Research Article

Selected Quality Attributes of Wheat Flour Added with Overozonized Wheat Flour

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Overozonized wheat flour was added to unozonized wheat flour at three different ratios (M1: 1 : 1; M2: 1 : 2; and M3: 1 : 3), and the mixed flour was evaluated for quality properties, including pH, protein component, dough property, pasting property, and steamed bread quality. The pH of the mixed flour gradually increased as the addition content of overozonized flour decreased. The three mixed flour had higher insoluble polymeric protein (IPP) content than unozonized flour. Compared with overozonized flour, M1 and M2 flour did not show a significant difference in IPP content, but M3 flour exhibited a decreased IPP content. Three mixed flour had higher dough development time and dough stability time than both unozonized and overozonized flour, and there was no significant difference among three mixed flour in these two dough parameters. Peak, trough, and final viscosities of the three mixed flour were between those of unozonized and overozonized flour. Steamed bread of three mixed flour had larger specific volume and better texture than that of overozonized flour, with steamed bread of M3 flour showing the best attributes. Among the three mixed flour, M1 flour was the closest to overozonized flour in volatile compounds of steamed bread. These results suggested overozonized flour can be mixed with unozonized flour to decrease the deterioration of overozonization on the dough and food-making properties of wheat flour, but the mixing ratio should be taken into consideration to obtain a better quality.

1. Introduction

Wheat is a staple cereal for nearly 35% of the world's population. As a dietary source of carbohydrates and proteins, wheat plays an important role in meeting energy and nutrient requirements of humans. Ozone (O₃) is the tri-atomic oxygen formed by addition of a free radical of oxygen to molecular oxygen. It is a potent oxidant that is generally recognized as safe (GRAS) for intended use in food since 1997 [1]. Ozone is not stable and can rapidly decompose into oxygen during usage [2]. Due to unique attributes, ozone attracts considerable research interest for applications in wheat grains and flour.

During the storage and processing process of wheat grains and flour, ozone is a good candidate for fumigation

gas, which can kill insects and inhibit the growth of microbes [3–6]. Ozone can react with mycotoxins (e.g., deoxynivalenol and aflatoxin) and reduce their toxicities by damaging their molecular structures [7–9]. Ozone is also effective in degrading residual pesticides that are used during the growth period, such as bifenthrin, deltamethrin, fenitrothion, and pirimiphos-methyl [10, 11].

As application research of ozone in wheat expands, its impact on properties of wheat flour has been gaining ever-growing attention. Li et al. [12] found that the development time and stability time of noodle dough was significantly increased as flour was treated with ozone treatment. Li et al. [13] observed the rise of dough development time and stability time as moistened wheat kernel were treated with ozone gas. However, deteriorated dough properties were

reported to overozonized wheat flour. Sandhu et al. [14] reported that dough stabilities of wheat flour exhibited a trend of increase at the initial stage of ozone treatment, followed by a decrease as treatment prolonged.

The food-making property of ozonized wheat flour varies with the ozone treatment condition. Li et al. [12] reported that moderate ozonization of wheat flour could improve the texture of the noodle products. However, Mei et al. [15] reported that overozonization of wheat flour had a negative effect on quality scores, volume, and structure of the steamed bread products. Mixing with unozonized wheat flour can be a simple strategy to utilize the overozonized wheat flour. However, to date, there have been few systematic studies reported on the quality attributes of the blends of overozonized and unozonized wheat flour. In this study, overozonized wheat flour was added to the unozonized at different ratios (1:1, 1:2, and 1:3), and the mixed flour was compared in dough properties, protein composition, pH, pasting properties, and qualities of the steamed bread products. This research can provide a reference for the proper application of ozone treatment in wheat industry.

2. Materials and Methods

2.1. Materials. Wheat grains (variety Xinong 797), harvested in 2019, were kindly supplied by a farmer in Xiangyang (China). Wheat grains were milled to flour using a Buhler MLU-202 mill (Buhler Group, Uzwil, Switzerland) with an extraction rate of around 70%. Acetonitrile, 1-propanol, and trifluoroacetic acid, chromatographic grade, were supplied by Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China). Nitrogen gas with a purity of 99.999% was supplied by the Wuhan Minghui Gas Science and Technology Co., Ltd. (Wuhan, China). Other chemicals were of analytical grade unless otherwise stated.

