EFFECTS OF MOISTURE CONTENT ON THE YIELD AND QUALITY OF OIL FROM TIGER NUT (*CYPERUS ESCULENTUS*)

*Adejumo, Bolanle Adenike and Salihu, Muhammd Enewo
Department of Agricultural and Bioresources Engineering,
Federal University of Technology, PMB 65, Minna, Niger State, Nigeria
*corresponding author:bolanleadejumo@gmail.com

Abstract
The effect of moisture content variation on the characteristics and oil yield of tiger nut (Cyperus esculentus) seeds was investigated. The oil was extracted using the Soxhlet method at 9.5%, 20%, 30% and 40% moisture content for sample A, B, C and D respectively. The extracted oil was characterized using standard methods. The result showed a percentage oil yield of 25.89%, 19.05%, 12.48% and 12.14% for sample A, B, C and D respectively. The viscosity (mm^2/s), specific gravity and smoke point ranges from 0.53-2.27, 0.91-0.84, and 231-215 respectively. The saponification value (mg/KOH/g), iodine value (g/100g) and acid value (mg/KOH/g) are 143.06, 185.13, 260.87, 294.52; 72.00, 88.45, 85.60, 88.45 and 3.37, 30.86, 65.90, 71.81 for sample A, B, C and D respectively. The peroxide value (m/mol/kg) and free fatty acid (mg/KOH/g) ranges from 2-21 and 6.73-143.62 respectively for the extracted oil at moisture content range of 9.5- 40%. Moisture content has no effect on the refractive index of tiger nut oil; the high free fatty acid value indicates its edibility. It can be concluded that oil yield decreases with increase in moisture content, with the highest oil yield obtained at 9.5% moisture content. Therefore, an initial seed moisture content of 9.5% is recommended for the extraction of oil to obtain maximum oil yield. The oil can be use as lubricant, cooking as substitute for other vegetable oil and good for soap making.

Keywords: Tiger nut, oil yield, saponification value, free fatty acid, peroxide value, viscosity

Received: 05.03.2018 Reviewed: 19.06.2018 Accepted: 06.06.2018

1. INTRODUCTION

Tiger nut (*Cyperus esculentus*) is an underutilized crop cultivated worldwide, which is sweet and rich in fat (Aliyu and Sani, 2009). Tiger nuts are small about the size of a peanut growing at the rhizome of the plant (Mason 2005, Temple *et al*; 1990). Tiger nut are daily ingredients of the diet of many people in North Africa and Spain (Oladele *et al*: 2009). According to Mason, 2005, tiger nuts have long been recognized for its health benefits with high content of soluble glucose, oleic acid, along with high energy content and also rich in mineral (Matinez, 2003).Tiger nut produces high quality oil about 25.5% of its content the edible and stable oil obtained from the tuber is said to be superior oil that compares favourably with olive oil (Muhammad *et al*, 2011).Tiger nut oil has golden colour and a nutty taste which makes it ideal for different users. The oil remains uniformly liquid at refrigeration temperature (Umerie and Enebeli, 1997).

Tiger nut oil has a high oleic acid and low polyunsaturated fatty acid (linoleic acid and linolenic acid) (Shaker *et al*, 2009; Ezebor *et al;* 2005), enough to cover daily minimum needs for an adult (around 10 g) and low acidity, and so is excellent to cover for the skin. It also has higher oxidative stability than other oils, due to the presence of polyunsaturated fatty acids and gamma-tocoferol (Adejuyitan *et al*, 2009; Ezebo *et al;* 2005).

Tiger nut oil is used in preparation of therapy for some cardiac and intestinal pathology, because of its high content of monounsaturated fatty acids (Adejuyitan *et al*, 2009, Shaker *et al*, 2009).Tiger nut oil extracted from tiger nut is used naturally with salads or for frying (Shaker *et al*, 2009). Furthermore, less fat is absorbed into the food as it creates a crust on the surface during cooking, preventing the oil itself being absorbed into the product. The oil compares well with corn; soybean, olive and cotton seed oil and can thus serve as a substitute for these oils especially in times of scarcity. In the textile industry, the oil is used to waterproof textile fibres. The oil is a potential source of biodiesel and much research has been conducted (He *et al*; 1996; Shaker *et al*, 2009).

