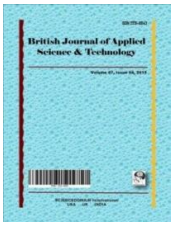

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Comparative Study of the Physicochemical Properties of Oils of Sheanut (*Vitellaria paradoxa)* and Cocoa (*Theobroma cacao*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author OOA designed the study, wrote the protocol, and supervised the work. Author AOV performed the physico- chemical and statistical analysis, wrote the first draft of the manuscript, managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This research work involves a study of the physico-chemical properties, fatty acid composition of oils of sheanut (*Vitellaria paradoxa*), cocoa (*Theobroma cacao*) and the effect of roasting on these properties. The data obtained were subjected to one-way analysis of variance (ANOVA) using the Statistical Package for Social Scientists (SPSS) 15 and the means were separated using the New Duncan's Multiple Range Test.

The physicochemical properties of the extracted oils were quite comparable, with roasting having little or no effect on them. The oils were found to be composed of both saturated (palmitic, stearic, arachidic, behenic, lignoceric fatty acids) and unsaturated (palmitoleic, oleic, linoleic) fatty acids. The study showed that sheanut samples contained higher percentage of linoleic acid, (5.67-6.43%)

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when compared with linoleic acid content of cocoa samples of 0.01%. Linoleic acid is one of the essential fatty acids required by the human body for various physiological functions. The total saturated fatty acids in the cocoa samples were found to be higher than that found in sheanut samples, while the total unsaturated fatty acids were found to be higher in sheanut samples than in cocoa samples.
The results revealed that sheanut will be a suitable substitute for cocoa in industrial applications.

Keywords: Cocoa; cocoa nib; fatty acids; physico-chemical; Sheanut.

1. INTRODUCTION

Cocoa belongs to the genus *Theobroma* in the family of *Sterculiaceae,* while sheanut belongs to the genus *Butyrospermum* in the family of *Sapotaceae* [1]. The tree crop, cocoa (*Theobroma cacao*) has played an important role in the economies of various regions of the world.Sheanut tree is a medium-sized deciduous tree which occurs mostly in West Africa, Northern Uganda and Southern Sudan. The seed contains 45 – 60% of the oil called shea butter, which is solid at room temperature [2]. Shea nut butter is one of the Africa's most sustainable natural resources and the shea tree is an important source of income; it is the third largest cash crop in Burkina Faso and Ghana, where it's surpassed only by cocoa and coffee [2]. Shea butter has been used for centuries in Africa for its moisturizing and healing properties, where it has been used to protect and condition skin, which have been damaged by the sun and wind [3].

The economic importance of the shea tree cannot be overemphasized, especially in the face of the unstable world market price for cocoa and the need to find suitable substitutes for cocoa in the beverage, confectionery and cocoa butter industries. In order to determine the suitability of sheanut as a substitute for cocoa and as a potential industrial raw material, there is need for comprehensive study of the sheanut oils [4]. Thus, this paper compares the physicochemical properties and fatty acid profiles of the oils extracted from the seeds of sheanut (*Butyrospermum parkii*) and cocoa (*Theobroma cacao*) and the effect of roasting on these properties.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Sample collection and preparation

The samples used for this study were raw cocoa nibs, roasted cocoa nibs, raw shea nuts and roasted shea nuts. The dried cocoa beans were obtained from Idanre Town, in Idanre Local Government Area of Ondo State, while the dried shea nuts were obtained from Bida Town, in Bida Local Government Area of Niger State; both states are located in Nigeria. The samples collection and analysis were carried out in 2010. The samples obtained were sun-driedfor two weeks, cleaned thoroughly to remove extraneous materials (stones, pebbles and twigs) and then separated into two portions. One portion was roasted in the oven at 120ºC for 2 hours, while the other portion was used in its raw state. The raw and roasted cocoa beans were shelled to obtain the cocoa nibs. The different samples were pounded separately with a pestle in a clean wooden mortar and thereafter ground with a laboratory Waring blender to obtain suitable particle sizes for laboratory analysis. The ground samples were stored in an air-tight plastic container and kept in the refrigerator, prior to analysis.

2.2 Methods

2.2.1 Physico-chemical analysis of extracted oils

The oils content of the ground samples were extracted with normal hexane using an extraction apparatus. The extracted oils from the samples were analysed for smoke point, flash point, fire point, refractive index, saponification value, peroxide value, Iodine value, specific gravity, free fatty acid, and unsaponifiable matter using methods described by [5,6].

2.2.2 Fatty acid profile analysis of extracted oils

According to [7], the fatty acid composition of fats and oils may be obtained by gas chromatographic analysis of the methyl or butyl esters of the fatty acids. The fatty acid composition of the oils was obtained by gas chromatographic analysis of the methyl esters of the fatty acids according to [7] method.

2.2.3 Esterification procedure for fatty acid analysis

The methyl esters of the fatty acids were prepared directly by treatment of the fat with sodium methoxide and were separated by gas chromatography.