2.2. Preparation of Overozonized Wheat Flour and Its Mixing with Unozonized Flour. Ozone gas was generated by using an ozone generator (HW-ET-20, Guangzhou Huanwei Environment Protection Science and Technology Co., Ltd., Jinan, China). Wheat flour (300 g) was treated with ozone gas at an air flow rate of 2.5 L/min, corresponding to an ozone flow rate of 3.8 g/h. Overozonized flour was obtained after 15 min of ozone treatment [15]. Overozonized flour was stored in a polyethylene bag in a refrigerator. After one week of storage, overozonized flour was mixed with unozonized flour in a glass bottle, which was vigorously shaken by hand to ensure uniformity. The mixed flour with overozonized flour/unozonized flour ratios (dry weight) of 1:1, 1:2, and 1:3 was coded as M1, M2, and M3, respectively. The unozonized flour and overozonized flour were coded as UOF and OOF, respectively. All these flour were stored in polyethylene bags in a refrigerator until use.

2.3. Determination of the pH of Wheat Flour. The pH of wheat flour was determined according to AACC method 02-52.

2.4. Protein Composition Analysis of Wheat Flour by Size-Exclusion High-Performance Liquid Chromatography (SE-HPLC). Protein composition of wheat flour was analyzed by the SE-HPLC method described by Schober et al. [16] with a slight modification. In brief, wheat flour was extracted with aqueous 50% 1-propanol, and the unextractable fraction was lyophilized. The nitrogen content of the dried unextractable fraction was determined by the combustion method to calculate the insoluble polymeric protein (IPP) content using a nitrogen-to-protein conversion factor of 5.70. Extractable fraction was analyzed with SE-HPLC to obtain the percentages of soluble polymeric protein (SPP), gliadin (Gli), and albumin and globulin (Alb/Glob). SE-HPLC was performed using a Waters e2695 HPLC system (Milford, MA, USA) and a Biosep SEC-4000 column (Phenomenex, Torrance, CA, USA). The injection volume was 20 μ L, and UV-detection was conducted at 210 nm. The column temperature was maintained at 40°C, and the mobile phase was 50% acetonitrile and 0.1% (w/v) trifluoroacetic acid at a flow rate of 0.5 mL/min.

2.5. Dough Property Analysis of Wheat Flour. The dough property of wheat flour was investigated by Mixolab (Chopin, Tripette & Renaud, Paris, France) according to AACC method 54-60.01. The Mixolab device was used to determine water absorption (WA), dough development time (DDT), and dough stability time (DST).

2.6. Pasting Property Analysis of Wheat Flour. The pasting profiles of wheat flour were determined using a Rapid Visco Analyser (RVA, Newport Scientific Pvt. Ltd., Warriewood, Australia). Flour dispersion (12% w/w) was equilibrated at 50°C for 1 min and then increased to 95°C at a rate of 12 °C/min, held for 2.5 min, cooled to 50°C at a rate of 12 °C/min, and held for 2 min. The paddle speed was set at 960 rpm for the first 10 s and then was reduced to 160 rpm throughout the rest of the experiment.

2.7. Steamed-Bread-Making Process. The steamed bread was made according to the work of Sandhu et al. [14]. The dough was fermented at 30°C and 85% relative humidity in a GVAS fully automatic proofing cabinet (MIWE Michael Wenz GmbH, Arnstein, Germany). After fermentation, the dough was sheeted 20 times on a dough sheeter (MP800, Yechang Food machinery Co., Ltd., Shanghai, China) and split into 100 g portions. The dough chunks were formed into rounded shapes by hand and fermented at 30°C and 85% relative humidity for 35 min. The proofed doughs were steamed for 25 min in a pot using a steam tray and boiling water. After cooling at room temperature for 1 h, the quality of the steamed bread was evaluated.

2.8. Specific Volume, Crumb Structure, and Texture Analysis of the Steamed Bread. The specific volume of the steamed bread was measured using a BVM-L370 volume measurer (Perten Instruments, Hågersten, Sweden). The crumb structure of the steamed bread was analyzed using the C-Cell

FIGURE 1: pH values of wheat flour added with different ratios of overozonized wheat flour. Means with the same letter were not significantly different ($\alpha = 0.05$).

Imaging System (Perten Instruments, Hägersten, Sweden). The texture of the steamed bread was tested using the TA-XT2i texture analyzer (Stable Micro Systems, Surrey, UK) with its Pasta Firmness/Stickiness Rig probe (P35). The steamed bread was cut into pieces of 15 mm thickness. The texture analyzer was set as follows: trigger type, auto-5 g; pretest speed, 3 mm/s; posttest speed, 1 mm/s; test speed, 1 mm/s; compression ratio, 60%; interval between consecutive compressions, 3 s; and compression time, 2 times.

