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Processing technology of tea bakery foods – a Review

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Abstract: Tea foods, especially tea bakery foods, play an important role in bridging the gap between supply and demand of tea industry. This paper reviews the processing technology of tea bakery foods which include tea breads, tea cakes, and tea biscuits during the past thirty years. It also points to the fact that there are no uniform quality evaluation methods for tea bakery foods. Effect of the chemical composition of tea on the quality of bakery food is discussed. According to differences in texture, chemical composition, and biological activity of functional components, different ingredients and their ratios should be adjusted to obtain high-quality tea bakery foods. To effectively preserve the special tea flavour, biological activities of tea components should be retained as much as possible. Tea baked foods were mainly evaluated through senses. There were many differences in the sensory evaluation indices, evaluation criteria, and the scores by different experts. Further, this paper provides a critical outlook of the developments needed in processing technology and quality improvement of tea bakery foods.

Keywords: tea; bakery food; processing technology; quality; sensory evaluation

Tea bakery products are made using tea extract, protein, sugar, flour, oil, eggs, milk, salt, yeast, baking powder, fruits, and hydrocolloids. These new food products not only provide nutrition but also serve to combine food and tea flavours. Tea foods satisfy the modern man's pursuit of consuming diverse, individualization, and fashionable food. It not only makes full use of the rich tea resources, but also significantly improves the added value of low value tea resources. Research on tea food is an important area of deep processing of tea leaves, which has significant economic and social benefits. Statistics show that the current mainstream products of tea-based food industry are tea baked foods, tea candies, and dried fruit tea. In recent years, there has been a growing consumer interest in supplementary products containing tea extracts. Tea extract is added to a variety of food products like bread (Wang *et al*. 2004), biscuits, dehydrated apple (Lavelli *et al*. 2010), and various meat products (Tang *et al*. 2001; O'sullivan *et al*. 2004; Mitsumoto *et al*. 2005), The market share of tea baked foods is the largest share amongst all tea products, accounting for about 68% of the tea market. Tea powder, tea juice, or tea extract is mixed with cereal and then baked at high temperature to obtain tea baked foods (Akhtar *et al*. 2011).

Currently, tea baked food is becoming increasingly popular, especially in China, mainly due to its special flavour and taste as well as its unique health benefits. The biological activity of tea phenolic compounds

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and their derivatives also promotes a protective effect by antioxidant mechanisms in biological and food systems, preventing the oxidative damage by acting over either precursors or reactive species (Marcia *et al.* 2013, Jose *et al.* 2016, Xu *et al.* 2018, Zhang *et al.* 2019). The number of consumers for tea baked food is increasing and so is its market demand. Due to a rapid increase in the consumption of tea baked food, the last decade has witnessed rapid developments in tea baked food industry, leading to an escalation in its production. The raw materials, baking formula, and processing technology all have a significant impact on the quality of tea bakery products. Studies on processing technology as well as designing the recipe of tea baked foods such as tea cake, tea bread, and tea biscuit have progressed in the last thirty years. With the fast growing popularity of this unique tea food, it is important to comprehensively review the advances made in this field. Therefore, the present paper attempts to assess developments in the production of tea baked food and describes the recipes of tea baked food products. The effect of chemical components in tea on the quality of tea bakery products has also been discussed. The problems encountered during baking concerning the quality of tea cakes and tea biscuits are analysed.

Type of tea baked foods

Tea baked foods are special tea foods made by baking of tea extract with wheat flour or other grains as raw materials. Baked goods form a very important diet in many countries (Milani *et al.* 2016; Els *et al.* 2018). However, the proportion of tea baked foods in the entire food category is still relatively low (Swieca *et al.* 2013; Gawlik *et al.* 2014). The varieties and categories of baked goods have gradually increased in recent years.

In addition to meeting the physiological needs, the standards required for properties of raw material, nutritional characteristics, health benefits, and safety in baked foods are more and more stringent. Traditional baked foods not only contain more fat and calories, but also relatively lack in functionality (Ribotta *et al.* 2004; Pico *et al.* 2015). Traditionally baked foods fail to fulfil the requirements for low-fat, low-calorie, and health properties, particularly for obese people (Loosveld *et al.* 2000; Kihlberg *et al.* 2004). Components of natural tea extracts have powerful antioxidant, anti-obesity, anti-pancreatitis, anti-inflammatory, anti-bacterial, anti-viral, anti-aging, and anti-cancer properties. They also promote blood circulation, prevent Parkinson's disease, etc. (Liming *et al.* 2014; Wahlund *et al.* 1996). Tea baked foods not only combine the traditional flavours of baked foods and tea flavour along with tea functionality (Tian *et al.* 2012), but also satisfy people's pursuit of diverse, functional, and personalized modern food. The number and types of tea, bread, and other baked food products are higher in China compared to the United States and Europe, and also the processing technology is relatively more perfect. Based on processing technology, tea baked foods can be categorized as tea breads, tea cakes, and tea biscuits. Large-scale consumption of baked foods worldwide is in the form of bread, whose processing includes mixing, kneading, fermentation, segmentation, integration, proofing, baking, cooling, and packaging (Xing *et al.* 2007). Bread is consumed by people all around the world. Germany is the main European market for bakery products, which has 25.96% of market share. Italy, France, Britain, and other countries have the second largest market share. Every country has its unique variety of bread.

Due to continuous improvements in processing by the Chinese pastry makers from the early twentieth century to the present, pastries with Chinese characteristics began to emerge steadily (Dewettinck *et al.* 2008; Decamps *et al.* 2013). China's bread processing technology has also reached an advanced level. From the early twentieth century to date, bread with Chinese characteristics has begun to emerge one after the other. Developments in bread processing technology have led to a variety of raw materials being used and consequently a more diverse variety of breads being made (Hathorn *et al.* 2008). At present, the bread categories in the market mainly include staple bread, fancy bread, conditioning bread, and Danish butter bread (Domenek *et al.* 2003; Rasiah *et al.* 2005). Research on tea bread mainly focuses on the processing technology of staple tea bread. However, other types of tea breads are rarely involved. Addition of tea powder, tea juice, or tea extract to the bread followed by roasting gives special tea bread, with its unique tea flavour (Wang *et al.* 2008; Yang *et al.* 2010). The technique of addition of tea extracts not only enhances the nutritional value and health benefits of bread (Dilek *et al.* 2007), but also extends the shelf life of bread at room temperature.

