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NUTRITIONAL COMPOSITION AND OIL FATTY ACIDS OF KUNDUR [*BENINCASA HISPIDA* (THUNB.) COGN.] SEED

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Abstract

The seeds from Kundur [*Benincasa hispida* (Thunb.) Cogn.], a fruit vegetable plant with high functional properties (especially in medicinal treatment), were analysed for nutritive parameters (dietary fiber, crude protein, crude fat, crude fiber, ash, and energy) and oil fatty acids composition. Proximate analysis of the seeds revealed the total dietary fiber as the principal component, comprising 58.43% of the seed. The contents of crude fat and crude protein were found to be 20.70 and 11.63%, respectively. The extracted Kundur seed oil mainly consisted of linoleic acid (C18:2 ω6), accounting for 67.37% of the total fatty acids. Other important fatty acid detected were palmitic (C16:0), oleic (C18:1 *cis*) and stearic (C18:0) acids with contribution of 17.11, 10.21 and 4.83%, respectively. The fatty acids profile of the tested Kundur seed oil was quite comparable to those of previously reported cucurbitaceae seed oils and some other wholesome oils, revealing that it can be used as a potential seed oil crop.

Introduction

Cucurbitaceae (Cucurbit) is an important family comprising one of the most genetically diverse groups of food plants. Most of the plants belonging to this family are frost sensitive and drought-tolerant (Whitaker & Bohn, 1950). Some important Cucurbit family members include; gourd, melon, cucumber, squash and pumpkin (Robinson & Decker-Walters, 1999). These are indigenous to both arid and temperate regions of the earth and require long periods of warm, dry weather for their optimal growth (Whitaker & Davis, 1962). The fruits from Cucurbitaceae species are valued for nutritional and medicinal purposes (Jeffrey, 1990). The remaining portion of the Cucurbit fruits, especially the seed (often discarded as agrowaste), can be utilized for other food applications such as preservative, and also in animal feed and oil extraction, contributing to less waste disposal and value-addition.

The uses of cucurbit seeds as potential sources of oils have been reviewed by Jacks *et al.,* (1972) who reported that the dehulled seeds contain about 50% of oil. The high content of oil, showing useful characteristics such as odorlessness, and good colour and appearance, make these seeds suitable for oil industrial applications (Al-Khalifa, 1996; Mariod *et al.,* 2009). Cucurbit seed oils mainly consist of palmitic (16:0), stearic (18:0), oleic (18:1 n-9), and linoleic (18:2 n-6 or ω-6) acids. Due to high amounts of polyunsaturated fatty acids, these oils have favorable nutritional status and beneficial physiological effects towards prevention of coronary heart disease and cancer (Yehuda *et al*., 2005).

Benincasa hispida (Thunb.) Cogn. (synonym; *Benincasa cerifera*) is one of the most valuable plants in Cucurbit family. It is also known as Kundur (Malay), ash gourd or winter melon (English), *Bhuru Kolu* or *Safed Kolu* (Gujarati), *Petha* (Hindi), *Kushmanda* (Sanskrit), *Dōngguā* (Chinese) and *Beligo* (Indonesian). Martin (1984) claimed that Kundur fruit seed is the best of cucurbits as the source of seed oil for the hot and humid tropics.

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Thus, preliminary consideration of Kundur fruit seeds as source of vegetable oil will not only add value to these agricultural crops, nevertheless it will also increase the number of sources of vegetable oils, available. However, little work has been reported on the nutritional composition of Kundur fruit seed, and especially on fatty acids profile of its oil. Therefore, the main objective of the present study was to evaluate the nutritional composition and oil fatty acids of Kundur seeds as potential source of valuable oil for commercial applications.

Materials and Methods

Seeds: Kundur (*Benincasa hispida*) fruits were harvested from the vicinity of Temerloh, Pahang, Malaysia in July 2009. Seeds were separated manually from fruits, and fibrous materials, then washed with tap water and oven-dried at 40 ^{o}C.

