Journal of Agriculture and Ecology Research International

17(2): 1-9, 2018; Article no.JAERI.47966
ISSN: 2394-1073

Determination of Yield and Quality Parameters of Lecithin Produced from Some Elite Varieties of Nigerian Sesame (*Sesamum indicum*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author AYM designed the study, wrote the protocol, performed the experimental analysis and wrote the first draft of the manuscript. Authors EO and MCO managed the statistical analysis of the study. Authors AMS and SS managed the literature searches. Author EGO wrote the final draft of the manuscript while author AOA managed the grammatical and final editing of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2018/v17i230043
Editor(s):
(1) Dr. Daniele De Wrachien, Department of Agricultural and Environmental Sciences, State University of Milan, Italy.
Reviewers:
(1) Marcelo Barcellos da Rosa, Federal University of Santa Maria, Brazil.
(2) F. J. Owuna, Usmanu Danfodiyo University, Sokoto, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47966

Original Research Article

Received 27 October 2018
Accepted 04 March 2019
Published 13 March 2019

ABSTRACT

Lecithin is usually derived as a by-product of vegetable oil processing. It is also known as phosphotidycholine, it is important for its wide use in food manufacturing, product development as well as pharmaceutical products formulation. The quantity of lecithin being imported into Nigeria for use in several industrial sectors is steadily increasing; the attendant effects of such huge importation can be minimized by sourcing lecithin from Nigerian varieties of oil bearing seeds such as sesame. Sequel to a careful selection of seeds, oil was extracted from four varieties of Nigerian sesame using soxlet extraction method. Lecithin was later produced from the extracted oil through oil degumming process. Lecithin quality parameters such as Iodine Values (I.V), Peroxide Values (P.V), Saponification Value (Sap.V), Acid Values (A.V) and Free Fatty Acid (FFA) values were subsequently evaluated for all oil and lecithin samples extracted. Percentage yield of lecithin isolated from the selected varieties of sesame namely: NCRIBEN 01M, NCRIBEN O2M, NCRIBEN

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04E and NCRIBEN 05E: are 3.57%, 3.64 % 2.85% and 3.14% respectively. Values of some quality indices such as the iodine values, peroxide values, Acid Values and Free Fatty Acid evaluated in this research project were found to fall within the FAO/WHO recommendations for lecithin. This study has therefore, contributed to the availability of detailed information from the characteristics stand point and quality index of oil extracted from the selected varieties of sesame and lecithin isolated from their oils. This study therefore concludes that lecithin may be sourced from some Nigerian varieties of sesame and their quality may be enough to meet various industrial applications.

Keywords: Lecithin; sesame; phosphotidycholine; oil degumming; quality index; Nigerian varieties.

1. INTRODUCTION

Lecithin is an important extra product of vegetable oil processing which has numerous applications in agriculture, health, pharmaceutical and food industries [1]. The compound which is also widely referred to as phosphotidycholine is a mixture of glycerol-phospholipids from animal, vegetable and microbial sources. It also contains varying amount of triacylglycerols, fatty acids, glycolipids, sterols and sphingolipid [2]. The major source of commercial lecithin is soybean oil and it is called 1,2-diacylglycerol-3-phosphorylcholine [3].

In human, the role of lecithin is enormous in nerve co-ordination especially in the control of nerve activities and breathing [2]. It is also extensively used in agriculture and one of its major applications is its incorporation into animal feeds where it supplies essential ingredients such as fatty acids needed in animal ration [4].

Lecithin also improves feed processing and adds to the physicochemical characteristics such as peroxide value required for feed palatability to animals. As a source of choline, lecithin serves as antioxidants for the highly unsaturated oil in animal feeds as well as in fertilizer production, lecithin serves as conditioning and spreading agent. It is also incorporated into pesticides where it is used for adhesion, as an antioxidant, biodegrading and dispersing agent, also as an emulsifier, stabilizer, viscosity modifier and penetrating agent [5].

