

## Original Research Article

# ISOLATION AND CHARACTERIZATION OF LECITHIN FROM SELECTED NIGERIAN VARIETIES OF SOYBEAN (*GLYCINE MAX*)

### ABSTRACT

Lecithin is an important by-product of vegetable oil processing that has foremost functions in health, food manufacturing and processing, industrial product development and pharmaceutical formulation. The importation of lecithin to Nigeria for Industrial use can be reduced through sourcing of lecithin from Nigerian varieties of oil bearing seeds such as soybean. Following careful selection of seeds, sorting and cleaning; oil was extracted from four varieties of Nigerian nationally released varieties of soybean using soxlet procedure. Lecithin was subsequently isolated from the extracted oil through the process known as degumming. 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 evaluated for all oil and lecithin samples extracted. Percentage yield of lecithin isolated from the selected varieties of soybean namely: TGX 1904-6F, TGX 1987-62F, TGX 1448-2E and TGX 1978-10F are 2.71%, 2.5% and 2.07% respectively. Value of some quality indices such as the Jodine values, peroxide values, Acid Values and Free Fatty Acid obtained from this study were also found to be within the FAO/WHO recommended specifications. This study has provided detailed information from the characteristics stand point and quality index of oil extracted from the selected varieties of soybean as well as lecithin isolated from their oils; such data is however desirable so as to channel each of the selected soybean varieties to appropriate utilization and enhanced value addition necessary to improve the soybean value chain in Nigeria. This study therefore concludes that quality lecithin may be sourced from some Nigeria varieties of soybean to meet various industrial purposes.

**Keywords:** Soybean, lecithin, quality index, oil characteristics, oil degumming.

### INTRODUCTION

Lecithin is an important by-production of vegetable oil processing industries which has several applications in health, agriculture and food industries (Dreon et al, 2010). The compound is a mixture of glycerol-phospholipids from animal, vegetable and microbial sources. It contained varying amount of triacylglycerols, fatty acids glycolipids, sterols and sphingolipid (Gordon, 2000). The major source of commercial lecithin is soybean oil and it is called 1,2-diacylglycerro-3-phosphoryl chlorine (Dashiel, 2003).

Lecithin has diverse role in human nerve activities especially in the control of nerve activities and breathing (Garden, 2003). Lecithin is extensively used in agriculture, one of its major applications is its incorporation into animal feeds where it supplies essential ingredients needed in animal ration (Nahoski, 2013): lecithin also improves feed processing and adds to physicochemical characteristics required for feed palatability to animals. As a source of choline, lecithin serves as antioxidants for the highly unsaturated oils 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, as an emulsifier, stabilizer, viscosity modifier and penetrating agent (Callins, 2010).

Lecithin is both lipophilic and hydrophilic hence its ability to attract both-water and fat characteristic which made it act as a bridge between water and oil (Olisa, 2009).

Industrially, lecithin plays diverse roles as a result of hydrophilic and lipophilic properties and these includes but not limited to roles play in several industrial sectors as an emulsifying agent, dispersing, wetting, conditioning agents. Also, antioxidant properties of lecithin made the compound essential as an ingredient in production of items such as; chocolate foods, chewing gum, edible oil, ice cream, instant foods, insecticides, ink, leather, macaroni and noodles etc. (Dreon et al, 2010).

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 (Lisa et al, 2016).

Production and quality of lecithin could however, be affected by crude oil storage, soil type, nutrient availability, climate changes, drying process and handling manner (Renfree, 2005).

Soybean (*Glycine Max(L)*) belongs to the leguminosae family, a plant which originated from Eastern Asia (Singh and Shivakumer, 2010). Nigeria is one of the largest producers of soybean in the world with an annual production output of

600,000 MT/annum (NCRI, 2016). The crop consists of approximately 40 % protein, 23 % carbohydrate, 20 % oil, 5 % mineral, 4 % fibre and 8 % moisture (Njoku et al, 2015). In 2009, soybean accounted for 365million tons of vegetable oil in the world far ahead of other oil crops (Singh and Shivakumar, 2010).

Soybean is however, one of the most valuable crop in the world as a source of oil and protein necessary for livestock, aquaculture and most importantly, for human consumption (Egbo, 2012). The production and demand of soybean world over has increased dramatically because of its growing popularity. For instance, the world production of soybean has grown from 28.6 million of metric tons in 1961-1965 to 217.6 million fold increase (Masuda and Goldsmith, 2009).

