20 Wheat Flour Products in North America

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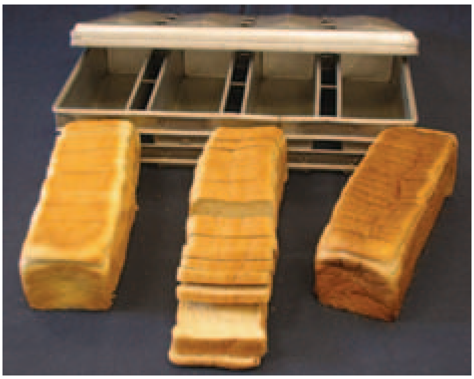
The required flour qualities for the applications of wheat flour treated in this chapter are summarized in Tab. 102.

20.1 Pan Breads[31]

Most pan bread produced in America is white pan bread. Whole wheat and multigrain breads are a significant but smaller percentage of pan breads produced in large commercial bakeries. Pan breads produced in retail and supermarket in-store bakeries are similar with regard to flour quality requirements but typically use a straight dough process and make up a much smaller percentage of total pan bread production. Although there are several different processes for producing pan breads, sponge and dough and liquid ferment systems are by far the most common today. These processes produce superior bread compared to straight dough and continuous mix processes that were more common in the past.

Sponge and dough processes involve mixing about 70% of the total flour with water, yeast and yeast nutrient to form dough, which is allowed to ferment under controlled temperature and humidity for 3 - 6 h. After fermentation the dough is remixed with the remaining ingredients such as salt, sugar, shortening, non-fat milk and dough improvers and conditioners.



Wheat Classes

HRW – *Hard Red Winter*
HRS – *Hard Red Spring*
HRW – *Hard White Winter*
SRW – *Soft Red Winter*
Durum – *Durum*

Tab. 102: Wheat flour qualities for specific baking and non-baking applications

		Pan	Baguettes Hearth Breads	Flat Breads	Buns	Croissants	Yeast Raised Doughnuts	Cake Doughnuts	Biscuits	Cookies	Crackers	Pasta
Flour type		HRW[a]	HRW &/or HRS	HRW &/or HRS	HRW	HRW &/or HRS	HRW & SRW	HRW & SRW	SRW[b]	SRW	HRW &/or SRW	Durum or HRW
Protein[c]	%	10.5-12.0	10.5-12.5	9.5-11.5[d] 11.5-14.0[e]	10.5-12.0	12-13	9.5-11.5	9-10	8-10	7.5-9.5	9-10.5	12-13
Ash[c]	%	0.48-0.52	0.48-0.52	0.50-0.54	0.48-0.52	0.50-0.54	0.46-0.50	0.46-0.50	0.48-0.54	0.38-0.42	0.48-0.52	0.55-0.75
Falling No.	s	230-270	230-270	230-270	230-270	230-270	230-270	≥300	≥300	≥300	≥300	≥300
Water absorption	%	n/a	63-66	58-62[d] 60-66[e]	59-63	62-66	56-60	52-56	50-54	48-52	48-52	n/a

[a] 14% moisture basis *[b] HWW may be substituted for HRW* *[c] SWW may be substituted for SRW in some regions of the U.S.*
[d] Hot press process *[e] Sheeted processes*

[31] Photograph courtesy of the American Institute of Baking (AIB), Manhattan, Kansas

Dough is allowed to relax for 5 - 20 min, then divided into loaf size, moulded into loaf shape and deposited in the pan. After proofing for approximately 1 hour in controlled temperature and humidity the bread is baked, cooled sliced and packaged. The flour protein (Tab. 102) must be of adequate strength to maximize volume and provide tender crumb texture, pleasant fermentation flavour, tolerance to process and shelf-life.

The liquid fermentation process is similar except that the initial fermentation takes place in a brew tank in a liquid form with less flour added [32] . The fermentation takes 1.5 - 3.0 h under controlled temperature. Once optimum fermentation is reached [33] the liquid ferment is chilled in a heat exchanger and utilized as needed to mix bread dough. The fermentation flavour resulting from this process is not as rich as a sponge and dough. The mellowing function of fermenting dough in sponge and dough is also compromised in a liquid fermentation process yielding less process tolerance and less dough strength.

Flour used in pan bread production is similar for both sponge and dough and liquid fermentation processes. Flour from hard wheat with 10.5 - 12.0% protein is typical. Flour should possess medium strength with good extensibility. Typical Farinograph specifications (Tab. 102) would indicate good water absorption without excessive time required to optimum mix. The mixing tolerance index and Farinograph stability should indicate tolerance to mixing and the process. The Falling Number should be 230 - 270 s, indicating optimum α-amylase. Typical ash levels are 0.48 - 0.52%. Whole wheat, wheat breads (part of white flour replaced with whole wheat or bran) and multigrain breads are produced in a similar manner to white pan breads. However, due to the dilution effect of the bran or multi-grains the wheat gluten protein is diluted, reducing dough strength as well as physically disrupting the continuous gluten network and thus further weakening the gluten strength. If the wheat germ remains in the flour, glutathione present in the germ acts as a reducing agent and further weakens the gluten structure. Consequently, bread dough must be augmented with stronger or higher protein, either by starting with stronger flours and/or adding vital wheat gluten to increase the gluten strength. The addition of increased oxidation further improves bread volume. Hard red spring wheat grown in the northern states of the U.S. and Canada typically has a higher protein content (13 - 15%) and is often used to improve wheat and multi-grain breads.

