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EFFECT OF TEMPERATURE ON PHYSICO - CHEMICAL PROPERTIES OF OIL EXTRACTED FROM AFRICA STAR APPLE SEEDS (*Chrysophyllum Africanum*)

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ABSTRACT

Africa apple seeds provide vegetable oils which are preferred to animal fats as people are becoming more health conscious now a – days. This has prompted the research to ascertain the quantity, quality, and edibility of the oil of African star apple seeds in industrial and domestic processes. Africa star fruits were obtained from a retail store at Oja Oba market in Ado – Ekiti. The seeds were obtained from fruit by cutting the fruits into half and the pulp seeds were cleaned with water and dried. The seeds were weighed and oven dried at temperature from 50°C to 65°C at an interval of 5°C after which they were milled and oil extracted using a solvent extraction method. Some physicochemical properties of the extracted oil obtained from the samples were analyzed. The result depicts that, oil yield, acidic value, fatty acidic value and moisture content decrease with increase in temperature while saponification value increase with increase in temperature. Also, the oil yield, density and moisture content of the extracted oil have statically significant effect when subjected to the selected temperature at $p < 0.05$. The saponification and iodine value was found to have a significant effect on all the chemical properties of the oil at $p < 0.05$. The oil contains more unsaturated fats and oil which indicate that the oil can be stored for a longer period while high saponification value of the oil indicates that the oil is better use in production of soap and shampoo.

KEYWORDS: Oil extraction; Drying; Africa stars; Peroxide; Refractive index; Acidic value; Fatty acid

INTRODUCTION

The African star apple (*Chrysophyllum Africanum*), locally called "udala" by the Ibos and "agbalumo" by the Yoruba's is found mostly in African Countries. It is also found in countries like Southern Nigeria, Cameroons, Ghana, Ivory Coast and Sierra Leone. It features prominently in the compound agro forestry system for fruit, food, cash income and other auxiliary uses including environmental uses (Adepoju, 2012). Various studies also showed that the seed is a good source of vegetable oil, biofuel and food ingredient (Idowu et al., 2016). The fruits are good for sore-throat, tooth-ache and for treating constipation. The bark of the fruit is used for the treatment of yellow fever and malaria while the leaf is used as an emollient and for the treatment of skin eruption, stomach-ache and diarrhoea (Adekanmi & Olowofoyeku, 2020).

The majority of agricultural nuts and grains contain oil that is extractable which can be of high commercial value. Various traditional methods have been used in the extraction of oil especially edible oil from materials of plant origin. Sadrolhosseini (2011) reported that hydraulic press, expeller pressing and solvent extraction are the three modern methods of extracting oil from seeds. Solvent method is being preferred to the other two methods because the solvent extraction method recovers almost all the oil and leaves behind only about 0.5% - 0.7% residual oil in the raw materials while mechanical pressing method leaves about 6% to 14% in the raw material (Li et al., 2015). Oil extraction from agricultural grains or nuts is usually process by roasting or drying nuts. Methanol, ethanol, petroleum ether form, hexane, cyclo hexane are the most commonly used solvent in extracting oil from seeds. Hexane is the mostly used solvent for oil seed extraction because of its high oil extraction capacity. Dasan and Goud (2014) reported that extraction capacity of oil depends on extraction time, extraction temperature and type of oil and solvent. Ogunniyi, (2016) and Yusuf et al., (2015) observed that heat treatment of seeds before extraction is very important in order to facilitate the oil extraction process by reducing the moisture content and also to increase the oil yield (Yusuf, 2016). Oyedele and Ogunnaike (2018) stated that the temperatures during the extraction of oil from seeds need to be monitored in order to obtain quality and increase in the yield of the oil. The physico - chemical properties such as colour, viscosity, iodine value, saponification value, peroxide value, refractive index etc are usually accessed for oils in order to evaluate their compositional quality, nutritional and sensory qualities. There are many factors which influence the yield of oil extraction such as method of extraction, seed particle size, temperature of extraction, ratio of solvent to the seed powder, pre – treatment conditions and the seed (Ghazali & Yasin, 2016).

Oil seeds are leading suppliers of superior quality and specialty vegetable oils to nutritional products and natural food. A lot of research had been done on extraction of oil from different seeds but there a few literatures on the pre – treatment of the seed before extraction of the oil from the seed. This research work however looks into the pre – treatment of Africa star seed before extraction and the physico – chemical analysis of the extracted oil.

