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Extraction, Characterization and Application of *Cocos nucifera* Oil

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Abstract:
Background*: The study aimed at the extraction, characterization and application of coconut oil obtained from allogamous and autogamous species.*
Materials and Methods*The oil was extracted using cold and hot press methods. The oils were characterized using the classical physicochemical method, classical phytochemical screening, and fatty acid analysis using Gas Chromatography.*
Results*: The results for the physicochemical analysis showed that acid value was 7.9 % (for native hot-pressed oil), 5.1% (for native cold-pressed oil) and 3.6% (for agric hot pressed oil). The iodine value was with the permissible limit. the saponification value was found to be high (329.6mg/kg) for the agric hot pressed oil, while the native hot and cold-pressed oil were within the permissible limit. The refractive index for all the oils was within the permissible limit of 1.4. the peroxide values also were found to be within the permissible limit as none exceeded 3mg/kg. Phytochemical screening revealed the presence of terpenoids and steroids in the oil. The fatty acid analysis revealed that the extracted oil is rich in fatty acids such as lauric acid (44.6-46.7%), myristic acid (16.2-21.4%), palmitic acid (6.8-8.3%), oleic acid (7.2-9.8%), linoleic acid (3.9-6.5%). They were within permissible limits. The extracted oil was used in the production of body cream. The cream produced was subjected to pH test and non-volatile matter, which were found to be within the standard acceptable limit.*
Conclusion:*The study investigated the physicochemical properties, fatty acid profile, as well as phytochemical properties of the extracted oil and applied the extracted oil in the production of cream.*
Keywords*:Cocos nucifera Oil, Application, Characterization, Physicochemical and Fatty acids.*

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I. Introduction

*Cocos nucifera*is a palm tree, that is widely spread in Asia, Africa, Latin America and in Pacific regions. This tree is tropical and can survive for so many years with so many ranges of products that are sold globally. *Cocos nucifera* based products have lots of benefits to mankind. It is used as a source of food, energy and as a cash crop to so many farmers in various countries. It thrives well on a good drained loamy and clayey soil. The growth of Coconut is favoured by a warm and humid climate. Mean annual temperature of 27^0C, an evenly distributed rainfall of 1500-2500 mm per annum and relative humidity above 60 % provides the ideal climatic condition for the vigorous growth and yield of the palm. With very good climatic conditions, coconut palm produces 12-16 bunches of coconut per year, each bunch with 8-10 nuts[1, 2, 3]. Coconut oil is a mutual component in personal body maintenance products such as soaps, lotions, and cosmetics. Lauric acid (a fatty acid) and its byproducts (e.g., lauryl sulfate) are used as detergents and surfactants in cleansers. Applying coconut oil right on the skin can increase the skin's moisture and lipid content, just like mineral oil. Coconut oil could add some antiseptic attributes to lotions or moisturizers that could benefit people with some skin conditions. Coconut oil is applicable in hair care not just because it has a high attraction for hair proteins and, but because of lauric acid's low molecular weight and straight linear chain, can infiltrate inside the hair shaft. Coconut oil decreases protein loss for both unspoiled and spoiled hair when used as a pre-wash and post-wash grooming product [4, 5]. Coconut oil is composed mainly of fatty acids some of which are saturated and others monounsaturated fatty acid. Coconut oil does not contain dietary cholesterol. The main fatty acids are lauric, myristic and palmitic acids. Virgin coconut oil has been found to contain more concentrations of polyphenols than standard coconut oil. The reasons for lower levels in standard coconut oil may be because minor components were destroyed during the manufacturing process and also because polyphenols which are polar compounds have a higher affinity for liquid coconut milk and fresh copra as opposed to dried copra [6, 7, 8]. In recent times, coconut oil is used globally for different purposes, especially for moisturization and hair treatment. Hence, there is a need to characterize the oil to know the components responsible for its moisturization properties. This study will provide useful information about the active ingredients in coconut oil that are

responsible for the freshness of the skin when it is applied as a moisturizer and the formulation of coconut oil-based skin product.

