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REVIEW

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Food additives and technologies used in Chinese traditional staple foods

Xiaolong Wang, Zhen Ma, Xiaoping Li, Liu Liu, Xiuxiu Yin, Kailong Zhang, Yu Liu and Xinzhong Hu*

Abstract

Noodles and Chinese steamed bread (CSB) represent 70% wheat flour consumption in China. However, fresh noodles and CSB are much produced in small workshop and on family basis. The relatively poor and unstable qualities of wheat flour, as well as the short shelf-life of fresh noodles and CSB have significantly retarded the efficient production of traditional staple foods at large scale and industrial level. This review summarizes the food additives, such as salts, vital wheat gluten, hydrocolloids, esters, enzymes, acids and lots of natural products, used to enhance flour quality and retard staling and microbe growth of noodles and CSB. In addition, recent advances focus on the physical treatments and packaging technologies applied in the production of fresh noodles and CSB were also introduced. The findings in this review would provide reference for further explorations toward the industrialization of traditional staple foods.

Keywords: Noodles, CSB, Quality improvement, Shelf-life extension, Food additives, Package technologies, Industrialization

Introduction

Noodle and Chinese steamed bread (CSB) are two major staple foods in China for many centuries due to their convenience, nutrients and palatability [1–3]. It has been reported that noodles and CSB, respectively, represented 40 and 30% wheat flour consumption in China [4, 5]. However, only 14–20% of wheat flour is applied in the industrial production, and fresh noodle and CSB are much produced in small workshop and on family basis. Currently, due to the socio-economic changes caused by rapid urbanization in China, producing fresh noodles and CSB on large and industrial scale is becoming an inevitable trend.

There are two crucial challenges for the industrialization of fresh noodles and CSB. On the one hand, the production of different noodles and CSB require wheat flours with medium to strong gluten strength, appropriate viscoelasticity and stable hot pasting property [6–8]. But the wheat cultivars in China cannot satisfy the requirements completely due to their weak gluten strength and quality fluctuation caused by genetic and environmental diversity [7, 9, 10]. On the other hand, during storage, some complicated physicochemical and biochemical changes occurred in fresh noodles and CSB, attributing to a shorter shelf-life [11–13]. It is well known that microbial proliferation and staling are the two critical reasons that result in the deterioration of fresh noodles and CSB [14–16]. Previous studies have figured out that mold, bacteria and yeast are the key microbes involved in the microbial proliferation of fresh noodles and CSB [17, 18]. The staling is attributed to both amylose and amylopectin of starch. Specifically, amylose re-association is related to the short-term retrogradation during the initial few hours, while amylopectin re-crystallization is associated with product firming in the longer term [19]. CSB possesses much high moisture content, around 39–44 and 42–47% in crumb and crust, respectively [20–22], so staling increasingly occurred with the water loss during storage, leading to the firmness increase and freshness loss of CSB. In contrast, fresh noodles with lower water content showed slower hardening rate although similar staling trend was observed [23]. In addition, enzymatic browning induced by polyphenol oxidase (PPO) had

*Correspondence: hxinzhong@126.com
College of Food Engineering and Nutrition Science, Shaanxi Normal University, Xi'an 710119, China

been implicated as a leading cause for short shelf-life of fresh noodle too [24].

To improve the quality of wheat flour and extend the shelf-life of fresh noodle and CSB, a variety of additives has been incorporated in the formulations. Salts, vital wheat gluten, hydrocolloids, esters, enzymes, acids and lots of natural products have been widely used as gluten fortifier, emulsifier, thickener, stabilizer, oxidants, reductant and pH regulator in individual or complex ways for improving flour-processing quality, as well as retarding staling and microbe growth of fresh noodle and CSB [25–32]. The quality of fresh noodle and CSB are not only dependent on the quality of the ingredients but also on the processing and storage conditions [3, 13, 21]. Manipulating production process and storage conditions, such as physical treatments with ozone, radiation, microwave, photons and vacuum mixing as well as packaging methods including vacuum packaging, modified atmosphere packaging (MAP), active packaging and hot packaging, showed promising results for enhancing the shelf life of fresh noodles and CSB [2, 12, 21, 33–35].

In this review, a significant portion of the literature is drawn from the Chinese journals and theses where a rather large amount of research was published. We summarized the recent advances in food additives, as well as processing and storage technologies towards quality improvement and shelf-life extension for fresh noodles and CSB, with an aim to provide reference for further research to support the industrialization of traditional staple foods.

Food additives used for quality improvement of noodles and CSB

Inorganic salt

Salt and alkaline (kansui)

In addition to wheat flour and water, salt, alkaline reagents, and combinations of salt and alkaline reagents (mixtures) are also incorporated in noodle manufacturing. Based on the ingredients, wheat flour noodles can be divided into two categories, one is white salted noodles (WSN) made from flour, sodium chloride and water, and another is yellow alkaline noodles (YAN) made from flour, sodium chloride, alkaline reagents (such as sodium and potassium carbonate) and water [36]. It has been proven that WSN originated in northern China represent 90% of total noodle production in China, the rest being mainly YAN [37].

Sodium chloride is an important component in noodles. The addition of sodium chloride at 2–3% level in Asian noodles could enhance the texture of noodles by strengthening and tightening the gluten network to increase the viscoelasticity [38]. It is known that adding sodium chloride decreases water absorption but it increases the dough development time. Although increase in the number of disulphide bond was observed when the dosage of sodium ranged from 1 to 5% [39], more research suggested that the optimum adding amount of sodium chloride was around 2% [32, 40], where the overall quality of noodles, including texture, brightness, cooking properties and flavor, was enhanced significantly [41, 42].

Alkaline reagents are preferred, especially by Cantonese people, for making alkaline noodles [32]. It is believed that the original purpose of adding alkaline in noodles is to prolong the noodle shelf life by retarding the mold growth [37]. Sodium carbonates, or potassium carbonates, or the mixture of the two (typically 9:1, kansui) are the most common alkaline salts used in alkaline noodles [43]. The addition rate of alkaline salts depends on the noodle types. Specifically, the optimum dosage is 1.0–1.5% for fresh alkaline noodles and 0.3–0.5% for steamed alkaline noodles [37]. The quantity of sodium hydroxide is usually 0.3–1.0% for the partially boiled alkaline noodles. Alkaline–flour interactions are responsible for several effects, including strengthening of the dough texture [44]; reducing the dough development time and dough stability; improvement in both the firmness and chewiness of noodles [45]; retardation of starch gelatinization and increase in starch paste viscosity [44, 46]; inhibition of enzyme activity and enzymatic browning [43, 47]; and also contribution to the bright yellow color, aroma and flavor [47].