MATERIALS AND METHOD

Africa star apple fruits were obtained from a retail store in Ado – Ekiti, Ekiti State. The fruits were carefully cut with a sharp knife to remove the seeds. The seeds were cleaned using distilled water in order to remove the pulp. 4500g of the seed was used for the experiment. 1,500 g of the seeds weighed using electronic weighing balance ((Model BLC3002) and divided into three equal parts of 500g as replicate. The three samples were oven dried at 50°C for 8 hours. It was kept in a dissector for natural cooling. The same procedures were repeated for 55°C, 60°C and 65°C. The samples were milled to powder using a kitchen blender (QBL-15L40) for easy oil extraction (Oyedele & Ogunnaike, 2018). The blended samples were kept in a clean air polythene bag and sealed.

Oil Extraction Procedure

Solvent extraction method was used in extracting oil from Africa star apple seeds using soxhlet extractor (Availar model). Oil extraction was done following the process proposed by Oyedele and Ogunnaike (2018). 30g of milled powdered seed was wrapped with filter paper and put into a porous thimble of a soxhlet extractor. This was mounted on a round bottom flask containing 333ml of n-hexane (solvent). The set up was then placed on the heating mantle. The temperature of heating mantle was set at 150 ºc after the whole arrangement had been connected to a water circulator. The extraction of oil occurred as the solvent (n-hexane) boiled, evaporated and condensed at the porous thimble where the wrapped paper was placed. The solvent washed down the oil into the flask and process continued` for 8 hours. After the process was completed, the oil extracted into the solvent was separated by re-heating the mixture of oil and n-hexane. The solvent evaporated while the oil was left in the flask (AOAC, 2000). The oil was then collected for characterization.

Oil Yield Determination

The oil yield was determined by using the relationship in equation (1)

Oil yield =

$$\frac{mass\ of\ oil\ extracted}{mass\ of\ the\ sample\ before\ extraction}\ X\ 100 \quad (1)$$

Determination of the Chemical Properties of the Extracted Oil

The chemical properties of the extracted oil were analysed using standard methods of AOAC (2000) method. The oil yield, acidic value, peroxide value, saponification, refractive index, iodine value, moisture content, density and colour were the properties determined for edibility of the oil. Also, analysis of variance was carried on the physico – chemical properties of the extracted oil at different temperature.

Data Analysis

Inferential analysis with the aid of IBM SPSS statically version 22 software was used to analyse the data collected. The analysis of variance was carried on the physic – chemical properties of the extracted oil at the different temperature at $p < 0.05$.

RESULTS AND DISCUSSION

Table 1 shows the physico-chemical properties obtained from oil extracted for Africa star apple seed at different drying temperature. Figure 1 shows the trend of some of the physico-chemical properties with the drying temperature.

Oil yield

The result as shown in Table (1) depicts that the oil yield deceased as the temperature increased. This is due to the fact there is the possibility of the oil cells to break down and the oil particle escape with the heat during the reheating of the oil and solvent. Similar trend was obtained by Ajala and Adeleke (2014) on Africa star apple. However, the values of the oil yield obtained in this study was low when compared with cotton seed (24%) and groundnut (46%) (Adebayo et al., 2012). This indicates that the seed contain a low quantity of oil. From analysis of variance (Table 3), the physical properties of the extracted oil had statistically significant effect when subjected to the selected temperature and there is no significant difference in the temperature at p < `0.05. This indicates that subjecting the oil to any of the temperature will yield same quantity of oil.

Refractive index

Refractive index is an important factor which determines the condition of the oil (Sadrolhosseini, 2011), in that it determines the optical clarity of the crude oil in relation to water. Table 1 depicts the values of the refractive index of the extracted oil at different temperature as 1.48. The refractive index values are in close range with values of 1.47 obtained from sesame oil, mustard oil and soybean oil (Codex Alimentarius, 1993) and Africa star apple seed by Ochigbo and Paiko (2011). The value of 1.48 shows that the oil is drying oil since the value falls between 1.475 and 1.485 for most drying oil (Akinhanmi et al., 2008). Also, from the analysis of variance (Table 2), it shows that the saponification and iodine values of the extracted oil as a significant effect on the extracted oil at a confidential level of 95%.

Iodine value

Iodine value oils obtained from the seeds were 110, 112, 111 and 110g/100g at $50^{o}C$, 55 ^{o}C, 60 ^{o}C and $65^{o}C$ respectively. The iodine value of 112g/100g obtained at $55^{o}c$ is higher than that of black Beni seed (106.26g/100g) and Ngusi but lower than desert melon (124.0g/100g) (Biwade et al., 2013). The iodine values are within the range of 110 - 140 which are classified as semi drying oil (Girsha et al., 2014). This implies that the oil has high unsaturated fats which will be suitable for paint, coating, varnish and lacquers. Also, the multiple comparisons of the chemical properties using a two – way analysis of variance, shows that at $p < 0.95$, as a significant effect on all the chemical properties of the oil. This implies temperature as a major effect on the iodine value of extracted oil.

