Food Research 9 (4) : 95 - 105 (August 2025)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

MINI REVIEW

Enhancing Chinese steamed bread: a comprehensive review of food ingredients and their impact on physical characteristics, rheological properties, and nutritional composition

[1]Abdul Aziz, A.H., [2]Zainol, M.K., [3]Putra, N.R. and [1,*]Mamat, H.

[1]*Food Safety and Security Research Laboratory, Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia*
[2]*Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, Mengabang Telipot, Kuala Nerus, Terengganu, 21030, Malaysia*
[3]*Research Center for Pharmaceutical Ingredients and Traditional Medicine, National Research and Innovation Agency, Bogor 16911, Indonesia*

Article history:
Received: 12 August 2023
Received in revised form: 12 October 2023
Accepted: 7 September 2024
Available Online: 9 July 2025

Keywords:
Steamed bread,
Fermentation,
Dough rheology,
Nutritional composition

DOI:
https://doi.org/10.26656/fr.2017.9(4).256

Abstract

Chinese steamed bread is made from wheat flour and water as the main ingredients and fermented with yeast. In recent years, significant progress has been made in incorporating innovative food additives into Chinese steamed bread (CSB) to improve its overall quality and meet the changing demands of modern consumers. This review provides an overview of these advances, focusing on the effects of food additives on the physical and rheological properties of the dough and the nutritional composition of the final CSB products. The knowledge gained from these studies was presented in a cohesive manner, allowing for a detailed discussion of the various aspects relevant to the production and analysis of Chinese steamed bread. By examining the latest research on the use of additives, this report aimed to identify potential ways to improve the sensory properties, nutritional profile, and overall appeal of CSB. It serves as a valuable resource for future research efforts to improve the quality and appeal of CSB.

1. Introduction

Chinese steamed bread (CSB), known as mantou, is a traditional wheat product that undergoes yeast fermentation and steaming. It occupies an important place in the Chinese diet, accounting for about 70% of wheat consumption in northern China (Hu *et al.,* 2015). A simple mixture of wheat flour, water, yeast, and sometimes a small amount of sugar or oil is usually used to prepare CSB (Huang and Miskelly, 2019). The dough is kneaded until it is smooth and elastic, and then allowed to rise for a while to allow the yeast to ferment and form air pockets in the dough. After the dough has risen, it is divided into smaller portions, formed into various shapes such as round or rectangular loaves, and then placed in a steamer (Figure 1). There are several preparation methods for steamed bread, with traditional methods involving mixing and shaping by hand. Table 1 showed a standard recipe for Chinese steamed bread with the ingredients and their respective amounts from various sources.

The fermentation and steaming process gives CSB its unique texture and flavour. The breads are placed in a steamer and steamed for a set amount of time, usually 15 to 20 mins. The steam penetrates the dough, gently cooking it and providing a soft, moist and slightly chewy texture. The unique flavour profile of CSB is attributed to the volatile compounds produced during the fermentation of the sourdough and influenced by metabolic activities (Zhang *et al*., 2016; Xi *et al*., 2021). The unique flavour of steamed bread often derives from its distinct cooking method and ingredients. Steamed bread is typically made by steaming dough or batter rather than baking it, which imparts a unique texture and taste. Additionally, the ingredients used, such as various types of flours, leavening agents, and flavourings, can contribute to the specific flavour profile of the steamed bread.

Several aspects need to be considered in CSB baking, including ingredients, technology, and nutrient composition. Ingredient selection and quality are critical, as even minor variations can lead to changes in volume, nutrient quality, and flavour (Zhu, 2014). Wheat flour is the most important ingredient for making CSB dough. Flour with low amylase activity, white colour, and little

*Corresponding author.
Email: *idamsah@ums.edu.my*

eISSN: 2550-2166 / © 2025 The Authors.
Published by Rynnye Lyan Resources

Table 1. Compilation of standard formulation of Chinese steamed bread from various references.

Ingredients/Source	Hou and Popper (2006)		Huang *et al.* (2021)	Mao *et al.* (2022)	Mamat *et al.* (2023)*
	South China	North China			
Wheat flour	1000 g	1000 g	400 g	8 g	100 g
Sugar	100-180 g	0-50 g	32 g	0.5 g	8 g
Baking soda/powder	10-20 g	10-20 g	0	2.5 g	0.5 g
Yeast	10-15 g	10-12 g	8 g	0	2 g
Salt	10-15 g	0	1.2 g	0	0
Fat	0	0	16 g	0	1.5 g
Water	450-500 g	500 g	180-200 g	135 g	60 g

*Formulations are according to the Baker's percentage

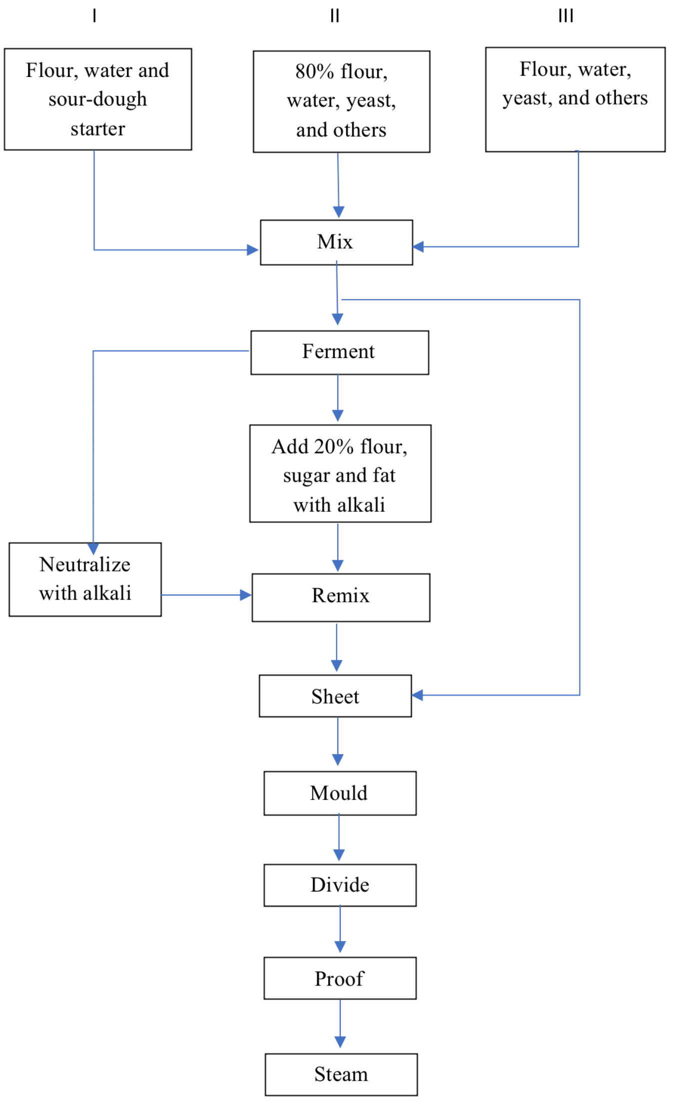

Figure 1. Chinese steamed bread making procedures flow diagram. I: Sour dough method; II: Sponge and dough method; III: Straight dough method. Source: Modified from Hou and Popper (2006).

