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Review Article

Classification, Processing Procedures, and Market Demand of Chinese Biscuits and the Breeding of Special Wheat for Biscuit Making

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With the improvement of living standards, consumers' demand for wheat food is gradually diversified. Biscuit, as a kind of convenience food, becomes a consumer's leisure snack due to its characteristics such as low processing cost, easy-to-carry and convenient-to-eat traits, long shelf life, diverse varieties, and rich tastes, which have attracted more and more people. Biscuits are composed of four main ingredients, which are flour, fat/oil, sugar, and water, whereas several secondary ingredients also are important sources of high molecular carbohydrates, plant proteins, vitamins, and minerals for human beings. In this study, we systematically summarized the related research of biscuits, including the main types of China's biscuits, the market demands, and statistics of wheat planting, production, and import in recent ten years, as well as the research of soft wheat breeding for biscuit. The flour consumption of biscuit industry has been maintained at more than 4 million tons, accounting for more than 30% of the flour consumption in food industry. The planting area of wheat in China has stabilized around 22.8 million hectares in 2010–2020, while the yield of wheat has increased 18.0% (20.86 million t) due to the increase of yield per unit of wheat. China's total annual pastry import bill increased 5 times and the gap between import and export bill of pastry has been increased more than 7 times from 2010 to 2020, suggesting the strong demand of the national pastry market. This research also provides a direction for the future breeding of special soft wheat for biscuits in China.

1. Introduction

The developed navigation industry in the 19th century made Europeans accustomed to carry one kind of food that was low in moisture and easy to store and could fight hunger, so biscuit, a simple food made of flour and water, was born. The word "biscuit" comes from the Latin word "Panis biscotus" meaning twice-cooked bread usually made for sailors and is named "marine biscuit." The biscuits were defined as "hard dry bread that transported to sea" by Dr. Samuel Johnson. The British were the first to make this kind of biscuit, including crackers, cookies, and wafers [1].

Biscuit is a kind of convenience food, which belongs to the category of baked food. Biscuit is a crisp food with less than 6% moisture content, which is made by main raw material weak gluten wheat flour with other auxiliary materials such as sugar (or without), oil, and other excipients through flour blending, molding, baking, and other processes. Due to its mature production technology, variety, and rich taste, biscuits can meet the needs of different consumers compared with other kinds of ready-to-eat snacks. Biscuit has attracted a wide consumption base due to its characteristics such as low processing cost, easy-to-carry and convenient-to-eat, and long shelf life [2, 3]. The good eating quality has led to the development of new type of biscuits of different categories and improved nutrition. Biscuits turn flour, fat, and sugar into nutritious and energy-rich snack foods that people accept at a low-cost way. It has become a new trend in the biscuit

industry to study compound flour baked cookies rich in special ingredients or to develop fortified biscuits. Biscuit can be used as strategic reserves in emergency situations such as food planning, earthquake resistance, and disaster prevention due to its good nutrition and storage characteristics.

Since the reform and opening up of China, people's living standards have been gradually improved with the development of economy and the influx of western technology and culture. As a classification of baked goods, biscuits began to develop rapidly. A large number of small enterprises with backward productivity go bankrupt or have been merged by big ones with the development of production technology. Likewise, the biscuit industry continues to merge into large-scale production with a healthily and orderly developed biscuit market [4]. The annual per capita consumption of biscuits in the United States, Britain, and western European countries is more than 10 kg, while in southeast Asian countries or regions, such as Singapore, Hong Kong, Thailand, and Indonesia, that is more than 4.25 kg. The annual per capita biscuit consumption of Japan and China is estimated at 7.5 kg and <2 kg, respectively [5]. Therefore, China's biscuit industry and market has strong potential. With the continuous growth of China's economy and the improvement of people's living standards, the biscuit manufacturing industry has developed from labor-intensive handicraft industry to technology-intensive industrial production, and biscuits have also developed from hunger-fighting snacks to leisure, nutrition, and health care food. A variety of biscuit products with rich nutritional value are constantly introduced to the market, showing the new vitality in the biscuit market. This study summarizes the related research of China's biscuits in the aspects of raw materials, types, production technology, domestic biscuit demand, and special wheat breeding for biscuits.

2. Biscuit Ingredients and Their Influence on Biscuit Texture

Biscuits consist of main and secondary ingredients. Among them, flour, fat/oil, sugar, and water are the basic main ingredients, whereas salt, egg, emulsifier, starter (sodium bicarbonate, ammonium bicarbonate), milk powder, and seasoning spices are optional secondary ingredients [6]. The main ingredients of different biscuits vary a lot, and according to their characteristics, there are different special secondary ingredients. Therefore, it is difficult to compare the use of each ingredient; here we mainly describe the role of the most commonly used ingredients in biscuit production. Wheat flour dough is a complex and heterogeneous system consisting of three main components: flour, sugar, and fat. Each of these ingredients plays a different role, contributing to its taste, texture, color, and flavor. The type and proportion of ingredients affect the quality of the final product.

2.1. Flour. Flour is one of the main raw materials of bread, cakes, biscuits, and other baking products. It is mainly composed of starch, protein, and water. Unlike protein, starch does not form a large network of gluten in biscuit dough, but acts as the main filler in the dough. Soft wheat flour with low protein content (8–11%) is considered to be an ideal flour for making biscuits because gluten forms a smaller network structure [7]. The addition of protein increases the hydration property of the mixture and the consistency of the dough, reduces the baking time of biscuits, and results in lower hardness and darker color [8]. Changing in flour protein content between 14% and 20% can lead to significant changes in dough rheological properties and biscuit size and texture [9]. In addition, the moisture content of flour and the amount of water added in dough have different effects on the properties of biscuit dough [7]. The increase of flour moisture will result in the increase of the fluidity and adhesion of the dough and biscuit diameter [10]. The particle size of flour is an important factor affecting the quality of biscuits, and its effect varies with different types of dough. The high extension of biscuits is related to the fine particles of soft wheat flour. The finer the flour is, the higher the density of biscuits and the lower the expansion are [6]. The average particle size of the flour used in most biscuit production is about 50 μm, of which less than 10% of the flour is larger than 130 μm [1]. However, glutenin in flour can cause immune response in some people, leading to celiac (CD), non-celiac gluten intolerance (NCGS), and wheat allergy. The market demand for gluten-free products is increasing rapidly. In addition, the higher content of carbohydrates in flour can easily lead to consumer obesity. Therefore, people use different kinds of flour to replace wheat flour or to add different nutrients to biscuits, such as multi-grain mixture [11], rice flour [8], millet or adzuki bean flour [12], oat flour [13], soybean and cassava flour [14], and so on.

2.2. Sucrose. Sugar can improve the structure and enhance the flavor of biscuits. Sucrose is the most commonly used sugar in biscuit baking. The sweetness of sucrose is provided by transformed fructose during baking. Sugar has a significant effect on the phase transition of biopolymers such as starch and gluten in biscuit dough [15]. Sugar disperses proteins and starch macromolecules through hydration to prevent the formation of gluten networks that make biscuits crispy. Based on the macro and micro data of dough and biscuits, Chevallier et al. [16] proposed that the structure of wheat biscuits is formed by the bridge between protein aggregates and lipids due to the melting of sugars during baking process. After cooling, the continuous glassy state of sugar and the intact or almost undamaged starch particles are embedded one after another. Regardless of the composition of wheat biscuits, both glutenin and sucrose are glassy [17]. On the contrary, Gallagher et al. [18] believe that the texture of wheat biscuit is mainly affected by starch gelatinization and supercooled sugars because of the rarely formed gluten networks in wheat biscuits. Maillard reaction occurs during the baking process of sugar, which enhances the color and flavor of cookies. Due to the differences of water content in dough, the sugar is partially or completely dissolved and recrystallized during cooling to increase the hardness and surface crack of the biscuit [19]. During

baking, the undissolved sugar gradually melts to extend the dough and cools into amorphous glass, giving the biscuit a crisp taste [20]. In addition, the crystal size and dissolution rate of sugar also affect the characteristics of biscuits. Extra coarse sugar crystal particles reduce the extensibility of biscuit dough and increase surface cracking due to the decrease of dissolution rate [21].