There are numerous varieties and ecotypes of soybean adapted to various ecological conditions (Ismaila et al, 2010). However, the National Cereal Research Institute – a Nigerian Government research and development organization has developed and released nine (9) different varieties of soybean adapted to various ecological and agronomic conditions of Nigeria (NCRI, 2016).

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. (NBS, 2011).

Meanwhile, the importation of such large amount of lecithin into the country constitutes a lot of pressure on the value of the Nigerian currency (Naira) as the importation involves huge 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 soybean which is being cultivated abundantly across most of the agricultural belt of the country.

Lack of significant information and data in terms of biochemical components such as lecithin as well as the unavailability information from the nutritional standpoints and oil characteristics have been discovered to be a major limiting factor to the development of a robust oilseed value chain in Nigeria (RMRDC, 2004).

Therefore, the evaluation of lecithin content of some Nigeria varieties of soybean is essential to the improvement of oilseed value chain in Nigeria. This is however, because if oil is extracted from soybean and lecithin is subsequently produced from the extracted oil, such development would enhance the value of soybean produced in Nigeria, hence the objective of this study. The enhancement of the value of soybean produced in Nigeria through its positioning as a reliable source of lecithin for industrial incorporation is however expected to yield increased cultivation of soybean in commercially large quantities, leading to the creation of more agri-business jobs and help to manifest the potentiality of the crop in contributing substantially to the Agricultural Transformation Agenda Support Programme (ATASP) of the current Federal Government of Nigeria.

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

## **MATERIALS AND METHOD**

The four cultivars of soybean namely; TGX 1904-6F, TGX 1957- 62F, TGX 1443- 2E and TGX1987-10F were obtained from the Soybean Research Programme of the National Cereals Research Institute, Badeggi in Niger State, Nigeria. The seeds were subsequently, subjected to the following experimental procedures:

### **Seed Preparation**

500g each of the four varieties were manually washed with distilled water, sorted and then dried at room temperature for two weeks after which they were pulverized using electronic blending machine and kept at 4<sup>0c</sup> until use.

### **Proximate Analysis**

The protein and ash contents were determined using AOAC (1990) number: 923.03 and IACST (1986) methods, Nitrogen conversion factors 6.235 was used to

calculate the crude protein of the soybean samples while oil contents and moisture contents of the samples were evaluated according to IUPAC (1988).

### **Extraction of Seed Oil**

The extraction of oil from the soybean seed varieties was carried out in accordance to the AOAC method (1990) 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 and each variety of the soybean 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.

### **Production of lecithin from Soybean Oil**

70ml each of soybean oil was measured into a cleaned and dried conical flask and heated up to 70<sup>0</sup>c, 2% of water was added at this temperature, six (6) drops of Hydrogen peroxide was then added and stirred with a magnetic stirrer for 1 hour, in accordance with Donatus et al, (2016). This method is called degumming of oil.

### **Characterization of Extracted Oil and Isolated Lecithin**

The AOAC (1990) and IUPAC (1988) 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).

### **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 ( $P < 0.05$ ).

## **RESULT AND DISCUSSION**

As shown in table 1: The proximate composition of selected soybean varieties; the moisture content ranged between  $3.04 \pm 0.14 - 3.5 \pm 0.55$  %, though, no statistically significant difference was observed among the four (4) Soybean varieties evaluated in this study, yet the moisture content conforms with acceptable moisture content of soybean put in the range of 2.80 to 4.8 % (IPGRI, 2014) Aside from the moisture content, there are statistically significant differences ( $P < 0.05$ ) in the values of all other proximate components of each of the evaluated varieties of soybean and the implication of this is that each of the the evaluated soybeans varieties has one component advantage over and above another variety and vice-versa; this is however a good indication for industrial and economic benefits because each of the varieties can be positioned for different utilization purposes based on proximate content related need, this may also encourage demand for all the evaluated varieties from different industrial sectors. This development is however, a veritable tool for the growth of the soybean value chain in Nigeria.