The high rate of production and lack of awareness of the benefits of tiger nut had been underutilized resulting in its wastage. There are no information on the effect of moisture content on the yield of the oil from tiger nut. But due to increasing awareness of the use of tiger nut oil, there is need to determine the appropriate set of processing parameters necessary for the optimum extraction of the oil. The aim of this work is to determine the effect on moisture content variation on the qualities of oil extracted from tiger nuts.

2. MATERIALS AND METHODS

2.1 Sample Collection and Cleaning.

Brown variety of tiger nut (*Cyperus esculentus*) seeds used for this work was bought from Kure market, Minna, Niger State (Plate 1). Cleaning was carried out by manual method of hand picking the impurities like stone and other foreign matters present in the sample. It was then brought to the Department of Agricultural and Bioresources Laboratory, Federal University of Technology Minna, Niger State, Nigeria. The initial moisture used to determine the percentage of water in sample was by drying the sample to a constant weight.

Plate 1: Tiger Nut Seeds

I. Determination of Moisture Content

This method was used to determine the percentage of water in a sample by drying the sample to a constant weight as prescribed by Association of Analytical Chemist (AOAC, 2006).

$$M_b = \frac{M_{di} - M_{df}}{M_{df}} \quad (1)$$

where:

- M_b = moisture content % dry basis;
- M_{di} = initial mass before oven drying;
- M_{df} = final mass after oven drying.

II. Variation of Moisture Content

The sample was divided into four portions Sample A, B, C and D to achieve the desired moisture content of 9.5%, 20%, 30% and 40% respectively with Sample A serving as the control. The desired moisture content of the samples attained were by adding calculated amount of distilled water and refrigerating for seven days. The quantity of water added was calculated from the following relation as given by Sacilik et al., 2003.

$$Q = \frac{w_i(m_f - m_i)}{100 - m_f} \quad (2)$$

where:

- Q = quantity of water added in grams (g);
- m_f = final moisture content of the sample in % dry basis;
- m_i = initial moisture content of the sample in % dry basis;
- w_i = mass of the sample in grams.

2.2. Experiment Set Up

The Soxhlet apparatus was set up. Two hundred grams (200g) of the crushed sample was weighed and mixed with (6-7ml) of N-hexane. The mixed sample was placed in a filter paper and properly wrapped and inserted into the assembled Soxhlet apparatus. The weight of the filter paper and sample was recorded. The solvent (2000ml) was measured using a measuring cylinder and then poured into a 500ml round bottom flask which is the lower part of the Soxhlet apparatus. This was then heated in a heating mantle at 30^{o}C for 5-6 hours. As the solvent boils, it evaporated into the reflux condenser and this hot solvent vapour was cooled by the surrounding water which flow continually through Soxhlet

arrangement. The cooled solvent then condensed back into the portion of Soxhlet containing the folded sample, this facilitates the extraction of oil from the sample. The oil that drops into the round bottom flask was a combination of oil and solvent.
The extraction of oil from each sample was replicated and the oil was recovered by solvent evaporation. It was heated at room temperature higher than that of the solvent until the solvent finally evaporates leaving behind the extracted oil. The procedure was carried out for all samples. The average oil yield on each sample was obtained as described by Nkafamiya II *et al*., 2007 and is given as:

$$\%\ oil\ yield = \frac{Weight\ before\ extraction - Weight\ of\ sample\ after\ extraction}{Weight\ of\ sample\ before\ extraction} \times 100 \qquad (3)$$

The characteristics evaluated according to the procedure prescribed by AOAC, 2006 are the physical and chemical properties. The physical properties include refractive index, viscosity, specific gravity/density and smoke point while the chemical properties include saponification value, acidic value, iodine value, peroxide value and free fatty acid.

2.3. Statistical Analysis

The data obtained from the above experiment was subjected to data analysis using the software package SPSS 15.0 (Statistical Package for Social Science).

3. RESULTS AND DISCUSSION

The results of the effect of moisture content on the yield of tiger nut oil are as presented in Table 1.

Table 1: Percentage Oil Yields of Tiger Nut

Parameter	**Sample A**	**Sample B**	**Sample C**	**Sample D**
Weight of sample	120	120	120	120
Weight of sample before extraction	88.93	97.13	105.02	105.02
Weight of sampleafter extraction	31.07	22.87	14.98	16.99
Oil yield (%)	25.89	19.05	12.48	12.14

where:
- Sample A = sample with 9.5% moisture content;
- Sample B = sample with 20% moisture content;
- Sample C = sample with 30% moisture content;
- Sample D = sample with 40% moisture content.

