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Physicochemical Characteristics Evaluation of Five Tropical Coconut Species Extracted Oil in South-East, Nigeria

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Abstract*: This work evaluated the five tropical coconut species and its physicochemical characteristics on oils extracted in south-east Nigeria, with a view to assessing their suitability. The oil extract serves as major source of energy recovery due to high percentage of lauric acid, which contributes to new cell formation. The physicochemical parameters includes color, odor, solubility, oil yield, saponification value, iodine value, peroxide value, and free fatty acids were determined using standard methods of analysis. . Kings Coconut (S1) recorded the highest oil yield of 10.7±0.94% than other species while Macapuna Coconut (S4) recorded the lowest yield of 6.23 ± 0.12 %. Iodine value for Fiji Dwarf Coconut (S5) was 7.27± 0.20 mgKOH/gs, which was the lowest compared to other species while Kings Coconut (S1) recorded the highest value of 9.37 mgKOH/gs, Fiji Dwarf Coconut (S5) recorded the highest Saponification value of 258 ± 1.63 mg KOH/g Oil while Kings Coconut (S1) and Maypan Coconut (S2) recorded the lowest value of 252 ± 0.00mg KOH/g Oil. Macapuna Coconut (S4) recorded the highest Free Fatty Acid value of 0.39 ± 0.02% while Kings Coconut (S1) recorded the lowest value of 0.1 ± 0.01%, Macapuna Coconut (S4) recorded the highest value of 0.64 ± 0.0 meq/kg while Kings Coconut (S1) recorded the least value of 0.38 ± 0.01 meq/kg. However, there were no significant differences among species at 95% confidence level in the physicochemical properties except for Free Fatty Acid. The result shows that the physical and chemical parameters of the solvent extracted oil from different species of coconut were within the permissible range as recommended by NAFDAC and APCC indicating that all the species may be used for domestic and industrial purposes. The results demonstrate the suitability of the oils which can be used by manufacturers in pharmaceutical sectors, cosmetic sector, and food vendors.*

Keywords: Solvent, Species, Physicochemical, Coconut oil, Free fatty acids**.**

Introduction

Coconut (*Cocos nucifera L.*) is an important agricultural palm species grown in tropical coastal areas with numerous nutritional and medicinal value [1]. Coconut is widely used in traditional medicine, it contains high percentage of lauric acid which when ingested can be easily transported directly to the liver and process as an immediate form of energy and other metabolites rather than being stored as fat [2]. Within the tropical coastal area, different species of coconut tree is grown in more than 93 countries around the world with about 11.95 million hectares producing 57,510 million coconuts annually [3, 4]. Every part of coconut fruit can either be consumed or converted into other valuable products, such as husk, shell, kernel, water, and oil which are of economic value [1]. The coconut kernel comprises of proteins, carbohydrates, oil, minerals and moisture. Mature coconut can be processed for oil, cooking, soap and cosmetics production making it an essential source of food and chemical applications [3, 5] Coconut oil is derived from mature kernel (12 months old from pollination) of the coconut by mechanical or natural means with or without the application of heat, which does not lead to alteration of the nature of the oil. It does not undergone chemical refining, bleaching or deodorizing and suitable for consumption in the natural state without the need for further processing and it consists mainly of medium chain triglycerides [6]. Coconut oil is a colourless liquid maintain at a temperature of 30 °C and above, and solidified at a temperature of 25 °C. It is a natural skin softener and moisturizer that reduce fine lines, puffiness and dark circles under the eyes. Solidified coconut oil is white in colour. Unrefined coconut oil reaches its smoking point at a temperature of 170 °C while refined coconut oil reaches its smoking point at 232 °C [7]. Coconut oil has a typical coconut smell to it only if it is not refined, bleached or deodorized. Coconut oil will form a white homogenous mixture when mixed with water and agitated. Without agitation, coconut oil will be insoluble in water. Coconut oil has a density of 924.27 kg/m3 [8]. The density of an oil depends on its saponifcation value (molecular weight), iodine value (unsaturation), free fatty acid content, water content and temperature [9]. With the rise of iodine value, the specifc heat of coconut oil will also be increased. Whereas in liquid state, the specifc heat increases slightly with molecular weight but decreases with iodine value. Extraction of oils from oil seeds is a major

influential step for their commercialization. The extraction process has a direct effect on the quality and quantity of oils obtained [10].

