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Physicochemical Analyses of Coconut (*Cocos nucifera L.*) Oil Obtained by Solvent (Aqueous and n-Hexane) Extraction Methods

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Abstract

The oil of coconut (cocos nucifera L.) was extracted by two different processing methods; aqueous (heating method) and solvent (soxhlet) extraction method. The physicochemical properties of the oil extracts were evaluated. The results showed that the density, specific gravity, viscosity and pH (aqueous extraction; 0.89 g/cm3, 0.91, 4.0 mpa.s, 4.7 and solvent extraction; 0.89 g/cm3, 0.91, 3.8 mpa.s, 5.1 respectively) of the oil extracts were relatively close. Other properties like the saponification value, free fatty acid, acid value and peroxide value of the aqueous and solvent extraction methods are 196.35 mgKOH/g, 0.56 mgKOH/g, 0.00028 mgKOH/g, 0.2 meq peroxide/g and 266.4 mgKOH/g, 0.95 mgKOH/g, 0.0047 mgKOH/g, 2.0 meq peroxide/g respectively..

INTRODUCTION

Coconut (*cocos nucifera L.*) is known in many languages by its local names for example it has been known as “Agbon” in Yoruba, as “Kwakwa” in Hausa and as “Aku oyinbo” in Igbo. Coconut oil, or copra oil is an edible oil extracted from the kernel or meat of mature coconut harvested from the coconut palm (*cocos nucifera*). Because of its high saturated fat content, it is slow to oxidize and thus, resistant to rancidification, lasting up to six month 24 ^{o}C (75 ^{o}F) without spoiling (Coconut oil, 2015) [1]. Historically coconut oil has been a life saver for many people, the health and nutritional benefits derived from coconut oil is unique and compelling. Dayrit *et al.*, 2001 [2] had stated that medium chain triglyceride, a fraction of coconut oil has been identified as an important, medically efficacious food. Indeed, diet for critically ill children, premature

infants and hospitalized patients use medium chain triglycerides as principle source of food which proves to be anticholosterogenic. Coconut oil has been called the healthiest dietary oil on earth. It is being used for thousands of years by pacific islanders and in Asia. It is marvelous oil gifted by nature from perennial palm tree. It is known for its nutrition, health and medicines to cure various diseases and keeps the body shiny without wrinkling and fit to work (Jarimopas, 2007) [3]. So many research have been conducted on the extraction processes and physicochemical analyses of coconut (cocos nucifera L.) oil. Okene *et al*., 2014 [4] study the physicochemical properties of coconut oil. The solvents used were isopropanol and petroleum ether. The physicochemical parameters of the extracted oil were determined by standard methods of analysis.

Probir *et al*., 2014 [5] also evaluate the extraction and physicochemical properties of coconut oil. The Coconut copra was subjected to aqueous and solvent extractions (using n-hexane). Additionally, the oil was extracted from the copra in soxhlet assembly using petroleum ether. Physicochemical and phytochemical analyses were conducted for the extracts and the oil, with commercial coconut oil as the experimental control. Fatty acid composition analyses showed mainly medium chain fatty acids in the copra oil with lauric acid as the predominant fatty acid (51.88 % and 44.84 % in soxhlet extracted and commercial oils respectively).

Sani *et al*., 2014 [6] reported on evaluation of physicochemical properties, phytochemicals and mineral composition of cocos nucifera (coconut) kernel oil. The oil was extracted using soxhlet apparatus and the physicochemical characterization, together with the phytochemical screening and determination of the mineral composition were carried out using standard methods. The oil was observed to have clear white appearance, liquid at room temperature and has a nutty smell when fresh and unpleasant when rancid. Cocos nucifera L. seed kernel was found to have low oil content of 26.61 %.

Che Man et al., 2012 [7] reported the physicochemical properties of virgin coconut oil extracted from different processing methods. The Virgin Coconut Oil (VCO) was prepared from fresh-dry (grated coconut route), chilling and thawing, enzymatic and fermentation method. All of the VCO produced conformed physicochemically to the standards established by the Asian and Pacific Coconut Community (APCC) and Codex Alimentarius Commission. The highest FA (fatty acid) was lauric acid in all of the VCO and ranged from 46.36 – 48.42 %. The aim of this research is to extract coconut oil by solvent (aqueous and n-hexane) extraction methods, evaluate and compare the physicochemical properties of the oil extracts.