The effect of moisture content on the physical and chemical properties of tiger nut seed oil are as presented in Table 2 and 3 while the analysis of variance of the effect of moisture content on the physical and chemical properties of tiger nut seed oil are as presented on Table 4 and 5 respectively.

Table 2: Physical Properties of Tiger Nut Oil

Parameter	**Sample A**	**Sample B**	**Sample C**	**Sample D**	***Standard for edible oil**
Viscosity 40^{o}C (mm^2/s)	0.53	0.70	1.09	2.27	60.00
Specific gravity (g/cm^3)	0.91	0.87	0.85	0.84	1.16
Density (g/cm^3)	9.06	8.65	8.52	8.39	10.00
Refractive index	0.0003	0.0023	0.0035	0.0034	1.46 $\pm$ 0.05
Smoke point	231	220	210	215	250

*F.A.O/W.H.O (2009) International standard for edible oils

Table 3: Chemical Properties of Tiger Nut Oil

Parameter	Sample A	Sample B	Sample C	Sample D	*Standard for edible oil
Saponification value (mg/kOH/g)	143.06	185.13	260.87	294.52	181.4 $\pm$ 2.60
Iodine value (g/100g)	72.00	88.45	85.60	88.45	80 - 106
Acid value (mg/kOH/g)	3.37	30.86	65.90	71.81	4.00
Peroxide value (m/mol/kg)	21.00	5.00	6.00	2.00	10.00
Free fatty acid (mg/KOH/g)	6.73	61.71	131.80	143.62	5.61 – 7.28

*F.A.O/W.H.O (2009) International standard for edible oils

Table 4: Analysis of variance of the physical properties of tiger nut oil significantly ($p\leq0.05$) affected by moisture content

Property	Sum of Square	Df	Mean square	F	Sig.
Oil yield	Between Groups 380.711	3	126.904	113645.062	0.000
	Within group 0.009	8	0.001		
	Total 380.720	11			
Viscosity	Between Groups 5.540	3	1.847	5540.425	0.000
	Within group 0.003	8	0.000		
	Total 5.543	11			
Specific gravity	Between Groups 0.006	3	0.02	20.750	0.000
	Within group 0.001	8	0.000		
	Total 0.007	11			
Density	Between Groups 0.749	3	0.250	2141.048	0.000
	Within group 0.001	8	0.000		
	Total 0.750	11			
Smoke point	Between Groups 2034.250	3	678.088	1.76.891	0.000
	Within group 30.667	8	3.833		
	Total 2064.917	11			

Table 5: Analysis of variance of the chemical properties of tiger nut oil significantly ($p\leq0.05$) affected by moisture content

Property	Sum of Square	Df	Mean square	F	Sig.
Saponification value	Between Groups 42848.894	3	126.904	108341.072	0.000
	Within group 1.055	8	0.001		
	Total 42849.949	11			
Iodine value	Between Groups 555.917	3	185.306	1588335.072	0.000
	Within group 0.001	8	0.000		
	Total 555.918	11			
Acid value	Between Groups 9219.553	3	3037.306	36878212.90.00	0.000
	Within group 0.001	8	0.000		
	Total 9219.554	11			
Peroxide value	Between Groups 690.00	3	230.000	230.000	0.000
	Within group 8.000	8	1.000		
	Total 698.000	11			
Fatty acid	Between Groups 36872.854	3	12290.951	1645.062	0.000
	Within group 0.001	8	0.000		
	Total 36872.855	11			

3.1. The Effect of Moisture Content on the Oil Yield of Tiger Nut

The results shows the percentage oil yield of tiger nut oil for Samples A, B, C and D to be 25.89%, 19.05%, 12.48% and 12.14% respectively. Sample A had a yield similar to that reported by Kamalu and Oghome, 2008 for tiger nut oil which states that tiger nut contains 25-30% edible oil. Sample B, C and D with moisture content of 20, 30 and 40% respectively produces lower oil below 25-30%, indicating that there is a reduction in the oil yield of tiger nut above moisture content of 9.5%. The result shows that the higher the moisture content, the lower the oil yield of tiger nut which is similar to other oil bearing seeds. The analysis of variances shows that moisture has significant effect on the oil yield of tiger nut, it decreases significantly with increase in moisture content.