Cake is an ancient Western dessert. When eggs, sugar, low gluten flour, milk, vegetable oil, and baking powder are mixed together and baked, a rich

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cake with a soft texture is produced (Schirmer *et al.* 2012). The main types of cake are batter cake, milk foam cake, and chiffon cake (Baixauli *et al.* 2008). Tea cake research focuses on tea chiffon cake and tea milk foam cake processing technology, but the tea batter cake processing technology is paid relatively less attention. Tea emulsion cake is a unique type which is made by adding tea powder, tea juice, or tea extract and without adding any solid fat. The main categories of tea lather cake include single-protein angel cake and whole-egg sponge cake (Manisha *et al.* 2012). The basic ingredients of tea batter cake have high fat contents (usually accounting for more than 50% of the total flour), which are added with tea powder, tea juice, or tea extract (Seyhun *et al.* 2003). Chiffon cake combines the characteristics of tea milk foam cake and tea batter cake, which together change the texture of the cake to a new category.

The wheat flour (or glutinous rice flour, starch, etc.), sugar, salt, and fat are mixed, formed and baked to obtain crispy biscuits. Biscuit categories include crisp biscuits, tough biscuits, soda crackers, crackers, cookies, sandwich biscuits, wafer biscuits, egg biscuits, sticky biscuits, biscuits, etc. (Di *et al.* 2008; Kulthe *et al.*2017). Presently, the study of tea crackers mainly focuses on the processing technologies of tea cookies, tea crackers, tea tough biscuits, and tea soda crackers (Steele *et al.* 1999). Tea extract, wheat flour, sugar, dairy products, loosening agent, and other raw materials are mixed, squeezed, extruded, section cut, and baked to obtain regular corrugated, high fat tea cookies (Zhou *et al.* 2008). Tea tough biscuits have a smooth appearance, rough surface, needle eye, cross-sectional level, and are tasty crispy baked foods. They include milk cakes, vanilla cakes, egg tarts, marijuana, Boston cakes, etc. (Zhou *et al.* 2009). Tea soda crackers mainly include salted and sweet fermented cakes (Li *et al.* 2015). Tea crisp biscuits are baked foods which have a porous cross-sectional structure and include cream biscuits, onion biscuits, sesame biscuits, meringue biscuits, etc.

Tea baked food formula

Tea bread processing formula. Tea ingredients used in tea bread include tea powder, tea extract, and tea juice, obtained from green tea, black tea, or Oolong tea. Shao *et al.* (2017) used Xinyang green tea powder in bread processing and found that the optimum amount of green tea powder was 3% of bread flour. The average volume of green tea in staple food was 5.75 ml/g, with sensory quality score of 98, moisture content of 32.7%, tea polyphenol content of 0.38%, and acidity was 2.98. The upper layer of green tea bread is complete, with uniform colour, a little yellow-green tea, tight tissue, resilient chew resistance, tea fragrance, and no tea bitter taste.

Ordinary black tea powder is also used to process hard black tea bread. The preferred amount of black tea powder is 1%. The amount of black tea powder has a significant impact on bread texture. The higher the amount of black tea powder, the greater is its hardness, adhesiveness, chewiness, rising, and the lesser is its elasticity (2016). Ultra-green tea powder has also been used for the processing of tea bread (Gu 2003). The amount of tea powder has a greater impact on bread quality. The greater amount of ultra-green tea powder was added, the worse is the quality of bread. The quality of tea bread with 3% of ultra-green tea powder was found to be better, as it could increase the water holding capacity of the bread, maintain freshness, and delay aging. The tea bread with ultra-green tea powder is yellow-green, soft, with green tea fragrance and is bouncy (Yang *et al.* 2008).

In summary, the addition of tea powder significantly improves the bread quality and boosts health, especially for the type and amount of tea. However, the standards of sensory quality evaluation adopted by different experts are inconsistent. It is difficult to virtually compare them under the same conditions. Currently, the quality evaluation of tea bread is mainly based on sensory evaluation which uses different sensory evaluation parameters and weights. Therefore, it is difficult to objectively evaluate which method is better and which is more reasonable. The standardization of tea processing technology, sensory evaluation standards, and other aspects of research need to be further improved.

Tea extract is a solid substance which is different from tea powder. It is obtained after hot water extraction, filtration and drying of green tea, black tea or oolong tea. The formula and quality of tea bread using tea extract as raw ingredient are different from those obtained using tea powder as raw material. The qualities of tea bread obtained using tea powder and tea extract were compared by Wen Haitao (Wen *et al.* 2005). Although the addition of superfine tea powder to bread gave unique tea flavour, some sensory qualities like texture and taste were not ideal yet. The texture was relatively hard and the taste was poor. The reason for this was that the particle size of ultrafine tea powder

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did not match the particle size of flour, and this was not conducive for the formation of gluten. In contrast to this, the quality of bread processed with tea extract was better (Duan *et al.* 2016). Moreover, it had a better effect on the inhibition of microorganisms than tea bread with ultra-fine tea powder. The tea bread with green tea extract also had a better inhibitory effect than the tea bread prepared from oolong tea extract and pu'er tea extract. According to Zou (2016), the addition of 0–2% green tea extract to bread had no significant effect on gas production capacity of yeast and specific volume of bread. Addition of green tea extract provided better water retention capacity than the control. Otherwise, when pu'er tea extract was added to make bread, the quality of bread was significantly improved (Si *et al.* 2011), and the retention rate of thearubigins in bread after baking was more than 60%, which indicated that a lesser amount of thearubigins was lost during bread baking.

Juices of green tea, oolong tea, and black tea, which were different from their powders and extracts, were obtained by hot water extraction. Using Guangxi Liubao tea in the recipe, which included 60.0% Six Forts tea juice, 1.2% active dry yeast, 12.0% white sugar, 25.0% whole wheat flour, 1.8% salt, and 6.0% butter, tea juice bread was prepared. The quality of this bread was also judged by sensory evaluation methods (Xie *et al.* 2016). The order in which each ingredient had an effect on the quality of tea juice bread was Liubao tea juice > active dry yeast > white sugar > whole wheat flour > butter > salt. Organic tea juice or other ordinary tea juice, rich in zinc and selenium, could also be used as raw ingredient for tea juice bread (Chen *et al.* 1999; Ren *et al.* 2009). The ingredients include flour 700 g, tea juice 70 g, sugar 70 g, salt 20 g, water 1050 g, margarine 50 g, skim milk 40 g, yeast nutrient solution 15 g, and yeast 25 g.

The above discussion shows that different experts have made certain contributions to formulating tea bread using different varieties of tea powders, tea extracts, and tea juices. However, due to the lack of uniform standard sensory evaluation parameters, it is so difficult to evaluate the quality of tea bread, processed by different experts. Moreover, the role and effects of tea powder, tea extract, the active ingredients and composition of tea juice, the added amounts of different tea materials on the quality of tea bread are not clear yet. The changes and role of polyphenols, catechins, theanine, caffeine, anthocyanins, theaflavins, thearubigin, and polysaccharides in tea during the processing of tea bread are not clear either. Therefore, more efforts are required to obtain an in-depth understanding of their roles.

