CHAPTER 1

The Science of Doughs and Bread Quality

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CHAPTER OUTLINE

INTRODUCTION

Cereals and cereal-based products have constituted the major component of the human diet throughout the world since the earliest times. Cereal crops are energy dense, providing approximately 10–20 times more energy than most juicy fruits and vegetables. Major cereal crops include wheat, rice, corn, and barley. The cereal crop most produced is corn (or maize) (31%), but it has relatively less importance than wheat and rice because it is not directly used for human consumption. Wheat and rice are the most important cereals with regard to human nutrition, and they account for 55% of the total cereal production. Nutritionally, they are important sources of dietary protein, carbohydrates, the B group vitamins, vitamin E, iron, trace minerals, and fibers. It has been estimated that global cereal consumption directly provides approximately 45% of protein and energy necessary for the human diet and only approximately 7% of the total fat (Table 1.1). The specific contribution of wheat to daily food intake corresponds to approximately 20% of the required energy and protein for the human diet (see Table 1.1).

Cereals have a variety of uses as food, although only two cereals, wheat and rye, are suited for the preparation of leavened bread. Nevertheless, wheat is a unique cereal that is suitable for the preparation of a wide diversity of leavened breads that meet consumer demands and requirements worldwide (Figure 1.1) (Rosell, 2007a). Among baked goods, bread has been a staple food for many civilizations. Even today, bread and cereal-based products constitute the base of the food pyramid, and its consumption is recommended in all dietary guidelines. Bread has a fundamental role in nutrition due to the adequate balance of

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TABLE 1.1 Contribution of Cereals to the Daily Food Intake

	Food Consumption (kg/Capita/Year)	Food Consumption (kcal/Capita/Day)	Protein Consumption (g/Capita/Day)	Fat Consumption (g/Capita/Day)
Total		2808.87	75.72	79.63
Cereals	151.07	1302.75	31.62	5.49
Wheat	67.00	518.00	15.34	2.18
Milled rice	54.21	541.92	10.07	1.28
Barley	1.13	8.04	0.23	0.03
Maize	18.54	152.72	3.66	1.22
Rye	0.98	7.42	0.20	0.03
Oats	0.52	2.94	0.12	0.05
Millet	4.05	33.26	0.89	0.35
Sorghum	3.90	32.72	0.97	0.33
Other cereals	0.74	5.73	0.16	0.02

Source: Food and Agriculture Organization (2007).