2.9. Analysis of Volatile Compounds by Gas Chromatography-Ion Mobility Spectrometry (GC-IMS). Volatile compounds of the steamed bread were analyzed using a FlavourSpec® GC-IMS instrument (Gesellschaft für Analytische Sensorsysteme mbH, Dortmund, Germany). Gas chromatography (GC) was performed with a 30 m OV-5 column to separate the volatile compounds. Nitrogen gas of 99.999% purity was used as the carrier gas. The elution gas was maintained at 5 mL/min for 2 min, increased to 100 mL/min in 10 min, then increased to 150 mL/min in 4 min, and maintained at this temperature for 1 min. The analytes were eluted and separated at 45°C, and then ionized in an IMS ionization chamber. Nitrogen gas at a flow rate of 150 mL/min was used as the drift gas for IMS, and the drift tube temperature was set at 45°C. IMS was performed at 45°C.

Data from GC-IMS were analyzed using LAV software, GC-IMS Library Search software, Gallery plot, and dynamic PCA plug-ins. The volatile compounds were identified with GC-IMS Library search by using the NIST database and the IMS database. LAV software was used to perform quantitative analysis after establishing standard curves. The Gallery plot plug-in was used to perform fingerprint comparison of the volatile compounds of samples. The dynamic PCA plug-in was used to perform principal component analysis.

FIGURE 2: SE-HPLC chromatograms for extractable protein of wheat flour added with different ratios of overozonized wheat flour.

FIGURE 3: Percentages of protein fractions of wheat flour added with different ratios of overozonized wheat flour. For a specific protein fraction, means with the same letter were not significantly different ($\alpha = 0.05$).

2.10. Statistical Analysis. Data are averages of duplicate observations and expressed as means $\pm$ standard deviations. An analysis of variance with a significance level of 5% was conducted, and Duncan's test was applied to determine differences between means using the commercial statistical package (SPSS Inc., Chicago, IL, USA).

FIGURE 4: Mixolab curves of wheat flour added with different ratios of overozone wheat flour.

3. Results and Discussion

3.1. pH. The acidity of wheat flour directly affects the property of dough [17]. pH values of wheat flour added with different ratios of overozone wheat flour are shown in Figure 1. The pH of overozone wheat flour was significantly lower than that of unozonized flour. This result might be due to the structure change of starch and lipids during ozone treatment. Under ozone treatment, hydroxyl groups of starch can be oxidized to carbonyl and carboxyl groups [18]. Ozone can react with unsaturated lipids through Criegee reaction, giving rise to acidic products [19, 20]. pH values of the three mixed flour were between those of the overozone flour and unozonized flour. With the addition ratio of overozone flour decreased, pH of the mixed flour gradually got close to the unozonized flour and away from overozone flour.

3.2. Protein Composition. Wheat protein comprises of four major types: glutenin, gliadin, albumin, and globulin. The insoluble polymeric protein (IPP) of glutenin is considered important in determining gluten quality [21]. HPLC chromatograms of extractable protein of wheat flour added with different ratios of overozone wheat flour are displayed in Figure 2, and protein compositions of wheat flour are shown in Figure 3. As Figure 3 shows, overozone wheat flour had lower SPP (soluble polymeric protein) content and higher IPP content than unozonized wheat flour. Chittrakorn et al. [22] suggested that ozone treatment of wheat flour could enhance the crosslinking of glutenin from low-molecular-weight polymeric protein to high-molecular-weight polymeric protein, leading to the increase of IPP fraction. Three mixed flour had higher IPP contents and lower SPP contents than unozonized flour. Compared to overozone flour, M2

TABLE 1: The Mixolab parameters of wheat flour added with different ratios of overozone wheat flour[†].

	WA (%)	DDT (min)	DST (min)
UOF	66.10 ± 0.00 ^b	1.13 ± 0.02 ^b	7.61 ± 0.52 ^a
OOF	71.30 ± 0.66 ^c	1.04 ± 0.03 ^a	1.74 ± 0.16 ^d
M1	66.00 ± 0.17 ^b	1.32 ± 0.06 ^c	9.48 ± 0.09 ^b
M2	65.73 ± 0.35 ^b	1.42 ± 0.17 ^c	9.26 ± 0.08 ^b
M3	64.83 ± 0.29 ^a	1.40 ± 0.17 ^c	9.34 ± 0.19 ^b

[†]Data were expressed as means ± SD. Means within a column that had the same letter were not significantly different ($\alpha = 0.05$). WA = water absorption; DDT = dough development time; DST = dough stability time.

