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Quality and Flavor Changes of Hunan Flavor Leisure Dried Bean Curd under Short Term Storage at Different Temperatures

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Abstract: Different temperature storage of Hunan flavor leisure dried bean curd not only caused changes in texture and quality, but also affected the volatile flavor substances of dried beans, which influenced the overall evaluation of dried beans. In this study, dried beans stored at different temperatures were measured using a mass spectrometer and lipid oxidation measurement method to analyze the effects of different temperatures on the quality and volatile flavor substances of dried beans under short-term storage. The test results showed that the internal color of Hunan flavor leisure dried bean curd became darker with the increase of storage temperature; the texture of Hunan flavor leisure dried bean curd stored at different temperatures changed, and the hardness of Hunan flavor leisure dried bean curd increased with the increase of temperature, and the most significant change was observed in Hunan flavor leisure dried bean curd stored at 60℃; the degree of lipid oxidation increased gradually with the increase of storage temperature; the volatile flavor substances also differed and produced different representative flavor substances. Different representative flavor substances were produced. Therefore, the lower the temperature, the smaller the change in the dried beans, and 4℃ is the best storage condition.

1. Introduction

Soybean is rich in nutrients, including 40% protein, 20% fat, 20% carbohydrates, etc., and contains many other minerals, vitamins, and essential minerals [1]. Therefore, soybean has the nutritional value of promoting intestinal health, including [2], lowering blood sugar and blood lipid., etc. Soybean also occupies an important position in the global consumption of food sector [3]. Soybeans are made into tofu, and dried beans are produced through processes such as pressing and drying, and further brined to make the final product, dried recreational beans, which not only extends storage time but also imparts a rich flavor to dried beans while retaining their nutrients.

With the accelerated pace of life and the improvement of living standards, people give great preference to foods that are easy to consume, rich in nutrition and good in flavor, thus dried beans are developed, and Hunan flavor leisure dried bean curd are vigorously developed. The different temperature storage of Hunan flavor leisure dried bean curd can not only cause changes in the texture and quality of dried beans, but also affect the volatile flavor substances of dried beans, and these changes are enough to affect the sales of Hunan flavor leisure dried bean curd [4]. Changes in food flavor substances are closely related to changes in their intrinsic chemical composition and nutritional value [5,6], and the identification of volatile compounds by assay. The existing techniques for detecting flavor include Electronic Nose, Gas Chromatography-Mass Spectrometry (GC-MS), and more recently Gas Chromatography-Ion Mobility Spectrometry (GC-IMC) [7]. Although GC-MS is the preferred technique for volatile compounds and is widely used [8], it has high detection sensitivity [9], but the pre-treatment is complicated and the detection time is long [10]. It is a method for the detection of trace volatile and semi-volatile organic compounds in different matrices. It is characterized by fast detection speed, small sample requirement, and good reproducibility [11], and can rapidly detect volatile flavor components in foodstuffs in a short time. The IMS instrument has a fast response and high sensitivity to ions at atmospheric pressure based on the mobility of neutral buffer gases in an electric field, and combines the high efficiency separation of GC with the advantages of ion mobility spectrometry for rapid analysis of traces, and after secondary separation to obtain The three-dimensional spectra of retention time, drift time and signal intensity were obtained after secondary separation [12,13]. Recently, GC-IMS technique has been widely used by scientists for flavor detection of food products. For example, Yang et al [14] used GC-IMS to analyze the changes of 47 volatile components of date fruits during refrigeration, identified volatile compounds mainly as alcohols, aldehydes, esters and ketones, and determined the characteristic volatile compounds sufficient to distinguish fresh fruits. GC-IMS has also been applied to other food flavor studies, such as indica rice [15], soybean curd [16], and white apricot [17].