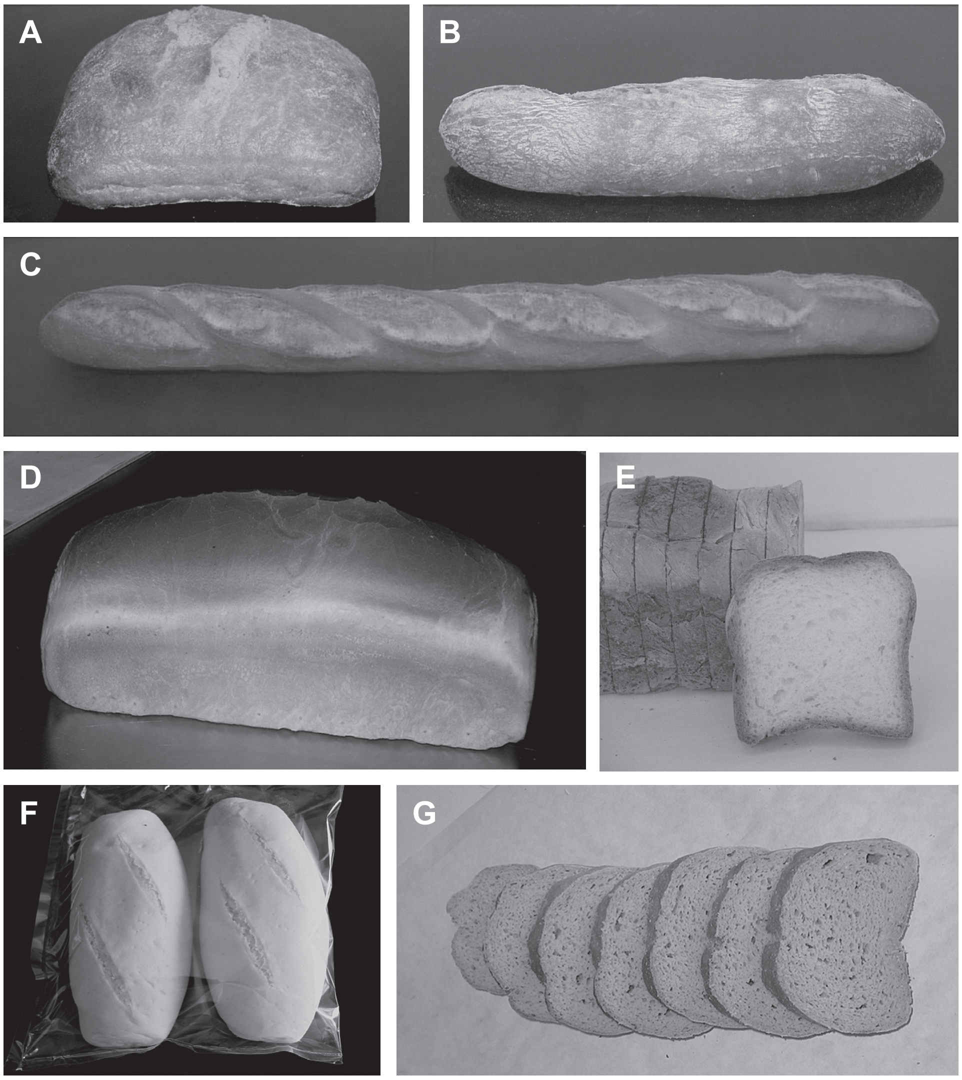

FIGURE 1.1
Different types of breads. There is a wide diversity of leavened breads that meet consumer demands and requirements worldwide. (A and B) Crusty bread named ciabatta, (C) baguette, (D and E) pan bread, (F) partially baked bread, and (G) fiber-enriched bread.

macronutrients in its composition; in addition, it provides some micronutrients and minerals.

NUTRITIONAL VALUE OF CEREALS AND THE IMPACT OF MILLING

All cereal grains have a fairly similar structure and nutritive value, although the shape and size of the seed may be different. In this chapter, wheat is used as a reference because it is the base of more foods than any other grain and the basis for the preparation of leavened bread; hereafter, the discussion refers to wheat grain.

The chemical components of cereals are not evenly distributed in the grain. Table 1.2 provides the nutritive value of the three main different parts in wheat. Bran, which represents 7% of the grain, contains the majority of the grain fiber, essentially cellulose and pentosans. It is a source of B vitamins and phytochemicals, and 40—70% of the minerals are concentrated in this outer layer. The endosperm, the main part of the grain (80—85%), contains mostly starch. It has lower protein and lipid content than the germ and the bran, and it is poor in vitamins and minerals. The germ, the small inner core that represents approximately 21% of the grain, is rich in B group vitamins, proteins, minerals such as potassium and phosphorous, healthful unsaturated fats, antioxidants, and phytochemicals. Cereals are rich in glutamic acid, proline, leucine, and aspartic acid, and they are deficient in lysine. The amino acid content is mainly concentrated in the germ.

Generally, cereal grains are subjected to different processes to prepare them for human consumption. These processes significantly affect their chemical composition and consequently their nutritional value.

The majority of wheat is milled into flour, which can be used to make many types of breads that differ in shape, structure, and sensory characteristics. Milling removes the fibrous layers of the grain; therefore, refined cereals do not have the same nutritional and health benefits as the grain or wholemeal (see Table 1.2). Without the bran and germ, approximately 45% of the grain proteins are lost, along with 80% of fiber, 50—85% of vitamins, 20—80% of minerals, and up to 99.8% of phytochemicals. In addition, important losses of amino acids (35—55%) occur during refining. Some fiber, vitamins, and minerals may be added back into refined cereal products through fortification or enrichment programs, which compensates for losses due to refining, but it is impossible to restore the phytochemicals lost during processing (Rosell, 2007b).

BREAD DOUGH MODIFICATIONS DURING THE BREAD MAKING PROCESS

A brief description of the bread making process is included so that the reader will understand the physical and chemical constraints to which the cereal main biopolymers, constituents of the dough, are exposed during the process (for more detailed information, see Cauvain, 2003). Different alternatives have been developed for adapting bread making to consumer demands and for facilitating the baker's work (Figure 1.2). Bread making stages include mixing the ingredients, dough resting, dividing and shaping, proofing, and baking, with great variation in the intermediate stage depending on the type of product. During mixing, fermenting, and baking, dough is subjected to different shear and large extensional deformations (including fracture), which are largely affected by temperature and water hydration (Rosell and Collar, 2009). Several physical changes occur during the bread making process, in which gluten proteins are mainly responsible for bread dough structure formation, whereas starch is mainly implicated in final textural properties and stability.