20.2 Baguettes and Hearth Breads [31]

In the U.S. baguettes are just one product and a relatively small part of a larger class of white hearth breads generally referred to as French or Italian breads. These breads are relatively lean compared to white pan breads. They are typically produced from a simple formula containing flour, water, yeast, and salt. Italian breads often have low levels of shortening added. As the shelf-life for breads marketed in America has increased, additional ingredients have been added. However, the quality of the crispy crusts associated with

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32 *Flour/water ratios vary widely from liquid brews with no flour to brews with about a 1 to 1 ratio of flour utilizing all of the liquid and the dough and an equal amount of flour. Generally liquid pre-ferments with greater amounts of flour produce a superior product. On the other hand liquid pre-ferments with no flour are easier and more efficient in processing.*

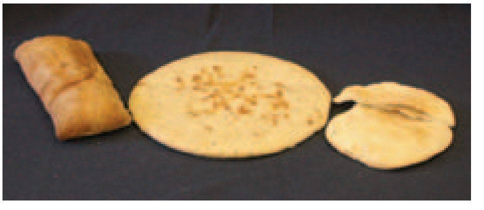
33 *pH and TTA (Total Titratable Acidity) are both used as indicators of optimum fermentation in the bakery. TTA is the preferred method as it is more accurate. Since temperature increases with fermentation many bakeries also track temperature increase during fermentation as an indicator of fermentation. Optimum ranges are established for each product and process through experience and these optimums are used as standards to monitor production.*

these breads is often compromised for the sake of shelf-life. A variety of Hard Red Spring and Hard Red Winter wheats is available to the American miller. These wheat classes range in strength from moderate to strong. This variety affords the baker an equally wide choice of flour, depending on the process requirements of the bakery and on end-product definition. The process for making hearth bread also varies, depending on the equipment available in the bakery and the desired end product. Most small and retail bakers utilize a straight dough process with all ingredients mixed initially and fermentation of the whole dough following.

Many larger commercial bakers use a liquid ferment or a sponge and dough procedure similar to that described for production of pan breads. In recent years sour dough breads have become more popular. Fermentation times are extended to 16 - 24 h along with addition of the pre-ferments necessary to develop sour flavours. Historically, many bakers used conventional bread ovens to produce French and Italian breads. This production decision made good use of existing equipment in the bakeries, but produced inferior crust characteristics. As the American consumer has become more discriminating about bread quality, many specialty retail bakeries and larger commercial bakeries are adding new ovens and processes to produce superior quality hearth breads. Due to innovative research, bakeries are also beginning to produce and distribute hearth breads in frozen dough and frozen finished forms with improved crust character.

The flours used in the U.S. for these products are characteristically higher in protein than those used by European bakers. The American baker has learned to approximate the European products with American flours and processes. The consumer in the U.S. is also accustomed to products made from stronger flours and defines quality on the basis of familiarity of the products. Both Hard Red Spring and Hard Red Winter wheat are used in white hearth bread production. Typical flours contain 10.5 - 12.5% protein, Hard Red Spring flours of higher protein being used to augment flours for products such as frozen dough that require more protein. In contrast to typical European flours, which are straight process flours, most North American millers select and blend certain streams to obtain desirable characteristics in the finished flours. The baker purchasing the flour defines these desirable characteristics. As with white pan bread, gluten strength and extensibility are crucial to the quality of French and Italian breads.

20.3 Flat Breads [31]



Production of flat breads in North America is somewhat limited in variety. Pita bread production has begun on a very limited basis. On the other hand flour tortillas, a flat bread type from Mexico, are currently one of the fastest growing bread products in the United States. The large Hispanic population in America initiated this market. The growth in popularity of Mexican foods, combined with the propensity of the American consumer to eat on the go, has driven the market and brought the use of tortillas into more and more non-traditional Mexican meals. This flour-based food "wrap" had reportedly grown into a USD 4 billion market by 2001. Tortillas are produced fresh in restaurants as well as in large-scale highly automated tortilla bakeries. Traditional bread bakeries are also adding tortilla-processing lines to expand into the tortilla markets. Tortillas are simply flour, water, shortening and salt formulas. Chemical leavening or baking powder is sometimes added to improve the texture and tenderness of the tortilla. Reducing agents have been added to improve the extensibility of the dough to facilitate high-speed production, and mould inhibitors have been added to increase

mould-free shelf-life. Flour is the main ingredient of the formula and the major contributor of textural properties and attractive appearance of the tortilla. Flour is also of primary importance to processing controls and limitations of modern processes. Flour must provide very extensible dough for processing, structure for shape and resilience in the final product and tender, moist eating texture. The resilience of the tortilla is critical, because most tortillas are served by wrapping tortilla around other food components. Without resilience the tortilla would tear during preparation or consumption as a hand held food. Flour therefore defines ease of processing and ease of handling by the user as well as the quality of the end product.

Three basic processes are used to make tortillas, all differing slightly in their flour requirements.