A unique characteristic of Lecithin is its dual lipophilic and hydrophilic feature hence its ability to attract both-water and fat, a characteristic which confers it with the unique ability to act as a bridge between water and oil [6].

In many industries, lecithin can perform varying roles as a result of its hydrophilic and lipophilic properties and these includes but not limited to roles it plays in several industrial sectors as an emulsifying agent, dispersing, wetting and conditioning agents. Also, antioxidant properties of lecithin made the compound ($C_{35}H_{66}N0_7P$) essential as an ingredient in the production of items such as; chocolate foods, chewing gum, edible oil, ice cream, instant foods, insecticides, ink, leather, macaroni and noodles etc [1].

Other industrial sectors where lecithin is required for production also includes; pharmaceutical and drug manufacturing, cosmetics, Self Emulsifying Drug Delivery Systems (SEDDS), beverage manufacturing and paint manufacturing [7].

Factors such as bio-crude oil storage, soil type, nutrient availability, climate changes, drying process and handling manner have been reported to affect production and quality of lecithin [8].

Sesame (*Sesamum indicum*) is a member of the *Pedaliaceae* plant family. The crop is one of the world's most important and oldest known oil seed crops [9]. It took the ninth position among the top thirteen oilseed crops which made up ninety percent of the world production of edible oil [9]. The crop is adapted and cultivated both in the tropic and temperate zones of the world [10]. It is grown mostly for the oil extracted from the seed which is edible and use for industrial and pharmaceutical purposes. Its oil contents ranges between 35-50 percent [9].

Sesame is popularly known as Beniseed in Nigeria and some other African countries. Numerous works have been carried out to adapt several varieties and ecotypes of sesame to various ecological conditions of Africa [11]. However, the National Cereals Research Institute – a Nigerian government research and development organization has developed and released six (6) different varieties of sesame adapted to various ecological and agronomic conditions of Nigeria [12]. These released varieties are often referred to as improved or elite varieties amongst Agricultural scientists in Nigeria.

The Nigerian Industrial sector imports approximately 1500 tons of lecithin annually for use in the agriculture, healthcare, pharmaceutical manufacturing, food processing, instant food production, cosmetics formulation, paint manufacture etc [13].

Meanwhile, the importation of such huge amount of lecithin into the country requires about one hundred and eighty (USD180, 000) thousand US Dollars which constitutes a lot of pressure on the value of the Nigerian currency (Naira) as the importation involves high amount of foreign exchange. Therefore, there is a growing pressure on local manufacturers to source raw materials locally, hence the need to conduct research towards the exploration of raw materials of oil-bearing seeds such as sesame which is being cultivated abundantly across many of the agricultural belts of the country.

Lack of significant information and data in terms of biochemical components such as lecithin as well as the unavailability of information from the nutritional standpoints and oil characteristics have been discovered to be a major limiting factor to the development of a robust sesame value chain in Nigeria [14].

Therefore, the evaluation of lecithin content of some Nigerian varieties of sesame is essential to the improvement of the Sesame Value Chain (SVC) in Nigeria.

The aim of this study was to however extract and characterize lecithin from oil of selected varieties of Nigerian sesame for industrial application.

2. MATERIALS AND METHODS

The four improved (elite) varieties of sesame namely; NCRIBEN 01M, NCRIBEN 02M, NCRIBEN 04E and NCRIBEN 05E were obtained from the Beniseed Research Programme of the National Cereals Research Institute, Badeggi, Nigeria in December 2017. The seeds were subsequently, subjected to the following experimental procedures:

2.1 Seed Preparation

500 g each of the four varieties were manually washed with distilled water, sorted and then dried at room temperature i.e. 25°c for two weeks after which they were pulverized with the use of Genotek model 122 electronic blending machine made in Germany and kept inside a 4°c Thermo cool refrigerator model 22341, made in China until use.

