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Quality characteristics of fresh noodles as affected by modified atmosphere packaging

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Abstract

The modified atmosphere packages (MAP) was used to preserve the fresh noodles and the effect of atmosphere ratio (N_2: CO_2 = 0:100, 20:80, 30:70, 40:60 or 50:50) on noodle quality was investigated with normal packages as control. The results showed that the MAP could significantly extend the shelf life of fresh noodles up to at least 7 d, compared with the control. On the 7th day of storage, the elasticity and hardness gradually decreased with the increase of N_2: CO_2 ratio ($P > 0.05$) even if the MAP group were poor than the control ($P > 0.05$). In terms of water content, on the 7th day of storage, the decrease of 0:100 group and 20:80 group was less than that of control group ($P < 0.05$), and the effect of water retention was better. On the 7th day of storage, pH in the MAP group decreased less than that in the control group ($P < 0.05$). During the same storage period, the inhibition effect of the 0:100 group was significantly higher than that of the control group ($P < 0.05$), while the L* values decreased less in the 0:100 and 30:70 groups than in the control group ($P < 0.05$).

Keywords: modified atmosphere packaging; fresh noodles; quality; preservation.

Practical Application: Modified atmosphere packages has promising potential for prolonging the shelf life of fresh noodles products.

1 Introduction

Noodles are one of the traditional staple foods of people. According to the state of eating noodles, noodles are usually divided into dry type (such as instant noodles, noodles, etc.) and wet type (fresh noodles). In which, fresh noodles are most popular by consumer due to the freshness, nutrition and delicious taste. However, the fresh noodles are easily spoiled caused by the rapid growth resulted from the high water content and water activity, which seriously limits the industrial production of fresh noodles. Therefore, how to prolong the shelf life of fresh noodles is a urgently problem in flour products industry.

Many researchers tried adding some chemical preservatives to control microbial growth of fresh noodles, Han found that the addition of monosodium fumarate increased the shelf life of fresh noodles by 5-12 d (Han et al., 2022), Yang found that fresh noodles treated with sodium dehydroacetate could extend their shelf life by 50 d at 4 °C (Yang et al., 2021), but it is not welcomed by consumers due to being contrary to food safety (Guo et al., 2020). Green and safety have been more and more people's attention (Li et al., 2021). As a result, many researchers have turned their attention to food packaging (Kavakebi et al., 2021; Li et al., 2022). The current rapid development of e-commerce has resulted in a need for improvements in the requirements of the package fresh food (Li et al., 2020). Several researchers have studied food packaging, Wangprasertkul showed that active biodegradable packaging containing sorbate and benzoate produced by extrusion extended the shelf-life of fresh noodles as a viable alternative to replace preservative addition into bulk foods (Wangprasertkul et al., 2021). In recent years, modified atmosphere packaging (MAP) is widely focused on in food packaging field attributed to the well antibacterial activities and food safety (Bai et al., 2017). Some researchers have applied MAP to food, Jin reported that an appropriate atmospheric ratio (10% O_2, 10% CO_2, 80% N_2) is optimal for maintaining the quality of fresh-cut amaranth, thereby prolonging the shelf life of fresh-cut amaranth by 2 days (Jin et al., 2021). Wang reported that the MAP (60% or 100%CO_2) treatment effectively delayed the onset of bacterial spoilage and extended the shelf-life of the smoked chicken legs to 25 d (Wang et al., 2022). Up till now, there are few researches on the influence of fresh noodles by MAP.

The aim of the study was to observe the effect of atmosphere ratios (N_2: CO_2 = 0:100, 20:80, 30:70, 40:60, 50:50) on fresh noodles for extending the shelf life by MAP technology, ultimately promoting industrial development of fresh noodles packaging.

2 Experimental

2.1 Materials

The packaging material used in this study is PA/PVDC/PE film with thickness of 50 um, purchased from Shijiazhuang Dadao Packaging Materials Co., Ltd. The oxygen and moisture permeability of PA/PVDC/PE film is 4.492 cm^3 (m^2-24 h-0.1 Mpa) and 6.661 g/m^2-24 h, receptively. The flour with an ash content (in dry basis) of 0.45% was provided by Chen Keming Food Co., LTD.