3.2. The Physical Characteristics of Tiger Nut Oil Produced at Various Moisture Content

a. **Viscosity**

The results showed that the higher the moisture content of the tiger nut seed, the higher the viscosity of the extracted tiger nut seed oil. The viscosity of the extracted tiger nut seed oil increased with increase in moisture content in a uniform linear manner up to 40% moisture content. However, based on the fluidity, sample A has the lowest viscosity of $0.53mm^2/s$. The viscosity is within the range reported by Eteshola and Oraedu (1999). This property makes tiger nut oil suitable for lubrication because of the low viscosity. Statistical analysis showed that moisture content has significant effect on viscosity of the oil from tiger nut (Table 4).

b. **Specific Gravity**

The results showed that specific gravity decreased with increase in moisture content. The specific gravity of the tiger nut oil was lower than that recommended for edible oil as reported by Chopra and Kanwar, 1992. However, the specific gravity of tiger nut oil is within the range reported for *Sesamum indicum L*. seed oil (Mohammed and Hamza, 2008) and $0.89g/cm^3$ for African Oil Bean seeds *Pentaclethra marcrophylla* (Odoemelam, 2005). This indicates that the oil could be used on commercial scale. Statistical analysis showed that moisture content has significant effect on specific gravity of the oil from tiger nut (Table 4).

c. **Density**

The results showed that density of the tiger nut oil decreased with increase in moisture content. The densities of tiger nut oil extracted at the various moisture contents are lower than that reported by Chopra and Kanwar, 1992 for edible oil. The sample A with 9.5% moisture content had the highest value of 9.06 g/cm^3. Statistical analysis showed that moisture content has significant effect on density of the oil from tiger nut (Table 4).

d. **Refractive Index**

The results showed that moisture content of tiger nut oil was lower than that reported for edible oil by Chopra and Kanwar, 1992. Moisture content variation had no significant effect on the refractive index of tiger nut oil.

e. **Smoke Point**

The smoke point which is the temperature at which the smoke is first detected decreased with increase in moisture content for tiger nut oil. The smoke points of tiger nut oil extracted are lower than that reported by Kamalu and Oghome, 2008 which is 250^0C. Statistical analysis showed that moisture content has significant effect on smoke point of the oil from tiger nut (Table 4).

3.3. The Chemical Characteristics of Tiger Nut Oil Produced at Various Moisture Content

a. **Saponification value**

The results showed that the saponification value of tiger nut oil increased with increase in moisture content. Sample A had saponification value within the range recommended for edible oil reported by Chopra and Kanwar, 1992. The saponification value of tiger nut oil were similar to that reported for shea butter oil, castor seed oil, jatropha and cotton seed oil (Warra *et al*, 2011a, Warra *et al*, 2011b). This indicates that the oil extracted at higher moisture content range of 20 to 40% would be suitable for soap making since its saponification value is higher than the recommended value for edible oil. The saponification values gives information concerning the character of the fatty acid present in the oil and the stability of the soap derived from it in water, and high saponification value contains low portion of fatty acids. Statistical analysis showed that moisture content has significant effect on saponification value of the oil from tiger nut (Table 5).

b. **Iodine Value**

The results showed that the iodine value of tiger nut oil increased with increase in moisture content. The tiger nut oil extracted at all the moisture content is within the range of international standard recommended for edible oil reported by Chopra and Kanwar, 1992. This showed that the oil has a high degree of unsaturated fatty acid which indicates that the oil will be suitable for consumption and can also be used as a non drying oil. The higher fatty acid also indicates its suitability in the manufacture of soap as reported by Kamalu and Oghome, 2008. The iodine value of the oil is the measure of unsaturated acid present, this indicates the non-drying qualities. Therefore, the test measures the amount of iodine consumed by the acid. The greater the iodine value, the greater the unsaturation and thus the greater the liquidity. The lower acid value of sample A indicates lower degree of unsaturation. Thus sample D with the highest moisture content has the highest iodine value, indicating that the higher the moisture content the higher the iodine value.

