which makes them unpalatable. Why is this?

The soapy taste that you observe is almost certainly the result of lipase enzyme activity in either the dough before baking or in the baked product during storage. Oats are prone to this problem because of the high level of lipase enzyme activity which is naturally present. Lipase splits fats into fatty acids which react with the sodium bicarbonate to yield the soapy flavour. The most common way of avoiding this problem is to use only oat products in which the lipase activity has been eliminated. This is achieved by steaming the oats and you should specify this to your supplier. Steaming should not have any adverse effects on the functionality of the oats, which is limited in biscuit making.

You should also examine your dough mixing and processing to ensure that there has been no incorporation of scraps of old dough or dough that have become heavily contaminated with microorganisms, which also have the potential for considerable lipase activity.

As commented above the lipase activity can have a microbial origin and so could also come from post-baking contamination. In normal circumstances the water activity of an oatmeal biscuit is too low to support microbial activity because of its low moisture content. However, if there has been any condensation on the surface of the biscuit then the water activity might have become high enough to initiate the necessary microbial activity. You should consider whether there have been any opportunities for warming and cooling that may lead to condensation in the pack.

Oat-based products may also develop off-odours and bitter tastes because of oxidative rancidity. In this case the low water activity in the product encourages the problem, along with exposure to light and traces of certain metals, e.g. iron and copper. Oxidative rancidity is normally a lengthy process, taking many weeks or months to become manifest. The inclusion of a suitable anti-oxidant in the fat is usually helpful in avoiding this problem.
11.7 How do biscuits and crackers get broken during storage, even if they are not disturbed?

The problem you describe is the one commonly referred to as ‘checking’ and is related to the distribution of moisture in the baked biscuit or cracker. It was first studied and the reasons for the problem reported by Dunn and Bailey (1928).

After leaving the oven the moisture remaining in biscuits and crackers is unevenly distributed. In particular, the edges and upper and lower surfaces have a much lower moisture content than the centre. During storage the moisture migrates from the higher moisture content centre to the drier areas in order to achieve equilibrium. This movement of moisture sets up a series of stresses and strains in the product which, because the product is inflexible, can be of sufficient force to crack the surface. In some severe cases the biscuit may completely break into a number of smaller pieces. The cracks develop along weaknesses in the product structure, many of which are microscopic in size.

The best means of avoiding this problem is to ensure a minimum of moisture gradient in the baked product. This commonly means baking at lower temperatures for longer times. Alternatively you can introduce immediate post-baking drying using radio-frequency or microwave heating. Ideally the moisture differential between surface and centre should be less than 1% and average biscuit moisture contents in the order of 2–3%.

It is possible for biscuits to absorb moisture from the atmosphere but this usually leads to softening of the biscuit rather than checking.

Reference
11.8  We are making a ginger crunch cookie. Why do we experience variations in size?

Variations in biscuit size often come from variations in flow during baking. The three main ingredients that control flow are sugar, ammonium bicarbonate and flour protein level.

If you want to increase flow then you can:

- increase sugar or glucose syrup level;
- increase ammonium bicarbonate (vol) level;
- use a flour with a higher protein content.

If you wish to decrease flow then you should use lower levels of the above ingredients.

Since you are experiencing variations in flow then you should check the weights of the three key ingredients to make sure that they are being delivered consistently. If there is no problem with the weights being delivered then you should look at the flour qualities.
11.9 When making ginger nuts we find that we do not always get the degree of cracking that we would like. Why is this?

The cracks that form on ginger nuts are mostly related to the level and balance of sugar types being used. You should try increasing the level of coarse sugar or reducing the level of fine sugar in the recipe.

The oven humidity can also affect crack formation and an increase may be of some help, especially if you can introduce the humidity into the first section of a multi-section oven.

The products may exhibit poor cracking because they are flowing too much (see 11.8).
12

Other bakery products

12.1 Why are we getting a grey-green coloration to our choux buns?

The grey-green discoloration is associated with the formation of ferrous sulphide in the batter. If you examine the internal surface of your buns you may see small black specks. It is most likely that these will give a positive reaction when tested for iron. The iron has probably come from the surface of your mixing bowl which is being abraded by the beater, or from the surface of the container used to boil the roux. The formation of ferrous sulphide is accelerated by prolonged heating or by heating at a high temperature, such as that typically used for the production of choux buns.

The discoloration in your choux buns is similar to the grey-green colour that sometimes forms on the surface of an egg yolk after the egg has been boiled for too long a period or allowed to cool slowly. The reaction is caused by the iron in the yolk combining with hydrogen sulphide from the white of the egg.

When making choux buns it is advisable:

• To ensure that the container used to mix the roux is not corroded, and that the mixing utensil does not abrade the surface of the container.
• To ensure that the roux is well cooled before beating in the egg. If cooling is normally done by mixing on a machine, ensure that the mixing tool does not abrade the surface of the bowl. If cooling is achieved by allowing the roux to lie in a metal container, ensure that it is not in contact with iron which may be exposed in a worn tinned bowl.
• To bake at as high a temperature, and for as short a period, consistent with the choux shells being adequately baked.
12.2 Why is powdered ammonium carbonate or ‘vol’ added to choux paste?

Powdered ammonium carbonate, or ‘vol’ as it is commonly known, is entirely different from other baking powders used in baking. When heated the whole of the material turns into three gases – ammonia, carbon dioxide and water vapour – and no residue remains in the product in the form of a salt. Not all the gases escape, with the result that a smell of ammonia remains after the products are withdrawn from the oven. This is because ammonia is extremely soluble in water. No action takes place until the products are heated. Vol should be stored in an airtight container to maximise its subsequent effectiveness.

When added to choux paste in quite small quantities vol helps to improve the volume, especially in the case of cream buns as these are required to be extremely light in character and to have the greatest possible volume. It is not always necessary to add vol to choux paste to obtain good volume if the choux products are correctly made. Neither is it necessary to add vol when making éclair cases as there is a tendency for the paste to ‘blow’ too much, thus spoiling the shape of the éclairs.

See also 11.1, 12.3 and 12.4.
12.3 Why are cream buns baked under covers but éclairs are not?

High volume is required for cream bun shells. In order to achieve this high volume the surface of the bun should remain moist for as long as possible in the baking process. When the buns are placed in the oven the heat gradually begins to expand the air beaten into the paste and to generate steam from the moisture in the product. If the buns were baked in a dry heat, the outer crust would soon set and prevent the paste from expanding to the extent required. If the atmosphere surrounding the products is kept moist then the outer crust remains soft and pliable, allowing expansion to continue as long as there is expansive force left in the paste. When no more moisture remains in the buns to be converted to steam, the crust of the bun dries and becomes set.

A humid atmosphere surrounding the buns during baking can be achieved in two ways. Firstly, the cream buns can be baked under covers or tins to keep the moisture generated near to the product. Secondly, filling the oven to full capacity will obviate the need for covers as the oven itself then acts as a steam-tight environment for the products.

Éclairs are not required to expand as much as cream buns and there is no need to bake these under tins. In order to help keep a regular baton shape the outer crust is formed after initial expansion has taken place and further growth is restricted.

See also 12.2 and 12.4.
12.4 What are the most important factors that control the volume of choux paste products?

When choux paste is being baked any air that has been beaten into the paste will expand and the water will be converted to steam. The expanded air and steam try to escape but to a large extent are prevented from doing so because both are trapped and retained by the gluten matrix and uncoagulated film of egg albumen. The egg albumen (protein) is extensible and will be inflated and distended by the internal pressures of the gases – air and steam.

Expansion of the paste only ceases when the egg albumen coagulates and both it and the gluten film lose their extensibility and gas-holding powers. Egg albumen coagulates at high temperatures and loses its extensibility and so the temperature of the paste at which the eggs are added is an important factor in getting maximum volume. The presence of strong films of uncoagulated egg protein in the paste when it goes into the oven is of the utmost importance for the achievement of good volume in the baked product. If the eggs are added to the paste before it has been allowed to cool adequately the fluidity of the eggs is quickly lost and the penalty is lower volume. Pastes can be left to cool to 24–41°C (75–106°F) naturally, by stirring with the beaters of the machine or by being spread onto a cold clean slab or tabletop. An economic advantage of cold paste is that it requires the addition of less egg and will still give a good volume product.

The consistency of the paste for choux pastry is another of the critical factors in controlling the volume of choux products. It also plays a prominent role in the appearance of the product. Ideally the paste should be as soft as possible but without causing the resultant pastry case to be of poor shape.

If the paste is too stiff when making éclairs they become unattractive in appearance and exhibit harsh surface cracks and breaks. If the paste is too soft they need more baking to dry them out otherwise they will collapse on being taken from the oven. Even if they are adequately dried out to prevent them from collapsing they will have a lower volume and look squashed in appearance. When the consistency is correct they are beautifully rounded, and have no harsh breaks, bursts or cracks to detract from their appearance.

For cream bun shells, the more they crack and burst, the better the product appears. To obtain this cracked shape the paste can be made a little softer than for éclairs. Again, however, if the paste is made too soft the buns will be of poor shape and can collapse. So although it is a good plan to make choux paste slightly softer when making cream buns, the difference is only slight and must not be overdone. When baking choux buns it is essential to create steam under sufficient pressure to aerate or inflate them as fully as possible before the coagulation of the proteins and before surface drying or crust formation occurs. This is achieved by baking the paste in a comparatively hot oven at 227°C (440°F), so that steam pressure is built up rapidly to expand the paste and to hold it in that condition until the coagulation of the proteins and the crust formation.
Frozen and spray-dried egg as well as liquid eggs are regularly used in the production of choux pastry. Care must be taken when using spray-dried egg that the egg has not been kept too long since in storage egg proteins are degraded through the activity of bacteria. Frozen eggs should be defrosted before use. Some adjustment in recipes may be required when using frozen egg as there may have been some change in egg viscosity as a result of the freezing/thawing operation.

See also 12.2.
12.5 We wish to make a large batch of éclair cases and store them for a few days before filling and icing them. What is the best way to keep them to preserve their quality?

Making large quantities of éclairs for storage before finishing has to be undertaken with care as the characteristics of the product do not lend themselves to storage for long periods. There are two potential quality losses during storage; they are the loss or gain of moisture. Both can adversely affect the eating character of the final product.

Éclair cases are expected to be dry and crisp eating but not hard. Initially after baking the cases should be quite firm. The moisture content at the centre of the case may often be higher than that at the surface. It is therefore important to minimise further moisture losses from the product surface during cooling otherwise the moisture gradient from the inside to outside of the case would be increased and may cause the case to crack. If baking is extended too long then the cases may become hard eating.

