# 1 Questions and Flour Problems

Most of the following questions have been compiled during the past decade. They were sent by fax or email, or communicated orally. Some of them seem to be redundant, because they were received from different sources. Very often, they concern common problems and daily challenges of millers. If the book treats the addressed issue in one of the following chapters, this will be indicated by a blue button, carrying the question number as reference mark.

## 1.1 Cultivation, Harvest and Wheat Supply

1 *Is there a connection between soil characteristics and the quality of wheat?*

Wheat needs good soils that ensure an adequate supply of nitrogen to the plant. Soil quality can be improved with suitable fertilizers and by the right choice of the preceding crop.

2 *How do the weather and fertilization affect the properties of gluten?*

Nitrogen fertilization and cool weather increase the amount of the softening gluten component gliadin. In warm, dry conditions more glutenin is stored, and this results in short and dry dough properties. Page 132

3 *What are the principles for storing freshly harvested wheat?*

At least the worst of the dirt and black dockage should be removed before the wheat grains are put into storage. The moisture content should also be measured so that excess water can be reduced by drying or regular turning over with the pneumatic system to prevent the growth of micro-organisms and other pests. The moisture content should be adjusted reliably to a level below 14 %; then the wheat can be stored for some long time without loss of quality.

4 *Which countries are the largest exporters of wheat?*

In 2003 - 2004 the USA exported the largest quantity of wheat (31% of world wheat exports), followed by Canada (16%), Australia (15%), Argentina (8%) and the EU (7%).
Page 13

5 *Which countries import the largest quantities of wheat?*

Egypt and Brazil with 6 million tons, closely followed by South Korea (4 mio t) and the Philippines (3 mio t).
Page 13

6 *What percentage of world wheat production is used for food?*

Of the annual production of about 600 mio t, almost 10% is lost through rodents, insects and improper storage conditions. About 15% is used to feed livestock, mostly in the EU, where 40% is used for feed. A small amount, about 5%, is used for technical applications, in particular secondary wheat products for the (bio)chemical industry such as starch and gluten hydrolysis products. A fast-growing non-food application of wheat (and other crops) is biofuel production. These figures leave about 70% or 400 mio t for food use.

7 *Will there be an adequate supply of wheat in the future?*

Although the wheat stocks seem to be falling slightly, there will probably be sufficient wheat at least in the next 2 or 3 decades because of the recovery of production areas in Eastern Europe and improved agriculture in China and India. By the end of this period, improved productivity of the wheat plant resulting from genetic modification may ensure a stable supply for a growing number of consumers.
Page 16

*8 Will China become a major wheat exporter in the near future?*

Although the wheat imports dropped sharply from almost 12 mio t in 1995 to 400 thousand t in 2003, imports have recently risen again because of rapidly increasing demand. The consumption of wheat products increases as the average income rises. The trend is supported by the still slowly growing population. So it is rather unlikely that China will soon become a wheat exporting nation like the EU, for example. Page 72

*9 When does the new wheat season of the major wheat exporting countries start?*

Even within one wheat-exporting nation there are broad harvesting seasons, with Argentina probably showing the sharpest division between the old and the new harvest; this is due to the comparatively small wheat planting zone. Furthermore, the winter wheat harvest usually starts and ends approx. 6 weeks earlier than the harvest of spring wheat.

| | |
|---|---|
| Argentina | November - January |
| Australia | August - January |
| Canada | July - September |
| USA | May - September |
| EU | June - August |
| China | May - August |
| India | February - September |

*10 How does fertilization affect gluten properties?*

Nitrogen fertilizers increase the overall protein of a variety, but the general properties are not changed: a normal gluten remains normal, with higher energy levels in the Alveogram and Extensogram; a soft gluten becomes even softer. The latter is due to an increase in gliadin, the soft component of gluten. Page 129

*11 Can the resistance of wheat towards diseases signifcantly be reduced by conventional breeding, or only by genetic modification?*

Breeding for resistance has always been a major target of the breeders, but the achieved results certainly can be improved, either by further breeding or by genetic modification through methods of modern biotechnolgy.

## 1.2 Varieties and Classes

*12 What is a variety?*

A wheat variety is characterized by specific attributes such as resistance to weather conditions, enzymatic activity or growth height. Other objectives in breeding a variety are its protein content and the properties of the gluten. Varieties are usually approved and then checked again and again through monitored cultivation.

*13 How is a wheat class defined?*

A wheat class comprises all those wheat varieties complying with the definition for the class, e.g. colour, hardness, protein etc. The names of the classes and their definitions are characteristic of each wheat growing nation. But even similar names (e.g. Hard Red Winter) do not necessarily mean that identical quality parameters are used for classification.

*14 Do the attributes of varieties vary?*

The attributes of varieties should establish themselves in the growing areas, but that is not always the case. Weather conditions, especially, can cause the dominance of various attributes of the variety to be lost. "Replanting" of the wheat grains, i.e. sowing grains already harvested, can also result in loss of the desired attributes, so only new seed should be used.

*15 How are consistent attributes of a variety achieved by breeding?*

For decades plant breeders have ensured the attributes of varieties by crossing different wheat varieties and practising careful selection over a period of many years. More recently biotechnological methods have been used, including the transfer of genes, in order to achieve successful breeding more quickly.

These methods will make it possible, for the first time, to introduce attributes from other organisms into the wheat to optimize characteristics such as weather resistance or water requirements. Genetic engineering enables the goals of breeding to be achieved faster.

16 *What are the goals of breeding up to the year 2010 in D, EU, USA, Canada, Russia/CIS, Argentina, China?*

In all countries breeding is ultimately directed towards increasing yield with less work. One possibility is to make the wheat plant resistant to pesticides, especially weed killers. Another goal of breeding may be to increase resistance to fungal attack. In view of climate changes the ability to thrive on dryer soils might be a further desirable characteristic.
Whereas plant breeders used to operate on the regional level, they are now major international groups that produce seed throughout the world and market it for specific regions.

17 *Which are the most common U.S. wheat classes for export?*

HRW, HRS (including DNS), and HWW mostly for bread flour;
SW and SRW are usually for cake and pastry flour and durum for pasta semolina.
Page 20

18 *We are currently using DNS/CWRS wheat which is no longer available or is too expensive at the moment. Which variety comes closest to it?*

Generally speaking, the balanced protein properties of these wheat varieties have to be achieved by mixing other wheats. In many cases it will be necessary to combine a wheat with very firm gluten with a softer wheat. There are doubtless many examples of this. One would be a mixture of about 30 % German Elite wheat with 60 – 70 % A wheat and possibly a small amount of B wheat; other possibilities would be 40 - 50% Australian Prime Hard mixed with Australian Soft, or Australian Soft and Australian Hard in suitable proportions.

Although it will not be possible to make such changes unnoticed in most cases, the miller's customers will usually be able to achieve optimum baking properties after a short time, once they have got used to the new flour.

19 *Can I replace 100% of the DNS wheat used in a bread flour if I apply the correct treatment?*

Yes, if the target is to replace untreated or suboptimally treated DNS with a cheaper wheat. But optimally treated DNS is hard to beat in most bread applications as far as volume yield and dough tolerance are concerned. Of course some wheat varieties, e.g. CWRS, perform at least as well as DNS, though they are probably not cheaper.

20 *Which is the main U.S. wheat class?*

Hard Red Winter accounted for 41.5% (27 mio t) of the total production from 1990 - 1999.
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21 *How are wheat classes distinguished from each other?*

Gene sequencing is the most accurate method of determining and distinguishing between wheat varieties. Determination of the migration of the proteins from a wheat in a gel by electrophoresis is also very precise. The visual and physical properties of a wheat can also be used to distinguish between wheat varieties, but errors are more likely to occur due to the multifactorial nature of the phenotype.
Page 45

22 *Are there methods for quick determination of wheat varieties?*

For Canadian wheat, a sophisticated system based on the visual differences is being used to determine wheat varieties (KVD, kernel visual distinguishability). But it is very likely that this system will be replaced by a more reliable DNA fingerprinting system which can be automated, in contrast to KVD.
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*23 Can Argentine wheat replace HRW or CWRS wheat?*

Yes – occasionally. Unfortunately there is still no wheat classification system, so the fluctuations from batch to batch and from year to year are quite large. That makes it difficult to identify a wheat class that can certainly compete with high quality North American wheat classes.

*24 Can the quality of French wheat be compared to that of Australian or North American wheat?*

Yes, it can. But the wheat is quite different. The quality of wheat from all for origins is usually very high; problems only occur when the wheat supplier changes. In most cases the milling and baking processes have to be adapted to the new wheat quality. After adaptation, similarly good results should be possible. Nevertheless, certain applications have been tailored to the wheat, so it will be difficult to produce a French baguette with all its inner and outer characteristics with Australian or American wheat, or to obtain a pan bread with extremely low specific weight such as American toast bread from French wheat.



## 1.3 Milling and Extraction

*25 Is the world milling industry growing?*

The capacity of the milling industry is slowly growing. This growths appears to be mostly due to the growth of the world population. Only in a few regions, particularly in Asia, the consumption of wheat flour is also growing. In contrast, the number of mills is decreasing due to mergers and increasing capacities of new mills.
Opinion obtained from Charles Sosland, Sosland Publishing Inc., USA.

