Improving the quality of soybean by-products by physical methods during its use in bakery technology. Review

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Abstract

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Introduction. Secondary raw materials of soybean processing (SMSP) have a high nutritional value, but its use in food is limited by a rough taste and a low content of soluble dietary fiber.

Material and methods. The subject of the study is the properties of SMSP, soluble dietary fiber, trypsin inhibitor, physical methods of raw materials processing, bakery products, and pastries. Research methods are analysis and synthesis of information of the world's leading scientific publications.

Result and discussion. Based on the analysis of research results it was determined that there is an influence of physical factors of SMSP processing on their nutritional value, technological and consumer features of finished products. Therefore, the relevance and perspective of the use of physical factors are proved. High pressure significantly affects soluble dietary fiber and functional features of legumes' wastes. At 400 MPa and 60 °C under high pressure, the content of soluble dietary fiber increases by 8 times during SMSP treatment in comparison to the untreated one. Swelling and water (oil) retention features are improved. After ultrafine grinding SMSP has improved technological indicators. Their use in baking leads to improved organoleptic characteristics. Ultrafine grinding improved the physical and chemical indicators of SMSP (viscosity, cation exchange capacity, ability to retain water and oil, solubility, hydration features, fluidity, antioxidant activity), technological indicators (test formability, the stability of its structure), organoleptic parameters. Microwave treatment has a strong penetration power. The electromagnetic wave leads to the increasing of pressure in the cell of material, its expansion, and rupture. It also leads to an increase in soluble dietary fiber content in SMSP. Microwave treatment is an effective way to inactivate the activity of a protease inhibitor in soybean cracks. Only two minutes roasting reduces the activity of the trypsin inhibitor to 13.33% from the initial one.

Conclusion. The use of physical methods combination of SMSP quality improvement is promising. Ultrafine grinding of SMSP has advantages in comparison to other physical methods. It affects significantly on physical, chemical, technological features and the quality of bakery products and pastries.

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Contents

Introduction

1. Dietary fiber
 - 1.1. Physiological function of dietary fiber
 - 1.2. Application of different types of fibers in bakery products
2. Application of bean dregs in baked goods
 - 2.1. Application of bean dregs in bread and cakes
 - 2.2. Application of bean dregs in biscuits
 - 2.3. Application of bean dregs in other food
3. Application of physical technology in baked goods and cereals
 - 3.1. High pressure
 - 3.2. Ultrafine grinding
 - 3.3. Microwave
 - 3.4. Other physical techniques
4. Improve quality of bean dregs by physical technology
 - 4.1. Improve soluble dietary fiber of bean dregs
 - 4.2. Removal of Removal of ant-nutritional factors
 - 4.2.1. Trypsin inhibitor
 - 4.2.2. Lectin
 - 4.2.3. Goitrogen

Conclusions

Introduction

China is a main producer of soybean products and the cultivation and processing industry of beans has a long history. The main products of soybean production include soybean milk and tofu, and the by-product of soybean milk production is soybean dregs [1]. Based on the vigorous development of China's soybean industry, the soybean food industry can produce tens of thousands of tons of wet bean dregs each year, with a residue up to 70%. The development of soybeans has brought great economic benefits to the food industry, which can produce 15 million tons bean dregs per year [2–4]. Soybean residue is rich in nutrients, containing 50% dietary fiber, 25% protein, 10% fat, 33% isoflavones, slightly higher amino acid content than soy milk, as well as calcium, phosphorus, iron and B vitamins. Therefore, bean dregs have the nutritional characteristics of high fiber, high protein, low fat and low reducing sugar, and is rich in mineral elements of potassium, calcium and magnesium et al [5–8]. The texture of bean dregs was similar to that of copra, Japanese like to add bean dregs into soup, salad and vegetables. It was obvious that bean dregs had good potential as a functional food material [9]. Bean dregs had a certain health care function and was a good dietary fiber raw material [10–17] (Table 1).

Generally, the development and use of bean dregs are more common in feed mills and food processing, or directly burned as waste, which causes certain economic losses [5] . In the food, it can be used in bakery products [18–20], noodles [21–23], and steamed bread [24]. At present, the dietary fiber products produced by deep processing of bean dregs had the disadvantages of high water content, poor taste, easy spoilage, and low soluble dietary fiber (14%), and contains some ant-nutritional factors, which had a great impact on the health of people or animals for a long time [25]. Therefore, to improve the added value of bean dregs in food was not only to increase the content of dietary fiber, but also to elimination of ant-nutrient factors in bean dregs, which is related to human health and safety.

Table 1

Main nutrition composition of products of soybean (g/100 g dry matter) (%)

Alias	Dietary fiber	Protein	Lipid	Reference
Bean dregs	52.8–58.1	25.4–28.4	9.3–10.9	[13]
Soy pulp	42.4	15.2	8.3	[14]
Bean curd dregs	49	33.4	19.8	[15]
Okara	54.3	33.4	8.5	[16]
Soybean residue	53.25	24.21	9.83	[17]

The content of soluble dietary fiber and the taste and quality of bean dregs can be improved by different processing technologies. A large number of studies show that the soluble dietary fiber of bean dregs can be improved by with physical technology. Such as novel blasting extrusion processing [26], steam explosion [27], electrohydrodynamic [28], and high pressure [29]. The application of these physical techniques also increases the soluble dietary fiber of other raw materials, such as that extrusion technology increased dietary fiber on cereals [30]. Ultrafine grinding technology can effectively improve the functional properties of the b-products of grain, provide the delicate taste for the product [31], this new technology has been proven and used to prepare ultrafine powders with good properties [32]. High pressure as a new technology and gradually applied to the b-products of grain, and has made great progress and contributions, at the same time, high pressure inactivated about 90% trypsin inhibitors [33]. Several efforts have been made by researchers to exploit the bean dregs and improve the quality of baked goods in the production of highly nutritious food products.

The content of soluble dietary fiber and the taste and quality of bean dregs can be improved by different processing technologies. Nowadays, ultrafine grinding technology can effectively improve the functional properties of bean dregs dietary fiber, which not only improves the utilization of soybean resources but also conducive to environmental protection. Ultrafine powder was the final product of ultrafine grinding, and has special physical and chemical properties not available in general particles, such as good solubility, dispersibility, adsorption, chemical reactivity and the like. Ultrafine powder has been widely used in many fields such as food, chemical, pharmaceutical, cosmetic pesticides, dyes, coatings, electronics and aerospace. In recent years, high pressure as a new technology in the food industry usually used in meat products, vegetables, drinks, jam, and a small part of grain products, and more in basic research.

This review compiles the research carried out on functional characteristics and utilization of dietary fiber of bean dregs in baked goods (bread, cake and biscuit). The effects of physical techniques on quality improvement of bean dregs were reviewed. In this review, we aim to highlight physical methods impact on bean dregs and baked goods are emphasized, as well as the effects of physical techniques on anti-nutrition factors. Further research should focus on technological innovations to develop high quality raw materials from soybean b-products to improve the quality of baked foods.

