Physical and Chemical Characteristics of *Citrullus lanatus* Var. Colocynthoide Seed Oil

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Abstract: Citrullus lanatus *var. Colocynthoide is one of the species of the Cucurbitaceae family which grows abundantly in Sudan. In this study, it was investigated as a new source of vegetable oil. An oil content of 35% was obtained. The extracted oil showed high stability against oxidation, with low level of trace elements and phosphorus compared to other edible vegetable oils. The oil showed high degree of unsaturation, and fatty acid composition was found in the range adopted by Food an Agriculture Organization (FAO). The IR spectrum is typical of that the vegetable edible oil. Most of the physicochemical properties were similar to those reported for cotton seed, groundnut and sunflower seed oils.*

Keywords: *Citrullus lanatus* var. Colocynthoide, oil content, physical and chemical characteristics

1. INTRODUCTION

Oils and fats are substances of vegetable or animal origin. They are insoluble in water and greasy to touch. The most important characteristic is that they have a caloric content more than twice as high as the other food stuff (9 kcal g^{-1}).[1] Also they act as lubricants during mixing of ingredients and as media for heat transfer carrier for fat soluble vitamins. Also, they are a source of essential fatty acids.[2]

The plants and animals that produce oils and fats in plentiful quantity and in a sufficiently available form for it to be an article of commerce are comparatively few. The larger source of oils at present is the seeds of annual plants.[3]

The high world demands for oils and fats to meet the multiplex human consumption and the multitudinous industrial needs are the reasons for the increase in the importance of oil seeds and make them play an important role in the national economy of the producing countries.[2]

Oilseed producing countries are anxious to increase the value of their primary exports by expanding processing industries. Establishment of a plant utilizing local crops will encourage allied or subsidiary industries and become a focal point for development.

Sudan is one of the major oilseed producing countries. The major oilseeds that commercially cultivated in Sudan are cottonseed, groundnut, sesame and recently, sunflower. They represent an important contribution to its export trade and major cash crops in several parts of the country as well as an important food item.[4] To ensure the increase of oils and fats, it is necessary to continue not only with the development of new varieties with improved oil yields, but also to search for new sources of oil.

The promising, unconventional and new sources of oil in the Sudan are the available species of the family Cucurbitaceae (indigenous to Africa).[5] Considerable amounts of oil-rich cucurbit seeds are available in Sudan. They are believed to produce edible oils, but these seeds are not currently exploited as oil sources on a large scale. They are either completely consumed or exported to near-by countries. Recently, several investigations have been carried out on many cucurbit seeds to exploit them as unconventional new sources of oil.

Citrullus lanatus var. Colocynthoide is one of the species which is available in a considerable amount in Sudan.[6] It is an ancestor type of the cultivated watermelon. It is locally known as “Gurum” and is semi-cultivated in the beach of the Nile River in the north of Sudan. The green parts of the plant are used as animal feeds, the seeds are used as a masticatory article and the residue is used as a source of heat energy for cooking.[7]

Due to the growth of the importance of oilseeds in the national economy of Sudan, the high demand to look for a new source of oil and the sufficient availability of this plant in Sudan, the scarcity of scientific studies of the seed oil of *Citrullus lanatus* var. Colocynthoide or “Gurum” has been investigated as a new source of vegetable oil.

2. EXPERIMENTAL METHODS

Sample of “Gurum” seeds were obtained from “Eldaba” (area in the north of Sudan). The samples were kept under suitable conditions to avoid changes.

2.1 Seed Characteristics and Composition

Seed color was determined visually. One hundred seeds of each type were picked randomly and weighed, dehulled and then, hulls and kernels were weighed again to determine the ratio of hull-to-kernel by weight.

The moisture, volatile matter and oil content were determined according to the reported methods[8] as described in Table 1. Forced draft oven BS (Gallenkamp, Model OV-160, England) was used for determination of moisture and volatile matter under the condition of the test and the temperature was adjusted at 130 ± 2°C.

2.2 Physiochemical Characteristics of the Oil

Physiochemical characteristics of the oil were determined according to the reported methods.[8] Lovibond tintometer (Model E, supplied by Griffin and George, Salisburg, England) and 5.25 inch cell were used for oil color determination. Determination of viscosity was carried out using rotaviscomete (Model B.M 1986, Keiki Co Ltd, Tokyo, Japan). Double beam

Table 1: Official Methods and Recommended Practices of the American Oil Chemist's Society (reapproved 1993).[8]

No	Method	Number
1	Moisture and volatile matter in seed	Ba 2-38
2	Oil content	Ac 3-44
3	Solvent extraction	Aa 4-38
4	Oil color	Cc 13b-45
5	Specific gravity	Cc 10a-25
6	Viscosity	Tq 1a-64
7	Refractive index (RI)	Cc 7-25
8	Moisture and volatile matter in oil	Ca 2c-25
9	Free fatty acids (FFA) and acid value (AV)	Ca 5a-4
10	Peroxide value (PV)	Cd-8-3
11	Iodine value (IV)	Cd 1-5
12	Saponification value (SV)	Cd 3-25
13	Unsaponifiable matter	Ca 6b-53
14	Colorimetric determination of phosphorus	Cd 12-55
15	Fatty acids composition	Ce 1-62
16	Trace elements	Ca 15-75

Spectrophotometer (150-2, UV/VIS–Shimadzu, Japan) was used for the colorimetric determination of phosphorus.

The analysis of fatty acids was carried out in the form of their methyl esters using gas-liquid chromatography (GLC) (Model CDPI, Pye Unicam, series 304, Cambridge, England) with computing integrator, flame ionizer detector and glass column packed with polyethylene glycol succinate on celite (oven temperature = 180ºC; column temperature = 180ºC; detector temperature = 250ºC, nitrogen flow rate = 35 ml min^{-1}).