Phosphates

In some cases, calcium carbonate or sodium/potassium phosphates with or without sodium chloride are also used in cereal foods. The food-grade phosphates (sodium, calcium, and potassium salts of phosphoric acid) impart numerous physicochemical properties in foods, including moisture adsorption, pH adjustment, buffering, protein dispersion, emulsification, ion exchange, sequestration of minerals, flavor, improved whipping, foam stability, cryoprotection, and texture development [48–50]. According to the national hygienic standard of food additives in China, 14 phosphates have been allowed to use as food additives. Sodium tripolyphosphate (STPP), sodium hexametaphosphate (SHMP), sodium pyrophosphate (SPP) and sodium dihydrogen phosphate (SDHP) are commonly used in a single or complex way in the processing of Chinese traditional cereal foods.

Wu et al. [51] found that the moisture-retention capacity of composite phosphate contributed to the full hydration and swelling of gluten protein, which subsequently enhanced the gluten network, dough stability, viscoelasticity and cooking resistance of noodles. It was reported that tripolyphosphate could improve the whiteness of noodle, while hexaphosphate contributed to a delayed browning of noodle [52]. The possible explanation for this finding is that phosphate provided a stable pH and prevented oxidation via sequestration cation in the dough, which both contributed to the good color retention of noodle [53]. Besides, phosphate could enhance the interaction between protein and starch, which not only conducted to a good viscoelasticity but also prevented the starch leaching during cooking [54].

Niu et al. [28] investigated the impacts of four inorganic phosphates on the thermodynamic, pasting and noodle-making properties of whole wheat flour. The Results showed that the gelatinization temperature and enthalpy of melting of starch in whole wheat flour were increased with the addition of phosphates. All phosphates significantly increased peak viscosity and final viscosity of whole wheat flour. Moreover, the whole wheat noodles incorporated with disodium phosphate, trisodium phosphate, and STPP showed brighter appearance, and the use of STPP and SHMP reduced the cooking loss of whole wheat noodles. Texture profile analysis of cooked noodles indicated that adding phosphates significantly decreased the firmness, while the springiness, cohesiveness, and resilience were slightly reduced. The microstructure of whole wheat noodles showed a close connectivity of the protein network and coverage of starch granules in the presence of inorganic phosphates. The results suggested that inorganic phosphates exhibited substantial effects on enhancing the quality of whole wheat noodles. Of all the flour inorganic phosphates, STPP seems to be the most effective one in improving the overall quality of whole wheat noodles.

The moisture retention capacity of phosphates could improve the weight and volume of CSB significantly, while the hardness of steamed bread was reduced as the water absorption increased [55]. Besides, the leaven function was enhanced due to the sequestration of minerals and enhanced protein–starch interactions caused by the addition of phosphates [56]. It has been reported that the phosphate also contributed to the whiteness of steamed bread, which mainly due to a more intense and uniform crumb was formed after the addition of phosphate [57]. Phosphates are commonly used in the quality improvement of quick frozen foods. Quick frozen dumplings accounts for 33% of the total quick frozen foods in China [58], however, the common problems, such as frost cracking, outflow of stuffing juice, sticky texture, poor elasticity, browning and cooking loss, appeared in the practical production retarded its industrialization [59]. Therefore, phosphates were used as additives to alleviate the above-mentioned challenges in production. Phosphates added in frozen dumplings gave cracking resistance and good appearance for frozen dumplings due to their water-holding capacity, in which STPP showed the best performance in all the applied phosphates [59]. For the browning inhibiting, the function of phosphates can be explained in two ways. First, the enzymatic browning was delayed by the sequestering of metal ions [60]. Second, the water-holding rate was increased by the phosphates, which prevented the browning reaction caused by the outflow of stuffing [61].

Vital wheat gluten

Gluten, the dough-forming protein of wheat flour, is the key to the unique ability of wheat suit to a wide range of products. Given the unique viscoelastic properties of wheat gluten, the dry vital wheat gluten, a commodity separated from wheat flour, was widely applied in Chinese traditional cereal foods. Vital wheat gluten usually contains approximately 75% protein, up to 8% moisture, and a small amount of starch, lipid and fiber [26]. It is commonly incorporated into the wheat flour or coarse grain powder to confer a stronger dough strength required for the noodle or CSB making.

Park et al. [62] investigated the impact of gluten on the white salt noodle making with flour from hard and soft wheat. The results showed that gluten incorporation (6%) reduced water absorption of noodle dough by 3%, shortened the length of the dough sheet by 15 and 18%, and increased the thickness of the dough sheet by 18 and 20% in soft and hard wheat flour, respectively. Noodles imbibed less water and imbibed water more slowly during cooking with gluten incorporation, which resulted in a 3-min increase in cooking time for both soft and hard wheat noodles. Despite the extended cooking time of 3 min, noodles incorporated with 6% gluten exhibited decreases in cooking loss by 15% in soft wheat. In hard wheat flour, cooking loss of noodles was lowest with 2% incorporation of gluten. For multi-grain noodles, buckwheat noodle making with 70% wheat flour and 30% buckwheat flour and addition of 5% vital wheat gluten led to the best viscoelasticity and sensory characteristics of cooked noodle [63]. The research conducted by Wang et al. [64] indicated that, when using the combination of vital wheat gluten and transglutaminase (TG) at appropriate formula, oat noodle quality was significantly improved. As reported by a variety of studies, vital wheat gluten played an important role in the quality improvement of CSB. It conferred enhanced specific volume, appearance and texture to CSB, the optimum dosage of vital wheat gluten for CSB making with wheat, wheat–oat mixture, and wheat–corn mixture are 2, 5 and 1%, respectively [2, 65, 66]. It is clearly reflected by the above results that the optimum amount of vital wheat gluten in the formulations of noodles and CSB was depended on the protein quantity and quality in flour, more vital wheat gluten was required for the flour protein with low content and poor quality.

Ester

Esters, acting as thickeners and emulsifiers, are widely used in the formulas of noodles and CSB. Numerous studies have reported that propylene glycol alginate (PGA) can be used for improving noodle quality. Yang et al. [67] carried out a research that PGA influences the acidity of wet noodles, property and texture. The water absorption, dough viscoelasticity, noodle hardness and elasticity were enhanced with the addition of PGA, its optimum adding amount was 0.3%. This finding was confirmed by the research of Yang et al. [68] who also found that the optimum dosage of PGA in fresh noodle was 0.3%. Liu et al. [69] investigated the effects of low-ester PGA on noodle quality. The results showed that low-ester PGA used in the noodles can effectively improve noodle quality; and when the content of low-ester PGA was between 0.2 and 0.3%, the hardness, chewiness and glue viscosity of noodles were increased greatly; meanwhile, the water absorption and dissolution rate of starch were reduced; noodles had the best chewiness, smoothness, and taste. The fatty acid sucrose ester was also involved in noodle making, which showed that the cooking quality of middling noodles improved greatly when the noodles were added 1.5% fatty acid sucrose ester [70].