2. Materials and Methods

2.1. Materials

The dried Hunan Pai casual beans used in the experiments were obtained from the market, equally distributed into four groups, and stored under different temperatures in sealed containers. The Hunan flavor leisure dried bean curd without any treatment were used as the control group and recorded as GB0, Hunan flavor leisure dried bean curd stored at 4°C for 1 month were recorded as GB1-4, Hunan flavor leisure dried bean curd stored at 25°C for 1 month were recorded as GB1-25, and Hunan flavor leisure dried bean curd stored at 60°C for 1 month were recorded as GB1-60.

2.2. Methodology

2.2.1. Quality Analysis

The internal color of Hunan flavor leisure dried bean curd stored at different temperatures was measured using a CR-400 automatic colorimeter (Shanghai Lili Environmental Technology Co., Ltd.). The measurement was performed as follows: Hunan flavor leisure dried bean curd were cut open on the surface, and the probe was aligned with a standard white plate for calibration before measurement, and the color difference was measured as L*, a* and b*, respectively [18,19]. Among them. L* values represent brightness, L* of 100 means white, L* of 0 means black; a* values represent red and green values, +a* means tending to red, -a* means tending to green; b* values represent yellow and blue values, +b* means tending to yellow, -b* means tending to blue.

The texture of Hunan flavor leisure dried bean curd stored at different temperatures was measured using a texture meter. The specific operation is as follows: a representative Hunan flavor leisure dried bean curd in each group is selected, 3 representative points of the edge as well as the central part of each Hunan flavor leisure dried bean curd are sampled, the hardness, elasticity and chewiness of the dried beans are measured, the data are recorded, and the average of the 3 measurements is taken as the final result. The test was performed as follows: the textural properties of the dried beans were measured using the TPA model; the samples were placed on a carrier table, and the probe to be tested was aimed at the center of the dried beans for testing. The test parameters were P/0.5; TPA model; compression speed of 40 mm/min, extraction speed of 30 mm/min and holding time of 5s.

2.2.2. Analysis of Lipid Oxidation

For the extraction of dried Hunan flavor leisure dried bean curd oil, refer to the method of Qing Zhang [20] et al. Accurately weighed 30 g of crushed Xiang Pai casual dried beans, mixed with chloroform-methanol mixture, extracted by ultrasonication, filtered and added with 0.88% mass fraction Na Cl aqueous solution, mixed with vigorous shaking and left to stratify, and the lower layer was retained. The lower layer was centrifuged at 3000 ×g for 10 min, the supernatant was withdrawn and the lower layer was kept as a clear orange-yellow solution. The lower layer was evaporated by rotary evaporation at 75℃ under reduced pressure for 1 h. The yolk lipids were obtained by nitrogen blowing in a water bath at 75℃ until constant weight. The extracted lipid was put into a brown bottle and kept under refrigeration at 0℃.

a) Determination of TBARS content

The content of TBARS was determined by spectrophotometric method with specific reference to GB 5009.181-2016 "Determination of malondialdehyde in foodstuffs" [21] in the National Food Safety Standard.

b) CDA value determination

The CDA values of the oils and fats were determined by referring to the method of Yuan Nuo [22] with slight modifications by adding 50 mg of sample oil to 25 m L of isooctane. The oil was dissolved by shaking and left for 10 min in the dark, and the absorbance was quickly measured at 233 nm using an enzyme marker (isooctane was used as a blank).

$$CDA\ (\%) = 0.84 \times A233 / (bc - K0) \qquad (1)$$

Where: A233 is the absorbance value of dried soybean oil at 233 nm. b is the optical diameter of the cuvette, 0.700 cm. c is the concentration of the solution to be measured, g/L. K0 is the absorption coefficient of the acid, 0.03

2.2.3. GC-IMS Analysis of Volatile Compounds

Volatile compounds were analyzed on a GC-IMS instrument Flavour Spec® (G.M.S., Germany) in dried Xiang Pai recreational beans stored at different temperatures. C4-C9 n-ketones were used as an external reference in order to calculate retention indices (RI) for the detection of volatiles under the same chromatographic conditions. Volatile compounds were identified by comparing the RI and drift time (DT) of standard compounds in the NIST database and GC-IMS database [8].

