Journal of Advances in Microbiology

Volume 22, Issue 12, Page 113-123, 2022; Article no.JAMB.95666
ISSN: 2456-7116

Determination of Microbiological Quality, Proximate Composition and Physicochemical Parameters of Margarine Produced from Oil Blends of Palm Kernel, Coconut and Melon

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Authors' contributions

This work was carried out in collaboration between both authors. Author FCA designed the study, wrote the protocol and packaged the final manuscript. Author OHS was very active in the laboratory and wrote the first draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMB/2022/v22i12712

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95666

Original Research Article

Received: 21/10/2022
Accepted: 29/12/2022
Published: 30/12/2022

ABSTRACT

The potential of margarine production from blends of melon, coconut and palm kernel oil, and the microbiological qualities and physicochemical parameters of the product were studied. The microbiological evaluation was carried out at the Microbiology Laboratory, Cross River University of Technology, Calabar, Nigeria, using pour plate and spread plate methods to ascertain the viable cell counts. The physicochemical composition, proximate properties were determined using standard methods. The enumeration of total heterotrophic bacterial count revealed low microbial count of 2.6 x 10^3 CFU/g, total coliform count was 2.5 x 10^2 CFU/g and total fungal count. 2.4 x 10^2 CFU/g. The value was within permissible limit of 10^4 CFU/g. The biochemical characterization and identification revealed *Staphylococcus* spp, *Bacillus* spp, *Salmonella* spp, *Escherichia coli,* and

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Micrococcus spp are the suspected bacterial isolates. While the fungal isolates are *Aspergillus* spp, *Fusarium* spp, *Penicillium* spp and *Rhizopus* spp. The percentage occurrence revealed that *Staphylococcus* spp had the highest prevalence of 33.3%, followed by *Escherichia coli* (26.7%), *Salmonella* spp (20%), *Bacillus* spp (13.3%), *Micrococcus* spp (6.7%). While the fungal isolates had the following prevalence; *Aspergillus* spp (50%), *Penicillium* spp (16.7%), *Rhizopus* spp (16.7%) and *Fusarium* spp (16.7%). Proximate analysis revealed moisture (15.0±0.5), ash (35.0±0.5), crude (17.50±0.25), lipid (22.50±0.03), protein (2.218±0.01), and carbohydrate (7.78±0.01). Results for physicochemical analyses showed that Iodine value was 0.372, saponification value was 22.103 and acid value, 1.159. This result indicates that palm kernel oil, melon oil and coconut oil had the best potential for the production of margarine which would be acceptable due to the low microbial count. However, the presence of *Staphylococcus* spp and *Salmonella* spp renders the product a potential health hazard in line with FDA guidelines. Therefore, maximum hygienic conditions during production is advocated and further analysis recommended on these samples to discover their maximum importance and industrial utilization.

Keywords: Margarine production; melon; coconut; palm kernel oil; microbiological qualities; proximate analysis; physicochemical parameters.

1. INTRODUCTION

"The interest of consumers in healthy eating is shifting towards the potential health benefits of foods known as functional foods. Functional foods refer to foods which positively affect one or more target functions such as reduction of diseases in the body along with its nutritional effects" [1]. "Fats and oils, along with carbohydrates and proteins are major components of the human diet. Fats provide energy and essential fatty acids that are required for proper growth and development" [2]. "Margarines, which originally were produced from lard and other animal fat sources, however, the linkage of saturated fats with heart disease results to the production of new margarine of vegetable origin. Margarine (a butter substitute) made primarily from vegetable oils is a research innovation. It is recognized as a healthy table spread and a cheaper alternative to butter for use in cooking and in food preparation" [3]. "Margarine falls under the food group often described as lipid (fats and oils). It delivers essential fats and vitamins our body needs. Just like any other fat, it delivers energy and gives food its taste and texture" [4]. "The recent trend of moving away from chemical-based remedies, towards more nature-based treatments is gaining momentum as a result of the increasing cost of healthcare and comparatively less residue effect associated with functional foods like margarine" [5].