Density

From Table 1, the density of the extracted oil decrease as the temperature increase. The same result was obtained on the previous work done on Africa star apple oil extraction (Ajala & Adeleke, 2014). The decrease in density as the temperature increase, this could that oil bearing seeds losses some of its properties such as moisture when heated at a higher temperature increases, hence the lower density as opined by Adejumo et al., (2013).

Peroxide value

The peroxide value indicates the process of lipid peroxidation which affects the shelf life of the oil (Onwuka, 2005). The peroxide value the extracted oil of African star apple obtained as 2.50mu/kg and this is within the value of 0 - 20 range given for most freshly edible oil (Muhammed et al., 2011). The lower value of peroxide value indicates that the oil will be able to withstand long storage without undergoing oxidative peroxidation. Also, the result (Table 1) indicates that the peroxide value has insignificant effect on the oil extracted as temperature increase. However, the peroxide value obtained was higher than that of previous works done on oil extraction of Africa star apple (Ajala & Adeleke, 2014) but lower than the values of peroxide for oil extracted at tiger nut (Oyedele & Ogunnaike, 2018).

Saponification value

Saponification values of African star apple oil obtained are 180, 186, 188 and 188mgKOH/g at 50^{o}C, 55^{o}C, 60^{o}C, 65^{o}C respectively. The result shows that saponification increases as the temperature increases. Also these values are higher than that obtained for Ausi (189.5mgKOH/g) and *curcubita maxima* pepo (190.69KOH/g) and lower than flutted pumpkin (179.025mgKOH/g), black beni seed (106.265mgKOH/g) and rubber seed (28.075mgKOH/g) (Biwade et al., 2013). Nevertheless, the values are similar with oil extracted from Moringa seed (Anwar & Bhanazar, 2003). The result also implies that the oil is edible when the seeds are dried at higher temperature since the values at these temperatures (60 and 65^{o}C) are within the range recommended by FAO/WHO (2009). The highly saponification values of oils lead to low production of esters and also indicate normal triglycerides best use as raw material for the production of liquid soap and shampoo (Akbar, 2009).

Acid value

Acid values obtained were 0.58, 0.52, 0.52 and 0.50 at 50^{o}C, 55^{o}C, 60^{o}C, 65^{o}C respectively. This shows that as the temperature increases there is a decrease in acid value of the seed. The acid value determines the quality of the oil since its measures the presence of corrosive free fatty acids and oxidation products (Girsha, et al., 2014). The acidic values of the extractions oil for the different temperature are within the range of 0.50 to 0.58. These values are within the acceptable limit for edible oil of ≤ 10 (Balley, 1982). The result shows that acidic value decreases with increase in temperature. This is in agreement with the report of Oyedele and Ogunnaike (2018) on effects of oil extracted from tiger nut. The low acidic value indicates that the oil is edible.

Free fatty acid

The free fatty acid measures that the extent to which the glycerides in the oil had been composed by lipase action which is acculturated by light and heat. From Table 1, it can be seen that the free fatty acid decreases with increase in temperature. This is similar to the results obtained by Ajala and Adeleke (2014) on previous work done on African star apple. Nevertheless, the free fatty acid of the extracted oil obtained at 60^{o}c (0.26%) and 65^{o}c (0.25%) are quite lower than that of *curcubita maxima* (0.27%) (Alfawaz, 2004). Also, the highest value of free fatty acid was obtained at 50^{o}c (0.30%) this was slightly lowered than that of *curcubita maxima* (0.39%) (Biwade et al., 2013). This could be due to different processing conditions. However, the lower free fatty acid values indicate that there is reduction in the exposure of the oil to rancidity as opined by Rogger et al., (2010) and Asuquo et al., (2012).

CONCLUSIONS AND RECOMMENDATIONS

Investigation of the effects of temperature on physic – chemical properties of oil extracted from Africa star apple seed was carried out. The oil yield of Africa star seed was low when compared with other seed oil and the oil yield decrease with increase in temperature. Also, the saponification and the iodine value from the multiple comparison of the chemical properties shows highly significant difference at $p \leq 0.95$. Also, the analysis of variance for the physical properties of the extracted oil indicates that their physical properties as a significant effect on the oil extracted at the selected temperature. The acidic value shows that the oil contains more unsaturated fats and oil. The oil from Africa star seed can be stored from longer period while high saponification value of the oil shows that there the oil is better use in production of soap and shampoo. Investigation of effects of oil yield of Africa star seeds at a lower temperature and the potential of the oil as biodiesel should be carried out.