1. Dietary fiber

1.1. Physiological functions of dietary fiber

Dietary fiber is the general term of the carbohydrates that are not easy or cannot be decomposed and digested by digestive enzymes and absorbed of human intestinal tracts after being ingested by human, including cellulose, hemicellulose, lignin, pectin, mucus, gum, β -glucan, arabinoxylan and so on. It was resistant to digestion and adsorption in the human small intestine and can be fully or partially fermented in the large intestine [34, 35]. With the development of society and the continuous improvement of human living standards, people had less intake of dietary fiber, and food nutrition has not been properly matched. In the long run, it will cause diseases such as diabetes and obesity. Dietary fiber intake requirements (25g for women and 38g men every day) [36]. Dietary fiber can affect the ecology of human intestinal microorganisms, promote intestinal peristalsis, increase satiety, lower blood glucose levels, and also has the effect of losing weight [37, 38]. The presence of dietary fiber may change the gelatinization temperature, molecular structure and crystallite structure of the starch, thereby further affect the digestive properties of the food. Daily intake of dietary fiber can reduce hunger, prolong food intake, and control cholesterol intake [39]. Dietary fiber can effectively inhibit the growth of harmful bacteria, promote the proliferation of beneficial bacteria, regulate the balance function of intestinal flora, and protect colonic health [40]. With the development of nutrition and related disciplines, more and more studies had found that dietary fiber plays a very important role in human health. It was an indispensable nutrient for human healthy diet, especially in the health of the digestive tract. Comprehensively, dietary fiber has physiological functions, such as lower blood fat and blood sugar, improve the intestinal environment, and control body weight [41, 42]. The bean dregs dietary fiber was mainly composed of cellulose, hemicellulose (dry weight content 40~60 g/100 g) and lignin. Dietary fiber includes soluble and insoluble dietary fiber. However soluble dietary fiber has a potential "prebiotic" label [43, 44]. Soluble dietary fiber has high viscosity and strong water holding capacity. It can be used by intestinal microorganisms and slow down the digestion rate. And delay the body's absorption of water compounds by carbon bodies, play a part in reducing postprandial blood glucose, and improve insulin sensitivity [45]. Dietary fiber includes soluble and insoluble dietary fiber. Soluble dietary fiber consists of naturally formed gels or viscous fibers such as hemicellulose, seaweed polysaccharides, guar gum, pectin, et al [46]. Soluble dietary fiber can reduce the mechanisms of postprandial blood sugar, for example, slowing the digestion of food in the stomach [47], antagonistic glucagon [48], inhibit the absorption of glucose in the small intestine [49]. Insoluble dietary fiber cellulose mainly contains cellulose and hemicellulose, which can promote gastrointestinal motility, accelerate food absorption through the gastrointestinal tract, reduce energy absorption, and clean the digestive wall, dilute carcinogens in food, and accelerate the migration of toxic metabolites [50, 51]. In addition, it is good for intestinal health and prevention of colon cancer.

There are a lot of foods containing dietary fiber, such as grains, vegetables, fruits, tea and other processed of scraps, and many wastes from food factory also containing large amount of dietary fiber, such as wheat bran, rice bran, yam skin, dragon skin, navel orange peel, tea stems and so on. Add dietary fiber to cereal products, not only can increase nutrition, prevents disease, but also improve the viscosity, texture, sensory properties of the product, and extend the shelf life of the food. Therefore, recycling and reusing waste resources not only enriches food types, but also increases the added value of products, which is of great practical significance.

1.2. Application of different types of fibers in bakery products

Different types of fibers were used in baked products to effectively improve the viscosity, texture, and sensory properties of the product, while reduced the heat of the product [52, 53]. It increases the nutrition and flavor of the product and better meets the consumer's demand for high dietary fiber food. Microwave reaction technology is combined with ultrafine grinding was used to separate the dietary fiber from the cardamom, and used in the production and development of biscuits. The results showed that the hardness of the biscuit product improved with the increase of cardamom dietary fiber content. Addition of 10% cardamom dietary fiber was used instead of wheat flour. The biscuit has anti-free radical properties, and was 6 times higher than that of the control group. Above 7.5% cardamom dietary fiber addition, the nutritional and quality properties of the biscuit improved [54]. Used jet mill to treat barley and rye flour for biscuit production, the composite flour was softer than the commercial flour, the color was darker, and the total phenolic content and antioxidant activity were higher, and barley flour was increased in hardness compared to biscuits made from whole wheat flour. Rye flour was darker in color, so the biscuits were darker in color [55]. Used bean powder and soy protein powder to make biscuits. Soybean protein powder has a higher protein content of 9.42% compared with that of wheat flour. The addition of soybean powder improved the nutritional quality of biscuits, and further increases the sensory score of biscuits [56]. By optimizing the formulation of the biscuits, the resistant starch 14%, sodium caseinate 14.51%, raftilose 25%, and simplesse 25.02%, a lo-sugar, low-fat "functional" biscuit was developed. Add to sodium caseinate can increase the hardness of the biscuit dough, and the thickness of the biscuit was positively correlated with the texture [57].

When making biscuits, by adding different types of dietary fiber, the sensory properties of the product can be improved, and the calories of the biscuits can be reduced, thereby becomes a functional food that is beneficial to the human body. For the addition of fiber, although the nutritional value of the product is improved, whether the taste and texture of the biscuits meet the needs of consumers, and whether the cost is accepted by the producer, we need to do further research. There are many foods contained fiber. The bean dregs were wastes in soybean processed. The bean dregs were mostly used in feed mills or discarded, which caused waste of resources. In order to further increase the added value of products, a large number of studies have proved that bean dregs highly utilized in food, and mostly used for the development of flour products. In recent years, in recent years, many varieties of bean dregs have been developed, such as taro, bread, biscuits, cakes, noodles, etc. The addition of bean dregs complements the nutritional value of the products, and increased the overall acceptability of the product. And bean dregs Not only develops new varieties, but also a new market has been developed.

2. Application of bean dregs in baked goods

With the development of the food industry, the availability of bean dregs has been gradually developed, and commonly used in baked goods (cakes, bread, biscuits). Addition the bean dregs in the flour and adds the correspond ingredients to make the bean dregs biscuits, it not only improved the flavor of the traditional biscuits, but also provided a new type of healthy food for consumers. A large number of literature studied has shown that the addition of bean dregs to flour. It can improve the nutrition and flavor of biscuits, and provided a new method for the utilization of soybean food [58, 59].

2.1. Application of bean dregs in bread and cakes

Bean dregs can be used in a variety of Western-style baked goods, it not only to provide natural fiber and protein, but also to provide a unique fragile texture for bread, muffins, donuts, brownies, marshmallows, etc [60]. The bean dregs bread was made from the bean dregs and the flour, assess the sensory, texture, and flavor of bread products. With the increased of the amount of bean dregs, the bean flavor of the bread was more intense. The hardness was gradually increased, and the internal texture was superior to ordinary bread. Above 10% level bean dregs powder, the bread was soft, with aroma, and the highest quality score. However, hardness, cohesiveness and occlusion of the bean dregs bread were higher, and the elasticity was lower, which provided a reference for the improvement of the bean dregs bread [61]. The used of bean dregs and grain rice to mix and make puffed biscuits, the rice cake made by mixing the ratio of bean dregs, and rice flour to 7:3 was most popular among the public. The addition of bean dregs was related to moisture and hardness, and the heating temperature and time were affected specific area of rice cake. The higher the content of bean dregs, the greater the hardness, the smaller the specific volume area and the lower the integrity. The bean dregs fiber was combined with rice flour, increased the adhesion strength between the particles and the toughness of the biscuit. With the increased of the amount of bean dregs, the L^* value and the a^* value of the product gradually decreased, and the b^* values increased significantly [62]. Make a new type of cake product, used eggs, flour, sugar, bean dregs and peanut dregs as raw materials. Among them, flour: peanut residue: bean dregs were (1:1:3). The finished cake was complete in shape, attractive in color and aroma, and the finished product is soft and elastic. The pores were evenly distributed and the flavor was outstanding. The total dietary fiber content was 3.1%, and better than traditional cake. Nevertheless, there is a fishy smell in bean dregs or peanut dregs, how to use a certain technology to effectively remove, and still need to be further research [63]. The mixture of bean dregs and rice flour is used to make gluten-free layered cakes. The addition of bean dregs has a great impact on the cake batter and the product. When the substitution percentage of rice flour by bean dregs increased the decrease in cake volume is observed, giving rise to harder and less cohesive cakes. When addition 10% of the bean dregs flour can improve the quality and nutrition of the cake [64]. When making bean dregs bread, based on wet bean dregs, sugar, yeast, butter, the dough was analyzed and the bread was sensory evaluated. In the test of dough, the decisive indicators were hardness, elasticity and chewability. The sensory evaluation of bread was related to the dough, and chewability does not have much effect on dough quality [65]. When making bean dregs bread, added 8% bean dregs can increase the water absorption properties of bread flour, and improve the stretching properties of the dough. Addition of bean dregs increased the hardness and chewability of bread, and delays the aging rate of bread [66]. The soybean cake was fermented in stages, which shorten the fermentation process. As the increased of fermentation time, the hardness of the bean dregs cakes increased significantly, and the elasticity, cohesiveness and resilience decreased significantly. The surface of bean dregs cake had obvious changes, the inside of the product occurred uniform air holes, and organization more uniform [67].