In bread making, mixing is one of the key steps that determine the mechanical properties of the dough, which have a direct consequence on the quality of the end product. Mixing evenly

TABLE 1.2 Proximate Composition (%) of Wheat and the Effect of the Milling Process on Nutrient Composition

	Wheat Grain	Bran	Flour	Germ
Energy (kcal)	329.0	216.0	364	360
Total carbohydrate (g)	68.0	64.5	76.3	51.8
Dietary fiber (g)	12.0	42.8	2.7	13.2
Total fat (g)	1.9	4.3	1	9.7
Saturated fat (g)	0.3	0.6	0.2	1.7
Monounsaturated fat (g)	0.3	0.6	0.1	1.4
Polyunsaturated fat (g)	0.8	2.2	0.4	6
Protein (g)	15.4	15.5	10.3	23.1
Amino acids				
Tryptophan (mg)	195	282	127	317
Threonine (mg)	433	500	281	968
Isoleucine (mg)	541	486	357	847
Leucine (mg)	1038	928	710	1571
Lysine (mg)	404	600	228	1468
Methionine (mg)	230	234	183	456
Cystine (mg)	404	371	219	458
Phenylalanine (mg)	724	595	520	928
Tyrosine (mg)	441	436	312	704
Valine (mg)	679	726	415	1198
Arginine (mg)	702	1087	417	1867
Histidine (mg)	330	430	230	643
Alanine (mg)	555	765	332	1477
Aspartic acid (mg)	808	1130	435	2070
Glutamic acid (mg)	4946	2874	3479	3995
Glycine (mg)	621	898	371	1424
Proline (mg)	1680	882	1198	1231
Serine (mg)	663	684	516	1102
Vitamins				
Vitamin A (IU)	9	9	—	—
Vitamin E (mg)	1.0	1.5	0.1	—
Vitamin K (μg)	1.9	1.9	0.3	—
Thiamin (mg)	0.5	0.5	0.1	1.9
Riboflavin (mg)	0.1	0.6	—	0.5
Niacin (mg)	5.7	13.6	1.3	6.8
Vitamin B_6 (mg)	0.3	1.3	—	1.3
Folate (μg)	43	79	26	281
Pantothenic acid (mg)	0.9	2.2	0.4	2.3
Choline (mg)	31.2	74.4	10.4	—
Minerals				
Calcium (mg)	25	73	15	39
Iron (mg)	3.6	10.6	1.2	6.3
Magnesium (mg)	124	611	22	239
Phosphorus (mg)	332	1013	108	842
Potassium (mg)	340	1182	107	892
Sodium (mg)	2	2	2	12
Zinc (mg)	2.8	7.3	0.7	12.3
Copper (mg)	0.4	1.0	0.1	0.8
Manganese (mg)	4.1	11.5	0.7	13.3
Selenium (μg)	70.7	77.6	33.9	79.2

Source: Gramene (2009).