II. Material and Methods

Collection of Samples

Matured coconut fruits of autogamous and allogamous species were obtained from oil mill market in Port Harcourt, Nigeria.

Extraction of the Coconut Oil

The coconut shell was removed and the flesh washed and blended to get a paste. The paste was then filtered with a mesh cloth to obtain the milk which was decanted to remove water present. After decantation, the concentrated milk was covered to prevent air from entering. Afterwards, it was placed in the dark for 12 hours to obtain the virgin coconut oil.The coconut shell was removed and the flesh washed and blended to get a paste. The paste was then filtered with a mesh cloth to obtain the milk which was decanted to remove water present. after decantation, the concentrated milk was heated at low heat to obtain pure coconut oil.

Fatty Acid Analysis

Fatty acids were analyzed using AOAC(1990) method and the method is described thus.Buck 530 gas chromatograph equipped with an on-column, automatic injector, electron capture detector, HP 88 capillary column (100m x 0.25µm film thickness) CA USA was used.The gas flow of the column, the inlet, the detector, and the split ratio was adjusted. Besides, the injector and detector temperature were set. The detectors were held at the high end of the oven temperature range to minimize the risk of analyte precipitation. The oven temperature was set to 1800c and the GC was allowed to warm up. While it was still warming up, the temperature condition was set. After which 1 microliter of the coconut oil sample onto column A using proper injection technique.

Physicochemical Analysis

Physicochemical analysis was done using the AOAC (1995) method, and the methods are outlined below.

Determination of Acid Value

A 25ml diethyl ether was mixed with 25ml alcohol and 1ml phenolphthalein (1%) and then carefully neutralized with 0.1 M Na0H. 2g of the oil was added to the mixed neutral solvent and titrated with aqueous 0.1 M Na0H with constant shaking until a pink color which persisted for 15 seconds was obtained.

Calculation;

$$\text{Acid value} = \frac{\text{titer (ml)} \times 5.61}{\text{Weight of sample}}$$

Determination of Iodine Value

A 5Ml of the oil was weighed by difference into a dry glass – stoppered bottle of about 250ml capacity. Then 10ml of carbon tetrachloride was then added to the oil, after which 20ml of wijis' solution was added and the stopper (previously moistened with potassium iodide solution) was inserted and then allowed to stand in the dark for 30 minutes. After 30 minutes, 15ml of potassium iodine solution (10%), 100ml of water was added and titrated with 0.1M thiosulphate solution using starch as an indicator just before the endpoint (titre value=aml). A blank titration was carried out at the same time beginning with 10ml of carbon tetrachloride (titration=bml)

$$\text{Iodine value} = \frac{(b - a) \times 1.269}{\text{Wt. (g) of sample}}$$

The wijis' solution was prepared by dissolving 8g of iodine trichloride in 200ml glacial acetic acid. Then 9g iodine of iodine was dissolved in 300ml carbon tetrachloride. The two solutions were mixed and diluted to 1000ml with glacial acetic acid.

Determination of Peroxide Value

For the peroxide value, 1g of the oil was weighed into a clean dry boiling tube, 1g of powdered potassium iodide was added as well as 20ml of solvent mixture (2 vol glacial acetic acid + 1 vol chloroform). The tube was placed in boiling water so that the liquid boils within 30 seconds and allowed to boil vigorously for not more than 30 seconds. After boiling the content was quickly poured into a flask containing 20ml of potassium iodide solution (5%), and the tube washed out twice with 25ml water and then titrated with 0.002M sodium thiosulphate solution using starch as indicator. A blank titration was performed at the same time.

