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CHEMICAL EVALUATION AND DETERMINATION OF ALPHA-TOCOPHEROL LEVELS OF SELECTED COCONUT OIL SAMPLES MARKETED IN NIGERIA

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ABSTRACT

In recent years, coconut oil has grown in global popularity due to many health benefits that have been attributed to it. In order to maximize the health and socioeconomic benefits inherent in the coconut value chain, it is important to ascertain that coconut oils that are of adequate standards are marketed. The present study investigated the quality characteristics and α-tocopherol contents in fifteen Nigerian marketed coconut oil samples. The quality characteristics evaluated by standard methods include acid value (AV), free fatty acid (FFA), peroxide value (PV), saponification value (SV), and iodine value (IV). The α-tocopherol content was determined by reverse phase-HPLC method. The α-tocopherol (mg) per serving and % daily value (% DV) was subsequently estimated from the values obtained from chromatographic analysis. The ranges of AV (mgKOH/Kg), FFA (%), IV (gI_2/100g), and SV (mgKOH/g) were 1.71 - 16.69, 0.86 - 8.40, 11.41 - 22.37, and 13.94 - 307.40 respectively. Peroxides were not detected in all the samples. The range of α-tocopherol content of the market samples was 0.37 – 1.77 mg/100g. The α-tocopherols (mg) per serving and % DV of the investigated coconut oil samples were 0.05 – 0.25 and 0.33 – 1.66, respectively. The quality characteristics of the samples varied significantly ($P< 0.05$) across different markets. Based on the results obtained, some market samples of coconut oil failed the critical chemical tests such as acid values, free fatty acid values, iodine values and saponification values. Result of this study suggest that to maximize the health and socioeconomic benefits inherent in the coconut value chain, the Government through her relevant regulatory agencies will need to ensure that coconut oils that are of adequate standards are marketed in Nigeria.

KEYWORDS: **Coconut oil; Quality tests; Alpha-tocopherol; RP-HPLC; %Daily Value.**

INTRODUCTION

Coconut oil of different varieties is derived from the kernel of coconut (*Cocos nucifera L.*) [1]. These varieties are Pure Coconut Oil (PCO), Refined Coconut Oil (RCO), Organic Coconut Oil (OCO), Virgin Coconut Oil (VCO), Organic Virgin Coconut Oil (OVCO), and Extra Virgin Coconut Oil (EVCO). The technique of extraction can have a significant effect on oil and its physicochemical properties [2]. Hence, the quality characteristics of coconut oil depend on the process and the raw materials used. For instance, EVCO comes from the fruit of fresh, mature coconuts and its processing does not involve high temperatures or added chemicals. Although, VCO differs in characteristics and is reported to be of better quality than RCO [1, 3]; however, a recent study suggested that EVCO's positive health impact on cholesterol might be similar to that of olive oil [4]. In recent years, amid claims that it can do everything from supporting weight loss to slowing the progression of Alzheimer's disease, coconut oil has grown in popularity. Consequently, many manufacturers now use coconut oil in packaged

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products, and more people use it for cooking, as many products, such as fried foods, sweets, shampoos, coffee, smoothies now contain coconut oil [5]. Many health benefits have been attributed to coconut oil. Chiwong *et al*. (2017) [6] argued that medium-chain triglycerides (MCTs), a component in coconut oil, may help boost levels of good cholesterol. In a related development, Khaw *et al.*, (2018) [4] reported that EVCO had a positive health impact on cholesterol, an observation that was like that of olive oil. Other reported health benefits of coconut oil include blood sugar control [7], stress reduction [8], anti-inflammatory [9], antimicrobial [10], liver health improvement [11], dental health improvement [12-14], and reduction of asthma symptoms [15].