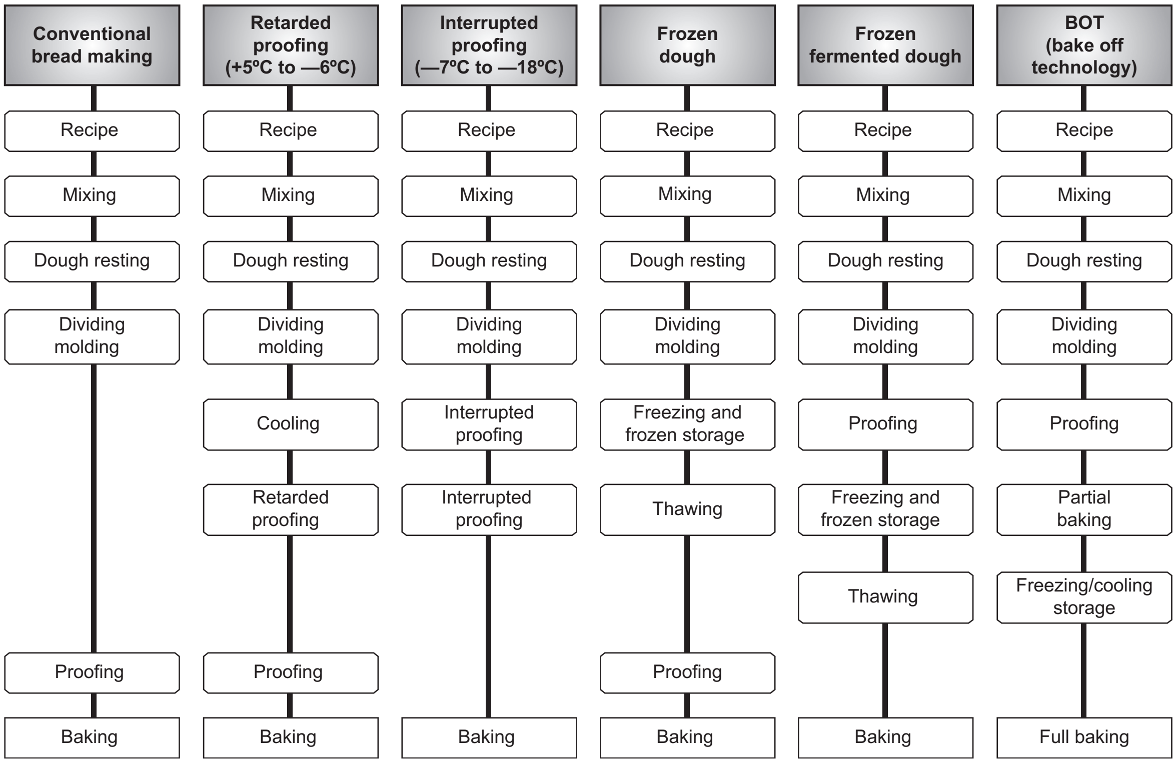

FIGURE 1.2
Current methods of bread making. Different alternatives have been developed for adapting bread making to consumer demands and for facilitating the baker's work. Bread making stages include mixing the ingredients, dough resting, dividing and shaping, proofing, and baking, with great variation in the intermediate stage depending on the type of product.

distributes the various ingredients, hydrates the component of the wheat flour, supplies the necessary mechanical energy for developing the protein network, and incorporates air bubbles into the dough. Each dough has to be mixed for an optimum time to fully develop, and at this stage it offers maximum resistance to extension. The period of barely constant torque determines the dough stability, which is dependent on the flour and mixing method used. Undermixing may cause small unmixed patches that interfere in the proofing stage. Conversely, if the mixing is excessive, dough properties change from good (smooth and elastic) to poor (slack and sticky) (Sliwinski *et al.*, 2004), and a decrease in the consistency is observed, which is attributed to the weakening of the protein network. Bread dough is a viscoelastic material that exhibits an intermediate rheological behavior between a viscous liquid and an elastic solid. Bread dough must be extensible and elastic enough for expanding and holding the released gases, respectively.

During initial mixing, wheat dough is exposed to large uni- and biaxial deformations. Moreover, the material distribution, the disruption of the initially spherical protein particles, and the flour component hydration occur simultaneously, and together with the stretching and alignment of the proteins, this leads to the formation of a three-dimensional viscoelastic structure with gas-retaining properties. The rheological properties of wheat flour doughs are largely governed by the contribution of starch, proteins, and water. The protein phase of flour has the ability to form gluten, a continuous macromolecular viscoelastic network, but only if enough water is provided for hydration and sufficient mechanical energy input is supplied during mixing. The viscoelastic network plays a predominant role in dough machinability and affects the textural characteristics of the finished bread (Collar and Armero, 1996). The viscoelastic properties of the dough depend on both quality and quantity of the proteins, and the size distribution of the proteins is also an important factor. Two proteins present in flour (gliadin and glutenin) form gluten when mixed with water and give dough these special features. Gluten is essential for bread making and influences the mixing, kneading, and baking properties of dough. According to MacRitchie (1992), two factors contribute to dough strength: the proportion of proteins above a critical size and the size distribution of the proteins. The properties of this network are governed by the quaternary structures resulting from disulfide-linked polymer proteins and hydrogen bonding aggregates (Aussenac *et al.*, 2001). Dough mixing involves large deformations that are beyond the linearity limit, which correlates with nonlinear rheological properties. The characterization of the viscoelastic behavior exceeding the linear viscoelasticity requires specialized devices that record dough consistency when subjected to mechanical stress and/or dual mechanical and temperature constraints (Rosell and Collar, 2009). The stability of failure in single dough bubble walls is directly related to the extensional strain hardening properties of the dough, which plays an important role in the stabilization of bubble walls during baking.

