Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.71622

Application of Tartary buckwheat bran flour modified by heat-moisture treatment in steamed bread processing

Sheng ZHANG[1], Wei ZHOU[1], Chungang CHEN[1*]

Abstract

The rheological properties of dough from modified Tartary buckwheat bran flour (MTBF) by heat-moisture treatment (HMT) and wheat flour (WF) were investigated in this study, and the application of MTBF in steamed bread processing was also evaluated. The results showed that the addition of MTBF had a significant effect on torque curve and parameters of the dough. With the increase of the weight proportion of MTBF in the blend (W_{MTBF}), the water absorption of the dough gradually increased, the protein weakening degree decreased at first and then increased, and the dough had better kneading resistance when the W_{MTBF} was 30% and 40%. With the increase of W_{MTBF}, the color of the steamed bread gradually darkened and yellowed, and the specific volume declined gradually. In addition, the hardness, gumminess and chewiness of steamed bread increased with W_{MTBF}, but its springiness, cohesiveness and resilience decreased. When $W_{MTBF} \geq 20\%$, internal texture structure of steamed bread was enhanced. Sensory evaluation indicated that the steamed bread developed at $W_{MTBF} = 20\%$ could obtain similar quality and pleasant appearance to common wheat steamed bread.

Keywords: Tartary buckwheat; bran flour; heat-moisture treatment; steamed bread; rheological property.

Practical Application: This work systematically studied the application of Tartary buckwheat bran flour modified by heat-moisture treatment in steamed bread processing, which can prompt the further development of Tartary buckwheat.

1 Introduction

Tartary buckwheat, also known as Tartary buckwheat, is a dicotyledonous crop of the family Polygonaceae. It has the characteristics of short growth cycle, cold resistance and strong stress resistance. It can still maintain good growth in the harsh environment (Krkošková & Mrazova, 2005; Brites et al., 2019). It is widely distributed in China, Russia, South Korea, Japan, Europe and other regions (Luthar et al., 2021), which has high nutritional value and medicinal value (Geng et al., 2022; Ruan et al., 2022). Compared with other food crops such as wheat, rice and corn, Tartary buckwheat is not only rich in protein, fat, starch, dietary fiber, minerals and vitamins, but also polyphenols represented by rutin. It can play a positive role in the prevention and treatment of chronic diseases, such as hypertension, hyperlipidemia, hyperglycemia and cardiovascular diseases (Glavač et al., 2017; Li et al., 2022; Yang & Lv, 2015; Yue et al., 2019). Tartary buckwheat bran is a by-product of Tartary buckwheat processing, which is rich in polyphenols and has a variety of biological activities (Ge & Wang, 2020; Liu et al., 2022; Brasil et al., 2021). However, at present, Tartary buckwheat bran is mainly used in feed production, resulting in great waste, and its comprehensive development needs to be carried out.

HMT is an important physical modification technology, which can change the physicochemical properties of some grains to meet the specific processing requirements in food production. Compared with chemical (acid hydrolysis, oxidation and cross-linking treatment) or physical methods (pregelatinization and dry heat treatment) (Varatharajan et al., 2010; Wang et al., 2022), HMT is effective and safe, has low production cost, and is suitable for food industry (Xiao et al., 2017). The grain modified by HMT can show ideal quality characteristics and unique aroma, and the shelf life of the product is prolonged (Vidya et al., 2013). Wu et al. (2020) found that heat treatment had a great effect on the properties of polyphenols and starch in Tartary buckwheat, which could significantly increase the content of soluble phenols in Tartary buckwheat. Deng et al. (2015) observed that high pressure, microwave heating and boiling could reduce the anti-nutritional factors of buckwheat, increase its protein digestibility in vitro, and retain the nutritional composition of buckwheat. Liu et al. (2015) investigated the physicochemical properties and texture properties of Tartary buckwheat starch treated with HMT under different water levels. Although HMT can be used to improve the physicochemical properties of Tartary buckwheat, its effect on its processing properties has not been reported. In view of this, the rheological properties of doughs from modified Tartary buckwheat bran flour (MTBF) by HMT (MTBF) and wheat flour (WF) were investigated, and the effects of WMTBF on appearance, texture, internal structure and sensory evaluation of steamed bread were also evaluated.