The cases should be allowed to cool thoroughly before being stored in a closed container otherwise condensation may occur and cause softening of the products. Because they have a low moisture content éclair cases are prone to absorbing moisture from the atmosphere and so should be stored at a low relative humidity or in air-tight containers.
12.6 Why do our choux buns collapse during baking?

It is important when baking choux products that the oven temperature is sufficiently high to impart heat quickly at the start of baking. Consequently a rapid recovery of the baking temperature after the product has been loaded into the oven is vital. If the temperature controls are set too low then the recovery rate is low, resulting in shrinkage or collapse of the products. If the steam damper is partly or totally open the problem is exacerbated. The best results are obtained when the steam damper is closed (no loss of heat) and the baking temperature is set as near 232°C (450°F) as possible.
We stand our finished choux buns on U-shaped cardboard and wrap them in a cellulose-based film. Recently we have observed the growth of mould colonies on the products. Why is this?

In general choux products with fillings are susceptible to mould growth, and if the products are wrapped, the danger of mould is increased because of the greater degree of moisture maintained around the choux buns by the cellulose wrapper. The cardboard on which you hold the products will absorb water from the product because of both gravity and moisture migration. It is important that good hygiene practices are observed not only in the production process but also in the storage of the U-shaped cardboard and the cellulose wrapping film. Both cardboard and wrapping film should be stored covered in a clean dry place.

From the hygiene point of view the surface of the choux products should be cool and dry before filling and coating. They should be kept covered while cooling and drying-off to prevent mould spores settling on them. If the goods are cut to insert the filling, keep the cutting knife free from mould spores by regularly wiping with either a 12% acetic acid solution diluted in water (for stainless steel knives only) or industrial (not household) methylated spirits diluted in an equal quantity of water, or hydrogen peroxide. Care should be taken when handling acetic acid or hydrogen peroxide. Where products are filled by injection through a nozzle then the nozzle should be wiped at regular intervals with solutions similar to those mentioned above. The products should be handled as little as possible to minimise contamination. Clean and wash benches and trays that are to be used.

Use of a semi-moisture-proof cellulose film will allow more moisture to ‘escape’ from the atmosphere surrounding the product and keep the humidity within the packing material at a lower level. Waxed or coated card will prevent moisture from being absorbed into the cardboard and supplying a source of water for mould growth.

If the water activities of the choux pastry and its filling are manipulated to bring their values closer there will be less likelihood of moisture migrating through and out of the product. If the water activity of the filling can be lowered towards that of the choux, there will be less mould growth because of the overall lowering of water activity in the composite product.
12.8 We find that our Viennese fingers go soft very quickly after baking. How can we prevent this from happening?

When biscuits go soft after wrapping it is usually due to moisture uptake during storage. When a biscuit is wrapped in a well-sealed, moisture-impermeable film, softening does not occur. There are other possible explanations. These are:

- the presence of moisture in the filling which leads to moisture absorption by the biscuit as a result of moisture movement from the filling;
- the presence of invert sugar;
- underbaking of the biscuit originally so that more moisture remains in the product;
- condensation on the internal surface of the packaging film.

Softening of the biscuit can be prevented by the use of a moisture-free filling such as a compound shortening or hardened palm kernel oil, instead of margarine, which contains some moisture. Check that the recipe does not use invert sugar syrup. Ensure that the biscuits are well dried out in baking and that the biscuits are cooled adequately before packing. Especially avoid transferring products to a cold atmosphere after packing since such changes in temperature can result in condensation on the inside of the wrapper.
12.9 We freeze our unbaked pizza bases in a nitrogen tunnel. On defrosting and baking we get bubbles forming on the top of the product accompanied with an open crumb cell structure. How can these problems be overcome?

It is important to ensure that the temperature in the nitrogen tunnel is not allowed, at any time, to go below $-30^\circ C$. Below $-30^\circ C$ the integrity of the yeast cells is broken, releasing the glutathione and proteolytic enzymes which weaken the strength of the protein films between the small air bubbles in the dough. As the dough begins to expand, the weakened gluten film ruptures and adjacent gas bubbles coalesce to form large ones. This is likely to be the origin of your open cell structure and the bubbles that you observe.

Other ways of producing a finer cell structure and reducing gas bubble formation include:

- adding low levels of an emulsifier or fat to improve gas bubble stability;
- minimising any dough resting time after mixing;
- increasing the level of improver that you use in the recipe;
- using a stronger flour.
12.10 Our scones are made from frozen dough but frequently lack volume. We also find that the crumb colour is rather brown. How can we improve our product quality?

Scones depend on chemical raising agents for their volume. Once the raising agents come into contact with water the chemical reaction to produce carbon dioxide begins. In the production of a frozen scone dough there is a loss in this aeration capacity because of the onset of the aeration reaction and subsequently a loss in volume in the baked product. To overcome the loss of aeration, a change to a slower-acting acid will help, e.g. sodium acid pyrophosphate (SAPP) or sodium acid aluminium phosphate (SALP). The level of baking powder should be about 5% of flour weight.

Alternatively you could try using an encapsulated form of sodium bicarbonate. The encapsulation is usually with fat which delays the production of most of the carbon dioxide gas until the product enters the oven and the fat melts.

Baking powder may deteriorate under storage. It should always be stored under dry conditions. If this is not feasible then the acid and the bicarbonate should be stored separately.

To overcome the rather brown crumb colour we suggest you replace any invert sugar with sucrose. The Maillard reaction is less in sucrose than with invert sugar and so the crumb colour should improve.

In terms of quality improvements, increasing the fat level in the recipe to 20% of flour weight will produce a richer product. The use of butter instead of shortening will improve the flavour.

See also 12.14.
12.11 Some of our scone bakings have a coarse break at the side and an open crumb cell structure but the results are not consistent. What steps should we take to obtain a better and more consistent product quality?

A coarse break at the side of the scone indicates that more gluten formation was achieved during mixing than is normally required for scones. The scone dough should be cleared, i.e. all the ingredients should be thoroughly blended, but you must be careful not to over-mix.

The level of baking powder should be sufficient to achieve aeration during baking. Use of cold water during mixing will minimise the baking powder reaction before baking and also help restrict gluten formation.

It is possible that the problem could be associated with variations in recovery times and baking conditions. A recovery period of 15–20 min after pinning and cutting and before baking is helpful as it allows the dough to relax and aerate slightly (from carbon dioxide) before baking. However, to minimise skin formation the dough should be placed in a relatively cool (less than 20°C), moist area (or covered) during the recovery period.

Small individual scones should be baked in a fairly hot oven, 240°C, and we suggest that you check that your oven temperature controls are performing satisfactorily.

See also 12.10 and 12.14.
12.12 How can we extend the shelf-life of our scones?

Staling of scones can be reduced in any of the following ways:

- Wrapping scones in a moisture-proof film will reduce moisture loss and give a softer eat but will not prevent inherent staling.
- Scones can be frozen but there is usually a loss in quality associated with this process.
- If freezing is not an option then including a suitable emulsifier (e.g. a high monoglyceride type of glycerol monostearate in emulsion or paste form) will keep the crumb softer. Proprietary ready-to-use products are available. Replacing the fat present with a high-ratio shortening or increasing the proportion of fat in the recipe may also be beneficial.
- Adding a humectant may help to retain moisture. We suggest replacing part of the sugar in the recipe with invert sugar, though higher levels of the latter may lead to excessive browning of the crumb. Glycerine may also be added but again high levels may lead to darkening of the crumb.
12.13 The surface of our scones is covered with speckles of a yellowish-brown colour. Why?

The discoloration is probably due to unreacted bicarbonate in the scone mixture. If glucona-delta-lactone is the neutralising acid it requires time to hydrolyse to gluconic acid. Giving a longer resting time before the scones are baked may resolve the problem. In some instances small brown specks in baked short pastry can be attributed to undissolved particles of sodium bicarbonate. In this case the problem can be solved by using a finer particle size (sieve of aperture size 0.06 mm). Alternatively resting the dough for at least 40 minutes allows the bicarbonate to dissolve and ensures that the speckles do not occur.
12.14 Why should particular care be taken when washing scones with egg wash to ensure that no egg runs down the sides of the pieces of dough?

After rolling and cutting out scone dough into round or finger shapes the surface of the scone is commonly washed with egg to obtain a glossy, rich brown skin on baking which makes them so attractive. If the egg wash is allowed to run or dribble down the sides of dough pieces their baked appearance is spoiled.

When the scones are baked the egg on the side walls will coagulate long before the baking powder inside the scone has evolved all of its carbon dioxide. This coagulated egg will form a more or less unyielding band, uniting the top skin with the bottom edge of the scone, and will prevent that side from rising to its full height. The gas produced by the reaction of the baking powder must cause expansion in some direction or other, and will take the line of least resistance. This will often cause the opposite side of the scone to rise even higher than would otherwise have been the case. The end result is that the scone rises unevenly and where the egg ran down the sides it will be spoiled by a yellow streak running from top to bottom, instead of the sides presenting an unbroken, smooth, white colour.

The problem is usually avoided by paying attention to detail, for example avoid getting too much wash on the brush, using too large a brush and too concentrated an egg wash.

See also 12.10 and 12.11.
12.15 Why does our royal icing not harden adequately?

For hard royal icing there are several points that should be observed. The mixing bowl in which the egg whites are beaten should be completely free from grease. Even small traces of grease will affect the aeration of the egg albumen. If the icing has not received adequate aeration it will have difficulty in setting well. However, it is important to whisk at a low speed as faster speeds tend to result in large bubbles in the icing. For the same reason, it is advisable to mix with the bowl about half full before beating. When the icing is applied it should be worked lightly on the surface of the cake to break down any large bubbles that may still be there.

Glycerine, which is sometimes added to prevent the icing becoming ‘flinty’, should be kept to a minimum as an excess will prevent the icing from setting. If making icing for ‘run out’ work then the icing should be thinned with egg white and not with water as this too will prevent the icing from setting. The cake should be kept in a dry atmosphere to allow the icing to set and should also be stored in a dry atmosphere otherwise the icing will soften (see 12.19).

Where royal icing is being applied to a cake covered with almond paste it is best to allow the paste to form a crust overnight in a well-ventilated, warm, dry area. In such cases two coats of royal icing are normally adequate, with the first coat being light and of normal piping consistency and being allowed to dry overnight. The second coat may be slightly softer to give a smoother finish. If the paste has a tendency to oil, or if there is insufficient time to allow two coats to be applied, hot fondant may be used to seal the surface of the paste.

