Comparative Study on the Physicochemical Characteristics and Fatty Acid Composition of Cashew Nuts and Other Three Tropical Fruits

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Abstract. In order to investigate the differences of three kinds of special fruits between cashew nut oil and macadamia nut oil in the aspects of physicochemical properties and fatty acid composition, the acid value, iodine value, peroxide value, saponification value, nonsaponification value, moisture and The volatile matter, pH, colour and fatty acid composition were compared. The results showed that the three oils had significant differences, and the macadamia had the highest oil content. The macadamia nut and cashew nut oil had a significant difference in oil yield. The price, iodine value, moisture and volatile matter content and colour difference were significant. The macadamia nut oil had the lowest acid value. The cashew nut oil had the highest iodine value and the lowest moisture and volatile matter content. The difference of the fatty acid composition of the three oils was that camellia seed oil contains α-linolenic acid, the cashew nut oil contains linoleic acid, and the macadamia nut oil contains lauric acid and myristic acid. This study identified the significant differences in oil content, extraction rate, physicochemical properties, fatty acid composition and relative content between the three oils, which provided basic data support for the development of functional products in the later period.

1. Introduction
Cashew nuts, macadamia nuts and camellia seed are important high-fat oil-like fruits in the tropical region of China. They have always been popular with everyone and occupy a large market in China. Cashew nuts belong to one of the world's four major dried fruits, mainly distributed in Côte d'Ivoire, Bissau, Vietnam, India, Cambodia, Hainan, China [1-5]; macadamia nuts are the "king of nuts", mainly distributed in Australia, Hawaii, USA China's Yunnan and other places; Camellia seeds are China's unique oil crops, mainly distributed in Hunan, Hubei, Guanxi, Guangdong and other places,
the extracted oil is known as "Chinese olive oil" [6-8]; these three tropical characteristics The most striking feature of fruit is that it is rich in fatty acids, especially the proportion of unsaturated fatty acids is very high. For this reason, it is widely used in daily chemical products, health foods, edible oils and other fields [9-12]. However, there are few comparative studies on the physicochemical properties and fatty acid properties. There is no relevant research to analyze its specificity, so the developed products are not targeted and the added value of the products is not high. Therefore, this study will be cashew nut oil, macadamia nut oil. The oil extraction rate, physicochemical properties and fatty acid composition of the three oils of Camellia oleifera oil are comparatively studied, and it is expected to find the highlight among them and provide basic data support for subsequent product development.

2. Materials and Methods

2.1. Experimental Materials

Camellia oleifera Abel Hubei Suizhou Yunwu Mountain Tea Farm, the water content of camellia seed kernel is 2.91%, crude fat is 49.50%; macadamia nut market water content is 1.24%, crude fat is 71.43%; cashew nut market the water content sold was 2.51% and the crude fat was 54.59%.

2.2. Oil extraction and oil extraction rate calculation

Weigh 80g of Camellia oleifera nuts, macadamia nuts and cashew nut kernels in 1000mL conical flasks respectively, add 640mL of n-hexane as extractant, according to the ratio of material to liquid 1:8, water bath temperature 60 °C, extraction time 1.5h The extraction is carried out, stirring is carried out from time to time during the leaching process, and the mixing of the n-hexane and the material is strengthened uniformly. After the extraction is completed, the mixture is cooled to room temperature, suction filtered, and then the solvent is separated by separation in a rotary evaporator to collect the crude oil, and then 10000 r The residue was further removed by centrifugation at /min, and the oil after centrifugation was stored in a refrigerator at 4 °C until use.

\[ \omega = \frac{m_2}{m_1(1-c_1)} \times 100\% \]

Where: \( \omega \) represents the extraction rate of oil and fat, %; \( m_1 \) represents the mass of the raw material, g; \( m_2 \) represents the mass of the fat obtained after the extraction, g; \( c_1 \) represents the water content of the raw material, %.

2.3. Determination of physical and chemical properties of fats

The crude fat is determined by the method of GB 2906-1982; the acid value is determined by the method of GB 5009.229-2016; the iodine value is determined by the method of GB/T 5532-2008; the moisture and its volatile matter are determined by the method of GB 5009.236-2016; the saponification value is referred to GB / Determination by T 5534-008 method; unsaponifiable matter is determined by reference to GB/T 5535.2-2008; colour determination is determined by the method described in [13].

