Research Article

Open Access

Study on the Effect of Jujube Powder on the Quality of Bread

Feng-Hua Meng¹, Xiao-Wen An¹, Jie Yang², Wang Zi-juana¹, Li Jia-ming¹ and Chang-Wei Ao^{1*}

¹College of Food Science and Technology, Hebei Agricultural University, Baoding, China

²College of Foreign Languages, Hebei Agricultural University, Baoding, China

ABSTRACT

As a traditional Chinese medicine and food, jujube is rich in minerals, dietary fiber, polysaccharides, vitamins and other healthy nutrients, which are the supplemental nutrition to wheat flour. This paper studied the bread quality with jujube powder and determined the appropriate ratio of jujube powder to wheat flour. The related characteristics of bread with jujube powder were analyzed by Electronic nose (E-nose), solid phase micro-extraction gas chromatography-mass spectrometry (SPME-GC-MS), scanning electron microscope, texture analyzer, and Sensory Texture Evaluation Methodology, respectively. The total phenolic content and antioxidant activity of the finished bread were evaluated. The results showed that with the increase of the addition of jujube powder, the specific volume, moisture content and elasticity of bread decreased gradually, while the softness and chewiness were increased progressively. The total phenol content and antioxidant activity of bread increased gradually with the adding of jujube powder content. The bread quality was the best when the addition of 4g of jujube powder/100g of wheat flour. While new volatile substances of jujube bread included hexane, 2, 3-dihydro-3, 5-dihydroxy-6-methyl-4H-pyran-4-one, n-Hexadecane, and 1- Caryophyllene, as well as alcohol. Microstructural analysis showed that the structure of stomata changed significantly with the adding of jujube powder. The size of stomata and density of bread are not significantly different from those of ordinary bread with less than 4% jujube powder.

*Corresponding author

Chang-Wei Ao, College of Foreign Languages, Hebei Agricultural University, Baoding, China. E-mail: aocw@163.com

Received: August 10, 2021; **Accepted:** August 16, 2021; **Published:** August 20, 2021

Keywords: Jujube Powder, Bread Quality, Flavoring Substances, Texture, Microstructure, Antioxidant Activity.

Introduction

Bread is mainly made of flour, yeast, and water, usually by the fermentation, shaping, and baking. It is one of the widest consumed staple foods in the world. However, nutrients of bread are loss by using refined white flour as the excessive pursuit of taste. To solve single variety and taste of bread, many scholars have studied on adding fruit and vegetable powder into wheat flour [1-5].

Jujube is a “Medicine-food homology” that is widely used in China. It is rich in proteins, sugar, organic acids, vitamins and trace elements in the reports. Besides this, jujube has the functions of improving insomnia, anxiety, nervous system, immunity, and digestion [6,7]. However, in recent years, Jujube, in China was more in demand. One of the most effective ways to prolong the shelf life of jujube is through drying and converting it into powder [8-10]. Jujube powder retains most of the nutrients in red jujube, which can be a supplement to the bread with a single-nutrient deficiency [11]. So with this, it is of great significance to study its effectiveness on bread quality. At present, there is little research on the effect of partial substitution of jujube powder. This paper will analyze the texture, flavor, microstructure, and antioxidant activity of bread with different amount of jujube powder and to find the suitable proportion of jujube powder with wheat flour. The results will lay the foundation for the industrial production of jujube bread in the future.

Materials and Methods

As one of the most productive jujube, ‘Jun zao’ was selected and purchased from Xinjiang province of China in 2019 and 2020. ‘Jun zao’ were sliced to about 5mm thickness and 6cm in length, dried with hot air at 85°C for 4 h (DHG-9420A; Shanghai Feiyue Experimental Instrument Co., Ltd., Shanghai, China), and pulverized with a grinder for 5 min (LD-200; Yongkang Hongtaiyang Electromechanical Co., Ltd., Yongkang, China). The obtained powder, referred to as jujube powder herein, was stored in a freezer (4°C) until use.

The ingredients (wheat flour) of bread were purchased from Beijing Cofco Limited, Beijing, China. Sugar, yeast, eggs and milk were purchased from local supermarkets, and other chemicals (pure reagents) were purchased from Beijing Solarbio Science & Technology Co., Ltd. (Beijing, China).

Proximate Nutritional Composition of Jujube Powder

Moisture was measured by the oven drying method, protein was measured by Kjeldahl method, and ash content was measured by the direct incineration method. Reducing sugar and total sugar were measured by the direct titration. The color of jujube powder was measured by spectrophotometer (CM-5; Konica Minolta Holdings, Lns., Japan).