FIGURE 5: RVA curves of wheat flour added with different ratios of overozone wheat flour.

and M1 flour did not show a significant difference in IPP content, but M3 flour exhibited a significantly decreased IPP content. This suggested that adding different amounts of overozone wheat flour can make a difference in the glutenin structure of the mixed flour and the mixed flour was close to overozone flour in IPP content at higher addition amounts.

3.3. Dough Property. Mixolab curves and parameters of wheat flour added with different ratios of overozone wheat flour are shown in Figure 4 and Table 1, respectively. The water absorption (WA) of overozone flour was significantly higher than that of unozonized flour. This result was consistent with the work of Mei et al. [15]. As compared to unozonized wheat flour, overozone flour exhibited a significant decrease in dough development time (DDT) and dough stability time (DST), indicating that dough strength was weakened. This result was consistent with the work of Zhuang et al. [23] and Zhang et al. [24]. The ozone-induced decrease of flour in DDT and DST was in contrast with the increased IPP content. This inconsistency can be attributed to the decrease of the pH value. Increase in acidity of wheat flour would result in stiffer and more fragile dough [25]. The DDT and DST of three mixed

TABLE 2: The pasting parameters of wheat flour added with different ratios of overozonized wheat flour[†].

	PV (cP)	TRV (cP)	BDV (cP)	FV (cP)	SBV (cP)
UOF	870.0 ± 26.9 ^a	651.0 ± 12.7 ^a	219.0 ± 14.1 ^a	1334.0 ± 43.8 ^a	683.0 ± 31.1 ^a
OOF	1085.5 ± 29.0 ^d	762.0 ± 19.8 ^d	323.5 ± 9.2 ^d	1516.5 ± 19.1 ^d	754.5 ± 0.7 ^c
M1	986.0 ± 11.3 ^c	709.5 ± 10.6 ^c	276.5 ± 0.7 ^c	1436.5 ± 21.9 ^{bc}	727.0 ± 11.3 ^b
M2	923.5 ± 23.3 ^b	671.5 ± 14.9 ^b	252.0 ± 8.5 ^b	1390.5 ± 14.9 ^b	719.0 ± 17.5 ^b
M3	985.0 ± 1.4 ^c	726.5 ± 5.0 ^c	258.5 ± 3.5 ^{bc}	1472.5 ± 5.0 ^c	746.0 ± 10.0 ^b

[†]Data were expressed as means ± SD. Means within a column that had the same letter were not significantly different ($\alpha = 0.05$). PV = peak viscosity; TRV = trough viscosity; BDV = breakdown viscosity; FV = final viscosity; SBV = setback viscosity.

TABLE 3: The specific volumes and texture attributes of steamed bread made from wheat flour added with different ratios of overozonized wheat flour[†].

	Specific volume (mL/g)	Hardness	Chewiness	Elasticity	Resilience
UOF	2.74 ± 0.10 ^c	1439.2 ± 31.6 ^a	1060.8 ± 16.3 ^a	0.889 ± 0.024 ^b	0.465 ± 0.008 ^c
OOF	1.78 ± 0.01 ^a	4527.4 ± 39.9 ^e	2981.9 ± 290.3 ^c	0.838 ± 0.016 ^a	0.452 ± 0.020 ^{bc}
M1	2.27 ± 0.01 ^c	2275.1 ± 97.2 ^c	1630.6 ± 124.7 ^b	0.898 ± 0.045 ^b	0.433 ± 0.013 ^b
M2	2.11 ± 0.10 ^b	2515.1 ± 11.6 ^d	1571.1 ± 12.7 ^b	0.833 ± 0.020 ^a	0.375 ± 0.006 ^a
M3	2.52 ± 0.01 ^d	2152.3 ± 98.8 ^b	1579.7 ± 88.3 ^b	0.898 ± 0.011 ^b	0.456 ± 0.005 ^c

[†]Data were expressed as means ± SD. Means within a column that had the same letter were not significantly different ($\alpha = 0.05$).