Coconut oil is composed of triacylglycerols, free fatty acids, mono- and di-glycerides, phospholipids, sterols, tocopherols, pigments, volatiles, trace metals, and oxidized products [16]. Taylor [17] reported that the major tocopherols present in coconut oil include ϒ-tocotrienol, ϒ-tocopherol, and α-tocopherol. It has been documented that coconut oil contains about 93% saturated fatty acids, 6.2% monounsaturated fatty acids and the rest is polyunsaturated fatty acids. The saturated fatty acids are of three types: short- chain triglycerides (SCTs; C1–C5), medium-chain triglycerides (MCT; C6–C12) and log-chain triglycerides (LCT; C14–C18). Approximately, 29% are saturated long-chain fatty acids (C14– C18) such as myristic acid (C14), palmitic acid (C16), stearic acid (C18). Others are medium-chain triglycerides (MCT; C6–C12) including caproic acid (C6), caprylic acid (C8), caproic acid (C10), and about 50% lauric acid (C12) content. The unsaturated fatty acids are oleic acid (C18:1) and linoleic acid (C18:2) [18].

Initially, coconut oil was classified along with saturated fatty acid food items and criticized for its negative impact on health. However, recent research studies have shown that coconut oil is a rich source of medium-chain fatty acids; hence, this has opened new prospects for its use in many fields [19]. In this regard, EVCO is recently being promoted as healthy oil. Though high in saturated fat, the main saturated fatty acid, lauric acid (C12:0), has been suggested to have different metabolic and hence health effects compared with other saturated fatty acids such as palmitic acid (C16:0), predominant in butter, palm oil and animal fat [4]. The predominant fatty acid in coconut oil, lauric acid (C12:0) as well as myristic acid (C14:0) are rapidly absorbed, taken up by the liver and oxidized to increase energy expenditure which is a possible explanation for why coconut oil may have different effects compared with other saturated fats [20].

Coconut oil is reportedly very stable to oxidative deterioration when exposed to atmospheric oxygen [21, 22] because it possesses a high degree of saturated fatty acids which contributes to its oxidative stability. Contaminants like copper and iron when present, has a decreasing effect on the stability of coconut oil while tocopherols have a stabilizing effect on the stability of coconut oil during processing. Some tocopherols are removed during processing and hence contribute to loss of stability of the coconut oil due to oxidation [16]. The purported coconut stability to oxidative stability notwithstanding, research efforts are being directed at further bolstering up coconut oil oxidative stability through the addition of essential oils of black pepper and ginger [23] and aminomethyl derivatives of 2-methoxyphenol [24].

Autoxidation of vegetable oil is affected by atmospheric oxygen and the oxidation process proceeds via free radical reactions involving unsaturated fatty acids. The primary products formed are hydroperoxides, which subsequently break down in a series of complex reactions, to yield secondary products including alcohols and carbonyl compounds which can be oxidized further to carboxylic acids [25, 26]. Meanwhile, studies have shown that the market conditions in tropical countries such as Nigeria could lead to increased microbial proliferation in vegetable oils and light induced oxidation [27-29]. Additionally, the hydrolytic and oxidative rancidity of fats have been positively correlated with moisture, light, heat, microorganisms, enzymes, presence of unsaturation in fatty acid chain, polyunsaturation, chemical structure of oils and fats, temperature, and pH [30].

The oxidative stability of vegetable oils is one of the key factors in determining its use in foods and their applicability in industrial situations [23, 26], it is therefore important to evaluate the quality characteristics of coconut oil along the value chain between production and usage in order to ascertain their suitability for food and industrial usage. In this regard, storage qualities of coconut oil have been studied in Romania [26] and Malaysia [31]. In Nigeria and India, there are reports on quality characteristics of coconut oils produced by different extraction methods [32, 33], but studies which focused on the qualities of market sample coconut oil in Nigeria are non-existent. Therefore, this study aimed to evaluate the quality characteristics and α-tocopherol content of multi-sourced coconut oil samples marketed in Nigeria.

