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Effect of drying conditions and solvent type on the physicochemical composition of African breadfruit (*Treculia africana*)

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The effects of drying conditions (sun and oven drying) and solvent type (petroleum ether, acetone and hexane) on the physiochemical, proximate and multivitamin composition of *Treculia africana* were investigated. Breadfruit samples were collected from Ogwu area of Enugu State, processed and subjected to physiochemical, proximate and multivitamin screening using standard methods of analysis. Percentage yields of breadfruit oil using the three solvents (under sun dried and oven dried conditions) are 19.81, 17.23, 21.92, 19.05, 15.50 and 19.56% for petroleum ether, acetone and hexane, respectively. Single factor ANOVA (P<0.05) shows that the physiochemical properties varied significantly with solvent type and drying method. The physiochemical composition of African breadfruit samples investigated in this study could be considered satisfactory as it compared favourably with results of similar studies in this area. Further studies are on-going on intensive edible test and separation refining of the oil sample to further establish and expand the results of this preliminary study.

Key words: *Treculia africana*, extraction, solvent, physico-chemical.

INTRODUCTION

Fats and oils, and their several lipid components are extensively used in the food and also in cosmetics, pharmaceuticals, oleochemicals and other industries. There has been a growing interest in vegetable oil and other oils from fruits and nuts due to their high concentration of bioactive lipid components, such as polyunsaturated fatty acids and phytosterols (Brufau et al., 2008). Natural vegetable oil and fats are increasingly becoming important in nutrition and commerce because they are sources of dietary energy, anti-oxidants, bio fuels and raw materials for the manufacture of some industrial products (Hall et al., 1996; Frank, 2009). However, the increasing use of vegetable oils in food products, pharmaceutical, cosmetics and most importantly in the production of biodiesel have introduced rise in demand for the oil (Hall et al., 1996). Thus, there is

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Table 1. Physical properties of breadfruit oil sample.

Breadfruit	Solvent	Specific gravity (g/mol)	Viscosity (μ)	Melting point (°C)	Percentage yield
Sun dried	Pet ether	0.85	7.90	23.26	19.05
	Acetone	0.93	7.90	21.13	15.50
	Hexane	0.86	7.91	35.04	19.56
Oven dried	Pet ether	0.83	7.90	23.28	19.81
	Acetone	0.92	7.87	21.02	17.23
	Hexane	0.88	7.90	35.00	21.92

need to focus on indigenous plant species containing oil to meet the increasing demand for vegetable oil (Cravotto et al., 2011).

Treculia africana is a multipurpose tree crop in the tropics and belongs to the family *Moraceae* and the seed contains edible fruit with high nutritional value (Ajiwe, 1995). In Nigeria, African breadfruit is commonly grown in South-Eastern and South-Southern parts of the country where their seeds are locally known as 'afon' and 'ukwa' in Ibo and Yoruba local dialects (Hatchinson, 1973). The seeds have been reported to contain about 14-17% crude proteins, 35-60% carbohydrate, 2.5% crude fibre and unsaturated fatty acid which compared well with those of melon-seeds, soybeans and groundnut oil (Ejiofor and Okafor, 1997; Ragone, 2006). This study is designed against this backdrop to tackle the challenges of diminishing sources of useful seed oils with the objective of extracting and characterizing the oil from the African breadfruit to establish its sustainability and usability as local raw material for industries.

MATERIALS AND METHODS

Sample collection and preparation

Representative samples were collected from breadfruit trees in Ogwu Local Government Area of Enugu State, Nigeria and allowed to decompose for a period of 1 month after which the seeds were dehusked using a metallic rod. The separated fused membranous brown testa were cleaned to remove sand particles and then dried under two conditions (oven and sun drying) until a constant weight was observed. The dried samples from the two drying categories were differently ground to fine particles using an electrical grinder machine (Brooks Crompton series 2000, UK).

