Physicochemical characteristics of argessi (C*hrozophora brochiana*), kenaf (H*ibiscus cannabinus*) and loofah (L*uffa cylindrica*) seed oils

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Abstract

A study on new sources of edible oils namely argessi (*Chrozophora brochiana*), kenaf (*Hibiscus cannabinus*) and loofah (*Luffa cylindrica*) was conducted to quantify the physicochemical characteristics of their seed oil. Percent crude oil content of the three plant species ranges were: 37 - 41, 20 – 23.5 and 19 – 24, respectively. Argessi and kenaf had yellowish and loofah had greenish oil colour. Melting points were: 13.0, 15.0 and 17.5^{o} C; free fatty acid (FFA): 0.82, 1.05 and 4.25%; saponification value (SV): 184.5, 184.8 and 182.4 mg KOH/g; iodine value (IV): 120, 126 and 108 g I/100 g oil; peroxide value (PV): 0.95, 0.98 and 1.20 meq/kg and the unsaponifiable matter: 0.075, 0.052 and 0.09% (w/w), for argessi, kenaf and loofah, respectively. The fatty acid composition (FAC) of argessi oil showed high level of linoleic (*C18:2*) 44.75%, followed by oleic acid (*C18:1*) 24.9%, stearic acid (*C18:0*) 15.6%, palmitic acid (*C16:0*) 13.9% and some traces of the linolenic (*C18:3*) 0.50%. FAC for kenaf oil was high in oleic acid (C18:1) 38.78% followed by palmitic (C16:0) 29.07%, linoleic (C18:2) 15.61%, stearic (C18:0) 7.11% and other fatty acids 9.4%. In loofah seed oil, the FAC was 21.15% oleic, 12.01% palmitic, 06.51% stearic, 59.41% linoleic and 0.45% linolenic. The triacylglycerol (TAG) profile of argessi oil showed presence of eleven TAGs: PLO 16.9%, LLL 15.8%, OLL 14.9%, POO 11.7%, OOL 7.7%, PLL 7.5%, SOP 6.0%, SOO 4.0%, POP 3.9%, OOO 2.8% and SOS 2.3%.

Introduction

Argessi plant (*Chrozophora brochiana* Vis) of the family Euphorbiaceae, is widely scattered in the poor savanna areas in Western Sudan as a range crop. During the drought years of 1983 - 1985, inhabitants of Western Sudan used the boiled seeds of the plant for food. Extraction of the oil is done by using traditional mills pulled by animals such as camels or cows (Hussein *et al*., 1994). Argessi is known as a range crop in Senegal, Chad, Ethiopia and Eritrea (Hanan, 1997). Preliminary studies by Mirghani (1990) showed that the argessi seeds have good edible oil yield. A comparative study (Mirghani *et al*., 1996) on the fatty acid composition (FAC) of the seed oil of argessi and niger (*Guizotia abyssinica*) showed that both seeds contain nearly the same type of fatty acids, with linoleic acid (*C18:2*) as the major component. Apart from that, there are very few reports in the literature on argessi seed oil.

Kenaf (*Hibiscus cannabinus* L.) is a member of the Malvaceae family. It is an annual, non-wood fiber plant indigenous to Central Africa and thought to have been domesticated in Western Sudan before 4000 B.C. The potential of kenaf oil in Sudan has been studied by Hussein (1988). It is now grown worldwide mainly as an annual fiber crop (Edmonds, 1991).

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In the USA, kenaf is well suited to the "Cotton Belt" as a warm-season annual crop. Kenaf research began at Mississippi State University in 1989. The American Kenaf Society (AKS) was founded in 1997. Recently, Harun and Othman (2002) investigated the potential new non-conventional raw material sources for the Malaysian biocomposite industry.

Loofah (*Luffa cylindrica* Roem) is a member of the Cucurbitaceae family, (called smooth loofah, dishcloth ground or sponge ground) consists of wild populations, ranging from South-central Asia to North-eastern Australia and South Pacific. The domesticated varieties are cultivated in Asia, Africa, various tropical American countries and the Caribbean (Robinson and Decker-Walters, 1997). It has been grown mainly for loofah sponge production (Davis, 1994). According to Porterfield (1955), seeds of loofah contain oil with high percent of free fatty acids. In the pure state, the oil is colourless, liquid at ordinary temperatures, of semi-drying type and can be used for food. Mirghani (1990) studied some physicochemical parameters of loofah seed oil.