c. **Acid Value**

The results showed that the acid value of tiger nut oil increased with increase in moisture content. The tiger nut oil extracted at 9.6% moisture content (Sample A) was the only one that had acid value lower than the range recommended for edible oil (Chopra and Kanwar, 1992). The acid value obtained for tiger nut oil of sample A was lower than that reported for Sheanut butter oil, but higher than that reported for castor seed oil, jatropha oil and cotton seed oil (Warra et al, 2011a). The higher the acid value of an oil, the lower its storage quality and vice-versa (Nielsen, 2003), this showed that the tiger nut oil have an excellent storage quality when compared to that of Sheanut butter oil (Warra et al, 2011a). The lower acid value indicates the extent of edibility of tiger nut oil (Kamalu and Oghome, 2008). This showed that only sample A with moisture level of 9.5% is edible. Statistical analysis showed that moisture content has significant effect on acid value of the oil from tiger nut (Table 5).

d. **Peroxide Value**

The results showed that the peroxide value of tiger nut oil decreased with increase in moisture content. The tiger nut oil extracted at 9.6% moisture content (Sample A) had the highest peroxide value of 21m/mol/kg, which was also higher than the range recommended for edible oil (Chopra and Kanwar, 1992). Tiger nut oil extracted between 20 to 40% moisture content had peroxide values lower than the recommended range for edible oil. The peroxide value of oil measures the deterioration of oil as a result of oxidation. Therefore, the lower peroxide value of tiger nut oil when compared to palm kernel oil indicates that the oil can be kept for a very long period of time (Ogbuagu, 2008). Statistical analysis showed that moisture content has significant effect on peroxide value of the oil from tiger nut (Table 5).

e. **Free Fatty Acid**

The results showed that the free fatty acid value of tiger nut oil increased with increase in moisture content. The tiger nut oil extracted at 9.6% moisture content (Sample A) was the only one that had free fatty acid value lower than the range recommended for edible oil (Chopra and Kanwar, 1992). Free fatty acid (oleic acid), determine the suitability of the oil for edibility or industrial uses. The free fatty acid value is low when compared to the *Hyptus spicigera* seed oil 3.50%. This showed that tiger nut oil is edible (Ladan *et al*, 2010).The free fatty acid value measures the extent to which the glycerides in the oil have been decomposed by lipase action. Rancidity is usually accompanied by free fatty acid formation; the determination is often used as general indication of the condition and edibility of the oil. Statistical analysis showed that moisture content has significant effect on free fatty acid of the oil from tiger nut (Table 5).

4. CONCLUSION

It can be concluded that tiger nut oil yield decreased with increase in moisture content with the highest yield obtained at 9.5% moisture content. Tiger nut oil is edible as well as suitable for soap making and lubrication with longer shelf life due to its high viscosity and low peroxide value. However, it is recommended that tiger nut oil should be extracted at moisture content lower than 9.5%.

5. REFERENCES

[1]. Adejuyitan, J. A., Otunola, E. T., Akande, E. A., Bolarinwa, I. F. and F. M. Oladokun (2009), Some Physicochemical properties of Flour obtained from fermentation of tiger nut (Cyperus esculentus) sourced from a market in Ogbomoso, Nigeria, African Journal of Food Science, 3:51-55

[2]. Aliyu, H. N. and U. Sani (2009), Production of Biscuit from Composite Flour as a Substitute for Wheat J Bioscience Research Communication 3:21-27.

[3]. AOAC (2006), Official methods of food Analysis of the Association of Official Analytical Chemists (AOAC) 18th Edition. Washington D.C.

[4]. Chopra, R.N. and Kanwar, J. S. (1992), Analytical Agricultural Chemistry, Fourth edition, Kalyani, Publishers New Delhi-ludhiana, Pp.351.

[5]. Eteshola, E. and A.C.I. Oraedu (1999), Fatty acid compositions of tigernut tubers (Cyperus esculentus L.), baobab seeds (Adansonia digitata L.) and their mixture. Journal of American Oil Chemistry Society., 73: 1996 : 255-257.

[6]. Ezebor, F., Igwe, C. C., Owolabi, F. A. T. and S. O. Okoh (2005), Comparison of the physic-Chemical characteristics, oxidative and hydrolytic stabilities of oil and fat of cyperusesculentusL.Andb utyrospermumparkii (shea nut) from Middle-Belt States of Nigeria. Nigerian Food Journal, 23:33-39.

[7]. FAO/WHO (2009), Report of the 21st session of the Codex Alimentarius Committee on fats and oils. Kola Kinabalu, Malaysia, 16 – 20 February 2009.