2.4. Fatty acid analysis

2.4.1. Grease of oil and fat. Take 0.2–0.4 g of stored sample oil and dissolve it in 12 mL sample bottle, add 6.0–8.0 mL of n-hexane to mix, add 0.5 mL of sodium hydroxide-methanol solution, shake 20 s. After standing, the supernatant was taken, dried with a small amount of anhydrous sodium sulfate, and filtered through a 0.45 μm lipophilic membrane, and the filtrate was placed in a test bottle for GC-MS analysis.
2.4.2. Measurement. The content of free fatty acids in the sample was measured by gas chromatography-mass spectrometer (GC-MS QP2010 plus, Shimadzu, Japan). The chromatographic conditions and column were as follows: HP-88 elastic quartz capillary column (100 m × 0.25 mm, 0.25 μm); the temperature program is kept at an initial temperature of 150 °C for 2 min, at 2 °C/min to 210 °C, and at 50 °C/min to 250 °C for 10 min. The inlet temperature was 250 °C, the injection volume was 1 μL, the total flow rate was 35.6 mL/min, the carrier gas was N2, and the split ratio was 50:1.

2.5. Data processing and analysis
All the analysis data of the experiment were obtained from 3 repeated experiments, and the statistical analysis software SPSS 22 was used for statistical analysis of the data.

3. Results and discussion

3.1. Comparative analysis of fat content and yield of cashew nuts and other three tropical fruits
It can be seen from Table 1 that the nutrient content and extraction rate of macadamia nuts are the highest among the three tropical fruit varieties: cashew nut, macadamia nut and camellia seed kernel. The crude fat content of camellia seed kernel is the least, and the extraction rate of cashew nuts is the lowest. The difference of crude fat content between nuts was very significant. The extraction rate of oil from Camellia sinensis and Macadamia nuts was not significant. There was no correlation between crude fat content and extraction rate in the extraction method. The higher the content, the higher the extraction rate. The higher.

Table 1. Comparative analysis of fat content and yield of cashew nuts and other three tropical fruits

| Items                  | Camellia seed kernel | Macadamia nut kernel | Cashew kernel |
|------------------------|----------------------|----------------------|--------------|
| Fat content/%          | 49.50±0.00           | 69.88±2.19           | 54.17±0.59   |
| Oil extraction yield/% | 76.22±0.76           | 87.59±0.02           | 49.55±0.07   |

Note: different small letters indicate significant difference at 5% level, the same as below.

3.2. Comparative analysis of the physicochemical properties of cashew nuts and three other tropical fruits
It can be seen from Table 2 that the acid value, iodine value, moisture, volatile matter and color value of the oil extracted from the three tropical characteristic fruit nuts of cashew nuts are significantly different, and the difference in pH value and non-saponification value is not significant. There is a difference between the oxidation value and the saponification value. Acid price: Camellia seed oil > Cashew nut oil > Macadamia nut oil; Iodine price: cashew nut oil > Camellia seed oil > Macadamia nut oil; Peroxide value: Camellia seed oil > Cashew nut oil > Macadamia nut oil; Moisture and its volatiles: macadamia nut oil > camellia seed oil > cashew nut oil.

Table 2. Comparative analysis of fat content and yield of cashew nuts and other three tropical fruits

| Items                  | Camellia seed kernel | Macadamia nut kernel | Cashew kernel |
|------------------------|----------------------|----------------------|--------------|
| Acid value ((KOH)/(mg/g)) | 1.30±0.06           | 0.140±0.048          | 0.440±0.070  |
| Iodine value (g/100g)  | 79.04±0.00          | 69.0±0.70            | 82.0±0.00    |
| Peroxide value (m mol/kg) | 1.45±0.05          | 0.34±0.03            | 0.40±0.04    |
| Saponification value ((KOH)/(mg/g)) | 184.00±0.36          | 183.00±0.46          | 188.00±1.51  |
| Unsaponification value (%) | 0.387±0.040         | 0.226±0.119          | 0.216±0.068  |
| Moisture and volatile matter (%) | 6.300±0.014        | 7.895±0.148          | 3.040±0.042  |
3.3. Comparative analysis of fatty acid composition and relative content of cashew nuts and three other tropical fruits

It can be seen from Table 3, Figure 1, Figure 2 and Figure 3. The three oils are rich in unsaturated fatty acids, all containing palmitic acid, stearic acid and oleic acid, but the content of each component is different, and the oleic acid content is the most significant. Compared with the relative content of unsaturated fatty acids in the three, the macadamia nut oil was the least, which was consistent with the iodine price of Table 2. The unsaturated fatty acid content of camellia seed oil and cashew nut oil did not differ much. From the characteristic components, camellia seed oil contains a-linolenic acid, macadamia nut oil contains lauric acid, myristic acid oil, cashew nut oil contains linoleic acid, and is very rich.