1. Manual process: This process requires flour that forms dough easily and that is reasonably easy to sheet and hand stretch. Since the dough is stretched gradually the flour requirements are not very critical.
2. Sheeted dough process: The sheeted and pressed processes are high-speed commercial processes that make much greater demands on the flour. The sheeted process involves producing a dough that is quite extensible, since the dough is sheeted from a dough piece about 3 - 6 cm in thickness down to a few millimetres in thickness in a few seconds by passing between two to five sets of rollers; it is then die-cut into a round shape. This dramatic extension of the dough with little time to relax between rolls is damaging to the gluten structure or strength of the dough. It also extends the dough in one direction only, causing an alignment of protein in a parallel fashion which further weakens the dough. This is especially evident when the tortilla is wrapped around other ingredients for its final use as a hand-held entree. Tortillas made by this process tend to tear or break in one direction (the direction of sheeting when produced), yielding a weak product with limited use for many applications.
3. Hot press process: In this process the dough is mixed, then after a brief relaxing time the dough ball is shaped and pressed at high pressure between two hot plates. This forms the dough ball into a thin round disk, sealing the surface. For both sheeted and hot-press tortillas the disk is then baked in a very rapid grill/bake process. This process bakes the product in about 40 - 60 s. Since the dough produced by the hot-press process is pressed from a round dough ball into a relatively large thin flat disk quickly under very high pressure the dough must be very extensible. This extensibility, coupled with adequate strength in the end product, is largely determined by the flour. The extensibility can be modified or improved by the addition of reducing agents such as L-cysteine or sulphite, both common ingredients of tortilla formulas.

Tortilla flours are usually hard wheat flours ranging from 9.5 - 11.5% protein for hot press, 10.0 - 11.5% for hand stretch and 11.5 - 14.0% for sheeted processes. Die-cut or sheeted dough requires higher protein to strengthen the final product and compensate for directional weakness of the protein. Hot press requires lower protein to facilitate extension in the press. Tortilla flour is typically untreated. Oxidation is not needed, as extensibility is crucial during processing and oxidation reduces extensibility. As with most baked products, flour consistency is important for tortilla production. However, the importance of consistency is more related to process extensibility than end product properties. Again the miller needs to be most concerned about adequate protein strength for resilience in the end product and optimum flour protein extensibility to ensure efficient processing. The Farinograph and Mixograph are valuable tools for maintaining consistent quality in the milling of flour for tortilla production. However, the flour extensibility characteristics critical to tortilla production can be evaluated better with the Extensograph or Alveograph.

20.4 Buns [31]

Due to the popularity of "hand-held meals" and sandwiches made at home or sold in fast food restaurants, the bun constitutes a very large part of the American bread market. Most large commercial bakeries produce buns along with other breads. Some bakeries, however, have dedicated bun lines or are even entire plants totally dedicated to bun production. In fact some large fast food restaurant chains have their own bakeries for bun production specifically for their restaurants, both in America as well as in other parts of the globe.

Buns are basically bread dough with more sugar and shortening than typical pan breads. The processes for dough mixing and fermentation are the same as for pan bread, with sponge and dough and liquid ferment processes common. However, there is a preference for liquid ferments in buns. The superior flavour of sponge and dough is less valued because the bun is consumed with meat and other condiments contributing flavour to the sandwich. The liquid ferment process is also more efficient and less costly in terms of capital investment. After the bun dough has fermented it is divided, shaped and placed in pans. The rheological properties of liquid ferment dough also perform well in dough pumping systems and dividers that are common with bun processes; this further explains the preference for liquid ferment. After fermentation, dividing and shaping, just as with pan bread dough, the dough is proofed in a humid hot-proofing chamber and baked. When the dough ball is formed for round buns and further shaped for oblong rolls, such as hoagies and hotdog buns, the dough must flow to fill the pan and yield the final desired shape. This flow is influenced by the formula and the process, but it is also controlled by flour properties. Flow relates to flour strength to maintain shape and bun height during proofing and baking, balanced against adequate extensibility to allow flow in the pan. These properties are more critical than in pan bread where the final bread shape is controlled by the pan. Consequently, uniform flour properties with consistent extensibility and elasticity are very important to bun flour quality. The flour of choice is typically hard wheat flour with an intermediate protein of 10.5 - 12%. The needs of the process determine the actual requirements, which will therefore vary from one process to another. For example, the requirements of sponge and dough may differ from those of liquid ferment. Conventional dough transfer to the divider with floor time allowing the dough to relax will probably require different flour properties from dough pumped directly to the divider without floor time. Rheological requirements for optimum process control and the best end product are determined by such demands of the process. The baker and the miller work jointly to determine the requirements and ensure a consistent ongoing supply of flour meeting the specific needs of the product and process. A close cooperative relationship between the baker and the miller is crucial for success in view of the stringent requirements of modern processes.

In addition to common rheological tests to monitor flour quality, dough recorders [34] are

[34] *Mixing devices equipped with dough recorders register processing parameters such as mixing time, temperature, speed, resistance and energy input, not unlike the Farinograph.*

becoming increasingly valuable to bakers for tracking mixing properties and performance in the bakery. The recorders allow the baker to see changes in mixing properties from dough to dough and are excellent indicators of changes in flour quality or other factors influencing product quality and process tolerance.

