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Bangladesh J. Sci. Ind. Res. **59(2)**, 67-72, 2024

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ISSN. 0304-9809

Physicochemical properties and yield of *Guizotia abyssinica* seed oil grown in South Wollo of Ethiopia

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ARTICLE INFO

Received: 04 December 2023

Revised: 17 April 2024

Accepted: 06 May 2024

eISSN 2224-7157/© 2023 The Author(s). Published by Bangladesh Council of Scientific and Industrial Research (BCSIR).

DOI: https://doi.org/10.3329/bjsir.v59i2.70197

Abstract

Niger (*Guizotia abyssinica*) plants are cultivated in various parts of Ethiopia. However, there are no investigation on physical properties of oil extracted from niger and its yield. The current work investigated the yield and physicochemical analysis of oil extracted from it. The extracted oil amount (40%) is good when compared to the reported Ethiopian Niger seed oil yields. The physico-chemical analyses of the oil were determined according to the standard procedures. Among the determined properties of the seed oil were moisture content (9.5 ± 0.40%), specific gravity at 25^0, (0.90 ± 0.02), acid value (1.20 ± 0.50 mg KOH/g oil), saponification value (175.0 ± 0.60 mg KOH/g oil), free fatty acid content (0.60 ± 0.25%), and ester content (173.8 ± 0.10 mg KOH/g oil). In conclusion, on the basis of investigated physicochemical properties it indicates that the oil extracted from seeds of *G. abyssinica* is a good quality of oil and have dietary recommendations.

Keywords: Oil; Niger seed; Oil yield; Physicochemical analysis; Food

Introduction

An oily substance is one that is both lipophilic (literally miscible with other oils) and hydrophobic (immiscible with water), and it is in a viscous liquid state ("oily") at room temperature or slightly warmer. Vegetable oils, petrochemical oils, and volatile essential oils are examples of compounds with different chemical structures, characteristics, and applications that are classified as oils (Shemsu, 2017). Vegetable oils, which are used to meet the needs of the food, cosmetic, and pharmaceutical industries as well as the demand for biofuels, are present in significant amounts in the oils obtained from a variety of crops (Quequeto *et al.* 2020). Oil seeds are valuable sources of edible, therapeutic, and industrial oils. They may also contain bioactive compounds with useful qualities that should be further investigated (Melaku, 2015).Works of literature indicates that several studies have investigated the use of different methods to extract oil from plant parts, but seeds are good ones. It has been determined that there are three primary methods for extracting oil: enzymatic, chemical, or solvent, and mechanical methods. Furthermore, methods such as microwave-assisted extraction (MAE), supercritical fluid extraction (SFE), and accelerated solvent extraction (ASE) are commonly employed (Nde and Foncha, 2020, Danlami *et al.* 2014).

A wide variety of oil seeds, such as linseed, niger seed, soybeans, cotton seed, sesame, ground nuts, sunflower seed, castor beans, and rapeseed, can be grown in Ethiopia (Shemsu, 2017). Niger is an oil seed crop cultivated. The scientific name of niger is Guizotia abyssinica Cass from the Asteraceae family. It has premium oils that could be used in the pharmaceutical and nutraceutical industries. The genus *Guizotia* comprises six species, of which *G. abyssinica* is the only one that is cultivated (Alemaw and Wold, 1995, Sarin *et al.* 2009).

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The niger plant is cultivated on a high scale of Ethiopia and India and on a low scale in several countries in Africa, Asia and America. It is consumed in many countries, including the United States, Europe countries, and Persian Gulf countries, including Iran, for bird feeding. About 50% of Ethiopian oil seed production and 3% of Indian oil seed production are made up of it (Bezuayehu *et al.* 2016, Nazanin *et al.* 2020). Niger plants are cultivated in various parts of Ethiopia with various physicochemical values. These variations may be due to soil type, climate, harvesting time, drying processes, extraction methods, solvent used for the extraction, and many other factors. However, there are no investigated physical properties and chemical compositions of the oil extracted from these plants to compare and contrast with the data obtained from other areas of the same plant seeds oil. Based on basis of these variations, the present study was undertaken with the main objective of extracting and comparing physicochemical analyses of *G. abyssinica* seed oil with other parts of the country's *G. abyssinica* seed oil.

Materials and methods

Seed collection and preparation

Guizotia abssynica seeds were purchased from a local market of South Wollo, Ethiopia. The purchased seeds were washed to remove the dirt particles with tap water. After washing, the air dried seeds were ground by an electrical grinder (Figure 1). The powders of the ground sample were obtained by drying for one to two days. Then, the prepared sample was kept for further analyses.

