Effect of Drying Methods on Peanut Quality during Storage

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Abstract: Storage is an important step after peanut harvest and drying. Many factors could affect the peanut quality during storage. The quality change differences of peanut after being dried by solar radiation and at 35°C, 40°C, 45°C, 50°C during later storage were investigated, including moisture content (MC) and germination percentage (GP) of peanut kernels, acid value (AV), peroxide value (PV), iodine value (IV), vitamin E (VE) content and fatty acid composition (FAC) of extracted peanut oil. And the impact of four storage conditions, air-room temperature (A-RT), air-low temperature (A-LT), vacuum-room temperature (V-RT) and nitrogen-room temperature (N-RT) on peanut quality after 10 months' storage were also studied in this paper. The results revealed that drying conditions had only a little influence on peanut quality during later storage. Peanut dried by solar radiation was more easily oxidized than that dried under other drying conditions. The effects of storage time were much greater. The GP, AV, PV, VE content and FAC, showed significantly changes along with storage. GP and VE content decreased, AV and PV increased, and some linoleic acid was oxidized to oleic acid after 10 months' storage. In addition, A-LT exhibited best performance in keeping peanut quality than A-RT, V-RT and N-RT, which demonstrated that low temperature was more advantageous for peanut storage than controlled atmosphere. These results above would provide useful information and reference for the peanut storage to apply in food industry.

Key words: peanut, storage, drying conditions, low temperature, controlled atmosphere

1 Introduction

Peanut (*Arachis hypogaea* L.) is widely planted and consumed throughout the world and it is an important vegetable protein and oil source¹⁻³. Peanut has high nutritional value, with about 26% protein, 50% oil (high content of unsaturated fatty acids, accounting for more than 80%), and 3% fiber, as well as high levels of calcium, thiamine, and niacin, etc.^{4,5}.

Drying and storage are two extremely important steps before peanut processing. Wet peanut needed to be dried to moisture content lower than 10% w.b.^{6,7} and then stored in dry environment to prevent mold development and aflatoxin contamination⁸⁻¹⁰.

In the process of storage, peanut is easy to be oxidized, rancidity, oil-run and produce aflatoxin^{1,11-13}. High peanut seed quality illustrated by high seed vigor and high germination percentage related to the low autoxidation substrates: malondialdehyde (MDA), lipoxygenase (LOX), and high antioxidants: catalase (CAT) and superoxide dismutase (SOD)¹⁴. Storage humidity, temperature and the material of package bag were all influence factors of peanut storage.

To maintain peanut quality during storage and reduce economic losses, many researchers have studied the quality changes of peanut under different storage conditions¹⁵⁻¹⁷.

Mutegi¹⁸ found that the moisture content, rancidity, physical damage, and aflatoxin contents of peanuts notably changed at different humidity. Martín^{19,20} demonstrated that peanut stored at 10°C was associated with less quality deterioration than that stored at 25°C, and peanut qualities (peroxide value, conjugated dienes, free fatty acids, saturated to unsaturated fatty acid ratio, oleic to linoleic ratio, iodine value, roasted peanutty flavor etc.) were better when packed in ethylene vinyl alcohol bags than that in polypropylene ventilated bags except for free fatty acids. Fu²¹ investigated that the influences of different packing materials on inhibiting aflatoxin production and maintaining the quality of peanuts, and found that peanuts stored in the polyester/aluminum/polyamide/polyethylene and polyamide/polyethylene bags were both better at inhibiting and controlling aflatoxin production. Liu's study²² exhibited that storage temperature (15°C, 25°C, and 35°C) led to different degrees of lipid oxidation of peanuts. Tempera-

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tures could affect peroxide value and malondialdehyde (MDA) content of oil extracted from peanuts significantly, which were the indicators of lipid oxidation degree²³⁾.

Besides the quality deterioration of lipid in peanut along with storage, the quality of peanut protein also changed. Sun²⁴⁾ investigated the molecular functional properties of peanut protein isolate during storage. Extending storage time resulted in a decrease in free sulfhydryl content, fluorescence intensity, surface hydrophobicity and emulsifying properties and an increase in protein particle size. The results also showed the content decline of α -helix and β -sheet, and the content rise of β -turn and random coil.