Preparation of Jujube Flour Breads

Flour formulations: (1) 100% whole grain wheat flour (used as the control group); (2) wheat flour with 4% jujube powder; (3) wheat flour with 8% jujube powder; (4) wheat flour with 12%

jujube powder; (5) wheat flour with 16% jujube powder. For the bread recipe, it was 300g flour, 3g salt, 18g sugar, 15ml milk, 15g butter, and 3g yeast.

Mixed them in the chef machine (HM740; Qingdao Hanshang Electric Appliance Co., Ltd., Qingdao, China) for 45 min. Ferment the dough for the first time in the fermentation box (Shenzhen Tianfa Trading Co., Ltd.) at 86°F (30°C), relative humidity of 75% for one hour. Divide the fermented dough into 50g each, and start the second fermentation at 93.2°F (34°C), humidity of 80% for 50 min. Then baked the fermented dough in the oven at 356-446°F (180-230°C) for 20-25min. Cooled the bread for one h and stored in polypropylene bag.

Sensory Evaluation of Jujube Flour Breads

After baking, the bread was to be cooled at a room temperature for sensory evaluation. Ten people were selected to grade the bread. Familiarize the staff with the scoring criteria before grading. The grading staff must comprehensively score the bread in terms of shape, color, taste, organization and other factors. The scoring criteria were shown in Table1. Carry out a preference test of the different breads that have been baked to find out which sample was preferred. Sensory evaluation of cooled bread samples was carried out by 10 trained panelists. Panelists were trained using four criteria (appearance, color, taste, texture, and acceptability).

Table1: Sensory Evaluation Standard of Bread

Project	Full mark standard	Score
Appearance	nicely shaped, plump and spotless	20
Color	golden-brown and uniform browning	15
Taste	Soft, fine, and smooth	20
Texture	Elastic and stomata uniform	20
Acceptability	Acceptable	10

Determination of Jujube Flour Bread Properties

Moisture of the bread was measured by a moisture meter (MOC-120H; SHIMADZU Co., Kyoto, Japan). The volume of jujube flour bread was determined by the millet displacement method (GB/T21118, China, 2007), while the specific volume was calculated as the ratio of the volume to the weight of the bread. The color of jujube flour bread was measured by spectrophotometer (CM-5; Konica Minolta Holdings, Lns., Japan). Texture analyses were performed using a TPA (TMS-Pro, Beijing Yingsheng Hengtai Science & Technology Co., Ltd., Beijing, China) with a cylindrical plunger (diameter, 36 mm). Bread was cut at the top and the crump of center (25 mm from the bottom) was compressed twice to 50% of its original height with a test speed of 1 mm/s [30].

GC-MS Analysis of Bread

To analyze the flavor with Gas Chromatography/Mass Spectrometry (GC-MS) (Agilent of the United States), put the SPME bottle with 5g bread sample in a constant temperature water tank at 60°C for 10min. Then extract passive headspace extraction (50/30µmDVB/CAR/PDMS) at 60°C for 50min.

GC conditions: capillary column HP-INNOWAX (60mm*0.25mm, 0.25µm), temperature rise: keep 40 °C for 3.5min, rise to 90 °C at 5 °C /min, then rise to 220°C at 12 °C / min, and stay for 7min.

The flow rate of the carrier gas was at 0.8ml/min, the injection hole temperature was 250°C, and there was no shunt.

MS conditions: electron ionization, quadrupole temperature 150°C, electron energy 70 eV, electron emission current 200 µ A; type of acquisition was full sweep within the range of m/z 33-495, ion source temperature of 200°C. The Sniffers: auxiliary gas N2, transmission temperature of 250 °C [12].

Microstructure Analysis of Bread

Cool the bread at room temperature for one hour and cut it into thin slices as in 1cm. Freeze it at -40°C and then dry it in a freeze dryer. Fix the dried samples on the table, put it into the electron microscope carrier for gold spray and structure scanning [13].

Antioxidant Analysis of Bread

The amount of total phenolic in the bread samples was measured using the Folin-Ciocalteu reagent method with minor modifications [13]. For the bread sample (5g) put in an electric blast drying oven at about 80°C for 1 hour. Put it into a 50ml bottle in a total solution volume of 90% methanol for the extraction by ultrasonic wave for 20min, and then taken to store in the freezer.

Determination of total phenol content

To determine the absorbance at 765nm, a stock solution of 0.4ml extract, 2 ml Folin-Ciocalteu reagent, and 1.6ml of 7.5% sodium carbonate solution was prepared. Intermittent shake using a UV-Vis spectrophotometer for 30 min. The distilled water was used instead of the extract as the control group. The total phenolic content was expressed as Gallic acid equivalents (GAE) in mg per g sample.

