J Am Oil Chem Soc (2007) 84:1079–1080
DOI 10.1007/s11746-007-1131-8

LETTER TO THE EDITOR

# Stereospecific Analysis of Fatty Acid Composition of Chufa (*Cyperus esculentus* L.) Tuber Oil

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Received: 2 July 2007 / Revised: 23 August 2007 / Accepted: 30 August 2007 / Published online: 15 September 2007


Sir,

Chufa (*Cyperus esculentus* L.) is a sedge-like plant known as earth almond, nut grass, or yellow nut sedge. The chufa tuber is regarded as a novel food lipid resource due to its substantial oil content, almond-like flavor, and ease of cultivation [1, 2]. Chufa tubers contain 17–25% oil on a dry weight basis. Some of the physicochemical characteristics of chufa tuber oil are similar to those of olive oil. Chufa tuber oil could be a potential new source of stable edible oil. The fatty acid composition of the triacylglycerols and the polar lipids of chufa tuber oil have been reported elsewhere, and oleic acid was the major fatty acid reported in both lipid classes [3, 4].

The chemical, physical and biological characteristics of lipids are largely dependent upon the composition and positional distribution of fatty acids on the glycerol backbone, thus the stereospecific analysis of fatty acids in the triacylglycerol was considered important for use of the lipid for both dietary and industrial purposes [5, 6]. It has been reported that the major fatty acid present at the sn-2 position of triacylglycerols of chufa tuber oil was oleic acid, similar to olive oil, although no information was available regarding the fatty acid composition of chufa tuber oil at the sn-1 and sn-3 positions [1].

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We determined the positional fatty acid distribution of chufa tuber at stereospecific positions; the sn-1, sn-2, and sn-3 positions in the triacylglycerols of chufa tuber oil.

Chufa tubers were washed with water, and oven dried to a moisture content of 20%. The total lipid (TL) was extracted in a Soxhlet apparatus using a mixture of chloroform and methanol at 40 °C. The total lipid extracted was dissolved in chloroform and separated into neutral lipids (NL), glycolipids (GL) and phospholipids (PL) using silicic acid column chromatography [7]. Stereospecific analysis of chufa oil was carried out using pancreatic lipase, phospholipase $A_2$, TLC and GC [8]. The fatty acid composition was determined using gas chromatography [9]. The fatty composition at the sn-3 position was calculated based on the equation, $3 \times$ [TG]–[sn-1 + sn-2 position].

The total lipid content of the chufa tuber was 17.6% on a dry weight basis. The neutral lipid (90% of the total) was the main lipid component in the chufa tuber oil, while glycolipid and phospholipid were present at 6.9 and 3.1%, respectively. The major fatty acids of the chufa tuber oil were identified as oleic (65.6%), linoleic (16.2%), palmitic (15.4%), and stearic (2.2%) acids in decreasing order (Table 1), while the minor acids were linolenic and palmitoleic. The oleic acid content of chufa tuber oil is much greater than that of most other vegetable oils, such as sunflower oil (23.6%), soybean oil (24.9%), or corn oil (23.8%), but comparable to that of olive oil [10–13]. Chufa tuber oil with its high percentage of oleic acid, should be relatively stable and resistant to oxidation [1, 3].

The fatty acid composition of the NL fraction was similar to the TL; however, the concentrations were slightly different. The NL contained slightly more oleic acid and slightly less palmitic and linoleic acid. The GL contained more palmitic, linoleic, and linolenic acid and

**Table 1** Fatty acid composition of chufa tuber lipids

| | Relative content (%) | | | | | |
|---|---|---|---|---|---|---|
| | $C_{16:0}$ | $C_{16:1}$ | $C_{18:0}$ | $C_{18:1}$ | $C_{18:2}$ | $C_{18:3}$ |
| Total lipid | 15.4 | 0.2 | 2.2 | 65.5 | 16.2 | 0.5 |
| Neutral lipid | 14.6 | 0.1 | 2.3 | 68.3 | 14.4 | 0.3 |
| Glycolipid | 20.4 | – | 2.1 | 58.3 | 18.5 | 0.7 |
| Phospholipid | 24.3 | – | – | 53.4 | 22.3 | – |

**Table 2** Positional fatty acid distribution of chufa tuber oil

| Oil | sn-position | Relative content (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | $C_{16:0}$ | $C_{16:1}$ | $C_{18:0}$ | $C_{18:1}$ | $C_{18:2}$ | $C_{18:3}$ |
| Chufa tuber | 1 | 12.8 | – | 3.3 | 60.4 | 23.5 | – |
| | 2 | 0.9 | 0.1 | 0.2 | 75.1 | 23.1 | 0.6 |
| | 3 | 32.6 | 0.4 | 3.1 | 61.1 | 1.9 | 0.9 |
| Olive[a] | 1 | 13.1 | 0.9 | 2.6 | 71.8 | 9.8 | 0.6 |
| | 2 | 1.4 | 0.7 | – | 82.9 | 14.0 | 0.8 |
| | 3 | 16.9 | 0.8 | 4.2 | 73.9 | 5.1 | 1.3 |

[a] Reference [13]

had less oleic acid than the NL. Fatty acids associated with sugar moieties are very unsaturated in higher plant chloroplasts [14]. The PL fraction contained greater amounts of palmitic and linoleic acid and lower amounts of stearic, oleic, and linolenic acid compared to the other lipid classes in chufa tuber oil.

The positional fatty acid distribution of chufa tuber oil is shown in Table 2. Oleic acid was the major fatty acid in the sn-1 and sn-2 positions. The percentage composition of fatty acids in the sn-1 and sn-2 positions was nearly the same as that of the total fatty acid composition; however, the concentration was slightly different. Oleic acid was also the main fatty acid in the sn-3 position followed by palmitic, stearic, linoleic, linolenic, and palmitoleic acid. This differed from others who reported that the fatty acids located at the sn-3 position was highly influenced by their respective concentration in the total fatty acids at the other positions [8, 15, 16]. Palmitic acid and stearic acid were distributed primarily in the sn-1 and sn-3 positions, while oleic acid and linoleic acid were found in greater amounts at the sn-2 position. In most vegetable oils, unsaturated fatty acids occupy the sn-2 position and saturated fatty acids are located in the sn-1 and sn-3 positions. The preponderance of linoleic acid at the sn-2 position is well known in vegetable oils [5, 8, 16]. The distribution of fatty acids between sn-1 and sn-3 position was nearly symmetrical for palmitic acid, stearic acid, and oleic acid, which is in agreement with Brockerhoff and Yurkowski [8]. Palmitoleic acid and linolenic acid were primarily associated with the sn-3 position, with undetectable amounts in the sn-1 position.

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