damaged starch is preferred for all types of steamed bread and rolls. The desired protein content, dough properties, and viscosity of the flour dough vary depending on the regional type of steamed bread. The properties of wheat and flour that affect the quality of steamed bread have been extensively researched. The importance of selecting high-quality flour to produce high-quality products has been emphasised (Liu *et al.*, 2015; Kou *et al.*, 2019).

CSB enjoys great popularity among the Asian population, and with the growing market for healthy food, the demand for CSB with improved nutritional quality and new properties is also increasing. Therefore, this review provides an overview of recent advances in the use of innovative food ingredients in CSB. Emphasis was placed on investigating the effects of these additives on the rheological characteristics of the dough, physical properties, and nutritional composition of the final CSB products. By examining recent advances in the use of additives, this review identifies potential ways to improve the sensory properties, nutritional profile, and overall appeal of CSB. The knowledge gained from this review provides guidance to researchers in their efforts to improve the quality and appeal of CSB, bringing it in line with the preferences and expectations of today's demanding consumers.

2. Dough rheological characteristics

The incorporation of innovative ingredients into wheat flour to enhance the physicochemical characteristics of CSB may encounter technical hurdles, primarily stemming from the absence of gluten, resulting in poor gas retention ability, reduced volume, and a crumbly texture. When attempting to improve the physicochemical properties of CSB by introducing alternative ingredients to wheat flour, the absence of gluten poses a significant challenge. Gluten, a protein found in wheat, plays a crucial role in providing elasticity and strength to the dough, enabling it to retain gas during fermentation and giving rise to a desirable bread structure. To address these challenges, various additives such as enzymes and emulsifiers have been employed to enhance dough properties and improve the overall quality of the final product.

Liu *et al.* (2017a) explored the effects of α-amylase, xylanase, and cellulase on the rheological properties of CSB dough. They explored different concentrations of α-amylase (6 and 10 ppm), xylanase (70 and 120 ppm), and cellulase (35 and 60 ppm) and evaluated their impact on dough characteristics. The findings of the study revealed that the addition of both individual enzymes and enzyme combinations resulted in improved extensibility, softening, mixing tolerance index (MTI), and reduced stickiness of the CSB dough. However, it was observed that the resistance to extension decreased as a result. Moreover, the researchers reported that the combination of α-amylase, xylanase, and cellulase exhibited a synergetic effect on the rheology of the dough. Specifically, when compared to using a single enzyme, the combination of enzymes at concentrations of 6 ppm α-amylase, 120 ppm xylanase, and 60 ppm cellulase increased the extensibility of wheat flour dough by up to 42%. This suggests that the combined action of these enzymes yielded superior dough extensibility.

Cao *et al.* (2021) investigated the effects of different emulsifiers (soy lecithin, sodium stearoyl lactate, and diacetyl tartaric esters of monoglyceride) and enzymes (glucose oxidase and transglutaminase) on the dough properties of the bread. The researchers discovered that the addition of each emulsifier at a concentration of 1% or each enzyme at a level of 1.5 U/g resulted in increased viscoelasticity and strength of the potato pulp dough. This enhancement was attributed to the reinforcement of the gluten network, which contributed to improved dough structure and properties.

Meanwhile, the selection of suitable additives, such as hydrocolloids or proteins with binding properties, may be necessary to improve gas retention and enhance the structure and texture of CSB. Sang *et al.* (2018) studied the interaction between ovalbumin and gluten protein and its impact on the properties of dough and the quality of Chinese steamed bread. The results of the study indicated that ovalbumin did not undergo hydrolysis by endopeptidases during the fermentation process of the dough. Instead, it was found that ovalbumin formed crosslinks with gluten proteins during the steaming phase. This interaction between ovalbumin and gluten proteins contributed to changes in the structure and properties of the dough and the resulting Chinese steamed bread. Additionally, the presence of ovalbumin was found to have a positive impact on the maximum dough height during dough development and the specific volume of the Chinese steamed bread. This suggests that ovalbumin played a role in improving the overall leavening capacity and volume of the bread.

Abdul Shukri *et al.* (2017) observed that the incorporation of crosslinked (CL) rice starch into wheat flour resulted in a decrease in the dough's stretchability without breaking, as evidenced by the extensograph test. This was attributed to the limited formation of gluten in the dough containing CL rice starch. The crosslinking in rice starch caused the starch chains to bind together, preventing interactions between starch-protein and protein-protein. As a result, the dough's ability to stretch was compromised, making it more prone to breakage compared to the dough without CL rice starch.

When whole grain flour is added to the dough, the water absorption capacity of the dough increases. Liu *et al.* (2017b) investigated the effects of incorporating buckwheat (BW) flour into wheat flour on the rheological properties of dough. The presence of BW in wheat flour led to the dilution of gluten and the disruption of the gluten network. Since gluten plays a crucial role in imparting viscoelastic behaviour to the dough and binding water, the decrease in gluten concentration due to the dilution effect resulted in increased water absorption. Additionally, the high fibre content in whole grain flour contributed to the increased water capacity, further reducing dough stability as the gluten concentration decreased and the proteins in BW lacked the ability to form a stable structure.

In a study by Liu *et al.* (2020), the impact of incorporating purple sweet potato flour into wheat flour on the rheological properties of dough was examined. During the fermentation of the dough, purple sweet potato flour disrupted the gluten network structure and decreased the dough's stability. This disruption occurred due to the damage caused to the starch content in purple sweet potato flour, which was utilised by amylase to produce additional glucose for yeast fermentation. Consequently, the increased production of gases by the yeast reduced the interactions between gliadin and glutenin, components of gluten, leading to a decrease in the dough's stability.