2.2 Proximate Analysis of selected sesame seeds

The protein and ash contents of the sesame seed varieties were determined using AOAC [15] number: 923.03 and IACST [16] methods, Nitrogen conversion factor 6.235 was used to calculate the crude protein of the sesame seed samples while oil contents and moisture contents of the sesame samples were evaluated according to IUPAC [17].

2.3 Extraction of Seed Oil

The extraction of oil from the sesame seed varieties was carried out in accordance to the AOAC method (1990) [15] which involves the use of soxhlet apparatus using petroleum ether as the extraction solvent which was added to the extracting flask in 2:1 volume ratio i.e. the volume of the extraction solvent was twice the weight of the seed added and each variety of the sesame sample was made to extract for between 5-7 hours after which the solvent and oil mixture was evaporated and the oil recovered from the solvent.

2.4 Production of Lecithin from Extracted Sesame Oil

70 ml each of sesame oil was measured into a cleaned and dried conical flask and heated up to 70°c, 1.4 ml of water was added at the 70°c temperature after which six (6) drops of Hydrogen peroxide was added and stirred with a magnetic stirrer for 1 hour as described by Donatus et al. [18]. This method is called degumming of oil. Lecithin was then isolated by adding 20 ml of acetone to the mixture because lecithin is insoluble in acetone; this was followed by purification of the extracted lecithin with the use of column chromatography [6,18,19].

2.5 Characterization of Extracted Oil and Isolated Lecithin

The AOAC [14] and IUPAC [16] methods were used to determine the Acid value, (A.V) peroxide value (P.V), Saponification value (SAPV) and the Refractive Index (RI) while the

Free Fatty Acid (FFA) of both oil and lecithin were determined following the IACST method (1986) [15].

2.6 Determination of Lecithin Yield

The total lecithin extracts from oil of each sesame variety were weighed and recorded in percentage:

Percentage = (Weight of lecithin yield × 100 / Total volume of oil)

2.7 Statistical Analysis

Values generated from triplicate laboratory trials were analyzed using Statistical Packages for Social Science (SPSS) version 16 (SPSS Inc. USA) and presented herewith as means and Standard Error of Means (SEM). Comparisons between different groups were determined by one way Analysis Of Variance (ANOVA) followed by Duncan Multiple Range Test (DMRT). The level of significance was set at P<0.05. Values presented in tables are means and SEM of three (3) determinations. Values along the same row with different superscripts are significantly different (P<0.05).

3. RESULT AND DISCUSSION

As shown in Table 1: The proximate composition of selected sesame varieties; the moisture content ranged between 2.68 ± 0.03 – 3.87 ± 0.55 %, going by the moisture content which gives a level of information about the actual content of the dry matter and the storability of plant materials, there is a statistically significant difference (P>0.05) in the moisture content of NCRIBEN 05E while no difference was obtained in the moisture content value of the other three varieties, this therefore implies that; NCRIBEN 05E is more storable than the other evaluated varieties yet the moisture contents of all the four evaluated varieties conforms with acceptable moisture content of sesame which is put in the range of 2.80 to 4.7% [20]. The carbohydrate contents of the evaluated sesame varieties can be applied in food processing and formulation requiring such range of carbohydrate contents though, there is statistically (P>0.05) significant difference in their proximate carbohydrate contents which makes it convenient for each of the varieties to be used for different proximate carbohydrate dependent purposes. The carbohydrate content of the studied sesame varieties however, ranged between 17.95± 0.80 – 27.11± 0.95, these values fall within ranges reported for sesame varieties of other tropical Sub Sahara African countries [7].

The result of the proximate composition of the evaluated sesame varieties (Table 1) however, shows that there are also significant difference (P>0.05) in the values of the most economic proximate parameters of ash, protein, fats and fibre in all the four sesame varieties.

