



EFFECT OF DRYING TEMPERATURES ON PHYSICOCHEMICAL PROPERTIES AND OIL YIELD OF AFRICAN STAR APPLE (*Chrysophyllum albidum*) SEEDS

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Abstract

African Star Apple seeds (*Chrysophyllum albidum*) were subjected to sun-drying and tunnel drying at 50°C, 60°C, 70°C and 80°C. The oil in these seeds were extracted and subjected to physical and chemical analysis. The results showed that increase in drying temperature of the seed decreased percentage oil yield, saponification value, free fatty acid, acid value, and iodine value. Boiling and flash point increases with increasing the drying temperature of the seeds. The properties evaluated indicated that the oil can have long shelf life and resistance to rancidity.

Key words: drying, temperature, oil yield, physicochemical, characteristics, African star apple seeds.

1. Introduction

Oilseed crops are major sources of lipids for human nutrition as well as for several industrial purposes. They are defined as those seeds that contain considerably large amounts of oil. The most commonly known oilseeds (conventional oil seeds) are groundnut, soybean, palm kernel, cotton seed, olive, sunflower seed, rapeseed, sesame seed, linseed, safflower seed, etc. It is being recognized more and more that the present resources of conventional oilseeds may not be adequate to meet the vegetable oil demands of the ever-increasing global population. The increase in world population and the ever-increasing demand for oils as well as oil meal has also resulted in tremendous increase in their prices. This increase in prices necessitates the need to investigate new sources of oils, especially among the nonconventional and underexploited oilseeds.

African Star Apple seed (*Chrysophyllum albidum*) is one of the nonconventional and underexploited oilseeds. The African star apple (Agbalumo in Yoruba, Udara in Igbo) is a native of many parts of tropical Africa. It features prominently in the compound agroforestry system for fruit, food, cash income and other auxiliary uses including environmental uses (Kang, 1992). The tree grows as a wild plant and belongs to the family of *Sapotaceae* which has up to 800 species and make up almost half of the order (Ehiagbonare et al., 2008). Within the fruit pulp are three to five seeds which are not usually eaten. Studies reported that the seed oil have potential for use as domestic and industrial oil. The continued increase in human population has resulted in the rise in the demand as well as the price of edible oils, leading to the search for alternative unconventional sources of oils, particularly in the developing countries. There is hundreds of un- or under-explored plant seeds rich in oil suitable for edible or industrial purposes. Many of them are rich in polyunsaturated essential fatty acids, which establish their utility as “healthy oils. Although the search for alternative oil sources is of utmost importance the world over, it is particularly of significance for the developing countries. The quest for novel and unconventional oilseeds has been on for the past two decades, as a consequence of which, several unconventional oilseeds have been identified and their properties characterized. It has been discovered that many of their constituents have unique chemical properties and may augment the supply of nutritional and functional products.

African Star Apple (*Chrysophyllum albidum*) is one fruit of great economic value in tropical Africa due to its diverse industrial, medicinal and food uses. However, the use of *C. albidum* seeds remains traditional and the species underutilized. The fruit pulp are usually eaten, while the seeds are usually discarded or threaded as anklets in dancing in Nigeria or to play out door games after which they are thrown away probably due to lack of information on the potential of the seeds, and lack of facilities nearby to process it. Studies reported that the seed oil have potential for use as domestic and industrial oil. Thus, it is possible to add value to seeds and nuts by extracting the oils. In this way, waste is converted to wealth.

Various studies have been carried on African star apple; such include nutrient and micronutrient composition by Adepoju (2012), ethnobotanical study (Houessou et al., 2012), Chukwumalume et al., (2010) also showed that the seed is a good source of vegetable oil. The processing applications of the oil have been suggested by Idowu et al. (2006). Other studies on the seed bordered on the antimicrobial properties; Idowu et al. (2006) also the use of seed oil as a biofuel and the potential use of the seed as food ingredient. But, little published information is available about the oil yield, physicochemical composition and benefit of the oil as edible oil as it is affected by processing conditions especially temperature factor. Therefore, this study seeks to investigate the effect of drying temperature on the oil yield and the physicochemical characteristics of the oil.

2. Materials and Methods

2.1 Sample Collection and Preparation

Fresh fruits of *Chrysophyllum albidum* were purchased from Odo-Oba market in Ogbomosho, Oyo State Nigeria. The seeds were removed from the fruit and decorticated manually. The resulting cotyledons were divided into samples A,B,C,D,E. Sample A was sundried at 36°C, samples B,C,D,E were tunnel dried at 50°C, 60°C, 70°C and 80°C respectively. The resulting dried samples were milled and packaged for oil extraction.