MATERIALS AND METHODS

Materials and samples

Fifteen samples of unbranded coconut oil (80% unrefined, 13% refined and 7% virgin) were obtained from open markets in three south-western States in Nigeria. Detail information on the samples used in this study is provided in Table 1.

Chemicals used in this study were obtained from Merck Chemicals Ltd (Darmstadt, Germany). They include potassium hydroxide, sodium thiosulphate, potassium iodide, hydrochloric acid, phenolphthalein, chloroform, n-hexane, Wijs solution, carbon tetrachloride, glacial acetic acid, and ethanol. Starch mucilage and distilled water were donated by Fidson Healthcare Pharmaceutical Industry, Nigeria. DL-alpha tocopherol was purchased from Supelco (Merck, Germany).

Chemical Analysis

Chemical parameters used in evaluating the quality of vegetable oils such as acid value (AV), saponification value (SV), iodine value (IV), and peroxide value (PV) were determined by standard methods [34].

Alpha-tocopherol estimation by RP-HPLC

The RP-HPLC method of [35], was used with some modifications for the determination of α-tocopherol content of the coconut oil samples. Column temperature was adjusted to 35 ˚C for better peak separation instead of 45 ˚C, while flow rate of 1ml/min which lasted for 5 minutes was used rather than 2 ml/min flow rate which lasted for 6 minutes. Dilution factor was adjusted to 60.

Preparation of standards and validation measurements

DL-alpha tocopherol **PHR1031**Supelco (10 mg) (Merck, Germany) was weighed into a 100 ml volumetric flask. Sixty (60) milliliters of the mobile phase (96 % ethanol) were added and stirred until dissolved using a magnetic stirrer. The solution was made up to 100 ml mark with the mobile phase and mixed properly to get a final concentration of 100 µg/ml. The flask was protected from light by wrapping with aluminum foil. Concentrations of 1.0 µg/ml, 2.5 µg/ml, 5 µg/ml, 10 µg/ml, 20 µg/ml were prepared from the stock solution respectively and filtered before their injection into the HPLC. Validation measurements carried out include linearity, recovery rates, ruggedness, limit of detection (LOD) and limit of quantification (LOQ). Data was collected by Agilent chromatograph automated chem. station software. Peak area was plotted against concentration to generate the calibration curve.

Chromatographic conditions and analysis

Alpha-tocopherol content was determined by reverse-phase high-performance liquid chromatography (RP-HPLC) using the method of Gimeno *et al*., 2000 with some modifications. The HPLC system was an Agilent 1100 HPLC series, USA equipped with a main controlling unit, quaternary pump, online degasser, waters x-bridge C18 column (100 x 4.6mm ID, 5um particle size), with 20µL injector loop and UV-Vis chem-station software detector. The mobile phase was methanol-water (96:4%$^{v}/_{v}$) which was freshly prepared and placed in the solvent system bottle provided. It was degassed and filtered through a 0.45 µm filter membrane. Elution was performed at a flow rate of 1.00 ml/min while the analytical column was kept at a temperature of 35^{o}C. The separation was done in isocratic mode and analytes were detected at 292 nm using a UV-Vis detector. The injection volume was 20 µL and each run lasted 5 min. The concentration of alpha-tocopherol in each sample was calculated using the alpha tocopherol calibration curve.

Estimation of α-tocopherol (mg) per serving and % daily value

The serving size of oils analyzed according to the labelled claim was 14 g/serving size. The α-tocopherol (mg) per serving was estimated using the following formula:

mg/serving = concentration (mg/100 g) coconut oil x serving size/ 100.

The Recommended Dietary Allowance (RDA) for both men and women is 15 mg (35 µmol)/day of α-tocopherol [36]. The percentage daily value (%DV) was estimated using the following formula: %DV = mg/serving x 100/ RDA

Statistical analysis

In this study, each test for the sample was analyzed in triplicate. Data were expressed as mean ± standard deviation (SD). Differences between means were analyzed by analysis of variance (one way ANOVA) using SPSS for windows Version 17.0 statistical package. Statistically significant difference was stated at $p < 0.05$.