The amount of sugar also has a great effect on the characteristics of biscuits. Increasing sugar content can reduce the viscosity and fermentation time of the dough and increase the hardness of biscuits [19]. Therefore, high concentration and small particles of sugar is conducive to the extension of biscuits; however, excessive sugar reduces the degree of dough softening and the consistency and cohesion of the dough, which in turn results in the tiling of biscuits, and affects the baking time of biscuits [15]. The difference in sugar content produces two very different kinds of biscuits: one is low-sugar biscuits with a sugar content of 17% to 25%, which is with the least spread of dough during baking, such as ordinary tough biscuits; the other is sweet crisp biscuits containing about 25% to 60% sugar (based on flour) and the dough will swell significantly during baking [7].

In the baking process, 10–20% of the reducing sugar in the biscuit dough combines with the amino acids, which contributes to the formation of biscuit color. Due to their high calorie content, sugars are replaced by artificial sweeteners in biscuit making, such as saccharin, acesulfame-K, aspartame, sucralose, cyclic esters, and fructose [22]. These sweeteners are very sweet, and they are good substitutes of sugar.

2.3. Fat. Fat is the third major ingredient in biscuit making, providing the tenderness and crisp taste of biscuits. Fat destroys the continuity of protein and starch by isolating water from protein and starch granules, thus preventing the dough from producing stickiness and the formation of large gluten networks [23]. It also inhibits the fermentation of carbon dioxide diffusion in the dough by forming a coating around the flour particles [24]. Fat can significantly affect the gelatinization performance of flour and increase the gelatinization temperature.

The mechanical properties of biscuits largely depend on the fat composition in dough. The type and proportion of fat in biscuit dough will affect the rheological properties of biscuit dough and the change of dough size during baking and finally affect the characteristics of baked products [25]. The type of fat affects the texture of dough, and biscuits with high solid fat content have higher breaking ability [26]. It is found that reducing fat content or using liquid fat to instead of solid fat can decrease the hardness and increase the viscosity and elasticity of biscuit dough and make biscuits with higher breaking strength [27, 28]. Many studies have found that the biscuit dough made from liquid oil with lower content of saturated fatty acids (such as sunflower oil) has better malleability during baking and larger biscuit diameter [27, 29]. Fats such as butter and vegetable oils are often called shortening. Shortening acts as a lubricant by blocking the formation of gluten and the adhesion of starch particles, making cookies more tender and uniform in shape after baking [29], resulting in better surface properties and higher brittleness [26].

Although fat plays an important role in baked goods, eating too much fat can lead to a variety of diseases, such as obesity, cancer, high cholesterol, and coronary heart disease [19]. In addition, baked goods are one of the main sources of trans fatty acids in the diet [30]. The study found that the content of trans fatty acids in biscuits varied from 0.1 to 3.2 g per 100 g. Glucose biscuits, sweet biscuits, and salt biscuits had the lowest trans fatty acid content (0.1 g /100 g), while butter biscuits had the highest trans fatty acid content (17.1 g /100 g) [31]. World Health Organization (WHO) recommends limiting trans-fat intake to less than 1% of total energy intake [32].

Therefore, it is necessary to select appropriate fat substitutes to reduce the fat content and trans fatty acids in biscuits. Fat substitutes can be divided into carbohydrates, proteins, lipids, emulsifiers, and synthetic fats. At present, many ingredients (emulsifier, sorbitol [33], poly (dextran) [34, 35], and crystalline fiber, etc.) are used as fat substitutes [36]. Carbohydrate-based fat substitutes, such as dextrin, modified starch, and hydrophilic colloids, form a gel-like matrix by combining water, providing the required smooth taste to mimic fat [35, 37]. Compared with polyglucose, using maltodextrin instead of fat can improve the color and appearance of biscuits and make cookies with a softer taste [35, 38]. Tarancón et al. [38] have developed healthy biscuits with fewer trans fatty acids using olive oil. Using vegetable oils instead of fat can shorten the shelf life of biscuits due to the taste, flavor instability, and oil oxidation [29]. However, it is an unsolved problem that fat substitutes have a great influence on the texture of biscuit; when reducing the fat in biscuit, the biscuit will become hard and brittle [34].

2.4. Water. Water plays an important role in biscuit baking because it provides the necessary media for the physical, chemical, biological, and biochemical reactions needed for the conversion of raw materials into the final baked goods. In addition, it also has a decisive impact on the overall quality and taste of biscuits [39]. Water hydrates gluten protein in the mixing process, gelatinizes starch in the baking process, and acts as a dispersing medium for other components [40]. The salt in the water will affect the characteristics of the dough. Hard water containing magnesium and calcium ions may have a "tightening effect" on the dough, while soft water may have a "relaxation effect" on the dough.

2.5. Salt. Salt is used as a surface condiment and decoration for delicious biscuits. Depending on the weight of the flour, a salt concentration of less than 2% produces a satisfactory taste [41]. Salt hardens gluten, increases the consistency of the dough, makes the dough easy to process, and slows fermentation and Maillard reaction. In addition, it is also conducive to the formation of hard shells.

2.6. Starter. Another important ingredient for biscuit making is the starter. Adding starter to the dough produces fermenting gases, which can cause holes in the cookie during baking. The most typical chemical starters are baking powder (a mixture of sodium bicarbonate and acid), sodium pyrophosphate, sodium bicarbonate ($NaHCO_3$), and ammonium bicarbonate (NH_4HCO_3). Sodium bicarbonate dissolves in the dough and reacts with the acid to produce carbon dioxide. When heated, ammonium bicarbonate decomposes to form carbon dioxide, ammonia, and water. Both the loosening agent and salt in the dough can affect the formation of hydroxymethylfurfural (HMF) and acrylamide in biscuits. The type of starter has a great influence on the formation of acrylamide and hydroxymethyl cellulase. In addition, compared with sodium salt, ammonium salt accelerates the degradation of sucrose, so it plays an important role in promoting the formation of acrylamide and HMF. Replacing ammonium bicarbonate with sodium bicarbonate can reduce the content of acrylamide to about 70% [42] and the production of HMF to 95% [43]. With the addition of NH_4HCO_3 (pH 7.82), the production of acrylamide after 15 min baking at 205°C increased by 6 times compared to the control without any raising agent (pH 5.82). On the contrary, in the presence of $Na_4P_2O_7$ (pH 6.78), the final acrylamide concentration of the samples was similar to that of the control, while in the presence of $NaHCO_3$ (pH 8.10), the final concentration of acrylamide even decreased by 52% [44].

3. Classification of Biscuits

3.1. Classification of Biscuit Based on the Formula, Process, and End Products. Generally speaking, according to the characteristics of biscuit formula, process, and end products, biscuits can be divided into five categories: coarse biscuit, tough biscuit, crisp biscuit, sweet crisp biscuit, and fermented biscuit.

3.1.1. Coarse Biscuits. The amount of fat and sugar is very small (0 : 10), and the main material is flour, with a ratio of 1 : 5 for the sugar and flour. The biscuit is formed by stamping or roller cutting. The biscuits are compact, crisp, and dry and can be used to make compressed biscuits.

3.1.2. Tough Biscuits. They have low sugar and oil content, good dough toughness, and forming by stamping and roll cutting. The end product has a large block type and a concave pattern on the surface, which is smooth. The cross section has layers, brittleness is prominent, and crispness is poor. This biscuit has a strong layered sense and a crisp taste. The higher the content of wet gluten, the better the toughness of the dough. Therefore, the flour used in tough biscuits requires a wet gluten content of 22% to 26% [45]. However, the content of oil and sugar is relatively low, and the ratio of oil to sugar is generally required to be 1 : 2.5, while the ratio of oil and sugar to flour is 1 : 2.5. The dough is mixed by hot powder technology with high extensibility and smooth surface. Due to the high-water content of the dough, it is suitable to bake at low temperature for a long time, which is beneficial to the dehydration of biscuit.