A large number of literature have shown that bean dregs were added to bread can increase the nutritional value of the product, improve the flavor and volume of the product, and also have the effect of delaying aging. However, due to the strong water absorption of the bean dregs, a large amount of the addition will increase the hardness of the product, and the elasticity, cohesiveness and recovery were reduced, thereby affecting the taste of the product. These studies can provide more reference for the improvement of the bean dregs bread. Soybeans have a certain taste of soybean meal, and directly affect the taste quality of the product. The reason was that the oxidization of fat oxidase in soybean causes the oil to

oxidize, thereby produce the taste of soybean meal. Bean curd in the bean dregs also exists, and whether it will affect the flavor of the product and other series of problems, and it should be paid close attention.

2.2. Application of bean dregs in biscuits

Biscuits as a widely consumed product in the world, it has rich nutritional value and become an indispensable snack food [68, 69]. Biscuits are baked goods with lower water activity than bread. Biscuits usually made from wheat flour, eggs, sugar, salt, oil and water [70]. Biscuits play an important role in the baked industry, the main factors affected the quality of biscuits was the texture, taste and appearance of biscuits. Improve the nutritional content of cookies and being accepted by consumers is the most important aspect [71, 72]. The word “biscuit” comes from France, it means r-baked bread, the earliest biscuits were baked from bread. The biscuits were mainly divided into tough biscuits, crisp biscuits and fermented biscuits on the market in China. The crispy biscuits were made of lo-gluten wheat flour as the main raw material, with more oil and sugar, and the taste was crisp. The dough of the plastic biscuit lacks elongation and elasticity, it has good plasticity, the biscuit is crispy and sweet, it is a highly acceptable biscuit variety. The tough biscuits are a kind of biscuit with less sugar and fat, it is composed of wheat flour, sugar (or suga-free) and oil as the main raw materials, and added leavening agent, modifier, and other auxiliary materials. After the process of powdering, rolling, forming, baking. The surface of the biscuit had many patterns, the appearance was smooth and flat, there was even pores, the section was layered, and the taste was crisp. Biscuits have become a kind of snack food instead of people's lives, because of different tastes and textures, it was suitable for all the people. With the improvement of living standards, a new generation of mea-making biscuits on the market, which can control calories, it is the main ingredient for obese patients to lose weight. Bean dregs have rich in dietary fiber, among them, insoluble dietary fiber content is high. However, the taste of the bean dregs is not easy to be accepted by the public. Therefore, the development of functional food has been done by researchers.

Mix fresh bean dregs with starch, soy flour, and hydroxypropyl methylcellulose to make biscuits. Among them, the highest water retention of the dough with hydroxypropyl methylcellulose was 147.8%. Bean dregs dough has the lowest elasticity, followed by soya flour dough. Soy flour crackers and hydroxypropyl methylcellulose crackers were harder during storage. Bean biscuits were crispy and chewy. However, fresh bean dregs may produce a fishy smell and may affect the shelf life of the finished product [73]. The amount of bean dregs added directly affects the performance of the biscuit dough, and the taste of the finished product, on the basis of adjusting the amount of oil, sugar and water added, the maximum amount of the bean dregs powder was 40%. The greater the amount of bean dregs added, will affect the formation of biscuits, but it may require the addition of more grease [74]. The bean dregs were rich in dietary fiber, and the bean dregs were retreated with ultrafine grinding used to make cookies. With butter, bean dregs powder, sugar powder and baking process as a single factor, through orthogonal experiments, determine the best process recipe for making bean dregs biscuits: flour 864g, bean dregs powder 180g, 300g sugar powder, 750g butter, baking temperature was 180 °C, bottom fire 160 °C, baked time 12 min. Under this formula, the biscuit has golden color and the shape to keep good, crispy taste and rich bean flavor. There were more bean dregs added, which was a kind of hig-fiber snack food, it suitable for most consumers, and included special people, it can improve human health to a certain extent [75]. The use of ultra-fine powdered bean dregs to produce suga-free bean dregs biscuits, and the quality of the products from the shape, texture, taste, aroma and color of the biscuits to determine the best process conditions for making biscuits: baked

temperature 160 °C, baked time 10 min, the bean dregs addition amount was 30%, the oil: sugar mass ratio was 1.0:1.5, the oil and sugar: the optimal ratio of the bean dregs flour was 1.0:2.0, and the ratio of baking soda to ammonium bicarbonate was 2:1. It is shown that the addition of bean dregs can increase the content of wet gluten in the flour. When the amount of bean dregs added was less than 7.5%. The rheological properties of the dough were good, which was beneficial to the formation of biscuits [59]. Untreated bean dregs were directly added to wheat flour for the development of crisp biscuits, the best optimized formula was obtained: bean dregs: Wheat flour were 3:7, butter was added in 30% of powder, and sugar was added in 20% of powder, baked temperature: 200°C on fire and 180°C under fire, the biscuit has a complete structure, uniform color and crispy taste, it has rich aroma of bean dregs and good quality [76]. But whether biscuits produced with wet bean dregs will reduce the shelf life of the biscuits, and whether the taste was better than the biscuits made from dried bean dregs. The addition of wet bean dregs will cause ant-nutritional factors in the biscuits, which were not conducive to the health of the human body. In addition to this, added to the bean dregs were not pulverized, which may affect the taste. The use of black bean dregs to make biscuits have a significant effect on the water holding capacity, texture, and senses of ordinary bean dregs. When the added amount is 40%, the hardness of the biscuit is the largest. It may be that the dietary fiber in the black bean dregs and the gluten contents in the dough are diluted, which affects the formation of the gluten network, which causes the biscuits to dry out and increase their hardness. Using headspace soli-phase microextraction gas chromatograph-mass spectrometry, the flavor content of 30% black bean dregs cookies is richer, dietary fiber (58.8 ± 0.481) g/100 g, protein content is (23.8 ± 0.175) g/100 g, fat content It was (8.08 ± 0.121) g/100 g, the amino acid nitrogen content was (0.132 ± 0.012) g/100 g, and the ash content was (3.56 ± 0.078) g/100 g [77].

Bean dregs biscuits were made with bean dregs powder, fat, white sugar, and skimmed milk powder as single factors. Through orthogonal tests, sensory evaluation and hardness were the main evaluation indicators. The results showed that the hardness of the biscuit gradually decreased with the increased of the amount of bean dregs, and the hardness was the highest when the additional amount was 20%. The final formula was: flour 88%, bean dregs powder 12%, skim milk powder 20%, fat was 45%, white sugar 40%, egg liquid 35%, baking soda 0.6%, salt 0.6%, the biscuits were golden in color, it has crisp, sweet and milky aroma, it has a certain health effect on the human body [78]. Bean dregs and cassava flour are mixed to produce glute-free biscuits, and inulin is used instead of sugar. Studies have shown that with the increase of bean dregs, the hardness of biscuits increases, color L* value decreases, and the color becomes darker. Using sensory evaluation as the main index, and adding 30% of bean dregs. The quality of the produced biscuits is good. Research under a light microscope revealed no abnormalities in the cookies. The protein and fiber contented of the biscuits has been increased and is welcomed by customers [79]. The addition of the bean dregs, rice bran and broken rice in glute-free sweet biscuits is conducive to improving the stability of biscuits. The experimental sweet biscuits had characteristics of color, weight, volume and diameters (internal and external) very similar to the commercial, whereas texture, lipids and energy value decreased, and water activity, moisture and protein increased during storage. The sweet biscuits showed the same stability when compared to the standard. Thus, the bean dregs, rice bran and broken rice were considered viable alternatives for the development of new products [80]. Bean dregs flour have great potential for application in confectionery products. The formulation of the molded sweet biscuit in which 30 % of the wheat flour was substituted by bean dregs flour was considered adequate. The color, flavor and overall quality of the molded sweet biscuit did not differ significantly from those of the standard biscuits [19].