Proximate analysis: The seeds were analyzed for crude protein, ash, crude fat and crude fiber according to the AOAC Official Method (Anon., 2000), 920.152, 930.05, 948.22, and 935.53, respectively. Carbohydrate contents were determined by difference [100 – (crude protein + crude fat + ash + total dietary fiber)]. All analyses were carried out in triplicate. Energy levels were calculated by multiplying protein and carbohydrate contents by a factor of 4 and fat by 9 (Weber e*t al*., 1996).

Total dietary fiber content: Total fiber content was determined according to the AOAC Official Method 993.21 (Anon., 2000).

Lipid extraction: The seeds were ground into powder using mortar and pestle. The material that passed through 80-mesh sieve was used for lipid extraction purposes. The powdered seed were extracted with 200 mL petroleum ether using Soxhlet apparatus for 6 h using water bath (Anon., 2000). The solvent was evaporated, and the lipid fraction residues were weighed (Yaniv *et al*., 1999).

Fatty acid methyl esters (FAMEs) preparation and gas chromatographic analysis: Kundur seed oil (50 µL) was solubilized in 950 µL of hexane and was esterified using sodium methoxide (Christie, 1993). The fatty acid composition was analyzed by GC (Hewlett-Packard 6890) equipped with a flame ionization detector (FID) and a fused silica capillary BPX-70 column (60 m × 0.32 mm; 0.25 µm film thickness). The oven temperature was set at 115 ^{o}C, raised to 180 ^{o}C @ 8 ^{o}C/min and held for 10 min. The temperature was finally raised to 240 ^{o}C @ 8 ^{o}C/min, and held for 10 min. A sample volume of 1 µL was injected using splitless injection mode. The carrier gas used was helium at a flow rate of 1.6 mL/min. Identification of the unknown FAMEs was made by comparison of their retention times with those of pure standards of FAMEs (Ariffin *et al*., 2009). The fatty acids composition was reported as relative percentage of the total peak area.

Statistical analysis: Two different Kundur fruit seed samples were assayed. Each sample was analyzed individually in triplicate. Data were reported as mean ± standard deviation (SD) for n = 2 x 3 = 6

Results and Discussion

Quality and proximate composition of seeds: The quality of cucurbitaceae seeds depend on harvesting the fruit at proper stages of maturity and also the storage conditions (Murugesan & Vanangamudi, 2005). According to Ahmed *et al*., (1987), the seeds of fleshy fruit will continue to develop and mature in the flesh until they are removed from the fruit. Figure 1 shows that Kundur (*Benincasa hispida*) seed changes its colour and texture as the fruit maturity progresses. The seeds are filled in the centre of the fruit with lightly attached to the pithy tissue of the fruits (Morton, 1971). According to Raveendra & Martin (2006), the Kundur seeds are flat, smooth, and buff, ranging from 1.0 to 1.5 cm in length and 0.5 to 0.8 cm in width, depending on the nature of the fruits. The seed contains small amount of triterpenoid (isomultiflorenol and cucurbitacin B), proteins (trigonelline, coffearin, and osmotin), steroids (β-sitosterol and stigmast-5-ene-3-beta-ol) and alkaloids (5-methylcytosine) (Lee *et al*., 2005).

Kundur seeds in the present work were constituted around 0.62% wet basis of the fruit. The nutritional components (total dietary fiber, crude protein, crude fat, crude fiber, ash, carbohydrate and energy) of the tested Kundur seeds are compared with other species of Cucurbitacea family (Table 1). The results showed that Kundur seeds contained high amount (58.43%) of total dietary fiber, whereas ash content were low (4.10%). When compared with seeds of other species of Cucurbitacea family, Kundur seeds offered the highest amount of crude fiber (45.00%) and the lowest amount of crude protein (11.63%). High content of total dietary fiber is associated with lowering blood cholesterol level and incidence of coronary heart diseases and bowel disorders. The amounts of crude fat and carbohydrate were determined to be 20.70 and 5.14%, respectively, while energy accounted for 253.38 kcal/100g of Kundur seed. The caloric value, proximate composition and high total dietary fiber suggest that Kundur seed can be used as an alternative or ingredient for cereals.