20.5 Croissants [31]

Crescent rolls, the predecessors of croissants in the U.S., have been produced for many years and are basically chemically-leavened refrigerated dough. Crescent rolls resembled croissants in shape, but the similarity ends there. The popularity of this product in the marketplace has declined in recent years and has been largely replaced by the more traditional European croissant roll. The American croissant is very similar to the European croissant; both are similar to slightly richer bread dough, ideally made with strong bread flour. After the dough is produced it is allowed to relax under cool refrigerated conditions. Then shortening (at about 12 - 16 °C) is deposited on the surface of the sheeted chilled dough (also about 12 - 16 °C). The dough is further folded until typically about 16 - 18 layers of shortening are produced. During the folding process the dough is retarded or cooled for extended periods of time, perhaps up to 24 h, to allow slow fermentation improving flavour and increasing dough extensibility for sheeting and processing. This lamination process is critical for establishing tender eating character and lacy interior crumb structure. The roll-in shortening also contributes to flaky texture, crisp crust and flavour. Butter is the shortening of choice since its unique plastic properties are ideal for developing texture and lacy interior, and it contributes to superior flavour. Margarine is sometimes used to replace part or all of the butter. This reduces cost but results in an inferior product.

As in most baked products flour is a major ingredient, defining much of the quality attributes of the end product made from the flour. This is also true of croissants. Relatively strong bread flour is preferred, with a protein content of about 12 - 13% [35]. The high level of butter or margarine laminated into the dough requires more dough strength to facilitate the sheeting or lamination process and to obtain maximum volume and tenderness in the final product. Basic croissant dough before lamination is very similar to bread dough with functional flour requirements that are also similar to bread flour. However, extensibility as determined by the flour protein qualities takes on added importance due to sheeting in the lamination process.

20.6 Deep-Fried Pastries

There are two classes of deep-fried pastries that are commonly produced in both retail bakeries and large commercial wholesale bakeries in North America. The first is yeast-raised doughnuts and the second cake doughnuts. Since they have longer inherent shelf-life, cake doughnuts are produced mostly in larger commercial bakeries. Due to consumer preference for very fresh yeast-raised doughnuts, most of these are produced in retail bakeries, supermarket in-store bakeries and doughnut shops. Both products have rather specific flour requirements that vary somewhat according to end-product and process requirements. In both cases flour blends of higher protein hard wheat flour and lower protein soft wheat flour are required, with a few exceptions which will be outlined in this section.

35 In France, the country of origin of croissants, the bakers are able to make good quality croissants from soft wheat flour with only 10 – 11% protein, probably because they are accustomed to this flour quality in this application since centuries.

20.6.1 Yeast-Raised Doughnuts [31]

Yeast-raised doughnuts, as the name implies, are made from a dough containing yeast as a leavening source. This dough is similar to bread dough. However, they normally contain 5 - 10% sugar and 5 - 10% shortening. Yeast levels are generally much higher too – 2 - 3 times those of bread. The basic mixing or dough development requirements are similar to bread. Most yeast-raised doughnuts are made with a straight dough procedure. In this process, all ingredients are added at once, and fermentation takes place with all the ingredients in the dough. Since the yeast levels are higher, fermentation requirements are much less than for typical bread. Some large commercial bakeries do use a sponge and dough or liquid fermentation system. The fermentation in these systems takes place in a sponge dough or liquid brew, which includes only water, yeast, yeast nutrients and part of the flour. After fermentation the rest of the ingredients are added for remixing of the final dough. Regardless of the fermentation system, the dough is subsequently shaped as required and allowed to proof or rise for 25 - 40 min. The proofing conditions are much drier than those required for breads; proof moisture is typically 40 - 70% for doughnuts as against 85 - 95% for breads. Then the dough pieces are fried in a deep-fat fryer at about 185 - 195 °C; they are either surface fried with a turning step or fried submerged, depending on the product variety and process limitations. After frying, the products are typically coated with a sweet icing or glaze, and some varieties are filled by injection with a fruit or crème filling. Yeast-raised doughnuts typically require a blend of hard wheat flour, usually with 11 - 12% protein, and soft wheat flour with 8.5 - 9.5% protein. The hard wheat flour predominates at 60 - 100% of the blend for most yeast-raised products. This blend is determined by the relative baking quality of the flours, the richness (relative percentage of sugar and shortening) of the formula and process requirements. Strong wheat flours require more soft wheat flour in the blend to mellow the hard flour strength. Weak hard wheat flours need less soft flour in the blend. Generally speaking, the richer the formula the stronger is the flour needed to carry the ingredients. Rich formulas consequently require more hard flour and less soft flour. If flour strength is inadequate the doughnuts will lack volume and tenderness, exhibit excess frying-fat absorption and lack tolerance to variation in fermentation, proofing and processing. If the flour strength is excessive the doughnuts will achieve very high volume in the fryer but will collapse after frying, yielding a net loss in volume and a less uniform appearance.

The doughnuts will also exhibit more large air blisters just under the surface of the crust of the doughnut. This creates a less regular appearance and the crust often breaks away during further processing and coating of the doughnut. This doughnut also exhibits tougher eating qualities.

There are two special process situations requiring stronger flour blends, and in fact only strong hard wheat flours are typically used. Pressure-cut doughnuts are produced by extruding ring shaped doughnuts under high pressure. Due to the negative impact of direct extrusion on the protein strength of the dough, flour with a much higher protein level is required. In fact hard wheat flours with 12 - 13.5% protein with no added soft wheat flour are typically used for pressure-extruded yeast-raised doughnuts.