Laboratory analyses

Physical characteristics

Colour, refractive index and viscosity were respectively determined using Lovibond tintometer (Model ES. No 5064E England), LAUDA Viscometer iVisc (DIN 51562 UK), and Kruss digital refractometer (DR301-95, Germany). Melting point (Mp) analysis was carried out using the Griffin melting point apparatus (ST15 OSA, UK) while specific gravity was evaluated using specific gravity bottles at the temperature 30°C.

Chemical characteristics

Saponification, acid, peroxide and iodine values were determined according to Association of Official Analytical Chemists (AOAC) (1997).

Proximate analysis

Fat content was determined using soxhlet and gravimetric method (Min and Boft, 2003), protein content was determined using kjeldahl method (AOAC, 1990) whereas crude fibre was determined using Weede's method (James, 1995; Onwuka, 2005). Also, moisture content was determined using oven-dry method (Pearson, 1976; AOAC, 1990) whereas ash content was determined by the method described by the Association of Official Analytical Chemists (AOAC, 1990). Total carbohydrate was estimated as the remainder after subtracting the moisture, ash, crude fibre, protein and fat content (Onwuka, 2005; Muller and Tobin, 1980).

Vitamin content analysis

Vitamins A, C, E, niacin, riboflavin and thiamin were determined by the methods described by Association of Vitamin Chemists (Kirk and Sawyer, 1998).

RESULTS AND DISCUSSION

Physical properties such as specific gravity, viscosity and melting point were determined in the oil extracted from breadfruit samples using different solvents and dried under the sun or inside an oven. The mean specific gravity obtained in this study (0.878) is similar to the value (0.934) obtained by Ajiwe et al. (1995) at room temperature in a similar research involving *T. africana* oil. Percentage yield was obtained for each of the oil samples (Table 1). Comparing the range of percentage yield of *T. africana* oil (15.50-21.92%) obtained under different conditions in this study with the yield of *T. africana* oil (20.83%) recorded in a similar research shows that the results are within range (Ajiwe et al., 1995).

A detailed look at Table 1 shows that hexane gave the best conditions (with the exception of specific gravity) for extracting oil from breadfruit samples under both sun dried and oven dried conditions. One-way analysis of

Table 2. Chemical properties of breadfruit oil sample.

Breadfruit	Solvent	Acid value (%)	pH	Saponification value	Iodine value	Peroxide value	Free fatty acid
	Pet ether	3.98	4.55	243.09	20.89	4.20	4.20
Sun dried	Acetone	4.83	4.32	268.04	22.11	4.23	4.23
	Hexane	4.45	5.90	262.03	14.48	4.02	4.02
	Pet ether	3.95	4.02	241.00	20.54	3.39	4.19
Oven dried	Acetone	4.79	5.26	267.91	21.52	3.82	3.90
	Hexane	4.21	5.74	260.05	19.10	3.46	3.94

Table 3. Proximate composition (%) of African breadfruit.

Breadfruit	Solvent	Moisture	Fibre	Fat	Ash	Protein	Carbohydrate
	Pet ether	8.31	1.09	12.86	3.51	12.55	61.68
Sun dried	Acetone	9.01	1.28	13.03	3.11	12.83	60.74
	Hexane	8.92	1.31	13.22	2.99	12.48	61.08
	Pet ether	6.54	1.12	12.07	4.01	11.79	64.47
Oven dried	Acetone	6.08	1.23	12.45	3.84	12.03	64.37
	Hexane	5.96	1.04	13.01	3.92	12.01	64.06

variance (ANOVA) at P <0.05 gave F value (62.02) > critical F value (3.098) showing that the physical properties of the oil varies significantly with the solvent type and drying method.