Extraction of oil from G. abyssinica seeds

The powder of *G. abssynica* seed was subjected to maceration extraction by n-hexane to obtain oil for physicochemical analyses. A total of 75.0 g of seed powder was extracted by 450.0 mL of n-hexane for 24 hrs according to the reported methods (Nde and Foncha, 2020, Danlami *et al*. 2014) with modifications. The oil was separated from the residue by using a separatory funnel and collected it in a beaker (Figure 1). The hexane was removed from the oil sample by using a water bath at 40^{o} and kept the beaker on open air for 24hrs. The obtained oil sample was kept for physicochemical analyses.

Determination of yield

Equation (1) was utilized to determine the extracted oil yield (Nazanin *et al*. 2020).

$$\%\ \text{Oil} = \frac{\text{Oil weight}}{\text{Sample weight}} \times 100\% \quad (1)$$

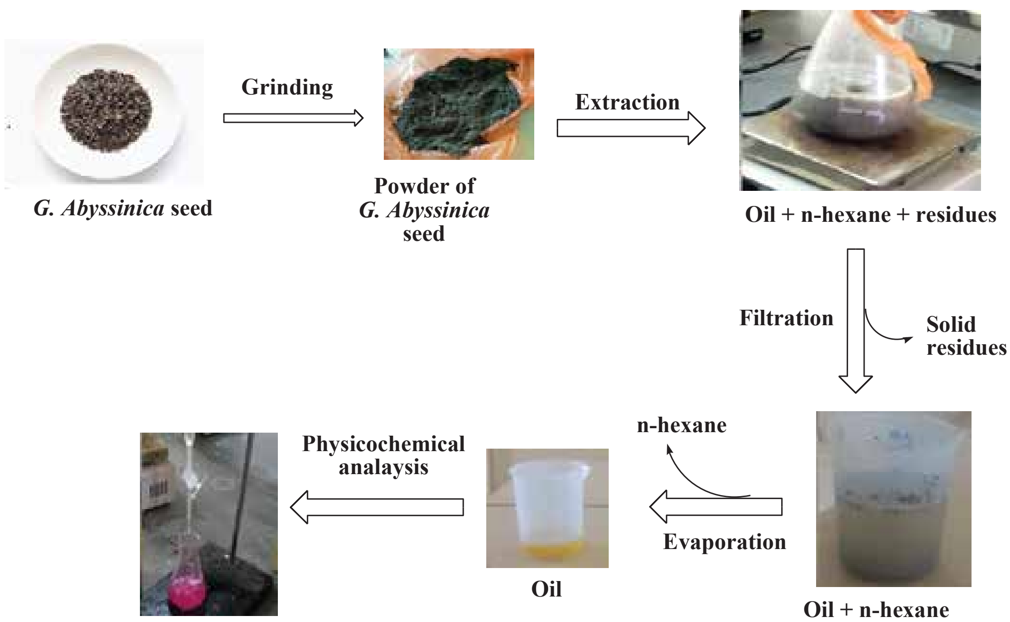

Fig. 1. Extraction of oil for physicochemical analysis from *Guizotia abssynica* seed

Determination of moisture content

A two gram of oil was weighed in a porcelain crucible. The crucibles containing samples were heated in an oven for one hour at 105°C and then cooled and weighed again until constant weight measurement. The procedure was repeated three times. The percentage of moisture in the sample was calculated from the formula according to Ibrahim and Yusuf (2015) with modification. It was done on a wet basis.

$$\%\ \text{moisture} = \frac{(\text{Wet weight} - \text{Dry weight})}{\text{Wet weight}} \times 100\% \quad (2)$$

Determination of specific gravity

A dry density bottle with a 10 mL volume capacity was precisely weighed, then filled with distilled water and weighed once more. In a similar manner, oil was added to another pre weighed, dried density bottle, and it was then weighed again. The experiment was repeated three times as described by Kukeera *et al*. (2015) and then the percent of specific gravity was calculated as Equation (3).

$$\%\ \text{pecific gravity} = \frac{W_{b+o} - W_b}{W_{b+w} - W_b} \quad (3)$$

where $W_b + o$ = weight (g) of the bottle filled with oil,

$W_b + w$ = weight (g) of bottle filled with water and

W_b = weight (g) of the empty bottle.