Doughnuts are also commonly produced in a frozen dough form for distribution to supermarket in-store bakeries and retail bakeries. Freezing of yeast-raised dough causes damage to the yeast and to the dough structure.

Consequently, this dough is produced with even stronger flours, most typically with 12.5 - 13.5% protein.

194 Use of weak or lower protein flour in pressure-cut doughnuts results in reduced volume and increases fat absorption in the finished products. Besides causing a loss of volume and excessive fat absorption, too little flour protein in frozen-dough doughnuts results in a loss of tolerance during frozen storage. The basic function of flour in yeast-raised doughnuts is the same as that in breads apart from the need to blend flours to produce optimum doughnuts.

20.6.2 Cake Doughnuts [31]

Cake doughnuts are similar to cakes in that they are rich, sweet batters produced with chemical leavening. However, their formulas are rather different from baked cakes due to deep fat frying of the batter. This batter is extruded directly into the frying fat. It is expanded during frying by the interaction of sodium bicarbonate and leavening acids (so-called baking powder). Since there are no constraints on the fluid batter while being cooked in a fluid frying medium, the final volume and shape of the doughnut is determined by the formula and process controls. Control of viscosity during the heating process is important for the quality of the final product. Flour is the predominant ingredient of the formula; flour quality is therefore important for controlling viscosity and batter flow and thus for the quality of the end product. The final properties of the doughnut are influenced by several factors. Firstly, frying fat is absorbed from the fryer during cooking. In fact about 20 - 24% of the final doughnut is fat, most of which is absorbed during frying. Control of this frying fat absorption is critical for the quality of the final product. The formula, process control and the quality of the ingredients, especially flour, are instrumental in fat absorption control. Secondly, control of the time at which the batter surfaces is also important. This is largely determined by leavening and process controls, especially batter temperature and floor time. If the time for the batter to rise to the surface of the frying fat is delayed, the doughnuts will be grossly misshapen. Thirdly, control of batter flow during frying is critical. The batter must break quickly and evenly along the frying-fat line on the inside of the doughnut and then flow to the centre. At the same time the outside of the doughnut ring should be strong enough to maintain its shape, forcing the batter to flow inwards rather than outwards. Flour is instrumental in influencing this property. However, proper balance of all the ingredients in the formula is essential too. Fourthly, the batter must have adequate strength just before the doughnut is turned to prevent excess bubbling or gassiness at the batter surface. This prevents excess fat absorption and small holes in the surface of the doughnut. Flour quality helps to support the batter strength at this point in frying also.

Since flour quality influences the performance 196
of the batter at several critical points during frying, proper control of flour quality is important to end-product quality. Flours used for cake doughnuts are a blend of soft wheat flour and hard wheat flour. The nature of the blend is determined by the quality contribution of each flour in the blend as well as the desired end product. Generally a soft wheat flour of 8.5 - 9.5% protein and a hard wheat flour of 10.5 - 12.0% protein are appropriate for cake doughnuts. Blends of 70/30 or 50/50 soft to hard flour are common for this purpose. However, if the quality properties of individual flours deviate from the norm, the blends may

differ from those described. These flours are generally not treated, apart from the addition of α-amylase to the hard flour as is typical of hard flours for use in bread. No bleach is added. Quality tests for hard wheat flours are typical of those used for breads. Quality tests for soft flours are typical of other soft wheat applications. Common tests to define soft wheat flour include moisture, protein, ash and MacMichael viscosity [36] . However, due to the uniqueness of cake doughnuts, practical frying tests are most effective and are commonly used by cake doughnut mix manufacturers in the United States. The Farinograph is not commonly used as a quality test for soft flours in America. However, there is some evidence in cake doughnut applications that consistent Farinograph MTI[37] and stability in soft wheat flour do correlate to consistent end product quality.

20.7 Cookies, Crackers, Biscuits and Wafers

With additional remarks by J.v. Wakeren

The definitions used by manufacturers and consumers of these product categories vary enormously, especially from country to country and from one language to another.
Even in English-speaking countries like the USA and the UK the products are given different names. In the USA they are called cookies or crackers, in the UK they are generally biscuits. Moreover, the brand name is often used to indicate a product.
The presence of products in a market may be influenced by the country where the product originated, for example crackers: in some countries soda crackers are popular (USA), and in others cream crackers (UK).
Wafers are similar all over the world and include flat, hollow and rolled wafers.

20.7.1 Cookies [38]

Cookies are made with dough containing higher sugar and shortening levels and often low in water content. They range from dry crunchy cookies to chewy intermediate-moisture varieties most typically produced in retail bakeries or in the home; both are mass-produced in large commercial bakeries.
Sweet cookies are very low in moisture, + 2.5%, and have a long shelf-life. With increasing moisture content the shelf-life becomes shorter, so the moisture content is carefully controlled. Retail cookies typically have a short life of perhaps a week or so.
Cookies vary widely in composition. The formula is defined by the desired end product and accordingly the process and machines that are used to produce the cookie. Each process has specific requirements in terms of dough rheology to facilitate processing.

There is also great variety of flavourings added for product differentiation. Common flavours are vanilla and butter. Cocoa powder, chocolate chips, oatmeal, raisins, large sugar crystals and nuts and decorations are other means of differentiation.