Determination of Scavenging Ability of DPPH Free Radicals

Free radical scavenging activity of bread samples was determined using the DPPH method [14]. with some modifications. A methanol solution (2 ml) containing different concentrations of extracts was added to 2 ml of freshly prepared DPPH methanol solution (0.2nm). An equal amount of methanol was used as a control. The measurement was performed in triplicate.

After incubation for 30min at room temperature in the dark, perform zero adjustment with methanol. Measure the absorbance at 517nm, and record it as A1. Instead DPPH with methanol had the control group and to record it as A2. Instead, bread extract with methanol as the blank group and record it as A3. Activity of scavenging (%) was calculated using the following formula:

$$\text{DPPH radical scavenging (\%)} = \frac{A_3 - A_1 + A_2}{A_3} \times 100$$

A1 is the absorbance value for the mixture of the extract and DPPH solution;

A2 is the absorbance value for the mixture of methanol and extract;

A3 is the absorbance value for the mixture of methanol and DPPH solution.

Statistical Analysis

All data were measured in triplicate and reported as mean ± SD. ANOVA was the method to have Correlation analysis and linear regression analysis with P-level less than 0.05 the calculations were performed using SPSS (version 23, SPSS Inc., Chicago, USA).

Results and Analysis

Proximate Nutritional Composition and Color of Jujube Powder

Table 2: Proximate Nutritional Composition and Color of Jujube Powder

Nutritional	(%)	color	
Moisture	7.67±0.72	L*	65.89±0.68
Protein	2.78±0.53	a*	8.66±0.80
Ash	0.59±0.02	b*	27.45±2.01
Total sugar	72.63±0.93		

Data are presented as mean values ± SD (n=3).

As showed in Table 2, the main component of jujube powder is sugar (72.63%). The caramelization reaction of jujube after high temperature baking results in jujube powder with reddish brown color.

Effect of Jujube Powder on Bread

Sensory Evaluation of Bread

Figure 1: Effect of jujube powder addition on sensory quality of bread

Sensory evaluation of the jujube flour bread was performed after 1 day of storage (Fig.1)

The color of bread increasingly deepens and the volume gradually decreases as jujube powder gradually increases. It remains consistent with specific volume, which affected the external sensory of bread. With the addition of jujube powder, the protein content in the mixed flour decreased, and the formation of gluten network gradually became worse. So the stomata formed inside the bread becomes smaller step by step, the taste gradually hardened, and the acceptability of bread decreased. To sum this up, an addition of 4% jujube has shown good effects with the control group in color, stomata, flavor, taste, and general palatability.

Color Analysis of Jujube Powder

Table 3: Color of Bread with Different Substitution Ration of Jujube Powder

Samples	L*	a*	b*	ΔE
0% jujube flour bread	76.67±3.10a	0.05±0.15e	15.71±1.21de	—
4% jujube flour bread	59.52±4.14b	2.29±0.62d	17.87±2.52d	17.43
8% jujube flour bread	58.12±3.25bc	4.53±0.70c	21.51±2.31bc	19.23
12% jujube flour bread	55.15±0.92cd	6.54±0.43a	23.69±0.98a	23.85
16% jujube flour bread	51.29±1.37de	6.00±0.93ab	21.02±1.82ab	26.60

Data are presented as mean±SD (n = 3). Different letters following the mean values within the same columns indicate differed significantly ($p < 0.05$). $\Delta E = [(L^*-L_0)^2 + (a^*-a_0)^2 + (b^*-b_0)^2]^{1/2}$

Compared with the blank bread, the L* value of the bread with the added amount of 4% ~ 16% jujube powder was significantly reduced. When the added amount of jujube powder was 16%, the bread was the darkest and the L* value was 51.29, which was 33% less than the blank bread.

Compared with the blank bread a* value, the added proportion of each red date flour bread increased significantly, with the red value reaching the maximum 6.54 at 12%, and there was no significant difference between 12% and 16%. The addition of jujube powder significantly changed the color of the bread. The reason for this phenomenon may be the Maillard reaction between reducing sugar in jujube and amino acids in flour during high temperature baking [16]. On the other hand, the red jujube contains natural water-soluble red jujube pigment, so the red color of steamed bread is deepened after adding red jujube powder.