3.1.3. Crisp Biscuits. They have high content of sugar and oil, adding dairy products, eggs, and other ingredients. The dough is semi-soft, with little elasticity and strong plasticity, so it is formed by roll cutting. The end product is small and thick, and the surface pattern is clear and mostly convex. The cross section is a loose and porous structure without layers, so that biscuits taste crumbly.

In crisp biscuits, the ratio of oil sugar to flour is 1 : 2, and the ratio of oil to sugar should also be controlled 1 : 2. The wheat flour used is weak gluten flour, and the wet gluten content is about 20%. The oil should be shortenings with good crispness to prevent the occurrence of oil running. Because the temperature of crisp dough is close to room temperature, cold flour technology is used to mix flour. The biscuits with high oil content are molded by roll printing, and the temperatures of bottom fire and surface fire are higher about 300°C, in order to facilitate product shaping and avoid oil stalls (the surface area can be expanded in a regular shape). The varieties with low oil content have low fire temperature and high bottom fire temperature after entering the furnace, which is conducive to its volume expansion and the formation of a hard shell on the surface.

3.1.4. Sweet Crisp Biscuits. They have high oil and sugar content, low water content, more milk, eggs, and other accessories. In sweet crisp biscuits, the ratio of oil and sugar to flour is 1 : 1.35, and the ratio of oil to sugar is also 1 : 1.35. The dough is small in elasticity, strong in crispness and soft, and is formed by extrusion or steel wire cutting. The end product is thicker, the cross section is compact porous structure, and the taste is crisp.

3.1.5. Fermented Biscuits. The content of sugar and oil is less, with a ratio of 10:0–0.5, and the gluten is formed more, with a ratio of 1:4–6 for the sugar and oil to flour. The gluten strength will be reduced by excessive fermentation of dough, the inclusion of shortening, and so on, and the dough is finally formed by roller cutting or printing. The surface of end product is generally unpatterned, and the hierarchical structure of cross section is clear, the brittleness is prominent, and the fermentation flavor is obvious. Soda cracker, a type of fermented biscuits, needs to go through secondary fermentation. Fermented dough is formed by rolling, crisping, and lamination. When baking, it is necessary to avoid the formation of a hard shell on the surface of the cake prematurely; otherwise it will not be conducive to the escape of carbon dioxide from the dough and the accumulation and expansion of the dough. After the cake billet expands to the maximum volume, the surface fire temperature should be strengthened to prevent the cake billet from collapsing for the low temperature, resulting in the biscuits not crisp enough.

3.2. Different Types of Biscuits in China. According to the processing technology and the biscuit industry standard GB/T20980-2007 "biscuit" in China, biscuit can be divided into 12 types of biscuits, such as crispy biscuits, cookies, fermented biscuits, tough biscuits, compressed biscuits, Sandwich biscuits, wafers, waffles, egg rolls, pancakes, decorative biscuits, sponge biscuits, and so on.

3.2.1. Crispy Biscuits. Crisp biscuits are made of wheat flour, sugar, and oil as the main raw materials, adding loosening agent and other auxiliary materials, and the surface patterns are mostly convex flowers and porous structures made by cold powder process, rolling or non-rolling, forming, and baking. The taste of the biscuits is crispy or crunchy, and the fragrance is mellow.

3.2.2. Cookies. Cookies are made of wheat flour, sugar, syrup, oil, and dairy products as main raw materials, adding loosening agent and other auxiliary materials, mixing powder by cold powder process, and forming by one of the methods of extrusion, wire cutting, or roll stamping. Crisp biscuits are baked with stereoscopic patterns or regular ripples on the surface.

3.2.3. Fermented Biscuits. Fermented biscuits are made of wheat flour, oil, and sugar (or sugar-free) as main raw materials, yeast as puffing agent, adding various excipients, mixed with flour, fermented and extended, roll cutting, molding, and baking. Biscuits are crisp or crumbly with unique flavor of fermented products.

3.2.4. Tough Biscuits. Tough biscuits are made by hot powder process, taking wheat flour, sugar (or sugar-free), and fat as the main raw materials, adding loosening agents, modifiers, and other auxiliary materials. The surface patterns are mostly concave flowers with smooth appearance. The cross section of the biscuit is layered, and its surface is flat and usually with pinholes. Biscuits are crispy.

3.2.5. Compressed Biscuits. Using wheat flour, sugar, oil, and dairy products as the main raw materials, adding other auxiliary materials, mixing, roller printing, and baking to make biscuits, then crushing, adding oil, sugar, nutritional fortifier, or adding other dried fruits, meat floss, dairy products, etc.

3.2.6. Sandwich Biscuits. They are biscuits with adding stuffing such as sugar, cream, dairy products, chocolate jam, various compound sauces, or jams between the cookie pieces (or the hollow part of the biscuits).

3.2.7. Wafers. Using wheat flour (or glutinous rice flour) and starch as the main raw materials, adding emulsifier, puffing agent, and other auxiliary materials, a porous sheet is made by mixing, pouring, and baking. Two or more layers of biscuits are usually added between the sheets with materials such as sugar, grease, and other stuffing.

3.2.8. Waffles. A biscuit made of wheat flour, sugar, and eggs as the main raw materials, adding loosening agents, flavors, and other excipients, then squeezing and baking biscuits.

3.2.9. Egg Roll. Take wheat flour, sugar, and eggs as the main raw materials, and add or not add fat. In addition, leavening agents, modifiers, and other auxiliary materials are added, followed by mixing, pouring or hanging, baking, and rolling.

3.2.10. Pancakes. A biscuit made of wheat flour (glutinous rice flour, starch, etc.), sugar, and eggs as the main raw materials, with or without oil, adding leavening agents, and other auxiliary materials, mixing, pouring, or hanging and baking.

3.2.11. Decorative Biscuits. A biscuit with a coating, line, or pattern on the surface of a biscuit coated with chocolate jam, jam, and other accessories or sprayed with seasonings or framed candy flowers.

3.2.12. Sponge Biscuit. The loose and light biscuits with strong egg flavor are made by flour blending, multiple rolling, molding, hot water blanching, cold water soaking, and baking using wheat flour, sugar, and eggs as the main raw materials and adding loosening agent.

4. Biscuits' Consumption and Demands

In 2019, the total output of wheat flour was 83.192 million t, the total import 284,000 t, the total supply 84.056 million t, the total domestic consumption 83.073 million t, and the total export 305,000 t. In the total consumption of wheat flour in China, the consumption of catering and baking food occupied 41.8% (34.704 million tons), and the food industry consumption occupied 16.6% (13.812 million) (Figure 1(a)). In the food industry consumption of wheat flour, the flour consumption of biscuit industry is 4.362 million t occupying 31.6% (Figure 1(b)), which is 10 percent higher than noodles while a few percent than instant noodles. Although the consumption of biscuit industry declined slightly from 2016 to 2109 (4.675 million t in 2018, 4.964 million t in 2017, and 4.936 million t in 2016) [46], the biscuit industry still plays an important role in the food industry market.

According to the statistics of the National Bureau of Statistics (https://data.stats.gov.cn/index.htm), China's total annual pastry export bill increased 73.2% with an average annual rate of 7.73%, while the import bill increased 5 times with an average annual rate of 50.0% from 2010 to 2020 (Figure 2). The gap between import and export bill of pastry has been increased more than 7 times with an annual rate of 77.2% (from 0.61 to 5.32 billion dollars) from 2010 to 2020, suggesting the strong demand of the national pastry market. The scale of the baked food market showed a steady expansion trend [47]. The total production of biscuits in China

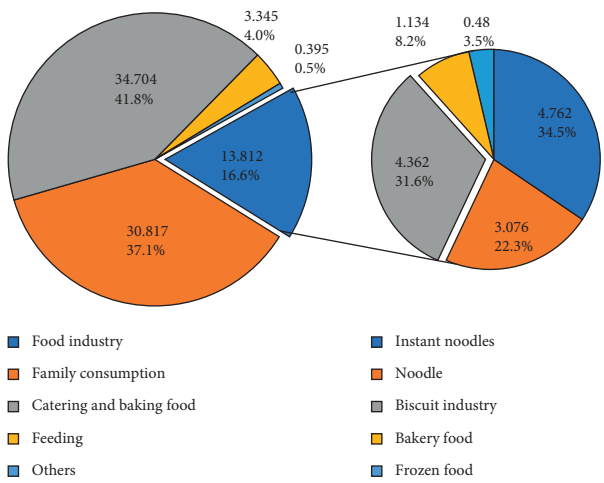

Figure 1: The consumption of China's wheat flour in 2019 from the statistics of Ma [46]. (a) The consumption and proportion of wheat flour in different industries of China; (b) the consumption and proportion of wheat flour in Food industry.