Coconut oil is known to have medicinal values including but not limited to antifungal, antioxidant, antibacterial, antiviral, hepatoprotective, low glycaemic index and enhancement of immune system [11] Coconut oil comprises 90–95% of saturated fatty acid [12]. Compare to long-chain fatty acid found in plant-based oil, medium-chain fatty acid is smaller in size, allowing higher cell permeability for immediate energy conversion instead of being stored as fat. When compared with long-chain fatty acids found in plant-based oil, medium chain fatty acid can also be digested more easily and at the same time it is also antimicrobial and antifungal [13]. The major fatty acid of coconut oil is a medium chain fatty acid (MCFA). MCFA serves as the source of energy and is easy to absorb, metabolize and store in the body [14] and it resist more to oxidation and polymerization than the oils with unsaturated fatty acids but when processed thermal and chemical treatments can influence the natural quality and composition of fatty acids [15]. However, research on populations that eat diets high in coconut oil have shown no harmful effects on the population's health [16] Coconut oil also contains 2.6% less calories as compared to other fats as it provides numerous human health benefits [17].

Coconut oil is largely consumed for its edible and non-edible purposes that includes cooking, bakery, confectionary, pharmaceutical, infant's food and cosmetics [18, 19]. Coconut oil is a major component in the human body maintenance product such as lotions, soaps and cosmetic. Lauric acid (a fatty acid) and its bye products (lauryl sulfate) are used for the production of detergents and surfactants in cleaning, when the body lotion is applied on the human skin, it can increase the skin moisture and lipid content, just like mineral oil and could also add some antiseptic attributes to lotions or moisturizers that could benefit people with adverse skin condition [2]. Extraction of oils from oilseeds is a major influential step for their commercialization. The extraction process has a direct effect on the quality and quantity of oils obtained [20]. Coconut oil is also used as a polish for wood furniture. It also acts as a dust repellent after applying it onto wood furniture. It also comes with a pleasant, delicate aroma [21]. Coconut oil can also be made into other everyday items, such as toothpastes, lip scrub, body scrub and shaving cream. Personal cleansing agents, such as shampoo [22], soaps [23] and detergents in body wash products [24], may also be produced from coconut oil as well.

Coconut oil is veritable agricultural product. The extraction of the oil to meet the rising demand for coconut oil in different industries compared to other vegetable oil due to its enormous benefits that's spans across boosting the nation's economy, nutritional and medicinal values. There are several species of coconut with variations in the physical and chemical characteristics. For this reasons, the study sought to provide quantitative assessment of different species of solvent extracted oil, giving a clear indication as to the best options and requirements for higher optimum production.

2. MATERIALS AND METHODS

2.1 Materials

Five mature harvested coconuts of different species as shown in Table 2.1 were obtained from the five states South-East region, Nigeria. The Coconuts were dehusked using locally design and fabricated coconut dehusking machine. A solvent extraction method was employed to extract the oil from the different species of coconut.

2.2 Solvent Extraction Method of Coconut Oil

Solvent extraction is the use of chemicals in the extraction of oil from oil seeds. The use of this method requires a complete refining process to ensure traces of the solvents are removed totally. Solvent extraction of cleaned, cracked, dehulled and conditioned thin soy flakes (0.25 – 0.30mm) with hexane is commercially practiced to extract oil as described in [25, 26].

2.3 Physicochemical Characteristics of Different Species Coconut oil

The physical and chemical properties were carried out on all the five species of coconut. All the tests were performed in accordance with the standard operating procedures of the American Oil Chemists Society (AOCS), Asian Pacific Coconut Community (APCC) and National Agency for Food and Drug Administration and Control (NAFDAC).