[36] MacMichael viscosity is a test often used for cake flours. In the test, viscosity is measured for a thin flour/water slurry with incremental increases in added lactic acid. The rate at which the viscosity increases and the final viscosity reached serve as an index of flour strength. Most quality cake flours have a MacMichael viscosity of 40° to 50° MacMichael.

[37] MTI stands for mixing tolerance index. This value is the difference in Brabender Units (BU) between the top of the curve at the peak and the top of the curve at 5 min after the peak is reached. A related measure called "drop-off" refers to the difference in Brabender Units between the 500-BU line and the centre of the curve measured at 20 min from the addition of water.

[38] Photograph courtesy of Mühlenchemie GmbH, Ahrensburg, Germany

Cream sandwich cookies are made with fillings in a wide variety of flavours.
An important factor in cookie production is controlling spread. Tight specifications and tolerances for cookie height and diameter are necessary to permit efficient packaging as well as quality assurance. Spread in cookies is best understood by explaining the mechanism of cookie baking. The process starts in the dough and continues in the oven. When the baking starts the fat melts, and as the baking process continues the amount of sugar dissolved by the water drives spread. As the temperature rises, the volume of the sugar solution increases. Sugar takes up water faster than gluten, so in dough with a higher sugar level there is less water available for gluten development; conversely, the less sugar the dough contains, the more water is available for gluten development, the result being less spread.

Any other ingredient with increased water absorption also restricts spread because it reduces the availability of water for gluten formation, assuming that the amount of water contained is the same. The starch certainly plays a role during baking but the question has really more to do with the gluten. At some point the factors limiting spread overcome the increasing influence of the sugar solution and the spread stops.
After baking, the sugar in the cookie re-crystallizes and determines the final texture of the cookie. The removal of excess moisture during baking is influenced by the geometry or shape of the cookie. Baking times and temperatures vary in order to achieve the required texture and the removal of moisture.

Flour is a major ingredient and the primary determinant of spread and height, and it influences the structure and textural properties of the final cookie. The main components of flour are starch and protein. About 80% of the total protein content consists of gliadin and glutenin; combined with water, these two form a viscoelastic mass called gluten. The presence of gluten is necessary in order to produce cookies and crackers with a good texture. The only cereal that contains gliadin and glutenin in the ideal proportions is wheat. There are exceptions, like gingerbread that do not depend on the properties of gluten.

It is important for the baker to consider the water absorption in the dough by different components of the flour, mainly in order to know which kinds of enzymes are necessary for use in a given product and to compensate for differences in flour quality. In cookie and cracker flour, protein constitutes 8 to 11% of the composition and absorbs ≥35% of the water; pentosans constitute 2.5 to 3% and absorb 25% of the water, 75 to 80% of the flour is starch and absorbs 40% of the water.

The most common process is rotary moulding. Other methods are extrusion, also called rout-press, dual extrusion, extrusion with wire cutting and depositing. An advantage of these processes is that there is no return dough.

A more complicated method is the cutting machine for which the dough is sheeted and passed between gauge rolls to obtain a continuous dough sheet from which the dough pieces are cut with a rotary cutting roll, or on older machines reciprocating cutting. The excess dough is returned to the hopper of the sheeter.

The rotary moulding process involves a crumbly dry dough that is pressed into a cavity in a moulding roll, the cavities often having intricate designs. The dough takes the shape of the cavity and the design. The excess dough is cut off by a knife. The dough is released from the cavity by an extraction band that is pressed against the moulding roll by a vulcanised roll. The dough pieces stick to the extraction band; they are then passed on to a swivel panning band and then to the oven band. The dough must have suitable texture to retain the shape of the mould. The formula is balanced with minimal stickiness to allow release from the mould. After baking the cookie dough should maintain the shape of the mould (in most cases). Consequently, dough rheology must control moulding and release and the desired spread.

Extrusion cookies involve placing a relatively soft dough in a hopper located over rolls, then forcing it through a gap to the appropriate die to make the desired size and shape. Strands of dough are normally deposited on a conveyor and cut before or after baking. With dual extrusion different masses are extruded simultaneously; the filled strands are cut off with a diaphragm or knife before baking or with a knife after baking.

Wire cutting is an extrusion process; when the dough is forced through dies in a continuous stream a reciprocating wire cuts off the dough pieces. Dual extrusion is possible, using different coloured doughs. The dough pieces may drop onto a belt and be transferred into the oven for baking or deposited directly on the oven band. The consistency of the dough must be such that it flows through the extruder easily. Again the rheology of the dough is balanced by means of the formula to optimise processing.

Deposited cookies are extruded in a similar fashion to wire-cut cookies except that there is no cutting step. The cookie dough is deposited directly on the steel band of the oven. Often the belt rises with each cut so that the cookie sticks to the belt, and when the band drops the dough piece separates easily from the die. The rheology of the cookie batter must be relatively soft to flow readily through the extruder and must stick to the belt to facilitate release. Shaped dies are often used to create cookies of various shapes such as round, star or oval. The dies can often make certain movements to create a specific shape – a swirl or a continuous zigzag, the latter being cut after baking.
Formulas for depositing often have a rather high fat content. Final spread must be adequate for expansion but retain the desired shape.