In summary, substantial studies have reported that the effects of different storage conditions on the quality of peanuts. However, few works have investigated the effect of different drying conditions on the later storage of peanut. The present study aimed to investigate the quality changes of peanuts during storage after being dried by solar radiation and at 35°C, 40°C, 45°C, 50°C. The effect of low temperature and controlled atmosphere on peanut storage were also studied.

2 Materials and Method

2.1 Samples

Tianfu No.3 peanut was planted in April in Weihui County (35.4° N, 114.1° E), Henan Province, China, and harvested in October. After preliminary drying in the field by the sun, the peanut was picked. And the initial moisture contents of the peanut were tested between 17.7% and 22.9%. Some of the wet peanuts were spread on the ground and dried by the sun as called solar radiation for 3 days, and some of them were dried by hot air at 35, 40, 45, 50 and 55°C for 18 h, 14 h, 10 h, 8 h and 6 h, respectively until the moisture contents were all below 10% as mentioned in our previous study²⁵⁾. Dried peanuts obtained under different drying conditions were then shelled by a dehulling machine (Yuxin Machinery Factory, Gongyi, China), respectively. And the shelled peanuts were used as samples for storage experiments.

2.2 Storage conditions

The shelled peanuts were stored under four conditions as below.

(a) Air-room temperature (A-RT)

The shelled peanuts were put into polyamide and polyethylene (PA/PE) bags, which was 0.16 mm in thickness, 40 cm in width and 60 cm in length. One bag can hold 1500 g samples. Then the bags with peanut samples were stored at room temperature (Fig. 1).

(b) Air-low temperature (A-LT)

The shelled peanuts were placed in PA/PE bags as described in (a) and stored at quasi-low temperature (less

Fig. 1 Changes of room temperature and quasi-low temperature during storage.

than 20°C, Fig. 1).

(c) Vacuum-room temperature (V-RT)

The shelled peanuts were first placed in PA/PE bags. Then the air in the bags was drawn using a vacuum packing machine (DZ400, Shanghai Afanlao Machinery Co, Ltd, China) to vacuum degree 90 kPa. The vacuum bags were sealed by a plastic film sealing machine (FS-300, Qingye Company, China). And the samples were then stored at room temperature (Fig. 1).

(d) Nitrogen-room temperature (N-RT)

The vacuum bags with shelled peanuts as mentioned in (c) were connected to steel cylinder by syringe needle, rubber tube and pressure reducing valve. And the high-purity nitrogen ($\geq 9.999\%$) slowly filled the vacuum bag. Then the pinhole was sealed by the sealing machine. The peanut samples were then stored at room temperature (Fig. 1).

The qualities of the shelled peanuts stored under these different conditions were analyzed after 0, 2, 4, 6, 8 and 10 months of storage, respectively.

2.3 Moisture content determination

The moisture content of shelled peanuts was measured according to the American Society of Agricultural and Biological Engineers (ASABE) method S410.2 at 130°C for 6 h^{26, 27)}.

2.4 Germination tests

Based on Chinese National Standard GB/T 5520-2011, samples of 50 shelled peanuts were sowed in wet sand and cultivated at 25°C in a climate incubator. The germination percentage was defined as the number of successfully spouted peanuts out of the total number of peanuts after 10 days cultivation.

2.5 Peanut oil analysis

2.5.1 Peanut oil extraction

Soxhlet extraction²⁵⁾, aqueous enzymatic extraction^{28–30)} and thermosonication assisted extraction³⁾ were the common extraction method of peanut oil. In this paper, peanut oil was extracted from the sliced peanut kernels by petroleum ether, and then the petroleum ether was removed with a rotary vacuum evaporator according to Qu *et al.*²⁵⁾ The extracted oil was then used for further chemical analysis.

2.5.2 Acid value

The acid values of peanut oil were determined according to the Chinese National Standard GB 5009.229-2016. The extracted oil (20 g) was placed into conical flask for dissolving the sample in ether-isopropanol solution. Then the solution was titrated with standard NaOH solution (0.1 mol/L) with phenolphthalein as the indicator.

2.5.3 Peroxide value

The peroxide values of peanut oil were measured by the Chinese National Standard GB 5009.227-2016, using 3 g oil from each sample and expressed as millimoles of active oxygen in 1 kg oil²⁵⁾.