2.3.1 Percentage Yield Determination

Oil yield from each of the test method of extraction was determined gravimetrically as the percentage ratio of the weight of the extracted oil to the quantity of the coconut meat used. Equation 1 was used in calculating the percentage yield of the oil.

$$\text{Oil Yiled (\%)} = \frac{\text{Weight of oil}}{\text{Weight of coconut}} \text{ x } 100\% \qquad 2.1$$

2.2.2 pH Determination

pH value indicates the level of acidity or alkalinity of a sample: A buffer solution prepared with distilled water was used to calibrate pH meter. The probe was rinsed for the sample considered at the point of no change in reading

Table 2.1 Coconut Species and their Locations

Coconut Species

	S1	S2	S3	S4	S5
Location (State)	Imo	Abia	Anambra	Enugu	Ebonyi
Coconut Species	Kings Coconut	Maypan Coconut	Malayan Yellow Dwarf Coconut	Macapuna Coconut	Fiji Dwarf Coconut

2.2.3 Moisture Content Determination

Moisture content was determined by method described by [27]. 5.0g of oil sample was weighed in a crucible with lid which was preheated, weighed and dried. It was then heated at 105 °C for about 24 hours until there is no change in the successive observations. The crucible with sample was then placed in the desiccator and allowed to cool to a room temperature. The crucible with oil sample was then re-weighed. The moisture content were then calculated using equation 2.1

$$\text{Moisture content (\%)} = \frac{\text{Initial weight of sample-Final weight of sample}}{\text{Initial weight of sample}} \text{ x } 100\% \qquad 2.2$$

2.2.4 Iodine value Determination

Iodine value (IV) for the oil samples were determined by using Wijs method. 4.0g of sample was mixed with 20ml cyclohexane to dissolve the fat content; 25 ml of Wijs solution was then added. The flask was closed, and the solution was shaken for 30 min continuously. Simultaneously, 20ml aqueous KI solution (15% v/v) and 100 ml of water were added to the mixture. It was then titrated with 0.1N Na2S2O3 until the disappearance of yellow color. Then a few drops of starch solution, turning the solution to blue, were added and the titration continued until the blue color vanished. The volume of Na2S2O3 consumed was recorded and represented as S. For the analysis, the same was repeated with blank sample and volume of Na2S2O3 consumed was recorded as B. The IV was calculated using equation 2.2

$$\text{Iodine Value (IV)} = \frac{(\text{B} - \text{S}) \text{ x N of sodium thiosulphate x } 12.69}{\text{weight of sample (g)}} \qquad 2.3$$

2.2.5 Saponification value Determination

The saponification value (SV) of the oil samples were determined using the International Union of Pure and Applied Chemistry (IUPAC) method [28, 29] 920.160. 2.0g of sample was weighed into a clean dried Erlenmeyer flask and 25ml of 0.5N ethanolic KOH was added and the mixture was boiled in a reflux condenser for 60 min. The mixture was then cooled to a room temperature and 1% phenolphthalein solution as an indicator was added to the cooled mixture and subsequently titrated against 0.5N HCl until the color of the mixture changes from pink to colorless. The volume of HCl was recorded and represented as S. Similarly, the same was repeated for the blank, and the volume of HCl was noted as B. The saponification value was calculated using equation 2.3.

$$\text{Saponification Value} = \frac{(\text{B} - \text{S})\text{mlof HCL x } 28.05\text{Weight of oil}}{\text{Weight of sample (g)}} \qquad 2.4$$

2.2.6 Free fatty acid (FFA) Value Determination

7.0g of different oil samples were mixed with 2 ml of phenolphthalein solution and a few drops of 0.1 M NaOH. Next 50 ml of ethanol was mixed and constantly shaken until a permanent faint pink color was obtained, which was then titrated against 0.25 N NaOH. The volume of NaOH spent was recorded as S and the same was repeated for the blank and the volume was recorded as B. the percentage of free fatty acid was calculated using equation 2.4

$$\text{Free Fatty Acid (\%)} = \frac{(\text{B} - \text{S})\text{ml of Naol}}{1.99 \text{ x weight of sample}} \qquad 2.5$$

Where, N-normality of NaOH

2.2.7 Peroxide value Determination

This was done using thiosulphate titrimetric method described by [30]. 1g of each oil sample was put in conical flask and 1g of potassium iodide was added and was mixed thoroughly followed by 20ml of mixed solvent containing glacial acetic acid and chloroform in the ratio 2:1 (v/v). Then the mixture with the sample was boiled briefly (≤ 1 min) and then quickly, 20 ml of 5% potassium iodide solution was added to it, and thoroughly mixed then followed by addition of 50 ml of distilled water and then titrated against 0.002 M sodium thiosulphate using 1% starch as indicator. Equation 9 was used to calculate peroxide value. 2.5