For a quick-setting icing the moisture content should be low. A low glucose content will avoid the uptake of moisture and a gum or stabilising material should be included.
12.16 We are receiving complaints of opaque spots on our fudge icing. Is there a remedy?

Spots on fudge icing are the result of recrystallisation of the sugar. The sugar graining is caused by insufficient mixing, by overheating or by loss of moisture from the icing to the cake or atmosphere.

In order to avoid moisture transfer the cake should be brushed over with boiling purée before icing. Adding glycerine to the icing at a rate of 0.5% will help keep the fudge icing soft and lowers the ERH of the icing, bringing it nearer to the ERH of the cake, which will also help reduce moisture migration.
12.17 After two days our royal icing tends to turn yellow. Can this discoloration be prevented?

There are many causes of discoloration in royal icing:

- Royal icing made with inferior types of albumen substitutes or weak albumen solutions will slowly discolor on ageing and become slightly yellow. Use of good quality ingredients should prevent the problem.
- The use of poor quality icing sugars produces a poor colour in the icing.
- If the icing is allowed to stand in a metal mixing bowl for too long or the palette knife is left in the icing for a long period of time, discoloration will occur, changing the white to a creamy colour. This can be because of reactions involving iron particles.
- In some cases ready-prepared marzipans are highly coloured by the manufacturer. This colour can be absorbed by the moisture in the royal icing which seeps through, causing it to change colour. To avoid this, after coating the cake with marzipan, brush it over with boiling apricot purée or a thin coating of fondant which has been heated to a higher temperature than would normally be used for coating purposes. These coatings act as a seal, preventing any seepage.
- If marzipan or almond pastes are worked excessively during their preparation they will become oily. This change may also occur if the atmospheric temperature in the work and storage areas are higher than normal. Ensuring that the work and storage areas are reasonably cool and the marzipan is not over-worked can prevent oils being released. In addition, to minimise the transfer of oily stains, the surface of the marzipan could be coated with a boiled apricot purée.
- Retarded drying of the royal icing can cause discoloration.
- Excessive quantities of glycerine can cause a creamy colour to form.

To obtain a sparkling white icing a little confectioner’s blue, say two or three drops should be added to each 500 g (1 lb) of icing.
12.18 After storing our coated products overnight we find that cracks form in the fondant coating. How can this problem be overcome?

Many faults encountered with fondant are associated with one or more of the following:

- The ERH of the components of the product.
- The degree of moisture permeability of any wrapping material.
- The glucose content of the fondant.

Fondants can remain soft or become hard depending on the formulation and process used for their manufacture. Surface problems with fondant such as white spots, streaks or stickiness also have some of their roots in the formulation and processing and others in the storage conditions and components on which they sit.

Cracks that appear on the surface of fondant are a result of the fondant drying out and hardening. A glucose syrup level below 12% total weight leads to very rapid hardening and so a level between 12 and 14% is recommended. Inclusion of 5 to 10% hard fat such as hardened palm kernel oil or a high-ratio fat containing an emulsifier can be used to prevent hardening.

The reverse of the problem with hardening is that of the fondant becoming sticky. The cause of this is the hygroscopic nature of the fondant. When stored in a humid atmosphere or surrounded with packaging film of low permeability or transpiration rate, the ERH of the fondant, being very much lower than its surrounding atmosphere, and the presence of undissolved sugar crystals cause uptake of moisture. This results in the fondant becoming sticky. Storage of fondant products in a refrigerated cabinet, which may have a relatively high humidity when filled with other goods could accentuate the problem. Thawing of frozen products in high-humidity conditions can also cause the problem.

In products where the fondant topping sits on a pastry product that is cream filled (e.g. chocolate éclair), moisture moves from the cream (with high ERH), through the pastry casing to the fondant topping (low ERH) and forms a thin film of water between the topping and the pastry case. Any jolt during transportation of the product can cause the fondant to slip off the product (the thin film of water acts as a lubricant). In this case the problem is alleviated if the ERHs within the components are brought closer together.

Further reading
12.19 I have heard that off-odours can be caused by the icing used for cake decorations. Is this true?

The icing itself should not cause off-odours. However, the varnish used on cake decorations can transfer odours to the icing. A preventative action would be to ‘air’ the decorations for a period before they are required so that any smell of varnish may disperse.
12.20 We make sugar paste shapes and store them in plastic containers for later use. In a few days the shapes soften and are inclined to droop. How might we overcome this problem?

If your containers are not sealed then the sugar paste shapes can take up moisture from the atmosphere. Generally the relative humidity of the atmosphere indoors is in the range 40–70% and so sugar paste shapes with a low ERH will absorb atmospheric moisture. You should try to minimise the headspace in the container used to store the shapes to limit the mass of water available for absorption by the paste.

It is possible that the formulation of the sugar paste contains too much humectant for your requirements. Try reducing the proportion until the ERH is in the range 75–78%.
12.21 We bake our meringues on aluminium sheets and are having problems with the meringues becoming discoloured. How can this problem be eliminated?

Aluminium baking sheets would not be expected to cause meringues to become discoloured unless the sheets were particularly dirty and the discoloration was on the surface.

If the discoloration is internal then the cause could be due to baking the meringue at too high a temperature or for too long. If the brown discoloration is overall this could be due to using fresh or frozen albumen. Reconstituted dried albumen is less likely to cause this problem as any reducing sugar present is removed before drying.
12.22 When making Italian meringues why is the boiling sugar water added slowly?

One of the effects of adding boiling sugar water to the beaten egg whites is that the air trapped by the albumen is heated and expands, so that the volume of the meringue foam increases considerably. If the sugar is added very quickly the albumen would almost immediately coagulate. In this condition it is much less elastic and any expansion causes the air cell walls to break and release their contents. Thus the meringue would become heavier rather than lighter.

Adding the sugar solution as a gradual stream while still whipping means the temperature of the mixture is slowly increased. Expansion takes place and the meringue becomes lighter. Then as further hot sugar solution is added, the temperature increases, and by the time it has all been added, it will have become sufficiently high to coagulate the thin films of expanded albumen. Each cell will be filled to capacity with expanded air.

The meringue should stand well without loss of aeration for prolonged periods. This explains why Italian meringue may be used for making buttercreams. After mixing the meringue and the butter there should be little breakdown of the air cells as each is coated with a delicate skin of coagulated albumen.

Cold meringue, on the other hand, readily breaks down in buttercream because the uncooked, and therefore uncoagulated, albumen chains are easily shortened by contact with the butter fat. The cells break open, release their trapped air, and the buttercream loses its lightness and bulk. Marshmallow, a gelatinous form of Italian meringue, is often blended with buttercream. Because of the structure of the marshmallow, the volume is retained when added to the buttercream, just as is the case with Italian meringue.
12.23 We are experiencing cracking of our meringue shells during baking. Why is this?

When the sugar concentration in the albumen mix increases from 2 : 1 to 3 : 1 the tendency increases for meringue shells to crack. If baking is carried out for short periods of time at high temperatures the problem is accentuated because the albumen on the surface coagulates earlier. Being hard and inflexible it cannot move with the pressure created by the still expanding centre and so the surface cracks.

The vapour pressure of the sugar solution decreases as the strength of the solution increases. This means that as the sugar concentration increases, moisture will evaporate more slowly during drying or baking and will contribute to the problem.

Reducing the sugar concentration to 1 kg to 400 ml albumen should help. Reducing the baking temperature will also have a beneficial effect.
12.24 We are having problems with softening of coffee meringues in which we use coffee powder as the flavouring. Is this the cause of the problem?

Adding coffee powder or coffee essence to the recipe does not usually cause meringues to soften provided they are baked thoroughly. Meringues are normally baked at about 116°C (240°F) for 3 h to ensure that they are completely dried out. It is advisable to bake the meringues in a dry atmosphere with the oven dampers left open.

The meringues should be cooled completely before packaging and stored in a warm dry atmosphere. If you do not have such storage conditions available they should be packed in either moisture-impermeable bags or sealed containers. Meringues are very high in sugar and consequently are hygroscopic (i.e. they easily absorb moisture from the surrounding atmosphere). If left in a humid atmosphere they will soon become sticky to touch and eventually will become soft. In wet weather where the atmosphere is more moist than usual the meringues should not be left exposed.
12.25 The aeration of our whipping cream varies from time to time and we often suffer volume losses. How can we improve the aeration and the consistency of our results?

The aeration time for whipping cream depends on the temperature of the cream, the speed of the beater, the fat content of the cream and the size of the batch. Whipping for too long will result in a rise in temperature of the cream and this will increase the time required to aerate it sufficiently. The fat content of the cream could be increased by adding some double cream. A faster whipping speed could be used until the cream starts to thicken, followed by a reversion to medium speed. Keep the cream in a refrigerator and only take it out just before use so that most of the fat remains in the solid form. Whipping times should be in the order of 2 min. Alternatively, use a cream whipping machine.

Working in smaller batches and adding an appropriate stabiliser are other options. Suitable cream stabilisers include:

- sodium alginate (Robb, 1971);
- sodium carboxymethyl cellulose (Robb, 1971);
- methyl ethyl cellulose (Ito and Hodge, 1985);
- guar gum (Ito and Hodge, 1985);
- locust bean gum (Ito and Hodge, 1985);
- xanthan gum (Ito and Hodge, 1985);
- carrageen (Robb, 1971);
- gelatine (Robb, 1971).

Many of these stabilisers will be blended to give commercial stabilisers which are offered for use with cream.

References


12.26 Why does our whipped cream collapse on standing?

During the whipping of cream the movement of the wires of the whisk through the fluid draw in small bubbles of air. Fat chains in the cream form at the interface of the air bubble and the aqueous phase, where they stabilise the bubbles and prevent them from rising and escaping from the cream after mixing. In the stable foam that is formed the liquid of the aqueous phase is effectively trapped in the spaces between the stabilised air bubbles. On standing, the bubbles in the cream become unstable and they collapse. In doing so the liquid previously held in the spaces between the bubbles now escapes and usually drains under the influence of gravity.

The rate at which the cream will collapse depends on the many factors that affect the stability of the foam. Since the main stabilising agent is the fat present there needs to be a minimum of 40% butterfat in order to produce a stable foam structure. The stabilising effect of the fat may be supplemented with other suitable stabilising agents (see 12.25).

The amount of stabilising material present limits the maximum amount of air that can be beaten into the cream. This is because the stabiliser must be located at the bubble surface. The greater the quantity of air incorporated into the batter, the larger the surface area that needs to be stabilised. With ever-increasing quantities of air being incorporated a point is reached when the stabiliser cannot stretch any further and the cream density stops falling.