2.2 Noodle fabrication

The water, salt and flour were weighed in the ratio of water: salt: flour = 33:2:65 and put into the vertical two-speed dough mixing machine (H20F Vertical, Lifeng Machinery Manufacturing

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Co., Ltd, China) for 10 min, and the dough was allowed to rise at 25 °C for 15 min. Then they were placed in the calender and noodle machine (ASC-80, Boyuan Machinery Factory, China) for calendering and shearing, and finally fresh noodles with a thickness of about 1.4 mm were produced. Before preparing the noodles, the entire laboratory was sterilized by UV light overnight and the laboratory temperature was kept at 25 °C during the preparation process. After the noodles were prepared, they were weighed and divided into 15 g/bag into UV-sterilized bags, and the whole process was carried out in an ultra-clean table (SW-CJ-2FD; Antai Air Technology Co, China).

2.3 MAP of fresh noodles

The fresh noodles are placed on the modified atmosphere packing machine (map-500D, Ju Steel Machinery Manufacturing Co., LTD, China), filled with gas and sealed, and stored at 7 °C.

2.4 Characterization of fresh noodles

Texture assessment

The texture properties of the cooked noodles were determined using a texture analyzer (TA.TOUCH, Baosheng Technology Co., LTD, China). Hardness and elasticity of cooked noodles was measured according to the description of Xing et al. (2021) with some modifications (Xing et al., 2021). For TPA analysis, an HDP/PFS probe was used and then calculated based on the texture profile analysis. The parameters were set as follows: pre-test speed: 2.00 mm/s, test speed: 0.8 mm/s, post-test speed: 0.8 mm/s, deformation variable: 70%, time: 5 s, trigger force: 5.0 g.

Determination of moisture content

Moisture content was determined according to the method described by Li et al. (2017). Moisture content was determined using a Moisture Detector (MB120, Ohaus Instrument Co., LTD, China) based on the manufacturer's instructions; noodle samples were cut into small pieces and put in the sample cell, and the lid of the machine was closed and the data was read until the Work done.

Determination of pH value

According to the method described by Kim et al. (2009), with slight modifications. The samples (25 g) were homogenized with 225 mL of sterile distilled water. The pH value was determined using a pH meter (pH-100, Lichen Technology Flagship Store, China).

Microbiological analysis

Microbial plate counting was performed according to GB 4789.2-2016 (Bai & Zhou, 2021), which roughly consisted of plate counting (TPC) of blank controls stored at 7 °C and five different aerated ratios of fresh noodles. Firstly, 8 g of NaCl was weighed with an analytical balance (SPN402F, OHAUS Instruments Co, Ltd, China) into 1000 mL of distilled water to prepare saline, and 23.5 g of plate counting agar was weighed into 1000 mL of distilled water to prepare plate counting agar culture solution, all of which were loaded into conical flasks and sealed with kraft paper and gauze, and subsequently placed into a vertical pressure pressure sterilizer with a pipette tip and a 9 mm diameter centrifuge tube. Vertical pressure steam sterilizer (SYQ-DSX-280B, Shenan Medical Equipment Factory, China) was autoclaved at 121 °C for 15 min. Take 15 g of sample noodles and add 135 mL of saline, then beat the sample with aseptic homogenizer (JX-05, Topher Electromechanical Technology Co., Ltd, China) at 12 m/s for 3 min to make the sample stock solution with a dilution gradient of 10^{-1}, then transfer and dilute to make 10^{-2} and 10 dilut $^{-3}$ ions, set up two parallel for each gradient, and also set up two blank controls (only in 10). Ltd.), followed by spreading the plate, and $^{-1}$ after spreading, the plate was cooled and sealed in constant temperature and humidity incubator (HWS, Jinghong Experimental Equipment Co., Ltd, China), incubated at 37 °C and 90% humidity, and TPC colony count was performed after 24-48 h.