However, the benefit of the statistically (P>0.05) significant difference observed in these parameters (Ash, Protein, Fat and Fibre) is that each of the varieties can be subjected to different utility, product formulation and value addition on the respective strength of data from these significantly different proximate stand point. This is in fact, a tool required to extend the values of these varieties of sesame within the Nigerian industrial sector [13].

For instance, the proximate Ash content helps to determine the amount and the type of mineral embedded in each variety while the proximate protein content is a requirement for industrial formulation of animal feeds. The fat content is helpful in understanding the potential of each seed varieties as sources of lipid based industrial raw materials such as lecithin. Proximate values observed for all the evaluated varieties however fall within ranges previously reported for sesame seed [18].

The percentage oil yield of the evaluated sesame samples is available in Table 2. The oil yield was higher in NCRIBEN 02M (5O.52 ± 0.70%) when compared to the yields from NCRIBEN 01M (41.23 ± 0.46%), NCRIBEN 04E (40.73 ± 0.64%) and NCRIBEN 05E (40.21 ± 0.81%) which had the lowest oil yield. However, from the result shown in Table 2, each of the evaluated sesame varieties can be said to posses appreciable inherent oil yield potential capable of making them useful as alternative sources of vegetable oil through which raw materials such as lecithin can be produced.

This is however so, as oil content of sesame is expected to range between 35-50% depending on a number of factors such as varietal morphological characteristics, agronomic conditions, environment etc [20].

Table 1. Proximate composition of selected Nigerian sesame (Beniseed) varieties

Variety	Moisture	Ash	Protein	Fat	Carbohydrate	Fibre
NCRIBEN 01M	3.37±0.11^{b}	6.69±0.15^{b}	14.12±0.20^{a}	40.42±0.30^{a}	27.11±0.95^{c}	7.11±0.95^{b}
NCRIBEN 02M	3.51±0.10^{b}	11.39±0.45^{d}	15.77±0.15^{a}	40.73±0.29^{a}	20.95±0.13^{b}	7.39±0.95^{b}
NCRIBEN 04E	3.87±0.55^{b}	8.48±0.20^{c}	18.16±0.24^{b}	45.35±0.33^{b}	17.95±0.80^{a}	6.51±0.03^{a}
NCRIBEN 05E	2.68±0.03^{a}	4.25±0.29^{a}	15.42±0.13^{a}	50.19±0.02^{c}	20.22±0.05^{b}	6.84±0.45^{a}

Values are mean ± SEM of 3 determinations. Values along the same row with different superscript are significantly different ($p< 0.05$)

Table 2. Percentage oil yield of selected varieties of Nigerian sesame

S/N	Variety	Oil Yield %
1	NCRIBEN 01M	41.23±0.46
2	NCRIBEN 02M	50.52±0.70
3	NCRIBEN 04E	40.73±0.64
4	NCRIBEN 05E	40.21±0.81

Table 3. Physicochemical characteristics of oils produced from selected Nigerian sesame varieties

Variety	Refractive Index	S.G	I.V 1_2/100g	P.V mEq/1000g	Sap. V (mgKOH/g)	A.V (mgKOH/g)	FFA (%)
NCRIBEN 01M	1.46±0.01^{a}	0.93±0.00^{a}	118.47±1.01^{a}	14.18±0.97^{b}	151.75±3.01^{a}	2.80±0.25^{a}	1.40±0.10^{a}
NCRIBEN 02M	1.66±0.02^{b}	0.93±0.01^{a}	116.95±1.24^{a}	10.32±0.16^{a}	180.62±4.78^{b}	2.01±0.01^{a}	1.00±0.08^{a}
NCRIBEN 04E	1.46±0.01^{a}	0.93±0.02^{a}	120.38±2.63^{a}	17.50±0.34^{c}	156.23±4.13^{a}	9.64±0.13^{b}	4.82±0.03^{b}
NCRIBEN 05E	1.47±0.01^{a}	0.93±0.00^{a}	118.34±1.46^{a}	13.17±0.39^{b}	194.10±6.09^{c}	10.32±0.14^{b}	5.16±0.01^{b}

Values are mean ± SEM of 3 determinations. Values along the same row with different superscript are significantly different ($P < 0.05$).
S.G=Specific Gravity, I.V=Iodine Value, P.V=Peroxide Value, Sap.V=Saponification Value, A.V=Acid Value, FFA=Free Fatty Acid.