Too much air in the cream will make it unstable and more likely to collapse with small changes in storage conditions, e.g. a small increase in temperature can cause the air to expand and increase the surface area that must be covered by the stabiliser. The aeration of cream may be expressed as relative density or specific gravity (see 13.4). It is also common to see cream aeration expressed as ‘overrun’. This is the reciprocal of density expressed as a percentage (thus a relative density of 0.77 = 130% overrun).

Careful control of cream temperature before during and after whipping needs to be taken. Before whipping ensure that the cream temperature is 3–5°C (38–40°F). If for any reason the cream temperature is above this, chill it in a refrigerator until its temperature has fallen to this level to increase the proportion of solid fat. During warm weather in particular, rinse out the bowl and beater with cold or chilled water, or preferably place in a refrigerator for some time before use.

Whisk the cream on a medium speed until it starts to thicken, then finish whisking on high speed. During warm weather the cream should be whisked in as short a period as possible to minimise the time it is exposed to the high atmospheric temperature. Aim to have the whisked cream at a maximum temperature of 10°C (50°F) at the end of whisking. After whipping, the bulk of the cream should be stored in a refrigerator at 3–5°C (38–40°F) and after depositing the cream temperature should not be allowed to exceed 10°C (50°F). Above this temperature the cream will start to collapse.

If attention to the cream temperature control is not enough to overcome the problem, then we suggest increasing the butterfat content to about 42%. If your
supplier is unable to provide this you could blend six parts by weight of
whipping cream containing 40% butterfat with two parts by weight of double
cream containing 48% butterfat.

It is not uncommon to experience whipping problems with fresh cream
arising from changes in the diet of cows. In the UK the so-called ‘spring flush’
problem with diary cream arises when cows move from winter feed to spring
grass and the composition of the fats in the cream may change (Bent, 1998).

Reference
(eds S.P. Cauvain and L.S. Young), Blackie Academic & Professional,
Recently we experienced a problem with a fishy taint in a batch of buttercream. Why?

Detection of taints varies from consumer to consumer and may be present in all or only part of the buttercream. Such off-flavours are not usually caused by microbial spoilage but rather by a chemical reaction. Because of its high fat content, buttercream is often susceptible to such problems.

A fishy taint in butter is due to the action of peroxides on the choline derived from the lecithin present. Both copper and iron can catalyse the development of this taint by accelerating peroxide formation and promoting the reaction of peroxides with the lecithins. The presence of as little as 1 ppm of copper can produce a fishy flavour in butter within three days. However, the off-flavour caused by the iron is not ‘fishy’.

Since only traces of copper are needed to accelerate a taint in buttercream, care should be taken that products containing butter or other fats do not come into contact with copper or copper-containing materials such as brass fittings, phosphor-bronze bearings or copper utensils.
12.28 How can we prevent our apple pie filling going mouldy within a few days?

If you do not want to alter the eating quality of the apple pie filling the easiest course of action is to add preservative. For example, adding 150 ppm potassium sorbate to the filling should extend its mould-free shelf-life to seven or eight days. However, for small batches of about 3.5 kg the quantity of sorbate involved is only about 0.53 g. The easiest way of adding such a small quantity of preservative would be for you to make up a bulk mix of sugar and potassium sorbate. For a recipe with 0.5 kg sugar per 3.5 kg batch of filling, each 0.5 kg of sugar in the bulk mix should contain 0.53 g sorbate. Thus if you make up 12.5 kg (28 lb) of bulk mix it should contain 13 g (0.5 oz) of potassium sorbate. It is essential that you mix the sugar and the sorbate very thoroughly, for example by mixing at slow speed for at least half an hour. You could then weigh off appropriate portions of the mix for each fresh batch of filling.
12.29 In some of our apple pies we find that the filling has turned blue. Why?

The blue discoloration in your apple pie filling is probably caused by a natural pigment. Natural pigments from blackcurrants, black grape skins and some flowers such as dahlias, lobelias and Michaelmas daisies contain anthocyanins. The most probable explanation of the coloration on your apple pie filling is that it has come from utensils or machinery that have previously been used for blackcurrant filling. If the same utensils are being employed for both types of filling, we suggest that you ensure complete removal of any traces of blackcurrant before the apple is applied.

Apples can turn pink if too high a temperature is used during baking. The pink discoloration is due to the hydrolysis of leucoanthocyanins present in the cell tissue of the apple. These normally colourless substances are closely related to the natural red or purple colours (anthocyanins) of fruit. The changes in the leucoanthocyanins to the coloured forms are accelerated by acidity, and the more acid apples appear to discolour more readily on heating than do less acid varieties. The apple most commonly grown in the UK for culinary purposes is the Bramley Seedling. It seldom develops a pink discoloration when canned as a solid pack apple processed at 100°C (212°F), but when used in apple pudding, special care has to be taken to keep the temperature below 110°C (230°F) to keep discoloration to a minimum.

To avoid discoloration in this case prepare a sugar/water/starch gel and allow it to cool before blending in the solid pack apples. It is inadvisable to add any extra acid to the filling.

See also 10.5.
Can you suggest a solution to the problem of shrinkage in our apple pie filling?

The main problem with shrinkage of apple pie fillings arises through the loss of water, either during baking or subsequent storage. In some cases this will be because the ERH of the filling is too high and you may need to lower it by adding some more sugar, or other suitable soluble material, e.g. dextrose.

The other possible reason for the problem arises from the physical breakdown of the fruit, 'pulping', which results in loss of filling volume. Bramley apples are generally considered to be the most satisfactory type of apple for baking purposes. It is possible, however, that well-matured fruit that has undergone canning may not be able to withstand baking as well as less mature fruit would in a relatively ‘fresh’ condition. You may wish to try using fresh apples that have been preserved in ascorbic acid or brine.

Alternatively, it has been reported that apples retain their shape better if they are soaked for half an hour in a solution of calcium lactate prior to baking. A solution made from 50 g (2 oz) calcium lactate in 2 l (4 pints) of water should be sufficient to treat 9 kg (20 lb) apples. You may find it worthwhile to carry out a trial using canned apples.
12.31 After a short period of storage we observe crater-like crystalline formations on our cheesecake topping. Why does this occur?

Crater-like crystal formations in fondant-type toppings are consistent with the formation of sucrose hydrate (Cauvain and Young, 2000). Localised white spots or streaks are the result of the formation of sugar crystals larger than those present in the mass of fondant. The presence of materials that might cause the fondant to ‘seed’ and form sugar crystals which then grow accentuates the problem.

Crystal growth can be retarded by increasing the level of glucose syrup in the fondant. The inclusion of glucose syrup in the simple syrup form used for thinning the fondant may prevent this seeding. A typical recipe for such syrup is:

- Water 1.25 l 2 pints
- Sugar 1.5 kg 3 lb
- Glucose 250 g 8 oz

The ingredients are brought to the boil and allowed to cool before use.

Care should be taken that the fondant is tempered correctly and not overheated (i.e. above 43°C, 110°F) during preparation. Preparation tanks should be inspected to check that a crust of hardened fondant has not formed round the rim as this can act as a source of ‘seed’ crystals for sugar crystallisation. Similarly any superfluous icing sugar or other material can cause the fondant to seed and form sugar crystals. Minimising moisture loss from the product can also alleviate the problem by preventing the localised sugar concentration reaching the point where recrystallisation is likely to occur.

Pitting and graining on the surface of iced toppings can sometimes be seen and leads to loss of sales. These are caused by the multiplication of osmophilic yeasts. From a hygiene viewpoint cleaning all surfaces that come into contact with such coatings, including all vessels used to hold or transport them, the bain-marie, all working surfaces, small containers and utensils, can minimise the uptake of spoilage organisms and materials which might cause seeding later. It is recommended that no left-over material is used as it is often the source of such problems.

Reference

12.32 Our crumpets have become blind, that is they have lost the characteristic surface holes. Why?

Crumpets that lack the characteristic holes on the top surface are commonly known as ‘blind’ crumpets. The phenomenon can arise from draughts blowing across the hot-plate, from too much grease on the rings or hot-plate, or from using too heavy a deposit weight. A minimum fermentation time of 1 h should be given before depositing the batter. Using a weaker flour (of about 10.5% protein) will allow more of the carbon dioxide gas to escape during baking and can help hole formation.
12.33 Why is a small amount of bicarbonate of soda added to pikelet batters just before baking?

Pikelet batter fermented by yeast has typically remained for 1.5 to 2 h before it is ready to be baked on the hotplate. Before baking begins, a little bicarbonate of soda is moistened in a drop of water and stirred into the batter. If the whole batch of pikelet batter could be baked at once there would be no need to add the bicarbonate of soda but often we need to bake the batter in a number of smaller batches, which extends the time the batter must remain aerated.

While standing, the batter continues to ferment and progresses towards sourness with increasing acidity being developed. Eventually the batter would be unusable. The bicarbonate of soda prevents this acidity by reacting with the acids formed during fermentation and helps the batter remain neutral.

Only a very small quantity of bicarbonate of soda is needed. If used at too high a level you may get an excessively yellow colour in the baked pikelets.
12.34 On some occasions our almond macaroons exhibit very coarse cracks on the surface instead of the fine cracks we are seeking. What is the cause?

Coarse cracks can be caused either by the deposited macaroons forming a skin before baking or by insufficient humidity during the initial stages of baking. If a skin has formed then the surface is no longer porous enough to allow moisture vapour to escape as the product is baked. Instead pressure builds up inside the macaroon, eventually causing the skin to form a coarse crack. Similarly if the oven is very dry at the start of baking then the surface of the macaroon quickly dries out, restricting the escape of moisture.

To avoid this problem do not leave the product standing in a warm, dry atmosphere and bake it off as soon as possible after depositing.
Why are macaroons baked in a cool oven?

Most products containing high percentages of sugar should be baked in a cooler oven or they will burn rapidly. Sugar caramelises at high temperatures and becomes hard. In the case of macaroons, the oven should be cool enough to allow the product to ‘grow’ by the expansion of the air cells beaten into the paste and to flow out to the correct size before the albumen of the egg whites is coagulated or set. It is also important that the product should not become too darkly coloured. A hot oven would not only burn the products but would cause rapid coagulation of the albumen and prevent full growth taking place, so that the final products would be of small volume and poor shape.
12.36 Why are Japanese biscuits stored in a warm, dry place?

Japanese biscuits are made from a meringue mixture to which ground almonds or roasted ground hazelnuts have been added. They are baked in a cool oven, allowed to cool, and are then trimmed with a plain, sharp-edged cutter so that they are all the same size. Alternatively they may be stencilled onto prepared baking sheets using specially made rubber stencil mats.