*26 What is the difference between dockage and Besatz?*
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*27 Does the particle size of the flour influence the effect of the enzymes?*

The finer the particle size, the larger is the area that can be attacked by the enzymes. Moreover, the constituents of the flour hydrate faster, and this makes them more readily accessible to the enzymes. This is especially true of amylolytic enzymes, because a fine particle size is often accompanied by greater damage to the starch (although this is not necessarily the case). The damaged starch grains already swell in the dough and are thus available to the amylases. Intact starch grains are not.

*28 Which particle size is better – 90 or 150 microns ?*

That depends on the properties you want the flour to have. Smaller particles usually mean more damage to the starch if the small size was achieved with ordinary cylinder mills. This results in greater water absorption and better breakdown by enzymes and yeast, but also reduced stability of the dough. In coarser flours there is not only less damage to the starch; the larger particles also swell more slowly, with the result that the doughs stiffen subsequently and thus become more stable. Coarser flours also cause less dust and have better flow properties.

*29 How does the milling yield (extraction rate) affect protein and ash? Is there some correlation between the protein and ash content of flour?*

Endosperm protein and the mineral content decrease from the outside of the kernel to the centre. At higher extraction rates, the amount of the aleuron and outer endosperm layers is larger than in flour from low extraction rates. This means that ash and protein increase with the extraction rate. They are both correlated to a certain extent.
Pages 34 and 103

30 *Why should the germ be removed from the kernel before milling? Why is there a difference in shelf-life between white flour and whole meal flour?*

The germ contains about 10% lipids, mostly unsaturated. The milling process would destroy the structure in which the lipids are bound, exposing them to atmospheric oxygen. Rapid oxidation (both enzymatic and non-enzymatic) and thus rancidity would occur. Whole meal flour containing the wheat germ is therefore less stable than white flour.
Page 3

31 *Why does flour from the wheat of a new crop / harvest display different attributes from those of flour from wheat that has been stored for several months?*

Maturation of flour is a natural process caused mainly by exposure to atmospheric oxygen. In almost all cases freshly milled flour has a much poorer performance than flour stored for 2 weeks.

32 *Is there any way of adding chemicals at the tempering stage, i.e. some water-soluble type, to achieve a whitening effect?*

There have been partially successful attempts to improve the removal of the bran by adding enzymes to the soaking water, which would result in a brighter colour of the flour. The author is not aware of any trials with oxidizing substances such as chlorine, benzoyl peroxide or hydrogen peroxide. The use of oxidizing agents might have some effect on the colour, but access to the carotenoids of the intact kernel is probably limited, so the approach would not be very effective.

33 *Why does the volume yield fall as the degree of extraction increases, although the protein content rises with higher extraction?*

The proteins of cereal are unequally distributed over the layers of the grain. The water-insoluble protein fractions glutenin and gliadin that are mainly in the endosperm, whereas the aleuron layer, although rich in protein, contains mainly water-soluble proteins that do not improve the baking properties.
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## 1.4 Flour Components

### 1.4.1 Starch

34 *What is the percentage of starch in wheat flour?*

Wholemeal flour contains 60% starch, and light-coloured flour with an extraction level of 75 to 80% contains about 70% starch. In both cases this is based on a moisture content of 14%.

35 *What are the differences between the starch fractions?*

Wheat starch consists of about 25% amylose and 75% amylopectin. The amylose is made up of glucose chains, i.e. of linked alpha-D-glucopyranosyl groups joined to the $C_1$ and $C_4$ atoms, with very few branching points at some $C_6$ atoms. One amylose molecule contains about 200 - 2,000 glucose sub-units. Amylose molecules have the structure of left-handed single or double helices. Amylopectin is a much larger molecule (approx. 6,000 - 100,000 glucose sub-units) characterized by frequent branching at the $C_6$ atom.

36 *How are starch and damaged starch determined analytically?*

The amount of starch in a wheat flour can easily be determined by washing the starch out and drying the suspension thus obtained. The determination of the damaged starch can be carried out by chemical end group analysis or modern enzymatic methods. In this case special enzymes are used that cause measurable conversion of materials.

37 *What role does starch play in the dough, in the baking process and during storage of the baked products?*

During preparation of the dough the starch attaches a large part of the water used in the process to its surface. Damaged starch can even bind water at temperatures below the gelatinization point. During baking the gelatinizing starch binds the water separated from the protein and adsorbs it. When the baked product cools down to a temperature below 60 °C the starch begins to age (retrogradation or syneresis). This process is very slow at first, but at temperatures between 15 °C and freezing point the starch ages much faster. This change in the starch makes the crumb of bread firmer, a process that can be reversed partially and for a short time by re-baking.
Page 255

38 *Do the carbohydrates of the wheat react with flour improvers and baking agents?*

The activity of the endogenous starch-degrading enzymes is usually too slight for the production of wheat bread, so they have to be optimized with suitable enzymes e.g. a-amylase or xylanase from microbial sources. Malt flours are only of limited use, since they also contain protein-degrading enzymes that soften the gluten.

39 *What are the processes that cause staling?*

Re-crystallization of starch, particularly amylopectin, and moisture migration from the crumb into the crust are the major causes of staling in bread.
Page 255

40 *Does the quality of the starch (not just damaged starch) in our flour affect the quality of the bread in addition to the usual parameters measured?*

For many years we have been observing a fluctuating response of the starch to rheological tests such as the Amylograph. Although one and the same wheat variety may have similar Falling Numbers and even similar maximum viscosity figures in consecutive years, the gelatinization temperature may vary considerably. So far it can only be speculated that the protein-starch-pentosan matrix of the starch granules differs. In years with less moisture it is likely to be denser, so gelatinization occurs at higher temperatures. In the bread, this will be perceived as a lack of crumb softness or reduced duration of the crumb softness. Malt flour, amylolytic and also xylanolytic enzymes help to improve the situation.

### 1.4.2 Proteins

41 *What is gluten?*

Gluten is often equated with the proteins of the wheat that are insoluble in water. It is a fact that glutenin and gliadin are the main constituents of gluten in terms of quantity and determine its basic character. But smaller components such as lipids or pentosans are firmly and in some cases even covalently bonded to the gluten and have a corresponding influence on its properties. Commercial gluten (dried vital wheat gluten) also contains starch and minerals that cannot be completely removed by aqueous extraction. That is why dried gluten only contains about 80% protein.

42 *Is there a connection between the quality of the protein and its chemical structure?*

The baking properties of wheat flour depend to a large extent on the amount of protein, the ratio of gliadin to glutenin and the properties of the latter, especially the disulphide bridges.

43 *How are proteins and gluten determined analytically?*

Protein in wheat flour can be determined chemically by the Kjeldahl method, but the procedure is very complex. A simpler method is to use a modern analytical system that works according to the Dumas method. The indirect test by near-infrared spectroscopy (NIR) is very widely used in the milling industry. If calibration is carried out carefully, near-

infrared transmission (NIT) also yields very precise results.
Page 43

### 44 *What effect do the proteins of the gluten and added vital wheat gluten have on water absorption?*

The water absorption capacity of native gluten is about 2.5 - 3 times its dry weight, i.e. a flour with 10% protein will result in approx. 25% wet gluten although not all of the protein ends up in the wet gluten.
Page 245

### 45 *What effect does the addition of vital wheat gluten have on the rheological properties of dough?*

Dry vital wheat gluten has a rather short gluten structure, so it reduces the extensibility of the dough and increases its resistance to extension. The energy input (area under the curve of the Alveogram and the Extensogram) does not necessarily increase. In the Farinograph the curve will be broader, with better stability and less softening.
Page 245

### 46 *How do the proteins of the gluten affect the shelf-life of the bread?*

Gluten increases the water absorption of the dough and the bread, and it improves the volume yield and crumb structure. So gluten also enhances the softness of the crumb and its ability to stay soft. Baked goods that are meant to stay crisp after baking (German breakfast rolls, French baguettes) should not contain too much protein because it will soften the crust too soon.

### 47 *What importance do the wheat proteins have for the production of cake doughs and wafer batters?*

In most cases cake is a foam in which protein is a structural component. Too much protein makes the structure rubbery. Many recipes therefore contain starch, which results in a shorter bite. For wafer batter, a low protein content is useful because it reduces the tendency to form gluten lumps. Furthermore, lower protein results in soft-melting wafers. On the other hand, higher protein levels can be used to produce very stable and crisp wafers (e.g. for ice cream cones) with reduced permeability for water. In this case, proteolytic enzymes should be used to avoid lump formation in the batter.
Page 280

### 48 *How does wheat gluten react with flour improvers and baking agents?*

When vital wheat gluten is added, oxidation should be reduced because the dry gluten already has a short structure. Sometimes it is even useful to add softening agents (cysteine, protease). Emulsifiers have at least an additive if not synergistic effect on the improving function of wheat gluten.

### 49 *Is it possible to increase or reduce the gluten content without adding dried gluten?*

There seem to be some additives with the potential to improve the swelling of protein. Of these, fungal proteases are mentioned most often.
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### 50 *Can I use flour with 12% protein as biscuit, cracker or wafer flour?*

Although flour with less than 10% protein is preferable for many biscuits, crackers and wafers, it is nevertheless possible in many cases to obtain good products with a higher protein level. If gluten formation occurs in the course of the processing, sufficient softening will be required, e.g. by reducing agents or enzymes. In the case of wafers the protein has to be destroyed in order to avoid lumping. An increased protein level then results in products with a firmer texture which are less prone to breakage and water migration. The use of starch to dilute the protein is only necessary if a very soft-melting texture is desired. See also *question 47*.
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*51 Does an increase in the gluten content of a bread mix always result in improved volume yield?*

The addition of dry vital wheat gluten results in a strengthening of the dough and increased water absorption (about 1.5 times the amount of added gluten). Gluten generally improves the tolerance of the dough and its gas holding capacity, and therefore increases the volume yield. But if the dough is too stiff for the chosen processing method, the volume yield will in fact decrease.