"The seed of melon is well known for their rich oil and protein content. Oil constitutes the largest nutritional component of the seed. The seed is reported to contain 32.55% protein, and 50% oil" [6]. According to Abbah, et al. [7] "the seed of Egusi melon contains 35% fats, 10% carbohydrate and 28% protein, with 72% by weight unsaturated fatty acids, and 57.4% of it being polyunsaturated fatty acids (PUFA). It is well documented that egusi melon oil contains good amounts of linoleic and oleic acid and other essential fatty acids which have protective effect against coronary heart disease" [7]. "In addition to its possible effect on lowering of blood cholesterol due to the presence of unsaturated fatty acid, the Egusi melon seed can also be an exceptional tool for combating protein-calorie malnutrition owing to its protein high nutritional quality" [8].

"Coconut oil (*Cocos nucifera*) has generated discussions about its possible effects on health, especially for being an oil rich in saturated fat" [9]. Unlike other vegetable oils, coconut oil is chemically very stable and not easily oxidized. It is very resistant to free radical attack and in combination with other oils, acts as an antioxidant, helping to prevent the oxidation of other oils. "Most of the fatty acids in coconut oil are composed by medium chain; thus, they are directly absorbed by the intestine and sent to the liver to be used as an energy source" [10].

The Production of margarine from blends of coconut, melon seed oil and palm kernel oil will improve the utilization and value of the melon seed. Also, consumption of margarine made from these oils rich in poly unsaturated fatty acids (PUFAs) and mono unsaturated fatty acids (MUFAs) which have proved to be a better substitute to other sources for margarine production. Hence, this study designed to

evaluate the microbiological quality and ascertain the physicochemical and proximate compositions of the produced margarine.

2. MATERIALS AND METHODS

2.1 Sample Collection

Samples used in this study were purchased from different locations within Calabar metropolis, Cross River State, and were aseptically transported to Microbiology Laboratory, Cross River University of Technology, Calabar, for further analysis. The samples include; coconut, palm-kernel, and melon, and they were of analytical standard.

2.2 Extraction of Margarine

Margarine was produced from 100% melon oil, coconut oil and palm kernel oil using the method described by Sayed et al. [11]. A basic recipe that include 81.7% oil blend, 0.3% emulsifier, 0.8% salt, 0.9% skim milk powder, 0.2% flavour, 0.01% antioxidant and 0.003% colour was used for margarine production. Emulsifier, antioxidant, flavor and colour were dissolved in the heated oil phase. Salt and skim milk powder were dissolved in water phase. The water phase was added gradually to the oil phase while agitating it to form a nice emulsion. For the solidification of margarine, the emulsion was stirred for 10 minutes and then cooled in ice bath containing 10% sodium chloride (NaCl). The emulsion was then mixed and solidified at a temperature of 11^0 C. the margarine sample stored in a refrigerator at 4^0c.

2.3 Microbiological Analysis

2.3.1 Determination of total heterotrophic bacterial count

Total Heterotrophic Bacterial Count of the samples was examined using the pour plate methods as described by Cheesbrough [12]. Serial dilution (10^1-10^{10}) was prepared from Margarine oil samples. One millimeter (lml) was taken from each selected dilution (10^2, 10^4 and 10^6) into sterile petri dishes in triplicates. The molten sterilized agar (Nutrient and MacConkey) were poured into the plates, swirled for even distribution of the inoculum within the agar medium and allowed to solidify and then incubated at 37^0C for 24 hours. Thereafter, plates with colony growth were counted and expressed in colony forming unit per millimeter (CFU/ml).

2.3.2 Enumeration of total coliform count

Total coliform count of the samples was determined using the spread plate method on MacConkey Agar medium. One millimeter (1ml) of the diluent from the samples was aseptically transferred into sterile petri dishes containing already sterilized MacConkey Agar, and were swirled for even distribution. They were incubated at ambient temperature for 3-4 days. Plates with colony growth were counted and expressed in colony forming unit per millimeter (CFU/ml).

2.3.3 Determination of total fungal count

Total fungal count was examined using the spread plate method on Sabouraud Dextrose Agar. Exactly one millimeter (1ml) of the diluents from the samples was aseptically transferred into sterile petri dishes contain already sterilized Sabouraud Dextrose Agar, and was swirled for even distribution. They were incubated at ambient temperature for 3-4 days. Plates with colony growth were counted and expressed in colony forming per millimeter (CFU/ml).