Color measurement

The fresh noodle sheets were cut into 8 cm × 8 cm pieces. The L* values and their changes were recorded by measuring two points on the front and back of each face piece at regular intervals every day (to ensure that the background of each group of samples was consistent) (Chen et al., 2019). The L* values are measured by colorimeter (CR-10, Konica Minolta, Japan).

2.5 Statistical analysis

Excel software was used to organize the data, and the results were expressed as mean and standard deviation. One-way ANOVA was performed for each variable to evaluate whether the differences were significant ($P < 0.05$), and data management and analysis were performed inside Origin 9.5 software, SPSS 26.0.

3 Results and discussion

3.1 The effect of MAP on the quality structure

Textural properties of cooked noodles are a major concern for consumers when choosing a quality noodle product (Khouryieh et al., 2006). The effect of MAP on the textural properties of fresh noodles is shown in Figure 1. From the figure, it can be seen that there was no significant difference between the test group and the control group under different MAP ratio treatments within the same storage period ($P > 0.05$), and the trend of elasticity change was not significant with the extension of storage time ($P > 0.05$), indicating that the effect of different MAP ratio treatments on the elasticity of fresh noodles was not significant.

As can be seen from 1-7d in the Figure 2, the hardness of each test group did not change significantly with time ($P > 0.05$). And at the same storage time, the hardness of the test groups under different MAP ratio treatments were lower than the control group, according to the analysis, the possible reasons were the extrusion of the noodles due to the long evacuation time before filling the gas, which affected their hardness; and also the increase in water content resulting in the increase of water absorption index and the decrease of water solubility

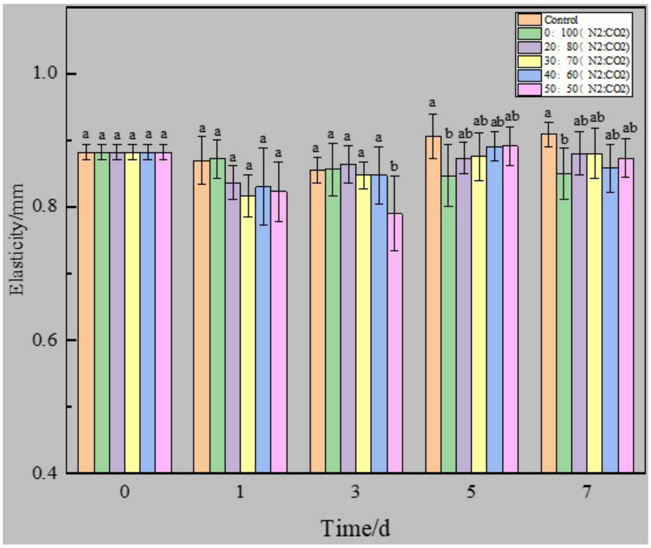

Figure 1. The changes of elasticity (cooked noodles) of fresh noodles treated with different MAP ratio during storage time. $^{a\sim b}$represents the significant difference of elasticity in the same storage time.

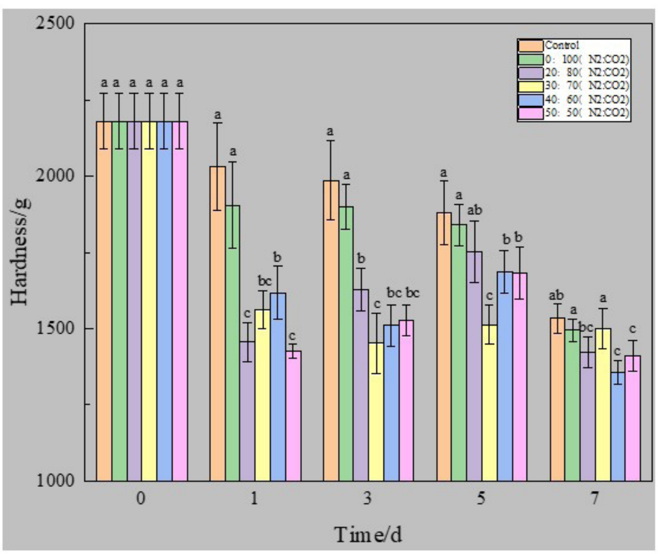

Figure 2. The changes of hardness (cooked noodles) of fresh noodles treated with different MAP ratio during storage time. $^{a\sim c}$represents the significant difference of hardness in the same storage time.

index caused by the increase of water content (Khare et al., 2016). However, the differences between the experimental group with 100% CO_2 volume fraction and the control group were not significant ($P > 0.05$) at the 1st, 3d, and 5th d of storage, and there was not much difference between the control group and the experimental group with each MAP ratio treatment at the storage up to the 7th d, which means that the MAP did not affect the hardness significantly.