Received 29 May, 2022
Accepted 23 July, 2022
[1] *School of Food Science, Henan Institute of Science and Technology, Xinxiang, China*
*Corresponding author: ccg28@126.com

2 Materials and methods

2.1 Materials

Tartary buckwheat (variety, Jinqiao 2) was purchased from Shanxi Agricultural University (Taiyuan, China). TBF was prepared according our previous report (Zhang et al., 2021). WF was the product of China Oil & Foodstuffs Corporation (Beijing, China). The dry yeast was from Angel Yeast Co., Ltd (Yichang, China).

2.2 Preparation of MTBF

According to a published method with some slight modifications (Collar, 2017), TBF was put into a screw bottle with an appropriate amount of deionized water, and its water content was adjusted to 43.6%. After mixing evenly, it was kept at 4 °C for 24 h. Then, the screw bottle containing the sample was heated at 123 °C for 2.1 h, during which it was shaken properly to make its reaction uniform. The treated TBF was dried at 40 °C, then crushed, sifted through 100 mesh and collected as MTBF for follow-up experiments.

2.3 Determination of rheological properties of dough

The rheological properties of MTBF-WF doughs (W_{MTBF} = 0, 10, 20, 30, 40, and 50%) were determined by a Mixolab 2 apparaus (Chopin, Paris, France) based on the "Chopin+" protocol (Zhang et al., 2021). The dough weight was set at 75 g, and the amount of water added was corrected based on 14% moisture content, which made the dough produce the torque of 1.1 ± 0.5 Nm at the mixing speed of 80 rpm. The protocol was run for a total of 45 min, including three stages: (1) Constant temperature stage, the dough was mixed at the speed of 80 rpm at 30 °C for 8 min; (2) Heating stage, the dough was heated to 90 °C at a rate of 4 °C/min in 15 min and kept for 7 min; (3) Cooling stage, the dough was cooled to 50 °C at a rate of 4 °C/min in 10 min and held for 5 min.

2.4 Preparation of steamed bread

The steamed bread developed by MTBF-WF dough (W_{MTBF} = 0, 10, 20, 30, 40, and 50%) were prepared according to a published method (Xie et al., 2022). First, 1.0 g dry yeast was dissolved in 38 °C water and set aside. 100 g flour mixture was poured into the dough mixer, mixed with pre-dissolved yeast solution, stirred for 7 min until dough was formed. The stirred dough was put into the fermentation tank for the first fermentation. The fermentation conditions were as follows: fermentation temperature 37 °C, relative humidity (RH) 85%, time 60 min. Then, the dough was rolled 10 times by a noodle sheeter with 5-mm roller gap, then divided into two pieces. Each piece was shaped by hand to yield a smooth dough ball, and proofed for 0.5 h at 37 °C and 85% RH. The dough pieces were steamed for 25 min, and cooled for 60 min for the following measurements.

2.5 Determination of color difference and specific volume of steamed bread

The color difference of steamed bread was determined using a CR-400 color difference meter (Konica-Minolta, Japan) based on CIE-L*a*b model. The steamed bread was weighed, its volume was determined by a volume meter, and the specific volume of steamed bread was calculated (Sun et al., 2020).

2.6 Measurement of textural properties of steamed bread

The textural properties of steamed bread were evaluated based on the TPA mode by a TA-XT Plus texture analyzer (Stable Micro Systems, Surrey, UK) equipped with a P/36R probe. The pretest speed, test speed and post-test speed of probe were was 3.0 mm/s, 1.0 mm/s and 1.0 mm/s, respectively. The compression strain was set at 30% while the auto trigger force was 5.0 g (Gao et al., 2018).

2.7 Determination of internal structure of steamed bread

After cooling 60 min at room temperature, the freshly prepared steamed bread was sliced into thin slices of 15 mm thickness and placed on the sample plate. Its internal structure was analyzed by a C-Cell imaging system (Calibre Control International Ltd, UK).

2.8 Sensory evaluation assay

According to the method of Ma et al. (2022), the sensory test of steamed bread was carried out by 9 members (5 females and 4 males). All the members were Asian and they ate steamed bread in their diet. Each person was provided with an evaluation form and a series of rating tables before the test. The samples were distributed at random. The appearance, color, texture, taste and flavor of each sample ranged from 1 (lowest) to 9 (highest). Its overall acceptability also ranged from 1 (lowest) to 9 (highest).

2.9 Statistical analysis

The experimental results were expressed as the average ± standard deviation (n = 3). The statistical comparison was based on the Tukey method with a confidence level of 95%.