Where
N = Normality (concentration) of titrant

2.3 Statistical Tool

The experiments were carried out in triplicates and statistical means and standard deviation were determined and recorded. The data obtained were analyzed statistically using Completely Randomized Design (CRD) to verify significant differences in the means of samples. This was done using the MSEXCEL data analysis tool pack at a 95% confidence level [31].

3. RESULTS AND DISCUSION

Table 3.1: Physical Properties of Coconut Oil

Specie(s)	Soluble in Water	Odour	Colour
S1	Insoluble in Water	Coconut Smell	Dark Slight Yellow
S2	Insoluble in Water	Coconut Smell	Slight yellow
S3	Insoluble in Water	Coconut Smell	Slight yellow
S4	Insoluble in Water	Coconut Smell	Dark Slight Yellow
S5	Insoluble in Water	Coconut Smell	Slight yellow

Table 3.1: Mean and Standard Deviation of the Physicochemical Characteristics of Oil from Different Species of Coconut.

	Species of Coconut									
	S1		S2		S3		S4		S5	
pH	7.23	±0.05	5.47	±0.38	7.07	±0.09	5.47	±0.09	7.43	±027
Oil Yield (%)	10.7	± 0.94	7.43	± 0.09	8.43	±0.34	6.23	± 0.12	9.27	±0.12
Iodine Value (mgKOH/gs)	9.37	± 0.20	8.67	± 0.17	8.83	± 0.26	8.73	± 0.04	7.27	± 0.20
Free Fatty Acid (%)	0.1	±0.01	0.32	±0.02	0.22	±0.02	0.39	±0.02	0.26	±0.00
Perioxide Value(meq/kg)	0.38	±0.01	0.47	±0.03	0.45	±0.02	0.64	±0.04	0.49	±0.02
Saponification Value (mgKOH/gs)	252	±0.00	254	±1.63	254	±1.63	257.67	±0.94	258	±1.63

The physical characteristics of the extracted oil indicated that all species of coconut were insoluble in water with the odour coconut smell and slightly yellow except for SI and S4 species that were dark slight yellow. S1 recorded highest oil yield of 10.7±0.94% followed by S5 (9.27 ± 0.12%), S3 (8.43 ± 0.34%), S2 (7.43 ± 0.09%) while S4 recorded the least value of 6.23 ± 0.12 %.However, there were significant difference at 95% confidence level.

Peroxide Value is an index of rancidity; thus the low peroxide value of the oil indicates resistance of the oil to peroxidation during storage [32].The amount of the peroxide number can be affected by high water content because water content in oil can act as a precursor for peroxide enzymes to oxidize unsaturated fatty acids so that peroxide is formed, besides that saturated fatty acids that undergo oxidation will form methyl ketones which cause rancidity in oil [27]. [28]. This akin to [33], that high peroxide recorded can be attributed to high water content available in the sample Peroxide values is also an indicated the ability of the oil to resist hypolitic and oxidation derioration [34] .The results revealed that S4 recorded the highest value of (0.64 ± 0.0 meq/kg) followed by S5(0.49 ±0.02 meq/kg), S2 (0.47 ± 0.03 meq/kg), S3 (0.45 ± 0.02 meq/kg) while S1(0.38 ± 0.01 meq/kg) recorded the lowest value. The peroxide values from different species were within the APCC and NAFDAC acceptable maximum value of 3 meq/kg. However, there was significant difference at 95% confidence level.