Table 3. Comparative analysis of fatty acid composition and relative content of cashew nuts and three other tropical fruits

| Number | Fatty acids species | Camellia seed kernel (%) | Macadamia nut kernel (%) | Cashew kernel (%) |
|--------|---------------------|--------------------------|--------------------------|-------------------|
| 1      | Lauric acid         | -                        | 0.02                     | -                 |
| 2      | Nutmeg acid (C14:0) | -                        | 0.41                     | -                 |
| 3      | Palmitic acid (C16:1Δ7) | 7.25                | 7.93                     | 8.39              |
| 4      | Palmitoleic acid (C16:1Δ7) | 0.08               | 0.08                     | -                 |
| 5      | Stearic acid (C18:0) | 2.34                    | 4.66                     | 9.70              |
| 6      | Oleic acid (C18:1Δ9) | 78.43                   | 59.49                    | 59.32             |
| 7      | Linoleic acid(C18:2Δ9,12) | -                     | -                        | 19.68             |
| 8      | α-linolenic acid (C18:3Δ9,12,15) | 0.05              | -                        | -                 |
| 9      | Arachidic acid (C20:0) | -                       | 4.36                     | 0.94              |
| 10     | Behenic acid (C22:0) | -                       | 1.47                     | 0.22              |
| 11     | Lignoceric acid (C24:0) | -                       | 0.62                     | 0.57              |

- Not detected
Figure 1. GC-MS spectrum of camellia seed oil.

Figure 2. GC-MS spectrum of macadamia nut oil.

Figure 3. GC-MS spectrum of cashew nut oil.

4. Conclusion
In order to compare the differences of three tropical characteristic fruit oils, such as cashew nut oil, macadamia nut oil and camellia seed oil, detailed analysis was carried out from the aspects of oil content, extraction rate, physicochemical properties and fatty acid composition. (1) The oil content and
extraction rate of the three oils are significantly different. The oil extraction rate is not directly proportional to the oil content. It is related to the structure of the pulp and the physical and chemical properties of the oil. Different fruits should choose the best. Extraction method [14-18]. (2) The physical and chemical properties of oils and fats directly affect the processing characteristics [19-20], storage stability [21-23], such as high iodine value, high degree of unsaturation; low acid value, low peroxide value, storage stability Good; high saponification value, shorter fatty acid carbon chain, strong permeability and so on. The results of comparative analysis showed that the macadamia oil had the lowest acid value, the lowest peroxide value and the best storage stability. The cashew nut oil had the highest iodine value, the highest degree of unsaturation, the highest saponification value and the short fatty acid carbon chain. The permeation performance is good; compared with the above two kinds of oils, the oil tea seed oil has high acid value, high peroxide value and relatively poor storage performance, and the storage condition is higher. (3) The fatty acid composition and degree of unsaturation of oil directly affect its eating quality and functional characteristics [24-27]. This comparative study found the difference between the three oils. From the analysis of characteristic components, camellia seed oil contains a-linolenic acid, macadamia nut oil contains lauric acid, myristic acid oil, cashew nut oil contains linoleic acid, and is very rich, so various oils have their own characteristics, due to these Special components give it special application effects, such as the unique a-linolenic acid in camellia seed oil. It is recognized by the world nutrition community that if infants and young children lack linolenic acid, it will seriously affect their intellectual development. Macadamia oil contains a characteristic nutrient acid, which is widely used in cosmetics to provide a good moisturizing and moisturizing effect. Cashew nut oil contains a special linoleic acid, which is not synthesized by the human body or synthesized very little. It is an essential fatty acid, which can lower blood cholesterol and prevent atherosclerosis [28-29]. According to the above characteristics, it is therefore possible to develop related functional products according to different component characteristics.

Acknowledgments
This work was supported by the Central Public-interest Scientific Institution Basal Research Fund for Chinese Academy of Tropical Agricultural Sciences (No.1630122017014, 1630122019008) and “the Belt and Road” The joint evaluation of the investigation and exploitation of agricultural resources in tropical countries (ZYLH2018010412).

References
[1] Marisa, M., Wall, W. Functional lipid characteristics, oxidative stability, and antioxidant activity of macadamia nut (Macadamia integrifolia) cultivars [J]. Food Chemistry, 2010, 121(4):1103-1108.
[2] Fukshima, S., Kindou, M., Ihn.H. Fixed food eruption caused by cashew nut [J]. Allergology international: official journal of the Japanese Society of Allergology, 2008, 57(3):285-287.
[3] He, B. Nigeria: It is proposed to increase the export of cashew nuts to stimulate economic growth [J]. China Fruit Industry Information, 2017, 34 (12): 37.
[4] Liu, Y.J., Zhu D.M., Huang M.F. Research Progress in the Utilization of Cashew Nuts [J]. Agricultural Products Processing, 2013, (22): 43-45.
[5] Zheng, S.J. Côte d'Ivoire has become a major exporter of cashew nuts in the world [J]. World Tropical Agriculture Information, 2014, (12): 25.
[6] Lei, J.B. Promoting the Development of Camellia Industry with Brand Construction [J]. Crop Research, 2018, 32(S1): 50-52.
[7] Sun, Z., Xue, Y., Zhang L. et al. Countermeasures for the development of multifunctional oil tea industry [J]. Forestry Science and Technology Communication, 2018, (09): 70-72.
[8] Yang, J.W. Green Processing Technology of Camellia Seeds [J]. Modern Food, 2018, (18): 146-147.
[9] Chen, H.A., Luo, Z.B., Feng, X.Y. et al. Progress in fatty acid content, analytical detection and molecular biology of Camellia oleifera seed oil[J]. Food Industry Science and Technology: 1-10.

