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# Nutritional composition of the kernels from *Canarium album* L.

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**Abstract**

The kernels from *Canarium album* L. (also called Chinese olive), largely cultivated in the southeast of China, were analyzed for their nutritional composition. The kernels had a high percentage of fats (52.8%) and proteins (29.5%). Soxhlet extracted kernel oil presented acid, iodine and saponification values of 0.56, 84.6 and 192, respectively. Gas chromatography–mass spectroscopy (GC–MS) analysis of kernel oil revealed that oleic acid (30.5%) and linoleic acid (41.8%) were the major unsaturated fatty acids, while palmitic acid (18.0%), stearic acid (7.83%) and arachidic acid (0.39%) were the main saturated ones. Potassium, calcium and magnesium were the predominant mineral elements present in the kernels. Sodium, iron, manganese and zinc were also detected in appreciable amounts. The kernel proteins were rich in arginine, glutamic and aspartic acids (3.19%, 5.02% and 2.47%, respectively) while the limiting amino acids were methionine and lysine.
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*Keywords:* *Canarium album* L.; Kernel; Oil; Amino acids; Fatty acids; Minerals

## 1. Introduction

*Canarium album* L. or Chinese olive (normally called Gan lan, Qing guo in China) is a fruit tree belonging to the Burseraceae family. It is indigenous to the southeast area of China and has been introduced to other Asian tropical and semi-tropical regions. *C. album* trees have a wide range of adaptability and are very robust. They can withstand temperatures below 6–7 °C in the winter as well as long periods of drought in the summer, with temperatures of about 40 °C. These trees can grow on poor soils and rocky hillsides, and can tolerate saline or alkaline soils and those with high lime content (Wei, Peng, & Mao, 1999).

*C. album* fruit is a drupe, similar to the Mediterranean olive (*Olea europaea* L.) and other drupes of stoned fruits, such as apricots or cherries, and with the same anatomy. Its main parts are the epicarp or epidermis, the mesocarp or flesh and the endocarp or pit, which consists of a fusiform woody shell enclosing three kernels. Like its Mediterranean counterpart, olive, the *C. album* fruit flesh has the organoleptic characteristics of strong bitter and astringent tastes. The natural bitterness and astringency of the fruit can be eliminated, or at least reduced, by processing to make it acceptable as food or as an appetizer (Yuan, Liu, & Tang, 2001).

*C. album* dried fruit is also a traditional medicine material which has some pharmacological functions, such as anti-bacterium, anti-virus, anti-inflammation and detoxification, in China (Ding, 1999). Some fresh fruits are edible and, unlike their counterparts, Mediterranean olives, the *C. album* fruits have relatively low oil contents, and most of them are generally processed in food industry to beverage, candy and confections, while the kernels are normally treated as waste products and largely discarded (Ssonko & Xia, 2005). Recent studies have shown that many fruit kernels or seeds are very nutritious and could find industrial application as food and animal feeds. They also contain high amounts of various oils and can be used as raw materials

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for cosmetics and paint formulation. To our knowledge, no reports exist on chemical composition of *C. album* kernels. The aim of the present study is to determine the nutritional composition of kernels from *C. album* L. and investigate the possibility of their application in human and/or animal consumption.

## 2. Materials and methods

### 2.1. Kernels

Mature kernel samples of *C. album* were obtained from plants that grow widely in Fujian province of southeastern China. The kernels were ground into 40-mesh (Chinese Standard Screen) small particles, using a household flour-mill (Tianjin, China).

### 2.2. Proximate analysis

Moisture, protein, fat, ash and carbohydrate contents of kernels were analyzed according to the methods of the Association of Official Analytical Chemists (AOAC, 1990).

### 2.3. Physicochemical properties of kernel oil

The oil was extracted from *C. album* kernels in a Soxhlet extractor, using petroleum ether (30–60 °C) as a solvent. The solvent-extracted meal was stored at 4 °C for later amino acid determination. Specific gravity and refractive index were determined at room temperature by using a specific gravity bottle and refractometer, respectively. For the determination of acid, iodine and saponification values, the methods of the Association of Official Analytical Chemists were used (AOAC, 1990). Three different samples of oil were analyzed in duplicate.

### 2.4. Fatty acid analysis

Fatty acids were transformed to their methyl esters (FAME), following the method of Hartman and Lago (1973), and were determined by using a gas chromatograph Trace Series (PEG20M) equipped with a flame ionisation detector; 1.5 μl of the FAME sample were injected and GC separation was carried out on a capillary column (PEG20M; 30 m × 0.25 mm × 0.25 μm). The carrier gas was nitrogen and the column flow rate was 0.8 ml/min. The oven temperature was held initially at 180 °C for 1 min, increased from 180 °C at 3 °C/min to 240 °C and then maintained at 240 °C for 10 min. The temperatures of the injection port and detector were 250 °C and 260 °C, respectively. FAME were positively identified by matching their retention time data and mass spectra with those of the standards from Sigma. The fatty acid composition was calculated from the total identified fatty acid area and the values were averages of at least two to three injections.