When baked and cooled, those not required for immediate use should be placed in boxes and stored in a warm dry place. By doing this the biscuits remain hard and quite dry. If the biscuits are allowed to remain in a damp or humid atmosphere they would go very soft and it would be impossible to handle them at the time of making up.

The dried biscuits are commonly sandwiched in pairs with buttercream and then finished in a variety of ways. After they have been made up in this way they soften owing to the uptake of moisture from the air to the cream. The high proportion of undissolved sugar makes the products hygroscopic and so liable to attract moisture. This often limits the shelf-life of such products.
12.37 Why does the chocolate coating on our marshmallow teacakes crack during storage? How can the problem be solved?

The cause of this problem is easy to explain but rather more difficult to eradicate. A marshmallow is a composite product made up of biscuit, marshmallow topping and chocolate coating. Each of these components has a different ERH or water activity. Moisture will move from one component to another, driven mainly by the relative differences in water activity between components.

Biscuits have a low ERH and will readily absorb moisture from the atmosphere and become soft. When marshmallow is deposited on the biscuit it will absorb moisture from the mallow (higher ERH) more easily than from the atmosphere and as a result it expands or swells (Cauvain and Young, 2000). This occurs in a period of time after the chocolate coating has dried and the overall effect is to crack the chocolate coating which is not extensible enough to take up the increase in size.

To overcome this cracking:

- The biscuit must not be allowed to absorb moisture from the mallow. You could try spraying the surface of the biscuit when cool with melted hydrogenated fat which places a moisture barrier between the biscuit and the mallow.
- The biscuit, before the mallow is added, must have absorbed enough moisture to have an ERH similar to that of the mallow. This can be achieved by increasing the ERH of the biscuit or by decreasing the ERH of the mallow through modifications to the formulations. Spraying the biscuit shortly after baking with water, using a fine nozzle, or storage in a moist atmosphere for about 12 h before depositing and enrobing should increase the ERH of the biscuit. For the marshmallow, replacing some of the sugar by glucose will decrease its ERH and enable it to hold on to its moisture. Using one of these remedies or a combination the moisture migration from mallow to biscuit should be reduced.

Reference

12.38 What causes the white bloom that sometimes occurs on chocolate coatings?

White bloom on chocolate coatings is the result of temperature cycling in preparation (the tempering – the heating and cooling regime used to stabilise cocoa butter fat crystals of the chocolate before coating) and storage which causes deposits of fat particles on the surface of the coating.

The types of chocolate used in a coating have a bearing on the coating’s susceptibility to bloom. For example:

- **Bakers’ chocolate** is very stable to fat bloom under storage conditions varying from 13–27°C (55 to 80°F).
- **Couverture** needs tempering and care should be taken to minimise inclusion of air during stirring as this can produce small bubbles, which contribute to fat bloom formation. Fat bloom occurs more quickly on plain than on milk couverture, particularly at high storage temperatures and also when alternating between high and low storage temperatures. Cooling couverture rapidly to temperatures lower than 13–18°C (55 to 65°F) makes it less susceptible to bloom on subsequent storage than cooling slowly to 21°C (70°F) (especially if the storage temperature is relatively high).

Surplus chocolate that has bloomed can be re-tempered to produce satisfactory results.
12.39 The bakers’ chocolate coating we use tends to flake off our éclairs. What is the likely cause of the problem?

Chocolate coating should be correctly tempered to avoid problems. Generally bakers’ compound chocolate should first be heated to 54°C (130°F) for plain or 52°C (125°F) for milk and then allowed to cool to coating consistency. The necessary temperatures are about 41–43°C (105–110°F) for plain and 38–41°C (100–105°F) for milk.

If the chocolate is not maintained at a constant temperature, there may be variations in the speed of setting. Very rapid setting, perhaps because cooling has occurred in a draught, may cause shrinkage and subsequent flaking.

If the shells are coated on the base, rather than the top, excessive grease on the baking sheet may be contributing to the fault. The presence of moisture on the surface of the shell before coating could cause lack of adhesion.
We would like to store our wedding cakes after coating with marzipan for some time before we ice them but find that the marzipan hardens. Why is this and how can we achieve our aims?

Wedding cakes contain many ingredients that are good at holding on to the moisture and collectively cause the cake to have a low water activity value. Marzipan has a higher moisture content and its ingredients are not so powerful at holding on to the moisture and so has a higher ERH. Consequently, moisture will move from the marzipan into the cake, thus causing the marzipan to dry and harden.

An increase in the addition of some glucose, which as well as helping to reduce sugar (sucrose) crystal size, acts as a humectant and thus helps to prevent moisture loss should overcome the problem. We suggest that you use either stock syrup (boil 1 kg sugar, 1 l water, 250 g glucose, allowing it to cool before use), or a mixture of 50% glucose, 50% water, rather than water alone, for softening purposes.
The edges of our soda farls become gummy a couple of days after baking. What is the cause of this quality defect?

The dark gummy seam on the side of farls is generally caused by inadequate baking. This could be due to the following:

- The temperature of the hotplate being a little higher than normal, causing the farls to be ready for turning sooner than they should be and the farl being removed from the hotplate slightly sooner than usual to prevent the surface being scorched. This would mean that the centre is inadequately baked and tends to collapse during cooling, producing the dark seams.
- It is possible that the centre of the farl never reached a temperature high enough to inactivate the amylase enzymes in the flour. The latter may still be active in the baked product, though it is unlikely that this is the cause of the fault unless you have bacterial amylase present.
- The water-absorbing capacity of the flour may have increased, requiring the inclusion of more water at dough mixing. In this case the product may need slightly longer and cooler baking conditions than normal to drive off the additional water.
12.42 Why is it that wine cakes do not break nicely if baked in over-greased tins?

If wine cake tins are heavily greased, not only will the bottoms of the cakes probably peel off, but also the cakes will bake out flat and will not break in the centre. The break is caused by the formation of a thin crust on the top of the cake before full expansion has taken place, the completion of which bursts through the thin crust and grows in the centre, forming the bold or ‘cauliflower’ head normally expected with this product.

If the sides of the tins are heavily greased, the batter will quickly slide up the greased surfaces and will rise level with the centre. This prevents the centre of the already-formed crust being broken by the final efforts of the baking powder and steam. These expansive forces are evenly distributed instead of being concentrated at the centre so that instead of the necessary burst taking place, the cake will be flat and unattractive.
12.43 Why do we find jam or marmalade goes watery?

Jams ‘set’ or ‘jelly’ because of the pectin content in the fruit. When fruit is not properly ripe, insufficient pectin is present, and jams are therefore watery and do not set well. Some fruits, even when ripe, never possess sufficient pectin to jelly properly. This is the case with strawberries and some other soft fruits. In these cases the juice of strong pectin-containing fruits is usually added to help the jam set well. Apples and gooseberries are often selected for this purpose. When the preserves do not set well it is often because of the use of fruit in an unripe condition.
13

What is?

13.1 What is the phosphotase test and how is it used in the bakery?

Phosphotase is an enzyme associated with animal, insect and microbial activity. The phosphotase test is used to establish whether or not an insect has been baked in a product or entered after the product has left the oven. It is valid for samples that have been stored for a long time. Even after several years’ storage dead insects give a strong positive reaction.

The following materials are required:

Buffer solution
Anhydrous sodium carbonate (AR grade) weighing 3.5 g and 1.5 g sodium bicarbonate (AR) per litre. (The buffer may be stored for up to three months in a tightly stoppered container of resistant glass.)

Substrate
Disodium para-nitrophenol phosphate.

Buffer substrate
Transfer 0.15 g of the substrate to a 100 ml measuring cylinder and make up to 100 ml with the buffer solution. This solution should not be stored for long periods, but may be kept refrigerated for a week.
Testing procedure
Rinse the fragments with water and then crush with a glass rod. After mixing the fragments with a few drops of water, transfer to a test tube and make with rinsings to about 1 ml. Add 5 ml of buffer substrate and, after mixing, incubate at 37 °C. Simultaneously incubate a blank comprising 5 ml buffer substrate and 1 ml distilled water. After 30 min compare the colours of the tubes. Normally the presence of phosphotase is indicated by the production of a dark yellow colour within 30 min. Weakly positive tubes may require longer for the full colour to develop. A negative result suggests that the insect had been heated.

The disadvantages of the test are:

- the test virtually destroys the sample;
- very small insects do not give a sufficiently strong reaction;
- false positive results may be given if the sample is heavily contaminated with microorganisms, e.g. moulds.
13.2 What is meant by hydrogen ion concentration and how is the pH scale determined?

The term means just what it says, namely the concentration of hydrogen ions that are present in a solution. It is a scientific method of referring to the degree or intensity of acidity or alkalinity and is based on the fact that, in solution, the molecules of some substances split up and disperse throughout the liquid to a greater or lesser degree. The pH of a liquid tells not only whether the liquid is acid or alkaline, but also to what degree or extent.

The symbol pH stands for the ‘potential of hydrogen’. The word ‘ion’ means traveller, so that the hydrogen ion concentration refers to the degree of dispersal of ions of hydrogen in a given solution. It also refers to the fact that such hydrogen atoms are in an active condition and are charged with positive electricity, commonly denoted as $H^+$. 

To understand this more, we must consider the state of affairs in pure water. This is neither acid nor alkaline, but it has been calculated that in neutral water one molecule in ten million ionises or splits up and disperses as one atom of hydrogen charged with positive electricity and one group of elements consisting of an atom of hydrogen and one of oxygen. This is known as a hydroxyl group and is charged with negative electricity ($OH^-$). There is therefore complete neutrality, the positive charge on the hydrogen atom exactly neutralising the negative charge of the hydroxyl group.

In pure water, being neutral, only one part in ten million parts is in this state of ionisation. Mathematically $1/10,000,000$ can be expressed as $10^{-7}$, that is ten to the minus seventh power. Hence in stating the pH of a neutral liquid such as pure water scientists write pH7, omitting the minus sign as being superfluous.

Let us now consider what happens when we have a liquid in which there is a higher concentration of hydrogen ions, such as is the case when an acid is diluted with water. Here there may be one part ionised hydrogen in a million parts of the liquid. This can be expressed as $1/1,000,000$, that is $10^{-6}$, and so is written pH6. This shows that the liquid is acid in character, but not very strongly so, for only one part in a million is actively acid or capable of reacting as an acid.

The greater the intensity of the acid the greater the concentration of hydrogen ions will be. The expressions pH5, pH4, pH3, pH2 and pH1 mean respectively that one part in 100,000, 10,000, 1000, 100 and 10 are in this condition. As the numeral beside the pH decreases so the intensity of the acid present in the liquid increases (see Fig. 31).