Formula for tea biscuit processing. At present, formulae for most of the tea biscuits are available with main focus on tea cookies, tea crisp biscuits, tea tough biscuits, tea soda crackers, which mostly use ultra-fine tea powder as the raw ingredient. Tea tough biscuits are crispy, tasty tea baked foods, which mainly use ordinary green and ultra-green tea powders as raw materials. Gradient test and their own sensory criteria were used to evaluate high quality green tea tough biscuits (Pan 2013; Wang *et al.* 2017). They used the following formula: 30.4% white sugar, 12.0% soybean oil, 5.2% super green tea powder, 0.8% sodium bicarbonate, and 0.8% ammonium bicarbonate. Other experts on tea tough biscuits had different opinions and they considered that the optimum amount of ultrafine tea powder should be 3% (Sui *et al.* 2012; Pan *et al.* 2013).

Cookie is a very popular baked food which has a delicate appearance and is crispy. However, it has higher fat and sugar contents and oily texture. Since tea is rich in cellulose and polyphenols, it can effectively improve the greasy characteristics of cookies. Current literature study shows that cookies mainly include instant milk tea and green tea powder. The formula for the preparation of milk tea cookies includes 25.0 g instant tea powder, 100.0 g low-gluten flour, 35.0 g sugar, 20.0 g eggs, and 55.0 g butter (Bao *et al.* 2014). The formula for green tea cookies includes 1.0% ultra-green tea powder, 26.0% to 31.5% wet gluten, 20% soft white sugar, and 20% shortening agent (Zhang *et al.* 2009; Li *et al.* 2014). The formula for corn green tea cookies includes 77.0 g low-gluten flour, 20.0 g corn flour, 3.0 g tea powder, 50.0 g sugar, 60.0 g butter, and 15.0 g eggs (Wang *et al.* 2013). The formula for black tea cookies includes 3.0 g ultra-black tea powder, 100.0 g flour, 100.0 g butter, 40.0 g sugar, 20.0 g eggs, 8.0 g milk, and 6.0 g custard powder (Wen *et al.* 2013). The tea biscuits prepared by all above formulas have not been evaluated by standardized quality tests. The sensory evaluation parameters and weights are so different that it is difficult to determine exactly which formula gives better quality of tea biscuits.

Tea soda crackers are of the cross-section structure, taste loose baked foods. There are many varieties of tea soda crackers, such as tea butter biscuits, tea onion biscuits, tea sesame biscuits, tea meringue cookies, etc. The formula for the preparation of matcha whole meal cookies includes 3.0 g green tea powder, 125.0 g whole wheat flour, 0.5 g salt, 40.0 g sugar, 1.45 g soda, and 55.0 g water (Yao *et al.* 2011; Zheng *et al.* 2013).

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The formula for black tea salt cookies includes 45.0 g black tea soup, 180.0 g low-gluten flour, 2.0 g salt, 1.5 g baking powder, and 30.0 g eggs (Xie *et al.* 2015). The methods for evaluating the quality of above tea soda crackers are not uniform, all using their individual sensory evaluation parameters, which makes it difficult to compare their qualities.

In summary, ultra-fine tea and matcha tea were used more for the preparation of tea cookies, tea crisp biscuits, tea tough biscuits, and tea soda crackers. In contrast, instant tea and tea juices were used less in the preparation of tea biscuits. At present, sensory evaluation standards and processing technology standards for tea biscuits are still relatively missing. The changes in composition and role of main chemical components of tea in biscuit processing still need a further study. It is a very interesting research topic and its intensive study is worthwhile.

Tea cake processing formula. There has been much progress in tea cakes during the past thirty years. However, the questions arising and shortcomings in tea cake research are similar to those of tea biscuits and tea breads. The unique and relatively uniform standards of sensory evaluation and tea cake processing technology standards are still absent.

At present, most of the raw ingredients for tea cake processing are ultra-fine tea powder and matcha. The formulae for tea cake, the variety and amount of ultra-fine tea powder required are all different in literature (Cao *et al.* 2012; Wang *et al.* 2015). The formula for ultra-fine green tea cake includes 6.0 g ultra-fine green tea powder, 180.0 g eggs, 100.0 g sucrose, 15.0 g vegetable oil, 2.5 g cake foaming agent, and 100.0 g low-gluten flour (Yang *et al.* 2006). Addition of ultra-fine tea powder has little effect on the specific volume of tea cake, but it has some influence on the core structure, taste, and appearance of tea cake (Song *et al.* 2005). In addition to ultra-fine green tea powder the black tea, oolong tea, jasmine tea, and rose tea powders can also be used to make tea cake (Jin 1999; Wang 2004). The optimum dosages of black tea, green tea, jasmine tea, and rose tea powders were found to be 0.855%, 0.4022%, 0.864%, 0.7978%, respectively. The quality of tea cake processed with jasmine tea powder was better, which could prolong the shelf life of cake and increase its nutritional value (Wang *et al.* 2011). The formula for phoenix oolong tea health cake includes 2.0 g phoenix oolong tea powder, 50.0 g flour, 50.0 g eggs, and 3.0 g soda powder (Huang *et al.* 2011).

Researches on matcha tea cake formulation focused more on the ratio of matcha tea to other ingredients. The formula for high-fibre and low-sugar pumpkin matcha cake was 3.0 g matcha tea, 100.0 g cake powder, 10.0 g soy dietary fibre, 10.0 g Yuanzhen sugar, 33.0 g eggs, 5.0 g cake oil, 4.0 g baking powder, and 12.0 g pumpkin powder (Li 2015; Ma *et al.* 2016). The quantity of matcha powder should not be too high; otherwise it affects the taste, colour, and texture of the cake. The formula for tasty tartar matcha tea cake includes 1.2 g matcha tea powder, 42.0 g eggs, 10.0 g flour, 15.0 g sugar, tartar powder, 3.0 g starch, and 5.0 g oil (Li *et al.* 2014). However, other references show that the amount of matcha tea powder should be 2.0 g (Su *et al.* 2014), 0.45 g (Ren *et al.* 2014), or 4.0 g (Wan *et al.* 2011). In summary, the amount of green tea powder added is less than 5.0 g, whereas the proportions of flour, eggs, sugar, water, baking powder, and other ingredients vary. Moreover, the sensory evaluation standards for tea cakes are also different, and so it is difficult to analyse and compare the pros and cons of the tea cake recipes (Xu 2015; Xu *et al.* 2015).

In addition, tea polyphenols or tea juice can also serve as an ingredient for tea cake. To prepare tea polyphenol brown rice sponge cake, 0.8 g of tea polyphenol was added to a composition of 20 g cake powder, 80.0 g sugar, 40.0 g milk, 18.0 g eggs, and 10.0 g oil. This cake had golden yellow appearance, normal uplift, and high nutritional value, baked rice flavour, good chewiness, refreshing taste, and good flexibility (Tan 2008; Tan *et al.* 2008).