3 Results and discussion

3.1 Rheological properties of MTBF-WF dough

The rheological test of dough can reflect the mechanical properties of dough under mechanical shear and heating. Its indicators include: water absorption, development time time, thermal stability, C2 (minimum torque during dough formation), C3 (peak viscosity), C4 (retention viscosity), C5 (viscosity of retrogradation end point), C3-C2 (gelatinization value), C3-C4 (viscosity disintegration value), C5-C4 (retrogradation value). The effect of W_{MTBF} on the rheological properties of MTBF-WF dough is shown in Figure 1 and Table 1. For different W_{MTBF}, the dough torque curve and parameters were also different. With the increase of W_{MTBF}, the water absorption of dough increased, which was due to the stronger water absorption of MTBF than WF. There was no significant difference in development time of dough when WMTBF was 20-50%. With the increase of W_{MTBF}, the stability time of dough increased at first and then decreased, and reached the highest when W_{MTBF} was 30% and 40%, indicating that the dough had better kneading resistance at this time. In addition The change trends of C3, C4, C5 and C3-C2 were consistent, and all decreased significantly with the increase of W_{MTBF}, suggesting that the higher the W_{MTBF}, the less easy the mixed flour to retrogradate. C3-C4 increased with the increase of W_{MTBF}, which also indicated that the thermal stability of sample decreased with the addition of MTBF, and the tissue adhesion was poor.

3.2 Specific volume and color difference of steamed bread

The specific volume and color of steamed bread are important indexes to evaluate the quality of steamed bread, which directly affects the acceptance of consumers (Pourafshar et al., 2015). Table 2 demonstrates the effect of W_{MTBF} on the specific volume of steamed bread. With the addition of MTBF, the specific volume of steamed bread decreased gradually, which was due to the "dilution" of MTBF on gluten protein, which hindered the formation of gluten network and reduced the swelling power of dough during fermentation, resulting in smaller volume of steamed bread. Moreover, as shown in Table 2, the W_{MTBF} in the blend increased, the L* value of steamed bread gradually decreased, the a* value gradually increased, and the b* value gradually decreased, suggesting that the color of the steamed bread gradually darkened and yellowed, which was related to the color of MTBF itself.

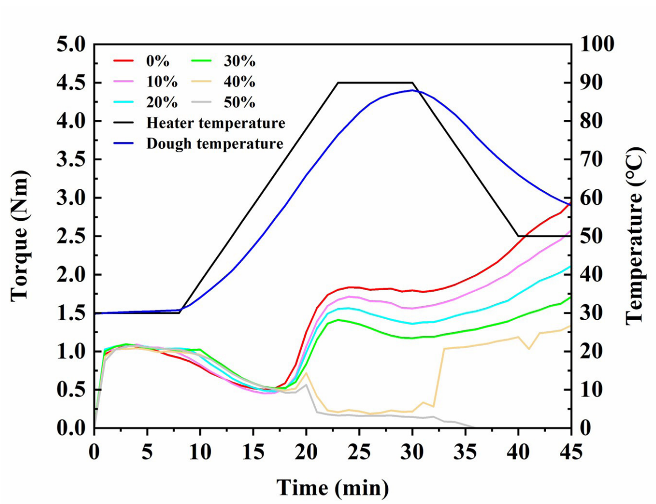

Figure 1. Effect of W_{HTBF} on the Mixolab curves of mixed dough.

3.3 Texture properties of steamed bread

Texture properties are related with the quality of wheat products (Li et al., 2020). The effect of W_{MTBF} on the texture properties of steamed bread were exhibited in Table 3. With the addition of MTBF, the hardness, gumminess and chewiness of steamed bread increased gradually. It was due to the dilution of gluten concentration in dough caused by MTBF, which destroyed the gluten network to a certain extent, and the structure of steamed bread was not fluffy enough. However, springiness, cohesiveness and resilience decreased with the increase of W_{MTBF}, which might be due to the fact that MTBF affected the formation of gluten network structure, resulting in incomplete gluten network structure after dough fermentation and difficult to restore to its original state after compression deformation.