Each sample was repeated three times and the assay conditions were as follows.

Headspace injection conditions: 2 g of sample was weighed and chopped for each group of Hunan flavor leisure dried bean curd, placed in a 20 mL headspace glass sampling bottle, sealed, with an automatic injection volume of 500 µL, incubation time of 15 min, incubation temperature of 60℃, injection needle temperature of 85℃, and incubation speed of 500 rpm.

GC-IMS conditions: capillary column (MXT-5, 15 m L, 0.53 mm ID, 1 um FT with autosampler device (CTC, Switzerland)); column temperature 60℃, analysis time 30 min; carrier gas N2 (purity ≥ 99.999%); IMS temperature 45℃; carrier gas flow rate program: initial flow rate 2 mL/min, hold for 2 min; linear ramp up to 10 mL/min within 10 min, linear ramp up to 100 mL/min within 20 min; drift gas flow rate: 150 mL/min. The flow rate of carrier gas: initial flow rate of 2 mL/min, hold for

2 min; linear ramp up to 10 mL/min within 10 min, linear ramp up to 100 mL/min within 20 min; drift gas flow rate: 150 mL/min.

2.2.4. Electronic Nose Analysis

The volatile composition of Hunan flavor leisure dried bean curd stored at different temperatures was analyzed using an iNose electronic nasal instrument (Shanghai Ruifang International Trade Co., Ltd.).Each sample was measured 3 times in duplicate. The detection parameters were, sampling time 120s; carrier gas flow rate 0.5L /min; waiting time 10s. The specific operations were as follows.

Casual dried beans were chopped and mixed, and 5g of dried beans were weighed as the measurement sample, placed in a 50 mL headspace sample bottle and allowed to stand for 30 min at room temperature (25°C), and the injection needle was used to extract the headspace volume for detection.

2.3. Data Processing and Analysis

Compound identification was performed using the qualitative and quantitative analysis software VOCal, and qualitative analysis of volatiles was performed using the built-in NIST and IMS databases. The fingerprinting was compared using the Gallery Plot plug-in. The data were processed and analyzed using IBM SPSS Statistics 22 and Excel 2010 software, and each group of experiments was repeated three times. The results were expressed as mean ± standard deviation. The data results were plotted using Origin software.

3. Results

3.1. Effect of Different Temperature Storage on the Quality of Hunan Flavor Leisure Dried Bean Curd

3.1.1. Internal Color Variation of Dried Beans in Hunan flavor Leisure Dried Bean Curd Casual

Table 1: Changes in internal coloration of dried recreational beans under different temperature storage

	L*	a*	b*
GB0	71.80 ±0.16d	2.64 ±0.13c	25.15 ±0.50b
GB1-4	69.53 ±0.43c	2.77 ±0.50c	26.69 ±1.44b
GB1-25	64.05 ±0.45b	5.26 ±0.37b	30.86 ±0.35a
GB1-60	49.83 ±0.22a	10.46 ±0.33a	29.97 ±0.92a

Note: In the same column, the same letter indicates that the difference between different processes is not statistically significant ($P > 0.05$), in the same column, different lowercase letters indicate that the difference between different processes is statistically significant ($P < 0.05$).

See Table 1 for the analysis results of the influence of storage at different temperatures on the internal color of Hunan style leisure dried beans. From Table 1, it can be seen that the differences in the internal brightness (L*) of dried leisure beans under different temperature storage were statistically significant ($P < 0.05$), not only the dried leisure beans under each temperature storage were significantly different compared with the blank group, but also Hunan flavor leisure dried bean curd stored at each temperature were significantly different from each other. In terms of the internal redness (a*) of Hunan flavor leisure dried bean curd, the GB1-60 reached a maximum value of 10.46; the GB1-25 were the second; the GB1-4 showed the least change and was not statistically significant compared with GB0 ($P > 0.05$). In terms of the yellowness (b*) of Hunan flavor leisure dried bean curd, the GB1-25 and GB1-60 were significantly different from GB0 and GB1-4 ($P < 0.05$), and GB1-4 were not significantly different from GB 0($P > 0.05$). For overall comparison, the color of dried recreational beans stored at 4℃ was the closest to the control group and was the best storage temperature.