Processing technology of tea bakery foods

Fermentation technology. Fermentation is one of the key processes for tea bakery products such as tea breads, tea biscuits, and tea cakes. The current research focuses on proofing time and fermentation time. According to Liu Mingming (Liu 2016), proofing time and fermentation time had a greater impact on the fermentation of black bread. When the bread proofing time reached 50 min and the fermentation time reached 100 min, the effect on bread fermentation was best. The preferred fermentation time for green tea bread was 30 min, with the best proofing time of preferably 120 minutes. The optimum fermentation time for oolong tea bread was 60 min along with the best proofing time of 150 minutes. Fermentation time of 30 min was better for pu'er tea bread which also had the best proofing time of 120 min (Wen 2005). Adopting the above technical parameters gave tea bread good appearance and flavour.

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Baking process technology. When baked at an insufficiently lower temperature for a shorter time, the tea bread is not properly baked, especially the core. However, when the tea bread is baked for a long time at a low temperature, although the tea bread matures, its texture still remains dry and tastes poor. When the tea bread is baked at a higher than normal temperature for a shorter baking time, it gives good surface colour to the bread, but the core remains immature. If the baking time of tea bread is extended, it causes cracking of the product and appearance of a paste on the outer crust, and so on. The effect of baking temperature of tea bread on the sensory attributes has shown the optimum baking temperature of bottom flame to be 180°C, temperature of surface flame to be 190°C, and the optimized baking time to be 14 minutes.

The quality of tea biscuits is mainly affected by baking temperature, baking time, and biscuit thickness. When the temperature on the biscuit surface reached 180–200°C, the temperature on the biscuit bottom reached 160–170°C, and the baking time was 8 min, the sensory quality of green tea tough cookies was better (Pan 2013; Wang 2017). Moreover, for tea cookies, the optimum temperature on the surface was 180–190°C, the temperature on the bottom of the cookies was 160–170°C, and the baking time was 15–18 min (Bao *et al.* 2014; Li *et al.* 2014). However, for matcha crisp cookies, the optimum temperature on the surface of tea cookies was 185°C, the temperature on the bottom of tea cookies was 190°C, and the baking time was 6 minutes.

The technical parameters for baking of tea cake are different from those for tea biscuits and tea cake. Baking temperature and time directly affect the colour, smell, taste, and shape of tea cake. When the temperature of tea cake surface was 160–180°C, the temperature on the bottom of tea cake was 170–200°C, and the baking time was 13–35 min (Cao *et al.* 2012; Wang *et al.* 2015). The sensory attributes of tea cake were better, such as smooth surface, pure fragrance, loose taste, and good aroma. Moreover, the same precise surface and bottom temperatures of tea cake can also make tea cakes with appealing sensory attributes. Response surface methodology was used to evaluate the optimized parameters of baking temperature and time for matcha cake (Cao *et al.* 2012). Results showed that the optimized baking temperature and bottom temperature were 183.7°C, and the optimized baking time was 16.7 min, which produced the matcha cake with hardness of 188.44 HB, and elasticity of 0.92.

Effect of composition on quality of tea bakery products

Mechanism of binding of tea chemical components with grain protein. Tea polyphenols, which include flavanols (catechins), anthocyanins and phenolic acids, constitute a major class of tea compounds, accounting for 18–36% of the total dry matter. Most of these substances have a special structure containing a number of phenols which are easily adsorbed and complexes with a variety of chemical components of tea (Cheng *et al.* 2011). The binding and precipitation of tea polyphenols and protein are responsible for the bactericidal and antiviral activities of tea polyphenols (Kuang *et al.* 2002). Moreover, the astringent taste is developed due to the binding of tea polyphenols with the protein in the epithelium of the oral mucosa. Early studies suggest that polyphenols were bound to proteins through hydrogen bonds (Huang *et al.* 1996). There were multiple points of linking between the large number of phenolic hydroxyl groups of polyphenols with the hydroxyl, amino, and carboxyl groups of the protein side chain (Tan *et al.* 2006). However, in-depth studies have shown that although polyphenols had the ability to bind to proteins, their binding was selective, which was mainly reflected by their differences in affinity between different polyphenols for different proteins (Zhu *et al.* 2016). Relatively high molecular mass, loose open structure, higher content of proline or other hydrophobic amino acids in the protein increased its affinity with polyphenols, which was different from the traditional hydrogen bonding of polyphenol-protein (Asquiht & Butler *et al.* 1986). Glycine, alanine, leucine, and proline are hydrophobic and have better binding ability with polyphenols (Fu *et al.* 2016).

In previous studies, the theory of hydrogen bonding of polyhydric hydrophobic groups in the polyphenol-protein reaction was explained by Haslma *et al.* (1989). The "hand-glove" model was used to illustrate this theory. Concentration of hydrophobic groups in protein molecules constituted a "hydrophobic bag". Polyphenol molecules entered the "hydrophobic pocket" and formed strong hydrogen bonds. Polyphenols with the relative molecular mass greater than 500 Daltons are more likely to bind strongly to protein. The higher the number of phenolic hydroxyl and hydrophobic groups, the greater the flexibility of the molecule, the higher is its water solubility, and the stronger is its binding ability to protein.

Relationship between complexation and flavour of tea bakery foods. The major constituents of wheat

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protein are globulin, gliadin, and glutenin. Sulphur bonding and polar amino acids, which provide elasticity to dough, mainly determine the dough strength (Orth *et al*. 1972). After complexation of globulin, gliadin, and glutenin with tea polyphenols, some of the monomeric tea catechins disappear. The complexation between tea polyphenols and saline and gliadin results in precipitation. However, there is no precipitate formed after the action of tea polyphenols with acid soluble proteins. Saltwater and prolamins in wheat proteins have lower molecular weights, while acid soluble protein is a macromolecular polymer. Due to soluble salts and low molecular weight prolamins in wheat proteins, tea polyphenols can rapidly combine with salts and prolamins to form precipitates (Kuang *et al*. 2002; Jia *et al*. 2004). However, tea polyphenols with partially large molecular weights can solubilize proteins, and there is no visible precipitate.

With the tea leaf polyphenol concentration of 0.02 mg/ml, the rate of gliadin deposition was maximal. At this time, the reduction of EGCG (epigallocatechin gallate), GCG (gallocatechin gallate), EGC (epigallocatechin), and ECG (epicatechin gallate) contents was 98.80%, 97.82%, 95.67%, and 93.53%, respectively, whereas the reduction of DL-C and EC contents was only 69.69% and 61.22%, respectively (Wen *et al*. 2005). This suggested that complexes were formed between the phenolic hydroxyl and gallic acid groups of catechin monomer with protein. When the concentration of tea polyphenols in large-leaf tea reached 0.03 mg/ml, the precipitation rate of tea polyphenols due to complexation with saline and gliadin was the highest. In addition, tea polyphenols have more bitter astringent taste. However, when a high concentration of tea polyphenols was added to bread, the tea bread did not have the bitter astringent taste, which could also be attributed to the complex formation between protein and catechins.