Volume, Moisture and Crumb Texture of Bread

Table 4: Effect of jujube powder on moisture content, specific volume and texture of bread

Indicators	0% jujube powder	4% jujube powder	8% jujube powder	12% jujube powder	16% jujube powder
Volume	4.53±0.12d	4.41±0.03cd	4.30±0.06c	4.13±0.03b	4.00±0.05a
Moisture Content	31.66±0.56d	31.16±0.36cd	30.25±0.85bc	29.09±0.64b	27.53±0.77a
Softness	14.60±0.30a	13.25±0.21a	22.1±0.57b	26.70±0.28c	48.45±1.20d
Elasticity	9.17±0.55cd	9.50±0.28d	8.20±0.85bc	7.70±0.28b	5.45±0.21a
Chewiness	49.89±1.46a	49.08±1.09a	66.68±2.44c	58.55±2.81b	57.78±5.01b

Data are presented as mean±SD (n = 3). Different letters following the mean values within the same rows indicate differed significantly (p < 0.05).

Table 4 shows the effects of jujube powder on the senses, specific volume, moisture content and texture of bread. Texture is an important index to measure the quality of bread, in which softness, elasticity and chewiness are important indexes to evaluate bread. Bread softness and chewiness are generally inversely proportional to bread quality, while elasticity is generally relational to bread quality [17,8]. As can be seen from Table 2, with the increase in amount of jujube powder, the softness and chewiness of bread increased, whereas on the other hand, the elasticity of bread decreased. The texture of bread is not significantly different as the addition of jujube powder is 4%. But the texture index of bread is significantly different as the addition of jujube powder is higher than 4%. It shows that, the addition of jujube powder weakens gluten network to a certain extent, thus affects the inadequate fermentation expansion of dough and the texture properties of bread.

Specific volume refers to the ratio of volume to mass, which reflects the expansion and gas-holding capacity of dough [19]. As it can be seen from Table 2, with the increase of the addition of jujube powder, the specific volume of bread decreased, and decreased significantly (P < 0.05) as the addition of jujube powder is more than 4%. There are two main reasons for the gradually decrease of moisture content in bread.

Firstly, the moisture content in high gluten flour is higher than that in jujube powder, which is mainly due to the decrease of protein content in mixed flour and the formation of gluten network with the increase of jujube powder. Secondly, sugar in jujube powder will reduce the absorption.

Flavor Analysis of Bread

Table 5: Volatile components of jujube flour bread

No.	Compound name	Relative content/%			RI	Odor description	Identification
		0% jujube	4% jujube	jujube powder			
Alcohols							
1	Ethanol	27.179	31.881	-	941	Alcoholic	MS, RI, odor
2	Isooctyl alcohol	0.657	0.988	-	1495	-	MS, RI
3	Leafalcohol	0.668	0.879	-	1401	Sour taste	MS, RI, odor
4	1-Tetradecanol	0.831	-	0.688	1976	-	MS, RI
5	1-Octanol	0.325	-	-	1563	Floral	MS, RI, odor
6	1-Nonanol	0.491	0.625	-	1666	Rose fragrance	MS, RI, odor
7	Furfuryl alcohol	0.409	0.356	1.239	1678	Lilac flavor	MS, RI, odor
8	3-Nonen-1-ol, (3Z)-	0.514	0.228	-	1401	-	MS, RI
9	Benzyl alcohol	0.765	0.639	-	1909	Floral	MS, RI, odor
10	Phenethyl alcohol	6.662	2.995	-	1943	Floral	MS, RI, odor
11	(-)-alpha-Terpineol	-	0.280	0.748	1715	-	MS, RI
12	(5-METHYL-2-FURYL) METHANOL	-	-	0.501	1783	fresh	MS, RI, odor
Acids							
13	Myristic acid	0.157	0.25	0.643	2759	-	MS, RI
14	Decanoic acid	0.404	0.218	3.23	2598	Microacid	MS, RI, odor
15	Nonanoic acid	0.916	-	-	2189	Grassy	MS, RI, odor
16	Octanoic acid	0.777	0.622	2.358	2078	-	MS, RI
17	Heptanoic acid	0.243	2.374	7.515	1970	-	MS, RI
18	Propionic acid	-	-	0.867	1551	Fruity	MS, RI, odor