*52 Should a flour mill be able to offer gluten-free mixes too?*

Any mill processing wheat, rye or barley would have substantial difficulty in making gluten-free products, because the whole mill is contaminated with gluten traces. The actual limit for "gluten-free" is 20 ppm in many countries. "Gluten-reduced" is the term for gluten levels below 200 ppm. 20 ppm gluten is equivalent to 0.02 g of wheat flour in 1 kg of mix, a quantity that can easily result from cross-contamination or residues in the plant. The production of gluten-free goods should therefore be reserved for specialists, e.g. rice mills or mixing companies with a near-pharmaceutical hygiene level.

*53 Why are there different factors for protein for food and feed wheat?*

Methods such as protein determination after Kjeldahl ascertain the nitrogen content of a sample. If the normal nitrogen content of the protein to be determined is known (e.g. from the literature), the nitrogen content found by analysis is multiplied by the reciprocal of the known quantity in order to calculate the actual protein content. For wheat this factor is 5.7, corresponding to 17.5% nitrogen in the protein. For composite foods, proteins of unknown origin and also for nutritional purposes (human and animal) the crude protein is calculated. In this case a factor of 6.25 (corresponding to 16% nitrogen) is used. The latter is being used more and more often to avoid confusing people who are not experts.

Since wheat gluten, for example, is used in both food and feed, the information on the protein content of samples from different sources may differ because different factors have been used. A protein content of 78% (factor 5.7) would then be equivalent to a value of 85.5% (at factor 6.25).
Pages 33 and 245

### 1.4.3 Lipids

*54 Do the lipids present in wheat play an important role in the processing of wheat flours?*

Wheat flour lipids are mostly unsaturated lipids. When the kernel is milled, the lipids are exposed to endogenous enzymes and to oxygen, which results in rancidity. More than 50% of the lipids are located in the bran and the germ (chapter 2.2, page 50), so thorough separation is a prerequisite for a long shelf-life of the flour with unimpaired sensory properties. Flour lipids, in particular the polar phospholipids and galactolipids, improve the volume yield of baked goods.
Page 239

*55 What is the composition of the wheat lipids?*

The wheat lipids are composed of roughly 1/3 non-polar lipids (oil) and 2/3 polar lipids (lecithin, galactolipids and others). They contain mainly unsaturated fatty acids.
Page 236

*56 Do the phospholipids contained in the wheat fats have any technological significance?*

They most probably contribute to volume yield; see also *question 54*.

*57 Are there interactions between the constituents of flour improvers / baking agents and the lipids present in the wheat?*

Lipolytic enzymes hydrolyse polar and non-polar lipids into more hydrophilic molecules;

oxidizing agents react with the unsaturated parts of the lipids causing off-flavour or colour losses (bleaching); emulsifiers probably also interfere with lipids, but the consequences are not known.

### 1.4.4 Dietary Fibres

58 *What dietary fibres do the outer layers of the wheat kernel contain?*

Cellulose, hemicelluloses (xylans, arabinoxylans and glucans) and lignins.

59 *What effects do the outer layers have on the behaviour of flours during preparation of the dough and baking?*

In particular the water-insoluble pentosans – or more precisely the water-insoluble xylans – reduce the volume yield by interacting with protein and absorbing water. Furthermore, the aleuron layer contains soluble protein which does not contribute to gluten formation but rather dilutes the function of gluten proteins.

60 *What effect do flour improvers and baking agents have on the dietary fibres in flours?*

Enzymes from the class of hemicellulases are able to break down some of the non-starch polysaccharides. Oxidative gelation of the pentosans is induced by oxidizing agents or amylases.

### 1.4.5 Minerals

61 *What is the connection between the flour yield and the mineral content?*

Since the outer layers of the grain have a higher mineral content than the endosperm, the ash content of the flour increases with the yield.

62 *What role do minerals play in the processing of flour to make bread, small baked products (e.g. rolls) and pastry goods?*

The minerals contained in the flour have little effect on processing. However, the proportion of (water-insoluble) non-gluten proteins, pentosans and enzymes increases along with the ash content; this permits greater water absorption but also results in weak doughs and a lower volume yield.

63 *Can flour improvers and baking agents reduce or compensate for the technical disadvantages of mineral-rich flours?*

Flour improvers and baking agents improve the processing characteristics of mineral-rich flours, making them superior to those of light-coloured, untreated flours. But when fully treated, the light-coloured flour has better baking properties than dark flour.

### 1.4.6 Vitamins and Fortification

64 *What are the most important vitamins and minerals for flour fortification?*

The most important vitamins and minerals for flour fortification are folate and iron. Other substances often used are the vitamins B1, B2 and niacin, and also the mineral zinc. Vitamin A is only added to flour in a very few countries, possibly for reasons of cost.

65 *What is the basis for the legal requirements in countries where fortification is prescribed by law?*

The legal requirements depend on the specific needs of the population in each country. These are determined in studies carried out by various organizations such as UNICEF, WHO and FFI. The FFI also recommends fortifying flour with at least iron and folate in every country.

66 *How do vitamins and minerals react to storage?*

Vitamins are especially sensitive to heat, moisture, oxygen and light. Nevertheless, they can be stored for at least 1 - 2 years in the tightly closed original container in a cool, dry place (20 °C, 50% relative humidity). Minerals store well; they can be kept for at least 2 years. Mineral and vitamin premixes should be stored in the original container in a cool, dry place and used within a year.

### 67 *What fluctuations in the analytical values are usual or acceptable?*

The fluctuations in the analytical values for a vitamin and mineral premix, and for the individual components of the premix, are usually between 5 and 10%, depending on the vitamin and the analytical method used. In the case of flour, absolute deviations of 1 mg/kg may occur if the vitamin content is less than 10 mg/kg; if the vitamin content is higher the fluctuations may be up to 10%.

### 68 *Why do human beings need vitamins?*

Vitamins play an important role in many processes in the human body, such as metabolism to generate energy, in the formation of cells, and in the muscles and the nervous and immune systems.

### 69 *Which vitamins are present in wheat grains?*

Wheat grains contain numerous minerals and the vitamins ß-carotene (pro-vitamin A), biotin, vitamins $B_1$, $B_2$, $B_3$ (niacin), $B_5$ (pantothenic acid), $B_6$, $B_9$ (folate), vitamin E and vitamin K.
Page 200

### 70 *How does the vitamin content of the flour change at a higher degree of extraction?*

A high degree of extraction causes a large proportion of the minerals and vitamins to be removed with the outer layers of the grain. Some vitamins are then only present in small traces or are lost altogether. (Iron is reduced to 1/3, folate to 1/5, and vitamin A and ß-carotene to as little as 1/10.)

### 71 *Do the active substances in flour improvers and baking agents influence the physiological effects of vitamins?*

The constituents of food may affect the absorption of minerals. Ascorbic acid, for example, can have a positive effect on the uptake of iron, whereas phosphate inhibits iron absorption.

### 72 *Are the vitamins in the grain stable?*

Yes, as long as the grain is undamaged. The influence of the pH, atmospheric oxygen, light and temperature – i.e. the conditions under which the grain is milled – reduce the content. Folate may be lost altogether. In the case of baking flours a loss of 70 - 90% has to be reckoned with as compared to whole meal. The higher the mineral content of the flour, the more vitamins are preserved.

### 73 *What is the purpose of fortifying light-coloured flours with vitamins?*

It is generally agreed that fortifying staple foods with specific additives to stabilize the health of the population is an important task of health policy. However, this could not be done until it became possible to produce vitamins synthetically. Wheat flour was first treated with B1, niacin and iron in the USA in 1938, and subsequently in the United Kingdom. There are now obligatory regulations in the USA and Canada. In the countries of the European Union, flour fortification is not subject to any restrictions.
Page 201

### 74 *Why is folate important?*

Folate is involved in the metabolism of amino acids and the synthesis of DNA and choline. During pregnancy it helps to prevent the occurrence of defects in the neural tube (the precursor of the brain and spinal cord). Folate also plays an important role in the prevention of cardiovascular disease by neutralizing the dangerous intermediate product homocysteine.
Page 201

### 75 *Which forms of iron can be used in flour fortification, and what is the difference between them?*

The most common are ferrous sulphate, ferrous fumarate and elemental iron powders. They differ in respect of bioavailability, iron content, price, and the potency of their reaction to other flour ingredients.

*76 Can micronutrients be added together with other flour improvers as one premix?*

Micronutrients should be added separately from flour improvers to prevent the destruction of vitamins through interaction of the improver with the nutrient premix.

*77 Are nutrients stable?*

Vitamins are sensitive to heat, light, humidity, oxidation, acids and alkalis; see also *question 66*. Minerals are generally very stable, but iron may be converted from its reduced form (Fe II) into its oxidized form (Fe III) which may have lower bioavailability.

*78 How can I ensure that iron added as part of a premix is not detected by the metal detectors, or picked up by the magnetic separators?*

Only iron in its pure form (mostly reduced iron) is picked up by the magnetic separator.
Iron salts like iron sulphate or iron fumarate are not ferromagnetic.
In no case should the iron be detected by the metal detector.
The particles are too small to create a measurable signal for the detectors in use today.
If there is a signal, this must be due to a to large particle, or very poor distribution of the iron powder in the flour.