2.5.4 Iodine value

Method for iodine values determination of peanut oil followed Chinese National Standard GB/T 5532-2008. Iodine value of peanut oil was expressed in grams of iodine absorbed by 100 g oil²⁵⁾.

2.5.5 Vitamin E determination

The contents of vitamin E for peanut oil were determined using VE test kits (Nanjing Jiancheng Bioengineering Institute, China) according to the manufacturer's protocol, which was on the basis of the reaction of VE and phenanthroline to form a pink complex with 533 nm absorbance.

2.5.6 Fatty acid composition determination

The composition of fatty acid of peanut oil was determined by gas chromatography (7890 B, Agilent Technologies, USA) with flame ionization detector (GC-FID) according to the Chinese National Standard GB 5009.168-2016 external standard method 7.1. The HP-88 capillary column (100 m × 0.25 mm × 0.20 μm) was employed to separate different fatty acids with 1.00 mL/min flow rate of carrier gas (nitrogen). The initial temperature was 140°C for 5 min, temperature programmed to 240°C at 4°C/min and holding at 240°C for 20 min. Split ratio was 1:50 and FID temperature was 260°C.

2.5.7 Data analysis

Origin (version 9.0) and SPSS (version 21.0) were used to data processing and statistical analysis. The significant difference was determined at the $p < 0.05$ level for One way analysis of variance (ANOVA) and Duncan's test.

(a)

(b)

Fig. 2 (a) Moisture content and (b) Germination percentage of peanut kernels treated with different drying conditions in A-RT storage condition for 10 months.

3 Results and Discussion

3.1 The effect of different drying conditions on the later storage of peanut

A-RT was chosen as storage condition to compare the quality change differences of peanut after being dried by solar radiation and at 35°C, 40°C, 45°C, 50°C during later storage.

3.1.1 Moisture content

Moisture content is one of the most important key factors for peanut storage. The moisture content of peanut at harvest is usually more than 35%–45%⁶⁾. If it is not dried in time, the mold would reproduce and grow fast at appropriate temperature. In case the dried peanut is stored in the humid environment, it is easy to absorb moisture and become moldy. And in severe cases, toxins can also be produced^{31, 32)}. According to the DB 21/T 2496-2015 peanut storage technical regulations, the safe moisture content of peanut kernel is less than 8%. Salamatullah *et al.*³³⁾ reported that the moisture content of peanut kernels of different harvesting time was determined between 4.47% and

7.93%. In our experiment, the moisture contents of peanut kernels dried by solar radiation and at 35°C, 40°C, 45°C, 50°C during later storage were displayed in Fig. 2(a). It can be seen that the moisture contents were all between $4.03 \pm 0.06\%$ and $5.94 \pm 0.12\%$. Therefore, the moisture contents of peanut kernels were all within the safe range.

3.1.2 Germination

Germination percentage (GP) is an important indicator to reflect the vitality of peanuts. The environmental conditions and moisture content could affect peanut germination³⁴. The columns in Fig. 2(b) displayed the effects of different drying conditions on the GP of peanut stored for same period of time in A-RT condition, which showed no significant difference. Therefore, drying conditions (solar radiation and at 35°C, 40°C, 45°C, 50°C) had no influence on the GP of peanut during later storage. The point-line diagram in Fig. 2(b) exhibited the effect of storage time on GP of peanut. The GP showed significant difference after 10 months' storage, from $95 \pm 3\%$ at the beginning, to $91 \pm 4\%$ after 8 months and $86 \pm 3\%$ after 10 months. Hence, storage time had an impact on the germination of peanut.

3.1.3 Acid value

Acid value (AV) is a measure of free fatty acid content in oil, and can be used as an indicator of rancidity. It can be seen from Fig. 3(a) that the effect of different drying conditions on AV during storage. On the whole, the AVs of oil that obtained from peanut dried by solar radiation, at 35°C and 50°C were a little higher than that obtained at other drying temperatures. This was due to that the moisture contents of peanut dried by solar radiation, at 35°C were higher than others during storage (Fig. 2(a)), making the oil easier to hydrolyze. And from our previous study, the AV of oil extracted from peanuts dried at 50°C (0.124 mg/g) was significantly higher than that from peanut dried by solar radiation (0.087 mg/g), at 35°C (0.090 mg/g), 40°C (0.085 mg/g) and 45°C (0.093 mg/g), showing that higher drying temperature was unfavourable for peanut quality.