Determination of Saponification Value

Approximately 2g of the oil was weighed into a conical flask and 25ml of alcoholic potassium hydroxide solution was added to it. A reflux condenser was attached and the flask was heated in boiling water for 1hr with frequent shaking. Afterwards, 1ml of phenolphthalein solution was added and the excess alkali was titrated hot with 0.5M hydrochloric acid (titration = bml).

$$\text{Calculation: saponification value} = \frac{(b-a) \times 28.05}{\text{Wt. (g) of sample}}$$

Determination of Specific Gravity

A 50ml pycnometer bottle was thoroughly washed with detergent, water, and petroleum ether, then dried and weighed. The bottle was then filled with water and weighed. The bottle was dried again and filled with the oil sample and weighed.

$$\text{Calculation: Specific gravity} = \frac{\text{weight of xml oil}}{\text{Weight of xml of water}}$$

Determination of Refractive Index

The Abbe refractometer was reset with a light compensator. The oil sample was seared on the lower prism of the instrument and closed. The light was then passed using the bangled mirror, as the reflected light appeared in the form of a dark background. With the use of fine adjustment, the telescope tubes were moved until the black shadow appeared central in the crosswire indicator. The refractive index was then read.

Determination of Smoke, Flash and Fire point

A 10ml of the oil sample was poured into an evaporating dish. A thermometer was then suspended at the centre of the dish ensuring that the bulb just dipped inside the oil without touching the bottom of the dish. The temperature of the oil was gradually raised using a hot plate. The temperature at which the oil sample gave off a thin bluish smoke continuously was noted as the smoke point. Similarly, the temperature at which the oil started flashing without supporting combustion was noted as the flashpoint. Again, the temperature at which the oil started supporting combustion was recorded as the fire point.

Classical Method for Analyzing Phytochemicals

The classical analysis was done using methods described by Gregory, (2005) on food analysis and instrumentation for saponin, tannins, steroid, flavonoids, glycoside, cardiac glycoside, terpenoids and alkaloids.

Product Formulation and Testing

The extracted coconut oil was used in the production of body cream. The cream was formulated using 40 per cent shea butter, which served as the base, 50 per cent coconut oil, 5 per cent vitamin E, 4 per cent glycerine and 1 per cent fragrance. The cream produced was tested for pH and non-volatile matter.

III. Results

Fatty Acid Profile

The results obtained showed that fatty acids are present in hot and cold-pressed extracted coconut oil. These fatty acids include linoleic acid, lauric acid, myristic acid, palmitic acid, arachidonic acid, oleic acid etc. Their percentage compositions are listed in the table below.

Table 1. Fatty Acid Profile of Coconut Oil

Components	Composition (%) in Native Coconut Oil (Hot Pressed)	Composition (%) in Native Coconut oil (Cold-Pressed)	Composition (%) in Agric coconut oil (Hot Pressed)	Codex Standard (%)
Linoleic acid	3.9	6.0	6.5	1.0-2.0
Lauric acid	45.5	44.6	46.7	45.1-53.2
Myristic acid	16.2	20.0	21.4	16.8-21.0
Palmitic acid	8.3	7.5	6.8	7.5-10.2
Arachidonic acid	6.5	-	1.4	NA
Osbond	5.2	6.9	5.7	NA
Oleic acid	7.2	9.8	8.3	5.0-10.0
Stearic acid	6.1	2.8	2.6	NA
Docosahexaenoic acid	1.0	1.8	0.4	NA
Linolenic acid	0.5	0.7	0.3	ND-0.2
Arachidic acid	-	0.0	0.0	ND-0.2