*79 Why do baked goods made from my iron-enriched flour have specks /spots?*

a) Larger iron particles oxidize ("rust") on the surface of the baked product.

b) Iron catalyzes chemical reactions, e.g. oxidation of phenolic compounds that turn into dark pigments.

## 1.5 Colour

*80 Although the ash content is only 0.5%, the flour has a dark colour. Why is that?*

There are wheat varieties with a higher pigment content (compare, for instance, U.S. Hard Red Spring Wheat with U.S. Hard White).
Page 20

*81 How can I brighten the colour of the flour?*

Chlorine, chlorine dioxide (both are gaseous) or benzoyl peroxide (powder) can be used for bleaching. In contrast to chlorine and chlorine dioxide, benzoyl peroxide has almost no maturing effect on the flour. The treatment with benzoyl peroxide takes 24 - 72 h to become visible.
Page 243

*82 How can a brighter flour or bread crumb be obtained?*

A brighter flour can be obtained with a lower extraction rate, because the outer layers of the wheat kernel contain more pigments.
Once the flour has been produced, treatment with chlorine and chlorine derivatives achieves a brighter colour, but is not acceptable in many cases for various reasons.
The addition of benzoyl peroxide also results in a brighter colour, visible 24 - 72 h after treatment of the flour.
The addition of enzyme-active soybean flour will make the bread crumb brighter due to oxidation of the pigments. Other additives such as ascorbic acid, oxidizing agents and hemicellulases create a finer crumb structure. A finer crumb structure appears brighter because it reflects the light better.
Page 243

*83 How can I brighten the colour of the bread crumb?*

Bleached flour will result in a brighter crumb colour. The same effect can be achieved with enzyme-active soybean or fava bean flour.
In all cases the flour pigments are affected.
Brightening with ascorbic acid, monoglycerides, hemicellulases and some other additives rests on a purely physical phenomenon: they reduce the pore size, i.e. they create a finer crumb structure. Smaller pores cast less shadow and therefore appear brighter.
Page 244

84 *My flour is white, the ash content is only 0.6%, but when a dough is prepared a greyish darkening occurs. What is the reason?*

In many cases this is due to metal residues in the flour, stemming from roller mills which are worn or badly adjusted.

85 *The flour is bright, but there are dark specks. Where do they come from?*

Check the sieves for holes.

86 *Flours of the types 500 and 750 with relatively high Falling Numbers and a high gluten content without any additives sometimes produce strange results at bakeries. The rolls have a peculiar red colour, not slightly brown like the typical products (no Maillard reaction). Apart from that, all the parameters of the baked goods are ok. What could be the reason?*

Possible reason are:

- The wheat has been treated with a red dye. This was done in Germany to take the wheat out of the food market (market intervention). The dye was not poisonous.
- Red Fusaria can also cause discoloration. This is a severe health risk and should be tested in microbial and toxin assays.
- Strong peroxidase activity can also result in such discoloration. Some wheat and rye varieties are rich in peroxidase. This wheat cannot be used for fresh noodles because it leads to discoloration of the products. It is difficult to reduce peroxidase activity, but some effect can be achieved by modifying the pH, i.e. by adding alkaline or acidic buffering agents.
- A high alkaline pH also results in a yellowish or even reddish discoloration. This effect is used to make yellow alkaline noodles in Asia. At a higher pH the Maillard reaction (non-enzymatic browning) also takes place faster and colour formation (reddish or brownish) can therefore take place at lower temperatures, i.e. in the crumb.



## 1.6 Storage (Wheat, Flour, Bread)

87 *We noticed an increase in the temperature of the wheat to 45 °C in parts of the silo during the winter. When we checked the wheat we couldn't find any signs of infestation. What may the reason have been? Can we still use the wheat?*

This phenomenon is probably due to self-heating caused by fermentation. This can occur if the wheat is not moved or sufficiently aerated during storage. If only a small amount is affected, the thoroughly mixed wheat can be used (unless the taste and smell are impaired), but the performance should be checked. Unusually short dough properties indicate heat damage to a larger proportion of the wheat.

88 *If the flour has been treated with enzymes /ascorbic acid /bleach, will its properties be maintained during storage? For how long?*

Most enzymes except glucose oxidase and transglutaminase are very stable in the flour too. In most cases the shelf-life is restricted by the organoleptic properties of the flour rather than by its baking performance. Ascorbic acid slowly oxidizes to dehydro-ascorbic acid, which is the oxidizing agent to which ascorbic acid has to converted anyway before it has an oxidizing effect. A shelf-life of 6 - 9 months is no problem.

89 *Why does flour milled from wheat of different ages behave differently when baked, although the age of the flour itself (i.e. number of days after milling) is identical?*

Maturation does not only take place in flour; it also takes place in the intact grain, although the chemical and biochemical processes are probably different. Maturation can be observed every year with the new crop: The optimum dosage of oxidizing agents (maturing agents) is high when the new wheat is first milled and can be (or has to be) reduced after longer storage.

**90** *Is there any additive I can use to protect flour against insect infestation?*

So far there seems to be no such additive. And there will probably always be an insect species that is not repelled by the treatment.

**91** *My flour forms lumps after a few weeks of storage, especially at the bottom of the bags. What can I do to prevent it?*

This may be due to a slightly elevated moisture level in the flour. The granulation also plays a role in lump formation. Very fine particles tend to form lumps more readily (semolina is more free-flowing than wheat flour).

**92** *I am having problems with the microbiology of my wheat and fear they will impair the shelf life of my flour. What product might help?*

If the flour has less than an even 15% moisture the microorganisms are unable to grow, so they cannot impair the shelf-life. On the other hand these microorganisms may just be a sign of inadequate cleaning of the wheat or failure to remove all the bran. If the lipid content of the flour is also high for this reason, the shelf-life will indeed be impaired. But we do not recommend treatment with chemical agents such as antioxidants.

The microorganisms may, however, play a role in the further processing of the flour. Especially if there is a large number of thermophilic spore formers (*Bacillus subtilis, B. mesentericus*), some may survive baking and cause degradation of the crumb of the bread. Preservatives such as propionate, acetic acid and even vinegar may help.
Pages 263 and 325

**93** *Why does flour go rancid, and how can this be prevented?*

At moisture levels above 15%, flours can go rancid because of the activity of fat-degrading enzymes. Storage at temperatures above 20 °C also plays a role in the effectiveness of the enzymes. A moisture content below 14% reliably prevents hydrolysis of the fat in the flour because the aw value is then so low that the enzymes are only very slightly active.

**94** *How can we avoid rancidity?*

The germ and the aleuron layer contain most of the flour lipids. If both are neatly removed while the germ is kept intact to avoid release of fat, rancidity will not occur during a reasonable period of storage. Furthermore, rancidity is triggered by exposure to light, moisture, heat and oxygen, so any condition reducing these factors also reduces rancidity.
Page 3

**95** *The wheat has a strange, musty smell. What is the reason? Can I use the wheat? How can I remove the smell?*

The smell is probably caused by unsuitable transportation or storage conditions resulting in mould formation. If the damage is only superficial, thorough cleaning and milling with a low yield will remove most of the substance that smells. In the past, attempts have also be made to mix the grain with active charcoal in order to absorb the substance responsible for the smell. The charcoal was subsequently removed by sifting.

**96** *The flour has a strange smell. Where does it come from? Can I use the flour?*

The off-smell may be a carry-over from the wheat (*see question 95*), or it may have been caused by unsuitable storage of the flour itself. There is no viable method for removing the smell from the flour. Adding it in small amounts to intact flour is probably the only way to use the flour.

**97** *The bread develops a strange smell during storage. What may the reason be?*

This is probably due to the potato disease. Later on, the crumb will form slimy strands when broken open.
Pages 263 and 325

## 1.7 Rheology

98 *What is rheology?*

Rheology is the branch of physics that deals with the elastic and plastic properties of systems and their flow characteristics. When combined with water, flour forms more or less viscous systems that solidify when baked. The science of rheology can provide information on quality in both states – baked and unbaked.

99 *What are "basic rheological properties"?*

Basic rheological properties are the parameters strength, viscosity, elasticity and plasticity. They are determined by measuring the effects of deformation forces on the dough. These forces may be of any magnitude, and the measurements are correspondingly large or small. For the rheology of dough the most important properties are viscosity and elasticity.
Page 119

100 *What am I to make of the "flowery" descriptions of the properties of dough and baked goods that are so popular with bakers?*

The observations of experienced bakers and the resulting jargon are still very valuable for describing product attributes that may also be problematic. Examples: silky; shred.
Page 122

### 1.7.1 Falling Number

101 *Why is the stirring time included when the Falling Number is determined?*

This was probably for historical and also practical reasons. The glass tube for determining the Falling Number was inserted into the boiling water bath and a manual stop watch was immediately started to monitor and control the stirring time. It would have been impractical – an extra step – to stop and re-start the watch manually at 60 s. Note that there was, and still is, an initial pause of 5 s and then actual stirring for 55 s to make a total of 60 s before the stirrer is released from the top position. Presumably the operator started the watch, rapidly put down the tube with the stirrer in the bath, and then had 5 s to turn a lever over the tube so it became fixed in the bath, and thereafter started the stirring at 5 s.
Reply kindly provided by Bo Allvin, Perten Instruments, Sweden.