In the case of neutral solutions we still refer to the hydrogen ion concentration but the dispersed atoms charged with positive electricity may not necessarily be hydrogen. The groups of negatively charged elements, however, neutralise these and alkaline reactions are recorded. For example, in sodium hydroxide, a well-known alkali, the ionised molecule will split up into one atom of sodium and one hydroxyl group. The former carries a weak positive charge and the hydroxyl group a stronger negative one, cancelling out the weak acid tendency and substituting stronger alkaline tendencies. Thus stronger
negative electrical charges can be recorded. As the pH numeral increases so alkalinity increases, and whenever the numeral is above 7 the substance or solution of substances is alkaline. The higher the figure above 7, the greater the strength or intensity of alkalinity will be.

Examples of the value of this information to the practical baker and confectioner include the following:

- The development of rope in bread. Rope spores cannot grow unless the dough or loaf is lacking in acidity. This degree of acidity is known and provided the pH of the baked product lies between 5.4 and 5.5, rope cannot grow in dough or bread.
- In the manufacture of high-ratio cherry cake the low-viscosity character of the batter does prevent the cherries from sinking during baking. However, if an addition of tartaric acid is made to the batter to bring the acidity to pH 5.4 or less, then the gluten of the flour is strengthened and batter viscosity increases so that the cherries remain suspended during baking (see 10.3). High-protein, high-ratio cake flour responds even more readily to the use of tartaric acid.

### Concentration of H⁺ ion

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<th>pH</th>
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<tbody>
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<tr>
<td>1 g per 10 litres</td>
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<tr>
<td>1 g per 100 litres</td>
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<tr>
<td></td>
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</tr>
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</tr>
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<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>1 g per 10 million litres</td>
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</tr>
<tr>
<td></td>
<td>8</td>
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<tr>
<td></td>
<td>9</td>
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<tr>
<td>Alkali increasing in multiples of 10</td>
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<tr>
<td></td>
<td>12</td>
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<td></td>
<td>13</td>
</tr>
<tr>
<td>17 g OH⁻ per litre</td>
<td>14</td>
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</table>

**Fig. 31** pH scale.
13.3 What is the meaning of the term syneresis when applied to bread?

Syneresis is the name given to a particular physical or colloidal change that takes place in starch and other gels as they age. It is caused by crystallisation or aggregation of polymers, causing loss of water from the surface of components. It is common with some starch gels, particularly those subjected to freezing and thawing. The released water may evaporate to be absorbed by other components by diffusion or vapour phase transfer, or may be lost from the product/component, causing it to dry out and shrink.

It is the change in starch crystallinity that brings about the staling of bread that is a day or two old, causing a sensory change equivalent to convey the impression that the bread contains less moisture and therefore has lost its freshness. Bread may lose actual water during the process of staling but there are many other changes occurring at the same time which will account for the dry-eating qualities of the bread (Pateras, 1998). This change in the condition of the starch is sometimes described as the ‘process of syneresis’ and is affected by the temperature and humidity under which the bread is kept.

If a loaf is kept for several days there is bound to be a loss of water by evaporation, but this water will not be lost regularly from the entire loaf. The loss is greatest at the part nearest to the crust. It has been shown that the loss of moisture from the centre of a loaf is exceedingly small and at the end of two weeks the moisture in the centre of a loaf is almost the same as the beginning. It would mean that if the outside portion of the loaf was cut off the interior would be almost as moist eating as a loaf a day old. However, this is not the case in sensory terms. A loaf several days old will be dry eating and stale equally throughout its whole structure. In fact there is a change in the method by which moisture is held in the loaf.

To illustrate this, prepare a stiff starch jelly and allow it to stand for a day or two. The water will partially separate out and will be seen on the surface while the gelatinised starch will seem to have become more solid. We can presume that something similar will occur in bread during storage. The starch will separate slightly from the water it was holding at the outset and the particles of bread will become dense and more insoluble, though apparently it does not mean that the small amount of water that has separated out will be evaporated. The bread particles, being more dense, will be harder to mix with saliva in the mouth so that a sensation of dryness and a difficulty in masticating the bread are experienced and make us think that the bread is dry.

Another point affecting the condition of the starch is the temperature at which the bread is stored. Bread stored at 4°C stales more rapidly than that stored at room temperature or under frozen conditions. At a low temperature of −5°C staling does not occur, though the act of freezing and thawing bread is the equivalent of 24 hours storage at ambient (Pence and Standridge, 1955).
References
13.4 In some technical literature there is reference to batter specific gravity or relative density. What is this? How is it measured? What is its relevance to cake- and spongemaking? Why is the volume of the baked product referred to in terms of specific volume?

It would seem logical to use the same unit of measurement for expressing the mass concentration of unbaked batters and baked cake products. However, when considering how this property is measured, it becomes clearer why a large part of the industry continues to use the different measures.

The density of a substance is its mass (weight) divided by its volume. The amount of air occluded in a batter is monitored by measuring its cup weight, that is, the weight of batter required to fill a cup of known volume. As the same cup size or volume is used for the comparison, the cup weight relates directly to specific gravity (now more commonly known as relative density) and this figure is used in the bakery for process control purposes without having to make any calculations. The lighter the cup and its contents (i.e. the larger the volume of air in the batter), the lower the relative density.

Thus batter relative density and batter specific gravity essentially measure the same property, the degree of aeration of the batter. Batter relative density in cakemaking is most commonly related to product volume; usually the lower the batter relative density, the larger the cake volume in a given set of circumstances will be. In contrast, baked products are monitored by measuring their volume. Since this is an important physical characteristic related directly to specific volume, that is the volume of a known mass, it is convenient to use this term.

Thus, practical considerations lead to the continuing use of different units in these circumstances for measuring mass concentration.
13.5 What is a super-saturated solution?

When a solvent is filled with the substance in solution so that it cannot dissolve any more it is said to have formed a ‘saturated’ solution of that substance.

Sugar is soluble in water. Water is therefore the solvent and sugar is the solute. To illustrate the principle of super-saturation, start by dissolving as much sugar as possible into some water. After adding sugar and constantly stirring the mixture for some time you will find it impossible to dissolve any more sugar. If you do add more it will remain undissolved and sink to the bottom of the beaker. If the contents of the beaker are now gently heated, the sugar at the bottom will dissolve and if more sugar is added it can also be dissolved. This process can be continued until once again the water can dissolve no more sugar. Again the water is saturated with sugar. It is obvious that the same amount of hot water has more sugar in solution than it could hold when cold. If the solution is then allowed to cool without stirring to the same temperature as the cold solution, the previously warm solution will contain more sucrose: it will be a cold super-saturated solution.

If a quantity of water at boiling point in which is dissolved as much sugar as it can hold is continued to be heated then, as the solution boils, water is driven off but the amount of sugar remains the same. This results in a hot super-saturated solution. The longer the solution is heated, the less water remains and the greater the degree of super-saturation. This causes a rise in temperature, which continues to increase until not only is all the water driven off but the sugar decomposes. At any stage between the production of super-saturation until caramalisation occurs the solution is in a very unstable condition. It would be easy to understand how simple it would be to cause the sugar to form again as crystals, and very little agitation, or merely the addition of a single crystal of sugar will cause the whole of the sugar to crystallise out again. This must be guarded against in the boiling of sugar and is also seen in some icings as surface eruptions.

To prevent the mass from graining through the ebullition of boiling liquid an acid (usually cream of tartar) is added or an amorphous sugar, such as corn syrup, which effectively does the work of preventing graining taking place until it is required to happen.
13.6 What was the Aquazyme process?

The Aquazyme process was a breadmaking process introduced in 1971. The process was based on a proprietary preparation called ‘Aquazyme’, available from Ch. Goldrei, Fouchard & Son Ltd (Liverpool), and added as a delayed ingredient during mixing. The main features of the process were as follows:

- The use of a proprietary product Aquazyme at the rate of 4 oz/gal (about 25 g/l) of water.
- Two stage mixing, each stage of equal length, total dough mixing time in minutes equal to the water absorption of the flour expressed in gallons/sack.
- The addition of the salt at the rate of 4 oz/gal of water and Aquazyme at the beginning of the second stage.
- The use of yeast at the rate of 8 oz/gal (about 20 g/l) of water, and a dough temperature of 27°C (80°F).
- A bulk resting of the dough after mixing for 10 minutes.

Example recipe:

<table>
<thead>
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<th>lb</th>
<th>kg</th>
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<tr>
<td>Yeast</td>
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</tr>
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</tr>
<tr>
<td>Aquazyme</td>
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<td>0.09</td>
</tr>
<tr>
<td>Salt</td>
<td>4½</td>
<td>0.09</td>
</tr>
</tbody>
</table>

The flour, yeast, fat and water are mixed for half the total mixing time (8½ min in the example recipe) and the mixing halted while the salt and Aquazyme are added. The mixing is then completed.

A similar system introduced by the London Oil Corporation in 1966 was the Camberzyme Process (Collins et al., 1968). To our knowledge neither process is available today.

Reference

13.7 What is trencher bread and how was it used?

It is believed that trencher bread was first mentioned in fifteenth century books on etiquette (David, 1977) though its origins are likely to be much earlier than the references. Trenchers were coarse slices of bread, from loaves four days old, used instead of a plate at a medieval meal. After the trencher had served its purpose as a plate and had been saturated by the sauces and juices of the meal laid upon it, it was eaten by the servant, cut up for the poor or given to the dogs.

Trencher bread was made from coarsely milled flour which probably comprised some wholemeal (wheat) flour and some whole barley or rye flour. The wholemeal flour may have been sieved to remove the fine white flour that would be used in the making of manchet bread. Manchet bread was the finest and whitest variety and only eaten by the nobility. The coarse flour was made up into large, flat, round dense loaves which were probably baked in an oven, though occasionally they were baked on a hot plate. The loaf was probably turned half way through baking to give two flat, firm crusts and an even layer of crumb.

The trencher loaves were stored for four days and then prepared by the servant using a special knife for the purpose. (The upper crust was destined to be the nobleman’s plate and may well be the origins of the phrase ‘upper crust.’) It is believed that the top and bottom crusts were removed, along with the side crusts leaving a square, crustless loaf about two to three centimetres high. This ‘loaf’ was then made into one or two square plates on which a serving of meat could be placed. In later periods the trencher bread was replaced by wooden or pewter platters.