Zhu and Sun (2019) demonstrated that the incorporation of freeze-dried purple sweet potato (PSP) into CSB formulations yielded favourable outcomes. The addition of PSP up to 50% elevated the antioxidant activities of CSB, offering improved protection against oxidative stress. Simultaneously, PSP inclusion resulted in a decreased glycemic response, which can aid in managing blood sugar levels. Furthermore, the study indicated that increasing levels of PSP led to higher polyphenol and anthocyanin contents in CSB, thereby enhancing its nutritional value and potential health benefits. These findings contribute to the expanding body of research on the utilisation of PSP as a functional ingredient in food formulations.

Yan *et al.* (2020) conducted a study on the impact of decreasing pH levels on the rheological properties of dough. They found that as the pH level decreases, the elastic and viscous modulus of the dough also decreases. This is attributed to the degradation of gluten proteins and the subsequent weakening of the dough structure.

https://doi.org/10.26656/fr.2017.9(4).256

The reduction in pH leads to less elasticity and viscosity in the dough due to the rapid degradation of gluten proteins, which results in damage to the network structure. Consequently, the intermolecular or intramolecular disulfide bonds between glutenin and gliadin, which contribute to the dough's elasticity and viscosity, are weakened. As a result, the dough exhibits low hardness and poor elasticity since the low pH levels are unable to facilitate gas retention due to the lack of interaction between gliadin and glutenin.

3. Effect of fermentation on steamed bread

The texture of steamed bread is influenced by factors such as gluten network formation during dough development, protein denaturation, and starch gelatinisation during cooking. A strong gluten network is important for gas cells in the dough to expand during fermentation and steaming (Hsieh *et al.*, 2017).

The fermentation of bread dough is a complex process that contains several components that can affect the fermentation rate of yeast cells (Figure 2). The constituents of dough and external factors play a crucial role in shaping the performance of yeast cells during the fermentation process. This performance, in turn, governs the outcome of fermentation, including the generation of CO_2, secondary metabolites, and aroma compounds (Struyf *et al.*, 2017).

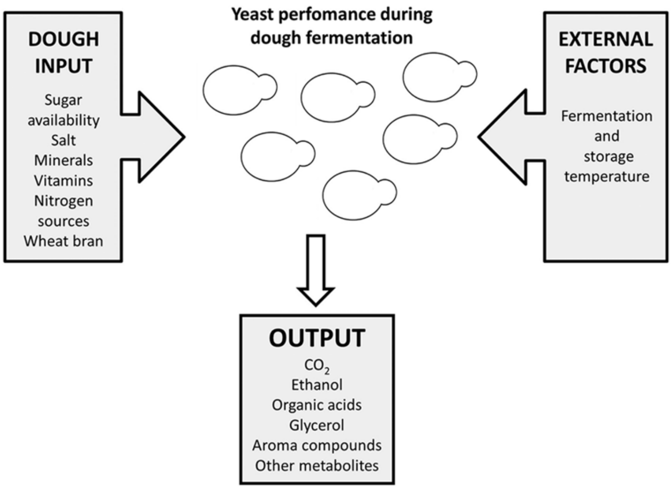

Figure 2. Factors affecting yeast performance in dough fermentation. Source: Struyf *et al.* (2017).

The fermentation time plays a crucial role in dough development, affecting various aspects such as dough rheology, texture, flavour, and nutritional properties. Gobbetti *et al.* (2016) conducted a study on sourdough fermentation, examining the effects of different fermentation times on dough characteristics and bread quality. They reported that longer fermentation times led to increased dough extensibility, improved crumb structure, and enhanced bread flavour due to the production of organic acids and aroma compounds during fermentation.

Similarly, Collar *et al.* (2007) explored the influence of fermentation time on dough rheology and bread quality parameters. Their findings showed that longer fermentation periods resulted in softer doughs, higher gas retention capacity, and improved bread volume and texture. They also observed changes in the protein structure and gluten network, leading to enhanced bread quality. Yue *et al.* (2019) employed various rheological methods to investigate the effects of fermentation time on dough rheology. The study revealed that fermentation time influences dough stickiness, extensibility, and biaxial viscosity. Understanding these rheological changes during fermentation is crucial for comprehending the underlying mechanisms shaping dough properties and ultimately ensuring the quality of the final product.

Sourdough fermentation contributes to the development of a gluten network that improves gas retention, resulting in a softer and more extensible dough, allowing for greater expansion. Both yeast and sourdough starter are used to ferment the dough for steamed bread. Sourdough improves the texture, flavour, nutritional value, and shelf life of steamed bread, while yeast plays a critical role in fermentation and dough expansion (Yeh *et al.*, 2009). The fermentation process, which involves LAB (lactic acid bacteria) and yeast, produces CO_2 and flavour components that contribute to the crumb structure and unique taste of steamed bread. Fermentation products are also associated with various health benefits (Zhu, 2014).

Cao *et al.* (2021) observed that the inclusion of soy lecithin and glucose oxidase (GOX) had a significant positive impact on the maximum dough height and gas retention capacity during fermentation. These effects facilitated dough expansion, resulting in a larger volume and improved leavening of the bread. The specific volume of the steamed bread was also increased by the addition of soy lecithin and GOX, leading to a more voluminous final product.

Besides the incorporation of novel ingredients into formulations, fermentation plays an important role in determining the nutritional content of CSB. Aplevicz *et al.* (2013) focused on the impact of fermentation time on the nutritional properties of wheat dough and bread. They discovered that longer fermentation times increased the bioavailability of certain nutrients, such as minerals and vitamins, through the action of microbial enzymes during fermentation. This suggests that fermentation time can affect the nutritional value of bread.

Moreover, Gao *et al.* (2022) investigated the effects of different fermentation (yeast and sourdough) and cooking (steam and baking) methods on the physicochemical, rheological, and morphological properties of dough and nutritional properties of CSB. The total amino acid content in steamed/baked bread was found to be lower compared to the content in fermented dough. Among all the samples tested, steamed bread fermented with sourdough exhibited the highest protein digestibility at 91.12%. When comparing different cooking methods, sourdough-fermented bread demonstrated a 10% higher protein digestibility compared to yeast-fermented bread.

4. Physical characteristics of steamed bread

From their soft and fluffy texture to their enticing appearance to their varied fillings, steamed breads offer a highly enjoyable eating experience. The physical properties of the basic ingredients of steamed bread, including wheat flour and yeast/sourdough, have a significant impact on the quality of the bread. The formation of gluten structure is closely related to the physical properties of wheat-based products such as steamed bread (Yan *et al.*, 2020). Protein composition in wheat has a significant impact on steam bread quality, and studies have found correlations between protein composition and steam bread quality. Optimising protein content can improve dough quality for steamed bread. Table 2 provides an overview of the effects of ingredients on the physical properties of steamed bread.