### 2.5. Amino acid analysis

The solvent-extracted seed meal was used for the determination of amino acids in an amino acid analyzer (Agilent 1100, USA). A sample (100 mg) was taken in an ampoule and hydrolysis was carried out using 5 ml of 6 M HCl at 110 °C for 24 h, except for tryptophan analysis, using 5 ml of 6 M NaOH separately. Filtered hydrolyzate was dried in a vacuum desiccator and redissolved in 0.1 M HCl containing sarcosine and norvaline as internal standards. One microliter of the solution was injected directly into an amino acid analyzer with reverse phase column (4 × 125 mm) $C_{18}$ at 40 °C and a UV detector at 338 nm and a fluorescence detector at 450 nm, using (a) 20 mM sodium acetate buffer, pH 7.2, containing 0.018% triethylamine and 0.3% tetrahydrofuran and (b) 100 mM sodium acetate buffer, pH 7.2 containing 40% acetonitrile and 40% methanol, both of HPLC grades. Double pre-derivatization of the amino acids was achieved by reacting with orthophtaldialdehyde (OPA), except for proline which was derivatized with 9-fluorenylmethyl chloroformate (FMOC). The carrier gas was maintained at a flow rate of 1.0 ml/min in a gradient of buffer a to buffer b. The identification of the amino acids in the samples was carried out by comparing their retention times with those of the standards from Sigma.

### 2.6. Mineral elements analysis

For the determination of mineral elements (potassium, magnesium, calcium, iron, zinc, copper, sodium and manganese), samples were digested by dry-ashing and dissolved in 1 M HCl (AOAC, 1990). The concentrations of the elements were determined with a flame atomic absorption spectrophotometer (Perkin–Elmer, model 2380).

## 3. Results and discussion

### 3.1. Proximate composition

The results of proximate analysis of *C. album* kernels are presented in Table 1. The kernels had high percentage of fat (52.8%) and protein (29.5%); which were much higher than those in melon (*Cucumis melo*) seeds (Maria, Bora, & Narendra Narain, 2001), Nigerian palm (*Elaeis guineensis*) kernels (Akpanabiatu, Ekpa, Mauro, & Rizzo, 2001), and legume (*Phaseolus angularis*) seeds (Chau, Cheung, &

Table 1
Proximate composition of *Canarium album* L. kernel (g/100 g dry weight basis)

| Components | Content[a] |
|---|---|
| Protein | 29.5 ± 0.9 |
| Crude fat | 52.8 ± 0.4 |
| Ash | 4.9 ± 0.08 |
| Total carbohydrate | 0.2 ± 0.03 |
| Moisture | 5.2 ± 0.1 |

[a] Means of three determinations ±SD.

Wong, 1998), and this value showed that the kernels had great potential as a new oil resource. The average contents of ash, carbohydrate and moisture in *C. album* kernels were 4.9%, 0.2% and 5.2%, respectively.

### 3.2. Physicochemical properties of kernel oil

Physicochemical properties of extracted kernel oil are shown in Table 2. The oil presented a specific gravity of 0.9126 and a refractive index of 1.4729, which were slightly higher than the corresponding values of Mediterranean olive oil reported by Mariette (1997). The saponification value of the kernel oil was 192, comparable to the value (189) of olive oil, while the iodine value (84.6) was lower than the corresponding values (88) of olive oil reported by Mariette (1997). The freshly extracted oil had a very low acid value (0.56) and a peroxide value of 3.5.

### 3.3. Fatty acid composition of kernel oil

The fatty acid composition of *C. album* L. kernel oil is given in Table 3. The results showed that two major acids (oleic and linoleic acids) accounted for more than 70% of the total fatty acids. *C. album* L. kernel oil was rich in unsaturated fatty acids, of which mono-unsaturated and poly-unsaturated fatty acids represented 31.1% and 42.1% of the total fatty acids, respectively. Linoleic and oleic acids accounted for 41.8% and 30.5% of the total fatty acids and they were significantly different from the linoleic acid value (7.8%) and oleic acid value (75.5%) in Mediterranean olive oil (Mariette, 1997). In this study, saturated fatty acids accounted for 26% of total fatty acids. The main saturated fatty acids were palmitic acid (18%), stearic acid (7.8%) and arachidic acid (0.39%). Odd-chain fatty acids, such as pentadecanoic ($C_{15:0}$) and heptadecanoic acid ($C_{17:0}$) were also present in very small concentrations.

Table 2
Physicochemical properties of *Canarium album* L. kernel oil

| Physicochemical properties | Value[a] |
|---|---|
| Specific gravity | 0.9126 ± 0.0018 |
| Refractive index | 1.4729 ± 0.0024 |
| Acid value | 0.56 ± 0.07 |
| Iodine value | 84.6 ± 0.63 |
| Saponification value | 192 ± 0.81 |
| Peroxide value | 3.5 ± 0.09 |

[a] Means of three determinations ±SD.