The objective of this study was to evaluate the physicochemical characteristics of oils extracted from the seeds of argessi, kenaf, and loofah that would help shed light on them as new promising sources of edible oil.

Materials and methods

Argessi seeds are similar to that of sorghum in shape and size but slightly darker in color. For this work seeds were collected from Western and Central Sudan (Tandalti and Gitena) by the National Oilseed Processing Research Institute (NOPRI), Sudan. Kenaf seed were brought from the Seed Propagation Centre, Sinnar, Sudan. Loofah seed were obtained from Gadarif town and Medani local markets. Moisture and volatile matter in the seed samples were determined using the AOCS Official Method Aa 3-38 (1993).

Oil content of the seeds was determined by milling with a blender (Braun Multimix System 200, with Multimix deluxe grinder, and extracting by Soxhlet apparatus using petroleum ether 40-60 according to the AOCS Official Method (Aa 4-38, 1993). The oil content was expressed as a percentage of the extracted oil to the sample weight (w/w). Extracted oil was stored under 4^{o} C in a dark glass bottle under nitrogen blanket for further analysis.

Free fatty acids (FFA), iodine value (IV), saponification number (SN), peroxide value (PV), and unsaponifiable matter were measured according to Official Methods and Recommended Practices of the American Oil Chemists Society, AOCS Official Methods Ca 5a- 40, AOCS Cd 1-25, AOCS Cd 3-25, AOCS Cd 8-53 and AOCS Ca 6a-40 (1993), respectively. Color was determined using Lovibond Tintometer, Model E (Tintometer Limited, Waterloo Road, Salisbury SP1 2JY, England). Refractive index was determined according to the AOCS Cc-25 as simplified in PORIM Test Methods (1995), and the apparatus used was digital refractometer PR-301 (45-90%), Atago Co. Ltd. Japan. The melting point (MP) and the density of crude oil were determined according to PORIM Test Methods (1995).

The fatty acid methyl esters (FAME) were prepared according to PORIM Test Methods (1995) by dissolving 0.05 g oil in 0.8 ml petroleum ether. Then 0.2 mL of sodium methylate was added and mixed by shaking for one minute using Autovortex Mixer SA1 (Stuart Scientific Co. Ltd. UK), layers were allowed to separate. From the upper layer, 5 *u*l which contain the FAME, were injected in a gas chromatography Model 5890 A (Hewlett Packard), fitted with flame ionization detector (FID), using R. I. Column: CW-20 m, capillary column. The carrier gas was helium at a flow rate of 2.1 mL/min. The oven temperature was

programmed, starting at 150^{o} C for 2 min, increasing to 180^{o} C at 30^{o} C/min. Injector and detector temperatures were held at 150 and 250^{o} C, respectively. The retention time of each peak was matched with that of the standard identified sample peaks.

The TAG composition were determined according to the AOCS Official Method Ce 5b-89 (1993) using Shimadzu LC-10 AD HPLC, equipped with a RID-6A refractive index detector (Kyoto, Japan) with commercially packed RP-18 column (250 x 4 mm) particle size 5 um (E. Merck, Darmstadt, Germany). The elution solvent was acetone: acetonitrile (63.5 : 36.5 v/v). Flow rate was one mL/min. Oven temperature was 30^{o} C.

Results and discussion

Physicochemical characteristics of oils

The physicochemical characteristics of the seed oils of the three plant species are all given in Table 1.

Argessi seeds

The average weight of 1000 seeds stored for more than 18 months was 34.5 g with moisture content of 3-5%. The oil content was 37 - 40%, which agreed with that of the previous study (Mirghani, 1990). Freshly extracted oil had 0.8% FFA and was light in color with 1.3 red, 9.0 yellow, 0.1 brightness and 0.0 blue. The solvent extracted oil has high red units of crude oil color and high value of FFA content. These values are likely to be slightly lower if the oil was mechanically pre-pressed (Hoffmann, 1989).