Figure 3(a) displayed that the storage time had an obvious influence on AV. The AV increased along with storage. For instance, the AVs of peanut oil obtained from peanut dried at 35°C were $0.09 \pm 0.01 \text{ mg/g}$ before storage, which increased to $0.62 \pm 0.01 \text{ mg/g}$ after 10 months. This

Fig. 3 (a) Acid value (b) Peroxide value (c) Iodine value (d) VE content of peanut kernels treated with different drying conditions in A-RT storage condition for 10 months.

was due to the hydrolysis of lipid in peanut during storage, which was in accordance with Martin's research¹⁹⁾.

3.1.4 Peroxide value

Peroxide value (PV) is usually used as an indicator of lipid oxidation^{22, 24)}. This parameter increases while the lipid deterioration advances during grain and food storage²⁵⁻²⁷⁾. At the same storage period, peanut dried by solar radiation revealed higher PV (Fig. 3(b)). This was due to that in addition to autooxidation, lipoxygenase produced by microorganisms can also catalyze lipid oxidation. Firstly, the drying conditions with higher temperature played the role of sterilization. The longer the storage time, the more obvious the sterilization impact. Secondly, the moisture contents of peanut dried by solar radiation were higher than that of other drying conditions during storage, which were shown in Fig. 3(b). In addition, the PV increased more rapidly after 6 months. For instance, the PVs of the obtained peanut (dried at 35°C) oil were 0.24 ± 0.02 mmol/kg before storage, which increased to 0.38 ± 0.03 mmol/kg after 6 months, 0.93 ± 0.05 mmol/kg after 8 months and 1.15 ± 0.03 mmol/kg after 10 months. This phenomenon may be owing to the increase of room temperature (Fig. 1) and the acceleration of oxidation rate.

3.1.5 Iodine value

Iodine value (IV) is important in evaluating the quality and shelf life of oils and fats, as it gives a good estimation of their susceptibility to oxidative degradation³⁵⁾. Generally, the higher the IV, the greater the unsaturation degree of the oil, and the higher the content of unsaturated fatty acids in the oil. The IV results were presented in Fig. 3(c), which showed that IVs of peanut oil obtained from peanut

dried in different conditions did not significantly changed during storage. And storage time also showed no significant effect on IV.

3.1.6 Vitamin E

Vitamin E (VE) content could also be used as an indicator of oxidative state for peanut³⁶⁾. It stabilizes polyunsaturated fatty acids in membrane lipid bilayers, thus protecting them from lipoxygenase attack and scavenging radicals³⁷⁾. Lipid oxidation process results in loss of VE. It can be seen from Fig. 3(d) that VE content of oil extracted from peanut dried by solar radiation was much lower than that dried by hot air at the same storage time. This result was consistent with the PV results. The PV of oil extracted from peanut dried by solar radiation was higher than that of other drying conditions. The PV and the VE content showed negative correlation. Moreover, the VE content reduced more rapidly after 4 months. The VE content of the obtained peanut (dried at 35°C) oil were 110 ± 0.58 µg/g before storage, which decreased to 104 ± 0.85 µg/g after 4 months and 70 ± 1.11 µg/g after 10 months (Fig. 3(d)).

3.1.7 Fatty acid composition (FAC)

Table 1 showed that there were more than 80% unsaturated fatty acids in peanut oil, which mainly included oleic acid and linoleic acid. After 10 months' storage, the contents of these fatty acids, C16:0, C18:0, C18:1-9, C18:2-6, C20:0, C20:1-9, C22:0 and C24:0, had no significant difference under different drying conditions (Table 1).

However, linoleic acid C18:2-6 decreased from $34.35 \pm 1.21\%$ to $32.48 \pm 0.20\%$, and oleic acid C18:1-9 increased from $43.96 \pm 0.06\%$ to $47.02 \pm 0.50\%$ after 10 months' storage as suggested by Table 2. This was due to that the

Table 1 Fatty acid composition of peanut oil extracted from peanut in different drying conditions after 10 months' storage at ART.