S4 recorded the highest value (0.39 ± 0.02%) of Free Fatty Acid, followed by S2 (0.32 ± 0.02%), S5 (0.26 ± 0.00%), S3 (0.22 ±0.02%) while S1 recorded the lowest value of 0.1 ± 0.01%. Free fatty acid is the percentage by weight of a specified fatty acid. High concentrations of free fatty acids are undesirable in crude oils because they result in large losses of the neutral oil during refining [35]. Hence, the free fatty acid obtained from this study, this values implies low rancidity of the oil and thus viable as edible oil. The Free

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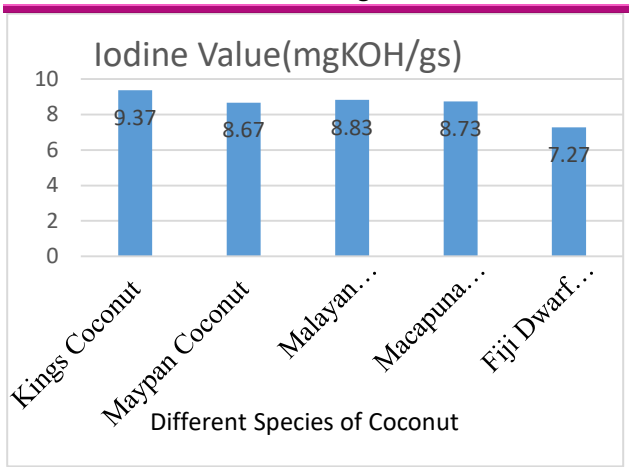