19	Isobutyric acid	0.112	0.113	-	1580	Yoghurt	MS, RI, odor
20	Acetic acid glacial	1.868	2.545	29.554	1478	Sour taste	MS, RI, odor
21	Undecanoic acid	-	-	0.32	2394	-	MS, RI
22	(E)-2-Octenoic acid	-	-	0.679	2200	-	MS, RI
23	Crotonic acid	-	-	0.389	1790	-	MS, RI
24	delta-Hexalactone	-	-	0.221	1846	Fruity	MS, RI, odor
25	5-Decanolide	0.473	0.735	-	2247	-	MS, RI
26	gamma-Nonanolactone	5.353	4.489	-	1965	Coconut fragrance	MS, RI, odor
27	γ-Octalactone	4.984	4.841	-	1961	-	MS, RI
28	Ethyl caprate	-	0.384	0.537	1649	Yoghurt	MS, RI, odor
29	Ethyl caprylate	1.368	1.696	-	1445	Nectar taste	MS, RI, odor
30	Ethyl caproate	0.586	0.914	-	1245	fruity	MS, RI, odor
31	Diethyl phthalate	-	0.049	0.068	2410	-	MS, RI
32	Dibutyl phthalate	-	0.34	-	2748	Floral	MS, RI, odor
33	Diisobutyl phthalate	-	0.48	-	2581	refreshing fragrance	MS, RI, odor
34	2(4H)-Benzofuranone,5,6,7,7a-tetrahydro-4,4,7a-trimethyl-	-	0.104	0.193	2417	-	MS, RI
35	Ethyl palmitate	-	-	0.737	2264	-	MS, RI
36	Methyl myristate	-	-	0.33	2065	Caramel	MS, RI, odor
37	Ethyl laurate	-	-	3.572	1854	Green fruit	MS, RI, odor
38	Methyl laurate	-	-	0.572	1815	Microacid	MS, RI, odor
39	Ethyl benzoate	-	-	0.169	1697	Fragrance	MS, RI, odor
Aldehydes							
40	Hexanal	-	0.533	-	1099	Herb flavor	MS, RI, odor
41	1-Nonanal	2.974	6.488	1.647	1408	Sweet taste	MS, RI, odor
42	Heptaldehyde	-	-	0.571	1203	-	MS, RI
43	Furfural	0.698	0.786	4.797	1489	Almond	MS, RI, odor
44	Decanal	0.712	0.754	0.556	1514	Orange	MS, RI, odor
45	Benzaldehyde	-	-	0.965	1555	Almond	MS, RI, odor
46	Phenylacetaldehyde	0.414	0.443	-	1676	Floral	MS, RI, odor
47	Metharolein	-	1.179	-	1058	Peculiar odor	MS, RI, odor
48	trans-2-Hexenal	-	-	0.065	1236	Herb flavor	MS, RI, odor
49	trans,trans-2,4-Decadien-1-al	-	0.129	-	1836	-	MS, RI
50	5-Methyl furfural	-	-	1.711	1604	Caramel	MS, RI, odor
Ketones							
51	2-Pentadecanone,6,10,14-trimethyl-	-	-	0.517	2215	-	MS, RI
52	Ethyl maltol	0.267	0.249	-	2007	Sweet fragrance	MS, RI, odor
53	Geranylacetone	0.407	0.407	0.482	1873	-	MS, RI
54	2-Undecanone	0.2	0.202	-	1613	Fruity	MS, RI, odor
55	2-Nonanone	0.273	0.29	-	1403	Fruity	MS, RI, odor
56	6-Methyl-5-hepten-2-one	0.201	0.242	0.144	1352	Citrus flavor	MS, RI, odor
57	4-Hydroxy-2,5-dimethyl-3 (2H) furanone	-	-	1.479	1899	Strawberry	MS, RI, odor
58	2,3-dihydro-3,5-dihydroxy-6-methyl-4h-pyran-4-one	-	0.851	12.614	2311	-	MS, RI
Alkanes							
59	Dodecane	0.897	-	-	1975	-	MS, RI
60	Tridecane	-	-	0.124	1299	-	MS, RI

61	Tetradecane	0.528	0.393	0.189	1438	-	MS, RI
62	Pentadecane	-	-	0.234	1500	-	MS, RI
63	Hexadecane	-	0.266	0.314	1600	-	MS, RI
64	Heptadecane	0.143	0.121	-	1699	-	MS, RI
65	Nonadecane	-	0.357	-	1899	-	MS, RI
66	Eicosane	-	0.354	-	1440	-	MS, RI
67	Heneicosane	1.166	0.139	-	2099	-	MS, RI
Alkeness							
68	1-Caryophyllene	-	0.106	0.487	1626	Orange	MS, RI, odor
other							
69	1,4-Xylene	0.377	0.361	-	1152	Floral	MS, RI, odor
70	1,3-Xylene	-	0.096	-	1200	Floral	MS, RI, odor
71	Naphthalene	0.319	0.316	0.362	1785	Fragrance	MS, RI, odor
72	2-Methylnaphthalene	-	-	0.754	1936	-	MS, RI
73	2-Acetyl pyrrole	-	0.192	2.402	2011	nutty	MS, RI, odor
74	2-Acetylfuran	-	-	1.164	1531	Caramel	MS, RI, odor
75	2-Pentylfuran	-	-	0.909	1244	Aroma of melon and fruit	MS, RI, odor

- Not checked out; MS-Spectrum library retrieval (matching degree>80); RI-retention index; odor-Identified by odor description; 0% volatile substances as control group and 4% jujube powder bread and pure jujube powder are extracted by solid phase micro extraction, separated and identified by GC-MS, and the relative content analysis by the peak area normalization method.