REFERENCES

Adebayo, S. E., Orhevba, B. A., Adeoye, P. A., Musa, J. J & Fase, O. J. (2012). Solvent extraction and characterization of oil from African star apple (*Chrysophyllum albidum* seed). *Academic Research International, 3*(2), 110 - 114.

Adejumo, B. A., Alakowe, A. T., & Obi, D. E. (2013). Effect of heat treatment on the characteristics and oil yield of *Moringa oleifera* seeds. *International Journal of Engineering and Science, 2*(1), 232 - 239.

Adekanmi, D. G., & Olowofoyeku, A. E. (2020). African star apple: Potentials and application of some indigenous species in Nigeria. *Journal of Applied Science and Environ. Management, 24*(8), 1307 - 1314.

Adepoju, O. T. (2012). Proximate composition and micronutrient potentials of three locally available wildly-grown fruits in Nigeria. *African Journal of Agricultural Research, 4*(9), 887 - 892.

Ajala, A. S., & Adeleke, S. A. (2014). Effect of drying temperatures on physicochemical properties and oil yield of African star apple (*Chrysophyllum albidum)* Seeds. *Global Journal of Engineering, Design & Technology, 3*(3), 12 -16.

Abdulkarim, S. M., Long, K., Lai, O. M., Muhammad, S. K. S., & Ghazali, H. M. (2005). Frying quality and stability of high-oleic Moringa oleifera seed oil in comparison with other vegetable oils. *Food Chemistry, 105*(4), 1382 - 1389.

Akinhanmi, T. F., Akintokun, P. O., & Atasie, V. N. (2008). Chemical composition and physio chemical properties of Cashew nut. *Journal of Agricultural, Food and Environmental Science, 2*(1), 4 - 8.

Akbar, E., Yaakab, Z., Kamarudin, S. K., Ismail, M., & Saliman, J. (2009). Characteristics and composition of Jatropha curcas oil seed from Malaysia and its potential as biodiesel feedstock. *European Journal of Scientific Research, 29*(3), 396 – 403.

Alfawaz, M. A. (2004). Chemical composition and oil characteristics of Pumpkin (*Curcubita Maxima*) seeds kernels. *Resource Bulletin, 29*, 5 - 18.

Anwar, F., & Bhanazar, M. I. (2003). Analytical characterization of Moringa oleifera seed oil grown in temperate regions of Pakistan. *Journal of Agricultural Food Chemistry,51*(22), 6558 - 6563.

AOAC (2000). Official Methods of Analysis of the Association of Official Chemists. (16th ed.). Gaitherburg, USA.

Asuquo, J. E., Anusiem, A. C. I., & Etim, E. E. (2012). Comparative study of the effect temperature on the adsorption of metallic soaps of Shea butter, Castor and Rubber seed oil onto Hematite. *International Journal of Modern Chemistry, 3*(1), 39 - 50

Balley, A.E. (1982). *Industrial oil and fat product* (3rd ed.). New York, USA: John Wiley – Interscience.

Biwade, K. E., Aliyu. B., & Kwaji, M. K. (2013). Physical chemical properties of Pumpkin seed oil relevant to biodiesel production and other industrial applications. *International Journal of Engineering, Business and Enterprises Applications, 4*(1), 72 -78.

Dasan, S. R., & Goud, V. (2014). Effect of pre –treatment on solvent extraction and physico-chemical properties of Castor seed oil. *Journal of Renewable and Sustenance Energy, 6*(6), 1 - 16.

FAO/WHO (2012): Report of the 36th session of the Codex Alimentarius Committee on Fats and Oils, Rome, Italy, 1 – 5 July, 2012.

Ghazali, Q., & Yasin, N. H. M. (2016). The effect of organic solvent, temperature and mixing time on the production of oil from *Moringa oleifera* seeds. IOP Conference Series: *Earth and Environmental Science, 36*, 1 – 7.

Girisha, S. T., Ravikamar, K., Mrunalini, B. R., & Girish, V. (2014). Comparative study of extraction methods and properties of non-edible oils for biodiesel production. *Asian Journal of Plant Sciences and Research, 4*(1), 28 - 35.