Fig. 1: Iodine Value (mgKOH/gs) of Coconut Oil

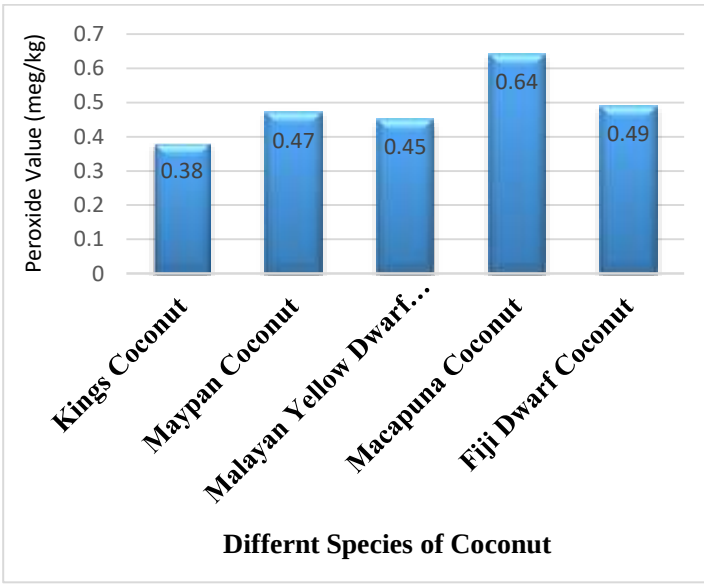

Fig. 2: Peroxide Value (meg/kg) of Coconut Oil

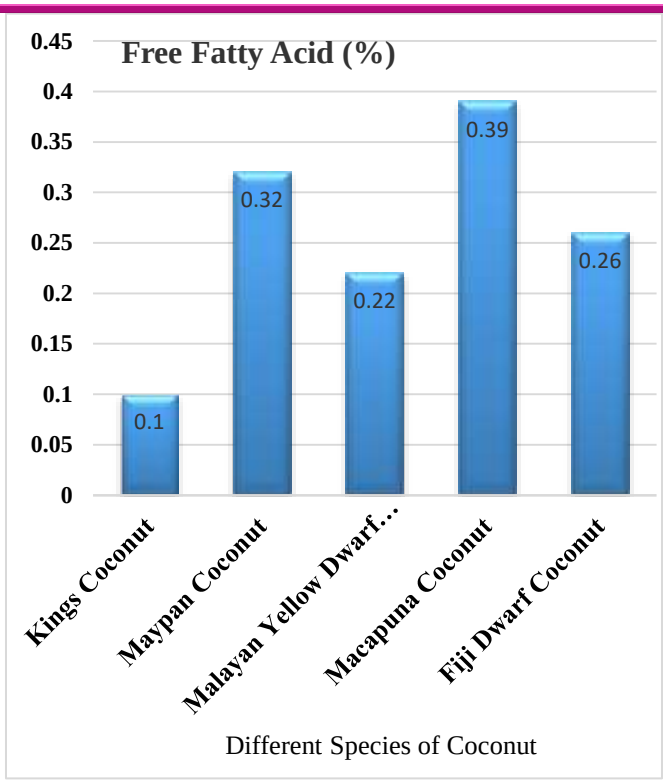

Fig. 3: Free Fatty Acid (%) of Coconut Oil

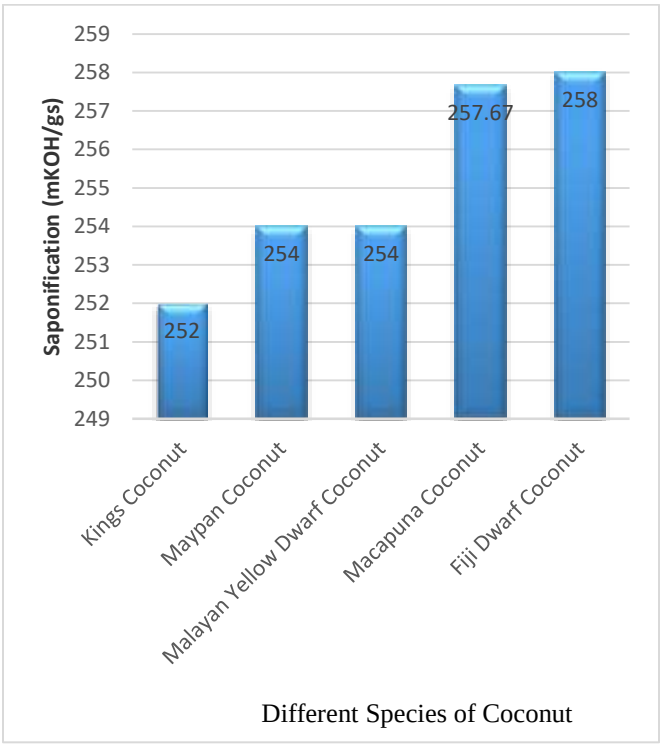

Fig. 4: Saponification Value (mKOH/gs) of Coconut Oil

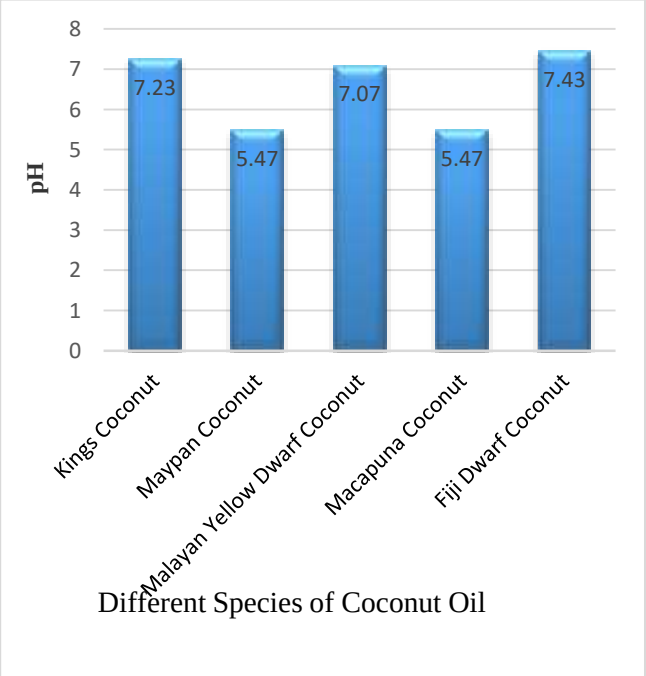

Fig. 5: pH Value of Coconut Oil

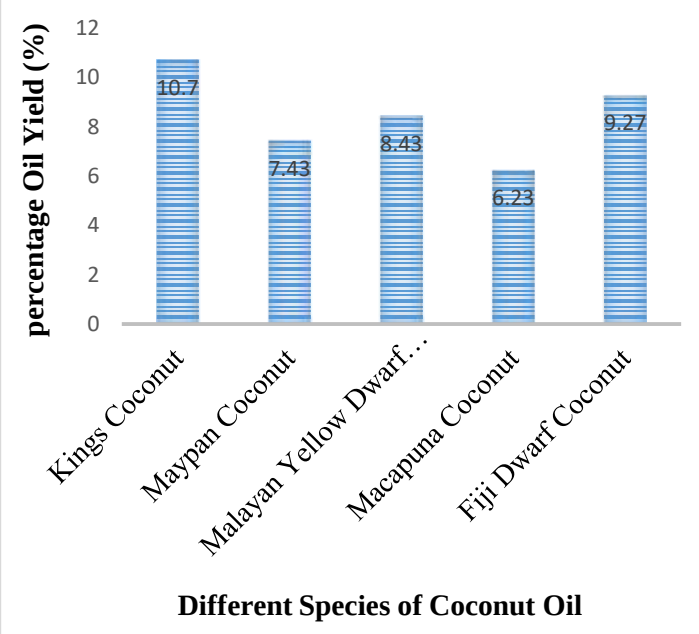

Fig. 6: Percentage Oil Yield (%) of Coconut Oil

Fig. 1: Shows that Kings Coconut has the most iodine value measured from the unsaturated fats and oils based on the number of double bonds present in the fatty acid. The increase in iodine value shows higher degree of unsaturation which make oxidization of fats and oils an indicator for oils to last longer [36, 37]. Thus, the highest Iodine value was recorded in Kings Coconut 9.37 ± 0.20 mgKOH/gs, followed by Malayan yellow dwarf coconut 8.83± 0.26 mgKOH/gs), Maypan cocnut (8.73 ± 0.04 mgKOH/gs), S2 (8.67 ± 0.17 mgKOH/gs), while Fiji dwarf cocnut recorded the least value of 7.27± 0.20 mgKOH/gs. . Fig. 2: present the peroxide value from all species across the south-east region were within the acceptable range of NAFDAC and APCC standard of 6.3 to 10.6 mgKOH/gs and 4.1 to 11 mgKOH/gs respectively. However, there was significant difference at 95% confidence level. Fig. 3 shows the free fatty acid (FFA) range of 0.10% - 0.39% across the five species were within the permissible limit ≤ 0.5% recommended by APCC and NAFDAC. The results from Figure 4 shows that the mean saponification values (SV) of oil from different species were within the recommended NAFDAC and APCC standard of 248 – 265 and 250-260 mg KOH/g Oil respectively. The highest saponification was 258 ± 1.63 mg KOH/g Oil, followed by S4 (257.67 ± 0.94 mg