Regarding CSB, calcium stearoyl lactylate (CSL), sodium stearoyl lactylate (SSL) and glyceryl monostearate (GMS) are widely applied in individual or composite ways for quality improvement. The optimum formulation for the best anti-aging was sodium stearyl lactate 0.15%, glyceryl monostearate 0.05%, sucrose ester of fatty acids 0.15% [27]. Besides, the effects of diacetytartaric esters of monoglycerides (DATEM), CSL and SSL on CSB was investigated, which indicated that CSL–SL was beneficial to dough viscoelasticity; mixture of DATEM, CSL–SSL in flour decreased the dough extensibility while noodle whiteness was increased [71].

Hydrocolloid

Gums consist of a number of water-soluble polysaccharides that come with different chemical structures and provide diverse functional properties such as gelling, thickening, stabilizing, foaming, emulsifying, as well as inhibiting syneresis during a freeze–thaw cycle, water-retention and texture-enhancing properties, by controlling the water molecule mobility [72]. Based on the previous studies, the impacts of gums on dough-functional performance and food quality are depending upon the nature, origin, particle size, molecular structure and ionic charges of the gums, and also on the dosages of gums added to the dough formulations [73]. Alginate, k-carrageenan, xanthan, guar gum, pectin, hydroxypropylmethylcellulose (HPMC) and some modified starches are extensively used in the formulations in the Chinese traditional cereal foods, especially for noodles and CSB. The positive functions of these hydrocolloids are summarized as following [74]: (1) improve food texture, (2) retard the retrogradation of the starch, (3) increase moisture retention, (4) extend the overall quality of the product during time, and also (5) as gluten substitutes in the formulation of gluten-free breads since gums could act as polymeric substances that mimic the viscoelastic properties of gluten in bread dough.

There are a number of studies focussing on the effects of hydrocolloids on dough-rheological characteristics. It has been reported that the hydration property of wheat flour–hydrocolloids mixtures was greatly increased due to the high affinity of hydrocolloids to water, which would affect the dough-rheological properties and food quality significantly [75]. Rosell et al. [72] investigated the effect of four widely used hydrocolloids, including sodium alginate, k-carrageenan, xanthan gum and HPMC, on the rheological properties of the wheat flour dough. The results showed that xanthan and alginate had the most pronounced effect on dough properties yielding strengthened dough. A great improvement in dough stability during fermentation was achieved by adding hydrocolloids. Liu et al. [75] investigated the effects of hydrocolloids (HPMC, carboxymethylcellulose (CMC), xanthan gum (XG), and apple pectin (AP)) at different concentrations on potato flour dough-rheological properties and found that HPMC remarkably increased the development time; potato flour dough containing CMC or 0.5% HPMC and AP exhibited lower stability than control. Conversely, the stability was increased by the addition of XG (1.0 and 2.0%) and HPMC (1.0%). Moreover, the effect of hydrocolloids on the pasting properties and gelling behavior of cereal four was also investigated. The influence of the selected hydrocolloids (guar gum, pectin, alginate, k-carrageenan, XG and HPMC) on wheat four pasting was tested by Rojas et al. [74] using amylograph and differential scanning calorimetry (DSC). The results showed that hydrocolloid addition largely modified the amylograph parameters of wheat four at the low levels tested [0.5 and 1% (w/w), four basis] and the extent of their influence depended upon the chemical structure of the added hydrocolloid. The greatest effect on pasting temperature was observed when 1% alginate was added, which produced a decrease of 3 °C. Xanthan and pectin increased the cooking stability while k-carrageenan and alginate did not modify it. The setback was augmented by guar gum and HPMC but alginate, xanthan and k-carrageenan showed the opposite effect. The bump area related to the formation of amylose–lipid complex, was favored by k-carrageenan, alginate and pectin, and slightly affected by xanthan and HPMC. Amritpal et al. [76] found that the addition of xanthan and guar gum improved peak viscosity, hot-paste viscosity and final viscosity for mung and corn starches; while for potato starch, guar gum increased peak and final viscosities and decreased hot paste viscosity while xanthan gum increased hot-paste- and final viscosities and decreased peak viscosity. All those results about the functional properties of hydrocolloids concluded that a unique trend did not exist and the impact of hydrocolloids on dough thermo-mechanical properties greatly depend on the nature of the flour components, the chemical structure of specific hydrocolloid and the quantity of added hydrocolloids [75].

Based on their unique physicochemical properties, hydrocolloids are increasingly incorporated in the formulations of Chinese traditional cereal foods in individual or composite ways, especially for noodles and CSB. The application status of different hydrocolloids is summarized in the next section.

Alginates are a group of viscous polysaccharides extracted from the cell wall of brown seaweeds or produced as an extracellular matrix by some bacterial species. As one of the popular hydrocolloids, alginate is an unbranched polymer composed of (1-4)-linked β-D-mannuronic acid and α-L-guluronic acid that are arranged in homopolymerically or heteropolymerically alternating sequence. Alginates have been widely used as thickeners, emulsifiers, water-holding agents and stabilizing agents in a number of food applications.

According to a number of reports from China, alginates were widely involved in the formulations of Chinese dry noodles and fresh noodles. Generally, noodles with optimum quantity of alginates usually exhibited an increase in the cooked weight, a decrease in the cooking loss and significant increase in the cutting and tensile forces [77, 78]. Moreover, the noodles containing more alginate showed lower lightness and redness, while yellowness was increased. The optimum additive amount of alginates for different noodles was also investigated. Zhao et al. [78] found that the sodium alginate with the viscosity of 300 mPa. s was suitable for noodle making, and the optimum concentration was 0.2–0.25%. Yang et al. [77] reported that the oat flour containing 0.3% sodium alginate exhibited best quality in oat noodle making. As for the buckwheat flour with high dietary fiber (5%), 4% sodium alginate contributed to the best performance of buckwheat noodles [79]. According to the quantity variation of sodium alginate incorporated in different noodles, it is supposed that the optimum quantity of sodium alginate is partially depended on the gluten strength of mixed flour. Wheat flour had stronger gluten strength comparing with oat and buckwheat flour, hence lower quantity of sodium alginate was used in the noodle making. Conversely, relatively the higher quantity of sodium alginate was required for the noodle making using oat flour or buckwheat flour due to their weak gluten caused by lack of gluten proteins. Apart from application in noodle making, alginates, acting as an anti-staling agent, were also increasingly involved in the making of CSB. The results from the study of Sim et al. [30] suggest that at 0.2% addition level, alginate is better than konjac glucomannan in delaying staling of CSB though slight reduction in spread ratio and specific volume were evident.

Apart from alginates, other hydrocolloids, such as CMC, carrageenan, xanthan, guar gum, pectin, konjac gum, artemisia sphaerocephala krasch gum, edible gelatin and some modified starches, usually play a similar role as alginates in improving the overall quality of fresh noodles, dry noodle or CSB. However, variations on detailed performance among these hydrocolloids were observed as reflected by the specific quality indicator.