2.2 Procedure for oil extraction

The extraction method that was used for this research is soxhlet extraction. 10 g by weight of the milled sample was filled in a thimble and weighed and recorded as W_1 and then filled with the milled sample, reweighed and recorded as W_2 . The round bottom flask was weighed and recorded as W_3 and then filled with the solvent (petroleum ether) up to two-third of the flask. The reflux condenser was fitted to the top of the extractor and the water flow was turned on. The round bottom flask was placed in the heating mantle and the temperature of the mantle adjusted to 65°C and the solvent is brought to the vaporization point. Each extraction occurs over a period of 3 to 4 hours. When the solvent has just siphoned over the barrel, the condenser was detached and the thimble removed. The filtrate was exposed to the atmosphere and the residual solvent was allowed to evaporate. (AOAC 2000).

2.3 Determination of oil yield.

The oil yield was determined by this equation

$$\text{Oil yield} = \frac{\text{mass of oil extracted}}{\text{mass of sample before extraction}} \times 100$$

Other analysis such as refractive index, pH value, specific gravity/density, saponification value, acid value, iodine value and peroxide value were carried out using AOAC 2000 methods.

3. Results and Discussion

3.1 Physical and chemical properties of the oil

The results presented in Table 1 and 2 show the effect of drying temperature on chemical and physical properties of oil extracted from African star apple seed respectively. The oil yields of the seeds cotyledons vary from 21.52% to 21.59%. The result shows that the sample A has the highest percentage oil yield of 21.59% while sample E has the lowest percentage of 21.52%. The oil yield decreases with increasing drying temperature because as the temperature of drying the seeds increased, there is possibility of oil cells to break down and oil particles escape with the heat; however statistically, the values are not significantly different. This trend is similar to that obtained by Adejumo *et al.* (2013) for moringa seed oil. The values of oil yield in this study are high compared to the values reported by Adebayo *et al.* (2012) and Agbede *et al.* (2011); they reported values less than 12% and 16% respectively. This variation is probably due to the processing methods, varieties of seeds and soil conditions. The oil yield is low compared to values of neem seed of 46%, cotton seed 24% and groundnut 46% as reported by Adebayo *et al.*, (2012). Since the oil yield is low compared to some vegetable oil seeds aforementioned, this indicates the oil may not be a good source of abundant oil.

Specific gravity varies slightly from 0.88 to 0.9 which shows that it is less dense than water. The values decrease with increasing drying temperature. However, the values are not significantly difference this may be due to the fact that the drying temperature has no significant effect on the specific gravity. This trend is similar to that obtained by Adejumo *et al.* (2013) for moringa seed oil. These values are similar with those obtained by Belewu *et al.*, (2010) and Tint & Mya (2009) for *Jatropha curcas* seed oil. The values of specific gravity of this work are within the range given by FAO/WHO (2009) for edible oil which is 0.9-1.16.

Table 1: Physical and chemical properties of the oil

Sample	Oil yield (%)	pH value	Specific gravity	Refractive index	Density (cm ³ /g)	Boiling point (°C)	Flash point (°C)
A	21.590±0.01 4 ^c	4.855 ± 0.007 ^b	0.900±0.0 ^a	1.405±0.00 ^{ab}	0.713±0.0 0 ^d	287.50±0.70 7 ^a	301.00±0.00 ^a
B	21.575±0.02 1 ^{bc}	4.850 ± 0.006 ^b	0.900±0.01 4 ^a	1.400±0.009 ^b	0.711±0.0 0 ^c	288.00±0.00 a	301.00±0.00 ^a
C	21.545±0.00 7 ^{ab}	4.812 ± 0.005 ^b	0.895±0.00 7 ^a	1.396±0.0032 ab	0.708±0.0 0 ^b	291.00±0.00 b	304.00±0.00 ^a
D	21.515 ±0.007 ^a	4.548 ± 0.070 ^a	0.885±0.00 a	1.395±0.000 ^a b	0.707±0.0 0 ^b	291.00±1.41 b	304.00±0.00 ^a
E	21.510±0.01 4 ^a	4.802 ± 0.003 ^b	0.883±0.00 7 ^a	1.390±0.000 ^a	0.705±0.0 0 ^a	295.00±1.41 4 ^c	306.00±0.00 ^a

Means with the same superscript within the column are not significantly different

Sample A = sun-dried, B=50°C, C=60°C, D=70°C, E=80°C.