Sheeted dough processes are used for cookies with different compositions and a wide variety of shapes. The surface appearance is smooth compared to cookies made with a rotary moulding machine. These products mostly have a low fat level. Products with a low fat content are often perforated with so-called docker pins to obtain a regular surface and optimum moisture distribution in the finished products.

The dough must have the consistency to allow extrusion (sheeting) onto a belt and transfer from the sheeter onto a conveyor. It passes over various conveyor webs and through sets of gauge rolls to create dough with uniform thickness that cuts easily without sticking to the gauge rolls and cutters. The dough is cut into the desired shapes by rotary cutting or by reciprocating cutting on older machines. Modern machines are fitted with two rolls, an embossing roll and a cutting roll. The embossing roll is for perforation (docker) and embossing with lettering and designs; the second roll is used for cutting. The dough rheology must facilitate sheeting and cutting and allow retention of the desired shapes. Again the ingredients of the formula, especially flour, contribute to these rheology requirements and the shape and consistency of the final product.

Flour is the predominant ingredient in cookie formulas. It is a major controlling factor in cookie spread, texture and volume and in adapting formulas to the rheological requirements of each process. The flour properties and for-mulation influence the consistency of the dough to suit the required process. They also influence control of the free water in the dough and in turn the volume of the sugar solution that drives spread during baking.

Consequently, choice of the right flour is important and ongoing consistent production of flour by the mill is equally important. Generally speaking, soft wheat milled to moderately high extractions is used in cookie applications. These flours are usually untreated and referred to as pastry flour, with a protein range of 7.5% - 9.5% and an ash content of 0.50%. High protein in flour restricts spread and soft flours facilitate spread. Bleaching or chlorination of flour also restricts spread, so it is usually unnecessary unless excess spread is a problem with a specific formula. Chlorination is not allowed in many countries.

Tests for controlling the quality of cookies include physical aspects, gluten washing and observation, ash and protein analysis, cookie baking tests, Brabender's Farino-, Extenso- and Amylograph and Chopin's Alveograph. The MacMichael viscosimeter is mainly used in the USA. Any test that indicates the ability of flour to absorb and control free water in the dough may prove to be of at least some value in controlling cookie quality.

20.7.2 American Biscuits

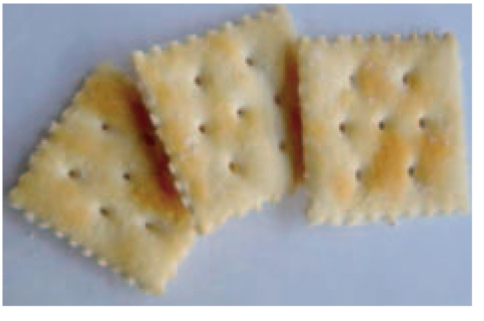
Fig. 192: Cheese and sausage biscuit [31]

American biscuits are generally served only at meals in place of bread. They are occasionally used with eggs, sausage, bacon etc. as a breakfast sandwich. The product is produced with soft wheat flours that have been heavily bleached to yield a bright white crumb appearance. The formula contains flour, water, salt, chemical leavening, a low level of sugar and a high to very high level of fat or shortening. The shortening is of a plastic nature, and when incorporated properly it results in a short flaky texture in the final biscuit. The dough usually has a short mixing time to cut in the shortening in discrete particles. When the dough is sheeted, discrete flakes of shortening are formed in it. The sheeted dough is then stamp-cut into round or hexagonal shapes and baked. Upon baking the shortening flakes create the flaky texture. The high level of shortening also forms a crust with a somewhat shiny appearance and almost fried texture. Several prominent U.S. fast food restaurant chains such as MacDonald's, Hardees and Kentucky Fried Chicken have produced biscuits fresh in the restaurants to facilitate the sale of menu items and for breakfast sandwiches (Fig. 192 and Fig. 193). However, many of these restaurants now purchase pre-made biscuits in baked frozen or frozen dough forms.

The flour most often used for biscuits is soft wheat flour with a protein content of 8.0 - 9.5%. The flour is heavily bleached with chlorine and/or benzoyl peroxide to produce a very white crumb colour in the finished product.

Fig. 193: Breakfast biscuit [31]

20.7.3 Crackers [38]



There are different types defined by the process and end products. Crackers might be described as thin crisp baked snack foods. They are generally unsweetened to slightly sweet but are often salty and made with fermented and/or enzyme-modified dough. Crackers with added flavours are gaining acceptance in the marketplace. Common added flavours are cheese, sour cream, spice, and various savoury flavours.

Chemicals – chiefly sodium metabisulphite (SMB) – are sometimes still used to modify the dough properties. This should be avoided since SMB has important drawbacks such as the loss of vitamin B_1 (thiamine), less colour, and the risk of allergic reactions. SMB should be replaced by enzymes that do not have these disadvantages. The result will be a better product, and clean labelling is possible since enzymes do not have to be declared in most countries because they are considered to be processing aids.

Soda and cream crackers are defined by the process and end product attributes. Both types are manufactured in large quantities in different countries around the world. Consumers prefer soda crackers in some countries and cream crackers in others. In many countries different cracker types are produced that are good but neither soda crackers nor cream crackers. Both soda and cream crackers are made with fermented dough. A sponge made up of flour, water, shortening and yeast is mixed and fermented. After 16 - 18 h of fermentation the sponge is remixed with the addition of flour, shortening, sugars, salt, soda etc., and fermented for another period of 4 to 6 h, a two-stage process.