Idowu, T. O., Iwalewa, E. O., Aderogba, M. A., Akinpelu, B. A., & Ogundaini, A. O. (2016). Antinociceptive, anti-inflammatory and antioxidant activities of Eleagnine: An alkaloid isolated from seed cotyledon of Chrysophyllum albidum. *Journal of Biological Science, 6*(6), 1029 - 1034.

Li, Y. M., Sue, N., Yang, H. Q., Bai, X. P., Zhu, O. X., Liu, H. X., & Li, J.O. (2015): The extraction and Properties of Carica papaya seed Oil. Advance *Journal of Food Science and Technology, 7*(10), 773 - 779.

Muhammad, N. O., Bamishaiye, E. I., Bamishaiye, O. M., Usman, L. A., Salawu, M. O., Nafiu, M. O., & Oloyede, O. B. (2011). Physicochemical properties and fatty acid composition of *Cyperus esculentus* (Tiger Nut) tuber oil. *Bioresearch Bulletin*, 2011(5), 51 - 54.

Ochigbo, S. S., & Paiko, Y. B. (2011). Effects of solvent blending on the characteristics of oils extracted from the seeds of *Chrysophyllum Albidium*. *International Journal of Science and Nature, 2*(2), 352 - 358.

Ogunniyi, A. S. (2016). Castor oil: A vital industrial raw material. *Bioresource Technology, 97*(9), 1086 - 1091

Onwuka, G. I. (2005). Foods analysis and instrument (Theory and practice) (1st ed.). Surulere, Lagos, Nigeria: Napthali prints.

Ogunnaike, A. F., Oyedele, O. A., & Ogundari, A. A. (2021). An investigation into the biodiesel properties of oil extracted from three papaya Cultivars. *International Journal of Research and Innovation in Applied Science, 6*(6), 132 – 137.

Oyedele, O. A., & Ogunnaike, A. F. (2018). The effects of drying on some physiochemical properties of extracted tiger seed oil. *World Journal of Engineering Research and Technology, 4*(2), 195-202.

Rogger, A. B., Rebecca, R. A., Georges., A., & Mathais, I. O. (2010). Chemical characteristics of oil from germinated nuts of several coconut cultivars (*Cocos nucifera l*). *European Journal of Science Resources, 391*, 514 - 522.

Sadrolhosseini, A. R., Moksin, M. M., Nang, H. L., Norozi, M., Yumis, M. M. W., & Zakaria, A. (2011). Physical properties of normal graded biodiesel and winter grade biodiesel. *International Journal of Molecular Sciences, 12*(4), 2100 – 2111.

Yusuf, A. K., Mamza, P. A. P., Ahmed, A. S., & Agunwa, U. (2015). Extraction and characterization of castor seed oil from wild *Rincinus communis L. International Journal of Science, Environment and Technology, 4*(5), 1392 - 1404.

Yusuf, A. K. (2016). A review of methods used for seed oil extraction. *International Journal of Science and Research, 7*(12), 233- 238.

Table 1: Physico – Chemical Properties of Extracted Africa Star Seed Oil.

Oil Parameters	Drying Temperature (°C)			
	50	55	60	65
Oil Yield (%)	7.26	6.92	6.92	6.93
Density (kg/m^3)	2.2	1.9	2.1	2.1
Refractive index	1.48	1.48	1.48	1.48
Acid value (mg/kOH/g)	0.58	0.52	0.52	0.50
Saponification value (mg/kOH/g)	180	186	188	188
Free fatty acid (% oleic acid)	0.30	0.28	0.26	0.25
Iodine value (g/100g)	110	112	111	110
Peroxide value (O_2/kg)	2.50	2.50	2.50	2.50

Table 2: ANOVA for the Chemical Properties of the Extracted Oil at Different Temperature.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	126136.201[a]	8	15767.025	6136.457	.000
Intercept	60614.566	1	60614.566	23590.924	.000
Parameters	126125.957	5	25225.191	9817.534	.000
Temperature	10.244	3	3.415	1.329	.302
Error	38.541	15	2.569		
Total	186789.307	24			
Corrected Total	126174.742	23			

Table 3: ANOVA for the Physical Properties of the Extracted Oil at Different Temperature.

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	46.235[a]	4	11.559	179.346	.001
Intercept	160.026	1	160.026	2482.949	.000
Temperature	.251	3	.084	1.300	.417
Physical Properties	45.984	1	45.984	713.484	.000
Error	.193	3	.064		
Total	206.455	8			
Corrected Total	46.429	7			