RESULTS

Table 2 gives results for the chemical parameters namely acid value, free fatty acid (FFA) value, saponification value, iodine value, and peroxide

value for each of the analyzed oil sample. The range of acid values (mgKOH/Kg) of the analyzed coconut oil samples was 1.71 - 16.69. The acid value of the samples varied significantly (P< 0.05) across the different markets.

The FFA values of the marketed coconut oil samples in the present study ranged from 0.86 to 8.40%. There was a significant difference (P< 0.05) among the samples obtained across the different markets. Peroxide values were not detected in the market samples of coconut oil in the present study. The iodine value range of the coconut oils investigated in the present study was 11.41 -22.37 g/100 g). The saponification values of the marketed coconut oil samples ranged from 13.94 to 307.40 mgKOH/g (Table 2). These values varied significantly (P< 0.05) across the different markets.

The results of the HPLC validation measurements are as follows: α-tocopherol recovery rates ranged between 97.2 and 98.9%. The calibration curves showed good linearity (r^2=1). The ruggedness value (%RSD) was 0.42 %. The LOD and LOQ values were 0.5 and 5 µg/ml respectively. The regression equation for the calibration curve was y = 8.1167x + 0.4142, r^2=1. Table 3 shows the alpha-tocopherol contents of coconut oil samples obtained from selected markets in three states in southwestern Nigeria and their corresponding per serving and percentage daily value. The alpha-tocopherol content for the fifteen coconut oil samples ranged from 0.37 - 1.77 mg/100g. There were significant variations (p<0.05) between different market samples. The range of α-tocopherol content of the market samples (unrefined oils) was 0.37 - 1.77 mg/100g while that of laboratory samples (samples 13 and 15); which were refined, bleached and deodorized, was 0.66 – 0.73 mg/100g.

DISCUSSION

The acid value indicates the level to which the glycerides in the oil had been decomposed by lipase action [38]. From the results of the present investigation, about one-quarter of the analyzed coconut oil samples had the acid values that were within the values stipulated by Codex [37] while the remaining three-quarter failed the acid value test. It appears that the coconut oil samples were subjected to enzymic lipolysis along the value chain before they were finally used by the respective consumers. This may be lending credence to earlier studies which stated that the market conditions in tropical countries such as Nigeria could lead to increased microbial proliferation in vegetable oils and light induced oxidation [27-29].

Prasanth and Gopala [32] reported FFA range of 0.01 – 2.02 % in freshly produced Indian coconut oils while a range of 0.19 – 0.39 % was reported by Ndife and co-workers [33] in Nigerian coconut oils. Hoover and co-workers [39] opined that free fatty acid content is an indicator of the hydrolytic rancidity (mainly due to the action of lipase or moisture) of the coconut oil which causes an undesirable flavor and aroma in the oil. Meanwhile, hydrolytic rancidity in coconut oil had been mostly attributed to the undesirable storage and improper maintenance of the quality of coconut seed ahead of processing, and the moisture content of the extracted oil [32]. Findings from the present study are indicating that the levels of product of hydrolytic rancidity (FFA) coconut oil were much higher than the values obtained in freshly produced coconut oil samples. This is a possible reflection of the influence of tropical market conditions which might have supported lipolysis either by the microbial enzymes of the associated microflora or the innate enzymes of the oil itself.

Peroxide value is an indicator for the measurement of the initial stages of oxidation in oils. The unsaturated fatty acids present in the oils easily react with atmospheric oxygen and form hydroperoxides [32]. Normally, coconut oils exhibit high oxidative stability due to the presence of large amounts of saturated fatty acids (>91%) and very small amounts of unsaturated fatty acids (<7 %) [21, 22, 26]. In addition, the presence of antioxidants like tocopherols is known to have stabilizing effect on the stability of coconut oil [16]. However, considering the absence of peroxide, in addition to elevated levels of the acid and FFA values in many of the samples, the rancidity of the samples that fell short of Codex standard [34] may likely not to be due to oxidation but hydrolysis in the investigated coconut oil.