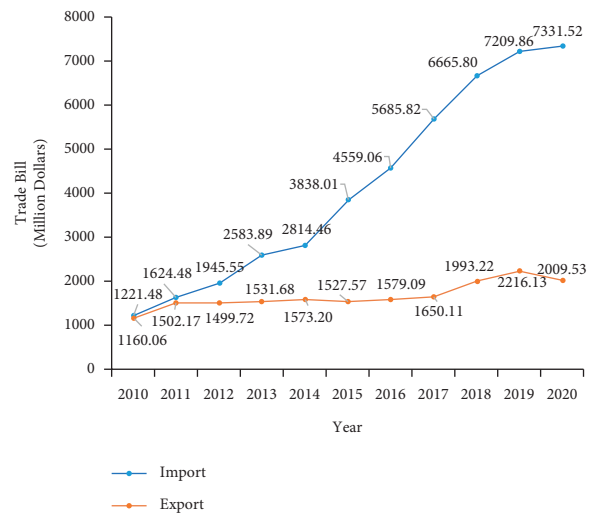

Figure 2: The total annual pastry import and export bill of China from 2010 to 2019.

increased at an average annual rate of 25.90% from 2005 to 2009, among which the output of biscuits in China was 1.3675 and 3.431 million t in 2005 and 2009, respectively, an increase of 2.5 times in 5 years [48]. At present, China's per capita consumption of biscuits is still keeping in a quite low state. The per capita annual consumption of biscuits in China is less than 2 kg, showing a big gap to that of developed countries (>10 kg), which should be related to the different eating habits [5]. From the perspective of long-term developing, China has a large population, and the people's living standards are gradually improving, and the demand for ready-to-eat leisure food is increasing, suggesting a great potential for the development of the biscuit industry. At this stage, function, nutrition, and fashion are still the main direction for biscuit development.

5. The Main Research of Soft Wheat for Biscuit

5.1. The Definition of Soft Wheat. The definition of soft wheat varies in different countries. For example, European countries call common wheat "soft wheat" and durum wheat "durum wheat," while in the United States, Australia, and Japan, those that have softer texture and lower protein content are called soft wheat,which is suitable for making biscuits and cakes.

At present, the representative weak gluten wheat abroad is American soft red winter wheat, American soft white wheat, and Australian soft wheat [49]. In China, according to the physical and chemical characteristics, wheat is divided into strong gluten wheat, medium gluten wheat, and low (weak) gluten wheat, among which the dough of low-gluten wheat has a short stability time (≤1.5 min) and is suitable for processing and baking food.

5.2. Characteristics of Soft Wheat and Its Distribution in China. Grain softness was an important trait of interest in wheat because of its role in producing flour suitable for making high-quality biscuits, cookies, cakes, and some other products. As early as the 1950s, the breeding and planting regionalization of soft wheat varieties were carried out abroad. At the same time, the relationships between grain texture, gluten protein content, rheological properties of dough, solvent retention and processing quality of cakes, biscuits, and other foods were studied deeply and systematically. Therefore, the breeding and production of high-quality weak gluten wheat varieties and the research of special flour have been greatly developed.

Hexaploidy wheat is usually divided into soft wheat and hard wheat. The flour produced by soft wheat is suitable to be used for making biscuits and cakes for its smaller particle size, less broken starch, and lower water absorption [50]. Durum wheat is more suitable for bread making because of its higher pentosans and protein content, higher lipid, and dry gluten content, as well as better ability to form elastic dough [51, 52].

In China, the early stage of wheat breeding focused on hard wheat with high protein content, which was mainly used for the improvement of bread and noodles, while the quality improvement of soft wheat started late. The hardness and quality of 1,361 commercial wheat samples and 687 wheat varieties collected in China in 2006 were analyzed by single grain analysis system (SKCS). The results show that, among the commercial wheat in China, hard wheat and soft wheat account for 35.2% and 7.2%, respectively, the proportion of soft wheat is low, and the wheat with different hardness is seriously mixed. The hard wheat and soft wheat in the variety wheat are 60.1% and 10.4%, respectively, and the proportion of soft wheat is still on the low side [53]. Soft grain, good extensibility, low protein content, and weak gluten strength are the main characteristics of high quality and weak gluten wheat [54]. China has formulated a national standard for weak gluten wheat (GB/T 17893–1999), with a flour content not less than 70%, a grain crude protein not more than 11.5%, a falling quality not less than 300 s, and a wet gluten content of wheat flour no more than 22%.

Low-gluten wheat generally grows in areas with excessive rainfall in the later stage. Strong gluten and medium gluten hard wheats are mainly grown in the north due to sufficient sunshine and less rainfall at mature stage, while more rain water is in the middle and lower reaches of the Yangtze River, where mainly medium and weak gluten soft wheat is grown. Weak gluten wheat in China is mainly distributed in Xinyang of Henan Province, and Jiangsu areas.

5.3. The Quality Index of Biscuit Special Powder and Breeding of Biscuit Special Soft Wheat. The bubble blowing is closely related to the quality of biscuits, so the bubble blowing indicator is often used to determine and control the quality index of biscuit special powder. Solvent retention capacity (SRC), proposed by Slade and Levine [55], is widely used in the prediction and evaluation of wheat flour quality, such as water SRC (WSRC), sucrose SRC (SSRC), lactic acid SRC (LASRC), and sodium carbonate SRC (SCSRC). It comprehensively reflects the physical and chemical properties of flour, such as gluten, pentosan, damaged starch, and water absorption and can predict the baking properties of flour as well. It is the leading method to evaluate the quality of soft wheat [55]. Studies have shown that SRC is less affected by environmental effects, which is mainly determined by genotypes [56, 57]. The correlation coefficient between biscuit quality and the parameters of farinograph and extensometer was small, while the elasticity/extensibility of blister, alkaline water retention capacity (AWRC), SCRC, and SSRC were closely related to the diameter of biscuits, which could be used as screening indexes of biscuit quality [56]. Therefore, it is feasible to use genetic improvement to reduce the SRC of selected varieties to obtain weak gluten wheat with high-quality [57]. Hardness can be used as an efficient and practical selection criterion in breeding; weak gluten wheat must use parents of corresponding quality types [58]. On the basis of the selection of grain hardness and protein content, reducing gluten strength and comprehensive water absorption of flour is the main goal of soft wheat breeding. WSRC, LASRC, and bubble blowing indicator are the most important screening indexes for soft wheat breeding [59].

The specific quality indexes of high-quality weak gluten wheat varieties for biscuit were put forward by Zhang [56], named SKCS. The grain hardness of high-quality weak gluten wheat varieties is 40, grain protein content ranges from 9.0% to 11.5%, flour protein content ranges from 8.0% to 10.0%, blister elasticity ≤40 mm, elasticity/extensibility ≤0.5, blower energy ≤7.5 × 10−3 J, AWSRC ≤ 59%, WSRC ≤ 53%, SCSRC ≤ 66%, LASRC ≤ 83%, and SSRC ≤ 87%. In addition, the contents of water-soluble pentosans and total pentosans were significantly negatively correlated with the diameter of biscuits [60]. At present, the high-quality weak gluten wheat cultivars in China basically are "Yangmai 15," "Yangmai 13," "Mianmai 51," "Zhengfeng 5," "Guangmai 1311," "Nongmai 126," "Wanxi 0638," and so on.