FAC (%)	Drying temperature (°C)				
	Solar radiation	35	40	45	50
Palmitic acid C16:0	10.88 ± 0.04^a	10.93 ± 0.28^a	10.85 ± 0.08^a	10.94 ± 0.02^a	10.93 ± 0.15^a
Stearic acid C18:0	2.92 ± 0.04^c	3.12 ± 0.14^{ab}	3.18 ± 0.02^a	3.02 ± 0.06^{bc}	3.14 ± 0.08^{ab}
Oleic acid C18:1-9	47.11 ± 0.30^a	47.02 ± 0.50^a	46.81 ± 0.29^a	46.90 ± 0.18^a	46.82 ± 0.30^a
Linoleic acid C18:2-6	32.57 ± 0.13^b	32.48 ± 0.20^b	32.5 ± 0.05^b	32.89 ± 0.21^a	32.47 ± 0.05^b
Arachidic acid C20:0	1.43 ± 0.06^a	1.47 ± 0.10^a	1.51 ± 0.06^a	1.44 ± 0.03^a	1.56 ± 0.09^a
Gadoleic acid C20:1-9	0.90 ± 0.09^a	0.80 ± 0.09^{ab}	0.82 ± 0.07^{ab}	0.79 ± 0.00^{ab}	0.75 ± 0.02^b
Behenic acid C22:0	2.68 ± 0.17^a	2.97 ± 0.23^a	2.76 ± 0.07^a	2.60 ± 0.05^a	2.71 ± 0.15^a
Lignoceric acid C24:0	1.51 ± 0.22^a	1.53 ± 0.20^a	1.58 ± 0.20^a	1.40 ± 0.29^a	1.62 ± 0.18^a
ΣSFA (Total amount of saturated fatty acids)	19.42 ± 0.44^a	19.71 ± 0.75^a	19.87 ± 0.28^a	19.42 ± 0.39^a	19.96 ± 0.31^a
ΣUFA (Total amount of unsaturated fatty acids)	80.58 ± 0.44^a	80.29 ± 0.75^a	80.13 ± 0.28^a	80.58 ± 0.39^a	80.04 ± 0.31^a

Data were expressed as means $\pm$ standard deviations. Different superscript letters show a significant difference ($p < 0.05$).

Table 2 Fatty acid composition of peanut oil extracted from peanut kernel under different storage conditions during drying temperature 35°C.

FAC(%)	0 months	After 10 months storage			
		A-RT	A-LT	V-RT	N-RT
Palmitic acid C16:0	11.27 ± 0.05 ^a	10.93 ± 0.28 ^b	10.77 ± 0.03 ^b	10.95 ± 0.12 ^b	10.87 ± 0.09 ^b
Stearic acid C18:0	2.77 ± 0.31 ^b	3.12 ± 0.14 ^{ab}	3.05 ± 0.08 ^{ab}	3.18 ± 0.14 ^a	3.09 ± 0.13 ^{ab}
Oleic acid C18:1-9	43.96 ± 0.06 ^c	47.02 ± 0.50 ^{ab}	46.80 ± 0.46 ^{ab}	47.34 ± 0.33 ^a	46.57 ± 0.44 ^b
Linoleic acid C18:2-6	34.35 ± 1.21 ^a	32.48 ± 0.20 ^c	32.94 ± 0.26 ^b	32.39 ± 0.05 ^c	33.13 ± 0.31 ^b
Arachidic acid C20:0	1.48 ± 0.22 ^a	1.47 ± 0.10 ^a	1.43 ± 0.05 ^a	1.46 ± 0.02 ^a	1.51 ± 0.13 ^a
Gadoleic acid C20:1-9	1.12 ± 0.02 ^a	0.80 ± 0.09 ^b	0.91 ± 0.24 ^b	0.73 ± 0.03 ^b	0.77 ± 0.01 ^b
Behenic acid C22:0	2.97 ± 0.23 ^a	2.66 ± 0.16 ^{ab}	2.64 ± 0.21 ^{ab}	2.55 ± 0.18 ^b	2.69 ± 0.20 ^{ab}
Lignoceric acid C24:0	1.71 ± 0.31 ^a	1.53 ± 0.20 ^a	1.46 ± 0.31 ^a	1.39 ± 0.38 ^a	1.37 ± 0.44 ^a
ΣSFA (Total amount of saturated fatty acids)	19.16 ± 0.36 ^a	19.71 ± 0.75 ^a	19.35 ± 0.50 ^a	19.53 ± 0.35 ^a	19.53 ± 0.73 ^a
ΣUFA (Total amount of unsaturated fatty acids)	80.84 ± 0.36 ^a	80.29 ± 0.75 ^a	80.65 ± 0.50 ^a	80.47 ± 0.35 ^a	80.47 ± 0.73 ^a