FIGURE 6: C-Cell images of steamed bread made from wheat flour added with different ratios of overozonized wheat flour.

flour were higher than those of unozonized and overozonized flour. This suggested the mixed flour had stronger dough strength than the two individual constituents. The mixed flour had greater IPP content than unozonized flour. Compared with overozonized flour, the mixed flour had a significant increase in the pH value. These two factors contributed to a superior dough

structure of mixed flour relative to the two-constituent flour. There was no significant difference among the three mixed flour in DDT and DST.

3.4. Pasting Property. Pasting curves of wheat flour added with different ratios of overozonized wheat flour are

TABLE 4: The volatile compounds of steamed bread made from wheat flour[†].

Volatile compounds	CAS#	RI	Rt (s)	Dt (ms)
Isopropyl acetate	C108214	102.1	658.6	35.836
Triethylamine	C121448	101.2	666.3	37.846
1-Methoxy-2-methyl-propane	C625445	88.1	574.5	19.178
2-Butanone	C78933	72.1	585.2	21.093
Ethyl acetate	C141786	88.1	573.5	18.986
3-Methylpentane	C96140	86.2	583.7	20.805
2-Pentanone	C107879	86.1	694.2	46.613
Isopentyl alcohol	C123513	88.1	755.2	78.756
2,3-Pentanedione	C600146	100.1	685.6	43.609
Dimethoxyethane	C110714	90.1	648.3	33.347
Acetic acid	C64197	60.1	617.9	27.009
1-Propanol	C71238	60.1	557.4	16.118
Butanoic acid	C107926	88.1	774.3	93.979
Ethyl propanoate	C105373	102.1	710.8	53.199
2-Formylbutane	C96173	86.1	658.4	35.772
1-Hexen-3-one	C1629603	98.1	773.7	93.462
trans-2-Pentenal	C1576870	84.1	739.1	67.98
Isobutyraldehyde	C78842	72.1	567	17.836
Benzaldehyde	C100527	106.1	978.4	288.66
2-Hexanol	C626937	102.2	979	289.026
1-Octen-3-ol	C3391864	128.2	976.8	287.565
2-Heptanone	C110430	114.2	879.7	206.494
2,3-Butanediol	C513859	90.1	806.8	125.868
Isobutyric acid	C79312	88.1	791.1	109.747
Butanal	C123728	72.1	623.5	28.108
Isobutanol	C78831	74.1	617.1	26.874
Butanoic acid	C107926	88.1	807.3	126.445
1-Pentyl butyrate	C540181	158.2	1050.8	337.486
trans-2-Pentenal	C1576870	84.1	754.4	78.155
Phenylethyl alcohol	C60128	122.2	1110.8	377.895
Styrene	C100425	104.1	890	217.033
2,3-Butanedione	C431038	86.1	573.1	18.922
Propanoic acid	C79094	74.1	756.3	79.565
1-Butanol	C71363	74.1	654.8	34.912
3-Methylbutanal	C590863	86.1	618.4	27.113
Acetol	C116096	74.1	711.1	53.319
Propanoic acid	C79094	74.1	685.9	43.711
2-Furanmethanol	C98000	98.1	878.7	205.339
Diethylnitrosamine	C55185	102.1	890.7	217.754
3-Methylbutanoic acid	C503742	102.1	839.9	162.577
1-Heptanol	C111706	116.2	978.6	288.813
1-Octen-3-ol	C3391864	128.2	977.5	288.026
Pentanoic acid	C109524	102.1	917.3	242.387
trans-2-trans-4-Heptadienal	C4313035	110.2	1018.4	315.673
1-Octen-3-one	C4312996	126.2	975	286.34
3-Octanone	C106683	128.2	977.8	288.271
n-Hexyl propionate	C2445763	158.2	1108.8	376.556
3-Methylpentanoic acid	C105431	116.2	935.1	257.157
2-Phenylethanal	C122781	120.1	1045.8	334.114
Acetol	C116096	74.1	655.2	34.987
3-Methyl-1-butanol	C123513	88.1	734.4	65.169
2-Butanone	C78933	72.1	615.5	26.557
n-Pentyl acetate	C628637	130.2	902.3	228.949
3-Furanmethanol	C4412913	98.1	977.8	288.247
Butanoic acid	C107926	88.1	790.1	108.79

[†]RI: retention index; Rt: retention time; Dt: drift time.