Results are shown in Table 3, more than 70 volatile compounds in 8 classes are isolated and identified, including alcohols 12, acids 11, esters 17, aldehydes 11, ketones 8, alkanes 9, olefins 1, others 7. Pure jujube powder has detected 45 types of flavor with 87.617%. Acid substances are the most in this case, and followed by aldehydes. A total of 38 types in 7 classes of volatile substances are detected in the control group, while 50 types in 8 classes of volatile flavor compounds are detected in 4% jujube powder bread. Therefore, relative content also differ. As expected, the addition of jujube powder can increase the odor substances of the bread and make the taste more unique.

Alcohol flavor has a high threshold value, with plant aroma and fragrance [20]. Five types of alcohol (3.176%) are detected in jujube powder. There are ten types of alcohol (38.501%) in control group and nine types of alcohol (38.871%) in jujube powder bread. They have been detected respectively, in which ethanol and phenyl ethanol are relatively high in bread. Most of the ethanol in bread is fermented by yeas, and some of them are oxidized by esters [21].

Phenylethanol with a sweet rose-like flower fragrance, is mostly found in apples, almonds, bananas, peaches and other natural foods, for which this is one of the edible spices for Chinese [22]. The fruit aroma gives about a unique flavor to the bread. However, 1-Tetradecanol and 1-octanol are only detected in the control group.

Acids are the main volatile substances in jujube powder. It can be seen from Table 3 that, the content of acetic acid is the highest among the acidic substances that is consistent with the results detected by Shan Lv (2017) and other scholars. The type of acidic substances in 4% jujube powder bread is lower than that in the control group. However, its relative content is higher than that in the control group, which may have caused by the addition of jujube powder.

The production of organic acids in the dough during fermentation leads to the production of acids in bread [22]. Esters are the substances with many types and contents in bread, which is the second largest flavor substances in bread, so esters are important substances that flavor bread. Esters are derived from the reaction of acids and alcohols during baking, in that which has wine or fruit odor [24]. The content of esters is 6.399% of jujube powder, 12.764% of control group and 14.032% of jujube powder. Among them, γ -Octalactone exists in both types of bread, and the relative content is 4.984% and 4.342%, respectively, which is the main flavor substance.

Diethyl phthalate, Di-n-butylphthalate and diisobutyl phthalate only exist in 4% of the jujube powder bread, which has greatly affect the flavor composition of jujube powder bread. The production of aldehydes is closely related to Maillard, which has the fragrance of flowers, grass, fruit and bring bread a unique aroma [25]. Nonanal is relatively high in content on aldehydes in two types of bread, which has the aroma of rose and citrus. Most of them exist in rose oil, cinnamon oil, and etc.

Nonanal in bread appears in the fermentation of microorganisms [25]. The content of aldehydes in jujube powder is 10.312%. Furfural is the main aldehyde substance in jujube powder. This is a small molecular substance degraded by VC in drying [26]. It can be seen from Table 3 that, the addition of jujube powder to bread can increase the content of furfural, that is beneficial to the formation of flavor.

Ketones have a special floral odor, to which its threshold value is higher than that of aldehydes. Ketones in jujube powder are mainly formed by the degradation of fatty acids [27]. Five types of ketones are detected in both types of bread, and their relative content that are 1.348% and 2.241%, respectively. Among them, 2-recom 3-dihydro-3-mine 5-dihydroxy-6-methyl-4H-pyran-4-one can only be detected in 4% jujube powder bread, indicating

that it is derived from jujube powder. Alkanes contribute little to bread flavor because of their low flavor activity [28]. There are four types of alkanes (2.734%) that were detected in the control group. Six types of alkanes (1.160%) are detected in the bread with 4% jujube powder bread.

1-caryophyllene is found only in the jujube powder bread, which exists in the jujube powder. In addition, naphthalene is detected in both types of bread. Naphthalene has a delicate odor and can bring bread a unique aroma. Both m-xylene and 2-acetylpyrrole are new substances detected in jujube powder bread, which leads the microbial metabolism of dough during fermentation and Maillard reaction during baking.

Microstructure Analysis of Bread

Figure 2: Microstructure (scanning electron micrograph) of jujube bread with different proportion. A) bread without jujube powder (control); B) bread with 4% jujube powder; C) bread with 8% jujube powder; D) bread with 12% jujube powder; E) bread with 16% jujube powder.