About 0.5g of the oil was weighed into a small screw-capped vial; 3 ml of petroleum ether was added, covered and shaked to dissolve the oil. About 0.15 ml of 1M sodium methoxide was added using pipette. The mixture was shaken vigorously for a few seconds and then injected into a gas chromatograph, HP 6890 model.

The data obtained were subjected to one-way analysis of variance (ANOVA) using the Statistical Package for Social Scientists (SPSS) 15 and the means were separated using the New Duncan's Multiple Range Test.

3. RESULTS AND DISCUSSION

Table 1 summarizes the physicochemical properties of the extracted oils of the samples. Natural fats and oils are identified by their physical and chemical properties. The smoke points for cocoa samples were 170ºC, while for sheanut were 140ºC. The smoke point is the temperature at which a fat or oil gives off a thin bluish smoke or flame [8].

The flash points for cocoa samples were 290ºC and for sheanut were 220ºC. The flash point is the lowest temperature at which an applied ignition source will cause the vapors of a sample to ignite. Therefore, it is a measure of the tendency of a sample to form a flammable mixture with air [9].

The fire points for cocoa samples were 310ºC and for sheanut were 250ºC. The fire point is the temperature at which oil gives off sufficient vapour which when ignited continues to burn for at least 5 seconds [10]. Thus, fire point of oil or fat is the temperature at which the substance will sustain continued combustion [8].Smoke, flash and fire points are particularly useful in connection with fats or oils used for any kind of frying [8]. A knowledge of flash and fire points of oils is helpful in providing safeguards against fire hazards during their storage, transportation, handling and use [10]. It was observed that roasting has no definite effect on these parameters.

The specific gravity of the sheanut samples compare well with the cocoa samples, with roasting having an increasing effect on the values. This indicates that the oils are less dense than water. According to [5,11], the specific gravity of cocoa butter must be less than 1.0.

The refractive index which is a useful property in the preliminary examination of oils and fats purity ranged from 1.453 to 1.488 at 25ºC for the extracted oils. Refractive index is the precise method related to the average chain length and degree of unsaturation of the fatty acid in the oil or fat being examined. According to [12], edible oils have refractive index of about 1.4; this confirms that the extracted oils are edible and pure. Roasting having an increasing effect on the values.

Table 1. Physicochemical properties of extracted oils

Parameters	Raw cocoa nib	Roasted cocoa nib	Raw sheanut	Roasted sheanut
Smoke point ºC	170^{b}±0.00	170^{b}±0.00	140^{a}±0.00	140^{a} ±0.00
Flash point ºC	290^{b}±0.00	290^{b}±0.00	220^{a}±0.00	220^{a} ±0.00
fire point ºC	310^{b}±0.00	310^{b}±0.00	250^{a} ±0.00	250^{a} ±0.00
Specific gravity	0.914^{b}±0.00	0.918^{c}±0.00	0.913^{a}±0.00	0.919^{d}±0.00
Refractive index	1.488^{d}±0.00	1.455^{b}±0.00	1.453^{a}±0.00	1.466^{c}±0.00
Sap. Value	176.35^{a}±0.02	185.44^{b}±0.01	189.48^{c}±0.02	192.31^{d}±0.02
Unsap. Matter %	1.18^{a}±0.00	1.21^{c}±0.01	1.20^{b}±0.00	1.23^{d}±0.00
F.Fatty Acid %	0.40^{b}±0.00	0.40^{b}±0.00	0.30^{a}±0.00	0.30^{a}±0.00
P. value meq/kg	0.44^{d}±0.00	0.38^{b}±0.00	0.40^{c}±0.00	0.36^{a}±0.00
Iodine value	36.07^{b}±0.13	35.27^{a}±0.13	40.40^{d}±0.00	39.27^{C}±0.13

Values are means ± standard error of three independent determinations. Values in the same row having the same superscript are not significantly different at P< 0.05, while values with different superscript in the same row are significantly different at P< 0.05.

Sap. Value= saponification value (the unit is mg KOH/g), unsap. Matter= unsaponifiable matter, F. fatty acid = free fatty Acid, P. value =peroxide value

The percentage free fatty acids for the analysed oils ranged from 0.30 to 0.40%. Free fatty acid (FFA) is used as a general indication of the condition and edibility of oils and fats.

The Standard Organization of Nigeria (SON) specified that the percentage FFA for cocoa butter should not be more than 1.75% [11]. The results obtained for these samples shows that they are edible and that they may be stored for long period with minimum spoilage through oxidative rancidity.

The saponification value which is the amount of alkali required to neutralize the fatty acids resulting from the complete hydrolysis of 1g of the oil or fat ranged between 176.35 and 192.31 mg/g. These values agree with 188 – 196 mg/g specified for cocoa butter by [5]. The saponification value (S.V) is inversely proportional to the mean of the molecular weights of the oil. Thus, the higher the S.V, the lower the molecular weight of the oil. The high S.V recorded for the oils indicates that they are of lower molecular weight and this makes them suitable for soap making [13]. The values of the roasted samples are higher than raw samples.

The unsaponifiable matter for the samples ranged from 1.18 to 1.23%. Most oils and fats of normal purity contain less than 2% of unsaponifiable matter. These values show that the extracted oils are pure [5]. The values of the roasted samples are higher than raw samples.