To select the optimum thickening agent for fresh noodle making, five kinds of hydrocolloids, CMC, sodium alginates, xanthan gum, guar gum and konjac gum, were incorporated in the making of fresh noodle at different concentrations [80]. The results indicated that overall quality of noodle was improved by the addition of all the five gums. The overall quality score increased to the maximum and then decreased with the quantity increasing of hydrocolloids. It is notable that the optimum concentration of hydrocolloids appeared between 0.3 and 0.4%, and the performances of xanthan gum and konjac gum were much better than that of the other three hydrocolloids.

Modified plant starch is an alternative source for hydrocolloids applied in fresh noodle, noodle containing it showed a much springier, smoother, more elastic, and chewier texture than those without it [81]. Yan et al. [82] investigated the effects of three modified starches (waxy potato starch, hydroxypropyl starch, hydroxypropyl distarch phosphate) and artemisia sphaerocephala krasch gum on the dough- and noodle-quality improvement. The results reflected that, when applied individually, artemisia sphaerocephala krasch gum at the concentration of 1%, hydroxypropyl starch at 3 or 7% resulted a better dough quality, while composite hydrocolloids consist of 1% artemisia sphaerocephala krasch gum and 5% hydroxypropyl starch or 1.25% artemisia sphaerocephala krasch gum and 7% hydroxypropyl starch contributed to a better quality of noodle.

The effect of different hydrocolloids on the quality of coarse cereal noodles was also studied. Chen et al. [83] found that the composite thickener showed better performance than single thickener on the quality improvement of oats noodles, and the optimum formula of the composite thickener was: konjac flour 0.2%, edible gelatin

4%, sodium polyacrylate 0.1% and CMC-Na 0.4%. Meanwhile, the functional property of five hydrocolloids in sorghum noodles was evaluated by Kou et al. [84], which concluded that the contribution of the tested hydrocolloids was ranked as: sodium alginate > CMC > konjac gum > guar gum > XG. Low-protein sorghum noodle got the best cooking quality and sensory quality when the sodium alginate was added at 1% level.

Comparing with noodles, few researches on the hydrocolloids application in CSB were reported so far. Sim et al. [30] found that when wheat flour was blended with 0.2% sodium alginates and 0.8% konjac gum to prepare CSB, the quality evaluation in terms of spread ratio, specific volume and staling behavior indicated that, at 0.2% addition level sodium alginates is better than konjac gum in delaying staling of CSB though the slight reduction in spread ratio and specific volume were evident, at 0.8% level, however, konjac gum seems to be better than sodium alginates in enhancing CSB properties. Liu et al. [75] investigated the effects of hydrocolloids (HPMC, CMC, XG, and AP) at different concentrations on the quality of gluten-free potato-steamed bread. The results showed that steamed breads with hydrocolloids presented higher specific volume and lower hardness, and the rapidly digestible starch and estimated glycemic index significantly decreased from 45.51 to 20.64 and from 69.54 to 55.17, respectively. They suggested that HPMC and XG could be used as improvers in the gluten-free potato-steamed bread.

The results described above together reflected that different hydrocolloids show different effects on wheat dough, noodle and CSB quality properties due, probably to their distinctly different molecular structures. It is supposed that hydrocolloids may form higher molecular weight aggregation via the interactions with protein and starch, and which were closely related to the type, ratio and content of the incorporated hydrocolloids. The incorporation of hydrocolloids always shows positive effects on the overall quality of noodles. In noodle making, higher dosage of hydrocolloids is required for the dough with weaker gluten strength, and composite hydrocolloids shows better performance in noodle quality improvement. The effects of hydrocolloids on CSB quality are largely dependant on their molecular structure and addition quantity. In dough matrix, entanglement coupling between glutenin molecules is responsible to maintain the elasticity of the dough, while the extensibility of the dough are governed by the breaking of secondary valence bonds and slippage of entangled chains under deformation. Therefore, low resistance and high extensibility are observed when the rate of chain slippage is much greater than the rate of elongation of the chain. However, if the rate of chain slippage is relatively low, meaning chains slippage occur insufficiently rapidly in response to the applied stress, the chains will break resulting very short distance of elongation. The hydrocolloids differ in structures and additional levels are supposed to change the rate ratio of the chain slippage and chain elongation uncertainly due to their different interaction patterns with the glutenin entanglement. These different interactions are prone to affect the gas-holding capacity of dough and lead to a good or poor CSB quality consequently. As for the anti-staling activity of hydrocolloids, it can be explained by their interactions with starch. The hydrocolloids present in CSB or noodles could hinder the development of macromolecular entanglement and retard the starch recrystallization, thus delaying the staling of CSB and noodles.

Enzymes

Enzymes, a group of "green" food additives with the advantages of low application dosage, high reaction rate, mild reaction conditions and instinctive safety, are commonly used in food processing [29, 85]. As reported in the previous studies, α-amylase, glucose oxidase, xylanase, lipase, lipoxidase and TG are increasingly involved into the production of noodles and CSB (Table 1).

Alpha amylase

Alpha amylase could hydrolyze the starch to dextrin, which provide carbon source to the yeast to produce enough carbon dioxide in dough fermentation [86]. Moreover, the amylose–amylopectin ratio that is closely related to the pasting stability could be changed after the incorporation of α-amylase. It is well known that the starch-pasting property is closely related to the noodle quality. Shi et al. [87] reported that shorter cooking time and lower water absorption of noodle were observed with the increased addition of α-amylase. The adding quantity of α-amylase was negatively related to L^* and a^* value of fresh noodle, while positively related to the b^* value. They concluded that the amylose–amylopectin ratio has been modified by the α-amylase addition, leading to the quality variation of fresh noodle. The study conducted by He et al. [88] showed that the development time of fresh noodle was decreased by the incorporation of α-amylase, and the α-amylase also contributed to the enhancement of texture and sensory properties of fresh noodle. In the CSB making, Ma et al. [89] reported that, when the addition quantity of α-amylase is below 30 mg/kg, the specific volume, internal structure, crumb texture and overall evaluation score of CSB were increasingly improved with the concentration growth of α-amylase.