As presented in Table 3, the physicochemical characteristics of oils extracted from the selected Nigerian varieties of sesame revealed no statistically significant difference ($P<0.05$) in the values of the Refractive Index (R.I),Specific Gravity (S.G) and the Iodine Value (I.V) amongst all the varieties evaluated and these parameters ranged between 1.46±0.01 – 1.47±0.01, 0.93±0.00 – 0.93±0.02 and 116.95±1.42 – 120.38±2.63 respectively while there are statistical significant difference ($P<0.05$) in the values of Peroxide Value (P.V), Saponification Value (Sap. V) Acid value (A.V) and the Free Fatty Acid (FFA), an indication that each of the varieties can be subjected to different utilization necessary to create demand for each of the evaluated sesame varieties.

Lecithin was isolated from oils of each of the evaluated Nigerian varieties of sesame, as presented in Table 4, lecithin yields of (3.57%, 3.64%, 2.85% and 3.14%) were obtained from NCRIBEN 01M, NCRIBEN 02M, NCRIBEN 04E and NCRIBEN 05E respectively. Lecithin yield from oils of the evaluated sesame seeds are higher than yield previously reported for Nigerian varieties of Soybean (2.07-2.71%) [6]. The higher yield of lecithin form the evaluated sesame varieties as compared to previously evaluated oilseeds such as soybean is therefore an indication that oils from sesame can serve as potential alternative sources of industrial lecithin for commercial purposes.

Table 4. Percentage yield of Lecithin produced from selected Nigerian sesame varieties

S/N	Variety	Yield %
5	NCRIBEN 01M	3.57±0.07
6	NCRIBEN 02M	3.64±0.07
7	NCRIBEN 04E	2.85±0.13
8	NCRIBEN 05E	3.14±0.06

As presented in Table 5, the saponification value of lecithin isolated from the evaluated sesame varieties was found to range between 171.00±0.04 – 204.08±0.05 mgKOH/g, these values are however, higher than the saponification values reported for the standard non-GMO lecithin; Alcolec^R being imported into Nigeria, the Saponification values as presented in Table 5 also fall within the FAO/WHO recommendation [21]. Meanwhile, Saponification value is directly related to the chain length of fatty acids, higher saponification value therefore indicates the presence of low molecular weight fatty acid in triglyceride which is well desirable for the industrial formulation of products such as paints and soaps.

The iodine values of isolated lecithin from all evaluated varieties of sesame were also measured and equally reported in Table 5, iodine values of lecithin produced and evaluated in this study ranges between 75.22± 0.12 – 78.37± 0.02 (1_2/ 100 g), these values are however lower than 89.26 (1_2 / 100 g) reported for lecithin isolated from boal [19]. Though, slightly lower than the iodine value of the standard lecithin adopted for this study; the iodine values obtained from this study still fall within the recommended range of 85 (1_2/100 g) which is an indication of their potential use in iodine value dependent industrial formulations such as in paints production.

Acid value as presented in Table 5, was found to range between 0.65±0.01 – 2.42±0.02%, the acid value is a quality index of lecithin and a measure of its acidity, the acid values of lecithin obtained in this study were much lower than the value of 33.10% reported for lecithin produced from Squid viscera oil [19]. The lower acid value of lecithin obtained in this study however, indicates higher quality of lecithin from the evaluated sesame varieties.