During proofing or fermentation, yeast metabolism results in carbon dioxide release and growth of air bubbles previously incorporated during mixing, leading to expansion of the dough, which inflates to larger volumes and thinner cell walls before collapsing. The growth of gas bubbles during proof and baking determines the characteristics of the bread structure and thus the ultimate volume and texture of the baked product. The yeast breaks carbohydrates (starch and sugars) down into carbon dioxide and alcohol during alcoholic fermentation. Enzymes present in yeast and flour also help to speed up this reaction. The carbon dioxide produced in these reactions causes the dough to rise (ferment or proof), and the alcohol produced mostly evaporates from the dough during the baking process. During fermentation, each yeast cell forms a center around which carbon dioxide bubbles are released. Thousands of tiny bubbles, each surrounded by a thin film of gluten, grow as fermentation proceeds. Kneading or remixing of the dough favors the release of large gas bubbles, resulting in a more even distribution of the bubbles within the dough.

The size, distribution, growth, and failure of the gas bubbles released during proofing and baking have a major impact on the final quality of the bread in terms of both appearance (texture) and final volume (Cauvain, 2003). As the intense oven heat penetrates the dough, the gases inside the dough expand, with a concomitant increase in the size of the dough. As the temperature rises, the rate of fermentation and production of gas cells increases, and this process continues until the temperature of yeast inactivation is reached (approximately 45°C). When proteins are denatured, the gluten strands surrounding the individual gas cells are transformed into the semi-rigid structure that will yield the bread crumb. Endogenous enzymes present in the dough are inactivated at different temperatures during baking. The sugars and breakdown products of proteins released from the enzyme activity are then available to sweeten the bread crumb and participate in Maillard or nonenzymatic browning reactions, which are responsible for the brown color of the crust.

In the past several decades, bread making processes have been adapted to consumer demands, and subzero and low temperatures have been included in flow diagrams for interrupting the processes before or after fermentation, or when partial baking is completed, for obtaining partially baked breads (see Figure 1.1) (Rosell, 2009). These technologies have facilitated the launching of a great number of fresh-baked goods available at any time of the day, and overall they help bakeries bring new products to the market quickly and successfully.

BIOCHEMICAL CHANGES DURING BREAD MAKING

Bread making is a dynamic process with continuous physicochemical, microbiological, and biochemical changes caused by mechanical–thermal action and the activity of the yeast and lactic acid bacteria together with the activity of the endogenous enzymes. The changes in the flour biopolymeric compounds take place during mixing, proofing, and baking. During mixing, dough is exposed to large uni- and biaxial deformations and a continuous protein network is formed, which is stabilized by disulfide bonds and modified thiol/disulfide interchange reactions. The input of mechanical energy that takes places during kneading confers the necessary energy for distributing flour components, favoring the protein interaction and the formation of covalent bonds between them, which finally leads to the formation of a continuous macromolecular viscoelastic structure. Depolymerization and repolymerization of the sodium dodecyl sulfate-unextractable polymers occurs by the repeated breaking and reforming of disulfide bonds within and between gluten proteins, where glutenin subunits are released in a nonrandom order, indicating a hierarchical structure (Aussenac *et al.*, 2001). Also in this structure, tyrosine cross-links contribute to dough elasticity, suggesting that a radical mechanism involving endogenous peroxidases might be responsible for dityrosine formation during bread making (Tilley *et al.*, 2001).

There is general agreement that gluten is the main contributor to the unique properties of wheat dough properties, affecting dough characteristics and, consequently, the quality of the fresh bread. Gluten is a non-pure protein system, and although the nonprotein components have significant effects, the rheological properties of gluten derive from the properties and interactions among proteins. Gluten proteins comprise two main subfractions: glutenins, which confer strength and elasticity, and gliadins, which impart viscosity to dough. Proteins mainly involved in the viscoelastic properties of the dough are the high-molecular-weight glutenin subunits, which affect dough viscoelasticity in a similar and remarkable way as the water content (Cauvain, 2003). Namely, the mixing process induces an increase in the amount of total unextractable polymeric protein and large unextractable monomeric proteins (Kuktaite *et al.*, 2004). Specifically, the amount of high-molecular-weight glutenins increases with a parallel decrease in the amount of low-molecular-weight glutenins, gliadins, and albumins/globulins (Lee *et al.*, 2002). Mixing also promotes the solubilization of arabinoxylans due to mechanical forces, and this solubilization proceeds further during resting due to endoxylanase activity, in addition to xylosidase and arabinofuranosidase activities (Dornez *et al.*, 2007).