MATERIALS AND METHODS

Materials

The essential materials used during the research work are mature coconut fruit obtained from akodudu in Ilorin, Kwara State, Nigeria, Analytical grade n-hexane, oven, soxhlet apparatus, rotary evaporator, titration apparatus and cloth.

Methods

Extraction of the oil

The oil was obtained via two different solvent extraction methods;

i. Aqueous extraction method (heating method)

ii. Soxhlet extraction method (n-hexane)

Aqueous extraction method

The husk of matured coconut was removed. The coconut copra (dried coconut flesh) was finely ground into a paste and sieved using cheese cloth. The filtrate was allowed to settle, which later separates out into two layers. The upper layer is called curd while the lower layer is water. The curd was separated from the mixture and allowed to stand for some time before any further step is taken. The oil was obtained by heating the curd at a particular temperature.

Soxhlet (n-hexane) extraction method

The coconut copra (dried coconut flesh) was crushed then subjected to solvent extraction using the soxhlet apparatus. n-hexane is the solvent used for the extraction process. The extraction was carried out at the boiling point of n-hexane (68 ^{o}C) for 6 h. The resulting solution was a mixture of the solvent and the oil. The n-hexane was distilled off in a rotary evaporator at 65 ^{o}C.

Oil Recovery

Oil recovery gives a quantitative measurement on the effectiveness of different method of extractions on the amount of oil produced. Below is the formula used for the calculation of the oil yield:-

$$\text{Percentage yield} = \frac{\text{mass of the oil extracted X 100}}{\text{Mass of the total seed used}}$$

Physicochemical analyses

The Physicochemical parameters of the extracted oil were determined by standard methods of analysis. Physicochemical analysis involve the measurement of various physical and chemical properties of the oil. Properties like the colour, density, viscosity, specific gravity, acid value, oil yield, saponification value and FFA (free fatty acid) value of the seed oil were determined.

Determination of specific gravity

The specific gravity was determined by weighing an empty 25 cm^3 S.G bottle, the bottle was filled to the mark with distilled water and weighed. The measurement was recorded. The same amount of oil was also weighed and recorded after drying the bottle. Below is the formula used for the calculation of the specific gravity of the oil:-

$$\text{Specific gravity} = \frac{W_1}{W_2}$$

Where W_1= weight of the oil W_2 = weight of the distilled water

Determination of saponification value

25 cm^3 of 10 % ethanolic KOH was added to 2 g of the oil and refluxed for 30 min. The unreacted KOH was back titrated with 0.5 M HCl using 3 drops of phenolphthalein. Saponification value was calculated using the following equation;

$$\text{Saponification value} = \frac{V_b - V_a \times 56.1 \times M}{W(g)}$$

Where V_a = titre value of oil V_b = titre value of the blank

M = molarity of the HCl W = weight of oil

56.1 = molecular weight of KOH

Determination of free fatty acid

1 g of the oil was weighed and introduced into 250 cm^3 conical flask, to this 3 drops of phenolphthalein was added followed by 20 cm^3 ethanol. The mixture was titrated with 0.1 M NaOH solution until pink colour appears. Free fatty acid was calculated by the following equation;

$$\text{Free fatty acid} = \frac{T \times M \times 56.1}{W\ (g)}$$

Where T = titre value M = molarity of the titrant

W= weight of oil 56.1= acid constant

Determination of acid value

The same experimental procedure given for (FFA) was also used for the determination of acid value, the value was calculated by the following equation;

Acid value = T ×0.0282 × W Where T = titre value

W = weight of oil 0.0282= constant

Determination of peroxide value

1 g of the oil was weighed into 250 cm^3conical flask to which was added a solvent mixture of glacial acetic acid 10 cm^3 and 10 cm^3 chloroform was added. 1 g of KI was added and the mixture was heated in a water bath for 5 min. To this whole mixture was added 20 cm^3 of 5 % KI and titrated with 0.002 M solution of $Na_2S_2O_3$ using starch solution as indicator. The peroxide value was calculated using the following equation;

$$\text{Peroxide value} = \frac{V_2\text{-}V_1 \times M \times 1000}{W\ (g)}$$

Where V_2 = titre value of oil V_1 = titre value of the blank

M = molarity of $Na_2S_2O_3$ W = weight of oil

Determination of pH Value

The pH of the oil was determined using HANNA pH meter.