5.4. Grain Softness Genes and Their Unitization in the Breeding of Biscuit Special Soft Wheat. Endosperm texture is the main factor affecting the final use of wheat. It is controlled by genes located on a major locus called Ha that controls grain hardness (Ha) [61, 62]. The Ha locus is located on the chromosome arms 5DS; its wild-type form (Ha) and the mutated form (ha) alleles are present in the soft and hard wheats of hexaploidy bread wheat varieties, respectively [61, 63]. The Ha locus consists of 10 closely linked genes, among which 3 genes in an interval of approximately 70 kb comprising of puroindoline a (Pina-D1), puroindoline b (Pinb-D1), and Grain Softness Protein-1 (Gsp-D1) are associated with grain texture [61, 64, 65]. Pina-D1 and Pinb-D1 encode 2 low molecular weight, tryptophan, and cysteine enriched proteins, called puroindolines, PINA, and PINB, respectively. It has been shown that these 2 proteins constituted a major fraction of a 15 kDa protein originally named "friabilin," which are presented on the surface of water-washed starch granules. They are normally accumulated in the starchy endosperm cells and aleurone cells of the developing kernels [66]. They are found in abundant and minimal amounts in soft and hard wheats, respectively [67]. The presence of the wild-type alleles (Pina-D1a and Pinb-D1a) encoding PINA and PINB, respectively, results in a soft phenotype whereas mutations in Pina-D1 or Pinb-D1 results in a hard phenotype [68]. As durum wheat contains only the A and B genome, its grain mechanical properties are the hardest. The most prevalent allele associated with grain hardness is the Pinb-D1b, corresponding to a glycine-to-serine point mutation in position 46. This is classified as a hard phenotype in bread wheat [69].

Ma et al. [70] analyzed the puroindoline allelic variations and their association with kernel hardness in a diverse panel of wheat accessions (including 1539 Chinese cultivars and 107 landraces, and another 141 foreign accessions). The frequencies of wild type allele of Pina-D1a (Pina) and Pinb-D1a (Pinb) accounted for 90.4% and 41.1%, respectively, and the kernel hardness varied from 1.4 to 102.7, suggesting that there is a huge number of germplasms that can be used in soft wheat breeding [70]. Marker-assisted selection (MAS) is a fast and effective method widely used in wheat breeding [71], which was also deployed to develop advanced wheat lines with soft grains [62]. The Pina-D1a gene was transferred from the donor parent Australian soft-grained variety Barham to an Indian variety, DBW14, a hard grain wheat with PinaD1b and PinbD1a genes, to improve its grain softness using Marker-assisted backcross breeding strategy in Rai et al. [62]. Meanwhile, the function markers for the alleles of the Pina-D1a and Pinb-D1a have be effectively and widely used in the selection of soft wheat and this accelerated the breeding progress in many researches [62, 71].

Puroindoline polymorphism (Pina and Pinb) explains over 60% of the variation in kernel hardness. However, the other genetic factors except Puroindolines have be exploited over the past 2 decades and numerous kernel hardness-associated quantitative trait loci (QTLs) have been identified on almost every chromosome in wheat [72–77]. For example, 1 major QTL on 4BS as well as 3 minor QTLs on 1BS and 5AL affecting super soft kernel texture were identified

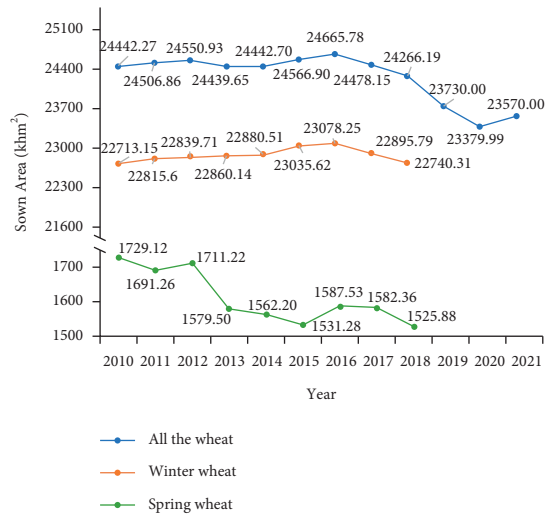

Figure 3: The sown area of wheat in China from 2010 to 2021. The sown area data of winter and spring wheat in 2019–2021 was with no records in the website of National Bureau of Statistics of China (https://data.stats.gov.cn/index.htm).

using a population of 268 F6 recombinant inbred lines (RILs) derived from the cross between Alpowa ("normal" soft) and "Super Soft" line (BC2SS163) in Kumar et al. [74], and 2 molecular markers significantly associated with kernel texture were identified and effectively used in MAS of soft wheat. Therefore, the multiple QTLs and the molecular markers significantly associated with kernel texture will enhance our understanding of kernel softness (hardness) and provide perspectives for future fine-tuning of grain texture and breeding the special soft wheat with high-quality to meet the needs of different biscuits.

6. Guidance on the Breeding and Demand of Soft Wheat for Biscuit

With the improvement of living standards, consumers' demand for wheat food is gradually diversified. According to the data from National Bureau of Statistics of China (https://data.stats.gov.cn/index.htm), we have obtained some statistics of Chinese wheat, including planting area, annual yield, import and export trade, etc. Most of China's wheat is winter wheat; the planting area of winter wheat in China has stabilized around 22.8 million hectares from 2010 to 2018; however, the sown area of spring wheat in China was decreased about 2.0 million hectares from 2010 to 2018 (Figure 3). The yield of wheat has increased 18.0% (20.86 million t) (Figure 4(a)) despite a slight decrease of the sown area for all the wheat (Figure 3), which is due to the increase of yield per unit of wheat (Figure 4(b)). The yield per unit of winter and spring wheat is increased about 700 and 550 kg/hm^2 from 2010 to 2018, respectively, and the average annual increase in yield per unit of all the wheat is about 96.5 kg/hm^2 from 2010 to 2021 (Figure 4(b)). Although the wheat production of China has been increasing, it is still unable to meet the domestic demand and has to be imported in large quantities from abroad every year (Figure 5). The total annual wheat imports amount and bill of China has increased to some extent from 2010 to 2020. In particular, the wheat imports amount and bill in 2020 was more than two times that in 2019 (Figure 5), which may be due to the impact of COVID-19 on China in 2020. With the decreasing of weak gluten wheat in wheat production in China, processing enterprises need to import a large number of foreign high-quality wheat to meet the pastry market demand (especially for biscuits) (Figure 2).

At present, China's per capita consumption of biscuits is still keeping in a quite low state, while the demands of biscuits are gradually increasing, suggesting a great potential market for biscuits industry. Soft wheat with weak gluten is the suitable wheat for biscuits and cakes making. For the current production, it is difficult for most varieties to reach the stable standard of high quality and weak gluten wheat, and the planting quality is unstable between years and regions [78]. The quality and yield of soft wheat are greatly affected by cultivation techniques and environmental conditions. Fertilizer and water management measures directly affect the yield and quality [79, 80]. The national standard requires that the protein content of weak gluten wheat is less than 11.5%. It is necessary to introduce high-quality weak gluten wheat germplasm resources with low protein content for genetic improvement. Contrary to the requirements of many quality indexes of soft wheat with weak gluten, the use of subunits with little effect on the quality improvement of strong gluten wheat or silencing of high-quality subunits may be beneficial to the improvement of weak gluten quality. Therefore, the deletion of high molecular weight glutenin subunits can be used to cultivate high-quality soft wheat with weak gluten [81]. In addition, the grain softness genes and QTLs can be effectively and widely used in the selection of soft wheat. With the decreasing of soft wheat in wheat production of China, it is necessary to optimize the current wheat quality structure, strengthen the improvement of wheat quality, and select soft wheat varieties with high quality and stable yield to meet the needs of the biscuit market.