**Table 1** Proximate composition of selected Nigerian soybean varieties

VARIETY	MOISTURE	ASH	PROTEIN	FAT	CARBONHYDRATE	FIBRE
TGX 1904-6F	3.38±0.10 <sup>a</sup>	6.48±0.35 <sup>b</sup>	38.79±0.32 <sup>a</sup>	28.72±0.60 <sup>b</sup>	14.66±0.34 <sup>a</sup>	6.94±0.26 <sup>ab</sup>
TGX 1987-62F	3.57±0.55 <sup>a</sup>	8.13±0.55 <sup>c</sup>	37.07±1.39 <sup>a</sup>	26.93±0.18 <sup>ab</sup>	17.94±0.26 <sup>b</sup>	6.33±0.21 <sup>a</sup>
TGX 1448-2E	3.04±0.14 <sup>a</sup>	5.09±0.19 <sup>a</sup>	44.00±0.28 <sup>b</sup>	24.24±0.76 <sup>a</sup>	15.94±1.36 <sup>a</sup>	6.00±0.71 <sup>a</sup>
TGX 1987-10F	3.29±0.17 <sup>a</sup>	11.21±0.95 <sup>d</sup>	40.02±0.39 <sup>b</sup>	21.37±0.34 <sup>a</sup>	15.56±0.35 <sup>a</sup>	7.16±0.14 <sup>b</sup>

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

The percentage oil yield of the evaluated soybean samples are presented in table 2. The oil yield was higher in TGX 1987 -10F( $32.23 \pm 0.13$  %) when compared to the yields from TGX 1904-6F ( $28.46 \pm 0.30$  %),TGX 1448 -2E ( $30.56 \pm 0.43$  %) and TGX 1987 -62F ( $28.26 \pm 0.23$  %) which had the lowest oil yield. From the result shown in table 2, each of the soybean varieties used in this study can be said to possess appreciable inherent oil yield potential capable of making them useful as sources of vegetable oil through which raw materials such as lecithin can be produced. This is however so, as oil content of soybean is expected to range between 25-35 % depending on a number of factors such as varietal morphological characteristics, agronomic conditions, environment etc (IPGRI, 2014).

**Table 2** Percentage oil yield of selected Nigerian Soybean varieties.

S/N	Sample Description	Oil Yield %
1	TGX 1904-6F	28.46±0.30
2	TGX 1987-62F	28.26±0.23
3	TGX 1448-2E	30.56±0.48
4	TGX 1987-10F	32.23±0.28

As presented in Table 3, the physicochemical characteristics of oils extracted from the selected Nigerian varieties of soybean 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  $1.45 \pm 0.10 - 1.46 \pm 0.03$ ,  $0.94 \pm 0.01 - 0.94 \pm 0.02$  and  $123.04 \pm 1.42 - 125.20 \pm 2.14$  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 soybean varieties.



**Table 3** Physicochemical characteristics of oil extracted from selected Nigerian soybean varieties

<b>Sample</b>	<b>Refractive Index</b>	<b>S.G</b>	<b>I.V 1<sub>2</sub>/100g</b>	<b>P.V mEq/1000g</b>	<b>Sap. V (mgKOH/g)</b>	<b>A.V (mgKOH/g)</b>	<b>FFA (%)</b>
TGX 1904-6F	1.46±0.03 <sup>a</sup>	0.94±0.02 <sup>a</sup>	123.09±2.04 <sup>a</sup>	24.00±0.23 <sup>ab</sup>	219.35±5.46 <sup>a</sup>	4.76±0.32 <sup>b</sup>	2.38±0.23 <sup>b</sup>
TGX 1987-62F	1.46±0.03 <sup>a</sup>	0.94±0.02 <sup>a</sup>	124.60±1.42 <sup>a</sup>	20.60±0.45 <sup>a</sup>	228.33±4.61 <sup>a</sup>	4.31±0.33 <sup>b</sup>	2.15±0.34 <sup>b</sup>
TGX 1448-2E	1.46±0.02 <sup>a</sup>	0.92±0.01 <sup>a</sup>	125.20±2.14 <sup>a</sup>	23.52±0.13 <sup>ab</sup>	339.60±3.47 <sup>b</sup>	3.08±0.41 <sup>a</sup>	1.54±0.24 <sup>a</sup>
TGX 1987-10F	1.46±0.10 <sup>a</sup>	0.93±0.01 <sup>a</sup>	123.04±4.02 <sup>a</sup>	28.00±0.45 <sup>b</sup>	252.45±4.57 <sup>a</sup>	4.31±0.22 <sup>b</sup>	2.15±0.46 <sup>b</sup>

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.