Table 1 Application of enzymes in the production of fresh noodles and CSB

Enzymes	Function properties		Dosage		References
	Fresh noodles	CSB	Fresh noodles	CSB	
Alpha amylase	Enhance dough fermentation, texture and sensory properties	Improving specific volume, internal structure and crumb texture	60 mg/kg 24 mL/100 kg	< 30 mg/kg	[87–89]
Glucose	Enhance appearance, chewiness, smoothness, cooking tolerance and whiteness	Soft crumb, high whiteness and delayed staling	20–40 mg/kg	20 mg/kg	[91–94]
Lipase	Enhance appearance, whiteness, and elasticity; flavor generation		60 mg/kg		[92]
Xylanase (XynA)		Improving specific volume and hardness		120 U/kg	[98]
Transglutaminase	Reducing water absorption and cooking loss		0.01% (buckwheat noodle)		[102, 103]
	Enhancing hardness and tensile force		2% (YAN)		

Glucose oxidase and lipoxidase

Glucose oxidase and lipoxidase had similar effects on flour-dough development, the hydrogen peroxide produced after the addition of these two oxidases would promote the formation of additional disulphide bond in dough matrix, enhancing the viscoelasticity of dough [90]. Besides, flour whiteness could be improved because of the interaction between carotene and lipoxidase [90]. Researches on the effects of glucose oxidase on noodle quality indicated that the noodle appearance, chewiness, smoothness, cooking tolerance and whiteness were improved by the addition of glucose oxidase and the recommended dosage was at 20–40 mg/kg [91, 92]. Glucose oxidase was also used in the formulation of CSB produced by wheat flour or multi-grain flour, it conferred soft crumb, high whiteness and delayed staling to the CSB and the optimum dosage was determined at 20 mg/kg [93, 94]. As for the lipoxidase, Cato et al. [95] investigated the effects of lipoxidase on WSN and found that whiter noodle sheets were obtained when a soybean lipoxidase was added to the formulation. Textural and structural properties of WSN were not adversely affected by enzyme addition, giving firm, elastic and non-sticky products. It is concluded that the incorporation of the lipoxidase offered prospects for color enhancement of white salted noodles. These findings were in line with the study of Zhang [96], who elucidating the contribution of a recombinant lipoxidase (ana-rLox) to the noodle quality improvement.

Lipase

The lipase could hydrolyze the lipid in flour into a mixture of fatty acids, monoglycerides and diglycerides. It is supposed that the monoglycerides are prone to form complex with amylose and protein, which reducing the starch staling and cooking loss of cereal foods [90]. Lipase was seldom used individually in noodle making. Shan et al. [92] studied the impacts of lipase and glucose oxidase on the noodle quality and found that the appearance, whiteness, and elasticity of noodles were improved at most when the formulation containing lipase at 60 mg/kg and glucose oxidase at 40 mg/kg simultaneously. Relationships between lipase, lipoxidase and peroxidase activity, along with quantity of individual free fatty acids and levels of headspace volatile compounds of boiled buckwheat noodles, were investigated using 12 different buckwheat varieties by Suzuki et al. [97]. The results indicated that lipase and peroxidase in buckwheat flour was involved into the flavor generation of boiled buckwheat noodles. This finding was important for increasing desirable flavor of buckwheat products as well as for selecting varieties with improved flavor.

Xylanase

Arabinoxylans (AX) constitutes the major non-starch polysaccharides in wheat, water-extractable AX (WE-AX) and solubilized high-molecular-mass AX (S-AX) have a positive effect on dough stability and mechanical properties, while water-unextractable AX (WU-AX) has a negative effect [98]. Therefore, xylanases that preferentially hydrolyze WU-AX and leave WE-AX and S-AX unharmed have the greatest beneficial effect on flour products, when added at the appropriate quantities [99, 100]. Yang et al. [98] have incorporated a recombinant xylanase named XynA to the formulation of CSB. The results showed that, when using XynA at the optimal amount in the preparation of CSB, both the specific volume and hardness of the CSB were improved greatly.

Transglutaminase

Transglutaminase (TG) catalyzes acyl-transfer reactions, creating inter- and intra-molecular cross-links between lysine residues and glutamines residues, forming the so-called e(c-glutamyl)-lysine isopeptide bonds [101]. The cross-linking action of TG leads to the formation of very high molecular weight gluten proteins, reinforcing the gluten protein network and enhancing the mechanical properties and hot stability of dough [102]. The investigation for effects of TG on quality of buckwheat noodle showed that, addition of TG significantly decreased the water absorption and cooking loss of noodles, increased the hardness and tensile force. When adding 0.01% TG, the lowest cooking loss of buckwheat noodle was observed [103]. Bellido et al. [102] investigated the effects of TG on the protein composition, mechanical properties and microstructure of yellow alkaline noodles. The results indicated that, in the presence of TG, the unextractable glutenin was greater than 225–300% over that of corresponding flour from three different varieties. Comparison of the mechanical properties of YAN formulated with and without TG showed that the firmness and elastic-like behavior of the noodle increased with the TG supplementation.

Composite enzyme

Although enzymes play important roles in the quality improvement of noodles and CSB, individual utilization of enzyme which catalyzing specific reaction always limits the overall quality improvement. As so, the explorations of composite enzymes aiming at the overall quality improvement of noodles and CSB have been conducted. A Box–Behnken and Response Surface Methodology were used to analyze the effect of enzymes on noodle quality. The independent variables were xylanase, glucose oxidase and lipase and their interactions between each other were also taken into consideration. The model was optimized by response of sensory evaluation score and L^*. The optimized formula of enzyme was xylanase 213 mg/kg, glucose oxidase 67.43 mg/kg and lipase 5 mg/kg [104]. Regarding the CSB, Ren et al. [105] found that the composite enzymes consisted of amylase 3 mg/kg, xylanase 10 mg/kg, lipase 4 mg/kg and glucose oxidase 18 mg/kg were appropriate for the CSB making, while Meng et al. [94] recommended the formula including glucose oxidase, lipase and α-amylase, respectively, at 20, 50 and 5 mg/kg for the CSB supplementation. It seems that the addition amount of α-amylase, glucose oxidase in the formula for the CSB making have remained relatively consistent. However, some enzymes, such as lipase and xylanase used in individual or composite ways for noodle making showed great variations on their optimum dosages. It is supposed that the differences in the ingredients, enzyme source and activity as well as processing conditions all lead to the optimum dosage variations of enzymes.

Although some enzymes, esters and hydrocolloids show the anti-staling property in the production and storage of CSB and noodles, but they interact with starch in different patterns. In terms of esters, they can form complexion with the helical amylose via hydrophobic bonds, thus reducing the recrystallization of starch. Meanwhile, the interaction between external branch of amylopectin and esters via hydrogen bonds also impedes the starch staling. The anti-staling mechanism of hydrocolloids is as follows: (1) the good film-forming property of hydrocolloids reduces the moisture loss; (2) the hydrogen bonds formed between hydrocolloids and starch impeding the recrystallization of starch; (3) the high water-holding capacity of hydrocolloids improves the moisture of noodles and CSB. As for the enzymes, α-amylase could hydrolyse the starch to dextrin, which interfering the crystallization of starch; lipase could hydrolyse the lipid into a mixture of fatty acids, monoglycerides and diglycerides, which reducing the starch staling like the role of esters.