2.3.4 Biochemical characterization of isolates obtained

In biochemical characterization, the following were performed to identify the isolate biochemical abilities: oxidases, catalase, coagulase, methyl red, voges-proskauer, indole, Citrate test and triple sugar iron test.

2.3.5 Identification of fungal isolates

The colonial morphologies of the fungal isolates on Saboraud Dextrose Agar were observed for colour and type of growth that is wooly or cottony. Microscopic identification as described by Murray et al. [13]. This was done by preparing wet mount using lactophenol cotton blue to observe the microscopic characteristics of the fungi such as type of hyphae (whether septate or non-septate). This was done by Placing a drop of Lactophenol Blue on a clean microscope slide, with the aid of an inoculating needle, gently a small portion of growth midway between the colony center and edge was remove and Placed in the dropped Lactophenol Blue on the slide. With two sterile dissecting needles, gently the fungus was teased apart so that it is thinly spread out in the Lactophenol. After which, a coverslip was placed on the edge of the Lactophenol and slowly lower it. Then placed

under the microscope for examination. Both microscopic and macroscopic features of the fugal isolates were matched based on the mycological atlas for fungal identification.

2.4 Determination of Proximate Composition

The sample was analyzed for the various nutrient's constituent by the methods of the Association of official Analytical Chemists [14].

2.5 Analysis of Ash Content

Five grams (5.0g) of the sample were weighed into crucible of known weight with the lid ignited in a muffle furnace for 2 hours at a controlled temperature of 550˚C. At the end of this process, the crucible and lid were cooled in the desiccators containing magnesium sulphate as drying agent. The final weight was noted and calculated using the formula;

$$\%Ash = \frac{weightofashin(g)\times 100}{initialweightofthesample}$$

$$\text{i.e.} = \frac{z-x\times 100}{initialweightofthesample}$$

Where,

z = weight of crucible plus sample before drying,
y = initial weight of crucible
x = final weight of crucible after ashing

2.5.1 Assessment of crude protein (By Kjeldahl Method)

Five grams (5.0) of the sample was weighed into 250ml standard kjeldahl flask containing 1 tablet of kjeldahl catalyst, some anti-bumping chip and 30ml of concentrated H_2SO_4 was introduced into digestion rack and heated gently for 1hour to prevent vigorous charring and frothing. The flask and its contents were then subjected to vigorous heating for 5hours until clear bluish solution was obtained. After digestion, the solution was cooled, and then quantitatively transferred into a 100ml standard flask and make up to the mark with distilled water. 10ml portion of this digestion was pipette into a micro kjedahl Markhan distillation apparatus and treated with 30ml 50% NaOH solution. The ammonia evolved was steam distilled as described by Markhan (1942) into a 100ml conical flask containing 10ml solution of saturated boric acid into 2 drops of double indicator (0.1% methyl red and 0.1% methyl blue in 100ml of ethanol) [14].

The tip of the condenser was immersed into the boric acid-double indicator solution and the distillation continued until about thrice the original volume was obtained. The distillate was then titrated with 0.1ml HCl (hydrochloric acid) solution until a purple-pink end point was reached. The percentage nitrogen content in the sample was obtained with appropriate calculation.

A blank was also determined by carrying out the above procedure except that the sample was not used. Calculation;

$$\%\text{ crude protein} = \frac{N}{14}\times\frac{Hclsample-Hclblank\times DF\times NF}{weightofsampleinmilligrams}$$

Where DF = Dilution factor, NF = Nitrogen factor

2.5.2 Determination of Crude Lipid (Fat)

Five grams (5.0g) of the sample was weighed into a small porcelain bowl and heated in an oven at 105˚C for 1hour. After cooling, the dried melon, coconut and palm kernel sample were transferred into a soxhlet thimble, the sample were covered with class wool and placed into a soxhlet apparatus (fat extraction unit). Dry and clean fat extraction flask (pre-weighed) was place into the extraction unit together with about 300ml of petroleum ether (BP 40-60˚C) and was allowed to reflux for 6hours. Extraction was carried out on the palm kernel sample.

Finally, petroleum ether evaporated off and the flask dried in an oven at 105˚C for 1hour and was transferred into desiccator to cool. The weight increase of the flask was estimated as corresponding to the fat content [14].