The data in Table 1 shows that proximate composition of Cucurbitaceae family seeds from different regions, Cameroon (Achu *et al*., 2005) and Sudan (Mariod *et al*., 2009), varied noticeably. Cucurbitaceae species from Cameroon contained high amount of crude protein and crude fat varying from 28.68 to 40.49% and 44.85 to 53.76%, respectively. While, cucurbitaceae seeds from Sudan had high amount of crude fiber and carbohydrate with contribution of 25.86 to 36.04% and 15.62 to 28.82%, respectively. According to Idouraine *et al*., (1996), the variation of nutritional composition among different cucurbit seeds might be attributed to various factors such as the agroclimatic conditions of the harvesting place, maturity of the seeds at the time of harvest, genetic makeup of the variety as well as fertilization and irrigation regimes employed for farming.

Oil fatty acids composition: The GC chromatogram (Fig. 2) showed the identification of palmitic, stearic, oleic, linoleic and linolenic acids in Kundur seed oil. Table 2 shows the fatty acids (FA) composition of Kundur seed oil in comparison with other cucurbitaceae seed oils. Linoleic acid, the predominant fatty acid in the oil, accounted for 67.37% of the total fatty acids. The contents of palmitic, oleic and stearic acids were found to be 17.11, 10.21 and 4.83%, respectively. Kundur seed oil also showed the presence of small amounts of isomers of palmitic acid and oleic acid i.e. palmitoleic acid (0.12%) and *cis*-vaccenic acid (0.38%), respectively. This is in agreement with the study of Ariffin *et al*., (2009) who reported the occurrence of isomeric fatty acids in Pitaya seed oil. However, our results (Table 2) did not show presence of traces of C20:0 and C22:1 as examined by Al-Khalifa (1996). The present FA composition revealed Kundur seed oil to be a rich source of a valuable essential fatty acid (linoleic acid C18:2 ω-6).

The FA composition of the Kundur seed oil in the present analysis was in agreement to those reported in the literature for other Cucurbitaceae seed oils (Table 2); generally containing low amounts of saturated fatty acids and high contents of polyunsaturated fatty acids (PUFA), especially C18:2. It is now widely accepted that diet with low saturated fatty acids and high in PUFA is beneficial for health.

Table 1. Nutritional composition[a] of Kundur (*Benincasa hispida*) seed in comparison with other cucurbit seeds.

Cucurbit seed	Seed yield (wet basis) (%)	Total dietary fiber (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)	Energy (kcal/100)	Reference
Benincasa hispida	0.62±0.02	58.43±2.92	11.63±1.07	20.70±1.84	45.00±3.59	4.10±0.17	5.14±0.57	253.38±3.67	
Citrullus lanatus var. colocynthoide	N.A.	N.A.	15.75	27.1	31.34	4.62	17.01	374.94	Mariod *et al.*, 2009
Cucumis prophetarum	N.A.	N.A.	14.5	10.9	31.58	8.33	28.82	271.38	Mariod *et al.*, 2009
Cucumis sativus	N.A.	N.A.	17.5	25.85	25.86	4.01	22.37	392.13	Mariod *et al.*, 2009
Luffa echinata	N.A.	N.A.	15.75	23.8	31.81	3.41	20.06	357.44	Mariod *et al.*, 2009
Cucumis melo var. flexuosus	N.A.	N.A.	15.75	22.33	36.04	5.69	16.19	328.73	Mariod *et al.*, 2009
Cucumis melo var. agrestis	N.A.	N.A.	16.62	23.33	34.36	5.3	15.62	338.93	Mariod *et al.*, 2009
Cucumeropsis mannii	N.A.	N.A.	40.49	44.85	3.81	3.74	7.11	594.05	Achu *et al.*, 2005
Cucurbita maxima	N.A.	N.A.	34.93	49.05	3.44	3.95	8.62	615.65	Achu *et al.*, 2005
Cucurbita moschata	N.A.	N.A.	32.03	50.81	3.54	4.75	8.86	620.85	Achu *et al.*, 2005
Lagenaria siceraria	N.A.	N.A.	34.19	50.08	4.04	3.68	8.01	619.52	Achu *et al.*, 2005
Cucumis sativus	N.A.	N.A.	28.68	53.76	4.15	3.47	10.01	638.6	Achu *et al.*, 2005