3.4 Internal structure of steamed bread

C-Cell image analyzer is a quality control system of wheat products based on computer recognition technology. By processing the image of the sample, it can comprehensively evaluate the internal structure of the products (O'Shea et al., 2015). Figure 2 showed the C-Cell images of steamed bread with different W_{MTBF}, and Table 4 presents the corresponding C-Cell parameters. It was found that with the increase of W_{MTBF}, the slice area, brightness, area of cells, wall thickness and cell diameter gradually decreased, cell contrast and cell number decreased at first and then increased, cell volume and coarse cell volume increased at first and then decreased, cell elongation and cell density gradually increased. These changes meant that the addition of MTBF made steamed bread rough at first and then became more compact and delicate. The change trend of brightness and L* was the same, which indicated that the

Table 1. Effect of W_{MTBF} on parameters values of Mixolab curves of mixed dough.

W_{MTBF} (%)	0	10	20	30	40	50
Water absorption (%)	58.800 ± 0.200^{f}	61.600 ± 0.100^{e}	65.400 ± 0.100^{d}	69.733 ± 0.252^{c}	74.400 ± 0.100^{b}	79.800 ± 0.200^{a}
Development time (min)	3.207 ± 0.060^{c}	3.343 ± 0.228^{bc}	3.540 ± 0.519^{abc}	3.467 ± 0.042^{abc}	3.883 ± 0.321^{ab}	4.007 ± 0.396^{a}
Thermal stability (min)	5.833 ± 0.252^{d}	7.200 ± 0.200^{c}	8.867 ± 0.153^{b}	9.833 ± 0.153^{a}	9.667 ± 0.153^{a}	9.000 ± 0.100^{b}
C1 (N·M)	1.100 ± 0.034^{a}	1.095 ± 0.012^{a}	1.091 ± 0.021^{a}	1.091 ± 0.032^{a}	1.074 ± 0.024^{a}	1.095 ± 0.024^{a}
C2 (N·M)	0.506 ± 0.010^{ab}	0.449 ± 0.005^{c}	0.482 ± 0.005^{b}	0.515 ± 0.010^{a}	0.494 ± 0.011^{ab}	0.428 ± 0.028^{c}
C3 (N·M)	1.852 ± 0.012^{a}	1.719 ± 0.011^{b}	1.576 ± 0.008^{c}	1.410 ± 0.006^{d}	0.805 ± 0.022^{e}	0.581 ± 0.031^{f}
C4 (N·M)	1.757 ± 0.013^{a}	1.544 ± 0.006^{b}	1.338 ± 0.026^{c}	1.147 ± 0.008^{d}	0.189 ± 0.013^{e}	0.138 ± 0.006^{f}
C5 (N·M)	2.967 ± 0.030^{a}	2.576 ± 0.020^{b}	2.124 ± 0.023^{c}	1.730 ± 0.034^{d}	1.298 ± 0.047^{e}	0.000 ± 0.000^{f}
C3-C2 (N·M)	1.346 ± 0.003^{a}	1.270 ± 0.006^{b}	1.094 ± 0.003^{c}	0.895 ± 0.006^{d}	0.311 ± 0.030^{e}	0.153 ± 0.009^{f}
C3-C4 (N·M)	0.095 ± 0.008^{e}	0.175 ± 0.006^{d}	0.238 ± 0.020^{c}	0.263 ± 0.003^{c}	0.616 ± 0.016^{a}	0.443 ± 0.026^{b}
C5-C4 (N·M)	1.210 ± 0.017^{a}	1.032 ± 0.018^{c}	0.787 ± 0.004^{d}	0.583 ± 0.032^{e}	1.109 ± 0.036^{b}	-0.138 ± 0.006^{f}

internal gloss and surface gloss of steamed bread were basically the same, and there was no significant difference after 30% addition ($p > 0.05$). It could be also found that the internal structure of steamed bread developed at $W_{MTBF} = 10\%$ was poor. When $W_{MTBF} \geq 20\%$, the degree of fineness of the internal tissue of steamed bread ascended. The reason may be that the air retention of the dough decreased during the awakening process, which led to the compactness and fineness of steamed bread after steaming.