A recipe and method for trencher bread:

<table>
<thead>
<tr>
<th>g/mix</th>
<th>lb/sack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholemeal flour</td>
<td>1120</td>
</tr>
<tr>
<td>Whole barley flour</td>
<td>560</td>
</tr>
<tr>
<td>Salt</td>
<td>24</td>
</tr>
<tr>
<td>Yeast</td>
<td>12</td>
</tr>
<tr>
<td>Water</td>
<td>1140 ml</td>
</tr>
</tbody>
</table>

Mix the dough on twin arm low-speed mixer for about 20 min and then ferment in bulk for half an hour. Scale dough pieces to 1.8 kg (4 lb), mould into a ball, rest for 10 min and pin out to discs 267 mm (10.5 inches) in diameter. Place dough on greased baking sheets, prove for about 50 min and bake for 45 min in an oven at 204°C (400°F). Once cool, wrap the loaf in a tea towel and store for four days. On the fourth day cut the loaf in the correct way to give one or more trenchers.

Reference
13.8 What is the product known as a Grant loaf?

The Grant wholemeal loaf is one recommended by Doris Grant (1944). Grant had taught household readers to mix and bake wholemeal bread by an easy method with no kneading and only one rising. The Grant loaf is not one intended for commercial production but rather for home baking. The following is the method and procedure suggested by Grant, with imperial units:

3½ lb English stoneground, wholemeal flour
2 pints 4 fluid oz of water at blood heat (or slightly less)
1oz sea-salt, Maldon salt or ordinary salt
1oz sugar, preferably Barbados muscovado cane sugar
1oz yeast (or up to 4 oz extra food value)

The production method was as follows:

• Mix the salt with the flour in a large basin and warm it (make lukewarm – not hot) on the oven top or above a low gas flame, so that the yeast will work quicker.
• Crumble the yeast into a pudding basin, add the sugar and a quarter pint of lukewarm water.
• Leave for ten minutes to froth up; then stir to dissolve sugar.
• Pour this yeasty liquid into the basin of warm flour. Add the rest of the warm water, and do so gradually in case all the water is not required.
• Stir the whole with a wooden spoon until the flour is evenly wetted, then mix well by hand for two minutes.
• The resulting dough should be wet enough to be slippery, but not too wet.
• Grease three two-pint tins inside and warm them well. Turn the dough into the warmed tins, put them about two feet above a low gas flame (or in the oven while the oven is warming up), cover with a cloth and leave for about 20 minutes to rise by about one-third. Bake in an oven at 205 °C (400 °F, regulo 5) for 45 minutes to an hour.

Grant considered that ‘real’ bread should be made from wholewheat grown on naturally fertilised soil and freshly stoneground (c.f. organic). She identified the most important production points as being:

• to warm the flour and the baking tins;
• to froth up the yeast separately;
• to make the dough wet enough to be slippery;
• to remember that wholewheat dough must not be kneaded and only requires a few minutes to mix.

David (1977) gives a metric recipe as:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholemeal flour</td>
<td>1.6 kg</td>
</tr>
<tr>
<td>Water</td>
<td>1.25 litres</td>
</tr>
</tbody>
</table>

SOFTbank E-Book Center Tehran, Phone: 66403879,66493070  For Educational Use.
Salt 30 g
Sugar 30 g
Yeast 30 g (or up to 120 g for extra food value)
Margarine or butter (optional) 60 g.

Tin size: three × 1kg tins
Baking temperature 205°C

We have tried out the method using 500 g wholemeal flour to 0.5 l water with mixing for 5 min with a household mixer. The resultant bread was coarse structured with fragile crumb but perfectly acceptable for home-made bread.

References
What is Baumkuchen and how is it made?

*Baumkuchen* is a speciality cake much loved by Germans. It takes its name, meaning tree or log cake, from the way the batter was originally deposited and baked, layer by layer on a thin log which was rotated over an open wood fire. It is said to have its origins with the ancient civilisations of the Greeks and Romans. It is believed the Romans brought the technique for producing the *Baumkuchen* as they conquered Northern Europe and in Germany the techniques were practised and enhanced to give the modern-day *Baumkuchen*.

A typical recipe is:

- 500 g butter
- 500 g sugar
- 1500 g egg
- 500 g flour

The recipe can be varied by adding other fillings such as ground nuts, honey, marzipan and rum or brandy.

The method of baking is critical and it is doubtful that it can be carried out without special equipment. Normally baking is carried out in a specially constructed oven which is heated at the bottom with open gas jets. Above, there is a revolving hardwood tapering roller or tube upon which is fastened either a piece of cloth or, more usually, buttered greaseproof paper, which is tied with thin string at regular intervals to assist in the adhesion of the batter and subsequent removal of the baked cake.

The batter, which is similar to that used for *Sandkuchen* (a traditional Madeira-type batter), is poured over the greased paper while the roller is constantly revolving. To prevent large cakes from slipping off the rollers, the latter are preheated and the first layers of cake are baked more thoroughly than the following layers. As each layer is cooked, a further layer is poured over until the desired thickness is obtained. Baking is accomplished by adjusting the heat source and/or the distance of the cake from that source.

In order to obtain the characteristic regular wavy appearance, the rotating cake is scraped with a large metal comb and finished with a specially shaped rod. Using a broad palette knife the cake is then marked in rings where the pieces of string hold the paper. While still in the oven the baked cake is decorated with apricot purée which serves as a glaze. Other finishes such as fondant or chocolate can be added afterwards. The roller is then removed and the entire cake cut up into rings or used in an upright position as a speciality cake for Easter or other festive occasion.

Sometimes the cake is removed immediately from the roller and cut into a variety of sections (e.g. rings, wedges, slices). The crumb of the *Baumkuchen* is firmer and drier than that of Madeira cakes. The regulation of the flames during baking is very important and experience is needed to get the best results.
13.10 **What are the origins of poppadams?**

Poppadams are like extra-large crisps and are an accompaniment for Asian foods (see Fig. 32). Alternative names are papadams, puppodums, appalan and papad. Papads are roughly round, the dimensions varying according to where the papad is manufactured. Most fall within the following dimensions: diameter 10–18 cm; thickness 0.5–1.5 mm; weight 4–24 g. A typical papad is about 16 cm in diameter, 1 mm thick and weighs about 15 g. The colour of the papads depends on the type and quality of flour and other ingredients used. The colour can be yellowish white to yellowish brown.

Papads are eaten with any type of meal or as a snack. One or two per meal per person is usual but as with many foods it depends on personal taste.

Papads are eaten after frying for a few seconds in oil, or grilling or microwaving. When fried in oil they expand by about 30–40%. After the heating process the papad becomes crisp and brittle.

A basic recipe is:

- 100 parts blackgram flour
- 45 parts water (variable)
- 8 parts salt
- 1 part sodium carbonate or 1.0–1.5 parts sodium bicarbonate

The flour is obtained by milling a pulse (bean) *Phaseolus mungo* or known more commonly as blackgram. Each pod contains between 5 and 15 oblong-shaped seeds, 3–4 mm long and 2–3 mm wide. The pods are dried under the sun, the
seeds taken out, their husks removed and the bean milled. Other types of flour are sometimes mixed with the blackgram flour to produce different varieties of papads.

The carbonate additions are essential as they improve the colour of the dried papad, prevent formation of brown patches during frying and to mellow the ‘pulsy’ flavour of blackgram. Salt is added to give flavour, improve the rolling properties of the dough and increase expansion during frying. Papads may be spiced by adding chilli, white pepper, black pepper, garlic or jira as desired.

The dough is made by an all-in method (the carbonates being dissolved in some water). When made, the dough is tough and sticky. It is rested for approximately 30 min, then divided into small balls about 4–6 cm diameter and 18–20 g in weight. The balls are then rolled out into thin circular discs of about 1 mm thickness and 15–17 cm diameter. Oil or corn flour is used as an aid during rolling.

Traditionally the rolled out papad is dried under the sun to reduce the moisture content to 14–15%. The papads are then ready for consumption. For storage, which should not be for long, the papads can be put in airtight containers or sealed in moisture-impermeable film.
13.11 What is kebab bread?

Kebab bread is the Western European name for the Middle Eastern bread known as Pitta or Khubz. This type of bread has been popularised by Greek-Cypriot restaurants who serve the bread with shish-kebabs.

The following recipe and method have been found suitable in commercial practice.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>kg</th>
<th>lb</th>
<th>oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>100</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Yeast</td>
<td>0.7</td>
<td>3</td>
<td>¼</td>
</tr>
<tr>
<td>Salt</td>
<td>2.5</td>
<td>11</td>
<td>¼</td>
</tr>
<tr>
<td>Water (fairly soft dough)</td>
<td>57</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

The flour used is white, untreated, unbleached and low in protein. The dough is mixed on a low-speed mixer for about 20 min to a dough temperature 27–28°C (80–82°F). After 45 min from the beginning of mixing the dough is scaled into 150 g (5 oz) pieces, moulded round, rested for 10 min, and then pinned to give a thin flat oval shape about 24–25 cm (9½–10 in.) long and about 11 cm (4½ in.) wide. The oval dough is proved between cloths for 10 min and then baked on the sole of an oven at 316°C (600°F) for about 5 min. Following baking, the pittas must be cooled for about 10 min, after which they can be stacked. The breads may be put into polythene bags once they are cool enough to keep them soft and flexible. They can be reheated under a warm grill before serving.

It is essential to use untreated flour since treated bread flour gives pittas with large blisters and an uneven distribution of crumb between top and bottom surfaces. Harsh mechanical pinning might benefit the product when compared to hand pinning.
13.12 What is balady bread?

Balady bread is an Egyptian bread product based on a sour dough or starter system. The starter dough is used in order to provide flavour rather than for leavening purposes. The bread is round, flat, puffs up during baking and is easily separated into two layers. The flour blend normally used for this product is 25–30% US flour of 72% extraction and 70–75% Egyptian flour of 82% extraction, the latter being similar to a blend of 75% CBP-type flour and 25% wholemeal.

Recipe for starter:

- 11 kg old dough
- 100 kg flour
- 50 kg water

Compressed yeast may be added in cooler weather. The starter dough is fermented for at least 3 h. The fermentation period may be longer, depending on how soon the starter is required for use.

Recipe for simple straight dough:

- 100 kg flour
- 75 l water
- 0.5–0.7 kg salt
- 5–15 kg starter dough

The ingredients are mixed for 20–25 min to produce a slack dough (not fully developed) which is then immediately scaled into 182 g (6.5 oz) dough pieces. The dough pieces are moulded into round shapes, placed on trays and sprinkled with bran. Intermediate proving lasts for 15 min. The dough pieces are then flattened into pancake shapes 20 cm (8 in.) in diameter and 1.5 cm (0.5 in.) thick and left to ferment for 1 h.