After the combination of tea polyphenols with bromelain, there were no changes in the isoelectric point of bromelain, optimum pH value, and optimum temperature. However, the affinity of bromelain for the substrate decreased, along with significant improvement in the stability of bromelain (Huang *et al*. 1996). When 0.25% (w/v) green tea polyphenol was added to 1.0% (w/v) egg, the foaming ability and foam stability of egg protein increased by 4–5 times. Moreover, addition of tea polyphenols improved the gel strength and gel temperature of egg protein. The combination of tea polyphenols with wheat protein helped to improve some of the characteristics of wheat protein, which was conducive to the formation of loose bread structure and for increasing the volume (Weiguo *et al*. 2007). Black tea pigment can not only significantly increase gelatinization viscosity, consistency index of the flow curve, storage modulus, and loss modulus (Zhu *et al*. 2016), but also it can significantly improve the hardness and chewiness of tea whole wheat bread (Ning *et al*. 2017).

EGCG could significantly reduce acrylamide formation by 37% and moisture content of bread by 6% (Zheng *et al*. 2013). The bread texture attributes were not affected. However, the brightness and yellowness of the tea bread surface were enhanced, whereas the redness, size, and porosity of the tea bread were significantly reduced. According to Wang *et al*. (2008), during the baking of tea bread, thermal degradation and epimerization of EGCG occurred simultaneously. The detailed mechanism was unclear and needs to be probed further.

Microcapsule technology was used to improve the stability of functional ingredients of tea, which were used to prepare high-quality tea baked foods. Under microencapsulation conditions of 180°C and 12 min, catechins could be effectively stabilized, and tea biscuits with good sensory quality could be obtained (Laura *et al*. 2017; Awa *et al*. 2018).

Summary

In the tea baking process, choice of raw materials, formulation, fermentation process, and baking process are all very important factors. The tea bakery food ingredients and processing methods were compared (Table 1). The consumption ratio and per capita consumption of different kinds of tea bakery foods in China were also compared (Figures 1 and 2). Due to differences in physicochemical properties of tea powder, tea juice, tea extract, their requirements in tea bakery foods are also different. Depending on the differences in texture characteristics, chemical characteristics, and biological activities of various functional components, different ingredients at appropriate ratios should be added so as to obtain high-quality tea bakery foods. In order to effectively preserve the special flavour of tea, biological activity of tea, the functional components should be retained as much as possible. There are more than 1000 kinds of volatile and non-volatile heat-sensitive substances in tea which include tea polyphenols, catechins, tea polysaccharides, theaflavins, theanine, chlorophyll,

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Table 1. Comparison of tea bakery food ingredients and processing methods

Bakery food types	Species of tea ingredients	Tea ingredients	Amount of tea ingredients (%)	Other ingredients	Processing methods
Tea bread	green tea, black tea, oolong tea, pu'er tea	superfine powder	0.1–3.0	bread flour, yeast, sugar, shortening, salt, milk, eggs, vegetable oil, milk powder, modifier	stir → fermentation → split → rolling → plastic → baking → cooling → packaging
	green tea, pu'er tea	tea extract	0.1–2.0		
	green tea, pu'er tea	liquid tea juice	8.0–60.0		
Tea biscuit	green tea, black tea	superfine powder	1.0–5.0	flour, sugar, vegetable oil, butter, sodium bicarbonate, custard powder, margarine	mixing the powder → allocate → fermentation → rolling → moulding → roasting → cooling → packing
	green tea	tea extract	3.0–10.0		
	green tea, black tea	liquid tea juice	5.0–18.0		
Tea bread	green tea, black tea, oolong tea, pu'er tea	superfine powder	0.1–25.0	flour, eggs, sugar, milk, honey, vegetable oil, cake oil, salt, pumpkin paste, baking powder, tartar powder, starch	beat → mixing → fermentation → injection → moulding → plastic → roasting → release → packaging
	green tea	tea extract	0.5–0.8		
	green tea, black tea	liquid tea juice	1.0–10.0		

aromatic substances, etc. Many changes in structures and activities of these substances occur during the fermentation and baking of tea bakery foods. However, studies on the pathways and mechanisms of these substances are still relatively less frequent. The effects and the role of these substances on the quality and function of tea bakery foods also require further in-depth research.

At present, the evaluation of tea baked foods is mainly based on sensory evaluation methods (Song *et al.* 2005; Yang *et al.* 2006; Tan *et al.* 2008; Wan *et al.* 2011; Cao *et al.* 2012; Li *et al.* 2014; Ren *et al.* 2014; Xu *et al.* 2015; Liu. 2016; Wang *et al.* 2017; Els *et al.* 2018). There are huge differences in the sensory evaluation indices, evaluation criteria, and in the scores by different experts (Huang *et al.* 2012). The underlying reason is that there are no standards as yet for the sensory evaluation of tea baked foods such as tea cakes, tea crackers, and tea. It is very difficult to draw a clear distinction between advantages and disadvantages