Steamed bread made from high-gluten wheat flour exhibits high water absorption (Chen *et al.*, 2016). Gas entrapment in wheat doughs is critical for the production of light and sour products, mainly due to the fact that gluten proteins form a continuous viscoelastic network during dough development. Proteins make up only a small portion of wheat flour (7 to 15%), with gluten accounting for 80 to 90% of flour proteins. Studies have shown that increasing protein content and gluten strength does not necessarily improve the appearance of steamed bread. To produce high-quality steamed bread, it is important to consider not only the protein and starch content but also their ratio. Increasing the gluten-starch ratio will result in a gradual decrease in the hardness and bite strength of the steamed bread. Protein content, gluten starch, and extensibility are positively correlated with the volume and elasticity of steamed bread (Zhu *et al.*, 2020).

The addition of soluble fibre in small amounts improves the quality of steamed bread. The addition of high-fibre wheat bran to steamed bread results in better elasticity and sensory acceptability. The addition of purified and fractionated dietary fibre, such as water-soluble arabinoxylans or water-insoluble arabinoxylans, has shown positive effects on the specific and total volume, elasticity, hardness, sensory quality, and storage stability of steamed bread (Zhu, 2014). Although the dietary fibre content of wheat flour is generally low (2% to 4%), the addition of dietary fibre to bread can improve its health profile. The addition of dietary fibre imparts functional properties to the final products, such as increased water-holding capacity, gelation, stabilisation, texturisation, and thickening (Noraidah *et al.*, 2023).

Several studies have investigated how additional ingredients or enrichments in wheat flour, the addition of food additives, and flour content affect crust and crumb colour and texture. A study by Abdul Shukri *et al.* (2017) examined the effect of adding crosslinked rice starch (CL) on the colour of steamed bread. The researchers found that the crust and crumb of steamed bread samples with CL rice starch were less yellowish than those without the addition of CL rice starch. This colour difference may be attributed to the natural whiteness of rice flour compared to wheat flour. In addition, the addition of CL rice starch in the steamed bread formulation resulted in the formation of a thin and soft crust because the rice starch had the ability to bind moisture. It also helped to bind and maintain the moisture content inside the steamed bread.

Another study by Liu *et al.* (2016) investigated the effect of adding potato flour to wheat flour on the surface colour of steamed bread. The results showed that the steamed bread with potato flour had lower L* (lightness) and higher a* and b* values (for redness and yellowing, respectively) than the steamed bread without added potato flour. This indicates that the addition of potato flour resulted in darker, yellow and red hues in the appearance of the bread compared to steamed bread made from wheat flour alone.

Wang *et al.* (2017) studied the effects of adding high amylose corn starch (HAMS) on the colour and texture of steamed bread. The results showed that the addition of HAMS at low concentrations did not significantly affect the crust colour. However, the researchers indicated that the colour of the crust could change noticeably when a higher concentration of HAMS (> 10%) is added to wheat flour. As for the texture of the crust, the steamed bread with a higher HAMS concentration (8-10%) exhibited less smoothness. This can be attributed to the fact that HAMS thin the gluten matrix, which consequently reduces its ability to form a cohesive network on the surface.

Hsieh *et al.* (2017) investigated the effects of whole grain flour substitution on the colour of the crust and crumb in steamed bread. The outcomes showed that

Table 2. Effect of ingredients on the physical characteristics of Chinese steamed bread.

Ingredient	Effect on steamed bread	Reference
Water-soluble arabinoxylans; water-insoluble arabinoxylans	Positive effects on the specific and overall volumes, elasticity, hardness, sensory quality, and storage stability of steam bread	Zhu (2014)
Cross-linked (CL) rice starch	The crust and crumb of steamed bread samples with CL rice starch were less yellowish compared to those without the addition of CL rice starch.	Abdul Shukri *et al.* (2017)
Potato flour	Darker, yellow, and red tones in the bread's appearance	Liu *et al.* (2016)
High-amylose maize starch (HAMS)	No significant effect on the colour of the crust; however, steamed bread with a higher HAMS concentration (8-10%) exhibited decreased smoothness.	Wang *et al.* (2017)
Wholegrain flour	i. A reduction in the L* value and white index (WI), decreasing the overall brightness of the steamed bread. ii. Grains with higher bran content tend to contribute more darkness to the final product.	Hsieh *et al.* (2017)
Hydroxypropyl methylcellulose, carboxymethylcellulose, xanthan gum, apple pectin	Steamed breads with hydrocolloids presented higher specific volume and lower hardness, and the rapidly digestible starch and estimated glycemic index were significantly decreased.	Liu *et al.* (2018)
Gluten protein	The crust colour became darker with an increase in the gluten protein ratio. Additionally, the surface of the steamed bread contracted and darkened.	Zhu *et al.* (2020)
Oleogels	i. No significant differences in the crumb structure, volume, height, and overall texture of the steamed breads. ii. Less porous and harder structure in the steamed breads.	Bascuas *et al.* (2021)
Sodium alginates (ALG); konjac glucomannan (KGM)	Chinese steamed bread with ALG or KGM addition was relatively low in spread ratio and specific volume, but softer and more resistant to staling on storage as compared to the control sample	Sim *et al.* (2021)
Carrageenan, xanthan gum, arabic gum, sodium alginate, and xylanase	i. A little effect on the hardness reduction and springiness retention of potato steamed bread during storage. ii. Potato steamed bread with a combination of α-amylase and lipase exhibited the lowest hardness, with a significant reduction, besides improving the specific volume, L*, and overall acceptability in sensory evaluation.	Ma *et al.* (2022)

using whole grain flour reduced the white index (WI) and L* value, lowering the brightness of the steamed bread from 73.9 to 63.3-68.6 overall. This shows that, as compared to wheat flour, whole grain flour gives the crust a darker look and lessens the whiteness of the breadcrumbs. In addition, Hsieh *et al.* (2017) evaluated how two distinct whole grains, brown rice and oat, performed as substitutes for steamed bread. When compared to white rice flour, they discovered that the steamed bread created with brown rice flour had a brighter appearance.