The other large biopolymer that plays an important role in the bread making process is starch. Amylose and amylopectin are the constituents of the starch granule. This biopolymer provides fermentable sugars to yeast and has a significant contribution to dough rheology, especially during the baking process (Cauvain, 2003). Pasting performance of wheat flours during cooking and cooling involves many processes, such as swelling, deformation, fragmentation, disintegration, solubilization, and reaggregation, that take place in a very complex media primarily governed by starch granule behavior. During heating, the native protein structure is destabilized, and unfolding may facilitate sulfhydryl—disulfide interchange reactions and oxidation together with hydrophobic interactions, leading to the association of proteins and, consequently, to the formation of large protein aggregates. Nevertheless, as the temperature increases, the role of the proteins becomes secondary, and changes involving the starch granules become predominant. During this stage, starch granules absorb the water available in the medium and they swell. Amylose chains leach out into the aqueous intergranular phase, promoting the increase in viscosity that continues until the temperature constraint leads to the physical breakdown of the granules, which is associated with a reduction in viscosity. During cooling of the loaf, the gelation process of the starch takes place, in which the amylose chains leached outside the starch granules during heating are prompted to recrystallize. The reassociation between the starch molecules, especially amylose, results in the formation of a gel structure. This stage is related to the retrogradation and reordering of the starch molecules.

In addition to these changes, it must be considered that bread making is a dynamic process with continuous microbiological and chemical changes, motivated by the action of the yeast and lactic acid bacteria, which occur during proofing and the initial stage of baking. Yeasts and lactic acid bacteria contain different enzymes responsible for the metabolism of microorganisms that modify dough characteristics and fresh bread quality. Therefore, wheat flour, yeasts, and bacterial population of sour doughs are sources of different endogenous enzymes in bread making processes and exert an important effect on dough rheology and on the technological quality of bread (Rosell and Benedito, 2003). Different processing aids, namely enzymes, are also used in bread making to improve the quality of the baked products by reinforcing the role of gluten, providing fermentable sugars, and/or contributing to stabilize the hydrophobic—hydrophilic interactions (Rosell and Collar, 2008).

Numerous biochemical changes occur during bread making that have direct effects on the sensory attributes and nutritional quality of the finished product. The contribution of low-molecular-weight proteins to the taste and flavor of bread depends on the content of peptides rich in basic and hydrophobic amino acids released during fermentation and baking, the proportion of hydrophilic peptides in unfermented bread, and the balance of endo- and exoprotease activities during those stages. Changes in the total or individual content of amino acids and peptides during the different steps of bread making modify the organoleptic characteristics of the bread (Martinez-Anaya, 1996). Amino acids are absorbed by yeast and lactic acid bacteria and metabolized as a nitrogen source for growth, resulting in an increase in the amount of gas produced, raising the alcohol tolerance of yeast and improving the organoleptic and nutritional quality of bread. They can also be hydrolyzed by the action of proteolytic enzymes from both flour and microorganisms on proteins as well as by yeast autolysis. The amino acid profile during bread making reveals that the total amino acid content (particularly for ornithine and threonine) increases by 64% during mixing and then decreases 55% during baking, with the most reactive amino acids being glutamine, leucine, ornithine, arginine, lysine, and histidine (Prieto *et al.*, 1990). Free amino acids in wheat flour and dough play an important role in the generation of bread flavor precursors through the formation of Maillard compounds during baking. In fact, leucine, proline, isoleucine, and serine reacting with sugars form typical flavors and aromas described as toasty and breadlike, whereas excessive amounts of leucine in fermenting doughs lead to bread with unappetizing flavor (Martinez-Anaya, 1996). The specific metabolic activities of fermentation microorganisms are responsible for the dynamics in nitrogen compounds, showing different metabolic rates for acidic, basic, aliphatic, and aromatic amino acids. Lactic acid bacteria contain proteases and peptidases, which release into the media amino acids and peptides that are easily metabolized by yeast and lactic acid bacteria, showing different nutritional requirements and exoproteolytic and endoproteolytic activities depending on the strain of lactic acid bacteria (Collar and Martinez-Anaya, 1994). In general, wheat doughs started with lactic acid bacteria show a gradual increase in valine, leucine, and lysine during fermentation, and there is also an increase in proline but only during the initial hours of proofing. In addition, the action of proteinases and peptidases from lactic acid bacteria on soluble polypeptides and proteins results in an increase in short-chain peptides that contribute to plasticize the dough and give elasticity to gluten. Jiang *et al.* (2008) observed a decrease in 17 amino acids in steamed bread; alanine underwent the highest loss (17.1%), followed by tyrosine (12.5%), and leucine was the least affected amino acid.