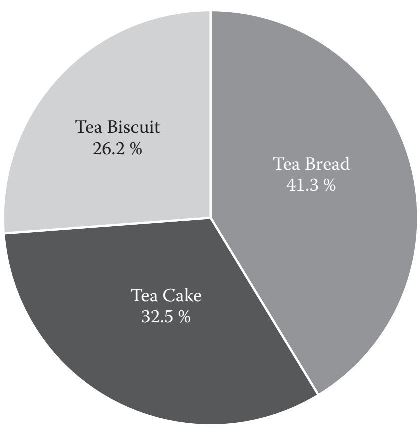

Figure 1. Consumption ratio of different kinds of tea bakery foods in China

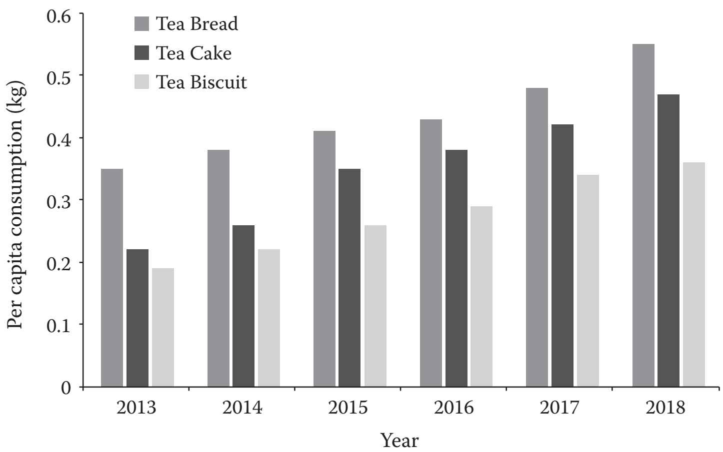

Figure 2. Per capita consumption of tea bakery foods in China

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of sensory evaluation methods for tea bakery foods in current literature. In many cases, the sensory scores are so discrete that it is difficult to obtain consistent results (Lee *et al*. 2016; Tsatsaragkou *et al*. 2016). Fortunately, statistics and computational chemistry may be used to objectively evaluate the colour, smell, taste and shape of tea baked foods, which can reduce the impact of human factors on the quality evaluation of tea baked food by the fuzzy information from quantitative evaluation. Fuzzy mathematics was employed to evaluate the sensory quality of tea soda crackers using the Design Expert software (StateEase, USA). The results of fuzzy mathematical evaluation and sensory evaluation of tea soda crackers were similar.

In addition, in order to reduce subjective errors in the sensory evaluation of tea baked foods, it is necessary to employ advanced techniques such as electronic tongue, electronic nose, and colour difference meter (Huang *et al*. 2012). Based on the data analysis of taste, aroma, appearance, and colour of tea baked foods, the optimization of processing technology of tea baked foods and the quality of tea baked foods can be improved more precisely. The performance of tea baked foods industry may also be improved successfully.

References

Akhtar S., Anjum F.M., Anjum M.A. (2011): Micronutrient fortification of wheat flour: Recent development and strategies. Food Research International, 44: 652–659.

Asquiht T., Butler L. (1986): Interactions of condensed tannins with selected proteins. Phytochemistry, 25: 1591–1593.

Awa F.M.B., Ma S.J., Li X.D., Liu L. (2018): Application of microencapsulation for the safe delivery of green tea polyphenols in food systems: Review and recent advances. Food Research International, 105: 241–249.

Baixauli R., Salvador A, Fiszman S.M. (2008): Textural and colour changes during storage and sensory shelf life of muffins containing resistant starch. European Food Research and Technology, 226: 523–530.

Bao L.L., Li S.(2014): Process technology of tea cookie.Food Safety Guide, 9: 73–74.

Cao S., Hu F., Xu Z.Q., Fang D., Lu N. (2012): Study on the processing technology and antioxidant of green tea cake. Science and Technology of Food Industry, 11: 286–288.

Cheng H.P., Wan Y.Q., Li C.H., Dong J. (2011): Study on the processing technology of matcha crisp cookies. Food Industry and Science technology, 12: 374–376.

Chen M.C. (1999): Study on process of the tea flavor bread. Food Research and Development, 20: 43–44.

Decamps K., Joye I.J., Rakotozafy L., Nicolas J., Coutin C.M., Delcour J.A. (2013): The bread dough stability improving effect of pyranose oxidase from trametes multicolor and glucose oxidase from aspergillus niger: unraveling the molecular mechanism. Journal of Agricultural and Food Chemistry, 61: 7848–7854.

Dewettinck K., Bockstaele V.F., Kühne B., Walle D.V.D, Courtens T.M., Gellynck X. (2008): Nutritional value of bread: Influence of processing, food interaction and consumer perception. Journal of Cereal Science, 48: 243–257.

Di M.R., Cavella S., Masi P. (2008): Predicting sensory cohesiveness, hardness and springiness of solid foods from instrumental measurements. Journal of Texture Studies, 39: 129–149.

Dilek K., Zeynep H., Alev B., Sinan K. (2007): Bubble and pore formation of the high-ratio cake formulation with polydextrose as a sugar- and fat-replacer. Journal of Food Engineering, 78: 953–964.

Domenek S., Morel M.H., Redl A., Guibert S. (2003): Rheological investigation of swollen gluten polymer networks: Effects of process parameters on cross-link density. Macromolecular Stmposia, 200: 137–145.

Duan Y.L., Liang Y., Li B., Zhang X., Li L. (2016): Effect of tea extracts on bread quality and antioxidant capacity. Food Science and Technology, 41: 137–142.

Els D., Filip V.B., Ingrid D.L., Frank D, Mia E. (2018): Validation of *in-vitro* antifungal activity of thyme essential oil on *Aspergillus niger* and *Penicillium paneum* through application in par-baked wheat and sourdough bread. LWT-Food Science and Technology, 87: 368–378.

FU Z.J., Michelle J.Y.Y., Zhou W.B., Zhang L, Chen Y.T., Lu J. (2016): Effect of (-)-epigallocatechin gallate (EGCG) extracted from green tea in reducing the formation of acrylamide during the bread baking process. Food Chemistry, 242: 162–168.

Gawlik-Dziki U., Swieca M., Dziki D., Baraniak B., TomiloJ., Czyz J. (2014): Quality and antioxidant properties of breads enriched with dry onion (*Allium cepa* L.) skin. Food Chemistry, 156: 72.

Gu Z.Z. (2003): Study on the process of tea ultra-fine powder bread. Food Science and Technology: 58–60.

Haslma E. (1989): Plat PolyPhenols vegetable tannins revisited. Cambridge University Press, 10: 170–172.

Hathorn C.S., Biswas M.A., Gichuhi P.N., Bovell-Benjamin A.C. (2008): Comparison of chemical, physical, microstructural, and microbial properties of breads supplemented with sweetpotato flour and high-gluten dough enhancers. LWT-Food Science and Technology, 41: 803–815.

Huang H.H., Gao K.R. (1996): Effects of tea polyphenols on the isolation and characteristics of bromeliad. Food Science, 17: 6–11.

https://doi.org/10.17221/214/2018-CJFS

Huang X.J., Lai H.X., Chen S.P., Chen X.J. (2011): Processing technology of characteristic phoenix tea health cake. Ningxia Agriculture and Forestry Science Technology, 52: 69–70.

Huang Y.Y., Zhang H.H., Zhang S.K., Li D.W., Zhu Y.J., Wang X.G., Jin Q.Z. (2012): Color difference value combined with sensory evaluation to optimize tea biscuit recipe. China Tea Processing, 2: 41–48.

Jia G.F., Fan L.X., Wang J.S. (2004): Structure, function and application of wheat gluten protein. Food processing, 2: 11–13.

Jin S.Z. (1999): Processing technology of tea powder cake. Guizhou Tea, 1: 39–41.

José M.L., Paulo E.S.M. (2016): Phenolic compounds of green tea: Health benefits and technological application in food. Asian Pacific Journal of Tropical Biomedicine, 6: 709–719.

Kihlberg I., Johansson L, Kohler A, Risvik E. (2004): Sensory qualities of whole wheat pan bread-influence of farming system, milling and baking technique. Journal of Cereal Science, 39: 67–84.