The effect of the gluten-starch ratio on the external appearance and interior structure of steamed bread was examined in a study by Zhu *et al.* (2020). The crust's colour darkened as the gluten-protein ratio rose, with the 20:80 ratio showing the most pronounced dark yellow tint. The surface of the steamed bread also shrank and darkened as the gluten ratio increased. The steamed bread shrank and appeared "burnt" when exposed to the atmosphere because the flour had a high concentration of the protein gluten. As a result, increasing the protein content and gluten strength did not help produce a more aesthetically pleasing appearance.

The effect of oleogels on the physical characteristics of steamed bread was studied by Bascuas *et al.* (2021). The bread's crumb structure, volume, height, and texture were examined as a result of the investigation into the use of oleogels in margarine. The study found that the crumb structure, volume, height, and general texture of the steamed loaves did not significantly change when oleogels were used in place of margarine. This shows that the oleogels might efficiently replace margarine without having a negative impact on the physical properties of the loaves. Furthermore, there were no discernible changes between the steamed loaves made with margarine and those made with oleogels in the triangle test used to assess texture differences. This suggests that consumers were unable to differentiate between the two varieties of bread based just on feel. It was observed that the steamed bread had a somewhat less porous and firmer structure when oleogels were used in place of margarine. This result raises the possibility that using oleogels may affect the internal texture of the loaves, giving them a denser and harder consistency than those baked with margarine.

To enhance the overall quality of steamed bread, various hydrocolloids such as carrageenan, sodium alginates, carboxymethylcellulose, guar gum, xanthan gum, hydroxypropyl methylcellulose, and arabic gum have been utilised. These hydrocolloids have shown efficacy in improving key attributes such as softness, specific volume, brightness, and shelf-life extension (Sim *et al.*, 2011; Liu *et al.*, 2018; Salehi, 2020; Ma *et al.*, 2022). The improved quality can be attributed to the ability of hydrocolloids to enhance the CO_2 holding capacity of the dough, thereby promoting better gas retention during fermentation (Liu *et al.*, 2017a). Additionally, hydrocolloids contribute to increased water retention within the dough, preventing excessive moisture loss during baking and leading to a softer texture in the final product (Gharaie *et al.*, 2015). Moreover, the presence of hydrocolloids can slow down the retrogradation of starch, which helps maintain the freshness and extend the shelf-life of the bread (Ma *et al.*, 2022).

5. Nutritional properties of steamed bread

Steamed bread is primarily composed of macronutrients, with proteins, carbohydrates, lipids, and dietary fibre playing important roles in its nutritional aspects (Haini *et al.*, 2021). Wheat flour, the main ingredient in steamed bread, contains various proteins such as glutenin, gliadin, globulin, and albumin, with glutenin and gliadin being the dominant proteins responsible for gluten formation. Protein content influences the quality of steamed bread, with a protein content of 10.0-12.5% yielding soft bread and 10.7-13.5% resulting in slightly harder bread. Optimising the protein ratio can improve the overall quality of steamed bread (Yang *et al.*, 2022).

Whole grain cereals are rich in dietary fibre, non-starch polysaccharides, and bioactive components, which provide numerous benefits for gut health and digestion. Including colourful fruits and vegetables, such as carrots, pumpkins, and purple sweet potatoes, in steamed bread enhances its nutritional value. These additions optimise the nutritional profile of steamed bread and make it a healthier choice for daily consumption (Wu *et al.*, 2018; Zhu and Sun, 2019).

Carbohydrates in steamed bread primarily consist of starch, low molecular sugars, and dextrin. These components provide energy for human metabolism and significantly impact the quality of traditional steamed bread. A higher ratio of amylopectin to amylose and a higher content of damaged starch positively influence the quality of the bread. Lipids, which are present in wheat flour at a concentration of approximately 1-2% (w/w), contribute to gluten formation. Ingredients like lecithin can give the bread a fine and smooth appearance and delay starch retrogradation. Although lipids do not prevent starch retrogradation entirely, they help in delaying the process (Chang *et al.*, 2021).

The addition of seaweed powder to steamed bread has been found to have notable impacts on various nutritional aspects, as demonstrated in a study conducted by Mamat *et al.* (2023). Their findings revealed significant changes in the ash, moisture, crude fat, crude fibre, and dietary fibre content of the bread. Moreover, the incorporation of banana flour into steamed bread has shown promising results in enhancing its prebiotic properties, as highlighted by Oupathumpanont *et al.* (2022). The researchers reported an increase in dietary fibre and calcium levels with a 40% substitution of banana flour in the bread's formulation. These studies emphasise the potential benefits of incorporating seaweed powder and banana flour into steamed bread, both in terms of nutritional composition and functional properties. The addition of seaweed powder contributes to changes in various components such as ash, moisture, crude fat, crude fibre, and dietary fibre. Similarly, the incorporation of banana flour enhances the prebiotic properties of the bread and leads to an increase in dietary fibre and calcium levels when substituted at a 40% ratio in the formulation. These findings open opportunities for further exploration and development of steam bread recipes, allowing for the creation of more nutritious and functional variations.

Steam bread made from wheat flour with elevated levels of organic trivalent chromium and amylose

https://doi.org/10.26656/fr.2017.9(4).256

exhibits a significantly lower glycemic index (GI) (75) compared to normal wheat flour (GI = 93). Similarly, steamed bread made from wheat flour with increased amylose content also has a lower GI (84) than that made from normal wheat flour (Zhu, 2019). Consumption of low-GI wheat flour can reduce the risk of postprandial glycemia, insulin resistance, type 2 diabetes, obesity, cardiovascular disease, and certain types of cancers (Kaur *et al.,* 2021).

There is a growing interest in incorporating bioactive ingredients, such as dietary fibre (DF) and phenolic antioxidants, into popular foods like bread, driven by increased consumer health awareness (Sivam *et al.*, 2011). The appropriate interaction between wheat proteins, fibre polysaccharides, and phenolic antioxidants is crucial for enhancing bread dough with DF and phenolic antioxidants. Dietary fibre intake is positively associated with various health benefits. In the case of steam bread, the addition of dietary fibre, including non-starch polysaccharides and resistant starch, can reduce the GI value (Haini *et al.*, 2022). For example, incorporating four types of hydrocolloids (hydroxypropylmethylcellulose (HPMC), carboxymethylcellulose, xanthan gum, and apple pectin) (2%) significantly lowered the estimated GI (eGI) to 59, with HPMC being the most effective (Zhu, 2019). The presence of hydrocolloids increases the viscosity of steam bread during digestion, which inhibits mixing and propulsive effects in the digestive system. This results in fewer interactions between starch and digestive enzymes, and the non-starch polysaccharides may also bind to amylases, reducing their activity. Moreover, replacing wheat flour with resistant starch reduces the content of rapidly digestible starch while increasing the resistant starch content, leading to a reduced eGI of steam bread (Haini *et al.*, 2022).