3.5 Sensory evaluation

As shown in Table 5, W_{MTBF} had different effects on appearance, color, texture, taste, flavor and overall acceptability of steamed bread. With the increase of W_{MTBF}, all the indexes decreased. The color score was consistent with the trend of L* in *3.2*, and the change of texture score was similar to that of hardness in *3.3*. The flavor score was low when $W_{MTBF} \geq 40\%$, which may be due to the bitter taste of TBF itself. When its addition amount was too high, it could reduce people's acceptance. When the W_{MTBF}

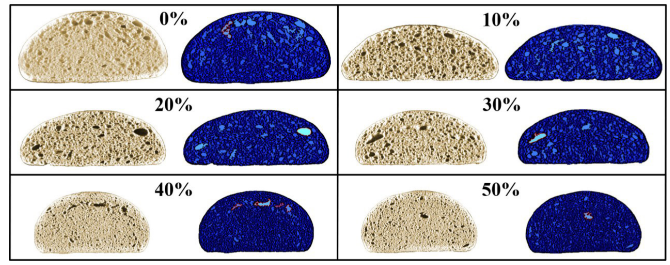

Figure 2. Effect of W_{MTBF} on the appearance of steamed bread slices.

Table 2. Effect of W_{MTBF} on the specific volume and color of steamed bread.

W_{MTBF} (%)	Specific volume (mL/g)	L*	a*	b*
0	2.68 ± 0.16^{a}	74.35 ± 0.90^{a}	-2.88 ± 0.08^{d}	13.52 ± 0.47^{b}
10	2.19 ± 0.11^{b}	42.30 ± 0.69^{b}	2.85 ± 0.09^{c}	15.67 ± 0.08^{a}
20	1.74 ± 0.08^{c}	33.93 ± 0.19^{c}	3.40 ± 0.14^{b}	12.39 ± 0.36^{c}
30	1.54 ± 0.04^{d}	32.75 ± 0.16^{d}	3.56 ± 0.19^{b}	11.20 ± 0.23^{d}
40	1.44 ± 0.02^{de}	31.67 ± 0.35^{e}	4.06 ± 0.07^{a}	10.92 ± 0.05^{de}
50	1.34 ± 0.06^{e}	31.00 ± 0.24^{e}	4.03 ± 0.15^{a}	10.67 ± 0.17^{e}

Table 3. Effect of W_{MTBF} on the textural properties of steamed bread.

W_{MTBF} (%)	Hardness (g)	Springiness	Cohesiveness	Gumminess (g)	Chewiness (g)	Resilience
0	1536 ± 98^{f}	1.089 ± 0.065^{a}	0.843 ± 0.015^{a}	1344 ± 84^{f}	1313 ± 84^{f}	0.591 ± 0.003^{a}
10	1863 ± 107^{e}	1.014 ± 0.100^{a}	0.803 ± 0.008^{b}	1701 ± 75^{e}	1633 ± 72^{e}	0.597 ± 0.007^{a}
20	2362 ± 136^{d}	0.914 ± 0.039^{b}	0.792 ± 0.017^{b}	2196 ± 108^{d}	2139 ± 91^{d}	0.579 ± 0.019^{a}
30	3733 ± 75^{c}	0.880 ± 0.006^{bc}	0.737 ± 0.004^{c}	3114 ± 64^{c}	3008 ± 90^{c}	0.505 ± 0.007^{b}
40	4142 ± 188^{b}	0.840 ± 0.012^{bc}	0.720 ± 0.008^{cd}	3394 ± 168^{b}	3299 ± 183^{b}	0.470 ± 0.014^{c}
50	4864 ± 167^{a}	0.818 ± 0.010^{c}	0.694 ± 0.027^{d}	3733 ± 135^{a}	3559 ± 106^{a}	0.431 ± 0.033^{d}

Table 4. Effect of W_{MTBF} on the internal structure parameters of steamed bread.