Lecithin was isolated from oil of each of the evaluated Nigerian varieties of soybeans, as presented in Table 4, lecithin yields of (2.71 %, 2.57 %, 2.28 % and 2.07 %) were obtained from TGX 1904-6F, TGX 1987 – 62F, TGX 1448 -2E and TGX 1987-10F respectively. Lecithin yield from oils of the evaluated soybean seeds are higher than yield previously reported for Nigerian varieties of melon seeds (0.72-1.17%) (Olisa, 2009). The higher yield of lecithin from the evaluated soybean varieties as compared to other oil seed is an indication that oils from these soybean varieties can serve as potential sources of industrial lecithin for commercial purposes.

**Table 4** Percentage Yield of Lecithin Isolated from Selected Nigerian Soybean

S/N	Sample Description	Yield %
1	TGX 1904-6F	2.71±0.05
2	TGX 1987-62F	2.57±0.12
3	TGX 1448-2E	2.28±0.04
4	TGX 1987-10F	2.07±0.04

As presented in table 5, the saponification value of lecithin isolated from the evaluated soybean varieties was found to range between 171.61±0.49 – 241.48±0.03 mgKOH/g, these values are however, higher than the saponification values reported for the standard non-GMO lecithin; Alcolec<sup>R</sup> being imported into Nigeria, the Saponification values as presented in table 5 also fall within the FAO/WHO recommendation. 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 soap and paints.

The iodine values of isolated lecithin from all evaluated varieties were also measured and also reported in Table 5, iodine values obtained in this study ranges between 78.61± 0.01 – 80.01 ± 0.03 (1<sub>2</sub>/ 100g), these values are however lower than 89.26 (1<sub>2</sub> / 100g) reported for lecithin isolated from boil (Uddin et al, 2011). Though, higher than the iodine value of the standard lecithin adopted for this study; the iodine values generated from this study still fall within the recommended range of 85 (1<sub>2</sub>/100g) which is an indication of their potential use in iodine value dependent industrial formulation such as paints production.

Acid value as presented in Table 5, was found to range between 1.950±0.01 – 2.06±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 extracted from squid viscera oil ( Uddin et al, 2011). The lower acid value of lecithin obtained in this study however, indicates higher quality of lecithin from the evaluated soybean varieties.

Peroxide value is also a 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  $10.60 \pm 0.00$  –  $16.97 \pm 0.02$  mEq/100g (Table 5). However, the peroxide value of TGX 19.87 - 62F was found to be within the recommended range of 10 mEq/100g, it is also within the range reported for the standard lecithin (Alcolec) brand which was reported to be 6 mEq/100g. Peroxide values of lecithin extracted from the other three soybean varieties were however, higher than that of the standard lecithin and also do not fall within the recommended range, a situation which may be as a result of genetic variation, handling, processing and environmental factors.

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

**Table 5: Physiochemical Characteristic of lecithin isolated from selected Nigerian Varieties of Soybean**

	Refractive index	S.G	I.V $I_2/100g$	P.V mEq/1000g	Sap. V (mgKOH/g)	A.V (mgKOH/g)	FFA (%)
TGX 1904-6F	1.46±0.03 <sup>a</sup>	0.92±0.01 <sup>a</sup>	79.51±0.03 <sup>a</sup>	13.93±0.06 <sup>b</sup>	241.48±0.03 <sup>b</sup>	1.950±0.01 <sup>a</sup>	0.97±0.00 <sup>a</sup>
TGX 1987-62F	1.46±0.00 <sup>a</sup>	0.92±0.03 <sup>a</sup>	80.01±0.03 <sup>a</sup>	10.60±0.00 <sup>a</sup>	237.02±0.00 <sup>b</sup>	2.52±0.00 <sup>ab</sup>	1.27±0.01 <sup>b</sup>
TGX 1448-2E	1.46±0.02 <sup>a</sup>	0.92±0.03 <sup>a</sup>	78.29±0.02 <sup>a</sup>	13.49±0.02 <sup>b</sup>	171.61±0.49 <sup>a</sup>	2.89±0.02 <sup>ab</sup>	1.45±0.01 <sup>b</sup>
TGX 1987-10F	1.46±0.00 <sup>a</sup>	0.93±0.00 <sup>a</sup>	78.61±0.01 <sup>a</sup>	16.97±0.02 <sup>c</sup>	187.80±0.046 <sup>a</sup>	3.06±0.02 <sup>b</sup>	1.53±0.01 <sup>b</sup>
ALCOLEC <sup>(C)</sup> Soybean lecithin standard (Non GMO Lecithin liquid) ( <a href="http://www.americanlecithincompany.org">www.americanlecithincompany.org</a> )	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.