Peroxide value is a measure of the peroxides contained in an oil or fat. The concentration of peroxides in an oil or fat gives an indication of the extent of spoilage. The peroxide values of the oils ranged from 0.36 to 0.44 meq/kg. The maximum peroxide value specified for cocoa butter by Standard Organization of Nigeria is 2.0 meq/kg [11]. The low peroxide values for these extracted oils indicate that they are edible and are less liable to oxidative rancidity at room temperature [14]. The peroxides values of the sheanut compare well with that of the cocoa, with roasting causing a slight reduction in the peroxides value of the roasted samples.

The iodine value which is a measure of the degree of unsaturation in oils or fats ranged from 35.27 to 40.40 for the samples. These values agree well with the iodine value of 33 to 42 specified for cocoa butter by Standard Organization of Nigeria [11] and are in agreement with earlier research work done on cocoa butter by [15]. Roasting decreased the iodine value of all the samples.

These values shows that the extracted oils contain mainly saturated fatty acids and that the less unsaturated oils with low iodine values are solid at room temperature [5].

Table 2 shows the percentage composition of methyl esters of the fatty acids present in the extracted oils. Fatty acids are aliphatic monocarboxylic acids, derived from, or contained in esterified form in an animal or vegetable fat, oil or wax. Natural fatty acids commonly have a chain of 4 to 28 carbons (usually un-branched and even numbered), which may be saturated or unsaturated. Fatty acids are produced by the hydrolysis of the ester linkages in fat or biological oil (both of which are triglycerides), with the removal of glycerol [16].

The results showed that all the oils composed of both saturated and unsaturated fatty acids. The quantified saturated fatty acids were palmitic, stearic, arachidic, Behenic and lignoceric acids, while the quantified unsaturated fatty acids were palmitoleic, oleic and linoleic acids. The percentage palmitic acid composition of the samples ranged between 3.79 and 17.59%. It was observed that the palmitic acid contents of the sheanut samples were lower than that of the cocoa samples, with roasting having an increasing effect on the palmitic acid content. These values were lower than 24% palmitic acid content reported for cocoa butter by [1].

The percentage stearic acid contents of the samples ranged from 38.61 to 49.35% with roasting having an increasing effect on it. The stearic acid contents of all the samples compare well except for raw sheanut which was lower. These values were higher than the 34% stearic acid reported for cocoa butter by [1].

Other saturated fatty acids quantified in all the samples were arachidic, behenic and lignoceric acids, but at trace levels.

The percentage oleic acid composition of the samples ranged from 30.80 to 49.9%, with roasting having a reducing effect on it. The oleic acid contents of the sheanut oils were found to be higher than that of cocoa oils. The oleic acid content of the examined cocoa oil was found to be lower than 38% oleic acid reported for cocoa butter by [1].

Table 2. Fatty acid composition (%) of extracted oils

Fatty acids	Raw cocoa nib	Roasted cocoa nib	Raw sheanut	Roasted sheanut
Palmitic acid	16.35	17.59	3.79	3.99
Palmitoleic acid	0.12	0.09	0.07	0.01
Stearic acid	47.00	49.35	38.61	48.79
Oleic acid	34.62	30.8	49.95	41.49
Linoleic acid	0.01	0.01	6.43	5.67
Arachidic acid	1.75	2.13	0.69	0.03
Behenic acid	0.08	0.02	0.23	0.01
Lignoceric acid	0.07	0.02	0.22	0.01
Saturated fatty acids	65.25	69.11	43.54	52.83
Unsaturated fatty acids	34.75	30.89	56.45	47.17

The sheanut samples contained higher percentage of linoleic acid, 5.67-6.43% when compared with cocoa samples of 0.01%. Linoleic acid is one of the essential fatty acids required by the human body for various physiological functions [17].

The total saturated fatty acids in the cocoa samples were found to be higher than that found in sheanut samples, while the total unsaturated fatty acids were found to be higher in sheanut samples than in cocoa samples.

In the body, essential fatty acids are primarily used to produce hormone-like substances that perform a wide range of functions, including blood pressure, blood clotting, blood lipid levels, the immune response, and the inflammation response to injury infection. Fatty acids play an important role in the life and death of cardiac cells because they are essential fuel for mechanical and electrical activities of the heart [18,19].

4. CONCLUSION

This research work compared the physicochemical properties and fatty acid composition of the oils of cocoa and sheanut, and the effect of roasting on these properties. The physicochemical properties and fatty acid composition of the sheanut oil compare favourably well with that of cocoa oil. The results also revealed that roasting significantly increased the physicochemical properties and fatty acids contents of the extracted oils with few exceptions.

The fatty acids analysis revealed that the samples composed mainly of saturated fatty acids; this confirmed their existence as solids at room temperature. Sheanut oil was found to contain a higher percentage of linoleic acid (an essential fatty acid) than cocoa oil; this property made sheanut oil better for human consumption than cocoa oil.

It can be conveniently concluded that sheanut and its products will be a suitable substitutes for cocoa in any industrial application. This research was conducted for one year only, and further research is needed to see the effects of environments in each year on these physicochemical properties.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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