The range of iodine value obtained in the present study is higher than those of freshly produced Indian (4.5 – 6.7 g/100 g) and Nigerian (7.52 – 11.15 g/100 g) coconut oils [32, 33]. The Codex Alimentarius [34] standard for iodine value is 6.3-10.6 g/100 g. The iodine value shows the degree of unsaturation of oils and fats [40]. Coconut oil is known to be composed mainly of saturated fatty acids (SFA), which corresponds to >91% of its total composition [41, 42]. Fresh coconut oil from Malaysia and Indonesia, India, and Nigeria had saponification values of 250.10 – 258.30, 239.90 - 256.70 and 248.12 - 261.33 mgKOH/g respectively [32, 33, 43]. Saponification value gives an idea about the average molecular weight of the oil and the molecular weight of the oil is inversely proportional to its saponification

Table 1: Detailed information on coconut oil samples obtained from selected markets in southwestern Nigeria.

Sample number	Type of Coconut oil	Place of purchase	Date of purchase
1	Unrefined	Ibadan (Open market)	08/04/2017
2	Unrefined	Ibadan (Open market)	08/04/2017
3	Unrefined	Ibadan (Open market)	08/04/2017
4	Unrefined	Ibadan (Open market)	08/04/2017
5	Unrefined	Ibadan (Open market)	08/04/2017
6	Unrefined	Lagos (Open market)	10/04/2017
7	Unrefined	Lagos (Open market)	10/04/2017
8	Unrefined	Lagos (Open market)	10/04/2017
9	Unrefined	Lagos (Open market)	10/04/2017
10	Unrefined	Lagos (Open market)	10/04/2017
11	Unrefined	Sagamu (Open market)	06/04/2017
12	Unrefined	Sagamu (Open market)	06/04/2017
13	Refined, Bleached and Deodorized	Sagamu (Laboratory extract)	06/04/2017
14	PureVirgin Coconut Oil	Sagamu (Open market)	06/04/2017
15	Refined, Bleached and Deodorized	Sagamu (Laboratory extract)	06/04/2017

Table 2: Chemical characteristics of coconut oil samples obtained from selected markets in three states in southwestern Nigeria.