[10] Wang, Z.Y., Nie, W., He, Y.C. et al. Research progress on extraction technology and active constituents of Camellia oleifera seed oil [J]. Journal of Southern Forestry Science, 2018, 46(05): 20-23.

[11] Xu, X.F., Yan, H., Zhang, Y. et al. Research progress on extraction and activity of three main components in Camellia oleifera seeds [J]. Packaging & Food Machinery, 2018, 36(04): 44-48.

[12] Miyasguta, T, Koizumi, R., Sagane, Y.et al., Safety data on single application of emu and macadamia nut oil on human skin[J]. Data in brief, 2017, 15:720-723.

[13] Liu, Y.J, Zhu, D.M, Huang, H. et al. Multi-scale Analysis of Cashew Cooking Quality [J]. Food and Machinery, 2014, 30(05):57-60.

[14] Fan, X.B. Study on extraction process of macadamia oil-water agent method [J]. China Oils and Fats, 2016, 41(06):15-18.

[15] Ge, H.L., Peng, L., Meng, X.H. et al. Comparison of quality of camellia oil obtained by different extraction methods [J]. Journal of Zhejiang Agricultural Sciences, 2017, 29(07):1195-1200.

[16] Liu, R.L., Yu P., Chen G.N. et al. Optimization of Ultrasonic-Microwave Synergetic Extraction of Macadamia Oil by Response Surface Methodology [J]. Northwest Pharmaceutical Journal, 2017, 32(06):718-722.

[17] Xu, L. Purification of Australian nut oil and defatted powder polysaccharide by subcritical butane extraction [D]. Jinan University, 2015.

[18] Zhong, J.Y., Deng R.Y, Hu, X.T. et al. Study on Process Conditions of Extracting Cashew Oil by Aqueous Method[J]. Journal of the Chinese Cereals and Oils Association, 2016, 31(01):31-35.

[19] Guo, Q.H. Changes in physical and chemical properties and nutritional quality of tea seeds during frying [D]. Hefei University of Technology, 2017.

[20] Ji, Y.Y. Study on quality change and oxidation stability of palm oil during hot processing [D]. Hainan University, 2017.

[21] Luo, W.,Zhang, Y.Z., Du X.L. et al. Influencing factors and control points of oil quality changes in vegetable oil storage process[J]. China Oils and Fats, 2016, 41(12):85-87.

[22] Pu, C.W., Yan, H., Liu, Y. Analysis of the Changes of Walnut and Its Oil Quality under Different Storage Conditions [J]. Chinese oils, 2018, 43(02):46-50.

[23] Tang, R.L. Study on Storage Stability and Prediction of Soybean Oil [D]. Nanjing University of Finance and Economics, 2016.

[24] Hristov, A.N. SUN, W. Effects of lauric acid and myristic acid on rumen fermentation, fermentation products and fatty acid composition of lactating dairy cows [J]. Chinese Journal of Animal Husbandry and Veterinary Medicine, 2011, 38(05):236.

[25] Guo, L.Q. Regulation of oleic acid on the expression of adiponectin in 3T3-L1 adipocytes and CDK5/PPARγ-mediated mechanism [D]. Southern Medical University, 2017.

[26] Jin, L., Wang, L.Z. Anti-inflammatory mechanism of conjugated linoleic acid and its progress in the regulation of inflammatory diseases [J]. Agricultural Science Research, 2018, 39(04): 58-63.DOI: 10.13907/j.cnki.nyxxj.2018.04 .007.

[27] Sun, H., Wang, S., Rong, R.F. Research Progress of Functional Lipids-Functional and Application of Conjugated Linoleic Acid [J]. Bioprocessing, 2016, 14(06):77-81.

[28] Wu, Q.Z., Du, B., Cai, Y.L. et al. Progress in physiological function and development of α-linolenic acid [J]. Food Industry Science and Technology, 2016, 37(10):386-390.

[29] Yao, Z., Hu, C.X., Li, X.P. Effects of oleic acid on the function and morphology of vascular endothelial cells [J]. Acta Agronomica Sinica, 2017, 39(06):574-578.