Comparing with other food additives, enzymes possess unique properties such as high specificity, high rate of catalysis, high thermo-stability and safety. Most of the enzymes applied in noodles or CSB are intended to catalyze the reaction of polysaccharide or proteins. The enzymes (especially amylases of various sources) aimed at the modification of starch, show great potential for the quality improvement of noodles. However, the transglutaminase, oxidases and protease, which focusing on the gluten network modification, might be of more benefit to the quality of CSB. Optimum dosage of enzymes in noodles or CSB is essential to maximize their function. However, the optimum dosage is susceptible to the food ingredients and processing conditions. As so, on the one hand, the enzyme suitable for specific noodle or CSB is required in future. On the other hand, the enzyme act at wide pH and temperature should be also developed. Comparing to the enzyme application in bread, more enzymes specific for Chinese traditional foods should be developed. For example, enzymes used for the flavor enhancement and anti-staling of CSB or noodles should be taken into consideration.

Preservative applied in the production of noodles and CSB

Because of high moisture content, the shelf life of fresh noodles and CSB is largely shortened by the microbial growth. Therefore, chemical and natural preservatives were commonly used to prolong the shelf time of traditional cereal products. Varieties of preservatives with different properties were involved into the production of fresh noodles. Inorganic acids, such as benzoic acid, sorbic acid and propionate as well as organic acids including glycine, lactic acid and citric acid were widely used as antimicrobial agents due to their pH-regulating capacity [31]. A complex preservative, consisting of ε-polylysine 120 mg/kg, citric acid 0.5%, potassium sorbate 0.08%, sodium diacetate 0.04% and calcium propionate 0.015%, developed by Zhang et al. [106] has been proved for extending the shelf time of fresh noodle to 60 h at 20 °C. Some oxidants were used as antimicrobial agents in fresh noodles. Chlorine dioxide and hydrogen peroxide at 0.04 and 0.03% in wheat flour has prolonged noodle shelf time to 4 and 6 days, respectively [107]. Composite preservatives consisting of natural products, such as nisin, lysozyme, natamycin, chitosan and Chinese herb medicine extracts, were also incorporated in fresh noodles. The appropriate mixture of dimethyl fumarate, nisin and natamycin has prolonged the shelf life of fresh noodle to more than 85 days at 37 °C [108]. While Zhou et al. [109] found that the combination of lysozyme and Chinese herb medicine extracts showed great potential to inhibit the microbial growth in noodles.

As for the preservatives application in CSB, fewer researches were conducted than that of fresh noodles. Zhao et al. [110] investigated the effects of different preservatives on CSB shelf time. The results showed that the shelf time of CSB reached over 78 h when incorporating the complex of vinegar and calcium propionate, while it felt below 12 h when vitamin c and ethanol were used. Besides, it is notable that, adding complex spicy essential oil diluted by pure ethanol (0.3 μl/L) together with cold storage condition can prolong the shelf time of CSB significantly [25]. Moreover, the impact of sourdough (10, 20, 30%) on quality and microbial shelf life of CSB was investigated. Results showed that the addition of sourdough (10, 20 and 30%) decreased the pH of CSB to 4.5, 4.3, 4.0, and extended the microbial shelf life to 8, 30 and 40 days, respectively [111].

According to the existed researches, lots of chemicals and natural products have been used for the shelf-life extending of fresh noodles, the potential of natural products especially Chinese herb medicine need to be further explored to meet the requirements of specific product. In contrast, fewer studies about the preservatives in CSB have been carried out, suggesting more works are needed in the future.

Technologies for shelf-life extension of noodles and CSB

It is well known that microbial proliferation and staling are the two critical reasons resulting in the deterioration of fresh noodles and CSB [2, 15]. The staling is attributed to both amylose and amylopectin of starch. Specifically, amylose re-association is related to the short-term retrogradation during the initial few hours, while amylopectin re-crystallization is associated with product firming in the longer term [19]. Fresh noodles and CSB have exhibited the similar staling trend during storage, although a slower hardening rate was observed in fresh noodles. As for the microbial growth, mold and bacteria are supposed to be the two crucial microbes determining the microbiological shelf life of fresh noodles and CSB [31, 111].

As mentioned in the previous sections, varieties of anti-staling agents including esters, hydrocolloids and enzymes, etc., as well as chemical and natural preservatives have been utilized to enhance the shelf life of fresh noodles and CSB. However, the increase in shelf life only depending on the food additives cannot satisfy the requirement of efficient production of fresh noodles and CSB at large scale and industrial level; hence, extending shelf life via manipulating production process and storage conditions has already become an irresistible trend [2, 12, 21, 33–35]. In the following section, the research progress focus on the physical treatment and packaging technology of fresh noodles and CSB would be introduced.

New technologies used in fresh noodle

Physical treatments

Treatment with ozone, radiation, microwave and vacuum mixing were reported as the new technologies enhancing shelf life or quality of fresh noodles. Li et al. [2] investigated the effects of ozone treatment on the microorganism mortality in wheat flour and shelf life of fresh noodles. The results showed that the total plate count (TPC) can be largely reduced in wheat flour exposed to ozone gas for 30 and 60 min. Microbial growth and darkening rate of fresh noodles made from ozone-treated flour were delayed significantly. While Yang et al. [35] found that the optimal ozone treatment parameters for fresh fish noodle were ventilation of 6 L/min for 20 min then sterilizing for 10 min. Under the conditions, the shelf life of noodles treated by 100% CO_2 in the package was 22 days at − 0.8 °C. Cai et al. [112] reported that the shelf life of fresh noodle increased to 10 days with the Co60 γray treatment at 10 kGy, while significant extending of shelf life of fresh noodle was also observed under the treatment at 4 kGy [113]. Moreover, Xie and Li [114] found that the fresh noodle can be stored over 28 days with the 20 s microwave (700 W) treatment at 4 °C. As for the vacuum mixing, − 0.06 MPa was considered as the best degree for noodle production. In addition, vacuum mixing could promote the formation of bound water in the dough and effectively reduce water activity at certain moisture content, resulting in the extended shelf life of fresh noodle [33].

Packaging technology

Vacuum packaging, modified atmosphere packaging (MAP) and active packaging are widely used in food package. Vacuum packaging is not suitable for fresh noodles due to the surface adhesion and deformation of noodles caused by the squeeze. The effect of reduced O_2- and elevated CO_2-modified atmospheres and abuse temperature (15 °C) on the growth of *Penicillium aurantiogriseum* were evaluated by Zardetto [115]. The results indicated that, no fungal growth was observed for up to 550 h of incubation at 15 °C when samples were packaged in atmospheres with CO_2 concentrations higher than 70%. Nobile et al. [116] explored the combined effects of chitosan and MAP to improve the microbiological quality of amaranth-based homemade fresh pasta. The results suggested that there was a combined effect between MAP and chitosan in delaying the microbial quality loss of pasta during storage. Moreover, it was also found that, among the tested MAP conditions, the ratio of N_2/CO_2 at 30/70 is the most efficient combination, which promoting an extension of the microbial acceptability limit beyond 2 months.

Generally, the individual physical treatment or packaging technology usually has limitation for extending shelf life. Exploration on the synergistic interactions among preservatives, temperature, physical treatment and packaging technologies should be highly regarded for long-term storage of noodles and CSB.