In some cases a starter or diastatic malt flour is used to initiate and increase the rate of fermentation. Using a properly selected combination of enzymes produces the same effect. Enzymes have a standard quality and their use therefore results in more uniform crackers. Good products are also made with short fermentation times ranging from 3 to 12 h with sponge / dough or a direct process. For short fermentation processes enzymes are used to obtain the required characteristics.

The extended fermentation matures dough, increasing the extensibility that facilitates processing. After fermentation the cracker dough is sheeted, layered (folded or cut and laid), laminated, and cut to shape with a cutting machine. For fermented crackers the cutting machine has to be fitted with a laminator that produces a dough sheet which is folded, or cut and layered. Soda cracker dough is layered without additions, and for cream crackers a mixture of flour, fat and salt is spread between the layers of dough. Fermented crackers are baked and leavened with internal steam formation and CO_2 resulting from the fermentation process. The baking process initially sets the structure, then moisture is reduced and colouring occurs in the last stage of the oven. In cracker production the desired volume and texture of the final product is mainly obtained through the fermentation process and relatively small levels of other raw materials. For sweet cookies the gluten is modified with higher levels of sugar and shortening. To modify the gluten in cracker dough, yeast is used for fermentation for the particular flavour. In addition, enzymes are used together with low levels of shortening, reducing sugars and probably some other materials such as milk solids. The flour normally used for crackers made with fermented dough is stronger than for sweet cookies.

Enzyme-modified crackers depend on the action of enzymes, which modify the gluten properties to achieve the desired extensibility of the dough. These crackers are produced by a straight dough process. After a resting time of some 2 - 4 h to give the enzymes time to react, the dough is sheeted, laminated, cut into the desired shape and then baked. There are cases where a short fermentation period is used to achieve the typical flavour.
The choice of enzymes is very important for both fermented and enzyme-modified crackers. In many cases only protease is used, but a combination of protease, amylase and probably hemicellulase is the better choice and often permits the reduction of other raw materials in the dough such as milk solids, malt flours, syrups and glucose, thus reducing the cost of raw materials. The dough is processed on a cutting machine; a laminator is not required for most enzyme-modified crackers. These crackers are leavened with chemical leavening agents.

Crackers are generally produced with soft wheat flours containing 9% - 10% protein.

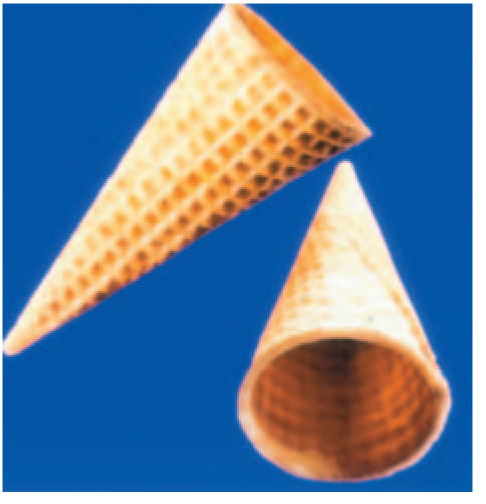
Stronger flour blends are more typical of fermented crackers. A typical ash content is about 0.5%. If the wheat quality varies, the baker may use enzymes to make adjustments. Hard (semi-) sweet biscuits (cookies) are produced with chemical leavening agents, and sodium metabisulphite is often still used as a reducing agent to relax gluten before processing.

20.7.4 Wafers *38*

There are flat and hollow, rolled and soft wafers. The batters for flat and hollow wafers are liquids containing basically flour, water, enzymes, fat/lecithin (often added as a mixture) and sodium bicarbonate. To enhance quality and produce variations it is possible to add egg powder, cocoa powder etc. These wafers do not have much flavour and are in reality carriers for cream fillings. They give the crunchy texture that can result in very interesting products. Wafers made from fermented batters have an interesting flavour and texture.

The batter is deposited and baked between plates on continuous ovens. After baking the wafers are cooled, filled, cut and wrapped as such or used as components of confectionery products and candy bars. Hollow wafers are produced with specially designed plates; they are round or in the shape of nuts, for example. After filling and cutting they are often enrobed. Some well-known products include some kind of grain/nut in each cavity, together with the cream. Sweet and savoury fillings are used for both plain and hollow wafers, cheese flavour being very popular in some countries. Rolled wafers are produced with special ovens in a continuous strip that is rolled after baking and filled with cream if desired. The formula contains more sugar and fat.

Popular uses are cones as edible ice-cream containers made with a flat wafer type batter or a rolled wafer type formula. A different baking machine is required for each type.
Soft wafers are thick and have a higher moisture content and thus a short shelf-life.



The flour used for wafers should have a low to medium protein content (approx. 8 – 11 % d.b.), either from hard or soft wheat. It is primarily a source for starch, whereas gluten formation is not desired. Higher protein content and coarser flour particles increase the stability and the density of the wafers. With higher protein content, proteolytic enzyme preparation are useful to avoid gluten lump formation and to lower batter viscosity (see also chapter 18.13.5, page 282).