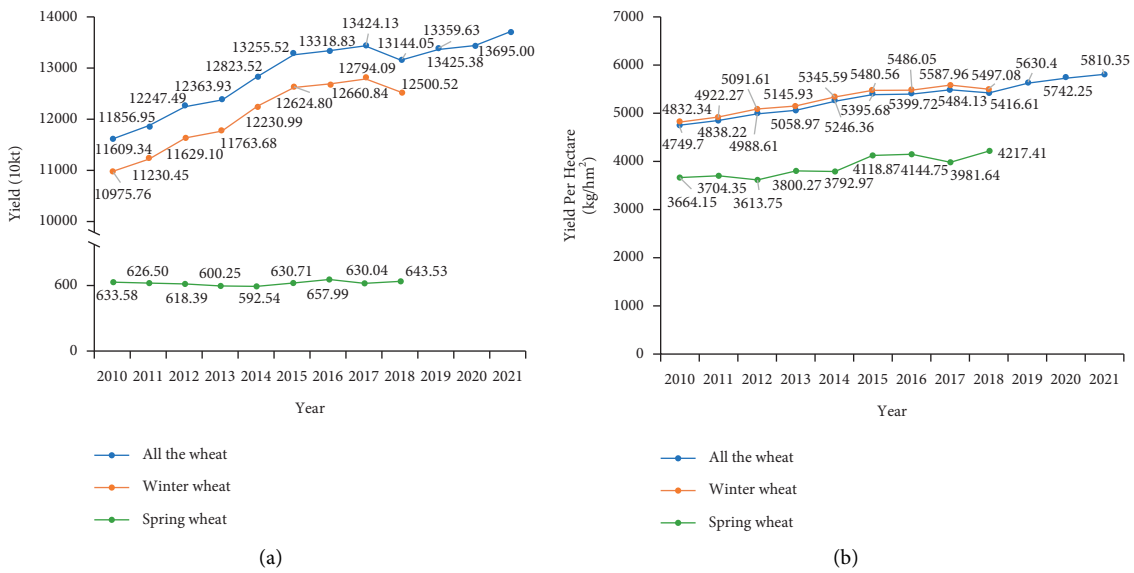

Figure 4: The total annual yield and average yield per hectare of wheat in China from 2010 to 2021. (a) The total annual yield of wheat in China from 2010 to 2021; (b) the average yield per hectare of wheat in China from 2010 to 2021. The annual yield and average yield per hectare of winter and spring wheat in 2019–2021 was with no records in the website of National Bureau of Statistics of China (https://data.stats.gov.cn/index.htm).

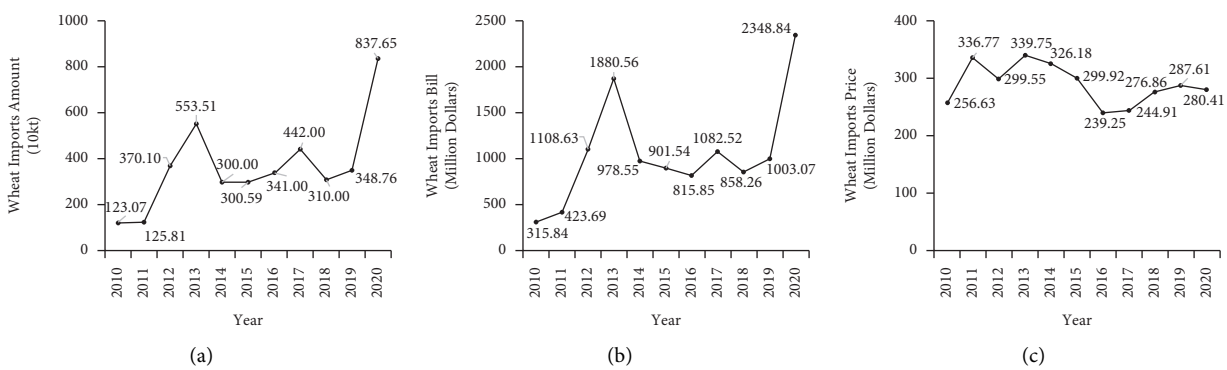

Figure 5: The total annual wheat imports amount, bill, and price of China from 2010 to 2020. (a) The total annual imports amount of wheat in China from 2010 to 2020; (b) the total annual imports bill of wheat in China from 2010 to 2020; (c) the total annual imports price of wheat in China from 2010 to 2020.

7. Conclusion

Biscuits, as a kind of convenience food, have attracted more and more people and become a consumer and leisure snack for their low processing cost, easy to carry and eat, long shelf life, diverse varieties, and rich taste. Biscuits are made up of four main ingredients like flour, fat or oil, sugar, and water and several secondary ingredients. The ingredients play a different role, contributing to their taste, texture, color, and flavor. The type and proportion of ingredients affect the quality of the final product. According to the characteristics of biscuit formula, process, and end products, biscuits can be divided into five categories, such as coarse, tough, crisp, sweet, and fermented. The types of biscuits in China vary a lot, which were with different processing technology and texture. At present, China's per capita consumption of biscuits is still keeping in a quite low state, while the demands of biscuits are gradually increasing, suggesting a great potential market for biscuits industry. Soft wheat with weak gluten is the suitable wheat for biscuits and cakes making. With the decreasing of weak gluten wheat in wheat production in China, it is necessary to optimize the current wheat quality structure, strengthen the improvement of wheat quality, and select soft wheat varieties with high quality and stable yield to meet the needs of the biscuit market.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Xin Hu and Lejia Hu contributed equally to this work.

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References

[1] D. Manley, *Manley's Technology of Biscuits, Crackers and Cookies*, Woodhead Publishing, Sawston, UK, 2011.

[2] P. I. Akubor, "Functional properties and performance of cowpea/plantain/wheat flour blends in biscuits," *Plant Foods for Human Nutrition*, vol. 58, no. 3, pp. 1–8, 2003.

[3] S. Hooda and S. Jood, "Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour," *Food Chemistry*, vol. 90, no. 3, pp. 427–435, 2005.

[4] S. Zheng, "Overview and trends of domestic biscuit industry," *Academic Periodical of Farm Products Processing*, vol. 3, no. 6, pp. 56–59, 2013.

[5] S. Ahmad and M. Ahmed, "A review on biscuit, a largest consumed processed product in India, its fortification and nutritional improvement," *International Journal of Science Inventions Today*, vol. 3, pp. 169–186, 2014.

[6] C. M. Mancebo, J. Picón, and M. Gómez, "Effect of flour properties on the quality characteristics of gluten free sugar-snap cookies," *LWT-Food Science and Technology*, vol. 64, no. 1, pp. 264–269, 2015.

[7] B. Pareyt and J. A. Delcour, "The role of wheat flour constituents, sugar, and fat in low moisture cereal based products: a review on sugar-snap cookies," *Critical Reviews in Food Science and Nutrition*, vol. 48, no. 9, pp. 824–839, 2008.

[8] C. M. Mancebo, P. Rodriguez, and M. Gómez, "Assessing rice flour-starch-protein mixtures to produce gluten free sugar-snap cookies," *LWT-Food Science and Technology*, vol. 67, pp. 127–132, 2016.

[9] Z. Maache-Rezzoug, J. M. Bouvier, K. Allaf, and C. Patras, "Effect of principal ingredients on rheological behaviour of biscuit dough and on quality of biscuits," *Journal of Food Engineering*, vol. 35, no. 1, pp. 23–42, 1998.

[10] C. S. Gaines, "Influence of dough absorption level and time on stickiness and consistency in sugar-snap cookie doughs," *Cereal Chemistry*, vol. 59, pp. 404–407, 1982.

[11] K. A. Kumar, G. K. Sharma, M. A. Khan, and A. D. Semwal, "A study on functional, pasting and micro-structural characteristics of multigrain mixes for biscuits," *Journal of Food Measurement and Characterization*, vol. 10, no. 2, pp. 274–282, 2016.

[12] E. H. Eneche, "Biscuit-making potential of millet/pigeon pea flour blends," *Plant Foods for Human Nutrition*, vol. 54, no. 1, pp. 21–27, 1999.

[13] D. E. Duta and A. Culetu, "Evaluation of rheological, physicochemical, thermal, mechanical and sensory properties of oat-based gluten free cookies," *Journal of Food Engineering*, vol. 162, pp. 1–8, 2015.