From Table 1, the various coconut oils appear to have a high amount of lauric acid, myristic acid, palmitic acid, linolenic acid and oleic acid. These findings agree with reports from various researches done on coconut oil by [9, 10, 6]. The numerous benefits of coconut oil can be accrued to the presence of different fatty acids as reported by [11]. Fatty acids can be classified for the presence of double bonds and the length of the carbon chain present. They are called saturated fatty acids if there is no double bond present and termed unsaturated fatty acids if there is a double bond present. Among the saturated fatty acids present in coconut oil under examination are; lauric acid, myristic acid, palmitic acid stearic acid as well as arachidic acid while linolenic acid, oleic acid and linoleic acid fall under the unsaturated fatty acids [12].Lauric acid ($C_{12}H_{24}O_2$) also known as dodecanoic acid with 12- carbon atom chain was the highest concentration in the coconut oil and there was no difference among the different species of coconut oil extracted. According to an online article on beauty and skincare (2019), lauric acid has antibacterial properties, it has been found to effectively fight acne. It was reported that bacteria Propionibacterium acnes are found naturally on the skin and when they overgrow, they lead to the development of acne. therefore, consistent use of coconut oil can help to reduce acne because of the high amount of lauric acid composition. Myristic acid also called tetradecanoic acid ($C_{14}H_{28}O_2$) was the second in terms of percentage composition. This is a saturated fatty acid with 14- carbon atoms. An online article on the truth about ageing (2019) revealed that myristic Acid functions as an opacifying agent, a surfactant (by breaking the barrier between water and oils and /or dirt) and a cleansing agent. This property has led to the application of coconut oil in the production of skincare and hair care products[12]. From the result obtained, the percentage composition of myristic acid was more in the Agric species hot pressed coconut oil meaning that in making the choice of coconut oil for cleansing products, the Agric species should be opted for. Palmitic acid ($C_{16}H_{32}O_2$) or hexadecenoic acid, appears was third in percentage composition of fatty acids with the highest amount in the Agric species of the coconut oil. Santa, [13], reported that palmitic acid is one of the saturated fatty acids present in our body. And as we age, the percentage amount reduces by 56 %. Therefore, coconut oil can be used as a

supplement for palmitic acid since it has a considerable amount present as reported by the present study. Palmitic acid can serve as an emollient, it softens the skin and helps retain moisture by forming an occlusive layer. It has antioxidant properties which help prevent free radical damage to the skin thereby maintaining youthful radiant skin. The reports also reveal that palmitic acid functions as an emulsifier and a surfactant. Because of its low surface tension, it allows water to combine with the oil and dirt molecules and wash them away. Thus, palmitic acid helps to remove dirt, sweat and excess oily substances from the skin and hair. All these attributes make palmitic acid a useful ingredient in the cosmetic industry for the production of facial cleansers, body washes, shampoos and bar soaps [13]. From the results obtained, oleic acid $C_{18}H_{34}O_2$ and linoleic acids $C_{18}H_{32}O_2$ have a significant amount in both species of coconut oil. Kendall, [14] reported that Oleic acid is the most common fatty acid in nature and is the most abundant fatty acid in human adipose tissue, and the second in abundance in human tissues overall, next to palmitic acid. It is also known as omega-9 fatty acids. It is good for dry or ageing skin because it permeates easily and deeply into the skin through its surface, replenishing lost moisture and stopping additional moisture from evaporating. The report also states that oleic acid has the potential to restore the natural oil of the skin, without clogging pores and leading to breakouts. He reported that oleic acid also has antioxidant properties that fight free radical damage caused by environmental stressors, such as UV rays, that lead to skin ageing. It is an anti-inflammatory that stimulates wound healing and repairs daily skin damage, as well as soothes conditions such as eczema, rosacea and psoriasis as it provides compounds that strengthen the integrity of cell membranes. All these properties made coconut oil widely used as a massage oil. Our body's tissue does not produce linoleic acid like oleic acid; even though it plays an equally important role in skin health as fat that promotes healthy cellular activity. Linoleic acid is an anti-inflammatory agent that stimulates cell regeneration [14]. Hence, the use of coconut oil as supplements to avail linoleic acid to the body. The present study has reported the availability of linoleic acid in coconut oil.

Physicochemical Results

The table below shows the results obtained from the physicochemical analysis.