102 *What conclusions can be drawn from the Falling Number?*

The Falling Number determines the viscosity of a flour-and-water suspension heated to just below boiling point by measuring the time a pestle takes to sink through the gelatinized starch. Low Falling Numbers indicate a degraded gel. The higher the Falling Number, the better are the remaining viscosity and the processing characteristics. A low Falling Number is accompanied by a high level of amylases naturally present in the grain; it is therefore an indication of sprouting.

103 *What influence do fungal amylases have on the Falling Number?*

In the concentrations at which they are normally used in flour treatment, added fungal amylases have scarcely any effect on the Falling Number since they are heat-labile and inactivated by heating. Fungal amylase can be determined with a modified version of the Falling Number measuring device (in which the final temperature can be set).

104 *What baking properties do flours with low or high Falling Numbers have?*

Doughs made from flours with low Falling Numbers tend to have moist surfaces and low stability, but browning, flavour formation and the shelf-life of the crumb (softness) are good. If the enzyme activity is too low the products "bake dry", i.e. the crumb is not succulent enough and its shelf-life is reduced.

105 *How can I reduce the Falling Number?*

Only enzymes with a certain heat-stability, e.g.

cereal or bacterial amylases, have an effect on the conventional Falling Number method. Since most bacterial amylases would survive the baking process and therefore liquefy the crumb of the bread, cereal amylases in the form of malt flour or malt flour extracts have to be used. Although fungal amylases cannot be detected in the Falling Number tests they nevertheless enhance the baked products. Pages 230 and 247

### 106 *How can I increase the Falling Number?*

By reducing the yield in order to remove those layers of the wheat kernel that have a higher amylase content, or by using a buffer to shift the pH into a range that is no longer optimal for the enzyme. Although a higher Falling Number may seem desirable to achieve certain specified flour properties, it is important to keep the bakeability of the flour and the attributes of the end product in mind. Pages 247 and 262

### 107 *Can I risk buying wheat with a Falling Number below 200 s ?*

Yes, if you can mix it with wheat with a higher Falling Number. You can estimate the Falling Number of a mixture by the following method:
1. Use the following formula to calculate the Falling Number Index (FNI) of the two flours to be blended ($FNI_A$ and $FNI_B$) and the desired Falling Number ($FNI_T$) of the blend:

$$FNI = \frac{6000}{FN - 50}$$

2. Calculate the ratio of the two flours in the blend with the aid of the FNI , e.g. using the rule of three ("blending cross") or the following formulas:

$$P_A = [FNI_B - FNI_T]$$
$$P_B = [FNI_A - FNI_T]$$

PA and PB are the proportions (absolute values) of flours A and B in the blend, expressed in parts. Together, the parts make up 100%. The proportion of flour A in the blend, expressed in percent, would therefore be:

$$P\%_A = \frac{P_A}{P_A + P_B} \cdot 100$$

and that of flour B:

$$P\%_B = \frac{P_B}{P_A + P_B} \cdot 100$$

The blend thus calculated should be tested with the Falling Number device before being run at the mill.

### 108 *Can I risk buying wheat with a Falling Number above 400 s ?*

Yes. In fact many wheat lots from Australia and North America do have an FN in this range. The reduced fermentation capability can easily be increased with enzyme preparations. But beware of lots from regions that do not normally supply wheat with a high Falling Number: the high FN may be a sign of heat damage.
Page 261

### 109 *Is it safe to buy wheat with an FN above 600 s ?*

Although they are fairly rare, Falling Numbers above 600 s can occur in sound wheat, especially in lots from Australia. Nevertheless, attention should be given to the gluten properties: a very short or – worse still – a crumbly gluten would mean heat damage.
Page 261

### 110 *Does xylanase affect the FN?*

Yes, because the hydrolysis of pentosans also reduces the viscosity of the flour slurry. But the effect is far smaller than that of amylase.

## 1.7.2 Amylograph and Rapid Visco Analyzer

### 111 *What does the Amylograph measure?*

The Amylograph records the changes in the viscosity of a flour-and-water suspension caused by gelatinization of the starch during a controlled heating period. The Amylogram therefore shows the changes in water-binding capacity that take place during swelling and gelatinization and in the course of enzymatic and mechanical breakdown of the starch gel.
Page 136

112 *What is the connection between the Amylogram and the Falling Number?*

There is no direct connection between the Falling Number and the Amylogram data, but a mathematical/statistical orientation in the same direction does exist (if the number of measurements is large enough!). This should be checked for each new harvest.
Page 137

113 *What does a Rapid Visco Analyser measure?*

The RVA is a "micro-Amylograph" that combines the advantages of a small sample (2 - 4 g) and the possibility of setting any desired temperature gradient. A distinction is made between a "stirring number" and "rapid pasting"; these correlate closely with the Falling Number and the Amylogram.
Page 137

114 *Can fungal α-amylase be detected with the Amylograph?*

No; unlike the Fungal Falling Number method, the Amylograph does not distinguish between amylases with different temperature-activity profiles.
Page 151

### 1.7.3 Farinograph and Consistograph

115 *What is measured in a Farinograph?*

The most important "recording mixers" are the Brabender Farinograph and the Swanson Working Mixograph. Both record the water absorption of a dough. They differ chiefly in their mixing method and thus in the mechanical stress to which the dough is exposed, but also in respect of the ratio of flour to water or the amount of water added to start mixing.
Page 124

116 *Are there correlations between the Farinogram and the industrial mixing process?*

Yes, but there are considerable differences too. The Farinograph uses a double-Z mixing device. The energy input is very high, the doughs are subjected to heavy stress. Since the doughs are small and therefore have a large surface area a large amount of air and thus oxygen can reach them, which accelerates oxidative (gluten-strengthening) processes. Nevertheless, it can be said in general that doughs that are stable in the Farinograph will be stable in the industrial mixing process too. Water absorption is a more complex matter. It is determined by adding as much water to the flour as is necessary to achieve a specified resistance to kneading. But if a dough is pliant, for example through the addition of emulsifiers, its stickiness and resistance are reduced. This leads to the conclusion that its water absorption is lower, although the dough would really be able to take up more water and would certainly be processable.

117 *Do Farinograms have any practical significance for rating non-wheat flours?*

Only the properties of wheat flours can be determined reliably with the Farinograph. All attempts to test other flours must be regarded as futile, since the Farinograph was developed especially for the visco-elastic properties of wheat dough. The use of other flours in the standard mixer easily leads to misinterpretation of the results, since the stickiness of these doughs and their plastic properties cannot be measured.

118 *Is there any correlation between the Farinogram and baking properties?*

In the continuous quality control system of a flour mill there is a strong correlation. But if wheat flours from different wheat batches or different producers are to be evaluated, the Farinogram is only of limited use. In principle, the Farinograph should be able to indicate important flour parameters such as water absorption, dough stability and mixing tolerance; but additives, especially, may modify the resulting curves in such a way that wrong conclusions can be drawn. Nevertheless, the Farinograph can also be used for quality con-

trol of treated flour in order to minimize the number of baking tests; an internal standard has to be created for this purpose.
Page 248

119 *How can water absorption be increased in the Farinograph (Consistograph)?*

Hydrocolloids such as guar gum or carboxymethyl cellulose are able to increase water absorption, but some enzymes improve the uptake of water too; they include pentosanase, which acts specifically on the insoluble pentosan fraction. Increased starch damage also increases water absorption but reduces stability.
Page 247

120 *How can water absorption be reduced in the Farinograph (Consistograph)?*

Enzymes acting on the water-absorbing flour components, i.e. starch, protein and pentosans, affect water absorption behaviour. Whether or not a reduction can be observed in the Farinograph will depend on the enzymes' specificity and dosage.

Some oxidizing agents seem to have a negative effect on water absorption. This is caused by a "tunnelling" effect: the mixing elements drill holes in the very dry and stiff dough, thus reducing resistance, which will be interpreted as reduced water absorption.
Page 249

121 *How can stability be modified in the Farinograph (Consistograph)?*

Increasing the size of the flour particles retards the uptake of water and also the breakdown of flour components, thus prolonging stability. Hydrolytic enzymes accelerate the breakdown and therefore reduce stability. Oxidases strengthen the dough – at least in the Farinograph with its small dough size and large surface:volume ratio (access of oxygen). Strong oxidizing agents reduce stability because they increase the energy uptake during mixing. This is not taken into account by the instrument and will therefore lead to overmixing, i.e. breakdown of the dough structure within a given time.
Page 248

122 *After maximum absorption the Farinogram drops sharply below the 500 F.U. line and ends in a thin curve. What is the reason, and how can I prevent it?*

The probable cause is proteolytic activity caused by insects (Sunn pest) or from microbial sources (proteases for biscuit and cracker flour).
Pages 261 and 284

123 *After maximum absorption the Farinogram decreases for a few minutes, but then it rises even higher than the first max. abs. peak. Why is that?*

Granular flour tends to show a retarded maximum. Oxidizing enzymes added to a flour of already good stability will also result in a continuously increasing curve. Furthermore, some strong flours, e.g. from Australian wheat, produce a mixing curve with this shape when treated with oxidizing agents such as azodicarbonamide.