Plant polyphenols are increasingly being used in bakery food formulations. Polyphenols and plant extracts have been found to reduce the release of glucose from steam bread by interacting with amylases or starch, thereby reducing enzyme activity and starch-enzyme interactions. For instance, the addition of 2% green tea extract significantly decreases the amounts of rapidly digested starch and the released glucose during the initial 1.5 hours of *in vitro* digestion (Goh *et al.*, 2015). Zhu *et al.* (2016) incorporated black tea extracts into a northern-style CSB formulation, using different concentrations of up to 175 mg gallic acid equivalent per gram of wheat flour. Their findings revealed that the inclusion of black tea resulted in an augmentation of antioxidant activity, as assessed through chemical assays. Additionally, the sensory evaluation indicated a positive overall acceptance of the black tea-fortified CSB, indicating that it was well-received by the participants.

Wu *et al.* (2018) conducted a study to explore the impact of varying concentrations of whole grain white sorghum flour (WSF) or red sorghum flour (RSF) on the formulation of CSB. Their research findings revealed that the incorporation of sorghum into CSB formulations led to a noteworthy increase in polyphenolic content and antioxidant activity, as determined by both chemical-based and cellular-based assays. In a recent study conducted by Shao *et al.* (2023), it was found that the addition of fermented soy milk to CSB resulted in notable enhancements to the dough's internal structure. This improvement led to better texture properties in CSB samples containing fermented soy milk.

Furthermore, Wang *et al.* (2022) conducted a study to investigate the impact of freeze-thaw cycling on the quality of pre-fermented red bean steamed bread (RBSB) dough and the cooked product. The researchers specifically examined how freeze-thaw cycles influenced the amino acid contents of RBSBs. The study revealed that the freeze-thaw cycles had a significant effect on the amino acid composition of RBSBs. After subjecting the dough to different numbers of freeze-thaw cycles, the contents of all amino acids were observed to decrease. The findings suggest that the freeze-thaw cycling process caused a reduction in the levels of amino acids present in RBSBs. Amino acids are essential building blocks of proteins and play a crucial role in determining the nutritional quality and sensory characteristics of food products.

In recent years, the use of green banana flour (BF) as a potential food ingredient to fortify traditional CSB has gained significant attention due to its numerous health benefits. In a study conducted by Loong and Wong (2018), it was found that BF-incorporated CSB, along with the addition of extra water, exhibited comparable consumer acceptability to the control group in most aspects. This study revealed that by incorporating BF into the CSB formulation and increasing the water content, the sensory properties of the bread could be significantly improved. The addition of extra water helped enhance the overall sensory experience, ensuring that the BF-incorporated CSB maintained its appeal to consumers. These findings suggest that BF holds great potential as a functional ingredient in fortifying traditional CSB, enriching it with health-promoting properties.

7. Conclusion

Through the examination of innovative food ingredients, researchers can gain valuable insights into how to optimise CSB production, ensuring that it aligns with the preferences and expectations of today's discerning consumers. By understanding the impact of ingredients on CSB's physical properties, dough rheology, and nutritional composition, researchers can uncover new opportunities to enhance its taste, texture, nutritional value, and overall consumer acceptance. This review acts as a foundation for future studies and provides a roadmap for researchers seeking to push the boundaries of CSB's quality and cater to the evolving needs of modern consumers. By harnessing the potential of innovative food additives, CSB can be transformed into a more appealing, nutritious, and delightful culinary experience.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

This study was supported through funding from the Ministry of Higher Education Malaysia (MoHE), project code: FRGS/1/2017/STG/UMS/02/5.

References

Aplevicz, K.S., Ogliari, P.J. and Santánna, E.S. (2013). Influence of fermentation time on characteristics of sourdough bread. *Brazilian Journal of Pharmacy Sciences,* 49(2), 233-239. https://doi.org/10.1590/S1984-82502013000200005

Bascuas, S., Morell, P., Quiles, A., Salvador, A. and Hernando, I. (2021). Use of oleogels to replace margarine in steamed and baked breads. *Foods*, 10 (8), 1781. https://doi.org/10.3390/foods10081781

Cao, Y., Jiang, L., Suo, W., Deng, Y., Zhang, M., Dong, S., Guo, P., Chen, S. and Li, H. (2021). Influence of emulsifiers and enzymes on dough rheological properties and quality characteristics of steamed bread enriched with potato pulp. *Food Chemistry*, 360, 130015. https://doi.org/10.1016/j.foodchem.2021.130015

Chang, Q., Zheng, B., Zhang, Y. and Zeng, H. (2021). A comprehensive review of the factors influencing the formation of retrograded starch. *International Journal of Biological Macromolecules*, 186, 163-173. https://doi.org/10.1016/j.ijbiomac.2021.07.050

Chen, Y.T., Shiau, S.Y. and Fu, J.T. (2016). Physicochemical properties of dough and steamed bread made from regular and whole wheat flour. *International Journal of Food Engineering*, 12(4), 411-419. https://doi.org/10.1515/ijfe-2016-0041

Collar, C., Bollain, C. and Rosell, C.M. (2007). Rheological behavior of formulated bread dough's during mixing and heating. *Food Science and Technology International*, 13(2), 99-107. https://doi.org/10.1177/1082013207078341

Gao, S., Hong, J., Liu, C., Zheng, X., Li, L. and Tian, X. (2022). Comparative study of different fermentation and cooking methods on dough rheology and the quality of Chinese steamed/baked bread. *Journal of Food Processing and Preservation*, 46(2), e16221. https://doi.org/10.1111/jfpp.16221

Gharaie, Z., Azizi, M.H., Barzegar, M. and Aghagholizade, R. (2015). Effects of hydrocolloids on the rheological characteristics of dough and the quality of bread made from frozen dough. *Journal of Texture Studies*, 46(5), 365-373. https://doi.org/10.1111/jtxs.12136

Gobbetti, M., Minervini, F., Pontonio, E., Cagno, R.D. and De Angelis, M. (2016). Drivers for the establishment and composition of the sourdough lactic acid bacteria biota. *International Journal of Food Microbiology*, 239, 3-18. https://doi.org/10.1016/j.ijfoodmicro.2016.05.022.