Protein—lipid interactions in wheat flour dough also play an important role because both lipids and proteins govern the bread making quality of flour. Lipids have a positive effect on dough formation and bread volume, namely polar lipids or the free fatty acid component of the nonstarch lipids, whereas nonpolar lipids have been found to have a detrimental effect on bread volume (MacRitchie, 1983). During mixing, more than half of the free lipids in flour are associated with gluten proteins, although there is no consensus about the type of interactions between lipids and proteins. However, evidence has been presented that nonpolar lipids are retained within the gluten network through hydrophobic forces, involving the physical entrapment of lipids within the proteins (McCann *et al.*, 2009). The same study suggests that glycolipids are associated with glutenins through hydrophobic interactions and hydrogen bonds, whereas the phospholipids presumably interact with either the gliadins or the lipid-binding proteins.

Vitamin content is also affected during the bread making process. The yeasted bread making process leads to a 48% loss of thiamine and 47% loss of pyridoxine in white bread, although higher levels of these vitamins can be obtained with longer fermentations (Batifoulier *et al.*, 2005). Native or endogenous folates show good stability in the baking process, and even an increase in endogenous folate content in dough and bread compared with the bread flour was observed by Osseyi *et al.* (2001). Nevertheless, the bread making process with yeast fermentation is beneficial for reducing the levels of phytate content with the subsequent increase in magnesium and phosphorus bioavailability (Haros *et al.*, 2001).

BREAD QUALITY: INSTRUMENTAL, SENSORY, AND NUTRITIONAL QUALITY

Bread quality is a very subjective term that greatly depends on individual consumer perception, which in turn is affected by social, demographic, and environmental factors. The perception of bread quality varies widely with individuals and from one bread to another. Scientific reports focused on the bread making process or recipes usually refer to instrumental methods for assessing quality, whereas studies focused on consumer preferences highlight the significant relationship between sensory quality and consumer perception. Alternatively, healthy concepts related to nutritional value are emerging as fundamental quality attributes of bread products (Table 1.3). Therefore, the global concept of bread quality could be integrated by instrumental attributes, those that can be objectively measured; sensory sensations including descriptive attributes related to consumer quality perceptions; and nutritional aspects related to healthiness and functionality of the bread products.

Regarding instrumental quality (see Table 1.3), due to the existence of a great variety of breads derived from different wheat grains, bread making processes, and recipes, it is almost impossible to identify specific features for assessing bread quality. Consequently, different features have been defined and quantified to evaluate breads, including volume (rapeseed displacement), weight, specific volume, moisture content, water activity, color of crust and crumb, crust crispiness, crumb hardness, image analysis of the cell distribution within the loaf slice, and volatile composition. All these instrumental measurements have been extensively used for investigating the impact of different flours, ingredients, processing aids, and bread making processes on baked products (Cauvain, 2003; Rosell and Collar, 2008). These measurements provide objective values that, although they do not reflect consumer preferences or freshness perception, are very useful for comparison purposes when the aim is the improvement of intrinsic bread features perceived as bread quality attributes.

The perceived quality of bread is a complex process associated with sensory sensations derived from product visual appearance, taste, odor, and tactile and oral texture. Generally, perceived quality of bread is intimately linked to freshness perception. Consumer test provides an important tool for understanding the consumer expectations of different bread varieties. A number of surveys have been conducted to determine consumer perceptions of and preferences for bread products (Dewettinck *et al.*, 2008; Heenan *et al.*, 2008; Lambert *et al.*, 2009). A descriptive sensory analysis carried out on 20 commercial bread types allowed consumer segmentation into three clusters: (1) preference for porous appearance and floury odor; (2) preference for malty odor and sweet, buttery, and oily flavor; and (3) preference for porous appearance, floury and toasted odor, and sweet aftertaste (Heenan *et al.*, 2008). In a European survey on consumer attitudes toward breads, two main groups were defined: frequent (daily) buyers with a focus on quality and pleasure and less frequent buyers (once a week) with a more pronounced interest in nutrition, shelf life, and energy (process) (Lambert *et al.*, 2009). The first group was called the "crust group" and the second one the "crumb group."