124 *What is the reason for a second peak in the Farinogram?*

This effect is mostly observed with wheat flour rich in protein. The second peak is caused by glutenin, which takes longer to develop than gliadin. The latter is responsible for the first peak. Anther reason for two peaks is a mixture of two very different wheats.
Page 126

125 *What is the Chopin Consistograph?*

A further development of the Alveograph, fitted with a pressure sensor that is connected to a computer for making measurements and processing the results. The device is very user-friendly.
Page 148

126 *Are the results from the Consistograph comparable to those from the Farinograph?*

Although the overall correlation is not very high, the general tendencies are similar. A correlation of r = 0.64 has been calculated between the water absorption values determined in the Consistograph and those of the Brabender Farinograph.
Page 148

### 1.7.4 Extensograph and Alveograph

127 *What is measured in an Extensograph and an Alveograph?*

These instruments measure the resistance of a dough to extension under controlled conditions. The shape of the curve shows the energy input (E in the Extensogram, W in the Alveogram). Different dough properties (short, normal, soft) and different protein levels (low, normal, high) are recorded.
Page 128

128 *How can the effect of flour improvers be measured rheologically?*

Of course baking tests are the analytical method for determining the nature and amount of the flour improvers to be added in the long term.
But Extensogram data, especially, react extremely sensitively to all additives whose effects result from reactions with the proteins in the gluten. It was on the basis of such data that the theory of the Rheological Optimum was established and became acknowledged throughout the world. It gives concrete information on which flour improvers can be used to achieve which changes in the properties of the dough.
Page 132

129 *What is the difference between the Extensograph and the Alveograph?*

So far the Alveograph method assumes the addition of a constant amount of water, which naturally results in doughs with different consistencies. The Extensograph method is based on doughs of equal consistency, since the optimum amount of water to be added has to be determined previously in the Farinograph. In the Alveograph the rheological effects of doughs can only be determined to a very limited extent under the present standard conditions.
But by extending the dough resting times it is possible to acquire as much valid information as with the Extensograph.
Page 130

130 *Can the effects of vital wheat gluten be detected with the Extensograph?*

Since vital wheat glutens from different sources may have a noticeable influence on the viscoelastic properties of wheat doughs, their effect is also visible in the Extensogram. However, it must be taken into account that the behaviour of an isolated wet gluten and a rehydrated dried gluten is different when they are used alone from their behaviour in a natural combination with starch, pentosans, lipids and other constituents of the dough.
Page 133

131 *What shape should the Extensogram have to indicate good bread baking properties?*

The area below the curve should be high, the ratio of resistance to extensibility should be approx. 1.5 - 3.0.
Page 130

132 *Can the correlation between the Alveogram and the baking results be improved?*

Yes, within certain limits. The water addition rate should be flexible, i.e. according to the needs of the flour.
Furthermore, a pressure-relaxation test has been recommended, where the airflow suddenly stops and the relaxation of the bubble is measured.
Pages 130 and 132

### 1.7.5 Gluten Index and Glutomatic

133 *What information does the Gluten Index provide?*

The more residue is left in the sieve of the centrifuge, the firmer is the gluten. Firm glutens usually result in more stable doughs with a high volume yield. For good volume yields a Gluten Index ›85 is desirable.

134 *Although we find 36% wet gluten with the Glutomatic, the baking properties are not satisfactory. How is this possible?*

Several reasons should be considered:

- There are wheat varieties, for instance feed wheat, that contain quite a large amount of gluten but have poor baking performance.
- A lack of enzymes can be another reason. Check the Falling Number.
- Also check for insect or heat damage by gluten extraction and/or rheological tests, e.g. Extensograms.

135 *Our in-house test results by Glutomatic wash meet the bare minimum specification. However, customers using the hand wash method have found the gluten quality to be too low and to cause greater wastage and thus a smaller quantity. What may the reason be?*

Depending on whether the gluten washed out by hand is
a) short and crumbly, or
b) rather weak and even slimy,

you may be facing a problem of heat damage or bug damage. Both seem to be fairly common with Indian wheat at times. As you know, heat damage would also be indicated by rather high Falling Numbers, while bad cases of bug damage would yield a terrible Farinogram with the curve decreasing more sharply than it would even with most standard proteases.

## 1.8 Spectroscopic Methods

136 *Why are spectroscopic methods used in cereal analysis?*

With the original gravimetric and chemical methods of analysis it was not possible to determine the properties and constituents of grain mixtures or flour-and-water doughs reproducibly and quickly within the time in which it was possible to intervene in technical processes. NIR spectrometry has done away with these difficulties and shortcomings.
Page 162

137 *What does NIR stand for?*

The near-infrared (NIR) region is the wavelength range between 800 and 2,500 nm of the electromagnetic spectrum, i.e. a very dark red that is no longer visible to the human eye.
Page 162

138 *What is meant by NIR spectrometry?*

The NIR procedure is a quick method by which individual components of a mixture of substances can be determined qualitatively and quantitatively. Constituents that contribute to the value of a product can be determined simultaneously within a few minutes and called up in sequence.
Page 162

139 *What is the difference between NIR and NIT?*

The difference between reflection and transmission techniques lies in the physical position of the detector. In the case of the reflection technique the detector receives the light reflected by the sample and is therefore in front of the sample chamber, whereas in the transmission technique the detector is situated behind the sample compartment.

140 *What quality parameters can be determined by NIR?*

In principle there are no limits to the uses of

NIR measurements. In the field of cereal analysis there are methods for grain and grain mixtures, flour and semolina, doughs, liquids, suspensions and foams. Standard NIR methods are used to determine the moisture, protein starch and fat content.
Pages 163 and 166

141 *What is the purpose of calibration?*

The NIR instrument has to be adjusted for the chemical structure to be determined, whose vibrations are to be measured. Calibration requires a large number of samples varying as widely as possible. Reference libraries have a stock of spectra that have been determined over long periods.
Page 166

142 *Why are not all flour analyses made just by NIR although the method is very much simpler and quicker?*

NIR analysis is an indirect method that yields very accurate results if the instrument is well calibrated. There are largely reliable calibrations for determining total protein, the moisture content and also, with some special instruments, the mineral content; but for the rheological tests, especially, mathematical models have to be used which are not yet fully developed.

143 *Can the quality of flour be measured in-line?*

With NIR-methods, quality parameters such as protein, ash or moisture can be determined continuously. The data can be used to control the milling process. Page 165

## 1.9 Oxidation

144 *How can I replace potassium bromate, azodicarbonamide or ascorbic acid?*

The replacement of potassium bromate requires an oxidizing agent, e.g. ADA or ascorbic acid, and an enzyme that helps to soften the dough. The fast-reacting ADA can be replaced by mixtures of calcium peroxide and ascorbic acid. Ascorbic acid can only be omitted (in the absence of any other oxidizing agent) if limitations to baking performance are tolerated. Oxidizing enzymes such as glucose oxidase are not very effective in the centre of the dough unless the mixing process is performed at elevated air pressure or with the introduction of oxygen into the dough.
Pages 225 and 254

145 *Why does benzoyl peroxide not succeed in bleaching my chappati flour (flour for flat bread, very high extraction rate)?*

Various explanations are possible:

a) The dark colour of wholemeal flour is not only due to carotenoids with which benzoyl peroxide reacts.
b) Because of the high concentration of pigments the BPO is exhausted before it achieves a brighter colour.
c) The benzoyl peroxide was premixed with flour and stored for more than just a few hours. This results in a partial or even complete reaction with the carrier, but not with the main flour.
d) The dark colour is partially caused by foreign substances, e.g. metal debris from the rollers or fortifying agents containing dark substances.

146 *Why does ascorbic acid turn yellow during storage, and does that affect its efficacy as an oxidizing agent in flour?*

It used to be assumed that this is due to the formation of an oxidized form of dehydroascorbic acid (DHA). But for two reasons this is probably not the case: a) no DHA is detectable in yellow ascorbic acid, and b) DHA forms white crystals. But there is some likelihood that DHA is just an intermediate product, because it is not very stable and converts into some unknown substances that are first yellowish and then brown when exposed to air. Whatever the reaction is, it does not affect the function of the ascorbic acid in baking, probably because the degree of degradation is very small.

147 *Can ADA added to my flour trigger a positive result when the flour is tested for nitrofurans?*

Yes. Nitrofuran metabolite residues (semicarbazides, SEM) were initially discovered in pigs, poultry and shrimps. They are formed as a tissue-bound residue following the administration of nitrofurazone, a banned antibiotic. However, SEM has also been found to occur in materials used for coating chicken meat in the production of cooked chicken products. Most positive findings have been associated with the use of either carrageenan or breadcrumbs (and other bread products). A subsequent investigation revealed that azodicarbonamide can break down during the bread making process to yield SEM, which is responsible for the positive nitrofuran results.

148 *Is it feasible to prepare premixes of benzoyl peroxide and wheat flour?*

A premix of benzoyl peroxide (BPO) and flour should be used immediately after preparation. Otherwise BPO reacts with the flour of the premix, sometimes resulting in off-flavour due to excessive oxidation, and no activity will be left for the main flour stream. A premix should be prepared with (almost) inert substances, e.g. calcium sulphate, calcium carbonate, or starch. Soybean flour, in particular full-fat soybean flour, is least suitable because the BPO will oxidize the lipids, causing severe off-flavour.
Page 243

149 *How does chlorination affect the properties of biscuit flour and products made from it?*

Chlorination does not only brighten the flour by oxidizing the pigments contained in it; it also oxidizes proteins and pentosans. Since biscuit flour contains little protein, and what it does contain is weak, oxidation of the protein (formation of disulphide bridges) has scarcely any effect on the baking properties. But oxidation of the water-soluble pentosans appears to have an effect on the foam stability of whipped masses and thus the structure of the baked products. In the case of heavy masses (high-ratio cake), especially, this results in much better volume and a finer texture. At present chlorinated flour can only be replaced to a very limited extent by thermally treated flours.