Goh, R., Gao, J., Ananingsih, V.K., Ranawana, V., Henry, C.J. and Zhou, W. (2015). Green tea catechins reduced the glycaemic potential of bread: An *in vitro* digestibility study. *Food Chemistry*, 180, 203-210. https://doi.org/10.1016/j.foodchem.2015.02.054

Haini, N., Jau-Shya, L., Mohd Rosli, R.G. and Mamat, H. (2021). Effect of type-2 resistant starch (high-amylose maize starch) on the physicochemical, nutritional, *in vitro* starch digestibility and estimated glycaemic properties of Chinese steamed breads. *Journal of Cereal Science*, 98, 103176. https://doi.org/10.1016/j.jcs.2021.103176

Haini, N., Jau-Shya, L., Mohd Rosli, R.G. and Mamat, H. (2022). Effects of high-amylose maize starch on the glycemic index of Chinese steamed breads (CSB). *Heliyon*, 8(5), e09375. https://doi.org/10.1016/j.heliyon.2022.e09375

Hsieh, P.H., Weng, Y.M., Yu, Z.R. and Wang, B.J. (2017). Substitution of wheat flour with whole grain flours affects physical properties, sensory acceptance, and starch digestion of Chinese steam bread (Mantou). *LWT - Food Science and Technology*, 86, 571-576. https://doi.org/10.1016/j.lwt.2017.08.051

Hou, G.G. and Popper, L. (2006). Chinese steamed bread. In Popper, L., Schäfer, W. and Freund, W. (Eds.). Future of flour – A compendium of flour improvement, p. 309-318. Germany: Agrimedia GmbH and Co.

Hu, X., Sheng, X., Liu, L., Ma, Z., Li, X. and Zhao, W.

(2015). Food system advances towards more nutritious and sustainable mantou production in China. *Asia Pacific Journal of Clinical Nutrition*, 24 (2), 199-205.

Huang, S.D. and Miskelly, D. (2019). Steamed Bread – a review of manufacturing, flour quality requirements, and quality evaluation. *Cereal Chemistry*, 96(1), 8-22. https://doi.org/10.1002/cche.10096

Huang, Y.C., Mense, A.L., Deng, L., Su, M.Y., Shih, K.H. and Bock, J.E. (2021). The characteristics of steamed bread from reconstituted whole wheat flour (WWF) of different hard wheat classes with different bran particle size distributions. *Foods*, 10(10), 2413. https://doi.org/10.3390/foods10102413.

Kaur, J., Kaur, K., Singh, B., Singh, A. and Sharma, S. (2021). Insights into the latest advances in low glycemic foods, their mechanism of action and health benefits. *Journal of Food Measurement and Characterization*, 16, 533-546. https://doi.org/10.1007/s11694-021-01179-z

Kou, X., Luo, D., Zhang, K., Xu, W., Li, X., Xu, B., Li, P., Han, S. and Liu, J. (2019). Textural and staling characteristics of steamed bread prepared from soft flour added with inulin. *Food Chemistry*, 301, 125272. https://doi.org/10.1016/j.foodchem.2019.125272

Liu, C., Li, L., Hao, C., Zheng, X., Bian, K., Zhang, J. and Wang, X. (2015). Effects of different milling processes on whole wheat flour quality and performance in steamed bread making. *LWT - Food Science and Technology*, 62, 310-318. https://doi.org/10.1016/j.lwt.2014.08.030

Liu, X.L., Mu, T.H., Sun, H.N., Zhang, M. and Chen, J.W. (2016). Influence of potato flour on dough rheological properties and quality of steamed bread. *Journal of Integrative Agriculture*, 15(11), 2666-2676. https://doi.org/10.1016/S2095-3119(16)61388-6

Liu, W., Brennan, M.A., Serventi, L. and Brennan, C.S. (2017a). Effect of cellulase, xylanase and α-amylase combinations on the rheological properties of Chinese steamed bread dough enriched in wheat bran. *Food Chemistry*, 234, 93-102. https://doi.org/10.1016/j.foodchem.2017.04.160.

Liu, W., Brennan, M., Serventi, L. and Brennan, C. (2017b). Buckwheat flour inclusion in Chinese steamed bread: Potential reduction in glycemic response and effects on dough quality. *European Food Research and Technology*, 243(5), 727-734. https://doi.org/10.1007/s00217-016-2786-x

Liu, X., Mu, T., Sun, H., Zhang, M., Chen, J. and Fauconnier, M.L. (2018). Influence of different hydrocolloids on dough thermo mechanical properties and *in vitro* starch digestibility of gluten free steamed bread based on potato flour. *Food Chemistry*, 239, 1064-1074. https://doi.org/10.1016/j.foodchem.2017.07.047

Liu, X.L., Yang, L.S., Zhao, S.L. and Zhang, H. (2020). Characterization of the dough rheological and steamed bread fortified with extruded purple sweet potato flour. *International Journal of Food Properties*, 23(1), 765-776. https://doi.org/10.1080/10942912.2020.1733600

Loong, C.Y.L. and Wong, C.Y.H. (2018). Chinese steamed bread fortified with green banana flour. *Food Research*, 2(4), 320-330. https://doi.org/10.26656/fr.2017.2(4).058

Ma, M., Mu, T., Sun, H. and Zhou, L. (2022). Evaluation of texture, retrogradation enthalpy, water mobility, and anti-staling effects of enzymes and hydrocolloids in potato steamed bread. *Food Chemistry*, 368, 130686. https://doi.org/10.1016/j.foodchem.2021.130686

Mao, S., Kaur, L., Mu, T.H. and Singh, J. (2022). Development and characterization of plant and dairy-based high protein Chinese steamed breads (mantou): Physico-chemical and textural characteristics. *Food Hydrocolloids*, 2, 100102. https://doi.org/10.1016/j.fhfh.2022.100102

Mamat, H., Ling, Y.Y., Abdul Aziz, A.H., Ab Wahab, N., Mohd Rosli, R.G., Sarjadi, M.S., Zainol, M.K., Putra, N.R., Che Yunus, M.A. (2023). Utilization of seaweed composite flour *(Kappaphycus alvarezii)* in the development of steamed bun. *Journal of Applied Phycology*, 35, 1911-1919. https://doi.org/10.1007/s10811-023-02989-y.