Determination of saponification value

To determine, the saponification value of the oil, 0.1 N KOH solution was prepared from ethanol and distilled water. Two grams of oil and 25 mL of ethanolic potassium hydroxide solution were placed in a conical flask and heated for 30 min. 2.0 mL of phenolphthalein was added to the saponified mixture after cooling and then titrated with 0.5 M HCl (Ogungbenle *et al*. 2015)

$$\%\ \text{saponification value} = \frac{56.1 \times (B - S) \times N}{W} \quad (4)$$

where: B = Volume in mL of standard HCl required for the blank

S = Volume in mL of standard HCl required for the sample

N = Normality of the standard HCl and

W = Weight in g of the oil taken for the test.

Determination of acid value

To determine the percent of acid value, 5 g of oil was poured into a 250 mL conical flask containing 50 mL of ethanol and then boiled. Next, 5 drops of phenolphthalein which contains 1 g of phenolphthalein in 100 mL of ethyl alcohol were added. Then the oil solution was titrated with 0.1 N KOH using phenolphthalein as an indicator according to Ogungbenle *et al*. (2015).

$$\%\ \text{Acid value} = \frac{56.1 \times V \times N}{W} \quad (5)$$

where V = Volume in mL of standard KOH used

N = Normality of the KOH solution; and

W = Weight/gram of the sample

Determination of free fatty acids (% FFA)

The percent of free fatty acids (FFA%) were computed according to the standard method (AOAC) technique as shown in Equation 6, (Otles and Ozyurt, 2015).

$$\%\text{FFA} = \frac{\%\ \text{acid value}}{1.99} \quad (6)$$

Ester value

The saponification value and acid value were used to calculate ester value of extracted oil by subtracting the acid value from the saponification value of oil (Akinola *et al.* 2010), Equation 7.

$$\%\ \text{Ester value} = \%\text{Saponification value} - \%\text{Acid value} \quad (7)$$

Results and discussion

Percent of oil yield

The extracted oil by maceration extraction from seed was bright yellow. The percent of the oil was calculated from 75.0 g of *Guizotia abyssinica* seed extract and 30.0 g of oil obtained. The extracted oil had a good oil amount 40% (Table- I) when compared to the reported Ethiopian seed oil yields, which range from 39.8% – 46.9% (Satish and Shrivastava, 2009). Additionally, other authors reported a wide range, 30% – 50% (Berihun and Molla, 2017) and 37%– 43% (Sarin *et al.* 2009)**,** in obtaining oil from niger seeds. Statistical data vary greatly on the production of *G. abyssinica* seed oil for various reasons. However, in all reported yields of the oil, the percentage ranges include the obtained result in this study. What does it mean? This result shows that the oil obtained from the study area had high oil extraction efficiency.

The physicochemical analyses of the oil were determined according to standard procedures (Paquot, 2013). Table I shows the obtained results. The properties obtained from of the oils showed their utility for human consumption and as raw materials in industrial products.

Table I. Physicochemical analysis result of *G. abssynica* seed oil

Parameters	Values[#]
Moisture content (%)	9.5 ± 0.40
Specific gravity (25)	0.90 ± 0.02
Saponification value (mg KOH/g oil)	175.0 ± 0.60
Acid content (mg KOH/g oil)	1.20 ± 0.5 0
Free fatty acids (%)	0.60 ± 0.25
Ester content (mg KOH/g oil)	173.8 ± 0.10

[#]Values represent means standard deviations (n = 3).

Moisture content

The amount of moisture from the extracted oil was analyzed according to the formula for calculating moisture. Then, the moisture content obtained from the oil was 9.5 ± 0.40 % (Table I). In any sample, too much moisture has been proven to cause caking, especially in flour, and can also determine the packing and viability of growth of microorganism (Adeyeye and Ayejuyo, 2000). Therefore, moisture content determination is one of the most fundamental and important parameter for analytical procedures. Hence, minimizing the moisture percentage of the oil has advantages in the storage stability since the lower the moisture content is, the enhanced the storability. This can remain accomplished by roasting the oil to remove wet and refining the extracted oil.

Specific gravity

Table I shows that the calculated specific gravity was 0.90 ± 0.02, which is analogous to the specific gravities of oils commencing the same species (Hailu *et al*. 2023, Yonnas *et al*. 2019), and the oil's specific gravity is similar to the specific gravity of other plant oils, such as pumpkin seed oil and okra seed oil (Ziaul *et al*. 2019, Rahman *et al*. 2023). Specific gravity or relative density is unit less since it is density of oil to density of water ratio. Since this is a ratio of densities, the number is uncomplicated and devoid of units. The figure represents the fatty acids' average molecular weight in the oil. Since the fatty acid chain length is proportionate to the fatty acid molecular mass, the specific gravity of the oil is proportional to the fatty acid mean chain length of the oil (Akinsanmi *et al*. 2015).