Determination of viscosity of the oil

The viscosity of the oil was determined using NDJ-1B Rotational viscometer.

Determination of The Density of The Oil

The density of the oil was determined with the aid of the Borosilicate density bottle.

$$\text{Density} = \frac{\text{Mass of oil (g)}}{\text{Volume of oil (cm}^3\text{)}}$$

RESULTS AND DISCUSSION

Physicochemical Analyses

The physicochemical analysis of the oil extracts were determined by standard methods of analysis. The following table presents the physicochemical properties of the coconut oil obtained by the two (aqueous and n-hexane) extraction methods.

Table 1: Physicochemical properties of the coconut oil extracts

S/N	Physicochemical properties	Aqueous (heating method) Extraction	Soxhlet (n-hexane) extraction
1	Colour	Brownish	Pale yellow
2	% Oil yield	7.91	8.89
3	Density	0.89 g/cm^3	0.89 g/cm^3
4	Specific gravity	0.91	0.91
5	Viscosity	4.0 mpa.s	3.8 mpa.s
6	pH value	4.7	5.1
7	Saponification value	196.35±13.3 mgKOH/g	266.4±0.95 mgKOH/g
8	FFA	0.56±0.1 mgKOH/g	0.95± 1.5 mgKOH/g
9	Acid value	0.00028±0.01 mgKOH/g	0.0047±0.000282 mgKOH/g
10	Peroxide value	0.2±0.2 meq peroxide/g	2.0±0.5 meq peroxide/g

Table 1 shows the physicochemical properties of the coconut oil obtained by aqueous (heating method) and soxhlet (n-hexane) extraction methods. Coconut oil extracts obtained in this study by the aqueous (heating method) and soxhlet (n-hexane) extraction methods were brownish and pale yellow in colour respectively. The oil yield was lower (7.91 and 8.89 %) than 21.61 % reported by Sani *et al*., (2014).

The specific gravity value obtained in this study was 0.91 for the oil obtained by the two extraction methods, which indicate that the oil is less dense than water. The specific gravity of coconut oil extracts is in the same range with that reported by Okene *et al*., (2014), which was 0.92. The saponification value obtained for the coconut oil extracts in this study was 196.35 mg KOH g^{-1} and 266.4 mg KOH g^{-1} for the oil obtained by aqueous (heating method) and soxhlet (n-hexane) extraction respectively. Because of high saponification value, the coconut oil is suitable for soap making (Ikhuoria and Maliki, 2007) [8]. The acid value obtained for the coconut oil extracts in this study was (0.00028 mg KOH g^{-1} and 0.0047 mg KOH g^{-}

^{1}), which was lower than the value (0.156) reported by Okene *et al*., 2014 and also lower than the value (0.79 mg KOH g^{-1}) obtained by Sani *et al*., (2014). The peroxide value (2.0 meq/g for the soxhlet extracted oil) was higher than the value (0.46 meq/g) reported by Okene *et al*., (2014) and lower than the value (10.00 meq/g) obtained by Sani *et al*., (2014).The free fatty acid value obtained in this study was 0.56 mg KOH/g and 0.95 mg KOH/g for the oil obtained by aqueous (heating method) and soxhlet (n-hexane) extraction respectively, was higher than the value (0.1 mg KOH/g) obtained by Okene *et al*., (2014) and lower than the value (20.49 mg KOH/g) obtained by Sani *et al*., (2014). The P^{H} value obtained was 4.7 and 5.1 for the oil obtained by aqueous (heating method) and soxhlet (n-hexane) extraction respectively. The acidic nature of the oil extracts might indicate a prolonged shelf-life.

CONCLUSION

The soxhlet (n-hexane) extraction method adopted in this study has a comparative edge over the aqueous (heating method) extraction. The higher oil yield, saponification value (SV), Free fatty acid (FFA), acid value (AV) and peroxide value (PV) of the solvent extracted oil is an indication that it is more cost-effective, less prone to deterioration and more suitable for soap making.

The oil obtained by the aqueous (heating method) extraction will be more preferable as an edible oil due to the benign (environment-friendly) solvent (water) used for the extraction.

Overall, this research is an indication that great potential exists for the use of coconut oil. The oil is suitable for both domestic and industrial use. It has reduced the sole dependence on palm oil and peanut oil.

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