3.2 Effect of MAP on moisture content

The changes of moisture content in the fresh noodles treated with different MAP ratios during the re-storage time are shown in Table 1. It can be seen that the moisture content in the fresh noodles of all groups showed a gradually decreasing trend with the extension of storage time, especially in the control group. The initial moisture mass fraction of the control group was 31.7%, while that of the 7th d was only 29.41%, with a more obvious decreasing trend ($P > 0.05$). The MAP ratio of 0:100 could still reach a higher content by the 7th d of storage and was significantly higher than that of the control group ($P < 0.05$). As discussed above, it can be concluded that MAP can effectively reduce moisture dissipation, and similar results were reported by Sanguinetti et al. (2016) when using MAP to preserve spaghetti, which contributed in reducing moisture dissipation when compared with the control group.

3.3 Effect of MAP on pH value

pH is considered as an important quality and safety indicator during food storage (Cheon et al., 2016). The pH values of the fresh noodles treated with different MAP ratio during the storage period are shown in Table 2. The normal pH value of noodles is about 5.6-6.2, and the initial pH value of the fresh noodles in this test group was 6.02. It can be found that the pH value decreased significantly ($P < 0.05$) with the extension of the storage period, and the pH value of the control group had decreased to 5.35 at the 7th day, which was beyond the normal pH range of fresh noodles. The pH value of the control group dropped to 5.35 by the 7th day, which was beyond the normal pH range of fresh noodles. In the same storage time, the pH value of the MAP group was significantly higher than that of the control group ($P < 0.05$).

Ghaffar et al. (2009) stated that the change in pH reflects the microbial activity in the noodles, which contain large amounts of water and nutrients (e.g., carbohydrates and proteins) that can be used by microorganisms to produce acidic metabolites, resulting in a decrease in pH of the noodle samples during the storage period, and because of the bacteriostatic effect of CO_2 The pH value of the MAP group decreased more slowly. At the 7th day of storage, the pH values of 0:100, 20:80 and 30:70 in the MAP group were significantly higher than those in the control group, and among the three MAP ratios, the pH value of 20:80 decreased the least, followed by 0:100 and 30:70. Therefore, the MAP could effectively prevent the pH value of fresh noodles from decreasing, it inhibited the growth of microorganisms, which was reflected in the fresh noodles preservation by extending the freshness period is extended.

3.4 Effect of MAP on microorganisms

The main microorganisms in fresh noodles are bacteria, mold and yeast. The growth and multiplication of microorganisms are partly responsible for the deterioration of noodle quality (Hong et al., 2021). The changes in the microbial counts of fresh noodles treated with different MAP ratios over the storage time are shown in Figure 3. As can be seen from the figure, the initial bacterial load was approximately the same, and the number of microorganisms had a significant increase ($P < 0.05$) with the extension of storage time. In the same storage time, the number of colonies in the MAP group was significantly lower than that in the control group ($P < 0.05$), and the difference between the

Table 1. Moisture content of fresh noodles treated with different MAP ratio during storage time.