As it is shown in fig.2, there is an effect of adding different proportions of jujube powder on the microstructure. The stomata of ordinary bread are large and uniform. With the increase of jujube powder, the stomata structure had changed significantly. The bread with 4% jujube powder also has complete, large, and uniform stomata. Therefore, when jujube powder is 8%-16%, the stoma in the bread is damage and could varie in size. This shows that the addition of jujube powder affects the tissue structure. With the analysis of texture data, the internal tissue is elastic and has very little change of 4% jujube powder bread compared with ordinary bread. The internal stomata become smaller so that the bread becomes compact, thus reducing the elasticity to 8%; There is a large collapse and serious inelastic both of 12% and 16% jujube powder bread.

Total Phenolic Content and Antioxidant Activity of Bread

Table 4: Phenolic Content and Antioxidant of the Breads

Indicators	0% jujube powder	4% jujube powder	8% jujube powder	12% jujube powder	16% jujube powder
Total phenols (mg GAE/g)	1.85±0.09a	2.71±0.22b	3.33±0.42c	4.02±0.15d	4.29±0.30d
DPPH free radical scavenging ability (%)	25.53±0.64a	32.57±0.69b	47.67±1.59c	66.59±2.96d	88.89±1.89e

Data are presented as mean±SD (n = 3). Different letters following the mean values within the same rows indicate differed significantly (p < 0.05).

Phenols have the ability of antioxidation and scavenging free radicals [9]. The content of total phenols and the scavenging ability of DPPH free radicals are important indexes to measure the antioxidant capacity of bread [29]. It can be seen from Table 4 that, the total phenol content and DPPH radical scavenging ability of bread have increased significantly with the increase amount of jujube powder. This is mainly because polyphenols in jujube powder can improve the antioxidant activity of bread.

Conclusion

The results have shown that, the flavor and color of bread obviously reflects the characteristics of jujube with the gradual increase of the amount of jujube powder. In comparison with the ordinary bread, the variety and content of flavor substances increases by 4% in the jujube powder bread. It has a favorable effect on bread

texture with specific volume sensory properties and so on. Jujube powder is accepted in the sense that, the elasticity, specific volume and pore size of the bread decreases significantly, if the addition of jujube powder is too high.

Also, the softness and chewiness have increased significantly, and the baking quality and acceptability have decreased considerably. To conclude, the bread with 4% jujube powder has the best quality and can significantly improve the antioxidant activity of the bread. In this study, we analyzed the effects of different amounts of jujube powder on bread quality, mainly on flavor, texture, microstructure and antioxidant activity. Finally, the appropriate addition amount of jujube powder is determined without affecting the normal sensory quality of bread.