## **CONCLUSION AND RECOMMENDATION**

The study has shown that the evaluated soybean oils contain appreciable quantities of lecithin. The isolated lecithin also demonstrated some industrial qualities sequel to the evaluated physiochemical characteristics which fall within certain recommendations of the FAO/WHO as well as earlier reported ranges.

A major importance of lecithin analysis is to find the quality index of lecithin as it is necessary for effective and proper utilization. It is therefore safe to conclude that the evaluated Nigerian varieties of soybean are likely potential sources of lecithin which may be used as raw material for cottage, industrial and commercial purposes.

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

A research into the enzymatic and Molecular modification of lecithin content of the evaluated soybean varieties may however aid the adoption of Nigeria varieties of soybean as a reliable source of lecithin for industrial use in Nigeria.

## REFERENCES

- Adebisi, M.A., Ajala, M.O., Ojo, D.K, Salau A.W. (2005). Influence of population density and season on seed yield and its components in Nigerian sesame genotypes. *Journal of Tropical Agriculture*, 43 (2), 13 -18.
- Adebayo, S. E. Orhevba, B, A., Adeoye, P. A., Musa, J. Y Fase, (2012).Solvent extraction and characterization of oil from African star apple (*Chrysophyllumalbidum*) seeds. *Academic Research International*, 3(2), 23-27.
- Anbarasu, K., Vijayalakshmi, G. (2007). Improved shelf life of protein-rich tofu using *Ocimum sanctum* (tulsi) extracts to benefit Indian rural population. *Journal of Food Science*, 72, 300-305.
- AOAC (Association of Official Analytical Chemists) (1990). Official methods of analysis, 13<sup>th</sup> Ed., Washington D.C: 98
- Borchani C., Besbes, S., Blecker C. H.,& Attia, H. (2010).Chemical Characteristics and Oxidative Stability of Sesame Seed, Sesame Paste, and Olive Oils. *Journal of Agriculture, Science and. Technology*. 12, 585-596
- Chemonics International Inc. (2002). *Overview of the Nigerian Sesame Industry*. The United States Agency for International Development (USAID)/Nigeria RAISE IQC Contract No. PCE-I-00-99-00003-00
- Fariku, S., Ndongya, A.E., &Bitrus, P.Y. (2007). Biofuel characteristics of beniseed (*Sesamumindicum*) Oil. *African Journal of Biotechnology*,6 (21), 2442-2443.
- Dashiell, A. (2003). American. Oil chemist Society (AOCS).Central Soya Coy. Fort Wayne. Indiana, 46818 USA; 443.
- Donates, C.O; Obioma, U.N., Patrick E.A, Jonas, A.O (2016).Extraction and characterization of lecithin from Nigerian Melon. *Journal of Advances in Biology and Biotechnology*. 10 (1) 264 – 272
- Dreon, D.M, Vranizan, K.M.,Krauss, R.M, Austin, M.A,Wood, P.D. (2010). The effects of polyunsaturated fats versus monounsaturated fat on plasma lipoproteins *Journal of American Medical Association*, 263(18), 2462 – 2466
- Egbo, N.N. (2012). Evaluation of the nutrient content and oil characteristics of melon seeds. M.Sc. Thesis in the Department of Microbiology, University of Port Harcourt, Port Harcourt, Nigeria, 97
- FAO (2008). Stat-Agriculture: Food and Agriculture Organization of the United Nations. Available from: <http://www.fao.org/site/2008>. [Accessed Date: May 23, 2008].
- FAO/WHO, (1980). Specification of identity and purity of sweetening agents, emulsifying agents, flavouring agents and other food additives. Retrieved on 24<sup>th</sup>March, 1980 from <https://books.google.com.bd/books>.FAO/WHO.