displayed in Figure 5, and pasting parameters are shown in Table 2. As compared to unozonized flour, overozonized flour exhibited an increase in pasting viscosity. Ozone-induced pasting property change of wheat flour was mainly related to the denaturation of alpha-amylase and oxidation of starch. Ozone treatment could inactivate the alpha-amylase of wheat flour, resulting in the decrease of starch depolymerization in the pasting process [23]. Ozonation could partly oxidize starch molecules, and the negative charges of resultant carboxyl groups increased the swelling of starch granules during heating [26, 27]. The three mixed flour exhibited peak viscosity (PV), trough viscosity (TRV), and final viscosity (FV) between those of unozonized flour and ozone-treated flour. There were only slight differences among the three flour in pasting parameters.

3.5. Specific Volume, Inner Structure, and Texture of the Steamed Bread. The specific volume and texture attributes of the steamed bread made from wheat flour added with different ratios of overozonized wheat flour are shown in Table 3, and the inner structure of the steamed bread are shown in Figure 6. As compared with the steamed bread of unozonized flour, the steamed bread of overozonized flour exhibited a decrease in specific volume, uniformity of pores and elasticity, and an increase in hardness and chewiness. This was consistent with the work of Mei et al. [15]. The steamed bread of the three mixed flour had higher specific volume and lower hardness and chewiness than that of overozonized flour. The steamed bread of the three mixed flour exhibited similar uniform distribution of pores. These results were consistent with the results of dough property. The dough strengths of mixed flour were greater than those of overozonized wheat flour. The enhancement of dough strength could improve the gas-holding capacity of dough, leading to increased specific volume and pore distribution uniformity of the steamed bread. However, the three mixed flour were still inferior to unozonized flour in specific volume and texture attributes of steamed bread products, and there were slight differences among their steamed bread in these parameters. Among the three mixed flour, the steamed bread of M3 flour exhibited the highest specific volume and lowest hardness.

3.6. Volatile Compounds of the Steamed Bread. The volatile compounds of the steamed bread identified by GC-IMS are shown in Table 4, and volatile compound fingerprints of the steamed bread made from different flour are shown in Figure 7. The steamed bread of overozonized and unozonized flour had a significant difference in volatile compounds. As compared to the steamed bread of unozonized flour, more amounts of off-odor compounds were observed in the steamed bread of overozonized flour, including butanoic acid, 1-octen-3-ol, and

FIGURE 7: Volatile compound fingerprints of steamed bread made from wheat flour added with different ratios of overozonized wheat flour. a and b indicate two repetitions of determinations.

FIGURE 8: PCA plot of volatile compounds of steamed bread made from wheat flour added with different ratios of overozonized wheat flour.

3-methyl-1-butanol [28]. 1-Octen-3-ol was an oxidized product of linoleic acid and was highly related to the rancidity of food fats [29, 30]. The steamed bread of the three mixed flour exhibited different fingerprints from that of the two-constituent flour. In general, the steamed bread of three mixed flour had lower amounts of off-odor compounds than that of ozone-treated flour.

Principal component analysis (PCA) was performed to analyze the variation in identified volatile compounds in the steamed bread, and the result is shown in Figure 8. The cumulative variance contribution rate of the first part PC1 (69%) and the second part PC2 (24%) was 93%. This result suggested that the two principal components can represent most of the information in the raw data [31]. Different positions were observed for the steamed bread of three mixed flour in the distribution map. The steamed bread of overozonized flour and M1 flour were relatively similar in

volatile compounds. The steamed bread of M2 and M3 flour were also similar in volatile compounds.

4. Conclusions

The blends of overozonized flour and unozonized flour were better than sole overozonized flour in quality. Compared with overozonized flour, three mixed flour had a decrease in the pH value and an increase in DDT, DST, and pasting viscosities. Steamed bread of three flour exhibited higher specific volume and lower hardness, chewiness, and off-odor flavor than that of overozonized flour. Three mixed flour were inferior to unozonized flour in specific volume and texture of the steamed bread. Overozonized flour and M1 flour were relatively similar in volatile compounds of steamed bread. M2 and M3 flour were also similar in volatile compounds of steamed bread. These results suggested that

the mixing of overozonized flour and unozonized flour can alleviate the deterioration of overozonization on the quality of wheat flour. This research can provide a basis for the proper utilization of ozone treatment in wheat industry. Other than steamed bread, the overozonized wheat flour can also be added in the formula of other wheat-based foods, and the effects deserve further research work.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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