Table 2. Physiochemical Parameters of the Coconut Oils

Parameters	Native Coconut Oil (Hot Pressed)	Native Coconut Oil (Cold-Pressed)	Agric Coconut Oil (Hot Pressed)	CODEX STANDARD %
Acid value (%)	7.9	5.1	3.6	10
Free fatty acid %	3.9	2.5	1.7	NA
Iodine value	7.6	5.5	8.1	6.3-10.6
Peroxide value mg/kg	2.0	2.3	1.8	3
Saponification value mg/kg	201.9	117.8	329.6	248-265
Viscosity pa . s	0.6	0.5	0.3	NA
Specific gravity	0.9	0.9	1.0	NA
Melting point ^{0}c	25.9	19.5	26.3	NA
Refractive index	1.4	1.4	1.4	1.448-1.450
Flash point ^{0}c	119.4	120	118.9	NA
Moisture content %	3.3	4.0	3.8	NA

Table 2. shows the result of the physicochemical analysis of the coconut oil samples. The acid value appears to be higher in the native species coconut oil (both the hot and cold-pressed extracted) even though all fall within the permissible limit of codex standard. The acid value of an oil is a measure of the number of free acids present in the oil. It is an indicator of ageing of the oil [12]. The values obtained from the oil shows that it is fresh and in good condition. The peroxide values obtained were within the permissible limit for coconut oil.

Kapila &Nimanthi, [12] reported that peroxides are primary oxidation products of coconut oil which are formed because of free radical reactions and they further break into shorter chain secondary oxidation products such as aldehydes and ketones that are volatile, which in turn give the oil the smell of rancidity, known as oxidative rancidity. The iodine value obtained were all within the permissible limit and is comparable to values reported by [15]. Iodine value (IV) is the measurement of the degree of unsaturation in oils. Since low unsaturation provides high oxidative stability to oils the values obtained from the analysis indicates that the oil is oxidatively stable. Saponification values obtained were seen to be higher in the oil extracted by hot-pressed method this is because saponification is the process that converts fat or oil into soap and alcohol by the action of heat. Although they were within the permissible limit. Saponification value (SV) measures the average molecular weight of fatty acids present in the oil. The values obtained shows that the oil obtained by hot extraction will be more effective in the production of cleansing products such as soap, shampoo, facial cleanser, body wash etc.

Phytochemical Screening Results

The table below shows the results obtained from the phytochemical analysis.

Table 3. Phytochemicals of Coconut Oils

Parameters	Agric Hot pressed	Native Cold-pressed	Native Hot pressed
Saponins	-	-	-
Tannins	-	-	-
Alkaloid	-	-	-
Cardiac glycoside	-	-	-
Anthraquinone glycoside	-	-	-
Steroids	+	-	-
Flavonoid	-	-	-
Terpenoids	+	+	+

Results from Table 3 shows that few phytochemicals are found in coconut oil, which is terpenoids and steroids in the Agric hot press.

Product Formulation and Testing

From works of literature and results obtained, coconut oil has been seen to have vital components that are of great benefits to the skin. Therefore, the oil extracted has been used in the production of body cream. The cream produced was made of 50 per cent coconut oil, 40 per cent shea butter, vitamin E and glycerin. Furthermore, the cream produced was tested to know if it conforms to the standard of National agency for food and drug administration control (NAFDAC), and the pH was found to be between 4.8-6.7 while the non-volatile matter was 11%. This show that the cream produced conforms to the acceptable standard.

Figure 1. Coconut Cream produced from Coconut Oil

IV. Conclusion

The study investigated the physicochemical properties, fatty acid profile, as well as phytochemical properties of the extracted oil. The fatty acid analysis revealed that the extracted oil is rich in fatty acids such as lauric acid (44.6-46.7%), myristic acid (16.2-21.4%), palmitic acid (6.8-8.3%), oleic acid (7.2-9.8%), linoleic acid (3.9-6.5%) etc. all were within permissible limits. The physicochemical analysis also revealed that the extracted oil has properties within the limits of the codex standard. Whereas the phytochemical analysis revealed that there was no phytochemical present in the extracted coconut oil. The extracted oil was used in the production of body cream. The cream produced was subjected to pH test and non-volatile matter, which were found to be within the standard acceptable limit.

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