Peroxide value is another major quality index of lecithin as it describes the extent of spoilage which may have occurred due to rancidity occasioned by handling and processing. Peroxide value of lecithin obtained in this study ranged between 6.96± 0.02 – 12.57± 0.02 mEq/100 g (Table 5). However, only the peroxide value of lecithin produced from NCRIBEN 02M was found to be within the recommended range of 10 mEg/100 g, it is also within the range reported for the standard lecithin (Alcolec) brand which was reported to be 6 mEg/100 g. Peroxide values of lecithin produced from the other three sesame varieties were however, higher than that of the standard lecithin and also do not fall within the recommended range, this situation may however be as a result of some genetic and morphological variations, seed handling, oil processing and some environmental factors.

Meanwhile, the FAO.WHO [21] has recommended a peroxide value of 10 mEq/100 g for food grade lecithin.

Table 5. Physicochemical characteristics of lecithin produced from selected varieties of Nigerian sesame seed

Variety	Refractive index	S.G	I.V 1_2/100g	P.V mEq/ 1000g	Sap. V (mgKOH/g)	A.V (mgKOH/g	FFA (%)
NCRIBEN 01M	1.46±0.01[a]	0.92±0.02[a]	76.50±0.01[a]	11.22±0.04[b]	171.00±0.04[a]	0.68±0.01[a]	0.34±0.00[a]
NCRIBEN 02M	1.46±0.01[a]	0.91±0.00[a]	78.37±0.02[a]	6.96±0.02[a]	186.32±0.07[b]	0.65±0.01[a]	0.33±0.01[a]
NCRIBEN 04E	1.46±0.01[a]	0.92±0.01[a]	75.22±0.12[a]	12.57±0.02[b]	182.52±0.48[b]	1.19±0.01[b]	0.59±0.00[b]
NCRIBEN 05E	1.46±0.00[a]	0.91±0.01[a]	76.14±0.02[a]	11.11±0.01[b]	204.08±0.025[c]	2.42±0.01[c]	1.21±0.00[c]
ALCOLEC [(C)]Soybean lecithin standard (Non GMO Lecithin liquid) (www.americanlecithincompany.org	NA	NA	80	6	124	29	14.5
FAO/WHO RECOMMENDATION	NA	NA	85 max	10max	NA	36max	18max

Values are mean ± SEM of 3 determinations. Values along the same row with different superscript are significantly different (P < 0.05).S.G=Specific Gravity, I.V=Iodine Value, P.V=Peroxide Value, Sap.V=Saponification Value, A.V=Acid Value, FFA=Free Fatty Acid.

4. CONCLUSION AND RECOMMENDATION

The study has shown that oils from the evaluated sesame (Beniseed) varieties contain appreciable quantities of lecithin enough to project these varieties as alternative sources of lecithin. The lecithin produced in the study also demonstrated some industrial qualities sequel to the evaluated physiochemical characteristics which fall within certain recommendations of the FAO/WHO as well as ranges earlier reported by previous workers.

The analysis of the quality index of lecithin is necessary for its effective and proper utilization. It is therefore safe to conclude that the evaluated Nigerian varieties of sesame are novel potential sources of lecithin which may be used as raw material for cottage and industrial purposes.

This development is however necessary for additional and effective utilization of the evaluated Nigerian sesame varieties as it is capable of leading to increased cultivation and its attendant effects on job creation which may result to a robust sesame value chain in Nigeria, a feat which is required to maximize the contribution of sesame to the Agricultural GDP of the Nigerian economy.

Cold press oil extraction method has been widely reported to enhance the yield of oil extractable from oilseeds, therefore, the fabrication of pro-youth and women friendly cold press oil extracting machines would enhance the subsequent production of lecithin from oils of sesame seeds. Also, a research into the enzymatic and molecular modification of lecithin content of the evaluated sesame varieties may however aid the adoption of Nigeria varieties of sesame as a reliable source of lecithin for industrial use in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Available:https://books.google.com.bd/books

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47966