The refractive index indicates the level of optical clarity of the crude oil sample relative to water. According to Table 1 the refractive index varies from 1.39 to 1.405. It decreases with increase in temperature. The increase in the values of refractive index is insignificant as temperature increases. Ngassapa *et al.* (2012) also reported insignificant increase in refractive index of vegetable oil blends at elevated temperature. The values obtained are similar with the value obtained for the African star apple seed oil by Ochigbo and Paiko (2011) of 1.46 and shows that the oil is not as thick as most drying oils whose refractive indices fall between 1.475 and 1.485 (Akinhanmi *et al.*, 2008).

The densities of the samples vary between 0.705 to 0.713 cm³/g. According to Table 1, density decreases as temperature increases. This shows that the higher the temperature, the lower the density of oil. This is probably due to the fact that an oil bearing seed tends to lose some of its properties such as moisture content when heated at higher temperatures hence resulting in lower density as reported by Adejumo *et al.*, (2013).

The flash point refers to the temperature at which volatiles evolving from the heated oil will show off. According to Table 1, the drying temperature has an insignificant effect statistically on the values of flash point temperature although the flash points varied from 301 to 305°C. In the same vein, the boiling point increased as drying temperature increased from 287.50 to 295°C in which Samples A and E has the lowest and highest value respectively.

Table 2 shows the values of acid values of the oil. Acid value is a direct measure of the percentage content of free fatty acids in a given amount of oil. It is a measure of the extent to which the triglycerides in the oil have been decomposed by lipase action into free fatty acids; Acid value depends on the degree of rancidity which is used as an index of freshness (Ochigbo and Paiko, 2011). The acid values obtained are from

Table 2: Chemical properties of the oil

Samples	Acid value (mgKOH/g)	Iodine value (mg/100g)	Peroxide value (mgEq/Kg)	Saponification value mgKOH/g	Free fatty acid value (mgKOH/g)
A	2.868 ± 0.002 ^d	33.220 ± 0.014 ^c	1.997 ± 0.017 ^a	195.850 ± 0.014 ^e	1.443 ± 0.009 ^c
B	2.864 ± 0.001 ^d	33.215 ± 0.007 ^{bc}	1.984 ± 0.001 ^a	195.815 ± 0.007 ^d	1.415 ± 0.020 ^{bc}
C	2.817 ± 0.003 ^c	33.195 ± 0.007 ^{abc}	1.977 ± 0.013 ^a	194.070 ± 0.014 ^c	1.413 ± 0.009 ^{bc}
D	2.803 ± 0.002 ^b	33.190 ± 0.014 ^{ab}	1.975 ± 0.007 ^a	194.010 ± 0.014 ^b	1.406 ± 0.005 ^b
E	2.527 ± 0.001 ^a	33.175 ± 0.007 ^a	1.975 ± 0.002 ^a	193.595 ± 0.007 ^a	1.371 ± 0.012 ^a

Means with the same superscript within the column are not significantly different

Sample A = sundried, B=50°C, C=60°C, D=70°C, E=80°C.

2.868 to 2.527 mgKOH/g as shown in Table 2. Acid values show that samples A and B are not significantly different but others are not different from one another. The acid value decreases in a uniform linear manner with an increase in temperature hence, the higher the temperature, the lower the acidity value, this trend is similar to that which was reported by Adejumo *et al.* (2013) for moringa oil. The values are within the range specified for edible oil as given by FAO/WHO (2009) which is 2.89±0.01. They are also similar with those obtained by Adebayo *et al.* (2012) for African star apple seed oils, Eka and Chidi (2009) and Akubugwo and Ugbogu (2007) for butternut oil. It is a common knowledge that these parameters are a measure of the level of spoilage of oil, so the fact that they are of low magnitude is a reflection of the freshness and edibility of the crude oil (Adebayo *et al.*, 2012).