The density of crude oil was 0.88 g/mL at ambient temperature (25^{o} C), which matches that of most vegetable oils. The refractive index was 1.4676$^{n}_{D}$ at 25^{o} C, which is in the range of sunflower, groundnut and soybean oils (Al-Kahtani, 1983). The melting point of the crude oil was 13^{o} C; which rank it as a low melting point oil. The IV was 120 IV units, similar to other vegetable oils such as sunflower with values of 103 to 120.4 (Kinman and Earle, 1964), soybean and groundnut reported to be 121.8 to 127, respectively (Mirghani, 1990 and Al-Kahtani, 1983). SN, 184.5 mgKOH/g oil, is also similar to most vegetable oils such as sunflower (Raie et al., 1979; and Sengupta *et al*., 1975), groundnut and sesame (Mirghani, 1990) and soybean (Al-Kahtani, 1983) seed oils.

Kenaf seed

The oil content of kenaf seed at 4.5% moisture content was 22.4%, which agrees with the previous result of Mirghani, 1990. Freshly solvent extracted oil had 1.05% FFA and was of bright yellow color with 2.1 red, and 23 yellow of Lovibond color standards. The density and the refractive index were 0.89 g/mL and 1.4677$^{n}_{D}$ at 25^{o} C, respectively. Melting point was 13.3^{o} C, which classifies the oil as low melting point oil. The IV and SN were 126 IV unit and 184.81mgKOH/g oil, respectively, which is similar to most vegetable oils (Al-Kahtani, 1983; Raie *et al*., 1979).

Loofah seed

The oil content of loofah seeds at 6.59% moisture content was 22.16%. The hull: kernel ratio was 44:56, which agreed with the study by Porterfield (1955), which showed the seeds

were about 49% testa and 51% kernel. It is feasible to decorticate the seeds prior to oil extraction because the kernel contains most of the oil in the whole seed (42.6%) while the hull oil content does not exceed 0.38%. The extracted oil had 5-7% FFA, greenish color of 5.1 red, 33 yellow according to Lovibond color standards. The density and the refractive index of crude oil were 0.91 g/mL and 1.4678^{n}_{D} at 25^{o} C, respectively. Melting point was 17.5^{o} C, which is a little higher than the above two types of oils but the oil is still liquid at ambient temperature like most vegetable oils. The IV and SN were 95-120 IV units and 182.4 mg KOH/g oil, respectively, which is also similar to most vegetable oils.

Table 1. Crude oil physicochemical characteristics of argessi, kenaf and loofah

Character	Argessi		Kenaf	Loofah
	Tandalti	Gitena		
Oil Content, %	37.6 ± 2.30	38.5 ± 2.10	22.4 ± 1.1	22.16 ±1.3
Density @ 25^{o} C, g/mL	0.88 ± 0.02	0.89 ± 0.02	0.89 ± 0.01	0.91 ± 0.01
Color	1.3 R, 9.0 Y	1.2 R, 10 Y	2.1 R, 23 Y	5.1R, 33 Y
Melting Point ^{o}C	13.0 ± 0.04	12.9 ± 0.06	13.3 ± 0.03	17.5 ± 0.04
Refractive Index (25^{o} C)	1.4676 ± 0.00	1.4676 ± 0.00	1.4677 ± 0.0	1.4678 ± 0.0
Iodine Value	119.76 ± 3.80	120.28 ± 3.42	126 ± 2.25	108
Saponification Number mg KOH/g Oil	183.5 ± 2.23	185.5 ± 2.40	184.81 ± 2.1	182.4 ± 1.82
Free Fatty Acids %	0.82 ± 0.04	0.76 ± 0.08	1.05 ± 0.02	4.2
Peroxide Value, meq/Kg	0.97 ± 0.02	0.93 ± 0.03	0.98 ± 0.05	1.20 ± 0.11
Unsaponifiable Matter, % (w/w)	0.06 ± 0.02	0.09 ± 0.01	0.07 ± 0.01	0.10 ± 0.03
Moisture Content of Seeds, %	4.61 ± 0.98	5.53 ± 1.40	4.5 ± 1.0	6.58 ± 0.89
Protein in Cake, %	27.4 ± 2.18	26.2 ± 3.00	23.62 ± 1.7	22.24 ± 2.0
Saturated: Unsaturated, Fatty acids	30.6 : 69.4	28.5 : 71.5	37 : 63	20 : 80

[a] *Mean of three replications.*

Fatty acid composition (FAC) of oils

FAC of the seed oil of the three plant species are given in Table 2.