[14] M. Ukwuru and A. Adama, "Chemical evaluation and storage stability of a beverage formulated from soybean and papaya pulp flour blends," *Plant Foods for Human Nutrition*, vol. 58, no. 3, pp. 1–11, 2003.

[15] R. G. M. van der Sman and S. Renzetti, "Understanding functionality of sucrose in biscuits for reformulation purposes," *Critical Reviews in Food Science and Nutrition*, vol. 59, no. 14, pp. 2225–2239, 2019.

[16] S. Chevallier, P. Colonna, A. Buléon, and G. Della Valle, "Physicochemical behaviors of sugars, lipids, and gluten in short dough and biscuit," *Journal of Agricultural and Food Chemistry*, vol. 48, no. 4, pp. 1322–1326, 2000.

[17] A. Baltsavias, A. Jurgens, and T. van Vliet, "Fracture properties of short-dough biscuits: effect of composition," *Journal of Cereal Science*, vol. 29, no. 3, pp. 235–244, 1999.

[18] E. Gallagher, T. R. Gormley, and E. K. Arendt, "Recent advances in the formulation of gluten-free cereal-based products," *Trends in Food Science & Technology*, vol. 15, pp. 143–152, 2004.

[19] B. Pareyt, F. Talhaoui, G. Kerckhofs et al., "The role of sugar and fat in sugar-snap cookies: structural and textural properties," *Journal of Food Engineering*, vol. 90, pp. 400–408, 2009.

[20] J. Delcour and R. C. Hoseney, "Principles of cereal science and technology authors provide insight into the current state of cereal processing," *Cereal Foods World*, vol. 55, pp. 21-22, 2010.

[21] H. M. Lai and T. C. Lin, *Bakery Products: Science and Technology*, Wiley, Hoboken, NJ, USA, 2006.

[22] Y. S. Savitha, D. Indrani, and J. Prakash, "Effect of replacement of sugar with sucralose and maltodextrin on rheological characteristics of wheat flour dough and quality of soft dough biscuits," *Journal of Texture Studies*, vol. 39, pp. 605–616, 2010.

[23] B. S. Ghotra, S. D. Dyal, and S. S. Narine, "Lipid shortenings: a review," *Food Research International*, vol. 35, no. 10, pp. 1015–1048, 2002.

[24] I. Davidson, *Biscuit Baking Technology: Processing and Engineering Manual*, Academic Press, Cambridge, MA, USA, 2016.

[25] J. Jacob and K. Leelavathi, "Effect of fat-type on cookie dough and cookie quality," *Journal of Food Engineering*, vol. 79, no. 1, pp. 299–305, 2007.

[26] H. Mamat and S. E. Hill, "Effect of fat types on the structural and textural properties of dough and semi-sweet biscuit," *Journal of Food Science & Technology*, vol. 51, no. 9, pp. 1998–2005, 2014.

[27] A. Devi and B. S. Khatkar, "Effects of fatty acids composition and microstructure properties of fats and oils on textural properties of dough and cookie quality," *Journal of Food Science & Technology*, vol. 55, no. 1, pp. 321–330, 2018.

[28] B. Pareyt, K. Brijs, and J. A. Delcour, "Impact of fat on dough and cookie properties of sugar-snap cookies," *Cereal Chemistry Journal*, vol. 87, no. 3, pp. 226–230, 2010.

[29] B. Mert and I. Demirkesen, "Reducing saturated fat with oleogel/shortening blends in a baked product," *Food Chemistry*, vol. 199, pp. 809–816, 2016.

[30] S. L. Elias and S. M. Innis, "Bakery foods are the major dietary source of trans-fatty acids among pregnant women with diets providing 30 percent energy from fat," *Journal of the American Dietetic Association*, vol. 102, no. 1, pp. 46–51, 2002.

[31] A. L. Amrutha Kala, "Studies on saturated and trans fatty acids composition of few commercial brands of biscuits sold in Indian market," *Journal of Food Science & Technology*, vol. 51, no. 11, pp. 3520–3526, 2014.

[32] W. Anne, Z. Peter, and B. Ingeborg, "Trans fat intake and its dietary sources in general populations worldwide: a systematic review," *Nutrients*, vol. 9, p. 840, 2017.

[33] E. I. Zoulias, S. Piknis, and V. Oreopoulou, "Effect of sugar replacement by polyols and acesulfame-K on properties of low-fat cookies," *Journal of the Science of Food and Agriculture*, vol. 80, no. 14, pp. 2049–2056, 2000.

[34] L. A. Campbell, S. M. Ketelsen, and R. N. Antenucci, "Formulating oatmeal cookies with calorie-sparing ingredients," *Food Technol-Chicago*, vol. 48, p. 98, 1994.

[35] M. L. Sudha, A. K. Srivastava, R. Vetrimani, and K. Leelavathi, "Fat replacement in soft dough biscuits: its implications on dough rheology and biscuit quality," *Journal of Food Engineering*, vol. 80, no. 3, pp. 922–930, 2007.

[36] D. Aggarwal, L. Sabikhi, M. H. S. Kumar, and N. R. Panjagari, "Investigating the effect of resistant starch, polydextrose and biscuit improver on the textural and sensory characteristics of dairy-multigrain composite biscuits using response surface methodology," *Journal of Food Measurement and Characterization*, vol. 12, no. 2, pp. 1167–1176, 2018.

[37] W. C. Yackel and C. Cox, "Application of starch-based fat replacers," *Food Technology*, vol. 46, pp. 146–148, 1992.

[38] P. Tarancón, A. Salvador, T. Sanz, S. Fiszman, and A. Tárrega, "Use of healthier fats in biscuits (olive and sunflower oil): changing sensory features and their relation with consumers' liking," *Food Research International*, vol. 69, pp. 91–96, 2015.

[39] R. S. Manohar and P. H. Rao, "Effects of water on the rheological characteristics of biscuit dough and quality of biscuits," *European Food Research and Technology*, vol. 209, pp. 281–285, 1999.

[40] S. Chevallier, P. Colonna, G. Della Valle, and D. Lourdin, "Contribution of major ingredients during baking of biscuit dough systems," *Journal of Cereal Science*, vol. 31, no. 3, pp. 241–252, 2000.

[41] R. Moreira, F. Chenlo, and M. D. Torres, "Effect of sodium chloride, sucrose and chestnut starch on rheological properties of chestnut flour doughs," *Food Hydrocolloids*, vol. 25, no. 5, pp. 1041–1050, 2011.

[42] M. Graf, T. M. Amrein, S. Graf, R. Szalay, F. Escher, and R. Amadò, "Reducing the acrylamide content of a semi-finished biscuit on industrial scale," *LWT-Food Science and Technology*, vol. 39, no. 7, pp. 724–728, 2006.

[43] K. Kukurová, Z. Ciesarová, B. A. Mogol, O. C. Açar, and V. Gökmen, "Raising agents strongly influence acrylamide and HMF formation in cookies and conditions for asparaginase activity in dough," *European Food Research and Technology*, vol. 237, no. 1, pp. 1–8, 2013.

[44] T. M. Amrein, B. Schönbächler, F. Escher, and R. Amadò, "Factors influencing acrylamide formation in gingerbread," *Advances in Experimental Medicine and Biology*, vol. 561, pp. 431–446, 2005.

[45] W. Ma, *Study on the Laboratory-Making and Evaluating Method of Short Biscuit*, Henan University of Technology, Zhengzhou, China, 2012.

[46] W. Ma, "Annual analysis of China's wheat flour consumption and industry status in 2019," *Grain Processing*, vol. 45, pp. 6–10, 2020.

[47] M. Xun, "Overview of China's baking industry," *Modern Flour Industry*, vol. 4, pp. 14–16, 2013.

[48] X. Zhang, Y. Zhang, D.-R. Gao, T. Die, and B.-Q. Zhang, "The development of weak-gluten wheat breeding and present situation of its production," *Journal of Triticeae Crops*, vol. 32, pp. 184–189, 2012.