Researchers have studied the recipe of biscuits, the combination of bean dregs and other powders to make biscuits, it can effectively improve the taste of the product and attractive color. The amount of bean dregs added varies depending on the powder used to carry out the biscuits. For biscuits, the proportion of dietary fiber added to the bean dregs can be increased, because the biscuits have lower requirements for gluten content. However, the sensory evaluation of biscuits has a considerable subjectivity, and different scholars have different opinions on the amount of bean dregs added in biscuits. After the bean dregs were mixed with the flour, the hardness of the product was much increased, and the amount of the bean dregs added was only 10% or less. The combination of bean dregs and starch, bean dregs can be added up to 30%, and will produce a certain degree of brittleness, if it exceeds a certain amount, it may affect the edible taste of the biscuit. There were a wide variety of biscuits, but the above researchers have studied more in bean dregs biscuits, while the research on tough biscuits was relatively rare, especially making recipes for biscuits, most recipes contain more fats and sugars. Although the bean dregs biscuits increased the nutritional needs of human beings to a certain extent, but for special people, whether it can be eaten normally, such a problem deserves our continued discussion. For example, using a certain processing method to treat the bean dregs for the addition of baked goods, so as to develop a functional biscuit suitable for all people to eat, low sugar, low fat, it is a huge challenge currently facing. At the same time, we must control the production process or use some new and improved technologies. In this way, functional food with high quality and nutrition can be obtained. Despite the fact that there are more and more researches on bean dregs, but in the face of existing defects, food workers need to continue to explore, and still require a lot of research work.

2.3. Application of bean dregs in other food

Bean dregs are not only used in baked goods, but also in steamed bread, noodles, dumpling skins and beverages.

Addition bean dregs the water absorption, silty index, formation time and stability time of dough increased and prolong the shelf life of steamed bread [81]. Added to wheat flour at the bean dregs powder of 0, 5, 10, 15 and 20 g/100 g used to make Chinese steamed bread. The results of the present study suggested that increased amount of bean dregs powder led to a significant increase in hardness, gumminess, chewiness and adhesiveness in dough and Chinese steamed bread [24]. The ultrafine grinding technology was used to treated bean dregs, and mix flour to make traditional Chinese steamed bread. The quality of steamed bun was the best when the added amount of bean dregs was 13% [82]. Replacing part wheat flour with bean dregs powder to make noodle and steamed bread. Addition to 25% and 15% of bean dregs powder mix with flour to make noodles and steamed bread respectively. Researches show that the noodle and steamed bread had almost similar qualities to those made from 100% wheat flour [83]. Bean dregs may improve rheological properties of silty clay and stretch in certain scope. Addition 16% of bean dregs can improve the rheological characteristics of the flour, and bean dregs noodles reaching the optimum conditions [84]. In addition to, taking bean dregs as raw material, different fungal fermented was used to make bean dregs sauce [85] and white soy Sauce [86].

At present, the bean dregs have been widely used in food, and made a great contribution to the food industry. Domestic and foreign scholars on the research of the bean dregs has not only is still in the primary stage, many researchers use special technology to improve the quality of the bean dregs, applied to food to improve product quality.

3. Application of physical technology in baked goods and cereals

3.1. High pressure

High pressure technology refers to the sealing of food materials in an elastic container or pressur-resistant device system. The pressure conditions are generally (100–700 MPa), it often used water or other fluid medium as a medium to achieve sterilization, and change materials, the purpose of physical and chemical properties. High pressure as a good non-thermal processed technology, it can ensure the safety of food, reduce the process degree of food, and maintain the original flavor of food [87]. High pressure can modify or denature macromolecules (such as starch, protein, etc.) by destroying secondary bonds in macromolecular substances, and small molecules composed of covalent bonds of vitamins, minerals, aroma components and pigments of substance has no significant effect. High pressure technology is commonly used in food processing, and the most mature application is fruit and vegetable processing. For example, used in high pressure technology for the production, sterilization and preservation of fruit and vegetables, jams and juices. High pressure technology also applies to the processing of meat products and aquatic products. For instance, pressure processing shellfish food can not only increase the safety and shelf life of raw meat, but also maintain the fresh taste of shellfish. At the same time, the removal of shellfish after high pressure treatment is more convenient. However, high pressure is increasingly used in the processing of food products, such as cereal crops, potato crops and legume crops. At present, the application of high pressure technology in the processing of food products is mainly the modification of starch and protein, such as changing the viscosity and transparency of food, and also relates to the physical and chemical properties relates to food flavor and nutritional value.

As early as 1990, Japan used high pressure treatment products for the first time. Ten years ago in Europe, high pressure processing food were already in the stage of research or trial production, and the label of “new food” was spread throughout Europe [88]. High pressure processing has become a technology with potential use for these purposes. Its main advantages are short processing time, uniform effect, good instantaneity [89]. The comparison with other technologies, such as heat treatment and pasteurization, these techniques fail to maintain the original color, taste and nutrition of the raw materials. While high pressure processing maintains the sensory attributes and nutritional value of the product [90–92]. High pressure processing has become a commercially viable food manufacturing tool. In food processing and preservation applications, the importance of *in-situ* engineering and thermodynamic properties of food and packaging materials in process design was emphasized [93]. In recent years, high pressure has become a new tool for improving gluten-free food, which has changed the properties of food, such as protein and starch [94].

Using high pressure technology to process sugar cookies, research shows that high pressure technology reduces the number of mesophilic bacteria, yeast, and mold microorganisms in the product. After high pressure treatment, the shelf life of biscuit dough is expanded, with a higher density. In the baking process, the maturation time of the biscuit is shortened, compared with untreated dough. Dough processed under high pressure technology corresponds to the biscuit produced, with a darker color, and the dough surface is smooth and uniform. There are even cracks on the surface of the biscuit, but it will not significantly influence the quality characteristics of the biscuit [95]. The cake batter is treated with high pressure technology. When the high pressure condition is 300–600 MPa, the duration is 3–6 min. Cake paste was measured for microbial flora, density, microstructure and rheology, and the cake was analyzed for specific volume, weight loss, color and

texture. The results showed that compared with the untreated ones, the number of molds and yeast decreased with increasing pressure. The density of the batter increases, the cake volume decreases, the surface color deepens, and the hardness increases [96]. Corn starch and rice flour are respectively subjected to high pressure treatment for bread production. Set the high pressure condition to 600 MPa, 40 °C, 5min. The results demonstrate that high pressure treatment can effectively slow down the aging speed of bread, extend the shelf life, and improve bread quality. Therefore, corn starch and rice flour under pressure treatment can increase the shelf life and quality of glute-free bread [97]. Sorghum flour is treated under high pressure for the production and processing of bread. When the pressure conditions at 200–600 MPa, 20 °C, and observe the rheological properties of the batter. When the pressure at 300 MPa, the batter structure weakens. When the pressure is higher than 300 MPa, the batter consistency increases. At 600 MPa, processing 2% sorghum flour can delay the aging of bread. Adding 10% sorghum flour, the exact volume of the bread is small, and the product quality is poor. Therefore, under appropriate pressure conditions, the amount of sorghum flour should be controlled [98].

High pressure technology has made a great contribution to grain products, changing the performance of grain and improving product quality. Cereals undergo high pressure treatment, which can effectively reduce the amount of microorganisms in food and extend the shelf life of food. After the batter is treated with high pressure, it can effectively improve the rheological properties, the structure of the batter is enhanced, and the color of the product can be increased. But as the pressure increases, the hardness of the dough will gradually increase. On the basis of improving the product, the quality of the product is not covered, so the pressure conditions corresponding to different products are different. Studies have revealed that the high hydrostatic pressure treatment in the heat rheology of batter, with the increased of pressure level, induced gelation of starch content. High pressure treatment at 450 MPa and 600 MPa, 25 °C for 15 min, the concentration of gouache paste was (1:5), gelation was completed, the higher concentration of slurry requires higher pressure, temperature or longer holding time [99]. High pressure treatment significantly increases dough hardness and adhesion and reduces stickiness. When making bread, use a scanning electron microscope to observe the cut surface of the bread. Under pressure at 0–200MPa, as the pressure increases, the pores become larger and larger, the protein is affected when the pressure level is higher than 50MPa, and the starch modification requires a higher pressure level. High pressure treatment has little change in the color of the dough, but during the baking process, the color of the breadcrumbs changes dramatically. Studies have shown that high hydrostatic pressure treatment can obtain grain products of the new type in the range of 50–200MPa [100]. Wheat starch slurry (10% w/v) was subjected to high hydrostatic pressure treatment at 300, 400, 500, 600 MPa, 20 °C for 30 minutes. The gelation temperature was lowered, the surface and internal structure particles of the starch were destroyed, and waxy wheat starch was effectively modified [101]. High pressure can change the secondary structure of SPI, 7S, 11S proteins in nanoemulsion. Enhance their stability, and can be used as an effective emulsifier [102]. The gelatinization characteristics of pea starch under high pressure were investigated. At 0–600 MPa, the initial viscosity increased from 8Cp to 34Cp. High pressure treatment can promote "cold gelation" of pea starch aqueous dispersion, and strengthen gelatinization of starch particles. In addition, the shape, size, and particle size distribution of starch particles is changed [103]. Antioxidant activity of buckwheat treated with high pressure was improved. It can also effectively inhibit the formation of fat. After comparison, this study shows that high pressure treatment at room temperature has better nutritional value than no-high pressure treatment [104]. Effects of high pressure and thermal processing on photochemical, color and microbiological quality of herba-plant infusion.