Time/d	Control	N_2: CO_2				
		0:100	20:80	30:70	40:60	50:50
0	31.70 ± 0.05^{aA}	31.70 ± 0.07^{aA}	31.70 ± 0.06^{aA}	31.70 ± 0.12^{aA}	31.70 ± 0.09^{aA}	31.70 ± 0.08^{aA}
1	30.64 ± 0.28^{bB}	31.68 ± 0.32^{aAB}	31.60 ± 0.35^{abAB}	31.48 ± 0.68^{abA}	30.57 ± 0.60^{bABC}	31.59 ± 0.59^{abA}
3	30.35 ± 0.17^{aBC}	31.29 ± 0.56^{aAB}	31.26 ± 0.64^{aAB}	31.27 ± 0.47^{aA}	30.62 ± 0.58^{aAB}	30.35 ± 0.17^{aC}
5	30.25 ± 0.09^{cC}	31.26 ± 0.21^{aAB}	31.22 ± 0.29^{aAB}	30.26 ± 0.34^{bcB}	30.07 ± 0.84^{cBC}	31.07 ± 0.55^{abAB}
7	29.82 ± 0.06^{bD}	30.99 ± 0.31^{aB}	30.63 ± 0.79^{aB}	30.37 ± 0.40^{abB}	30.25 ± 0.09^{abC}	30.57 ± 0.40^{aBC}

$^{a\sim c}$represents a significant difference between the same row, and $^{A\sim D}$represents a significant difference between the same column.

Table 2. pH value of fresh noodles treated with different MAP ratio during storage time.

Time/d	Control	N_2: CO_2				
		0:100	20:80	30:70	40:60	50:50
0	6.02 ± 0.01^{aA}	6.02 ± 0.01^{aA}	6.02 ± 0.01^{aA}	6.02 ± 0.01^{aA}	6.02 ± 0.01^{aA}	6.03 ± 0.01^{aA}
1	5.76 ± 0.02^{abB}	5.78 ± 0.10^{abB}	5.85 ± 0.01^{aB}	5.77 ± 0.02^{abB}	5.71 ± 0.01^{bB}	5.80 ± 0.01^{abB}
3	5.48 ± 0.06^{cC}	5.76 ± 0.02^{aB}	5.60 ± 0.01^{bC}	5.80 ± 0.01^{aB}	5.46 ± 0.01^{cD}	5.46 ± 0.01^{cC}
5	5.39 ± 0.02^{cD}	5.70 ± 0.02^{aB}	5.55 ± 0.01^{cE}	5.46 ± 0.03^{bC}	5.44 ± 0.01^{bD}	5.45 ± 0.01^{bC}
7	5.35 ± 0.01^{cD}	5.43 ± 0.02^{bC}	5.39 ± 0.02^{aD}	5.42 ± 0.02^{bC}	5.57 ± 0.08^{aC}	5.42 ± 0.02^{cD}

$^{a\sim c}$represents a significant difference between the same row, and $^{A\sim D}$ represents a significant difference between the same column.

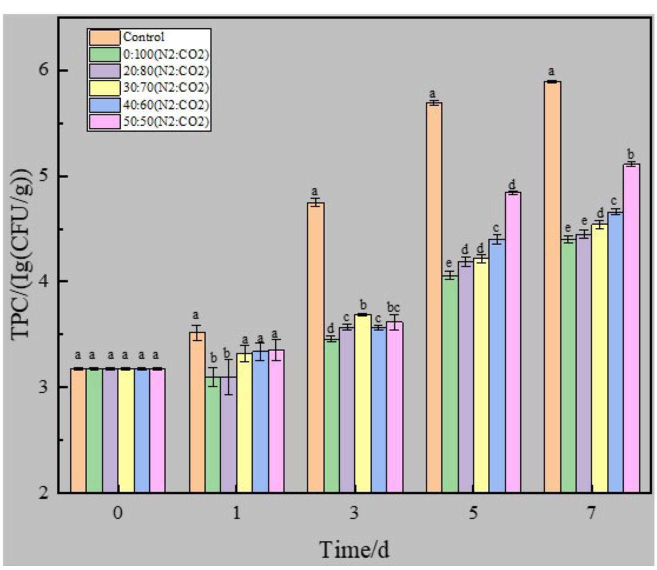

Figure 3. The changes of total plate count of fresh noodles treated with different MAP during storage time. $^{a\sim d}$represents the significant difference of TPC in the same storage time.

best and the worst was nearly 2 orders of magnitude. The reason for this is that King & Nagel (1967) suggested that CO_2 can impede the metabolism of microorganisms such as single cells, thus affecting the enzymatic decarboxylation metabolism of microorganisms and thus inhibiting their growth. From 1-5 d of storage, it can be seen that the 0:100 test group inhibits microorganisms significantly better than the other groups ($P < 0.05$), while in storage up to the 7th d it can be found that the difference between the 0:100 test group and the 20:80 test group is not significant ($P > 0.05$), and it was also reported by Zardetto (2005) that when the CO_2 volume fraction of raw spaghetti MAP is higher than 70%, it can effectively inhibit the growth of bacteria. Therefore, MAP can play an effective role in preserving fresh noodles, and the effect of MAP ratio of 0:100 and 20:80 is more obvious.