KOH/g Oil), S2 (254 ±1.63 mg KOH/g Oil), S3 (254 ± 1.63 mg KOH/g Oil) and while Kings Coconut recorded the lowest 252 ± 0.00 mgKOH/g Oil. Fig. 5. Shows the pH value of different species of coconut were within 7.23 to 7.43 and maypan and macapuna coconut have 5.47. Fig. 6. Shows that kings coconut has the highest yield followed by Fiji dwarf coconut, and the lowest was in macapuna coconut. The SV is related to the mean molecular mass of fats and oils and inversely proportional to the chain length of the fatty acids of fats and oils [1].

Conclusion

The study reveals that the physical and chemical properties of the solvent extracted oil from different species of coconut were within the permissive range as recommended by NAFDAC and APCC. The coconut was obtained from the five states that makes up the South-East region of Nigeria.

S1 recorded the highest oil yield of 10.7±0.94% than other species while S4 recorded the lowest yield of 6.23 ± 0.12 %. Iodine value for S5 was 7.27± 0.20 mgKOH/gs, which was the lowest compared to other species while S1 recorded the highest value of 9.37 mgKOH/gs, S5 recorded the highest Saponification value of 258 ± 1.63 mg KOH/g Oil while S1 and S2 recorded the lowest value of 252 ± 0.00 mgKOH/g Oil. S4 recorded the highest Free Fatty Acid value of 0.39 ± 0.02% while S1 recorded the lowest value of 0.1 ± 0.01%, S4 recorded the highest value of 0.64 ± 0.0 meq/kg while S1 recorded the least value of 0.38 ± 0.01 meq/kg. However, there was no significant difference among species at 95% confidence level in the physicochemical properties except for Free Fatty Acid. This study will serve as a guide for manufacturers in the selection of coconut species for optimum production of quality edible and non-edible products.

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