Noraidah, H., Jau-Shya, L., Ramlah, M.R., Mohd Sani, S. and Hasmadi, M. (2023). Physicochemical, functional properties, *in vitro* starch digestibility and estimated glycaemic index of composite flour influenced by resistant starch. *Food Research*, 7(2), 272-279. https://doi.org/10.26656/fr.2017.7(2).827

Oupathumpanont, O. and Wisansakkul, A.A. (2022). Improvement the texture and prebiotic properties of steam bun quality using cultivated banana (Musa ABB cv. Kluai 'Namwa') flour. *Food Research*, 6 (6), 157-164. https://doi.org/10.26656/fr.2017.6(6).800

Salehi, F. (2020). Effect of common and new gums on the quality, physical, and textural properties of bakery products: A review. *Journal of Texture Studies*, 51(2), 361-370. https://doi.org/10.1111/jtxs.12482

Sang, S., Zhang, H., Xu, L., Chen, Y., Xu, X., Jin, Z., Yang, N., Wu, F. and Li, D. (2018). Functionality of ovalbumin during Chinese steamed bread-making processing. *Food Chemistry*, 253, 203-210. https://doi.org/10.1016/j.foodchem.2018.01.150

Shao, T., Ma, X., Zhang, Y., Wu, R., Wang, X., Gu, R. and Chen, X. (2023). Physical and nutritional properties of Chinese Steamed Bun (mantou) made with fermented soy milk. *LWT - Food Science and Technology*, 183, 114849. https://doi.org/10.1016/j.lwt.2023.114849

Abdul Shukri, F.S., Refai, S.A., Shukri, R., Muhammad, K., Mustapha, N.A., Wan Ibadullah, W.Z. and Ramli, N.S. (2017). Dough rheology and physicochemical properties of steamed breads fortified with crosslinked rice starch. *Bioactive Carbohydrates and Dietary Fibre*, 12, 1-6. https://doi.org/10.1016/j.bcdf.2017.10.002

Sim, S.Y., Noor Aziah, A.A. and Cheng, L.H. (2011). Characteristics of wheat dough and Chinese steamed bread added with sodium alginates or konjac glucomannan. *Food Hydrocolloids*, 25(5), 951-957. https://doi.org/10.1016/j.foodhyd.2010.09.009

Sivam, A.S., Sun, D., Geoffrey, N., Quek, S.Y. and Perera, C.O. (2011). Physicochemical properties of bread dough and finished bread with added pectin fibre and phenolic antioxidants. *Journal of Food Science*, 76(3), H97-H107. https://doi.org/10.1111/j.1750-3841.2011.02086.x

Struyf, N., Van der Maelen, E., Hemdane, S., Verspreet, J., Verstrepen, K.J. and Courtin, C.M. (2017). Bread dough and baker's yeast: An uplifting synergy. *Comprehensive Reviews in Food Science and Food Safety*, 16(5), 850-867. https://doi.org/10.1111/1541-4337.12282

Wang, S., Khamchanxana, P., Zhu, F., Zhu, C. and Pan, J. (2017). Textural and sensory attributes of steamed bread fortified with high-amylose maize starch. *Journal of Texture Studies*, 48(1), 3-8. https://doi.org/10.1111/jtxs.12208

Wang, Q., Zhang, H., Zhu, W., Li, C., Xu, Y., Ding, X. and Zhou, X. (2022). Physicochemical properties and nutritional quality of pre-fermented red bean steamed breads as affected by freeze-thaw cycling. *International Journal of Food Properties*, 25(1), 748-763. https://doi.org/10.1080/10942912.2022.2060252

Wu, G., Shen, Y., Qi, Y., Zhang, H., Wang, L., Qian, H., Qi, X., Li, Y. and Johnson, S.K. (2018). Improvement of *in vitro* and cellular antioxidant properties of Chinese steamed bread through sorghum addition. *LWT - Food Science and Technology*, 91, 77-83. https://doi.org/10.1016/j.lwt.2017.12.074

Xi, J., Zhao, Q., Xu, D., Jin, Y., Wu, F., Jin, Z. and Xu, X. (2021). Volatile compounds in Chinese steamed bread influenced by fermentation time, yeast level and steaming time. *LWT - Food Science and Technology*, 141, 110861. https://doi.org/10.1016/j.lwt.2021.110861

Yan, B., Yang, H., Wu, Y., Lian, H., Zhang, H., Chen, W., Fan, D. and Zhao, J. (2020). Quality enhancement mechanism of alkali-free Chinese Northern steamed bread by sourdough acidification. *Molecules*, 25(3), 726. https://doi.org/10.3390/molecules25030726

Yang, B., Zhang, Y., Yuan, J., Yang, M., Yang, R., Gu, Z., Xie, C., Zhou, Q., Jiang, D., Zhou, J. and Wang P. (2022). Impact of different frozen dough technology on the quality and gluten structure of steamed breads. *Foods*, 11(23), 3833. https://doi.org/10.3390/foods11233833

Yeh, L.T., Wu, M-L., Charles, A.L. and Huang, T.-C. (2009). A novel steamed bread making process using salt-stressed baker's yeast. *International Journal of Food Science and Technology*, 44(12), 2637-2643. https://doi.org/10.1111/j.1365-2621.2009.02096.x

Yue, Q., Liu, C., Li, L., Zheng, X. and Bian, K. (2019). Effects of fermentation on the rheological characteristics of dough and the quality of steamed bread. *Journal of Food Processing and Preservation*, 43(10), e14115. https://doi.org/10.1111/jfpp.14115

Zhang, G.H., Wu, T., Sadiq, F.A., Yang, H.Y., Liu, T.J., Ruan, H. and He, G.Q. (2016). A study revealing the key aroma compounds of steamed bread made by Chinese traditional sourdough. *Journal of Zhejiang University Science B*, 17(10), 787-797. https://doi.org/10.1631%2Fjzus.B1600130

Zhu, F. (2014). Influence of ingredients and chemical components on the quality. *Food Chemistry*, 163, 154-162. https://doi.org/10.1016/j.foodchem.2014.04.067

Zhu, F., Sakulnak, R. and Wang, S. (2016). Effect of black tea on antioxidant, textural, and sensory properties of Chinese steamed bread. *Food Chemistry*, 194, 1217-1223. https://doi.org/10.1016/j.foodchem.2015.08.110

Zhu, F. and Sun, J. (2019). Physicochemical and sensory properties of steamed bread fortified with purple sweet potato flour. *Food Biosciences*, 30, 100411. https://doi.org/10.1016/j.fbio.2019.04.012

Zhu, Y., Xiong, W., Wang, L. and Ju, X. (2020). Insight into the effect of gluten-starch ratio on the properties of Chinese steamed bread (Mantou). *International Journal of Biological Macromolecules*, 163, 1821-1827. https://doi.org/10.1016/j.ijbiomac.2020.09.022

https://doi.org/10.26656/fr.2017.9(4).256