The free fatty acid values of the oil vary from 1.371 to 1.443 mgKOH/g as shown in Table 2. The samples are significantly different from each other. The value of free fatty acid in this study is greater than the value of sunflower of 0.085 mgKOH/g, cotton seed oil of 0.225 mgKOH/g, soya bean oil of 0.176 mgKOH/g but comparable with palm oil of 1.374 mgKOH/g however less than the value coconut oil of 2.540 mgKOH/g as reported by Ngassapa and Othman (2001). The values are also less than the values of African star apple oil reported by Adebayo *et al.* (2012) with value of 2.25 mgKOH/g; this may be due to varieties in the seed and different processing condition employed. As shown in Table 2, the values of free fatty acid decreased with increase in temperature of drying the seed. This means that at higher temperatures of drying the seeds, agent of rancidity of the oil such as moisture is much reduced than at lower temperature. According to Rogger *et al.* (2010), Asuquo *et al.* (2012) it is advisable for the oil to have lesser free fatty acid thus reducing its exposure to rancidity.

The iodine value of samples varies from 33.175 to 33.220 mg/100g as shown in Table 2. These are lower than the range (80-106) specified by FAO/WHO (2009) for edible oil. The iodine value decreases in a uniform manner with an increase in temperature and the values are significantly different. The iodine value in this study is in close agreement with the value 31.06±0.80 mg/100g from previous work on African star apple seed by Akubugwo and Ugbogu, (2007). However, the iodine values in this work is lower than that obtained for shea nut butter by Enweremadu and Alamu (2009). Oils are classified into drying, semi-drying and non-drying according to their iodine values. Since the iodine value of *Chrysophyllum albidum* seed oil is lower than 100, it could only be classified as a non-drying oil. The low iodine value indicates that the oil has a low content of unsaturated fatty acids thus resembles olive oil and groundnut oil, could be employed for manufacture of soaps, lubricating oils and lighting candles which traditionally requires fats or saturated oils (Dosunmu and Ochu, 1995). Thus, the oil will not attract high interest in the paint and coatings industry unless it undergoes dehydration before use (Abayeh *et al.*, 1998). Its suitability for the manufacture of soaps, lubricating oil and candles makes it as an attractive option because this oil, being not known yet commercially for consumption, can help to minimize dependence on use of known edible oils for making such products (Ochigbo and Paiko, 2011). The iodine value is a measure of the unsaturated acid present in the oil. Therefore, the test measures the amount of iodine consumed by the acid.

Peroxide value of samples ranges between 1.9773 to 1.9975 mg/g as shown in Table 2. These values are in line with the standard specified by FAO/WHO (2009) for fresh edible oil which is below 10mgEq/kg. Peroxide value is used to monitor the development of rancidity through the evaluation of the quantity of peroxide generated in the product (initiation product of oxidation). The peroxide value is usually less than 10 per gram of a fat sample when the sample is fresh. Though peroxide value decreases with an increase in temperature the samples have no significant difference. Peroxide value is an indication of level of deterioration of oil. The low peroxide values further confirms the stability of the oil. Higher values between 20 and 40 results to a rancid taste (Akubugwo and Ugbogu, 2007). The low acid and peroxide values are indicators of the ability of the oil to resist lypolitic hydrolysis and oxidative deterioration (Akanni *et al.*, 2005)

The saponification values of the samples vary between 193.60 to 195.85 mgKOH/g according to Table 2. These values are within the range recommended by FAO/WHO (2009) international standard for edible oil which is 188-265mgKOH/g. The saponification value decreases with an increase in temperature and the samples differ significantly. This trend is similar to that reported by Adejumo *et al.* (2013) for moringa seed. It also compared favourably with values of 199.50 mg/KOHg obtained by Anderson-Foster *et al.* (2012) for blighasapida seeds, for sesame seeds 189 to 190 mgKOH/g as reported by Mohammed and Hamza, (2008) and some common oils like palm oil (196 – 205 mgKOH/g, groundnut oil (188 – 196 mgKOH/g), corn oil (187 – 196 mg/KOH/g) as reported by FAO/WHO (2012). However, the saponification values in this work are lower than that of coconut oil (253mg/KOH/g) and palm kernel oil (247 mg/KOH/g) as reported by Pearson (1976). According to Ezeagu *et al.* (1998), a saponification value of 200 mg KOH/g indicates high proportion of fatty acids of low molecular weight. This shows that the oil may have a potential for use in

soap making and cosmetics industry and for the thermal stabilization of poly vinyl chloride (PVC); These properties make them useful as sources of essential fatty acids required in the body (Akanni et al., 2005).

4. Conclusion

African star apple seed oil yield decreases slightly with increase in drying temperature. The drying temperature had significant effect on most physicochemical properties. It can be concluded that the oil yield, saponification value, free fatty acid, acid value, and iodine value decreases with increase in drying temperature. Boiling and flash point increases with increasing temperatures.

5. References

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