- Furumoto T., Iwata M., FerojHasan A. F., & Fukui H. (2003). Anthrasesamones from roots of *Sesamum indicum*. *Phytochemical*, 64(4), 863-866
- Gordon, M.W. (2000). Contemporary Nutrition Issues and insight. 4th Edition. Boston McGraw-Hill Publishers: 23-45
- IACST (1986). Official methods of analysis. International Association for Cereals Science and Technology. 6<sup>th</sup> edition. Available on <http://www.icc.org>.
- Ismaila, U., Gana, A.S., Tswana, N. M., Dogara, D. (2010). Cereals production in Nigeria: Problems, constraints and opportunities for betterment. *African Journal of Agricultural Research*, 5(12), 1341-1350
- IPGRI (International Plant Genetic Resources Institute) (2004). Descriptors for soybean (*Glycine max*) the International Plant Genetic Resources Institute, Rome, Italy, IPGRI
- ISO (1990). Official methods of analysis, International Organisation for Standardization: ISO: 5508.
- IUPAC (International Union of Pure and Applied Chemistry) (1988). Official methods of analysis, IUPAC: 2.301. Available on <http://www.iupac.org>
- Kandangath R. A., Pal, A., Khanum, F., Bawa, A. S. (2010). Nutritional, Medicinal and Industrial Uses of Sesame (*Sesamum indicum* L.) Seeds - An Overview, *Agriculturae Conspectus Scientificus*, 75, 4 159-168.
- Kolawale, O, Ojo, S.O. (2007). Economic efficiency of small scale food crop production in Nigeria. *Journal for social science*, 14(2), 123-130.
- Liu, C., Wang, X., Ma, H., Zhang, Z., Gao, W, Xiao. L. (2008). Functional properties of protein isolates from soybeans stored under various conditions. *Food Chemistry*, 111, 29-37
- Masuda, T, Goldsmith, P. D. (2009). World Soybean Production: Area Harvested, Yield, and Long-Term Projections. *International Food and Agribusiness Management Review*, 12, 143-161.
- NBS (Nigerian Bureau of Statistics) (2011). Raw material commodity survey, 3<sup>rd</sup> quarter report, Nigerian Bureau of Statistics, Abuja, Nigeria: NBS.
- NCRI (National Cereals Research Institute) (2016). Beniseed research programme report. Annual research evaluation and monitoring workshop. National Cereals Research Institute, Badeggi, Nigeria: NCRI.
- Njoku, U, Ifeoma, I. (2015). Evaluation of the nutritional potentials of Beniseed. *Nigerian Journal of Biochemistry and Molecular Biology*, 23 (1), 39-41.
- Olisa, N.M. (2009). Extraction, Characterization And Industrial Uses Of Lecithin From Three Varieties of *Cucumis Melo* (Melon Seed) Oil. M.sc. Thesis in the department of Biochemistry, University of Nigeria, Nsukka, Nigeria. Pp58

- Phillips K. M., Ruggio D. M, Ashraf-Khorassani, M. (2005). Phytosterol composition of nuts and seeds commonly consumed in the United States. *Journal of Agriculture and Food Chemistry*, 53(24), 9436-9445.
- Renfree.C. (2005). *Lecithin Chemical and Supplementation* American Oil Chemists Society. Indiana, Fortwayne publications: 97
- RMRDC (Raw Materials Research and Development Council) (2004). Survey report of ten selected agro raw materials in Nigeria. Raw Materials Research and Development Council, Abuja, Nigeria. 89 .
- Salunkle,D.K., Hamalathan, K., Krisnapura, P., &Sreeramaiah, H.(1991). Sesame. In: *World oil seeds; history, technology and utilization*.New York, van Nostand, 371 – 402.
- Singh G, Shivakumar, B. G. (2010).The Role of Soybean in Agriculture.In:Singh. G (eds.). *Soybean: Botany, Production and Uses*.Wallingford, UK, Cabi Publishing:24-47
- Spiller, G.A. (2006).*Handbook of lipids in human Nutrition*. Boca, Raton. CRC. Press: 34
- | Sugano, M,&Akinmoto,K.A. (1993). Multifunctional Giftfrom Nature. *Journal of Chinese Society and Animal Science*,18, 1-11.
- Uddin, M.S., Kishimura, H., & Chun, B.S.(2011). Isolation and Characterization of Lecithin from Squid (*Todarodespacificus*) Viscera Deoiled by Supercritical Carbon Dioxide Extraction. *Journal of Food Science*, 76 (2), 350-354.
- USDA (United State Data Agency) (2012). Annual report. Available on [www.usda.org](http://www.usda.org).
- Vasconcellos, J.H. (1982). *American Oil Chemists Society*, 59 (2), 79-81.
- Were, B. A., Onkware, A. O., Gudu, S., Welander, M. and Carlsson, A. S. (2006). Seed Oil Content and Fatty Acid Composition in East African Sesame (*Sesamumindicum*L.) Accessions Evaluated over 3 Years. *Field Crops Research*, 97, 254-260.