3.1.2. Texture Variation of Hunan Flavor Leisure Dried Bean Curd

The results of the analysis of the effects of different temperatures on Hunan flavor leisure dried bean curd are shown in Table 2. From Table 2, it can be seen that in terms of cohesiveness and elasticity, there was no significant difference between Hunan flavor leisure dried bean curd stored at any temperature; in terms of hardness, the GB1-60 reached the highest value of 1347.60gf, which was significantly different from the other three groups of dried beans, and there was no significant difference with the control group .In terms of hardness, the 60℃ samples stored with dried leisure beans reached the highest value of 1347.60gf, which was significantly different from the other three groups of dried leisure beans. The storage condition not significantly different from the control group was 25℃. For masticability, recreational beans stored at 60℃ were significantly different in the other three groups. Therefore, the GB1-25 had the best texture, and the largest gap between the GB1-60 and the GB0.

Table 2: Textural changes of dried recreational beans under different temperature storage

	Hardness 1 (gf)	Chewiness (gf)	Cohesiveness	Springiness
GB0	793.01±21.34c	684.83±31.31b	1.27±0.09a	0.89±0.02a
GB1-4	985.84±119.23b	756.60±55.34b	1.52±0.04a	0.91±0.04a
GB1-25	692.86±77.06c	555.93±68.44b	1.42±0.03a	0.89±0.01a
GB1-60	1347.60±91.69a	1148.01±398.88a	1.43±0.30a	0.86±0.08a

Note: In the same column, the same letter indicates that the difference between different processes is not statistically significant ($P > 0.05$), while in the same column, different lowercase letters indicate that the difference between different processes is statistically significant ($P < 0.05$).

3.2. Lipid Oxidation of Dried Beans

3.2.1. Effect of Different Sterilization Temperatures on the TBARS Content of Brined Eggs

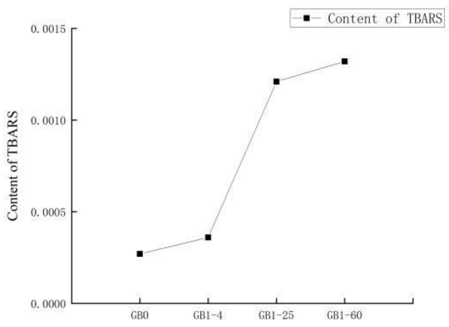

Figure 1: Effect of different storage temperatures on the TBARS content of dried recreational beans

TBARS is the result of the reaction of malondialdehyde, a secondary product resulting from the oxidative decomposition of unsaturated fatty acids in oils and fats, with TBA, and the level of its content indicates the extent of secondary fat oxidation [23-25]. As can be seen from Figure 1, an increase in TBARS content occurred in all samples of dried recreational beans stored at different temperatures compared to the control dried recreational beans, indicating that heat treatment caused fat oxidation, resulting in an increase in TBARS content in dried recreational beans. The TBARS content of leisure bean dried gradually increased with increasing storage temperature. However, GB1-60 increased the TBARS content the most, with about 0.00132mg / kg, indicating that the higher the storage temperature, the faster the rate of leisure dry bean fat oxidation.. This is similar to the results of Huijian Zhou et al [26] who studied the effect of sterilization temperature (121 ℃ and 105 ℃) on the TBARS content of braised aged goose meat, where the higher the temperature, the faster the rate of fat oxidation.