W_{MTBF} (%)	0	10	20	30	40	50
Slice area (mm^2)	3116 ± 86^{a}	2640 ± 44^{b}	2514 ± 61^{c}	2339 ± 29^{d}	2291 ± 43de	2226 ± 42^{e}
Brightness	141.556 ± 1.090^{a}	47.783 ± 0.370^{b}	34.838 ± 1.832^{c}	25.369 ± 1.482^{d}	23.929 ± 0.165^{d}	23.436 ± 0.450^{d}
Cell contrast	0.760 ± 0.005^{a}	0.571 ± 0.004^{cd}	0.565 ± 0.039^{d}	0.634 ± 0.022^{b}	0.606 ± 0.005^{bc}	0.592 ± 0.018^{cd}
Number of cells	2425 ± 80^{a}	2046 ± 74^{c}	2264 ± 109^{b}	2499 ± 89^{a}	2486 ± 56^{a}	2511 ± 77^{a}
Area of cells (mm^2)	48.443 ± 0.451^{a}	49.484 ± 0.555^{a}	46.199 ± 1.122^{b}	41.393 ± 1.213^{c}	39.320 ± 0.371^{d}	39.743 ± 1.187^{d}
Wall thickness (mm)	0.441 ± 0.001^{a}	0.434 ± 0.009^{a}	0.401 ± 0.008^{b}	0.395 ± 0.005^{b}	0.391 ± 0.004^{b}	0.379 ± 0.006^{c}
Cell diameter (mm)	1.678 ± 0.051^{a}	1.623 ± 0.104^{a}	1.295 ± 0.169^{b}	0.941 ± 0.023^{c}	0.895 ± 0.022^{c}	0.898 ± 0.024^{c}
Cell volume (mm^3)	4.891 ± 0.366^{b}	6.599 ± 0.458^{a}	5.162 ± 0.855^{b}	3.489 ± 0.159^{c}	3.249 ± 0.056^{c}	3.191 ± 0.121^{c}
Coarse cell volume (mm^3)	8.127 ± 0.639^{b}	11.825 ± 0.369^{a}	8.723 ± 1.217^{b}	5.882 ± 0.642^{c}	5.505 ± 0.241^{c}	5.524 ± 0.295^{c}
Cell elongation (mm)	1.496 ± 0.018^{c}	1.480 ± 0.017^{c}	1.529 ± 0.018^{b}	1.578 ± 0.017^{a}	1.581 ± 0.007^{a}	1.584 ± 0.022^{a}
Cell density	0.778 ± 0.005^{c}	0.775 ± 0.036^{c}	0.902 ± 0.064^{b}	1.069 ± 0.044^{a}	1.085 ± 0.033^{a}	1.128 ± 0.053^{a}

Table 5. Effect of W_{MTBF} on the internal structure parameters of steamed bread.

W_{MTBF} (%)	Appearance	Color	Texture	Taste	Flavor	Overall acceptability
0	8.6 ± 0.2^a	7.9 ± 0.4^a	8.1 ± 0.5^a	8.2 ± 0.3^a	8.0 ± 0.3^b	8.5 ± 0.2^a
10	8.4 ± 0.3^a	8.3 ± 0.5^a	7.8 ± 0.3^{ab}	8.0 ± 0.3^a	8.4 ± 0.2^a	8.6 ± 0.1^a
20	7.9 ± 0.2^b	6.7 ± 0.5^b	7.6 ± 0.4^b	7.3 ± 0.4^b	8.2 ± 0.3^{ab}	8.2 ± 0.4^b
30	7.4 ± 0.2^c	3.3 ± 0.3^c	6.6 ± 0.5^c	6.2 ± 0.2^c	6.9 ± 0.4^c	7.3 ± 0.5^c
40	6.0 ± 0.4^d	3.0 ± 0.5^c	5.8 ± 0.4^d	4.5 ± 0.3^d	4.5 ± 0.4^d	5.6 ± 0.3^d
50	5.7 ± 0.3^d	2.9 ± 0.4^c	5.6 ± 0.4^d	4.3 ± 0.3^d	2.8 ± 0.3^e	4.9 ± 0.5^e

was in the range of 0-20%, these scores were close. It could be concluded that the steamed bread developed at W_{MTBF} = 20% could obtain similar quality and pleasant appearance to common wheat steamed.

4 Conclusion

The MTBF-WF blend could be used for the preparation of steamed bread. The kneading resistance of mixed dough was the best when W_{MTBF} was 30% and 40%. With the increase of W_{MTBF}, the hardness and stickiness of dough decreased, the gelatinization property became worse, the gelatinization rate slowed down, the tissue adhesion decreased, and it was not easy to retrogradate. With the increase of W_{MTBF}, the color of the steamed bread gradually darkened and yellowed, and the specific volume declined gradually. In addition, the hardness, gumminess and chewiness of steamed bread increased with W_{MTBF}, but its springiness, cohesiveness and resilience decreased. The steamed bread developed at W_{MTBF} = 20% had better sensory score. Our results indicate that MTBF is a new food source, which can be used in the development of new wheat foods.

Funding

This work was supported by the Natural Science Foundation of Henan (No.202300410158), the Training Plan of Young Key Teachers in Henan (No.2020GGJS167) and the Key Scientific Research Project of Colleges and Universities in Henan Province of China (22A550011).