Atomic absorption spectrophotometer (AAS) with comuting integrator (Model SP9, Pye Unicam, Cambridge, England) was used to determine the trace elements. IR spectrum was obtained using IR spectrophotometer (IR 435, Shimadzu Corporation, Kyoto, Japan).

3. RESULTS AND DISCUSSION

Seed color (brownish-yellow) resembled that of many members of the family, moisture and volatile matter (6.2%) are in the normal range while seed weight (7.95–8.28 g/100 seeds) showed high value compared to colocynth seed. “Gurum” seeds showed a slightly lower percentage of hulls versus kernels (43–40:57–60) as compared to that of colocynth seed (53–55:47–45), as hull-to-kernel ratio is one of the important factors that determine the importance of dehulling due to its low content of oil. So, the importance of dehulling should decrease with the decreases of the hull percentage. Oil content (35.5%) resembled that reported for groundnut (36%–37%) but higher compared to that of colocynth seed (20%–26%).[9]

The results obtained showed that “Gurum” seed oil matches most common Sudanese oils (Table 2) in their specific gravity (AT 25/25°C = 0.919 and AT 25/60°C = 0.896), viscosity (38 cP), RI (AT 60°C = 1.4589), moisture and volatile matter (5.52%), FFA (1.16%), AV (2.31), IV (128.9), SV (189–201 mg KOH/g oil) and unsaponifiable matter (0.49%).

Table 2: Physiochemical characteristics of common Sudanese oils.

No	Characteristics and Compositions	Seed Oil		Reference
1	Specific gravity	Sesame and sunflower	0.885–0.889	9
2	Viscosity	Cotton seed	40–50	9
3	RI	Cotton seed	1.4572	13
		Groundnut	1.4550	13
		Sesame	1.4580	13
4	Moisture and volatile matter	Colocynth seed	5%–7.5%	9
5	FFA	Colocynth seed	0.35%–1.5%	9
		Melon seed	0.49%–1.30%	13
6	PV	Cotton seed	34.1–36.02	13
		Groundnut	23.0–30.0	13
		Sunflower	20.87	9
7	Phosphorus content	16.5		9
8	IV	Cotton seed	103–143	13
		Sesame	128	13
		Groundnut	132	13
		Sunflower	125	13
		Colocynth seed	122–127	9
9	SV	Cotton seed	183–198	9
		Groundnut	198–2	9
		Sunflower	191.8	9
		Colocynth seed	19–206	9
10	Unsaponifiable matter	Cotton seed	0.5%–2.0%	9
		Sesame	0.55%–1.5%	9
		Groundnut	0.4%–1.0%	9
		Sunflower	0.3%–0.5%	9
		Colocynth seed	1.65%–1.72%	9

"Gurum" seed oil showed a low PV (4.76 meq kg^{-1}). This indicates that it must be more stable to oxidation (due to the presence of anti-oxidant naturally present in the oil) as compared to common Sudanese oils (Table 2). Also, "Gurum" seed oil showed low phosphorus content (1.65%). The result increases the "Gurum" seed oil nutritionally, since lower phosphorus content result in lower refining losses.[10]

Most of trace elements in oils are pro-oxidant and it is important to remove them from the oil during the refining, so the lower value of these elements in "Gurum" seed oil (Table 3) makes it more stable as it compared to the common Sudanese oils (Table 2).

Table 3: Trace elements in "Gurum" seed oil.

Element	Fe	Cu	Zn	Ni	Ca	Mn	Co	Mg
Concentration (ppm)	0.65	0.21	0.41	0.01	9.00	0.16	3.05	7.00

The fatty acid composition of "Gurum" seed oil was determined using area under the curve. The unsaturation index was also calculated (%$C_{18:1}$ x 1 + %$C_{18:2}$ x 2 + %$C_{18:3}$ x 3). The results of fatty acid composition of "Gurum" seed oil (Table 4) are in a good agreement with that reported for melon seed oil.[11] Also, comparing this result with that of colocynth seed oil,[9] the results showed that the oleic acid in "Gurum" seed oil was higher than that of colocynth seed oil. Moreover, this result was in the range of the fatty acid composition adopted by FAO.[12]

The unsaturation index of "Gurum" seed oil was slightly higher compared to that reported for melon seed oil,[11] and lower compared to colocynth oil.[9] Since the unsaturation index paralleled the IV, so these results were expected comparing to the IV. The IR spectrum of "Gurum" seed oil was obtained and compared to the spectrum of colocynth,[9] sunflower and cotton seed oils.[13] It was found that the IR spectrum of "Gurum" seed oil was similar to those of the above oils.

The IR spectrum of "Gurum" seed oil (not shown) consists of three sharp bands in the region 2850–3300 cm^{-1} as indication of O-H stretching bands of the fatty acids carboxylic group. The carbonyl band at 1750 cm^{-1} indicates the presence of aliphatic esters. The IR spectrum showed two bands at 1470 cm^{-1} and 1380 cm^{-1} as indications for $\delta_{as}CH_3$ and $\delta_{s}CH_3$ respectively. The bands at 1230 cm^{-1} and 1180 cm^{-1} indicates the presence of acetate C(=O)–O and asymmetric O–C----C. No band appears at 970–1080 cm^{-1} for isomers with conjugated *trans* double bond system. The IR spectrum of "Gurum" seed oil shows typical vegetable edible oils spectra,[14] since *trans* fatty acids of vegetable oils are absent and the double bonds appears in the *cis* form only.[15]

Table 4: Fatty acid composition and unsaturation index.

Fatty acid composition %				Unsaturation index
$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	
9.97	7.78	14.69	67.56	149.81

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