3.2.2. Effect of Different Sterilization Temperatures on CDA Values of Brined Eggs

CDA value is an important indicator reflecting the oxidative decomposition of polyunsaturated fatty acids into hydroperoxides, CDA exists for a short time and will be decomposed quickly to form oxidation products, which is an important basis to reflect the degree of primary oxidation of lipids [27]. As can be seen from Figure 2, CDA values showed an increasing trend with the increase in storage temperature, indicating that the increase in temperature accelerated the oxidative decomposition of fat. The GB1-60 showed the highest increase in CDA values compared to the GB0, with an increase of about 0.466%.

The increase in CDA value caused by the increase in storage temperature is caused by the increase in temperature that promotes the oxidation and decomposition of polyunsaturated fatty acids to produce more hydroperoxides, that is, the higher the temperature, the greater the CDA value. This is similar to the results of a study on brined chicken thighs by K.G. Zhang [28], which found that the CDA values of both subcutaneous and intramuscular fat of chicken thighs tended to increase as the cooking temperature increased.

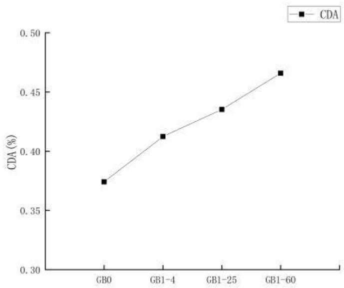

Figure 2: Effect of different storage temperatures on CDA values of dried recreational beans

3.3. Comparison of the Unique Volatile Components of Dried Recreational Beans Stored at Different Temperatures

To clarify the specific differential substances in the samples, all peaks were selected for fingerprinting comparison, and the results showed that the volatile components of Hunan flavor leisure dried bean curd stored at different temperatures differed significantly. Figure 3 shows the visual information related to the type and corresponding content of volatile compounds in all samples of dried recreational beans [29].

Among all the samples of dried recreational beans, it can be visualized that there were more significant differences in VOC of dried beans at different storage temperatures, especially between the GB1-25 and the GB1-60, while the GB1-4 is relatively close to the control group. In the GB1-25 samples, the contents of terpenes and derivatives such as α-sideroprene, α-pinene, γ-pineolene, β-laurene, and basilene were significantly higher in GB1-25. 2-pentanone, cyclopentanone, 2-hexanone, 2-heptanone, 2-octanone, ethyl sulfide, pentanol, and hexanol were significantly higher in the GB1-

60. While the GB0 and the GB1-4 were relatively similar, the contents of n-heptane and (E)-2-hexenal were higher in both samples.

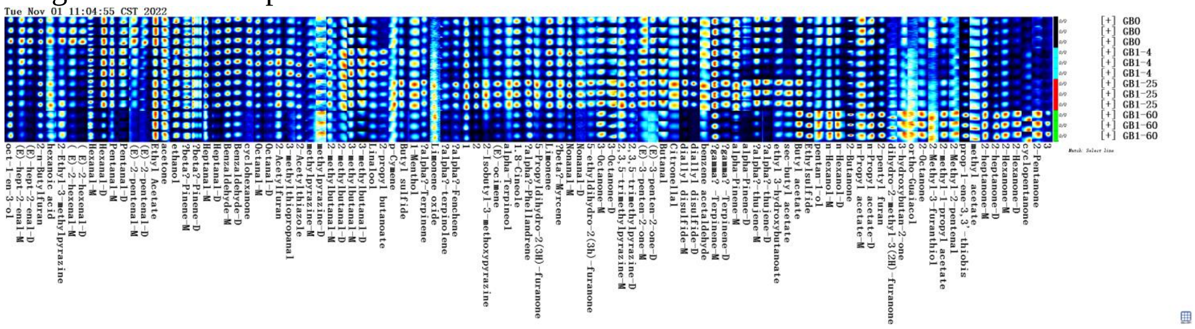

Figure 3: Fingerprint profiles of dried Hunan Paicasual beans stored at different temperatures Gallery Plot