After fermentation the excess bran is shaken off and the dough pieces are peeled into a hearth oven. Baking lasts for 1.5 min at temperature of 450–600°C (842–1112°F). The crust forms rapidly and after about 1 min baking steam develops in the dough. At this point the dough rises very rapidly. The bread is removed from the oven by peeling.

Immediately after baking the bread is about 12 cm (5 in.) in height, and as it cools the centre sinks to a height of 4–6 cm (2–3 in.). The finished product has a firm crust with a very soft moist interior. The crumb may be split and filled with beans, cheese, etc.
13.13 How are chapattis made?

Chapattis are a baked product related to bread and originate in Asia, where they are eaten with almost every main meal. Traditionally, chapattis are made fresh for each meal and are roughly round in shape (see Fig. 32), with a diameter ranging from 12 to 18 cm and thickness varying from 1 to 3 mm. A great deal of variation in size and formulation occurs depending on personal preference.

Typical recipe:

- Flour 1 kg
- Water 650–750 g

Wheat flour is used to make chapattis. The extraction rate can be anything between 75% and 100%. The dough is made by mixing flour and water, with salt and fat added according to personal taste. The recipe does not contain yeast. The dough, which is fairly firm, is rested for up to 30 min before being scaled into portions weighing 30–85 g. These are rounded into balls. A further rest is desirable before rolling the balls into thin discs 1–3 mm thick.

The rolled out chapattis are cooked on both sides using a hot plate at a temperature of 233–260°C (450–500°F). Cooking time will depend on the thickness, and continues until the chapattis start to blister on both sides and the colour starts to turn brown. This stage takes approximately 1–2 min for each side. Chapattis may be eaten after this stage has been reached or they may receive a second baking called ‘puffing’. In the puffing process, which takes just a few seconds, a chapatti is placed under a grill or over a red-hot fire and it immediately puffs up into a ball. As soon as it has puffed it must be taken away from the grill or fire or it will burn. At this stage the chapatti is composed of two layers of skins with a space between. Puffing is rarely carried out on chapattis more than 2 mm thick as they do not puff well.

After puffing, the chapattis collapse back to the original shape and they should be stacked one on top of the other to avoid drying out. To prevent them sticking together, the surface of the chapatti is greased with butter, a practice with the added advantage of making them soft and imparting a buttery flavour. The final chapattis will vary in colour according to the type and extraction rate of flour used, but almost all will have brown blisters, some of them slightly burnt. If chapattis are stored after cooking for more than a few hours, they tend to stick together and lose their attractive eating characteristics. Stale chapattis can be improved by reheating but they do not regain their original quality.
13.14 What are stotty cakes and how are they produced?

Stotty cakes (stotties) are a traditional Tyneside delicacy prepared from a bread-like dough enriched with fat and sugar. A close relation is the bread cake found in Yorkshire. Both products are not strictly cakes in that they are not prepared from a batter.

A typical recipe is as follows:

<table>
<thead>
<tr>
<th>% flour weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
</tr>
<tr>
<td>Salt</td>
</tr>
<tr>
<td>Lard</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Yeast</td>
</tr>
<tr>
<td>Milk powder</td>
</tr>
<tr>
<td>Water, approx.</td>
</tr>
</tbody>
</table>

The dough is scaled at about 340 g (12 oz), then rounded and flattened as for teacakes. The dough pieces are baked either between two sheets or baked on the oven sole and turned halfway through baking. Very occasionally, stotty cakes may contain fruit.
13.15 What is ganache?

Ganache is the name given to a blend of chocolate and cream. To prepare it 1 kg grated couverture is placed in a stainless steel bowl. Over this is poured 1 l boiling, fresh cream and the mixture is stirred. The heat of the boiling cream melts the couverture and the two amalgamate to form a smooth paste. This should be stirred occasionally until it is cool.

Ganache takes many forms and is used in many ways. Since cream is expensive, various methods of reducing costs can be adopted but in all cases may reduce the quality of the product. For example, cream can be replaced by non-dairy cream, by milk or by water containing a little margarine or butter. The couverture may be replaced with cheaper bakery chocolate.

Milk ganache can be made by using milk chocolate instead of plain couverture and this type of material is excellent when blended with an equal quantity of butter cream flavoured with kirsch, for making fillings for continental types of gateaux and torten.
13.16 What are tortillas?

A tortilla is a non-fermented product made from maize flour, and is the basis for many traditional Mexican dishes. The past few years have seen a rapid increase in the consumption of Mexican-style foods. Tortillas are hot-plate goods and have a simple recipe:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole maize flour</td>
<td>100</td>
</tr>
<tr>
<td>Water</td>
<td>33</td>
</tr>
<tr>
<td>Lime (calcium hydroxide)</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The lime must be suitable for use in food and comply with local food legislation.

The recipe uses whole maize flour which has been passed through a US 40 mesh sieve (screen size 0.016 in.). The tortilla dough, known as masa, is formed into individual circular dough pieces about 15 cm diameter and 2 mm thick and cooked on a hot plate until both surfaces are slightly browned.

Tortillas can be eaten alone like bread, or fried with a cheese topping (nachos). However, the most popular form appears to be the taco. After frying the tortilla can be filled with items such as meat, tomato, cheese, olives, peppers and sauce. Alternatively the tortilla may be softened in oil or sauce, rolled round a meat or cheese filling and baked to produce an enchilada.

Wheat flour tortilla are also available and used in a similar manner to the maize tortilla. The advantage of the flour tortilla is that it remains soft eating and has a blander flavour than the maize version.
What are the origins of the cottage loaf?

Bread is made and baked in a variety of shapes and sizes, one of these being the ‘cottage’ loaf. Its origins are not known for certain. There would not seem to be any particular reason why a loaf should be made from two moulded dough pieces and then assembled one on top of the other before baking. Loaves made in this fashion have been known for hundreds of years. In ancient times a loaf called a *nastus*, was made in this form and Nicostratus, an ancient poet, wrote of it as follows:

Such was the size, O Master, of the Nastus,
A large white loaf. It was so deep; its top
Rose like a tower quite above its basket;
Its smell when that the top was lifted up,
Rose up, a fragrance not unmixed with honey.

Although there would not seem to be any misunderstanding nowadays as to what is meant by a cottage loaf, there seems little available information as to how it has obtained and retained its name. It is possible that many years ago, when baking was largely done at home, and where accommodation was limited and family sizes larger than today, the housewife had to invent some means of

![Side view before joining](image1)

![Side view after joining and cutting](image2)

![Top view after joining and cutting](image3)

*Fig. 33* Cottage loaf cutting.
getting sufficient bread baked to satisfy the demands of the family. By placing one ‘cake’ of bread on top of another, keeping the top smaller than the bottom so that it would not topple over in the oven or come into contact with the walls of the oven the housewife created a single loaf composed of two ‘cakes’ of bread. The two ‘cakes’ were held together by a deep indentation (perhaps by the baker’s elbow) made vertically downwards from the upper into the lower portion.

This, of course, is supposition but in all probability it was lack of space in the oven that first made the cottager experiment with one loaf on top of another and so evolved what easily might be called the ‘cottager’s’ loaf, which has now become a cottage loaf. A variation of the loaf is one called a ‘cottage brick’ where two brick-shaped dough pieces were baked on top of the other.

Both versions of cottage loaf are notoriously difficult to make. Each part is proved separately and then combined before final proving is reached. Care has to be taken that the two surfaces which are to be joined are flat and that the lower dough piece does not collapse under the weight of the upper one. The cutting or ‘notching’ of the product is as much about controlling loaf shape as it is about providing a distinctive appearance (see Fig. 33).

Further reading
Preface

From time to time we all encounter problems in the manufacture of baked products. Sometimes they are seen as defects in the baked product which arise for no obvious reasons. On other occasions we simply need to understand what are the most important criteria to consider if we have to or want to change ingredients or processing conditions.

Solving baking problems has always been the province of the bakery ‘experts’, those mysterious persons who always seems to know how to restore the loss of quality, or what recipe and process changes to introduce to achieve a given quality. To those of us who do not have the necessary expert knowledge, such persons are often held in awe. Yet problem solving is not as much of a ‘black art’ as we might think. With a methodical approach and keen observation then the answers to many of our bakery problems are indeed ‘elementary’.

Our expert problem solvers usually have one distinctive advantage – experience. They have seen it all before! Or if they have not, then they know a good reference book or another expert to consult.

This book owes much to the work of bakers, technologists and cereal scientists formerly working for the British Baking Industries Research Association and later the Flour Milling and Baking Research Association, both based at Chorleywood, Hertfordshire, in the UK. Over 50 years these experts in cereal science, milling and baking studied and identified many causes of bakery problems and recorded them for others to access. In this book we have taken the opportunity to synthesise their work, and to update and enlarge it from our own experiences.

We hope that you will find some value in our efforts and that the contents of this book will help you become that mysterious bakery expert.

Stanley P. Cauvain
Linda S. Young
We wish to dedicate this book to
the bakers, technologists and scientists who worked at
the British Baking Industries Research Association
and
the Flour Milling and Baking Research Association
formerly based at Chorleywood, UK
13.18 What is micronised wheat?

The micronising process involves the treatment of grain by infrared irradiation, and is not to be confused with ultra-fine grinding by the ‘Micronizer’ fluid energy mill. When infrared rays penetrate they cause the molecules of the material to vibrate at a frequency of 60,000 to 150,000 megacycles per second. This results in rapid internal heating and a rise in water vapour pressure. The grains become soft and turgid causing them to swell and fracture. Immediate rolling or flaking gelatinises the starch, considerably enhancing digestibility and feed value of the grain.

Micronising drastically reduces the counts of bacteria and moulds. The counts from two sample wheats are given below:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Bacteria Count per g</th>
<th>Mould Count per g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated wheat</td>
<td>540,000</td>
<td>1200</td>
</tr>
<tr>
<td>Micronised wheat</td>
<td>&lt;100</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

The effect on the milling is less efficacious. For example, in a measured experiment a control wheat conditioned to 15% moisture content (m.c.), yielded 67.3% flour, and a micronised wheat similarly conditioned yielded only 36.4% of flour. The micronised wheat flour produced was of poor colour, and clean-up of bran was unsatisfactory. It was concluded that micronised wheat was unsuitable for the normal roller-mill process to produce white flour.

The flour from micronised wheats would not be suitable for normal bakery products since the gluten quality would be spoilt by the heat generated in the micronising procedure but often finds use where the thickening properties of the gelatinised starch have value, e.g. soups.