Chemical properties such as acid value, pH, saponification value, iodine value, peroxide value and free fatty acid of the extracted oil from breadfruit samples were determined using standard methods and their results shown in Table 2. The range of saponification value (241.00-268.04 mg/g) observed in this study was higher than the saponification value (146.44 mg/g) recorded by Ajiwe et al. (1995). High saponification value indicates that the oil is of high molecular weight hence can be a good raw material for soap and shampoo making industries. Iodine value ranged from 14.48-22.11 g/100 g which was comparatively lower than 111.90 g/100 g recorded by Ajiwe et al. (1995) but comparable with 14.50-25.17 g/100 g obtained by Nwabueze and Okocha (2008). The degree of unsaturation of oil can be determined by measuring its iodine value. The low iodine value of this oil suggests that the oil may not function as drying oil. Acid value recorded in this study (3.95-4.83%) was comparable with 3.21-3.55% reported by Nwabueze and Okocha (2008) but lower than (13.35%) recorded in a similar study by Ajiwe et al. (1995). Acid value determines the free fatty acids in the oil. During oil processing, fatty acids which are found in the triglyceride form, may get hydrolyzed into free fatty acid. The higher the acid value found, the higher the level of free fatty acids which suggests a decrease in the oil quality (Obasuyi and Nwaokoro, 2006). Acceptable levels of acid value for all oil samples should be below 0.6 mg KOH/g (AOCS Official Method Cd 8-53, 2003). The high acid value recorded in this work indicates that the oil would need some form of purification to increase stability since low acid value suggest stability of oil (Oscar, 2002).

From Table 2, it can be deduced that the best extracting solvent to use under sun dried conditions is acetone because with the exception of acid value and pH, it gave optimal results for all other chemical pro-perties investigated in the samples.

Similarly, acetone was also the preferred extracting solvent to use under oven dried conditions because it gave optimal results for all chemical properties investigated with the exception of pH and free fatty acid parameters (Table 2). One-Way ANOVA at P<0.05 gave F value (2441.64) > critical F value (2.534) showing that the chemical properties of the oil varies significantly with the solvent type and drying method.

From Table 3, it can be seen that under sun dried conditions, petroleum ether showed the best extraction efficiencies for carbohydrate and ash content of breadfruit samples, hexane showed highest extraction efficiencies for fat and crude fibre content of samples whereas acetone showed highest extraction efficiencies for protein and moisture content of samples.

However, under oven dried conditions, petroleum ether showed the best extraction efficiencies for moisture, ash

Table 4. Vitamin composition (mg/100g) of African breadfruit.

Breadfruit	Solvent	Riboflavin	Niacin	Vitamin E	Vitamin A	Vitamin C	Thiamin
Sun dried	Pet ether	0.43	0.50	5.88	10.01	20.24	0.04
	Acetone	0.46	0.49	5.71	9.88	20.03	0.03
	Hexane	0.41	0.55	5.57	9.93	20.33	0.05
Oven dried	Pet ether	0.33	0.41	4.61	8.92	19.08	0.02
	Acetone	0.37	0.43	4.48	8.43	18.93	0.01
	Hexane	0.32	0.46	4.29	8.37	19.13	0.02

and carbohydrate content of samples, acetone showed highest extraction efficiencies for crude fibre and protein content whereas hexane showed highest extraction efficiency for fat content of the samples studied (Table 3). One-Way ANOVA at P <0.05 gave F value (3380.66) > critical F value (2.534) showing that the proximate composition of the breadfruit samples varies significantly with the solvent type and drying method.

The mean total ash content was 3.56% which is slightly higher than 2% (Ogunleye and Parakoyi, 1992), 1.2% (Dalziel, 1937), 2.80% (Nwabueze and Uchendu, 2011) and 2.13% (Ujowundu et al., 2013) recorded as ash contents in breadfruit samples of similar researches and comparable to 3.24 reported by Akubor and co-workers (Akubor et al., 2000). The ash content indicates the nutritional value and product quality of food (Kirk and Sawyer, 1998). The fat content (12.07-13.03%) was higher than 4.23% reported by Nwokolo (1996). The oxidation of constituent free fatty acids in dietary fats provides energy. The fat can serve as carriers of fat soluble vitamin and provitamins like carotenes. A minimum fat requirement of 6% in complementary formulation has been recommended (Obatolu, 2002), and the fat yield for each of the solvents meet this requirement.