## 1.10 Dosage of Additives

150 *The capacity of my mill is 100 tons/day. I want to improve the flour with ascorbic acid and enzymes. What options do I have?*

All! The improvers can be added separately or as premix, e.g. with middlings, using one or more micro-feeders of adequate dimensions. They can also be added in a batch process provided that a sufficiently large mixer is available.

151 *We have to make a premix of flour-improving agents with a carrier. What carrier should we use?*

The best shelf-life of the premix is achieved with calcium sulphate or carbonate as a carrier, but both increase the ash content of the flour. Starch and soybean flour are also possible, but expensive. Flour or middlings are another option, the latter having better flow properties.
If benzoyl peroxide (BPO) is to be used, the carriers of choice are calcium carbonate, calcium sulphate or starch, because with one of the other carriers BPO would already lose part or all of its function in the premix.

152 *We want to make a premix of vital wheat gluten and benzoyl peroxide. Will the BPO maintain its efficacy? And for how long?*

BPO reacts with the small amount of lipids in the gluten and loses at least some of its oxidizing capacity. If the batch time can be limited to approx. 4 h, most of the bleaching effect will still be present.

## 1.11 Shelf-Life of Bread

153 *How can the microbial shelf-life of bread or pastry goods be prolonged?*

Baked goods are almost sterile, or at least pasteurized, when they leave the oven. Microbial contamination occurs through re-infection. Re-infection can only be prevented by a sterile packaging area following the oven, or by a second heating step with the bread already wrapped in heat-stable packaging material. If this is not feasible, cooling of the baked goods is another option, but this accelerates the staling rate (see below). If no wrapping is applied, more extensive baking (and thus drying of the surface) improves resistance to mould growth.
Finally, preservatives help to suppress microbial growth.
In order to limit the off-taste caused by the preservative, combinations of several agents are recommended, e.g. propionate or sorbates with acetates.
Lowering the pH with sour dough or acidulants enhances the effect of the preservatives.

154 *How can the shelf-life of the crumb softness be prolonged?*

Storage at elevated temperatures, e.g. 40 °C, prolongs the softness but increases the risk of mould spoilage. Ingredients that improve the specific volume improve the "offset softness" at the beginning of storage. A soft, silky crumb structure is a prerequisite for a good shelf-life, so all improvers that enhance the volume and the crumb structure also prolong the shelf-life of the goods.

Furthermore, some emulsifiers such as SSL, CSL, lecithin and monoglycerides slow down the rate of staling and thus retard the hardening of the crumb.
Amylolytic enzymes with medium heat stability, which are able to survive the early stages of the baking process but are safely inactivated later, also enhance the softness of the crumb by inhibiting the staling process.
Page 154

## 1.12 Composite Flours

155 *What are composite flours (CFs)? What are they developed and produced for?*

Tuberous plants rich in starch such as cassava, yams and sweet potatoes that grow in the dry regions of the world are not suitable for making conventional baked products on their own, but they can be put to good use in combination with wheat flour. This encourages the growing of local plant species, saves on hard currency and improves the supply of protein to the population.
Page 193

156 *What is the difference between composite flours (CFs) and ready-mixed flours?*

Whereas ready-mixed flours contain all the durable ingredients of the recipe for a specific baked product, CFs are just a mixture of different flours from plants rich in starch and protein, with or without wheat flour, for certain groups of baked goods.
Page 193

157 *What baked goods can be made with CFs?*

In principle all baked goods can be made with composite flour, but the loss of quality with yeast-risen products is often considerable. Pastry goods, on the other hand, can tolerate a larger proportion of non-wheat flour.

158 *Is it possible to compensate for the quality deficits of CFs with the aid of flour improvers?*

Ascorbic acid, potassium bromate and enzymes are effective with CFs too. DATEM, CSL and GMS also greatly enhance the results of baking. The key to good processing characteristics is the proportion of gluten, which is reduced by the addition of non-wheat flours. Measures to enhance the gluten and also the addition of vital wheat gluten improve the bakeability of the flour. The target substance for flour improvement

with CFs (and with most mixtures of wheat and rye flour too) is always the wheat flour content. The non-wheat flour merely has a "diluting" effect on the flour improver.
Pages 197 and 278

159 *What are the limits to the use of cassava/maize/millet etc?*

A normal wheat flour tolerates 10% non-wheat flour with little loss of quality, but 20% already impairs the quality noticeably even if the flour is fully treated. Nevertheless, bread with 30% cassava, for example, still has quite acceptable eating properties.
Pages 194 and 278

160 *Can CFs be used in programmes to combat coeliac disease?*

Yes, provided that all grain containing gluten is avoided.

161 *Can CFs be evaluated with the usual rheological methods?*

Yes, if the proportion of non-wheat flour does not exceed 30%. But new specifications have to be made out for the CF.

## 1.13 Ready-Mixed Flour

162 *What advantages do ready-mixed flours have over ordinary bakers' and house hold flours?*

The purpose of ready-mixed flours is to make the production of certain groups of baked goods quicker, simpler and therefore cheaper. Since ready-mixed flours contain all or most of the dry ingredients of the baked product, many steps in the baking process can be carried out simultaneously, simplified and rationalized.
Page 288

163 *What groups of baked goods are suitable for production with ready-mixed flours?*

In principle all groups, with the exception of very special products.
The specific advantages lie in the fact that the flours contain the optimum ingredients and additives for each group of products. In contrast to "normal" commercial flours this makes it possible to produce specific top qualities over a long period with standardized working methods.
Page 289

164 *Are there other reasons for producing and using ready-mixed flours besides the convenience aspect?*

A consideration that will become more and more important for the whole of the milling industry in future is the production of baked goods with a health benefit.
Nutrition research in all fields throughout the world is directed towards the development of new types of health food.
If the cereal processing industry is not to lose too much ground in this race, it will have to demonstrate its nutritional benefits based on the current image not only in marketing and advertising but above all through the development of innovations of its own:
vegetable proteins, low fat content, dietary fibres and special minerals will be important features.
Page 294

165 *What foods are suitable as ingredients of ready-mixed flours?*

In principle all foods that can be processed into powdered semi-finished products without loss of quality and are sensorily compatible with baked goods.
Page 290

166 *What additives are necessary for the production of ready-mixed flours?*

The nature and quantity of additives such as emulsifiers, lecithin, enzymes, thickeners etc. will depend on consumer expectations and the traditional uses of the products concerned.
Page 291

167 *What technical equipment is necessary for the production of ready-mixed flours?*

The most important equipment is evenly-running mixers in which the ingredients to be mixed are subjected to as little mechanical stress as possible. High-quality products in powder form are available for working in fats. Special mixers are needed if normal fats are to be used. When the product is being filled in sacks, and during transportation and storage, great care must be taken to prevent separation of the ingredients.
Page 292

168 *Under what circumstances is it worthwhile producing ready-mixed flours?*

The production and processing of ready-mixed flours are technical procedures that are constantly changing and developing. As a rule, small firms are not in a position to watch these developments so closely that they can be put to successful use in the company. Even big mills that deliberately restrict themselves to the production of commercial flours should not make half-hearted experiments in this field. Specialist blending plants with equipment that is programmed for flexible use have a good starting position if they develop their knowledge of the substances involved, for example through cooperation agreements.
Page 293

169 *How large are the markets? How good are the chances they offer?*

There are no reliable figures; the share of the flour market is estimated at 3 - 3.5%. There is a definite trend towards premixes, i.e. semi-finished goods for specific steps in the production process. The current mass production of bread and small baked goods such as rolls is not carried out with the aid of ready-mixed flours; more stable markets may be expected for special pastry goods and "ethnic food", for example. There is a future for the export of know-how enabling goods to be produced in the developing countries.
Page 293

## 1.14 Durum, Pasta and Noodles

170 *Where is durum wheat grown?*

Throughout the world, provided that the climatic conditions are suitable (warm and dry). The biggest exporting countries are Canada, the USA and Australia.

171 *Is there an alternative to durum wheat?*

No. In spite of all the successful breeding and selection with soft and hard wheat and so much technological development there is no alternative (page 353). But the properties of pasta made from Triticum aestivum can be greatly enhanced by adding egg, gluten and especially enzymes.
Page 274

172 *What importance does flour treatment have for the quality of pasta?*

We occasionally find pasta flours that have been treated with ascorbic acid. It is doubtful whether they have a positive effect on the end product. It is probably more a question of adherence to specifications whose values have been determined by rheological methods. But enzymes, especially those with a hemicellulolytic or lipolytic effect, can bring about a great improvement in quality. However, in most cases their use will depend on the difference in price between high-quality wheat and an inferior grade.

173 *Are there other applications for durum products besides pasta?*

Yes, in special types of bread (e.g. in Italy and Greece) and in baked products in general to produce a crumb with a yellowish tinge. The baking properties are good and come up to those of hard wheat.

174 *What possibilities do flour improvers and baking agents offer for enhancing the quality of pasta products?*

Emulsifiers, above all monoglycerides and

lipolytic and hemicellulolytic enzymes, can be used to improve processing characteristics, the quality of the products and eating properties.
Page 274

*175 Why do uncooked noodles darken, and how can this be avoided?*

Polyphenol oxidase present in flour causes oxidation and polymerization of phenolic components and thus the formation of brown pigment in wheat flour dough. Refrigeration or immediate cooking or frying prevents browning.
Page 333

*176 What is the best wheat for Asian noodles?*

Chapter 23.2.8 lists many suitable wheat varieties. Generally speaking, the wheat should not be too hard in order to reduce starch damage; it should be low in ash and polyphenol oxidase to ensure a bright colour.