Sample number	Type of Coconut oil	Acid value mgKOH/Kg	Free fatty acid (%)	Peroxide value (mEq O_2/kg)	Iodine values (g/100g)	Saponification values (mgKOH/g)
1	Unrefined	7.39±0.03^{bc}	3.72±0.03^{bc}	0.00±0.00^{a}	19.87±1.23^{b}	27.88±0.21^{g}
2	Unrefined	6.89±0.02^{c}	3.47±0.02^{c}	0.00±0.00^{a}	20.51±1.13^{b}	35.55±1.27^{g}
3	Unrefined	6.96±0.02^{c}	3.50±0.02^{c}	0.00±0.00^{a}	22.37±2.32^{a}	13.94±1.25^{h}
4	Unrefined	6.52±0.01^{c}	3.28±0.01^{c}	0.00±0.00^{a}	19.80±1.30^{b}	26.49±1.13^{g}
5	Unrefined	8.06±0.02^{b}	4.05±0.02^{b}	0.00±0.00^{a}	17.82±1.03^{c}	225.84±1.23^{c}
6	Unrefined	3.69±0.00^{d}	1.86±0.00^{d}	0.00±0.00^{a}	17.82±1.11^{c}	294.15±2.01^{a}
7	Unrefined	2.18±0.01^{e}	1.09±0.01^{e}	0.00±0.00^{a}	19.35±1.45^{b}	257.21±1.11^{b}
8	Unrefined	6.69±0.03^{c}	3.37±0.03^{c}	0.00±0.00^{a}	18.52±0.91^{c}	257.21±1.23^{b}
9	Unrefined	4.62±0.02^{d}	2.32±0.02^{d}	0.00±0.00^{a}	15.25±1.16^{d}	307.40±1.20^{a}
10	Unrefined	2.07±0.01^{e}	1.04±0.01^{e}	0.00±0.00^{a}	17.11±2.00^{c}	130.35±1.01^{e}
11	Unrefined	9.04±0.01^{b}	4.55±0.01^{b}	0.00±0.00^{a}	11.41±1.15^{e}	180.53±1.21^{d}
12	Unrefined	16.69±0.02^{a}	8.40±0.02^{a}	0.00±0.00^{a}	13.39±2.23^{e}	66.22±0.37^{f}
13	Refined, Bleached and Deodorized	3.92±0.01^{d}	1.97±0.01^{d}	0.00±0.00^{a}	15.38±1.45^{d}	149.59±2.12^{e}
14	PureVirgin Coconut Oil	1.71±0.01^{f}	0.86±0.01^{f}	0.00±0.00^{a}	15.12±1.03^{d}	133.14±1.99^{e}
15	Refined, Bleached and Deodorized	3.92±0.02^{d}	1.97±0.02^{d}	0.00±0.00^{a}	15.25±1.07^{d}	149.17±1.21^{e}
CODEX STANDARD	(Refined oils)	≤ 0.6	≤0.3	≤ 10	6.3 – 10.6 (crude vegetable oils)	248 – 265 (crude vegetable oils)
	(Cold pressed and virgin oils)	≤ 4.0	≤ 2.01	≤ 15		

Values are means of triplicate determinations. Within column of each treatment values with different superscripts are significantly different (P< 0.05).

Table 3: Alpha-tocopherol contents of coconut oil samples obtained from selected markets in three states in southwestern Nigeria and their corresponding per serving and percentage dietary value.

Sample number	Type of Coconut oil	α-tocopherols content (mg/100g)	α-tocopherol (mg) /Serving	% Daily Value
1	Unrefined	0.43±0.01^{g}	0.06±0.01^{g}	0.40±0.01^{g}
2	Unrefined	0.68±0.03^{d}	0.10±0.03^{d}	0.67±0.03^{d}
3	Unrefined	0.37±0.02^{h}	0.05±0.02^{h}	0.33±0.02^{h}
4	Unrefined	0.59±0.01^{f}	0.08±0.01^{f}	0.53±0.01^{f}
5	Unrefined	0.56±0.02^{f}	0.08±0.02^{f}	0.53±0.02^{f}
6	Unrefined	0.92±0.02^{c}	0.13±0.02^{c}	0.86±0.02^{c}
7	Unrefined	1.04±0.02^{b}	0.15±0.02^{b}	1.00±0.02^{b}
8	Unrefined	0.55±0.01^{f}	0.08±0.01^{f}	0.53±0.01^{f}
9	Unrefined	0.64±0.01^{e}	0.09±0.01^{e}	0.60±0.01^{e}
10	Unrefined	0.85±0.02^{c}	0.12±0.02^{c}	0.80±0.02^{c}
11	Unrefined	1.77±0.02^{a}	0.25±0.02^{a}	1.66±0.02^{a}
12	Unrefined	0.60±0.01^{f}	0.08±0.01^{f}	0.53±0.01^{f}
13	Refined, Bleached and Deodorized	0.73±0.02^{d}	0.10±0.02^{d}	0.67±0.02^{d}
14	PureVirgin Coconut Oil	0.76±0.02^{d}	0.11±0.02^{d}	0.73±0.02^{d}
15	Refined, Bleached and Deodorized	0.66±0.01^{e}	0.09±0.01^{e}	0.60±0.01^{e}
CODEX STANDARD		ND - 17	ND – 2.38	ND – 15.87

ND= Not detected. Values are means of duplicate determinations. Within column of each treatment values with different superscripts are significantly different (P< 0.05).

value. It also indicates the length of the carbon chain of the acid present in the oil, and the percentage of short-chain acids present in the glycerides of the oil is directly proportional to the saponification value [32]. Different extraction methods employed during coconut oil production could results into significant variation in their saponification values [44]. The wide variability among the marketed coconut oil samples investigated in the present study might be due to different extraction methods.