N.A.: Data not available

[a]Values are means ± SD of 3 replications of 2 representative samples (n = 2 x 3 = 6).

Table 2. Fatty acid composition (%) of Kundur seed oil in comparison with other cucurbit seed oils.

Cucurbit seed oil	Common name	C16:0	C16:1	C18:0	C18:1 *cis*	*C18:1a	C18:2	C18:3	SFA	MUFA	PUFA	Reference
Benincasa hispida	Wax guard	17.11±0.22	0.12±0.00	4.83±0.10	10.21±0.16	0.38±0.03	67.37±0.35	0.21±0.01	21.94	10.71	67.58	Reference
Citrullus colocynthis	Wild gourd	10.1	N.A.	6.7	13.1	N.A.	70.1	N.A.	16.8	13.1	70.1	Yaniv *et al.*, 1999
Cucumis dipsaceus	Wild cucumber	10	N.A.	5	6	N.A.	78	N.A.	15	6	78	Chisholm & Hopkins, 1964
Cucumis melo	Honeydew melon	11	N.A.	4	15	N.A.	70	N.A.	15	15	70	Chisholm & Hopkins, 1964
Cucumis sativus	Cucumber seed	16	N.A.	5	7	N.A.	71	N.A.	21	7	71	Mattson & Volpenhein, 1963
Cucurbita ficifolia	Asian pumpkin	12	N.A.	4	26	N.A.	57	N.A.	16	26	57	Chisholm & Hopkins, 1964
Cucurbita foetidissima	Buffalo gourd	9.7	N.A.	4.5	27	N.A.	58.5	N.A.	14.2	27	58.5	Weber *et al.*, 1980
Cucurbita lanatus (Chinese)	Watermelon	10.4	0.21	7.6	12.5	N.A.	68.5	0.13	18	12.71	68.63	Al-Khalifa, 1996
Cucurbita lanatus (Egyptian)	Watermelon	11.91	0.24	8.2	15.4	N.A.	62.4	0.1	20.11	15.64	62.5	Al-Khalifa, 1996
Cucurbita lanatus (Iranian)	Watermelon	11	N.A.	8	17.8	N.A.	63.7	0.11	19	17.8	63.81	Al-Khalifa, 1996
Cucurbita maschata	Winter squash	13.1	0.3	6	26.2	N.A.	53.2	0.12	19.1	26.5	53.32	Al-Khalifa, 1996
Cucurbita pepo	Squash seed	17	N.A.	7	16	N.A.	60	N.A.	24	16	60	Mattson & Volpenhein, 1963
Lagenaria siceraria	Bottle gourd	14	N.A.	3	7	N.A.	76	N.A.	17	7	76	Chisholm & Hopkins, 1964
Luffa cylindrical	Dishcloth gourd	13	N.A.	6	15	N.A.	66	N.A.	19	15	66	Chisholm & Hopkins, 1964
Telfairia pedata	Oyster nut	35	N.A.	14	7	N.A.	44	N.A.	49	7	44	Chisholm & Hopkins, 1964

N.A.: Data not available

Values are means ± SD of 3 replications of 2 representative samples (n = 2 x 3 = 6).