Saponification value

The saponification value of niger seed oil, was 175.0 ± 0.60 mg KOH/g oil (Table-I). The obtained value is included in the range of niger seed saponification values of oil (171.67 – 194.67 mg KOH/g) (Hailu *et al*. 2023) and okra seed oil saponification values (174.38 and 184.80 mg KOH/g) (Rahman *et al*. 2023). Since soap is a byproduct of alkaline hydrolysis and is made of potassium or sodium salts of higher fatty acids, saponification is the alkaline hydrolysis of oils or fats. Information about the average molecular weight of each fatty acid present is contained in saponification. The basic procedure involves titrating excess potassium hydroxide with a standard volumetric hydrochloric acid solution after boiling a sample under reflux with an ethanolic potassium hydroxide solution. The saponification value is a crucial analytical measure for determining the average molecular weight of the fatty acids in the glycerides that make up oil. The molecular weight of the fatty acids in the glycerides increases with decreasing saponification value and vice versa (Negera, 2018).

Acid value

The acid value of the extracted oil (1.20 ± 0.50 mg KOH/g oil) (Table I) is similar to the estimated acid value in Table II. This result is similar to the previously obtained acid value of niger seed oil (Hailu *et al*. 2023) and other seed oils, such as *Nicandra phaysaloids* and *Linum Usitatissimum* L. (Danlami *et al*. 2014; Bhavsar *et al*. 2019). The FAO/WHO recommendation states that all edible oils have a maximum allowable level of less than 0.6 mg KOH/g of oil. The current finding indicates a maximum purity and suitability for soap production, but the oil's edibility at this level is very low and it is not advised for consumption. The value is slightly higher than the acceptable range for edible oil. Consequently, additional processing is required to reduce its acidity level so that it can be consumed (Janporn *et al*. 2015). The acid value is a number that indicates how much potassium hydroxide (in milligrams) is needed to neutralize the free acids in 1.0 g of the substance. If the system contains additional acid components like amino acids or acid phosphates, the acid value could be overestimated. Since the acid value is frequently a good indicator of the conversion of triacylglycerol into free fatty acids, it negatively affects the quality of many lipids. The hydrolytic rancidity is quantified by the acid value. It generally indicates whether or not the oil is edible. Because triglycerides are transformed into fatty acids and glycerol as an oil ages, the older the oil, the higher the acid value will be (Negera, 2018).

Table II. The mass of oil required for the acid test centered on the expected acid value as described in International Organization for Standardization (2009).

Acid value expected (mg/KOH/g oil)	Required mass of oil for test (g)
< 1	20
1–4	10
4–15	2.5
15–75	0.5
> 75	0.1

Free fatty acid percentage

The extracted oil has greater acid values than the standards (0.6 mg KOH/g), signifying that the oil from the *G.abyssinica* has the highest free fatty acid values. Based on this, the current finding has higher %FFA than the standard oil %FFA, which matches the reported researches (Nuru and Paulos, 2021).

Ester value

The ester value was derived from the acid and saponification values. It was computed by deducting the acid value from the niger seed oil's saponification value. The saponifiable fatty acids in the oil, excluding the free acids, are indicated by the ester value (Aremu *et al*. 2015).

Conclusion

The production oil and physicochemical analysis of niger seed oil were done to compare and contrast the characteristics of the oil from the *G. abssynica* grown in the study area and to recommend for high oil production and it's used as edible oil. The results show a low acid value, high saponification value and low levels of free fatty acids value indicating that the oils are edible and have a long shelf life of *G. abssynica* seed oil could be a substitute edible oil source that people would prefer. However, despite being rich in oil and economically significant for the subsistence of small and marginal farmers in the country's arid and semi-arid regions, the plant *G. abyssinica* is treated as an overlooked, underutilized crop. The production of the niger seedis limited to only protection of soil erosion, the feedstock crop, and human consumption asa roasted grain in many parts of the country. In order to achieve this, modern farming, harvesting, and storage practices are advised in order to produce food crops and oil for the diet in order to increase food and nutritional security.

Competing interests

The authors declare that they have no competing interests.

Acknowledgements

Authors acknowledge the Department of Chemistry, Mekdela Amba University, Ethiopia for facilitating the laboratory works.

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