When the high pressure treatment conditions are at 400 or 500 MPa and 25 °C for 15 or 30 minutes, the natural color of the product can be better retained. The comparison with pasteurization (90 °C, 1–3min). These two treatments can effectively eliminate yeast and *E. coli* [105]. High pressure technology was used to process potato starch, and it for cycles of 6, at 400 MPa, showing higher peak viscosity and attenuation value. For cycles of 3, the peak time and final viscosity was higher than those of the natural control sample. This shows that the treatment under high pressure has a significant effect on the sample. This study can be used to prepare food for slow digestion and hypoglycemia [106]. High pressure treatment can enhance the mixing properties of lo-grade wheat flour in food applications.

When the high pressure conditions are at 500 and 600 MPa, the flour moisture is controlled at 56%, and the starch particles are combined with protein aggregation, which causes the protein network in the dough to break. When the moisture content is 33%, the structure of the dough is promoted, the formation of a protein network and the strength of the dough are increased. At 500 or 600 MPa for 5 minutes, the protein structure is modified and the starch granules remain intact [107]. Taro, carrot and sweet potato are processed under high pressure at 600MPa for 5–30min. The results showed that high pressure treatment caused certain physical damage to the three vegetable structures. It can result in cell wall of vegetables to rupture, increase the drying speed, and shorten the processing time. Reduce gelatinization temperature for sweet potato starch. Increased softening and pre-gelatinization of carrot and sweet potato starch, making it more convenient for consumers to process [108]. The high pressure was used to modify the sweet potato residue, and the microstructure of the insoluble dietary fiber of the sweet potato residue was observed as a loose, smooth, honeycom-shaped porous network structure. The modified insoluble dietary fiber of sweet potato residues has a significant effect on the ability to regulate blood sugar, blood lipids, and eliminate foreign harmful substances. When the modified conditions are at 600 MPa, 15 minutes, and 60 °C, it is helpful to adjust the ability of blood glucose and blood lipid; The modified conditions can remove external harmful substances at 100 MPa, 10 min, and 42 °C. And this method should also be used to study the modification of cereals such as bean dregs [109]. After the soybean in the grain is subjected to high pressure treatment, it can prevent the migration of water in the soybean, make the moisture distribution in the soybean uniform, and shorten the soaking time for the production of soybean products. Scanning electron microscopy analysis showed that the microstructure of soybeans could be changed after high pressure treatment, and it could help soybeans absorb water. Found by DSC and SD-PAGE, some proteins of soybean were denatured during high pressure treatment [110].

Most of the above researchers were enriched in the studied of cereal starch, which has a modification effect on starch slurry, and can destroy the surface and internal structure particles of starch. The high pressure on the dough can increase the hardness and reduce the presence of microorganisms. The treatment of buckwheat can increase the antioxidant activity. High pressure treated grain pressure is controlled at 400–600 MPa for 10–15 min. Treated starch by high pressure can be used to make hypoglycemic food, high pressure treatment can destroy the structure of the product, loosen the surface of the raw material, and form a porous structure, thereby shortening the pretreatment time. However, for high pressure processing of cereals, there is no specific research areas have been provided. And it currently enriches in basic research. Therefore, the grain after high pressure treatment needs further excavation in food, which provides more new ideas for applied research.

3.2. Ultrafine grinding

Ultrafine grinding is a mechanical or hydrodynamic method that overcomes the internal cohesive force of the solid to break it, thereby pulverizing the material particles of 3 mm or more to 10–25 μm . In the process of ultrafine pulverization, the bean dregs are modified by friction, extrusion, collision and other forces [111]. Based on the principle of micron technology, ultrafine grinding can make the product fine in size, larger in specific surface area and specific surface activity; the ultrafine grinding product has excellent physical and chemical properties, and the utilization rate is improved [112]. Ultrafine grinding can significantly change the structure, and specific surface area of raw materials. it compared with traditional mechanical processed methods, ultrafine powders can improve the physicochemical properties of raw materials, for example, it has better hydration properties and fluidity, stronger free radical scavenging activity, flavor and mouthfeel. This new technology of superfine grinding has been proven, and used to prepare ultrafine powders with good properties [1]. At present, most countries use ultrafine grinding technology to treat pollen, tea, wheat bran, rice bran, peel, rice, soybean, beet pulp, animal bone, seaweed, edible fungi and other raw materials to preserve nutrients and improve taste [113]. At the same time, this technology has contributed greatly to the development of baked goods and other products

Used the three different grain sizes of ordinary bean dregs, hig-grade ultr-micro bean dregs powder and lo-grade ultr-micro bean dregs powder and prepare mooncakes with flour, the sensory evaluation, color and texture were used as the evaluation criteria, the results showed that the ultrafine powdered bean dregs were better than the moon cake made of ordinary bean dregs powder and formed well, the texture showed a trend of rise and then decreased. When the bean dregs powder was added to 20%, it reached the maximum value 13561.81g, as the amount of additional increased, the finished product darkens and was not easily formed. When the hig-speed ultrafine grinding bean dregs was added at 16%, the finished moon cake was the best, but if it was necessary to further increased the replacement amount of ultr-micr-bean residue. It can be considered from the point of view of bean dregs dislocation and edible rubber assisted molding. Thus preparing a wide moon cake of high dietary fiber [114]. Ultrafine grinding technology processes wheat flour and corn flour for bread production. At 9,000, 10,000, and 11,000 rpm, as the speed increases, the water retention capacity, swelling, water solubility, and gelatinization of cereal flour are improved. The quality of the product is enhanced, the volume of bread produced is increased, and the hardness is reduced [115]. The finer wheat bran granules help develop cereal bread with nutritional value. Studies have found that the amount of bi-contactable phenolic acids in whole wheat bread and brown bread is higher than white bread, and the finer bran particles in bran bread, the higher the bioacceptability of phenolic acid [116]. Both the mixing characteristics of the dough and the quality of the bread product are affected by the thickness of the bran. When the bran particle size is small, the brain cells cause rupture, which reduces the quality of the bread [117]. Micronisation has the potential to increase antioxidant activity and soluble fiber of proso bran. it can be used for enrichment of gluten-free bread with fiber and phenolics [118]. The use of ultrafine grinding technology in the production of more baked goods in the grain, it can increase the aging rate of the product, and reduce the hardness of the product, it's suitable for special populations.

The application range of ultrafine pulverization was relatively wide. The use of ultrafine pulverization in tea leaves enables the tea to dissolve into the water more quickly, and the scent was more prominent and effective to save the immersion time. For example, instant tea sold on the markets. The use of ultrafine grind of Chinese medicinal materials not only enables greater medicinal properties, but also reduces the loss of scraps

and facilitates taking them. It can also introduce traditional Chinese medicine into everyday diets and develop a variety of health care products. This technology can be used on micron and submicron scales, and used in cereals such as whole wheat flour modification and related technologies [119].