[49] F. Wang, D. Li, F. Yuan, and D. Wu, "Viewing the development of Chinese flour processing industry from the situation of developed countries," *Modern Flour Milling Industry*, vol. 5, pp. 1–6, 2014.

[50] J. C. Murray, A. M. Kiszonas, J. Wilson, and C. F. Morris, "Effect of soft kernel texture on the milling properties of soft durum wheat," *Cereal Chemistry Journal*, vol. 93, no. 5, pp. 513–517, 2016.

[51] C. Paesani, M. Moiraghi, L. Sciarini, and G. T. Pérez, "Whole-flours from hard and soft wheat genotypes: study of the ability of prediction test to estimate whole flour end-use," *Journal of Food Science & Technology*, vol. 58, no. 4, pp. 1462–1469, 2021.

[52] M. Katyal, N. Singh, A. S. Virdi et al., "Extraordinarily soft, medium-hard and hard Indian wheat varieties: composition, protein profile, dough and baking properties," *Food Research International*, vol. 100, pp. 306–317, 2017.

[53] H. Sun, C. Wu, Z. Yang, W. Jiang, H. Tang, and Z. Zhou, "Research on hardness quality status and hardness classification of wheat in my country," *Journal of Chinese Cereals Oils Association*, vol. 23, pp. 38–42, 2008.

[54] J. Yao, H. Ma, P. Zhang, G. Yao, X. Yang, and P. Zhang, "Research progress on quality of weak gluten wheat in China," *Jiangsu Journal of Agricultural Sciences*, vol. 4, pp. 919–924, 2009.

[55] L. Slade and H. Levine, "Structure-function relationships of cookie and cracker ingredients," *The Science of Cookie and Cracker Production*, vol. 9, pp. 23–141, 1994.

[56] Q. Zhang, *Quality Evaluation of Soft Wheat Biscuits*, Chinese Academy of Agricultural Sciences, Beijing, China, 2004.

[57] Q. Zhang, Z. He, J. Yan et al., "Application of solvent retention capacity in soft wheat quality evaluation," *Journal of Triticeae Crops*, vol. 24, pp. 140–142, 2004.

[58] X. Zhang, L. Man, D. Liu, W. Jiang, Y. Zhang, and D. Gao, "Analysis of quality traits and breeding inspiration in Yangmai series wheat varieties," *Scientia Agricultura Sinica*, vol. 053, pp. 1309–1321, 2020.

[59] P. Zhang, J. Yao, H. Wang et al., "Soft wheat quality traits in Jiangsu province and their relationship with cookie making quality," *Acta Agronomica Sinica*, vol. 46, pp. 23–34, 2020.

[60] H. Xu, Y. Zhang, H. Wang et al., "The content of pentosan in different quality types of wheat and its relationship with quality," *Journal of Triticeae Crops*, vol. 4, pp. 613–617, 2009.

[61] C. F. Morris, "Puroindolines: the molecular genetic basis of wheat grain hardness," *Plant Molecular Biology*, vol. 48, no. 5/6, pp. 633–647, 2002.

[62] A. Rai, A. Mahendru-Singh, K. Raghunandan et al., "Marker-assisted transfer of PinaD1a gene to develop soft grain wheat cultivars," *3 Biotech*, vol. 9, p. 183, 2019.

[63] P. Mattern, "Location of genes for kernel properties in the wheat cultivar "Cheyenne" using chromosome substitution lines," in *Proceedings of the 4th International Wheat Genetics Symposium*, pp. 703–707, Columbia, MO, USA, August 1973.

[64] M. F. Gautier, M. E. Aleman, A. Guirao, D. Marion, and P. Joudrier, "*Triticum aestivum* puroindolines, two basic cystine-rich seed proteins: cDNA sequence analysis and developmental gene expression," *Plant Molecular Biology*, vol. 25, no. 1, pp. 43–57, 1994.

[65] S. Rahman, C. J. Jolly, J. H. Skerritt, and A. Wallosheck, "Cloning of a wheat 15-kDa grain softness protein (GSP). GSP is a mixture of puroindoline-like polypeptides," *European Journal of Biochemistry*, vol. 223, no. 3, pp. 917–925, 1994.

[66] P. Greenwell and J. Schofield, "A starch granule protein associated with endosperm softness in wheat," *Cereal Chemistry*, vol. 63, pp. 379-380, 1986.

[67] A. C. Hogg, T. Sripo, B. Beecher, J. M. Martin, and M. J. Giroux, "Wheat puroindolines interact to form friabilin and control wheat grain hardness," *Theoretical and Applied Genetics*, vol. 108, no. 6, pp. 1089–1097, 2004.

[68] M. J. Giroux and C. F. Morris, "Wheat grain hardness results from highly conserved mutations in the friabilin components puroindoline a and b," *Proceedings of the National Academy of Sciences*, vol. 95, no. 11, pp. 6262–6266, 1998.

[69] X. Q. Huang and M. S. Röder, "Development of SNP assays for genotyping the puroindoline b gene for grain hardness in wheat using pyrosequencing," *Journal of Agricultural and Food Chemistry*, vol. 53, no. 6, pp. 2070–2075, 2005.

[70] X. Ma, M. Sajjad, J. Wang et al., "Diversity, distribution of puroindoline genes and their effect on kernel hardness in a diverse panel of Chinese wheat germplasm," *BMC Plant Biology*, vol. 17, no. 1, p. 158, 2017.

[71] P. K. Gupta, R. K. Varshney, P. C. Sharma, and B. Ramesh, "Review molecular markers and their applications in wheat breeding," *Plant Breeding*, vol. 118, no. 5, pp. 369–390, 1999.

[72] M. Arbelbide and R. Bernardo, "Mixed-model QTL mapping for kernel hardness and dough strength in bread wheat," *Theoretical and Applied Genetics*, vol. 112, no. 5, pp. 885–890, 2006.

[73] C. Groos, E. Bervas, and G. Charmet, "Genetic analysis of grain protein content, grain hardness and dough rheology in a hard × hard bread wheat progeny," *Journal of Cereal Science*, vol. 40, no. 2, pp. 93–100, 2004.

[74] N. Kumar, A. M. Kiszonas, M. I. Ibba, and C. F. Morris, "Identification of loci and molecular markers associated with super soft kernel texture in wheat," *Journal of Cereal Science*, vol. 87, pp. 286–291, 2019.

[75] N. Kumar, J. M. Orenday-Ortiz, A. M. Kiszonas, J. D. Boehm, and C. F. Morris, "Genetic analysis of a unique "super soft" kernel texture phenotype in soft white spring wheat," *Journal of Cereal Science*, vol. 85, pp. 162–167, 2019.

[76] G. Wang, J. M. Leonard, A. S. Ross et al., "Identification of genetic factors controlling kernel hardness and related traits in a recombinant inbred population derived from a soft × "extra-soft" wheat (*Triticum aestivum* L.) cross," *Theoretical and Applied Genetics*, vol. 124, no. 1, pp. 207–221, 2012.

[77] M. Tu and Y. Li, "Toward the genetic basis and multiple QTLs of kernel hardness in wheat," *Plants*, vol. 9, no. 12, p. 1631, 2020.

[78] X. Hu, G. Zhou, L. Wu et al., "2006-2014 China's wheat quality changes between annual and quality areas," *Journal of Triticeae Crops*, vol. 36, pp. 292–301, 2016.

[79] Z. Lu, T. Dai, D. Jiang et al., "Effect of nitrogen application on the formation of population index and yield and quality of weak gluten wheat," *Acta Agronomica Sinica*, vol. 33, pp. 590–597, 2007.

[80] X. Zhu, W. Guo, J. Zhou et al., "Effects of nitrogen on grain yield, nutritional quality and processing quality of wheat for different end uses," *Scientia Agricultura Sinica*, vol. 36, pp. 640–645, 2003.

[81] D. Gao, X. Zhang, B. Zhang, D. Zhu, and G. Lu, "Concept on wheat quality improvement in middle and lower reaches of Yangtze river valley," *Journal of Triticeae Crops*, vol. 33, pp. 840–844, 2013.