*C18:1a is *cis*-vaccenic acid

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids

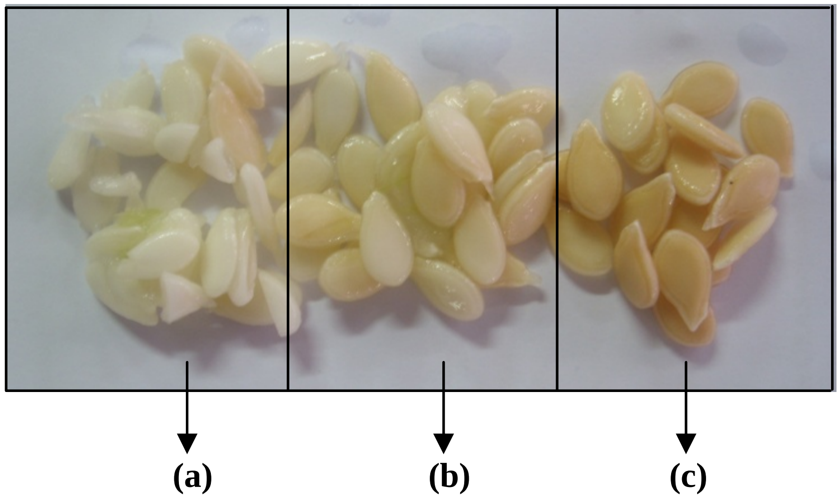

Fig. 1. Colour changes in Kundur (*Benincasa hispida*) seed at different maturity stages (a) first month, (b) second month, (c) third month.

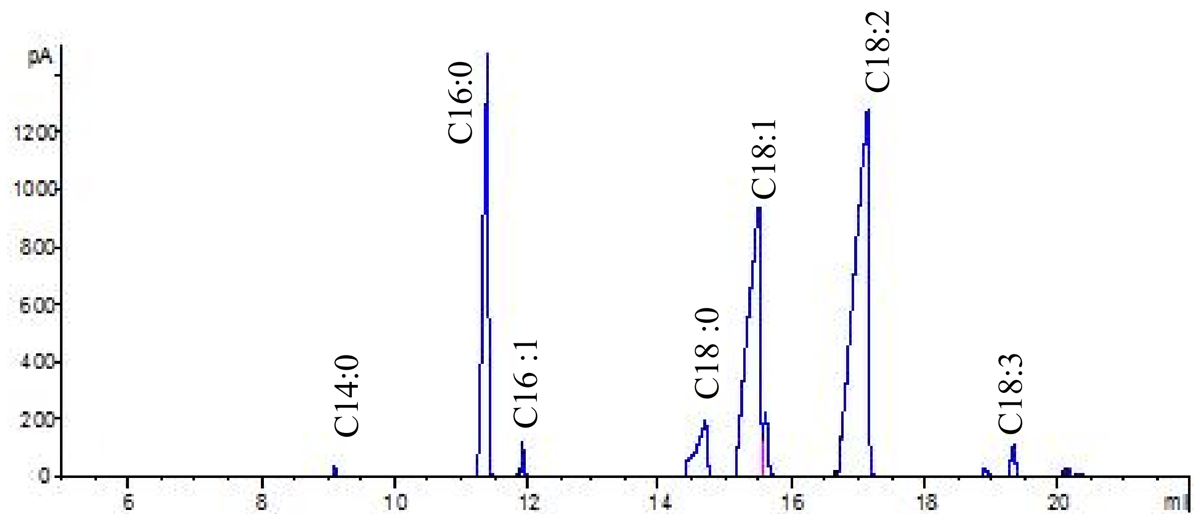

Fig. 2. GC Chromatogram for fatty acids profile of Kundur (*Benincasa hispida*) seed oil

It is obvious (Table 2) that all Cucurbitaceae seed oils, except *Telfairia pedata*, expressed the presence of more than 50% of PUFA (C18:2). However, the levels of C18:2 and other fatty acids varied among the species referred. These differences might be due to varying features such as harvesting time, seed drying conditions, seasonal variation and fruit seed maturity. Kundur seed oil exhibited the highest level of linoleic acid among the other oils from the same plant family. The high proportion of PUFA and monounsaturated fatty acids (MUFA) and low amounts of saturated fatty acids (SFA) indicate the possible higher oxidation rate of Cucurbitaceae seed oils due to high degree of unsaturation. Although none of these oils are presently utilized on industrial scale, but some are used as cooking oil in several countries of Africa and the Middle East (Al-Khalifa, 1996).