Data were expressed as means ± standard deviations. Different superscript letters show a significant difference ($p < 0.05$).

unsaturated bonds of linoleic acid were oxidized during storage to form oleic acid.

3.2 The effect of different storage conditions on peanut quality

Peanut dried at 35°C were dehulled and stored in four different storage conditions (A-RT, A-LT, V-RT, N-RT) for 10 months.

3.2.1 Moisture content

The moisture content of peanut kernels before storage was $4.80 \pm 0.12\%$ (Fig. 4(a)). After 10 months' storage in A-RT, A-LT, V-RT and N-RT conditions, the moisture contents were $4.88 \pm 0.06\%$, $5.24 \pm 0.14\%$, $4.70 \pm 0.05\%$ and $4.94 \pm 0.07\%$, respectively (Fig. 4(a)). They were all in the safe moisture range (below 8%).

3.2.2 Germination

The changes in the GP of peanut kernels under different storage conditions (A-RT, A-LT, V-RT and N-RT) were investigated. The results were presented in Fig. 4(b). It can be found that the GP decreased from $95 \pm 3\%$ to $86 \pm 3\%$ in A-RT storage condition after 10 months' storage, which was lower than that under other storage conditions. The GP of peanut stored in A-LT, V-RT, N-RT conditions showed no significant difference. Therefore, low oxygen concentration and low temperature were the favorable factors to maintain the GP of peanut.

3.2.3 Acid value

The AVs of oil extracted from peanut stored under A-RT, A-LT, V-RT and N-RT conditions were displayed in Fig. 5(a). The initial AV of peanut oil (obtained from peanut dried at 35°C) was 0.09 ± 0.00 mg/100 g, which indicated good quality in terms of the degree of lipid hydrolysis. The

AV increased significantly after 10 months of storage under A-RT, A-LT, V-RT and N-RT storage conditions. Compared with other storage conditions, peanut kernels stored at A-LT had the lowest acid value, 0.45 ± 0.03 mg/100 g. The acid values reached 0.66 ± 0.02 mg/100 g and 0.71 ± 0.01 mg/100 g in V-RT and N-RT storage conditions, which was a little higher than that in A-RT condition (0.62 ± 0.01 mg/100 g). These results illustrated that low temperature could inhibit the hydrolysis of triglycerides in peanuts to produce free fatty acids, which controlled atmosphere could not.

3.2.4 Peroxide value

Considerable variability in PV of oil extracted from peanut (dried at 35°C) was detected under different storage conditions, which was shown in Fig. 5(b). At the beginning of storage, the PV was 0.24 ± 0.02 mmol/kg. After 10 months' storage, there were significant differences among different storage conditions, varied between 0.64 ± 0.06 mmol/kg (A-LT) and 1.15 ± 0.03 mmol/kg (A-RT). The peanut stored under V-RT and N-RT conditions showed lower PVs than that of A-RT storage, which were 0.88 ± 0.05 mmol/kg and 0.77 ± 0.04 mmol/kg, respectively. From these data, it can be concluded that temperature and oxygen concentration influenced the PV. And low temperature and controlled atmosphere could retard the oxidation of peanut.

3.2.5 Iodine value

There were no significant difference in IV of peanut oil after 10 months' storage under different storage conditions, which was displayed in Fig. 5(c). This indicated that unsaturation degree of peanut oil under different storage conditions showed no significant difference.

Fig. 4 Changes of (a) Moisture content and (b) Germination percentage of peanut kernels in four storage conditions, A-RT, A-LT, V-RT and N-RT after 10 months.