Crushing whole grains with ultrafine grinding technology can improve the water absorption and stability of the flour. The exact volume area of the steamed bread was increased, and the steamed bread color was improved. The bran is ground and recombined with red wheat, and the steamed bread has a high sensory score. Therefore, ultrafine pulverization can improve the characteristics of power and improve the quality of products [120]. After the whole grain flour and starch are subjected to ultrafine grinding, reduction in starch crystallinity was resulted. Along with these structural changes, decreased viscosities and higher pasting stability [121]. Ultrafine grinding technology for preparing wheat bran dietary fiber. The results show that ultrafine pulverization can effectively pulverize fiber particles to the submicron level. As the particle size decreases, the hydration characteristics of wheat bran dietary fiber are significantly reduced, insoluble dietary fiber is converted to soluble dietary fiber, the antioxidant activity is improved, but the DPPH free radical scavenging activity is reduced [122]. Wheat bran has three kinds of ultra-fine crushing treatments with different particle sizes, and is applied to the production of steamed bread. Among them, the bran with the smallest particle diameter causes the strength of the dough to decrease, and the CO₂ produced is reduced. The exact volume area of the steamed bread becomes smaller and the hardness increases, which adversely affects the quality of the steamed bread. It can be seen that ultrafine grinding particles help improve the quality of steamed bread in a certain range, but it is not as fine as possible [123]. Ultrafine powder treats bean dregs and applies to noodles. The study concluded that compared with ordinary bean dregs, the bean dregs had a smaller particle size and increased soluble dietary fiber content. Adding bean dregs can make the dough form a stable structure, and the noodles are hard to break. Adding 7.5% ultrafine bean dregs powder reduces the cooking loss rate, almost no bean smell, and a high sensory score. Therefore, the ultrafine grinding bean dregs can significantly increase the nutritional value of the product when coupled with the noodles [124].

The above research scholars have shown that ultrafine grinding can reduce the particle size of raw materials, and improved the solubility and antioxidant activity. Superfine grinding has a wide range of applications, such as chocolate, which can increase the taste, smooth effect, and used in shells, it is a great source of calcium. Applied in the production of healthy food, if the particles are slightly larger, it will affect the taste and will not function as a health care. This requires ultrafine grinding technology, which is pulverized to a sufficiently fine particle size, and an effective mixed operation is provided to ensure uniform distribution of the food, and to facilitate absorption by the human body. Therefore, ultrafine grinding has become one of the important technologies for modern food processed, especially for health food processing. The used of this technology is currently seen in Chinese research scholars. So this technology should be respected.

3.3. Microwave

Microwave heating is now attracted much attention as an alternative heating source. Microwaves enable rapid and uniform heating of polar substances by direct and internal heating generated by friction of dipole rotations [125]. Microwave baking are easy and fast. However, for products that need to be baked for a long time, the microwave technology cannot be faced with the traditional technology. The main factor is the protein and starch in

the flour, so the formula has to be adjusted and the lo-gluten flour with protein content of 8.7% needs to be selected. The bread baked by microwave is softer and has a better shell and texture [126]. When making the bread without gluten, the addition of whey protein concentrate increases the volume and moisture content of the bread. After microwave baking, the hardness of the bread increases, the glycemic index decreases and the shelf life is prolonged, which is good for people who suffer from obesity, diabetes and celiac disease [127]. The presence of endogenous α -glucanases in rice flour, can cause a substantial reduction in α -glucan molecular weight, affecting detrimentally their efficacy for bioactivity. Heat-treated with microwave power (900 W) applied in cycles of 20s intervals combined with downtimes of 1 min, it was applied to the rice flours before breadmaking at flour water contents (25%) and treatment time (4 min) to reduce α -glucanase activity. Bread volume is better than untreated. Microwaving rice flour helps improve gluten-free bread, as well as of any α -gluca-containing yeas-leavened bakery product without altering its sensorial attributes [128].

3.4 Other physical techniques

Two-screw extrusion process to produce bean dreg-maize snack foods, it showed that the products extruded at the optimized condition had the best appearance, taste, texture and overall acceptability [129]. Electrohydrodynamic (EHD) technique improves the drying speed of bean dregs. The bean dregs cake after drying kept a whole shape and there was no cranny in the surface, the color of the sample became distinctly browner than that of the untreated [130]. Ultrasonic parameters had predictive capacity for breadmaking performance for a wide range of dough formulations. Lower frequency attenuation coefficients correlated well with conventional quality indices of both the dough and the bread [131]. Bran hydration, autoclaving and freezing treatments and their combinations are promising approaches to reduce the dehydration of whole grain wheat flour dough and to improve wholegrain wheat flour bread loaf volume [132]. There is no doubt that these technology has made a great contribution to food and agricultural b-products, provides important help for the production of baked goods.

4. Improve quality of bean dregs by physical technology

4.1. Improve soluble dietary fiber of bean dregs

Soluble dietary fiber of bean dregs is a carbohydrate-based polymer with significant health benefits that is enriched in whole grains, nuts, fruits, and vegetables. In recent years, in order to increase the soluble dietary fiber fraction of fiber-rich plant food bean dregs, different approaches were investigated. At present, there are research reports on the quality improvement of bean dregs, the commonly used treatment techniques are chemical [133]. The chemical process is complex and the degree of hydrolysis is difficult. Biological [134, 135], the biological process is complex, the period is long and the condition is difficult to control. Physical approach is safer than the other two approaches, the biggest advantages come from short processing time, simple process, no solvent residue and low cost. In addition, there are many ways to combine technologies [136]. However, the combined technology has not been applied to bean dregs. Research shows that ionic liquid method, different ionic liquid treatments can significantly increase the content of soluble dietary fiber (SDF) in the bean dregs, wherein 1-ethyl-3-methylimidazolium acetate > ionic liquid of

acetate > chloride ion ionic liquid, bean dreg crystal structure damaged, water holding capacity and oil holding capacity were significantly increased [137]. Soluble dietary fiber is extracted by an enzymatic method, so as to optimize the optimal process conditions of enzymatic method. Studies have found that when enzyme activity is weak. The effect of the extracted soluble dietary fiber is better than the enzyme with higher activity. However, the temperature is sometimes difficult to grasp, and if the temperature is too high, denaturation is likely to occur, which affects the reaction rate [138].

Physical processing of bean dregs is commonly used. It refers to change the chemical composition and physical structure of bean dregs dietary fiber through physical and mechanical effects such as high temperature, high pressure and high shear force, thereby improving the physical and chemical characteristics and functional quality of bean dregs. Common physical methods, such as Blast Extrusion Processing (BEP), are a new type of food processing technology. Numerous researchers have used it to improve the functional properties of cereals such as oats, gluten-free flour cereals [30, 139]. This study investigated the effect of blasting extrusion processing (BEP) on the increase in soybean residue SDF content under optimal conditions (170 °C and an extrusion screw speed of 150 r/min). Compared with the control, the content of soluble dietary fiber from soybean residues treated by BEP (BEP SDF) was increased from $2.6 \pm 0.3\%$ to $30.1 \pm 0.6\%$. In addition, BEP SDF showed improved water solubility, water retention capacity and swelling capacity [26]. Two-screw extrusion was applied for soluble dietary fiber extraction from soybean residue. The soluble dietary fiber content of bean dregs reached 12.65%, which was 10.60% higher than that of unextruded and boiled bean dregs [140]. A novel *i-situ* enhanced extrusion with the aim to improve the solubility of dietary fiber in bean dregs was developed. The SDF fraction of the extrude (21.35 g/100 g) was higher than that of untreated OKP (2.30 g/100 g). The novel extrusion improved the water and oil holding as well as swelling capacities of OKP when compared to untreated and reference extrudes [141]. In addition, steam blasting technology is widely used. It puts fibrous raw materials in high pressure steam for a certain period of time. When high pressure is released instantly, the superheated steam in the raw material gap quickly vaporizes and the volume expands rapidly [142]. Use steam is blasting to treat bean dregs to make tough cookies. The results demonstrate that steam explosion has a greater impact on the composition and content of dietary fiber in bean dregs. At 1.5 MPa/30 s, the maximum soluble dietary fiber reached 36.28%. After steam blasting, the amount of bean dregs added is 10%, and the quality of biscuits is significantly improved. Therefore, the appropriate strength of steam explosion treatment can greatly improve the soluble dietary fiber in bean dregs and improve the quality of bean dregs in tough cookies [143].