New technologies used in CSB

Physical treatments

Similar to noodles, a series of physical treatments have been applied to increase the shelf life of CSB. Han and Wang [117] studied the effects of irradiation on the quality of CSB, the results showed that ^{60}Co at 6 kGy companied with 10 min steaming sterilization (100 °C) pre-treatment can effectively extended the shelf life of CSB for 6 months. The sterilization of steamed bread made by yeast and special flour were investigated by Xiong et al. [118]. The results indicated that the shelf life of CSB was extended to 3–6 months when the sterilization condition was microwave 150 °C for 70 s. Liu et al. [34] explored the effects of photos on the quality of CSB, the results reflected that, after the samples were stored at 4 °C for 2, 4, 7, and 12 days, the sensory scores of the photon-treated group were all higher than those of control group, and mold spots appeared on the control samples on day 12. The differences on the retrogradation degree and protein conformation between CSB with and without photon treatment revealed that the preservation effects of photons on steamed bread could be achieved by affecting the starch retrogradation and protein-secondary structure of steamed bread.

High temperature (above 100 °C) companied with appropriate irradiation or microwave treatment showed excellent performance on the shelf-life extension of CSB. However, the greatly extended shelf life was mainly ascribed to the inhibited microbial growth in CSB. Increasing hardness and taste variation were observed with the prolonging of storage time. Different from irradiation or microwave treatment, photon treatment was supposed to prolong the shelf life of CSB due to its anti-staling activity, but much faster microbial growth occurred during storage comparing to irradiation or microwave treatment. Because the limitation of different physical treatments, composite treatments or physical treatments combined with food additives should be considered for the shelf-life extension of CSB.

Packaging technology

Several packaging methods towards extending shelf life of CSB have been developed. The effects of MAP on the quality of CSB showed that, the shelf life of CSB can be increased significantly when packing without oxygen. Extended shelf life of CSB was observed with the increasing content of CO_2, and the shelf life was prolonged to 12 days when packing with the 100% CO_2. In addition, the shelf life of CSB was extended to 18 days when the ultraviolet radiation and MAP packaging were applied simultaneously [119].

The active packaging [oxygen absorber (OA) and ethanol emitter (EE)] has been applied to extending the shelf life of CSB [21]. Microbiological shelf life of CSB (mold, bacteria and yeast) was extended up to 11 days [(by oxygen absorber combined with ethanol emitter (OA + EE)]. Textural and DSC analysis showed that active packaging decreased the CSB staling. This may be due to the packaging which prevented the moisture loss during storage. CSB packaged with (OA + EE) had lower hardness development in the first 7 days of storage than that with OA [21]. Ethanol might act as plasticizers for the protein fractions, lowering the protein–starch associations during storage. Though ethanol had no effect on the recrystallization of amylopectin, it might interact with amylose fraction for the formation of complexes. The amylose–ethanol complexes may reduce the amylose–amylose interactions for retrogradation.

The moisture migration from crust to crumb was related to the staling of CSB [120]. Hot packaging is a novel technology that can be used for extending CSB shelf life. As shown in Fig. 1 [120], the moisture migration in CSB was ended after storage in room temperature for 20 days. Two challenges need to be faced in hot packaging: the water vapor will condense inside the package and the packaging bag will expand because of heat. But, the unique advantage is that it can protect against

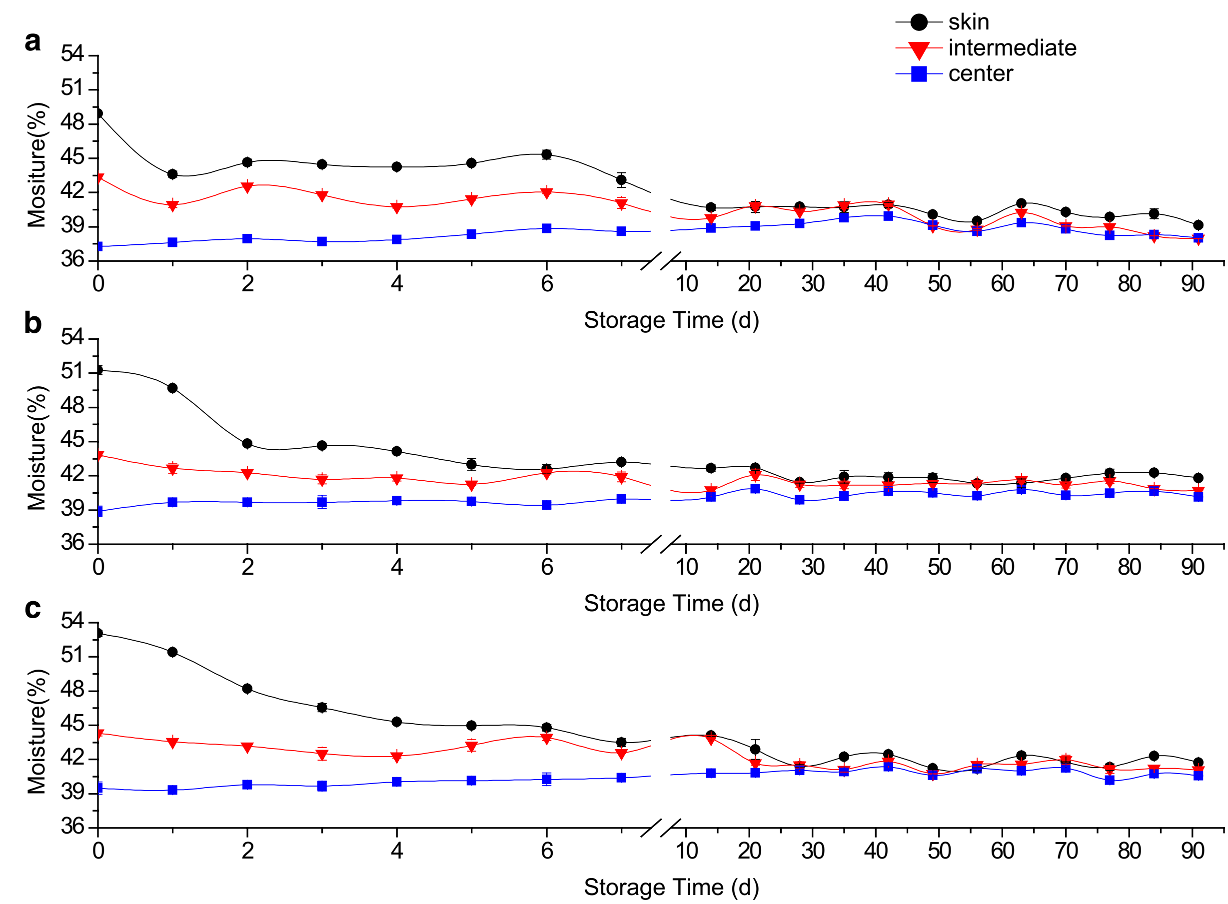

Fig. 1 The changes of moisture of different zones of steamed buns during storage at room temperature: water addition of dough is 40% (**a**), 42% (**b**) and 44% (**c**) (adopted from [120])