References

Brasil, V. C. B., Guimarães, B. P., Evaristo, R. B. W., Carmo, T. S., & Ghesti, G. F. (2021). Buckwheat (*Fagopyrum esculentum Moench*) characterization as adjunct in beer brewing. *Food Science and Technology*, 41(Suppl. 1), 265-272. http://dx.doi.org/10.1590/fst.15920.

Brites, L. T. G. F., Ortolan, F., Silva, D. W., Bueno, F. R., Rocha, T. S., Chang, Y. K., & Steel, C. J. (2019). Gluten-free cookies elaborated with buckwheat flour, millet flour and chia seeds. *Food Science and Technology*, 39(2), 458-466. http://dx.doi.org/10.1590/fst.30416.

Collar, C. (2017). Significance of heat-moisture treatment conditions on the pasting and gelling behaviour of various starch-rich cereal and pseudocereal flours. *Food Science & Technology International*, 23(7), 623-636. http://dx.doi.org/10.1177/1082013217714671. PMid:28610447.

Deng, Y., Padilla-Zakour, O., Zhao, Y., & Tao, S. (2015). Influences of high hydrostatic pressure, microwave heating, and boiling on chemical compositions, antinutritional factors, fatty acids, in vitro protein digestibility, and microstructure of buckwheat. *Food and Bioprocess Technology*, 8(11), 2235-2245. http://dx.doi.org/10.1007/s11947-015-1578-9.

Gao, Q., Liu, C., & Zheng, X. (2018). Effect of heat treatment of rye flour on rye-wheat steamed bread quality. *International Journal of Food Science & Technology*, 53(5), 1109-1119. http://dx.doi.org/10.1111/ijfs.13662.

Ge, R. H., & Wang, H. (2020). Nutrient components and bioactive compounds in tartary buckwheat bran and flour as affected by thermal processing. *International Journal of Food Properties*, 23(1), 127-137. http://dx.doi.org/10.1080/10942912.2020.1713151.

Geng, S., Li, Y., Lv, J., Ma, H., Liang, G., & Liu, B. (2022). Fabrication of food-grade Pickering high internal phase emulsions (HIPEs) stabilized by a dihydromyricetin and lysozyme mixture. *Food Chemistry*, 373(Pt B), 131576. http://dx.doi.org/10.1016/j.foodchem.2021.131576. PMid:34799133.

Glavač, N. K., Stojilkovski, K., Kreft, S., Park, C. H., & Kreft, I. (2017). Determination of fagopyrins, rutin, and quercetin in Tartary buckwheat products. *Lebensmittel-Wissenschaft + Technologie*, 79, 423-427. http://dx.doi.org/10.1016/j.lwt.2017.01.068.

Krkošková, B., & Mrazova, Z. (2005). Prophylactic components of buckwheat. *Food Research International*, 38(5), 561-568. http://dx.doi.org/10.1016/j.foodres.2004.11.009.

Li, J., Geng, S., Zhen, S., Lv, X., & Liu, B. (2022). Fabrication and characterization of oil-in-water emulsions stabilized by whey protein isolate/phloridzin/sodium alginate ternary complex. *Food Hydrocolloids*, 129, 107625. http://dx.doi.org/10.1016/j.foodhyd.2022.107625.

Li, X., Wang, C., & Krishnan, P. G. (2020). Effects of corn distillers dried grains on dough properties and quality of Chinese steamed bread. *Food Science & Nutrition*, 8(8), 3999-4008. http://dx.doi.org/10.1002/fsn3.1604. PMid:32884681.

Liu, H., Lv, M., Peng, Q., Shan, F., & Wang, M. (2015). Physicochemical and textural properties of tartary buckwheat starch after heat–moisture treatment at different moisture levels. *Stärke*, 67(3-4), 276-284. http://dx.doi.org/10.1002/star.201400143.

Liu, X., Geng, S., He, C., Sun, J., Ma, H., & Liu, B. (2022). Preparation and characterization of a dihydromyricetin–sugar beet pectin covalent polymer. *Food Chemistry*, 376, 131952. http://dx.doi.org/10.1016/j.foodchem.2021.131952. PMid:34973639.

Luthar, Z., Golob, A., Germ, M., Vombergar, B., & Kreft, I. (2021). Tartary buckwheat in human nutrition. *Plants*, 10(4), 700. http://dx.doi.org/10.3390/plants10040700. PMid:33916396.