*177 Can noodle dough be evaluated by standard rheological methods?*

Rheological methods were developed for bread doughs with a much higher water addition rate than noodle doughs. The Farinograph, Extensograph and Alveograph cannot therefore be used for evaluating noodle doughs. Nevertheless, an experienced person will be able to correlate at least some of the figures obtained by these methods with the noodle-making properties of flour.

In addition, the pasting properties of the flour obtained from the Alveograph of the RVA, and to some extent also from the Falling Number device, give valuable information on the processing properties of noodle flour.
Page 343

*178 Is there a correlation between the protein content of durum wheat and pasta quality?*

The quality of pasta increases with the protein content. At least 12% is necessary for good quality pasta.
Page 329

## 1.15 Rye

*179 Is there rye breeding just as there is wheat breeding?*

Although some rye is grown and bred in the USA and Australia, 90% of all rye comes from Europe.
Since the hybrid varieties were introduced around 1970 there has been tremendous progress in respect of higher yields and less dependence on soil characteristics.
Page 179

*180 What biochemical properties are characteristic of rye?*

The very brief secondary dormancy of rye often results in signs of sprouting in the early stages of ripening. They are marked by increased enzymatic activity.
To a certain extent the role of the gluten in wheat is taken on by the pentosans in rye (content: 7 - 10%).
The insoluble part of the pentosans counts as dietary fibre. Rye starch consists of about 25% amylose and 75% amylopectin; the starch grains are mainly of the "B" type (diameter approximately 10 µm).
Medium-sized starch grains are now thought to have special technical functions in respect of shelf-life.
The baking properties of rye flours are determined largely by the α-amylase formed during germination; its activity reaches a peak when the grain has a moisture content of about 30 - 40%.
This intensive enzymatic activity is also a reason for the widespread use of sour dough. The acidification restricts the activity of the enzymes.
Page 186

*181 How is rye assessed?*

The following criteria are considered important: thousand grain weight (TGW), crude protein content, peak Amylogram values for viscosity and temperature, and the Falling Number.

### 182 *What are the most important test methods for determining the quality of rye?*

The milling properties are determined in a standard milling test using a Bühler laboratory mill. Since 2002, both flour and meal have been used for testing the baking properties. The parameters determined are the Amylogram, the Falling Number and the Rye Viscogram after Brümmer. The tests should also include a baking trial.
Page 181

### 183 *What baking tests are used at present to evaluate rye?*

Of the three standard baking tests for classified rye flours the one most often used for determining basic characteristics is the sour dough baking test that comes close to the real conditions at a bakery. There is also a yeast baking test without acidification and a lactic acid baking test in which acidification is achieved by adding a standardized amount of lactic acid depending on the mineral content of the rye flour. The most important parameters of the sour dough baking test are dough yield, dough properties, texture, elasticity of the crumb, purity of taste and the potential flavour resulting from the sour dough.
Page 182

### 184 *What is the Rye Viscosity Test (RVT)?*

The RVT is based on the swelling curve of the Amylogram. It uses a specific buffer and makes it possible to obtain, within 30-45 min, data that correlate with the baked volume of the bread. It can be used to optimize bread rye qualities for the market and serves as a selection criterion for rye breeders.
Page 187

### 185 *What problems are caused by the baking properties of rye flours?*

The constituents of rye have a less compact chemical structure; by this we mean they are less resistant to breakdown by enzymes. Rye starch already gelatinizes at 55 °C (wheat at about 65 °C), and the proteins hydrolyze faster too. These disadvantages of rye have to be compensated for by measures on the part of the baker. For example, rye doughs have to be mixed more slowly in order not to destroy the protein structure.
No gluten is able to form in rye doughs because of their high pentosan content. The gas retention capacity of rye doughs is therefore much lower than that of wheat doughs. Moreover, the dough properties are not viscoelastic but plastic. Further problems are caused by wet dough surfaces and a tendency to stick to machinery and tools.

### 186 *Why is acidification of the dough recommended when rye flours are used?*

Rye doughs are nearly always made with acid (sour dough) in order to reduce the pH. Since the activity of alpha-amylases reaches a maximum at a pH of around 5.4 but is very low at 4.2, doughs with a reduced pH can easily be made up into rye bread without the products having a soggy, inelastic crumb. Such a negative change comes about through excessive degradation of the starch by the amylolytic enzymes during baking.
The reason for the high enzymatic activity of most rye flours is the shorter seed dormancy of rye. In many rye varieties warm, humid weather directly after ripening can trigger the germination process in the blade to form a new plant. This process is termed sprouting. By lowering the pH it is possible to make bakery products with a long shelf life even from flour containing sprouted grain.

### 187 *How is good rye bread made?*

Whereas efforts used to be directed mainly towards preventing sprout damage, this is now of secondary importance thanks to the development of suitable rye varieties and control of the baking processes on the basis of the Falling Number and the Amylogram. There is now a preference for Falling Numbers between 120 and 150 s, and multistage sour dough processes are still usual.

But very acid conditions when a new sour dough starts to ferment inhibit the action of the enzymes. The main objective of all sour dough processes is now to form flavour components and their precursors in order to enhance the sensory properties of the bread. Working instructions are included.
Page 190

188 *Why is it so important to determine the gelatinization properties of rye flour?*

Unlike wheat flour, rye flour contains very little structural gluten. In rye flour this skeleton-forming function is performed by pentosans and starch. The Amylogram shows both the viscosity resulting from the two components and the gelatinization properties, especially the gelatinization temperature. As the gelatinization temperature falls, the starch becomes increasingly susceptible to attack by amylases. Moreover, rye starch gelatinizes at a lower temperature than wheat starch. This means that amylases have greater significance than with wheat flour, where it is primarily the starch damaged by milling that is open to attack.
Page 104

189 *Is rye bread healthier than wheat bread?*

Advantages can be concluded from the smaller need for pesticides and fertilizers for a constant yield, and less ability to host *Fusarium*; the toxin content is therefore lower. Furthermore, the protein is of higher value. On the other hand, rye and rye hybrids are susceptible to ergot.
Page 180

190 *Can the same milling line be used for wheat and rye?*

In principle it is possible to mill rye on a wheat mill. The throughput will drop by about 50% and will be lower than on a comparable rye mill. The structure of the flour will also be different, namely coarser. Moreover, the flour colour tends to be less typical (with less greenish-blue sheen).

## 1.16 Baking

191 *Why does sandwich bread made from our flour (100% DNS) have a coarser texture when xylanase is added, whereas we would expect the opposite effect?*

Xylanases create a finer crumb structure by optimizing the gluten-pentosan network. The network is then able to form thinner membranes so that more and smaller bubbles are formed. The effect depends on the properties of this network (natural fluctuations are possible) and particularly on the properties and dosage of the xylanases.
Many xylanases from *Trichoderma* and also an overdose of other xylanases result in a coarser pore structure. Naturally the processing conditions have an impact on the effect of the enzymes too. A high water addition rate, high dough temperatures and long fermentation increase the tendency towards a coarser crumb.

192 *How can crustiness be improved?*

Given identical baking processes, flour with a lower protein content tends to yield bread with a better and longer-lasting crustiness. Malt flour, amylases and DATEM improve the crustiness further. In general, baked goods with a larger specific volume will be crustier than their smaller counterparts, because a larger surface is exposed to heating. This increases the baking loss and the browning reactions and therefore improves the crustiness.
Page 291

193 *What specifications should flours for buns, baguettes and yeast-raised doughnuts have?*

Page 295

194 *Can wheat quality affect the absorption of fat into a doughnut?*

Yes. If the flour is too weak, the fat absorption will be higher.
Page 302

### 195 *What is the reason for blisters under the surface of doughnuts?*

Most likely skin formation due to exposure to a dry atmosphere in the fermentation chamber or prior to frying. Other possibilities: excessive moisture in the fermentation chamber; dough that is too strong because of a wheat mix (hard wheat, more than 33% wet gluten) or oxidative treatment.

### 196 *What flour type is to be recommended for cake doughnuts?*

Soft wheat flour with 8.5 - 9.5% protein and hard wheat flour with 10.5 - 12.0% protein are suitable. Blends of 70/30 or 50/50 soft to hard flour are common.
Page 302

### 197 *Can flour affect the formation of acrylamide?*

The formation of acryl amide depends on the presence of the amino acid asparagin and reducing sugars, in particular glucose and its derivatives. Flours with a high amylase content (low Falling Number), a high maltose number or high starch damage are therefore likely to result in increased acrylamide formation. Whole grain wheat and rye flour contain more asparagin than white sifted flour. The germ has the highest content of asparagin.

### 198 *What flour quality should be used for steamed bread?*

Although the required flour quality differs considerably from one type of steamed bread to another, there are some common traits: the protein content is typically rather low or medium (7.5 - 11.5%), the ash content should be below 0.45% and the Falling Number well above 300 s. Other rheological properties such as the Farinograph figures can be very different, depending on the type of steamed bread.
Page 311

### 199 *What are typical problems of steamed bread caused by flour?*

| | |
|---|---|
| Small volume | Low protein; intrinsic enzyme activity too high /too low |
| Shrinkage | High protein |
| Dark colour | Dark wheat variety; high extraction rate; highprotein |
| Flat shape | Weak protein, enzyme activity too high |
| Holes in the crumb | Very short protein; enzyme activity too high |