Extrusion technology is used to process bean dregs to prepare soluble dietary fiber. When the liquid-solid ratio is 26: 1, at 89°C, for 68min, and alkali concentration is 1.12%. The soluble dietary fiber in extruded bean dregs were 34.12%, which was significantly higher than that of untreated (13.51%) [144]. Under the condition of microwave treatment at 200°C for 7min, the dissolution rate of soluble polysaccharide from bean dregs increased by 70%. There is also wet grinding, bean dregs insoluble dietary fiber (IDF) was downsized to nanometer range by wet milling, which is applied as functional ingredient in foods [145]. Under the condition of microwave treatment at microwave treatment, the dissolution rate of soluble polysaccharide increased 70% from bean dregs [146]. Enzymatically prepared bean dregs dietary fiber is processed by IHP, and treated at 40, 90 and 120 MPa, respectively. The water holding capacity, expansion ratio and combined hydraulic strength was increased. The viscosity of the prepared dietary fiber solution was measured the pressure increases and rises in used rheometer. Microscopic observation of light transmittance, loose tissue, finer

fibers, improved the quality of the bean dregs dietary fiber, and there was no deterioration during refrigeration for one month. IHP can improve the quality of the bean dregs fiber, but the cost of enzymatic preparation is higher [147]. The lo-yield nuclear magnetic technology was used to study the moisture distribution of bean dregs under high pressure. Under high pressure conditions at 400MPa for 15min, the bean dregs were processed. The binding degree of bound water, flowing water and free water in bean dregs all changed significantly. High pressure treatment reduces the moisture content of bean dregs. After the high pressure treatment, most of the internal structure of the bean dregs was destroyed, wrinkles appeared on the surface, the structure shrank, and many holes were on the surface. It can reduce energy consumption for the processing of bean dregs food [148].

In recent years, great progress has been made in the research of high pressure and ultrafine grinding technology it has become a research focus in the field of enhancing the quality of bean dregs. Ultrafine grinding can effectively pulverize fiber particles to the submicron level. Insoluble dietary fiber was converted to soluble dietary fiber, and the antioxidant activity was improved [149]. Ultrafine grinding sets of different pulverization frequencies and time to process the bean dregs. Based on the physical and chemical characteristics of bean dregs, the crushing optimal parameters were obtained at a frequency of 80 Hz, and once processed. The water solubility, swelling, viscosity, and cation exchange capacity of bean dregs is significantly improved. The water and oil holding capacity of bean dregs has decreased to some extent [150]. High pressure has a significant impact on the soluble dietary fiber and functional properties of bean dregs. At 400 MPa and 60 °C under high pressure, the content of soluble dietary fiber increased 8 times when treated with bean dregs, compared with untreated. Swell ability and water holding (oil) properties are improved [29]. After high hydrostatic pressure treatment at 600 MPa for 30 min, the solubility of bean dregs dietary fiber is improved, which makes it more suitable for functional food processing [151]. High pressure homogenization strength is related to the solubility of bean dregs. Under high strength pressure, the structure of bean dregs particles are destroyed, and the fiber and protein of bean dregs are released [152]. Using lactic acid bacteria fermentation method and dynamic high pressure to treat bean dregs, the content of soluble dietary fiber in bean dregs was correspondingly increased, being (9.7, 14) g/100g. Insoluble dietary fiber content decreased from 11.6g/100g to (7.8, 4.5) g/100g, respectively. It can be observed that soluble dietary fiber and insoluble dietary fiber can be converted into each other under different processing conditions. There were no significant differences in dietary fiber content when bean dregs were treated under dynamic high pressure. Microstructure discovery dynamic high pressure can break down the cellulose structure and make the surface rough. The lactic acid bacteria fermentation method results in modification of the fiber structure and reduction of crystallinity [153].

It can be observed that these physical methods have significantly increased the content of soluble dietary fiber in bean dregs. The biggest advantages come from short processing time, simple process, no solvent residue, and low cost. It is possible to damage the structure of the soybean b-products during physical processing. For example, extrusion technology changes the structure of fiber molecules through intense pressure, friction and shear force, thus exposing the molecules to more soluble groups, thus increasing the content of soluble dietary fiber. Microwave has a strong penetration ability, the electromagnetic wave act on the material, resulting in the increase of the material cell pressure and expansion and rupture, the soluble dietary fiber content of bean dregs is increased. However, excessive treatment affects the content of soluble dietary fiber should pay attention to the control of treatment conditions. Typically, a combined method may have greater effects than any single approach. However, the combination of multiple technologies is rarely applied to bean dregs, especially

the combination of multiple physical technologies. Although different processing techniques improved the quality of the bean dregs to a certain extent and increased the content of soluble dietary fiber in the bean dregs. However, the ant-nutritional factors in bean dregs are the key factors affecting the quality of the bean dregs. An interesting finding is that some physical techniques can eliminate trypsin inhibitors under certain conditions.

4.2. Removal of Removal of ant-nutritional factors

Ant-nutritional factors (ANF) are substances that adversely affect the digestion, absorption, and utilization of nutrients, as well as adverse reactions that cause humans and animals. Soy was full of nutrients, but there are also a variety of ant-nutritional factors affecting the use. Ant-nutritional factor in soybean is a limiting factor, which not only hinders the body's absorption of nutrients, but also limits the comprehensive development and utilization of beans. Therefore, effectively controlling or eliminating ant-nutritional factors is one of the important ways to increase the utilization of soybeans [154]. Few types of ant-nutritional factors found in legumes that usually inhibit the bioavailability of many nutrients, such as hydrocyanic acid, trypsin inhibitors activity, phytic acids, hemagglutinins etc. However, the bean dregs contain three ant-nutritional factors: trypsin inhibitor, lectin and goitrogen, the most important is the trypsin inhibitor. These ant-nutritional factors limit the nutritional properties and affect the digestibility of certain nutrients [155]. When the researchers used bean dregs to make cookies, ant-nutritional components rise by the bean dregs ratio increase in cookies composition. The removal or degrade of the ant-nutritional factors in the bean dregs is of profound significance for improving functional food of bean dregs. Hence, further research has to initiate to decrease the ant-nutritional factors in bean dregs [156]. However, trypsin inhibitor, soybean lectin, glycinin and -conglycinin are the most important ant-nutritional factors in soybean. The bean dregs mainly contain three ant-nutritional factors: trypsin inhibitor, goitrogen and prothrombin.

4.2.1. Trypsin inhibitor. Trypsin inhibitor is a protein and about 7–10 species are found in soybeans. Among them, Kunitz trypsin inhibitor and Bowman-Birk trypsin inhibitor are the two most representative and important inhibitors. Soybean trypsin inhibitory factor (STI) is one of the main ant-nutritional factors in soybean. The content is about 2%. The ant-nutritional effects of trypsin inhibitors are mainly as follows: reducing protein digestion, inhibiting animal growth, and causing pancreatic enlargement [157]. The removal of ant-nutritional factors is mainly through physical, chemical and biological methods. In recent years, many scholars have focused on researching new and efficient methods of inactivation, such as chemical methods and high temperature transient methods, gene breeding methods, it has been able to reduce the content of trypsin inhibitors in soybeans and has been extensively studied.

After fermentation of *Bacillus natto*, the nutritional composition of bean dregs changed. The wet bean dregs were adjusted to moisture, sterilized, and then cooled to different concentrations of *Bacillus natto*, the fermentation was carried out at 37 °C for 22 h and then cooked at 4 °C for 22 h, the taste was obviously improved. Trypsin inhibitor activity and phytic acid content was significantly decreased ($P < 0.05$) [158]. With bean dregs as the main raw material, used single screw extrudes in the content of bean dregs (0%, 15%, 30%, 45%), material moisture (40%), extrusion temperature (two zones: 140°C~150°C, three Area: 170°C~180°C) extrusion preparation of tissue protein. The results showed that the content of phytic acid and soluble dietary fiber increased, the activity of total phenol, total flavonoids and trypsin inhibitor decreased, the in vitro digestibility increased, and the correlation

coefficient between various nutrient factors decreased after extrusion [159]. The trypsin factor in soybean milk was treated at a high temperature of 93 °C for 60–70 min, and the inactivation rates reached 90%. It takes 5–10 min at 121 °C, but excessive temperature and time make maillard reaction between basic amino acids such as lysine and reducing sugar, reduce the content of free amino acids, protein digestibility and nutritional value of protein [160]. In addition to, high pressure treatment can inactivate trypsin inhibitor and lipoxygenase in soybean or soy milk, and a higher pressure at 800 MPa was required for the treatment of lipoxygenase, or the combined temperature is 60 °C at 600 MPa. During the germination process of broad beans, use of 0.171M saline can reduce the activity of trypsin inhibitors [161].