contamination, and save space without cooling. For CSB manufacturers, hot package technology can significantly increase processing efficiency and reduce costs. To solve the problems of the short storage time, mold growth at room temperature storage, retrogradation in steamed bread production, and also to meet the requirements of safety and convenience, as well as industrialization, there is promising data from the technology using traditional yeast for fermentation, combined with online hot-packing technology to produce CSB. The results showed that the microorganism index, including *Staphylococcus aureus* and *E. coli*, met the requirements of the national standard. In addition, there was no significant change in protein content, moisture content, fat content, a\nd starch retrogradation, as measured using X-ray diffraction [120]. Utilizing this technology, water vapor disappeared after 3 days of storage, without leading to water condensation on the surface, thus having a similar effect as vacuum packaging. This technology saved energy consumption and minimized secondary contamination during transportation and retailing. The CSB packaged by this technology can be maintained fresh up to 90 days without any additives, giving good taste along with least starch retrogradation [120].

As described above, to achieve the prolonged shelf life, physical treatment and high concentration of CO_2 were required for the MAP, while oxygen absorber and ethanol emitter had to be prepared for the active package. In contrast, hot packaging, which showing additional advantages such as low secondary contamination, self-sterilization, self-vacuum, low energy input and simple operation, contributed to the much longer shelf life than that of MAP or active packaging. It is supposed that the hot packaging technology would be widely applied in the storage of Chinese traditional staple foods in future.

Conclusion and future perspective

Traditionally, fresh noodles and CSB are much produced in small workshop and on family basis in China. Developing noodles and CSB industry requires efficient strategies to solve the problems appeared at processing and storage stages. To date, there are great advances in the development of food additives towards good quality and prolonged shelf life of fresh noodles and CSB. On the one hand, salts, vital wheat gluten, hydrocolloids, esters and enzymes have been incorporated in individual or composite ways to enhance the processing quality or to retard the staling of fresh noodles and CSB. On the other hand, antimicrobial agents, such as acids, oxidants and some natural products were utilized to extend the microbiological shelf life of fresh noodles and CSB. Apart from additives, manipulating production process and storage conditions also showed promising results for enhancing quality and shelf life of fresh noodles and CSB. Treatment with ozone, radiation, microwave, photons and vacuum mixing, as well as packaging methods such as vacuum packaging, MAP, active packaging and hot-online packaging have been employed to manufacture fresh noodles or CSB with significantly extended shelf life.

Quality improvement and shelf-life extending are still two major challenges for the production of fresh noodles and CSB at large scale and industrial levels. Compared to the research on bread, pasta and instant noodles, little is done in fresh noodles and CSB. To further promote the industrialization of fresh noodles and CSB, following topics should be better addressed in future:

(1) To ensure the excellent and stable quality performance of wheat flour, wheat cultivars suitable to the production of specific noodle or CSB should be screened out.
(2) Sodium salts, such as sodium chloride, sodium alginate, sodium hydrates and sodium phosphates were involved in the formulations of noodles and CSB for the quality improvement. However, high intake of sodium deviated from the principle of low sodium diet. As so, sodium in noodles and CSB need to be partially substituted by potassium, enzyme or some organic products with the similar property.
(3) Comparing with other additives, enzymes have inherent advantages in the production of noodles and CSB. Although some enzymes have been applied as the substitutes of traditional additives, for example lipase has been used to replace some emulsifiers, while TG is the substitute of vital gluten, further investigation about the food-grade enzymes is still required to support the large scale production of noodles and CSB in China. First, more accurate formula of composite enzyme aiming at specific noodle or steamed bread need to be developed. Second, based on the technology of recombinant DNA, protein engineering, etc., novel recombinant enzymes suitable for the specific processing conditions should be manufactured. Finally, although enzymes used in food processing have historically been considered non-toxic, some characteristics, such as allergenicity, activity-related toxicity, residual microbiological activity and chemical toxicity arising from their chemical nature and source, are of high concern. Therefore, safety evaluation of the food-grade recombinant enzymes including those produced by the genetically modified microorganisms is still essential to assure consumer safety.
(4) Hydrocolloids and enzymes usually act as emulsifier, thickener, gluten fortifier, anti-staling agent even antimicrobial agent in the processing and storage of noodles and CSB. The function properties of these additives mainly attributed to their interactions with protein, starch, lipid and other components in foods, hence further exploration on the interaction mechanisms need to be conducted.
(5) Multi-grain noodle and CSB is being a research focus due to their nutritional value and high consumer acceptance. However, oat, buckwheat or other cereals usually show poor viscoelasticity in dough development due to the lack of gluten proteins, thus more formulas of composite additive consisting of vital wheat gluten, hydrocolloids, TG and other gluten fortifiers should be developed to enhance the dough stability of multi-grain flour. Moreover, complex additive aiming at specific products has played important role in the noodle and CSB making, the mechanism of cooperation and antagonism of different additives such as salts, hydrocolloids, enzymes and preservatives in the mixture should be clarified to support the development of new composite additive with accurate formula.
(6) Physical treatments and packaging methods have showed much higher efficiency in shelf-life extending for noodles and CSB. On the one hand, novel technologies such as high pressure, ultrasound, pulsed electric field, and plasma treatments can be employed for their potential anti-staling impact. On the other hand, the function mechanism for the physical treatments and packaging methods are worth of further investigation.

Abbreviations

CSB: Chinese steamed bread; MAP: modified atmosphere packaging; WSN: white salted noodles; YAN: yellow alkaline noodles; STPP: sodium tripolyphosphate; SHMP: sodium hexametaphosphate; SPP: sodium pyrophosphate; SDHP: sodium dihydrogen phosphate; TG: transglutaminase; PGA: propylene glycol alginate; CSL: calcium stearoyl lactylate; SSL: sodium stearoyl lactylate; GMS: glyceryl monostearate; DATEM: diacetytartaric esters of monoglycerides; HPMC: hydroxypropylmethylcellulose; CMC: carboxymethylcellulose; XG: xanthan gum; AP: apple pectin; DSC: differential scanning calorimetry; AX: arabinoxylans; WE-AX: water-extractable arabinoxylans; S-AX: solubilized arabinoxylans; WU-AX: water-unextractable arabinoxylans; TPC: total plate count; OA: oxygen absorber; EE: ethanol emitter.

Authors' contributions
XH and XW conceived the paper. XW, XH, ZM participated in the literature view and selection and in drafting of the manuscript. XL and LL participated in the literature selection and revised the manuscript critically. XY, KZ and YL participated in the literature selection, paper writing and revising. All authors read and approved the final manuscript.

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