Argessi seeds

As shown in the Fig. I and Table 2, linoleic acid (C18:2) was the most dominant fatty acid (43.1 – 46.0%) followed by oleic acid (C18:1) 24.5 - 25.3%, stearic acid (C18:0) 14.6 - 16.3%, palmitic acid (C16:0) 13.6 - 14.2% and some traces of linolenic acid (C18:3) 0.44 – 0.5%, palmitoleic acid (C16:1) 0.19 – 0.21% and myristic acid (C14:0) 0.17 – 0.18%. Results of earlier study reported by Hilditch and Williams (1964) for another argessi species, *C. plicata*, from Sudan, agreed with this result. The high content of C18:2 which is more than 40%, gives the oil semi-drying properties due to the high degree of unsaturation that suggests it could be useful in paints and coating applications.

The result also suggests that argessi oil has a potential of a new type of vegetable oil of high-unsaturated fatty acid content. The ratio of unsaturated fatty acid to the saturated ones was 70:30 in average. The content of the essential fatty acids C18:2 and C18:3 were also high; an indication of good nutritional value. The oil has a potential of being blended with other types of oils such as palm oil. Since the main unsaturated fatty acids in argessi oil are oleic (C18:1) and linoleic (C18:2), it could be considered in the oleic/linoleic acid group (Orthoeter, 1996). This group is widely used and comparable to other fats and oils, such as corn,

cottonseed, peanut, olive, sunflower, sesame, safflower and rice bran oil. The oleic / linoleic acid group of vegetable oils contain no trisaturated triacylglycerol (Orthoeter, 1996) as indicated from the HPLC result (Table 3). The high % of trilenolein (LLL) found in argessi oil is an uncommon feature in the plant family Euphorbiaceae.

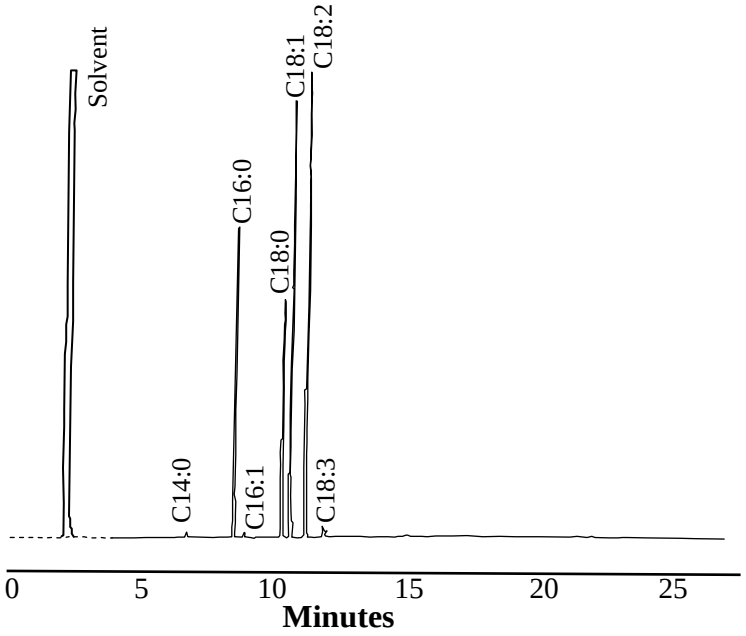

Fig. 1. Chromatogram of the fatty acid of argessi seed oil.

Table 2. Fatty acid composition of argessi, kenaf and loofah seed oil

Fatty acids	Composition (%) [a]			
	Argessi		Kenaf	Loofah
	Tandalti	Gitena		
Myristic (C 14:0)	00.18 ± 0.02	00.17 ± 0.03	-	Traces
Palmitic (C 16:0)	14.15 ± 0.32	13.58 ± 0.41	29.07 ± 0.50	12.01 ± 0.20
Palmitoleic (C 16:1)	00.21 ± 0.01	00.19 ± 0.02	-	-
Stearic (C 18:0)	16.28 ± 0.12	14.59 ± 0.33	07.11 ± 0.13	06.51 ± 0.11
Oleic (C 18:1)	25.25 ± 0.05	24.50 ± 0.16	38.78 ± 0.24	21.15 ± 0.41
Linoleic (C 18:2)	43.11 ± 0.24	46.00 ± 0.07	21.61 ± 0.09	59.41 ± 0.30
Linolenic (C 18:3)	00.44 ± 0.08	00.60 ± 0.05	00.50 ± 0.02	00.45 ± 1.00
Unknown	00.36 ± 0.02	00.35 ± 0.02	02.90 ± 0.45	Traces
Saturated	30.61	28.34	37	19
Mono-unsaturated	25.46	24.69	38.78	21.15
Di-unsaturated	43.11	46.00	21.61	59.41
Tri-unsaturated	00.44	00.60	00.50	00.45