Significant variations in alpha-tocopherol content among coconut oils of different origins could be due to a variation in coconut seed quality, loss in tocopherols during storage, initially higher moisture content, storage temperature, drying methods such as sun drying or oven drying and or processing conditions employed during the extraction of the oil [32]. The values of alpha-tocopherol content obtained in the present study were lower than 1.90 - 3.00 mg/100g and 2.92 - 4.28mg/100g reported for fresh Indian and Nigerian coconut oils respectively [32, 33]. In a related development, Codex Alimentarius [34] reported a value of 17 mg/100g in some coconut oil samples.

Tocopherols are lipid soluble natural antioxidant found mainly in most vegetable oils. They show good antioxidant properties on lipid peroxidation and the scavenging of reactive oxygen species [32]. As a Vitamin E analogue, they are also viewed as an enzyme activity regulator for protein kinase C which plays a role in smooth muscle growth [45]. Alpha-tocopherol is the most studied and dominant biological potent tocopherol isomer [46]. The following ranges (mg/100g) of this phytonutrient: 13.6 – 67.4, 2.3 – 57.3, 4.9 – 18.8, 10.0 – 38.6, and 40.3 – 93.5 have been reported in cotton seed oil, maize oil, palm oil, rapeseed oil and sunflower seed oil respectively [34]. The concentration of tocopherol in coconut oil is comparatively low to other vegetable oils [17]. Results of the present study agree with this, as the % daily value (% DV) of the oil samples ranged between 0.33 and 1.66 % These values agree with the results from previous work carried out by Changbumrung and co-workers [47]. A food source of Vitamin E is one that has a percentage daily value (%DV) that is greater than 5% of Recommended Dietary Allowance (RDA) [48]. In consideration of the foregoing, coconut oil might not be considered as a food source of vitamin E.

A cursory comparison of the alpha-tocopherol data generated from the present study with those obtained on fresh coconut oils [32, 33] depicts that the alpha-tocopherol contents of the former was much lower than the latter. As noted by Prasanth and Gopala [32], poor storage condition, in addition to seed quality and oil extraction methods could contribute to low alpha-tocopherol content of coconut oil. In this connection, the three southwestern cities of Nigeria from which the coconut oils were purchased are situated within the rain forest belt of Nigeria with the following climatic conditions: Ibadan (temperature, 26.5˚C; mean annual rainfall, 1311 mm), Sagamu (mean temperature, 27.1˚C; mean annual rainfall, 1514 mm), and Lagos (temperature, 27.0˚C; mean annual rainfall, 1693 mm) [49]. In addition, many of the investigated coconut oil samples were packaged in transparent bottles and exposed to direct sunlight by the local marketers. The effect of the prevalent climatic conditions in the cities where coconut oils were obtained coupled with the poor handling of these products along the value chain might be responsible for the low α-tocopherol contents of the investigated market samples compared with the freshly produced ones.

CONCLUSION

In recent years, coconut oil has grown in global popularity due to many health benefits that have been attributed to it. However, the result of the present study indicates that some market samples of coconut oil in three southwestern states in Nigeria fail the critical chemical tests such as acid values, free fatty acid values, iodine values and saponification values. In order to maximize the health and socioeconomic benefits inherent in the coconut value chain, the Government through her relevant regulatory agencies will need to ensure that coconut oils that are of adequate standards are marketed. In addition, the marketers of this product will need to be given adequate orientation in respect of proper handling and storage of coconut oil, which is a thermo and photo-sensitive product.

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