Kuang W., Zhao R.Y., Wang J.S. (2002): Study on the relationship between wheat protein and bakery quality. Journal of Zhengzhou Institute of Technology, 23: 95–98.

Kulthe A.A., Thorat S.S., Lande S.B. (2017): Evaluation of physical and textural Properties of cookies prepared from pearl millet flour. International Journal of Current Microbiology and Applied Sciences 6: 692–701.

Laura G.G., Marai H.R., Paula T., Mathieu T., Nicolas F., Jorge F.V.R, Susana F., Amparo L.R. (2017): Impact of microencapsulation within electrosprayed proteins on the formulation of green tea extract-enriched biscuits. LWT-Food Science and Technology, 81: 77–86.

Lavelli V., Vantaggi C., Corey M., & Kerr W. (2010). Formulation of a dry green tea–apple product: study on antioxidant and color stability. Journal of Food Science, 75, C184–C190.

Lee D.S., Kim Y., Song Y., Lee J.H., Lee S., Yoo S.H. (2016): Development of a gluten-free rice noodle by utilizing protein-polyphenol interaction between soy protein isolate and extract of Acanthopanax sessiliflorus. Journal of the Science of Food and Agriculture, 96: 1037–1043.

Li B., Liu M.L. (2014): Study on the process technology and formulation optimization of tea cookie. Processing of Agricultural Products, 12: 36–37.

Li H., Li C.F., Ren J., Jiang H.Y., Zhou P., Wei X.L. (2014): Effect of shading time on matcha and matcha cake quality. Journal of Shanghai Normal University (Natural Sciences), 43: 573–577.

Li J.J. (2015): Study on the processing technology of matcha cake. Food Enigineer, 4: 18–21.

Li X.W., Zhang J., Li X.Y., Xu H., Lu N. (2015): Establishment of shelf-life prediction model for tea soda crackers. Journal of Food Science and Technology, 33: 74–78.

Liming C., Choi I., Lee C.K., Park K.K., Baik B.K. (2014): Bran Characteristics and bread-baking quality of whole grain wheat flour. Cereal Chemistry, 91: 398–405.

Liu M.M. (2016): Study on Black Tea Bakery and Green Tea Cake Combination Products. [Ph.D. Thesis.] Hefei, Anhui Agricultural University. (in Chinese)

Loosveld A., Delcour J.A. (2000): The significance of arabinogalactan-peptide for wheat flour bread-making. Journal of Cereal Science, 32: 147–157.

Ma L., Li H.T., Liu Y.Y. (2016): Study on the technology of high fiber and low sugar pumpkin matcha cake. Food Research and Development, 37: 59–62.

Manisha G., Soumya C., Indran D. (2012): Indrani. Studies on interaction between stevioside, liquid sorbitol, hydrocolloids and emulsifiers for replacement of sugar in cakes. Food Hydrocolloids, 29: 363–373.

Marcia D.S.P. (2013): Tea: A new perspective on health benefits. Food Research International, 53: 558–567.

Milani R.F., Morgano M.A., Cadore S. (2016): Trace elements in camellia sinensis marketed in southeastern Brazil: extraction from tea leaves to beverages and dietary exposure. LWT-Food Science and Technology, 68: 491–498.

Mitsumoto M., O'Grady M. N., Kerry J. P., Buckley D.J. (2005): Addition of tea catechins and vitamin C on sensory evaluation, colour and lipid stability during chilled storage in cooked or raw beef and chicken patties. Meat Science, 69, 773–779.

Ning J.M., Gary G.H., Sun J.J., Wan X.C. Amaud D. (2017): Effect of green tea powder on the quality attributes and antioxidant activity of whole-wheat flour pan bread. LWT-Food Science and Technology, 79: 342–348.

Orth R.A., Bushuk W. (1972): A comparative study of the proteins of diverse baking qualities.Cereal Chemistry, 49: 268–275.

O'Sullivan C.M., Lynch A., Lynch P.B., Buckley D.J., Kerry J.P. (2004). Use of antioxidants in chicken nuggets manufactured with and without the use of salt and/or sodium tripolyphosphate: effects on product quality and shelf-life stability. International Journal of Poultry Science, 3: 345–353.

Pan Y. (2013): Study on process technology and quality of green tea tough biscuits. Hefei, Anhui Agricultural University: 7–16.

Pan Y., Yang Z.Z., Wang Y.Z., Huang H., Lu N. (2013): Process technology of tea tough biscuits. Packaging and Food Machinery, 31: 14–17.

Pico J., Bernal J., Gómez M. (2015): Wheat bread aroma compounds in crumb and crust: A review. Food Research International, 75: 200–215.

https://doi.org/10.17221/214/2018-CJFS

Rasiah I.A., Sutton K.H., Low F.L., Lin H.M., Gerrard J.A. (2005): Crosslinking of wheat dough proteins by glucose oxidase and the resulting effects on bread and croissants. Food Chemistry, 89: 325–332.

Ren J. (2014): Research of high Selenium matcha food. Shanghai, Shanghai Normal University: 51–54.

Ren T.Y., An Y.H. (2009): Study on process of the organic tea bread with high content of zinc and selenium. Food Science and Technology, 6: 6–8.

Ribotta P.D., Perez G.T., León A.E., Anon M.C. (2004): Effect of emulsifier and guar gum on micro structural, rheological and baking performance of frozen bread dough. Food Hydrocolloids, 18: 305–313.

Schirmer M., Jekle M., Arendt E., Becker T. (2012): Physicochemical interactions of polydextrose for sucrose replacement in pound cake. Food Research International, 48: 291–298.

Seyhun N., Sumnu G., Sahin S. (2003): Effects of different emulsifier types, fat contents, and gum types on retardation of stalling of microwave-baked cakes. Nahrung-Food, 47: 48–251.

Shao Y, Wang B.G., Zheng Y.Y., Lian M.M., Hou H.D., Zhu G.Y. (2017): Research of Xinyang green tea staple bread. Preservation and Processing, 17: 60–64.

Si H.Q., Song W.J., Li C.W. (2011): Changes and detection methods of theabrownin Content in bread. Food Science and Technology, 36: 150–152.

Song L., Tong L.Y., Li Y.L. (2005): Formula research of ultra-fine tea powder chiffon cake. Cereals, Oils and Foodstuffs, 2: 68–69.

Steele V.E., Bagheri D., Balentine D.A., Boone C.W., Mehta R., Morse M.A, Sharma S., Sigman C.C., Stoner G.D., Wargovich M.J., Weisburger J.H., Zhu S., Kelloff G.J. (1999): Preclinical efficacy studies of green and black tea extracts. Proceedings of the Society for Experimental Biology and Medicine, 220: 210–212.