[a] *Mean of three replications.*

Kenaf seed

Kenaf seed oil (Table 2), was high in oleic acid (C18:1) 38.78% followed by palmitic acid (C16:0) 29.07%, linoleic acid (C18:2) 21.61%, stearic acid (C18:0) 7.11%, linolenic acid (C18:3) 0.50% and others of 2.9%, this agrees with previous result of Hilditch and Williams (1964) with regard to oleic and stearic acids but differs in palmitic (15-19%) and linoleic (26-43 %) acids. Duke (1979) also reported that kenaf seed oil contains 45.3% oleic-, 23.4% linoleic-, 14% palmitic-, and 6.0% stearic- acids. The ratio of saturated fatty acids to the unsaturated is approximately 37:63. The content of undesirable cyclopropenoid fatty acids can easily be avoided by refining.

Loofah seed

FAC of the loofah seed oil (Table 2), consisted of linoleic acid (C18:2) 59.41% oleic acid (C18:1) 21.15%, palmitic acid (C16:0) 12.01%, stearic acid (C18:0) 6.51%, linolenic acid (C18:3) 0.45%, and traces of myrestic acid (C14:0); this agrees with the result of Hilditch and Williams (1964) particularly in the linoleic acid content (64.6%). The ratio of the saturated to the unsaturated fatty acids was 20:80 in average. In other studies a ratio of 30:70 was reported. The discrepancy may be explained by several combined factors likely to affect the fatty acids composition.

Triacylglycerols composition (TAGs)

The TAGs of argessi seed oil are shown in Table 3 and Fig. 2. They were almost identical for seeds collected from Tandalti and Gitena: LLL 15.8%, OLL 14.9%, PLL 7.5%, OOL 7.7%, PLO 16.9%, OOO 2.8%, POO 11.7%, POP 3.9%, SOO 4% SOP 6% and SOS 2.3%. The ratio of mono-acidic: di-acidic: tri-acidic regardless the type of fatty acids and their position in the TAG was 1:2.65:1.17. This result explains the low melting point (13^{o} C) of this oil.

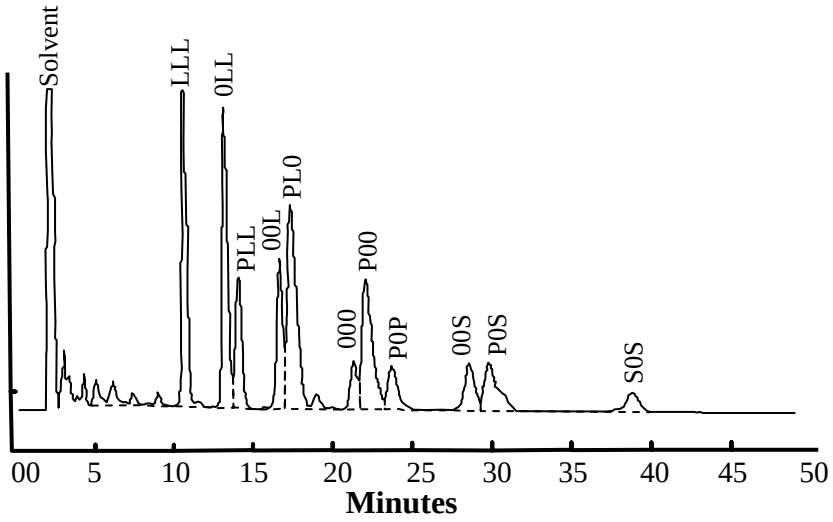

Fig. 2. Triacylglycerol profile of oil extracted from argessi seed.