Consumers are becoming more conscious about the relationship between nutrition and health. Currently, innovations in bread are mainly focused on nutritionally improving bread

TABLE 1.3 Overview of the Parameters That Can Be Used for the Quality Assessment of Breads

Instrumental quality	Sensory analysis
Specific volume	Visual appearance
Crust color	Odor
Crumb texture fresh	Tactile and oral texture
Hardness	Taste
Springiness	Overall acceptance
Cohesiveness	Nutritional quality
Chewiness	Proximate composition
Resilience	Carbohydrates
Crust indentation	Proteins
Hardness	Fat
Area	Dietary fiber
Crust thickness	Glycemic index
Water activity	Load index
Moisture content	
Width:height ratio	
Crumb cell analysis	
Number of alveoli	
Average area	
Average diameter	
Circularity	
Volatile compounds	

through enrichment or the use of different flours (Collar, 2007; Rosell, 2007b). Particularly, older consumers and those who are attentive to their health are the most concerned about nutritional aspects of bread (Lambert *et al.*, 2009). Although labels related to the composition of bread are mandatory only for packed breads (regulatory constrain), the majority of consumers would prefer to have that information for all bread varieties. Despite the fact that the nutritional composition of bread varies with the type of bread, bread is an energy-dense product due to the carbohydrate content in the form of starch. It also provides important amounts of protein and dietary fiber and does not contain cholesterol (Table 1.4). Bread is the

TABLE 1.4 Nutritional Information of Different Commercial Bread Varieties

	Nutritional Composition					
Bread Variety	**Energy Value (kcal/100 g)**	**Carbohydrates/ Sugars (g/100 g)**	**Fats/Saturated (g/100 g)**	**Proteins (g/100 g)**	**Dietary Fiber (g/100 g)**	**Sodium (g/100 g)**
White loaf	268	53/2.5	1.8/1.0	9.8	1.8	0.5
Baguette	279	53/1.9	1.8/0.7	9.9	6.6	0.7
White wheat pan bread	232	43/4.3	3.2/0.4	7.9	2.5	0.5
Whole wheat pan bread	247	41/6.0	3.0/1.0	13.0	7.0	0.5
Fiber-enriched pan bread	221	43/4.3	1.0/0.2	9.6	4.2	0.7
Protein-enriched wheat bread	245	44/1.0	2.0/0.0	12.0	3.0	0.5
Reduced-calorie wheat bread	198	44/3.0	2.0/0.0	9.0	12.0	0.5
Mean	229	43/3.7	2.2/0.3	10.3	5.7	0.5
SD	20.1	1/1.9	0.9/0.4	2.1	3.9	0.1

most important source of dietary fiber, although the content of this macronutrient decreases significantly during the refining process; as such, wholemeal breads are the recommended bread type for healthy diets.

CONCLUSION

Bread dough is a versatile matrix that, after proofing and baking, yields a variety of bread products. Traditionally, bread has been seen as a staple food, with nearly ubiquitous consumption worldwide, because it constitutes an important source of energy and provides most of the nutrients and important micronutrients. However, changes in consumer eating patterns have resulted in the modification of the perception of bread from a basic food to a nutritious and healthy product, a vehicle of functional ingredients, or the target product when nutrition deficiencies are detected in the population. Namely, bread not only contains traditional nutrients but also provides other compounds that are beneficial to health and well-being. The nutritive and sensory values of cereal grains and their products are, for the most part, inferior to those of animal food products. Nevertheless, genetic engineering, amino acid and other nutrient fortification, complementation with other proteins (notably legumes), milling, heating, germination, and fermentation are methods employed for improving the nutritive value of breads. Research has also introduced novel flour and traditional grains, such as amaranth, quinua, sorghum, or spelt, to improve the nutritional value of baked products and also to meet the demands and requirements of targeted groups with special food needs.

SUMMARY POINTS

- Worldwide, bread is one of the most consumed foodstuffs.
- Bread making stages include mixing the ingredients, dough resting, dividing and shaping, proofing, and baking, with great variation in the intermediate stage depending on the type of product.
- Bread making is a dynamic process with continuous physicochemical, microbiological, and biochemical changes.
- A global concept of bread quality could be integrated by instrumental attributes objectively measured, sensory sensations, and nutritional aspects.
- Bread has a fundamental role in nutrition derived from the adequate balance of macronutrients in its composition; moreover, it provides some micronutrients and minerals.
- Some fiber, vitamins, and minerals may be added back into refined cereal products through fortification or enrichment programs.

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