The crude fibre contents (1.04-1.31%) are appreciable and it has been reported that consumption of diet rich in fibre can reduce the incidence of colon cancer and antherosclerosis since they lower blood cholesterol level (Hamilton and Bhati, 2003; Ujowundu et al., 2013). In addition, the mean protein content of the samples was 12.28% which is comparable to 13.56% (Nwabueze and Uchendu, 2011), 13.07% (Ujowundu et al., 2013) but lower than 18.17% (Oyenuga, 1968) recorded as protein content of breadfruit samples in related studies. The value of protein contents indicate that consumption of African breadfruits reduce the incidence of protein malnutrition in places where protein rich foods are in limited supply. The mean carbohydrate contents in bread-fruit (62.737%) are commendable and may significantly contribute to daily requirement which is 55 to 65% of total food calories. The mean carbohydrate content in the samples was comparable to 61.04% (Ujowundu et al., 2013) but lower than 68.64% (Ogunleye and Parakoyi, 1992) and 72.44% (Nwabueze and Uchendu, 2011) carbohydrate contents recorded in similar researches. The carbohydrate content could make African breadfruit to be a good composite flour in baking and confectionary products. The mean moisture content of the samples was 7.47% which is lower than 8% (Nwabueze and Uchendu, 2011) and 9.23% (Ujowundu et al., 2013) recorded as moisture content of breadfruit samples used in similar studies by other researchers.

Table 4 shows the vitamin composition (in mg/100 g) of African breadfruit sample, under sun dried conditions; petroleum ether has the greatest extraction efficiencies for vitamin A and E content of samples, hexane has the highest extraction efficiencies for vitamin C, niacin and thiamin content of samples whereas acetone exhibits highest extraction efficiency for riboflavin content of breadfruit samples.

However, under oven dried conditions, petroleum ether has the highest extraction efficiencies for vitamin A and E; hexane has the best extraction efficiencies for niacin and vitamin C while acetone has the best extraction efficiency for riboflavin. In addition, petroleum ether and hexane has the same extraction efficiency for thiamin. The values recorded for the mean ash, carbohydrate, protein and crude fibre contents of samples in this study are comparable to results obtained in similar studies.

One-way ANOVA was used to compare the vitamin composition of various breadfruit samples extracted and dried under different conditions and results showed that analysis of variance (F) value (1401.06) > critical F value (2.534) at P<0.05; indicating that the vitamin composition in the samples varies significantly with solvent type and drying method.

Comparing the vitamin composition of breadfruit samples in this study with that of related research shows that riboflavin (0.39 mg/100 g), niacin (0.47 mg/100 g), vitamin E (5.09 mg/100 g) and vitamin C (20.18mg/100g) levels in breadfruit samples investigated in this study were comparable to their corresponding components (riboflavin, 0.49 mg/100 g; niacin, 0.57 mg/100 g; vitamin E, 5.76 mg/100 g; vitamin C, 20.18 mg/100 g) in a related research (Ujowundu et al., 2013) except for thiamin (0.03%) and vitamin A (9.27 mg/100g) which were actually higher that (0.02%) recorded by Ujowundu et al.

(2013).

Conclusion

The oil yields in this study favoured the use of hexane as extraction solvent and the saponification value indicate that the oil can be used in soap making industries. The physiochemical, proximate and multivitamin composition of African breadfruit samples could be considered satisfactory and hence they are a good source of nutrition.

There is however need for more research on ways of improving the extraction yield of breadfruit oil to make it more viable as an economical source of edible and/or non-edible oil for diverse applications.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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