3.5 Effect of MAP on noodle color

Color plays a decisive role in both the quality of noodles and consumers' desire to buy them (Hu et al., 2020). And for Chinese fresh noodles, clean and bright appearance makes the most popular among consumers, while dark or gray color is a negative attribute (Li et al., 2012). In order to evaluate the effect of different MAP ratio treatments on fresh noodles, we made measurements of L* values, it can be found from the Table 3 that with the extension of storage time, L* values basically showed a decreasing trend ($P < 0.05$), where the test group treated by different MAP ratios decreased relatively slowly ($P < 0.05$). Chang et al. (2017) showed that CO_2 could prevent the softening of peaches by inhibiting cell wall degradation enzyme activity, it is assumed that the reason for the slow decline of L* values in this paper is not only because the sealing of the bag isolates a large amount of oxygen, but also because the CO_2 inhibits the growth of multiple oxygen. It is also possible that the CO_2 inhibits the activity of polyphenol oxidase, which slows down the oxidation reaction and thus the rate of L* value decline. Therefore, the MAP can effectively slow down the decline of L* value. the darkening of the fresh noodles. And from the 5th d, it can be found that the 0:100, 20:80, and 30:70 test groups can still maintain a good whiteness after 5 d of storage.

Table 3. The changes of L* value of fresh noodles treated with different MAP ratio during storage time.

Time/d	Control	N_2: CO_2				
		0:100	20:80	30:70	40:60	50:50
0	82.37 ± 0.06^{aA}	82.20 ±0.10^{aA}	82.23 ±0.06^{aA}	82.33 ±0.06^{aA}	82.13 ±0.06^{aA}	82.30 ±0.10^{aA}
1	76.77 ± 0.06^{dB}	80.53 ±0.06^{aB}	82.26 ±0.05^{aB}	79.53 ±0.40^{bB}	79.70 ±0.46^{bB}	78.94 ±0.05^{cB}
3	74.85 ± 0.05^{cC}	79.10 ±0.10^{aC}	79.20 ±0.10^{aC}	79.09 ±0.01^{aC}	78.40 ±0.10^{bC}	78.50 ±0.10^{bC}
5	72.85 ± 0.05^{eD}	76.81 ±0.01^{cD}	76.73 ±0.02^{cD}	77.23 ±0.11^{bD}	78.23 ±0.06^{aC}	75.25 ±0.05^{dD}
7	72.42 ± 0.08^{eE}	76.04±0.21^{bcE}	75.76 ± 0.02^{cE}	76.23 ±0.11^{bE}	76.53 ±0.35^{aD}	74.97 ±0.11^{dE}

$^{a\sim e}$represents a significant difference between the same row, and $^{A\sim E}$ represents a significant difference between the same column.

4 Conclusion

Under the refrigeration condition of 7 °C, the MAP had a significant effect on the freshness of fresh noodles, which could effectively slow down the decrease of pH, inhibit the growth of microorganisms, where the MAP groups with N_2: CO_2 ratios of 0:100 and 20:80 had a better preservation effect than the other groups. There was a significant improvement in the color of the fresh noodles after MAP, but the effect on the textural properties (hardness and elasticity) of the fresh noodles was not significant. For moisture content, N_2: CO_2 ratios of 0:100 and 20:80 were more helpful to reduce moisture loss than the other groups. These results indicate that the MAP has potential application in preservative packaging for prolong the shelf life of fresh noodles. The N_2: CO_2 ratio of 0:100 is more suitable for fresh noodles preservation.

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