Table 3
Fatty acid composition of *Canarium album* L. kernel oil

| Fatty acid | Value[a] (% total fatty acids) |
|---|---|
| Myristic acid ($C_{14:0}$) | 0.05 ± 0.006 |
| Pentadecanoic acid ($C_{15:0}$) | Tr[b] |
| Palmitic acid ($C_{16:0}$) | 18.0 ± 0.06 |
| Palmitoleic acid ($C_{16:1}$) | 0.32 ± 0.04 |
| Hexadecadienoic acid ($C_{16:2}$) | 0.20 ± 0.01 |
| Heptadecanoic acid ($C_{17:0}$) | 0.11 ± 0.01 |
| Stearic acid ($C_{18:0}$) | 7.83 ± 0.02 |
| Oleic acid ($C_{18:1}$) | 30.5 ± 0.16 |
| Linoleic acid ($C_{18:2}$) | 41.8 ± 0.08 |
| Linolenic acid ($C_{18:3}$) | 0.21 ± 0.01 |
| Arachidic acid ($C_{20:0}$) | 0.39 ± 0.05 |
| Eicosenoic acid ($C_{20:1}$) | 0.29 ± 0.01 |
| Behenic acid ($C_{22:0}$) | 0.13 ± 0.07 |

[a] Means of three determinations ±SD.
[b] Tr, trace (⩽0.01%).

### 3.4. Amino acid composition

The amino acid profile of protein in *C. album* L. kernels is shown in Table 4. Eighteen amino acids were detected in *C. album* L. kernels, including eight essential amino acids, namely methionine, isoleucine, leucine, lysine, threonine, phenylalanine, valine and tryptophan and 10 non-essential amino acids. Like other oil seed proteins, the *C. album* kernel protein was also rich in arginine, glutamic and aspartic acids (3.19%, 5.02% and 2.47%, respectively), and these three amino acids constituted 41.9% of the total amino acids. Table 4 shows that essential amino acids were present in lower concentrations, of which the methionine and lysine (0.71% and 0.72%, respectively) were found to be the first and second limiting amino acids in comparison with the essential amino acids profile of FAO (1981) reference protein. The ratios of essential amino acids to total amino acids and essential amino acids to non-essential amino acids were 0.34 and 0.52, respectively, and they were very close to the ideal ratios (0.4 and 0.6, respectively) suggested by FAO/WHO (1973).

### 3.5. Mineral content

The mineral profile of *C. album* L. kernel is shown in Table 5. Potassium was the most abundant, with the

Table 4
Amino acid content of *Canarium album* L. kernel

| Amino acid | Content[a] (%) |
|---|---|
| *Essential* | |
| Isoleucine | 1.05 ± 0.10 |
| Leucine | 1.87 ± 0.03 |
| Lysine | 0.72 ± 0.01 |
| Methionine | 0.71 ± 0.05 |
| Phenylalanine | 1.24 ± 0.13 |
| Threonine | 0.83 ± 0.07 |
| Valine | 1.30 ± 0.08 |
| Tryptophan | 1.18 ± 0.04 |
| *Non-essential* | |
| Alanine | 0.96 ± 0.02 |
| Arginine | 3.19 ± 0.14 |
| Aspartic acid | 2.47 ± 0.11 |
| Cystine | 0.52 ± 0.02 |
| Glutamic acid | 5.02 ± 0.22 |
| Glycine | 1.25 ± 0.09 |
| Histidine | 0.61 ± 0.06 |
| Proline | 1.16 ± 0.11 |
| Serine | 1.10 ± 0.10 |
| Tyrosine | 0.83 ± 0.01 |

[a] Means of three determinations ±SD.

Table 5
Mineral content of *Canarium album* L. kernel

| Mineral | Content[a] (mg/100 g) |
|---|---|
| K | 587 ± 3.4 |
| Ca | 226 ± 1.8 |
| Na | 40.1 ± 1.4 |
| Mg | 186 ± 2.7 |
| Fe | 12.4 ± 0.3 |
| Mn | 2.5 ± 0.4 |
| Zn | 1.8 ± 0.2 |
| Cu | 0.9 ± 0.1 |

[a] Means of three determinations ±SD.

content of 587 mg/100 g, followed by calcium and magnesium with values of 226 mg/100 g and 186 mg/100 g, respectively. The calcium level seemed to be fairly high compared with other plant seeds (kernels) such as *Pinus pinea* L., *Elaeis guineensis*, *Phaseolus aureus* and *Canavalia gladiata* (Akpanabiatu et al., 2001; Cevdet & Iclal, 2004; Mubarak, 2005; Sagarika Eknayakea, Jansz, & Naira, 1999). Table 5 reveals that sodium and iron were present in moderate amount (40.1 and 12.4 mg/100 g, respectively), while manganese, zinc and copper levels were low (2.5, 1.8 and 0.9 mg/100 g, respectively).

## 4. Conclusions

No detailed studies on the chemical composition of *C. album* L. kernels have been previously reported. The above analytical data revealed that *C. album* L. kernels had relatively high protein, fat, potassium and calcium contents. The kernel proteins were rich in essential amino acids and therefore had a high nutritional value. The kernel oils of *C. album* L. were rich in oleic and linoleic acids, which have a beneficial effect on blood lipids by lowering blood pressure and serum cholesterol. The results showed that *C. album* L. kernels had great potential for use as food and/or feed resources.

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