References

- Mancebo CM, Martínez MM, Merino C, de la Hera E, Gómez M (2017) Effect of oil and shortening in rice bread quality: Relationship between dough rheology and quality characteristics. *Journal of Texture Studies* 48: 597-60.
- Monthe O C, Grosmaire L, Nguimbou R M, Dahdouh L, Ricci J (2019) Rheological and textural properties of gluten-free doughs and breads based on fermented cassava, sweet potato and sorghum mixed flours. *LWT - Food Science and Technology* 101: 575-582.
- Sharma B, Gujral HS (2019) Modulation in quality attributes of dough and starch digestibility of unleavened flat bread on replacing wheat flour with different minor millet flours. *International Journal of Biological Macromolecules* 141: 117-124.
- Shrivastava C, Chakraborty S (2018) Bread from wheat flour partially replaced by fermented chickpea flour: Optimizing the formulation and fuzzy analysis of sensory data. *LWT - Food Science and Technology* 90: 215-223.
- Ning JM, Hou GG, Sun JJ, Wan XC, Dubat A (2017) Effect of green tea flour on the quality attributes and antioxidant activity of whole-wheat flour pan bread. *LWT - Food Science and Technology* 79: 342-348.
- Najafabadi NS, Sahari MA, Barzegar M (2016) Effect of gamma irradiation on some physicochemical properties and bioactive compounds of jujube (*Ziziphus jujuba* var *vulgaris*) fruit. *Radiation Physics and Chemistry* 130: 62-68.
- Reche J, Hernández F, Almansa MS (2018) Physicochemical and nutritional composition, volatile profile and antioxidant activity differences in Spanish jujube fruits. *LWT- Food Science and Technology* 98: 1-8.
- Chen QQ, Bi JF, Wu XY, Yi JY, Zhou LY, Zhou Y, (2015) Drying kinetics and quality attributes of jujube (*Ziziphus jujuba* Miller) slices dried by hot-air and short- and medium-wave infrared radiation. *LWT- Food Science and Technology* 64: 759-766.
- Chen Cheng D, Zhu C, Cao J, (2012) The protective effects of polyphenols from jujube peel (*Ziziphus Jujube* Mill) on isoproterenol-induced myocardial ischemia and aluminum-induced oxidative damage in rats. *Food & Chemical Toxicology*, 50: 1308.
- Zhang YL, Huang LX, Zhang CH, Xie PJ (2016) Effects of different drying methods on the quality of *Ziziphus Jujube* Mill. cv. Hupingzao. *Science and Technology of Food Industry* 37: 76-79+85.
- Liu HY, Wang PL, Li Z, Yin Q (2019) Experimental research on drying characteristics and quality of jujube powder under two drying methods. *Food Science and Technology* 44: 88-95.
- Heenan SP, Dufour JP, Hamid N (2009) Characterisation of fresh bread flavour: Relationships between sensory characteristics and volatile composition. *Food Chemistry* 116: 249-257.
- Jafari M, Koocheki A, Milani E (2018) Functional effects of xanthan gum on quality attributes and microstructure of extruded sorghum-wheat composite dough and bread. *LWT - Food Science and Technology* 89: 551-558.
- Javanmardi J, Stushnoff C, Locke E (2003) Antioxidant activity and total phenolic content of Iranian *Ocimum* accessions. *Food Chemistry* 83: 547-550.
- Changwei Ao, Anping Li, Abdelnaser A, Elzaawely Tran D, Xuan Shinkichi Tawata (2008) Evaluation of antioxidant and antibacterial activities of *Ficus microcarpa* L. fil. extract. *Food Control*. 19: 940-948.
- Jing L, Qian L, Hua BK (2013) Physico-chemical Properties and Antioxidant Activity of Maillard Reaction Products from L-lysine and Reducing Sugar Model System. *Food Science* 34: 80-85.
- Hernández-Aguirre MA, Islas-Hernández JJ, Sánchez-Pardo ME, Rodríguez-Ambríz SL, Osorio-Díaz P (2019) Response surface methodology for optimization of gluten-free bread made with unripe banana flour. *Journal of Food Measurement and Characterization* 13: 1652-1660.
- Wang R, Zhou W, Yu HH (2006) Effects of green tea extract on the quality of bread made from unfrozen dough processes 86: 857-864.
- Hager AS, Elke K, Arendt EK (2013) Influence of hydroxypropylmethylcellulose (HPMC), xanthan gum and their combination on loaf specific volume, crumb hardness and crumb grain characteristics of gluten-free breads based on rice, maize, teff and buckwheat. *Food Hydrocolloids* 32: 195-203.
- Liu RS, Wan JJ, Zhang K (2010) Effects of Freeze Drying and Storage of Oat Sourdough Starter on Volatile Flavor Compounds of Bread. *Food Science* 31: 15-19.
- Yang F, Xu YQ, Wang Q (2019) Processing Technology Optimization and Volatile Flavor Compounds Analysis of Oatmeal Tangerine Pith Bread. *Journal of Sichuan Tourism University* 2: 23-28.
- Lu J, Liu P, Zhang L Z (2014) Changes in Volatile Flavor Compounds in Sufu during Fermentation [J]. *Food science* 35: 175-179.
- Gobbetti M, Simonetti MS (1995) Volatile compound and organic acid productions by mixed wheat sour dough starters: influence of fermentation parameters and dynamics during baking. *Food Microbiology* 497-507.
- Zhang W, Cheng XY, Huang WN (2014) Nutritional Properties, Staling Characteristics and Volatile Flavor Compounds of Natural Yeast Sourdough Bread. *Food science* 35: 33-38.
- Feng D Y, Zhou Y Y (1993) Maillard Reaction and Strecker Degradation And Their Influence on Food Flavour and Food Nutrition. *Journal of Anhui Normal University (Natural Science)* 79-84.
- Zhu LJ, Shi Y, Liu XY (2016) Solid phase micro-extraction combined with gas chromatography-mass spectrometry analysis of volatile flavor compounds of corn pancake. *Food Industry Technology* 37: 102-122.
- Lü S, Ling M, Dong HS (2017) Effect of Drying Temperature on the Aroma Components and Physiochemical Properties of Jujube. *Food science* 38: 139-145.
- Meng N, Sun Y, Liu M (2020) Effects of Potato Flour on Baking Properties and Flavor Compounds of Bread. *Food Science* 41: 223-229.
- Lin LY, Liu HM, Yu YW (2009) Quality and antioxidant property of buckwheat enhanced wheat bread. *Food Chemistry* 112: 987-991.
- Ding S, Peng B, Li Y, (2019) Evaluation of Specific Volume, Texture, Thermal Features, Water Mobility, and Inhibitory Effect of staling in Wheat Bread affected by Maltitol. *Food Chemistry* 283: 123-130.

Copyright: ©2021 Chang-Wei Ao. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.