Table 3. Triacylglycerols composition of argessi seed oil collected from two locations

Triacylglyceride [b]	Composition (%) [a]	
	Tandalti	Gitena
LLL	16.0 ± *0.50*	15.6 ± *0.42*
OLL	15.0 ± *0.46*	14.8 ± *0.61*
PLL	07.5 ± *0.37*	07.4 ± *0.40*
OOL	07.7 ± *0.33*	07.7 ± *0.32*
PLO	16.9 ± *0.52*	16.8 ± *0.58*
OOO	02.9 ± *0.05*	03.0 ± *0.07*
POO	11.7 ± *0.21*	11.8 ± *0.19*
POP	03.9 ± *0.03*	04.0 ± *0.08*
SOO	04.0 ± *0.05*	04.0 ± *0.06*
SOP	06.0 ± *0.10*	06.0 ± *0.09*
SOS	02.3 ± *0.02*	02.4 ± *0.00*
Other	01.8 ± *0.03*	01.4 ± *0.01*
Mono and Di-glycerides	04.0 ± *0.44*	04.9 ± *0.52*

[a] *Mean of three replications.*

[B] *L, linoleic acid; O, oleic acid; P, palmitic acid; S, stearic acid*.

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References

Al-Kahtani, H. A. (1983). Quality of soybeans and their crude oils in Saudi Arabia. J. Am. Oil Chem. Soc. 66: 109-113.

AOCS (1993). Official Methods and Recommended Practices of the American Oil Chemists' Society, 4th. Edn. (ed. D. Firestone), American Oil Chemists' Society, Champaign, IL.

Davis, J. M. (1994). Luffa sponge ground production practices for temperature climates. Hort. Science 29:263-266.

Duke, J. E. (1979). Ecosystematic data on economic plants. Quart. J. Crude Drug Res. 17 (3-4): 91-110.

Edmonds, J. M. (1991). The distribution of *Hibiscus L*. section *Furcaria* in tropical East Africa. International Board for Plant genetic Resources (IBPGR), Rome, Italy, pp. 15-24.

Hanan, N. P. (1997). Plant genetic resources information. French Institute of Scientific Research for Development (Senegal) ORSTOM, p. 313 – 314.

Harun, J. and Othman, M. S. (2002). Malaysian Biocomposite Industry: Emerging Products and challenges in Sustaining Global Status Through R & D, 4th Asian Science and Technology Congress (4ASTC 2002), 25-27 April 2002, Kuala Lumpur, Malaysia.

Hilditch, T. P. and Williams, P. N. (1964). The chemical constitution of natural fats, 4th edition. Chapman and Hall.

Hoffmann, G. (1989). Vegetable oil separation technology. In: The chemistry and technology of edible oil and fats and their high fat products, Academic Press, 111 pp.

Hussein, I. H. (1988). The Potential of kenaf oil. In: Proceedings of the second oilseed conference, Wad-Medani, Sudan, 8-9 Feb.

Hussein, I. H., El-Hasien, S. A., Mirghani, M. E. S. and Ali, M. O. H. (1994). Vegetable oils in Sudan, a review. National Oilseed Processing Research Institute (NOPRI), University of Gezira, Sudan.

Kinman, M. L., and Earle, F. R. (1964). Agronomic performance and composition of the seed of sunflower hybrids and introduced varieties. Crop Sci. 4: 417-420.

Mirghani, M. E. S., Hussein, I. H., Dagne, E. and Bekele, T. (1996). A comparative study of seed of *Chrozophora brochiana* and *Guizotia abyssinica.* Bull. Chem. Soc. Ethiopia. 10: 161-164.

Mirghani, M. E. S. (1990). Studies on conventional and new sources of vegetable oil in the Sudan. MSc Thesis, University of Gezira, Medani, Sudan.

Orthoeter, F. T. (1996). Vegetable oils. In: Bailey's industrial oil and fat products (ed. Y. H. Hui). 5th edition. Vol. 1, Wiley-Interscience Publications, 35 pp.

PORIM Test Methods (1995). Palm Oil Research Institute of Malaysia Test Methods, Ministry of Primary Industries, Malaysia, pp. 83-101, 109-111, 112-113, 116-121.

Porterfield, W. M. Jr. (1955). Loofah - the sponge gourd, Econ. Bot. In: Cucurbits (eds. T. W Whitaker and G. N. Davis). Interscience Publishers Inc. NY. 211-223

Raie, M. Y., Ahmed, M. and Khan, S. A. (1979). Fatty acid composition of the oil of sunflower seed cultivated in Pakistan. J. Sci. Indus. Res. 22: 94-96.

Robinson, R.W. and Decker-Walters, D. S. (1997). Cucurbits. CAB International, pp. 94-97.

Sengupta, S., Sen, R. and Roy, B. R. (1975). Indian sunflower seed oil, its chemical constitution and characteristics color test. Res. Indus. India 20: 215-216.