Heat process is widely used for food preparation, which is one of an effective method used to inactive heat liable ant-nutritional factors. The heating was efficient trypsin inhibitors and lectin inactivation, being 15 min at 121 °C sufficient to reduce more than 90% of these compounds [162]. The trypsin inhibitor was completely inactivated after soaking soybeans in 24.3% humidity for 1 hour, and after being treated with microwave frequency at 2450 MHz for 4 minutes, which was shorter than the heating period (6 min) needed for unsoaked soybeans [163]. Microwave treatment is an effective way for inactivation of protease inhibitor activity in cracked soybeans, roasting for only two minutes reduced the trypsin inhibitor activity to 13.33% of the initial [164]. The microwave cooking reduced ant-nutritional factors in bean thus improved the protein digestibility, while the cooking method is not studied extensively yet [165]. Roasting treatment, the processing under 230 °C for 25 min presented more decrease in trypsin inhibitor from soybeans [166]. Autoclaving cause significant reduce in trypsin inhibitor of chickpea [167]. Extrusion process was the best method to abolish trypsin inhibitors (99.54%), phytic acid (99.30%) and tannin (98.83%) [168]. Ultrasound treatment at 20 kHz about 20 min inactivates trypsin inhibitor by 55% [169]. High pressure processing (HPP) is another emerging novel processing technique followed in the food industry and evaluated as an alternative for the inactivation of Trypsin inhibitors. The researchers suggest that temperatures at 77–90 °C and pressures at 750–525 MPa less than 2 min, about 90% trypsin inhibitors inactivation [170]. At 600 MPa for 60 min at 60 °C, 100% inactivation of trypsin inhibitors [171].

4.2.2. Lectin. The physiological activity of lectin has two side. Most lectins are resistant to digestion in human proteases, and even have adverse effects, such as stimulating the intestinal wall and impeding the digestion and absorption of nutrients. Therefore, lectins were deemed to be ant-nutrient substance. How to eliminate ant-nutrition is a matter of concern in the food processed field. Thrombin is a common ant-nutritional factor in bean dregs. It can hinder the absorption of animals.

In soybean, lectin is attended by a concentration of 10–20g/kg, which can stimulate the intestine Wall, hinder digestion, absorb nutrients and affect the metabolism of small intestinal mucosal cells, and affect the bacterial ecology in the intestine [172]. It is a glycogen protein. Defat soybean meal contains about 3% of prothrombin and is under a molecular weight of 120,000. It comprises of 4 identical subunits, each with a molecular weight of 30,000, each molecule [173]. The presence of toxic phytic acid, hemagglutinin, trypsin inhibitors and hydrocyanic acid in beans, it affects the use of food in the human body [155].

Ant-nutritional factors in velvet beans processed by ultraviolet radiation. Studies have shown that UV treated seed has lower levels of phytic acid, hydrogen cyanide and total oxalate compared to seeds soaked overnight. Ultraviolet radiation (60–90 min) completely eliminated the trypsin inhibitor activity in the seed. Both treatments completely eliminated plant hemagglutination activity [174]. Soybean hemagglutinin is not heat-resistant, and can

be inactivated quickly under hot and humid conditions. Even the activity completely disappears. Studies have shown that when purified prothrombin was dissolved in 25% sodium citrate solution. It can inhibit thrombin formation [175]. In the conventional processing, the heating method was generally adopted to remove the ant-nutrition of the lectin in the legume food, and the physiological activity of the lectin was also completely lost.

4.2.3 Goitrogen. The thyroid hormone is extremely small in soybean, and its precursor substance is glucosinolate, which was enzymatically hydrolyzed by glucosinase, and the resulting ligand further generates cyanogen, thiocyanate and isosulfur, Wherein the isothiocyanate is automatically cyclized to an oxazolidinethione under neutral conditions, and the latter three substances mainly affect the morphology and function of thyroid gland, which is the main substance leading to goiter. The pathogenic mechanism of goitre is that it preferentially binds to iodine in the blood, resulting in an insufficient source of iodine for thyroxine synthesis, leading to compensatory hyperplasia of the thyroid gland.

Soy can inactivate glucosinolates by dry heat to prevent it from producing goiter. At (90 °C, 15 min) or (100 °C, 10 min) or (110 °C, 5 min), the residual rate of enzymatically degradable glucosinolates was above 98%, but in the case of tissue breakage and the presence of aqueous media (such as germination, wet heat treatment, etc.), it was recommended that the first step of dry heat kills glucosinolates [176]. Dry heat treatment has an obvious effect on the removal of soybean goiter, and warm heat treatment has obvious effects on prothrombin and protease inhibitor. Soybean germination combined with heating treatment can remove somatostatin and protease inhibitors. Used 90 °C dry heat treatments, 15min or more, and then used 125 °C wet heat treatments for more than 10min, the ant-nutritional factor removal rate reaches 95% [177]. Dry heat treatment has a significant effect on the removal of thyroxine from soybeans, while wet heat treatment has a beneficial effect on soybean prothrombin and protease inhibitors. Dry heat treatment at 90 °C for more than 15 minutes, then the best heat treatment at 125 °C for 10 minutes, the removal rate was as high as 95%, it's convenient and energy-saving [178]. The dry heat treatment conditions were 90°C for 15min, 100°C for 10min, 110°C for 5min. Inactivate glucosinase in soybean so that it cannot enzymatic digest glucosinolates. Therefore, no goiter is produced and the residual glucosinolates can reach 98% [179].

The above researchers, whether using chemical or physical methods, can effectively remove ant-nutritional factors in beans. However, the chemical method is under a large residual amount and low safety. The sensible method commonly used is heating treatment, such as dry heat treatment or wet heat treatment, which can eliminate different ant-nutritional factors. This method is low in cost, good in effect, simply in the process, and widely used, but it takes a lot of time. The trypsin inhibitor can be inactivated under the effect of atmospheric pressure steam. If the temperature is lower than 100 °C for 30min, the trypsin inhibitor activity in soybean can be reduced by about 90%. In the case of high-pressure treatment, the heating time depends on temperature, pressure, and material properties. At present, pressure baking is often used in the industry. When the temperature is between 130 °C and 133 °C, 2500kPa, soy lectin and trypsin inhibitor can be inactivated, but the disadvantage is that the cost is high and the color of the product cannot be effectively controlled. The soaking method can remove ant-nutritional factors, but it takes time and is not suitable for large-scale production processes. The extrusion puffing method inactivates the ant-nutritional factors of soybeans, ruptures the cell wall of the raw material, and increases the digestibility of nutrients, but damages the raw material itself. Microwave treatment can penetrate into the inside of the untreated material, causing the inactivation of ant-nutritional

factors. Mechanical processing includes crushing, dehulling, etc. Many ant-nutritional factors mainly exist in the epidermal layer of crop seed. Separation through mechanical processing can reduce ant-nutritional factors. But this method is only suitable for the treatment of seed.

Conclusions

Bean dregs has high nutritional value, but it has a rough taste and has low soluble dietary fiber. Therefore, in the production of bean dregs products, special consideration should be paid to the nutrition, taste and appearance of the products, especially in baked goods. In addition, some ant-nutritional factors in bean dregs, it affects human health. At present, the most commonly used removal methods are dry heat treatment and wet heat treatment, so it is necessary to explore new processing methods, eliminate the ant-nutritional factors in the bean dregs, improve the quality of the bean dregs, and increase the added value of the products.

Relevant research shows that high pressure technology can effectively reduce microorganisms in products and extend the shelf life. The new technology of ultrafine grinding has been proven to improve the roughness of the cereals, make the power fine and improve the flavor of the product. Microwave technology is convenient and fast, which has replaced the traditional heating method. However, this method is not fully adapted to the traditional process formula, so more research is needed in the development of the product.

The combination of various technologies has become a new hot spot in recent years, which is more effective than a single technology. High pressure, ultrafine grinding and other physical technology have enormous advantages. At present, there is no research report by domestic and foreign scholars. Therefore, the combination of these two technologies is called upon to become a new type of processing technology. It can contribute to the development of high dietary fiber functional biscuits and promote the progress of baked goods. For this aspect of research, we still need a lot of research work.

Conflict of interest statement. The authors report no conflict of interest.

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