3.2.6 Vitamin E

Peanut is a rich source of polyphenolic antioxidant compounds, including resveratrol, tocopherol, phytosterol, catechin, epicatechin, and quercetin³³. Salamatullah *et al.*³³ reported that gallic acid, 3,4-dihydroxy-benzoic acid, (+)-catechin, and 1,2-dihydroxybenzene were the key phenolic compounds of peanut kernels. The gallic acid content of peanut kernels ranged from 1.36 mg/L to 2.85 mg/L. The 3,4-dihydroxybenzoic acid content of peanut samples were 1.73 mg/L-3.56 mg/L. Additionally, the (+)-catechin content of the peanut kernel samples changed between 2.17 mg/L and 5.15 mg/L, and the 1,2-dihydroxybenzene content of peanut kernels were 2.67 mg/L-5.85 mg/L. In this paper, the results of the VE content of peanut oil during storage were shown in Fig. 5(d). The initial VE contents of peanut oil was 110 ± 0.58 $\mu\text{g/g}$. After 10 months of storage, VE contents of peanut oil extracted from peanut stored at A-RT, A-LT, V-RT and N-RT were 70 ± 1.11 $\mu\text{g/g}$, 84 ± 1.53 $\mu\text{g/g}$, 72 ± 1.03 $\mu\text{g/g}$ and 81 ± 1.16 $\mu\text{g/g}$, respectively. Therefore, low temperature showed good

performance on protecting the antioxidant system of peanut.

3.2.7 Fatty acid composition

The dominant fatty acids in peanut oil were oleic acid (43.96%-47.34%), linoleic acid (32.39%-34.35%) and palmitic acid (10.77%-11.27%), followed by behenic acid (2.55%-2.97%), stearic acid (2.77%-3.18%), lignoceric acid (1.37%-1.71%), arachidic acid (1.43%-1.51%) and gadoleic acid (0.73%-1.12%), which can be seen in Table 2. It can be seen that there was no significant difference in the fatty acid composition after 10 months' storage under ART, ALT, VRT and NRT storage conditions.

Table 2 also presented the effect of storage time on FAC. The total amount of saturated and unsaturated fatty acids showed no significance after 10 months. However, the FAC of linoleic acid C18:2-6 decreased from 34.35% to 32.48% (A-RT), 32.94% (A-LT), 32.39% (V-RT), 33.13% (N-RT) after 10 months' storage. The proportion of oleic acid C18:1-9 increased from 43.96% to 47.02% (A-RT), 46.80% (A-LT), 47.34% (V-RT), 46.57% (N-RT). That of stearic acid C18:0 increased from 2.77% to 3.12% (A-RT), 3.05% (A-LT), 3.18% (V-RT), 3.09% (N-RT) after storage. It demonstrated that the peanut oil was oxidized during peanut storage. At the same time, palmitic acid C16:0 (from 11.27% to 10.93%, 10.77%, 10.95%, 10.87%), gadoleic acid C20:1-9 (from 1.12% to 0.80%, 0.91%, 0.73%, 0.77%), behenic acid C22:0 (from 2.97% to 2.66%, 2.64%, 2.55%, 2.69%) and lignoceric acid C24:0 (from 1.71% to 1.53%, 1.46%, 1.39%, 1.37%) all showed declined trend. This may be due to the decomposition of the nutrients in peanuts during storage.

4 Conclusion

This study demonstrated that drying conditions (solar radiation, 35°C, 40°C, 45°C, 50°C) had only a little impact on peanut quality during later storage. Peanut dried by solar radiation was more easily oxidized than that dried under other drying conditions. The PV and VE content of oil extracted from peanut being dried by solar radiation was significantly different with that of other drying conditions. The effect of storage time on peanut quality was more obvious than that of drying condition. Most indicators, GP, AV, PV, VE content and FAC, showed significantly changes along with storage. For storage conditions, low storage temperature performed best to keep peanut quality than controlled atmosphere storage and A-RT storage.

Fig. 5 Changes of (a) Acid value (b) Peroxide value (c) Iodine value (d) VE content of peanut kernels in four storage conditions, A-RT, A-LT, V-RT and N-RT after 10 months.

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