Comparing Kundur seed oil with others wholesome seed oils i.e. sunflower, safflower, sesame and flaxseed oils (Table 3), it is evident that its amount of C16:0 and C18:0 is comparable with white and red flesh pitaya seed oils (>20%). The content of an essential fatty acid (C18:2) in Kundur seed oil is closely comparable to that of sunflower oil, however slightly lower than those of grapeseed and safflower seed oils. According to Smit *et al*., (2004), essential fatty acids are the compounds which cannot be endogenously synthesized and must be supplied through the diet because of their requirement for human body. There are two parents in essential fatty acids, which include linoleic acid (C18:2 ω-6) and α-linolenic acid (C18:3 ω-3).

Table 3. Fatty acid composition (%) of Kundur seed oil in comparison with other common vegetable seed oils.

Seed oil	Scientific name	C16:0	C18:0	C18:1	C18:2	C18:3	Essential fatty acid (C18:2 + C18:3)	Reference
Kundur seed	*Benincasa hispida*	17.11 ± 0.22	4.83 ± 0.10	10.21 ± 0.16	67.37 ± 0.35	0.21 ± 0.01	67.26	
Flaxseed/linseed	*Linum usitatissumum*	5	4	19	14	58	72	Erasmus, 1986
Grape seed	*Vitius vinifera*	8	4	15	73	N.A.	73	Zamora, 2005
Red flesh pitaya seed	*Hylocereus undatus*	17.9	5.5	21.6	49.6	1.2	50.8	Ariffin *et al.*, 2009
Rapeseed	*Brassica napus*	2.7	1	20.6	13.8	6.2	20	Anonymous, 2004
Safflower seed	*Carthamus tinctorius*	N.A.	12	13	75	N.A.	75	Erasmus, 1986
Sesame seed	*Sesamun indicum*	9	4	41	45	N.A.	45	Zamora, 2005
Sunflower seed	*Helianthus annuus*	7	5	19	68	N.A.	68	Zamora, 2005
White flesh pitaya seed	*Hylocereus polyrhizus*	17.1	4.4	23.8	50.1	1	51.1	Ariffin *et al.*, 2009

N.A.: Data not available

Values are means ± SD of 3 replications of 2 representative samples (n = 2 x 3 = 6)

The number following "Omega-" represents the position of the first double bond, counting from the terminal methyl group on the molecule. Essential fatty acids (EFA) function as precursors of long chain polyunsaturated fatty acids. The EFA mainly contribute towards the production of prostaglandins which regulate body functions such as heart rate, blood pressure, blood clotting, fertility, conception, and also play positive role in immune system by regulating inflammation and encouraging the body to fight against infections (Yehuda *et al*., 2005;Youdim *et al*., 2000).

Conclusion

The results of the present study showed that Kundur seed contained appreciable amounts of total dietary fiber and crude fat. The oil, extracted from the Kundur seeds, harvested from Temerloh, Pahang, Malaysia, was rich in linoleic acid (C18:2 ω-6) as well as it exhibited low levels of saturated fatty acids, suggesting its potential food uses for health benefits. While the seed yield (fruit weight basis) was low, however, the richness and usefulness of linoleic acid in Kundur seed oil could overcome this disadvantage. Additional research on the detailed physicochemical and bioactive properties of Kundur seed and seed oil is crucial to explore their commercial and functional foods applications.

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