3.4. Electronic Nose Analysis of Dried Bean Flavors

Under the same conditions, the electronic nose test was performed on four groups of Hunan flavor leisure dried bean curd with different treatments and the results were obtained as shown in Figure 4. It can be seen from the figure that some of the sensors were significantly changed in all four groups of dried casual beans compared to each other, so Hunan flavor leisure dried bean curd with different temperature treatments had flavor differences and they also had differences in volatile compounds, the same as the results of GC-IMS determination, the flavor of Hunan flavor leisure dried bean curd stored at different temperatures had differences. Li et al [30] used electronic nose to make a distinction between real and fake brands of dried casual beans, where the results were similar to the results of this study.

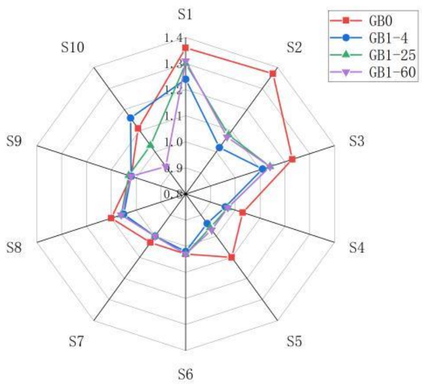

Figure 4: Different temperature processing Hunan flavor leisure dried bean curd flavor radar map

4. Conclusion

The analysis and comparison of Hunan flavor leisure dried bean curd stored at different temperatures for a short period of time were carried out using a fully automatic colorimeter and a mass spectrometer. The results showed that the internal three temperature storage of L* gradually decreased with the increase of temperature, namely the internal brightness of the dried bean decreased, and each dried bean sample showed significant differences, a* and b* also increased with the increase of temperature, but not all samples showed significant differences. For a* values, the GB1-25 and the GB1-60 groups were significantly different from the GB0. The b* value comparison can divide the samples into two groups, the GB1-25 and the GB1-60 as a group, the GB0 and the GB1-4 into a group, and there are significant differences between the two groups.

For the texture of the leisure dried beans, there is no significant difference in the cohesion and elasticity of the leisure dried beans samples stored at any temperature. The GB1-60 had the highest hardness and masticability, reaching 1347.60gf, 1148.01gf, respectively, and the hardness was significantly different from the other three groups of leisure bean stems.

Oxidation of lipids occurred in all treated groups of samples and TBARS content gradually increased with increasing temperature, which indicates that heat treatment caused fat oxidation resulting in increased TBARS content in dried recreational beans. The highest increase in TBARS content was observed under storage at 60 ℃ with a content of about 0.00132 mg/kg, indicating that the higher the storage temperature the faster the rate of fat oxidation in dried recreational beans. Also the CDA value tended to increase with the increase in storage temperature. GB1-60 showed the highest increase in CDA value when compared to GB0, reaching about 0.466% of the increase in content.

When comparing the volatile flavor substances obtained from all Hunan flavor leisure dried bean curd samples using GC-IMS, it can be visually seen that there were more significant differences in the VOC of dried beans at different storage temperatures, especially the GB1-25 and GB1-60, while the GB1-4 is relatively close to GB0. The GB1-25 contained significantly higher levels of terpenes and derivatives such as α-lateral cypressene, α-pinene, and basilene. The contents of substances such as 2-pentanone, cyclopentanone, 2-hexanone, 2-heptanone, 2-octanone, ethyl sulfide, pentanol and hexanol were significantly higher in the GB1-60. The contents of substances such as 2-pentanone, cyclopentanone, 2-hexanone, 2-heptanone, 2-octanone, ethyl sulfide, pentanol and hexanol were significantly higher in the samples stored at 60℃. While GB0 and GB1-4 were relatively similar, the contents of n-heptane and (E)-2-hexenal were higher in both samples.

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