Su L., Duan Y., Yin L.Q. (2014): Study on the processing technology of matcha cake. Journal of Inner Mongolia Agricultural University (Natural Science Edition), 35: 87–91.

Sui X.F., Zhao P., Wang Y.Z., Chen F.Z., Qin L.K. (2012): Study on the nutritional function components analysis and application of ultra-fine tea powder. Food Research and Development, 33: 173–177.

Swieca M., Gawlik-Dziki U., Dziki D., Baraniak B., Czyz J. (2013): The influence of protein–flavonoid interactions on protein digestibility *in vitro* and the antioxidant quality of breads enriched with onion skin. Food Chemistry, 141: 451–458.

Tan S. (2006): Effect of tea polyphenols on foaming properties of protein and application in cake. Changsha: Hunan Agricultural University: 20–25.

Tan S., Wu X.L., Wu X., Liu Y., Wu W.G. (2008): Application of tea polyphenol in the chiffon cake. Food Industry and Science Technology, 29: 67–69.

Tang S.Z., Kerry J.P., Sheehan D., Buckley D.J. (2001): Antioxidative mechanisms of tea catechins in chicken meat systems. Food Chemistry, 76, 45–51.

Tian J., Cao Y. (2012): Current and situation trend of China bakery industry. Agricultural Science, 7: 51–52.

Tsatsaragkou K., Protonotariou S., Mandala I. (2016): Structural role of fibre addition to increase knowledge of non-gluten bread. Journal of Cereal Science, 67: 58–67.

Wahlund K.G., Gustavsson M., Macritchie F., Nylander T., Wannerberger L. (1996): Size characterisation of wheat proteins, particularly glutenin, by asymmetrical flow field-flow fractionation. Journal of Cereal Science, 23: 113–119.

Wang G.X., Sun D.H., Mei Z.F. (2008): Study on preparation of sponge cake using whole egg powder. Science and Technology of Food Industry, 6: 245–247.

Wang L.H. (2015): Study on the processing technology and quality of ultra-fine green tea powder. [Ph.D. Thesis.] Yaan, Sichuan Agricultural University. (in Chinese)

Wang N.X. (2017): Process and problem analysis of green tea tough biscuits. Modern Food: 118–119.

Wang R., Zhou W. (2004): Stability of tea catechins in the breadmaking process. Journal of Agricultural and Food Chemistry, 52, 8224–8229.

Wang R., Zhou W.B., Jiang X.H. (2008): Mathematical modeling of the stability of green tea catechin epigallocatechin gallate (EGCG) during bread baking. Journal of Food Engineering, 87: 505–513.

Wang R.D. (2004): Study on microwave assisted baking technology of green tea pumpkin cake. Food Processing, 3: 49–51.

Wang Y.Z. (2013): Study on the application of corn and green tea in the processing of cookies. Hefei: Anhui Agricultural University: 25–35.

Wang Z.J., Li Y., Jiang L.Z., Wang J. (2011): Determine amount and variety of tea powder in tea cake by golden section method. Food Industry and Science Technology, 32: 231–233.

Wan Y.Q., Wu Y.H. (2011): Processing of matcha cake. Journal of Anhui Agricultural Science, 17: 169–170.

Weiguo W., Mike C., Howell N. (2007): The effect of instant green tea on the foaming and rhelogical specialities of egg albumen proteins. Journal of the Science of Food & Agriculture, 87: 1810–1819.

Wen H.T. (2005): Study on the processing technology and mechanism of tea bread. [Ph.D. Thesis.] Changsha, Hunan Agricultural University. (in Chinese)

https://doi.org/10.17221/214/2018-CJFS

Wen X.J., Zhang W., Wang Y., Chen K.P. (2013): Process of tea cookie. Tropical Agricultural Sciences, 33: 55–59.

Xie C.M., Wen L.X., Ren E.F., Li X.R., Wang L.L., Zhang F., Ai J.W. (2016): Study on Liubao tea health bread. Food Science and Technology, 41: 114–120.

Xie C.M., Wen L.X., Wang L.L, Ren E.F., Luo X.J., Ai J.W., Ye X.Y. (2015): Formular research of black tea salty favor biscuits. Public Technology, 17: 85–87.

Xing R.X. (2007): Discussion on bread manufactures technology. Food engineering, 1: 49–50.

Xu H.L. (2015): Effect of tea polyphenols on processing properties of brown rice, polished rice and starch. Changsha: Central South University of Forestry and Technology: 58–61.

Xu H.L., Wu Y., Li A.P., Zhang Y.Q. (2015): Development of tea polyphenol brown rice sponge cake. Food and Grease, 28: 54–58.

Xu J.Y., Wang M., Zhao J.P.,Wang Y.H., Ikhlas A.K. (2018): Yellow tea (*Camellia sinensis* L.), a promising Chinese tea: Processing, chemical constituents and health benefits. Food Research International, 107: 567–577.

Yang L.R., Chang H., Li C.X., He Y.J. (2010): The research on chiffon cake. Journal of Shanxi Agricultural University. (Natural Science) (Ed.), 30: 556–559.

Yang X.P., Zhou L.T., Cui J.G., Lin Y.H. (2006): Processing technology of ultra-fine green tea powder. Food Industry, 6: 16–18.

Yang Y.Q., Zeng Z.Y. (2003): Study on the process of tea flavor bread. Food and Oil Science and Technology, 6: 14–15.

Yao Y.F., Zhong Y.F. (2011): Study on the process method of pulp biscuits. Food Industry: 6:29

Zhang H., Ruili Q., Yoshinori M. (2019): The impact of oolong and black tea polyphenols on human health. Food Bioscience, 29: 55–61.

Zhang X.F., Wang Y., Yang S.L., Ding Z.T. (2009): Study on development of cookie made with green tea. Science and Technology of Food Industry, 30: 278–282.

Zheng L.N., Liu L. (2013): Formular research of matcha wholemeal cookie. Modern Food Science and Technology, 29: 1362–1364.

Zhou Y.B., Wang D.F., Wan X.C., Zhang L., Du X.F., Hu W.S. (2009): Effect of tea polysaccharide addition on the properties of bread made from two f1ours. Journal of Food Processing and Preservation, 33: 798–813.

Zhou Y.B, Wang D.F., Zhang L., Du X.F., Zhou X.L. (2008): Effect of polysaccharides on gelatinization and retro gradation of wheat starch. Food Hydrocolloids, 22: 505–512.

Zhu F., Ratchaneekorn S., Wang S.N. (2016): Effect of black tea on antioxidant, textural, and sensory properties of Chinese steamed bread. Food Chemistry, 194: 1217–1223.

Zou L. (2016). Effect of grape pomace on the senzory quality and antioxidant capacity of steamed bread. Cereals & Oils, 7: 19–23.

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