[8]. He, Y. Z., Milford, A. H., Yusuf, A. and L. Nan (1996), Yellow nut-sedge (Cyperus esculentus L.) tuber oil as a fuel. Research Journal of Applied Sciences1996 5:177-181.

[9]. Kamalu, C.I.O and P. Oghome (2008), Extraction and Characteristics of Tiger Nut Oil. Journal of Chemistry Society of Nigeria.Vol. 33, nol, pp. 79-89, 2008.

[10]. Ladan, Z., Okonkwo, E. M., Amupitan, J. O., Ladan, E. O and Aina, B. (2010), Physicochemical Properties and Fatty Acid Profile of Hyptus spicigera Seed Oil. Research Journal of Applied Sciences vol.5, no. 2, pp. 123-125.

[11]. Mason,D. (2005), Tiger Nuts In:http://www.nvsuk.org.uk/growing_show_vegetable_1/tiger_nut.php 2005. Accessed December, 2009.

[12]. Muhammed, N.O., Bamishaiye, E. L, Bamishaiye, O. M., Usman, L. A, Salawu, M. O, Nafiu, M. O and Oloyede O.B. (2011), Physicochemical properties and fatty acid composition of Cyperus esculentus (Tiger nut) Tuber oil, Bioresearch Bulletin 5:51-54.

[13]. Mohammed, M. I. and Hamza, Z. U. (2008), Physicochemical Properties of Oil Extracts from Sesamum Indicum L. Seeds Grown in Jigawa State-Nigeria, Journal Applied Environment Management, Vol.12 no. 2, pp. 99-100, 2008.

[14]. Martinez, V. (2003), scientific analysis of effects of tiger nut on heart disease and related aspects In: Tiger Nut and Health 2003, Research Journal of Applied Sciences.

[15]. Nielsen, S. (2003), Food analysis, laboratory manual 3th Edition Kluwer Academic Premium Publishers, London, Pp 88-89, 2003.

[16]. Nkafamiya II, A. B. A, Manji, A .J., and Moddibo, U., (2007), Degredation properties of Adansonia digital (Boabo) and prosopsis Africana (Lughu) oils on storage. African Journal of Biotechnology, (6): 751-755.

[17]. Odoemelam S.A., (2005), Proximate Composition and selected Physicochemical Properties of the Seeds of African Oil Bean (Pentacle thramarcrophylla), Pakistan Journal of Nutrition vol.4, no. 6, Pp. 382-383, 2005.

[18]. Ogbuagu M.N., (2008), Inhibitory effect of onion and garlic extracts on the rancidity of palm and palm Kernel Oils, Journal Chemistry Society of Nigeria, vol. 33 no. 1, Pp 43-44, 2008.

[19]. Oladele K.A., Osundahunsi FO and AY Adebowale (2009), influence of Processing Techniques on the Nutrients and anti-nutrients of Tigernut (Cyperus esculentus L.) World Journal Dairy&Food Science., 2009; 2: 88-93.

[20]. Sacilik, K., Ozturk, R.J and Keskin, R. (2003): Some Physical Properties of Hemp Seeds, Journal of Biosystem Engineering 86(2).191-198.

[21]. Shaker, M. A., Ahmed MG, Amany MB and LN Shereen (2009), Chufa Tuber (Cyperus esculentus L.): As a New Source of Food. World Applied Science Journal 2009; 2:151-156.

[22]. Temple, V. J., Ojobe, T. O. and M. M. Kapu (1990), Chemical analysis of Tiger nut (Cyperus esculentus), Journal Science Agricculture 1990 50:261-263.

[23]. Umerie, S. C. and J. N. Enebeli (1997), Maltcaraml from the nuts of Cyperus esculentus Journal Biological Resource Technology., 1997; 8: 215-216

[24]. Warra, A.A., Wawata, I. G., Hassan, L. G., Gunu, S.Y. and Aujara, K. M. (2011a), Extraction and physicochemical analysis of some selected Northern Nigerian industrial oils, Scholars Research Library: Archives of Applied Science Research, vol. 3, no 4, pp. 536-541, 2011.

[25]. Warra, A. A., Gunu, S.Y., Jega, A and Aisha, J. A (2011b), Soap Production from Shea nut Butter, International Journal of Applied Sciences, Vol. 5, no. 4:410-412, 2011.