Ma, M., Mu, T., Sun, H., & 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. http://dx.doi.org/10.1016/j.foodchem.2021.130686. PMid:34399176.

O'Shea, N., Rößle, C., Arendt, E., & Gallagher, E. (2015). Modelling the effects of orange pomace using response surface design for gluten-free bread baking. *Food Chemistry*, 166, 223-230. http://dx.doi.org/10.1016/j.foodchem.2014.05.157. PMid:25053049.

Pourafshar, S., Rosentrater, K. A., & Krishnan, P. G. (2015). Changes in chemical and physical properties of Latin American wheat flour based tortillas substituted with different levels of distillers dried grains with solubles (DDGS). *Journal of Food Science and Technology*, 52(8), 5243-5249. http://dx.doi.org/10.1007/s13197-014-1566-5. PMid:26243948.

Ruan, J., Zhou, Y., Yan, J., Zhou, M., Woo, S.-H., Weng, W., Cheng, J., & Zhang, K. (2022). Tartary buckwheat: an under-utilized edible and medicinal herb for food and nutritional security. *Food Reviews International*, 38(4), 440-454. http://dx.doi.org/10.1080/87559129.2020.1734610.

Sun, H., Liu, X., Tian, Z., Fan, J., Meng, Y., Nan, X., Yang, Z., Zeng, X., & Kang, L. (2020). Influence of potato flour on dough and steamed bread quality and correlation analysis. *International Journal of Food Engineering*, 16(1-2). http://dx.doi.org/10.1515/ijfe-2019-0273.

Varatharajan, V., Hoover, R., Liu, Q., & Seetharaman, K. (2010). The impact of heat-moisture treatment on the molecular structure and physicochemical properties of normal and waxy potato starches. *Carbohydrate Polymers*, 81(2), 466-475. http://dx.doi.org/10.1016/j.carbpol.2010.03.002.

Vidya, S., Ravi, R., & Bhattacharya, S. (2013). Effect of thermal treatment on selected cereals and millets flour doughs and their baking quality. *Food and Bioprocess Technology*, 6(5), 1218-1227. http://dx.doi.org/10.1007/s11947-012-0888-4.

Wang, S., Guo, L., Miao, Z., Ma, H., & Melnychuk, S. (2022). Effects of maternal vitamin D3 status on quality characteristics of pork batters in offspring pigs during cold storage. *Food Science and Technology*, 42, e102021. http://dx.doi.org/10.1590/fst.102021.

Wu, X., Fu, G., Li, R., Li, Y., Dong, B., & Liu, C. (2020). Effect of thermal processing for rutin preservation on the properties of phenolics & starch in Tartary buckwheat achenes. *International Journal of Biological Macromolecules*, 164, 1275-1283. http://dx.doi.org/10.1016/j.ijbiomac.2020.07.135. PMid:32682042.

Xiao, Y., Liu, H., Wei, T., Shen, J., & Wang, M. (2017). Differences in physicochemical properties and in vitro digestibility between tartary buckwheat flour and starch modified by heat-moisture treatment. *Lebensmittel-Wissenschaft + Technologie*, 86, 285-292. http://dx.doi.org/10.1016/j.lwt.2017.08.001.

Xie, D., Lei, Y., & Sun, Y. (2022). Effects of heating method and refrigerating time on nutritional quality and digestive characteristics of refrigerated Chinese steamed bread. *Food Science and Technology*, 42, e10122. http://dx.doi.org/10.1590/fst.10122.

Yang, X., & Lv, Y. P. (2015). Purification, characterization, and DNA damage protection of active components from tartary buckwheat (*Fagopyrum tataricum*) hull. *Food Science and Biotechnology*, 24(6), 1959-1966. http://dx.doi.org/10.1007/s10068-015-0258-x.

Yue, Y., Geng, S., Shi, Y., Liang, G., Wang, J., & Liu, B. (2019). Interaction mechanism of flavonoids and zein in ethanol-water solution based on 3D-QSAR and spectrofluorimetry. *Food Chemistry*, 276, 776-781. http://dx.doi.org/10.1016/j.foodchem.2018.10.083. PMid:30409662.

Zhang, S., Chen, S., Geng, S., Liu, C., Ma, H., & Liu, B. (2021). Effects of tartary buckwheat bran flour on dough properties and quality of steamed bread. *Foods*, 10(9), 2052. http://dx.doi.org/10.3390/foods10092052. PMid:34574162.