The lipid (fat) was calculated using the formula;

$$\%\text{ fat} = \frac{weightoffat\times 100}{weightofsample} \qquad \text{i.e. } \frac{T-D\times 100}{W}$$

Where,

T = final weight of flask used for extraction,
D = initial weight of flask used for extraction
W = weight of sample used for extraction

2.5.3 Determination of Crude Fibre

The procedure for estimation of the crude fibre in the sample was carried out in different stages;

a) Acid digestion filtration and rinsing
b) Base digestion and ignition method [14].

Five grams (5.0g) of the sample was weighed out into 250ml beaker containing 2% H_2SO_4 and mixed well and heated for 30minutes with constant steaming. After boiling the sample was filtered and washed with distilled water to remove the acid content until the residue was acid

b) Base digestion

The residue was further treated with 50ml of 2% NaOH solution and heated for 30minutes with constant steaming. The residue was made base free by filtration and washing with distilled water. The residue left was treated with methanol and filtered. It was dried in a crucible of known weight, at 100˚C, followed by ignition in furnace at 550˚C.

The weighed of the ash left after ignition was recorded and calculation was done using the formula below;

$$\% \text{ fibre} = \frac{weightd\ if\ ference}{weight\ of\ sample} \times \frac{100}{1}$$

2.5.4 Determination of Carbohydrate

This was obtained by difference, that is, the differences obtained after subtracting the percentage crude protein, lipid, ash, moisture and fibre from 100% dry matter.

2.5.5 Determination of Moisture Content

The moisture content of the sample (palm kernel) was determined following the guidance of the Association of Official Analytical Chemists [14]. Five grams (5.0g) of the sample was dried to constant weight at a temperature of 70˚C in a hot air circulating oven. The moisture content was expressed in terms of percentage wet weight.

The calculation was done as shown below;

$$\% \text{ moisture} = \frac{loss\ in\ weight \times 100}{initial\ weighto\quad fsample}$$

$$\text{i.e.} \quad m = \frac{W2-W3\times 100}{W2-W1}$$

Where,

W1 = initial weight of crucible,
W2 = weight of crucible + sample before drying
W3 = weight of crucible + sample after drying

2.6 Physicochemical Parameters

Physicochemical properties of oils are determined to know the quality, purity and identification of the oil extract [14].

2.7 Determination of Acid Value

Ten grams (10) of the fat sample was weighed accurately and dissolved in about 50ml of fat solvent and titration was carried out with 0.1ml/litre KOH using phenolphthalein (1ml) as an indicator. The titration was continued until a faint pink colour persists for 20-30 seconds. The number of millimeters of KOH required was noted and the acid value of the fat calculated.

Note; 0.1mol/liter KOH contains 5.6gm/litre or 5.6mgm/ml KOH.

2.8 Examination of Iodine Value

This analysis was performed on the intact lipid. To a 5.0ml aliquot of the lipid solution containing a known amount (2mg) of lipid extract 5.0ml of the pyridine dibromide solution in a 50ml glass-stopper Erlenmyer flask was added; and mixed, left at a room temperature in the dark for 15minutes; add 0.5ml of KI solution. 0.5ml of water and a few drops of starch indicator. Titrate the liberated iodine with standard 0.02N thiosulphate solution.

A blank consisting of 5ml of chloroform alone was run simultaneously. Calculation was done following the formula below:

$$\text{Iodine value} = \frac{(a-b)}{c} \times \frac{1.27}{5}$$

Where a = blank titre, b = sample titre, c = weight of lipid (g)

2.9 Determination of Saponification Value

The saponification is defined as the milligram of KOH required to saponify 1gm of fat. Since fats are mixture of acylglycerols and they in turn contain various chain length fatty acids, the saponification value is an index of the average molecular size of the fatty acid present. One gram (1g) of the fat was accurately weighed in a tarred beaker and dissolved in 3ml of the fat solvent. The content of the beaker was quantitatively transferred to a 250ml conical flask by rinsing the beaker 3times with a further mil of the solvent (equal volume of 95% ethanol and ether). Alcoholic KOH (25ml of 0.5mol/litre) was added and attached to a reflux condenser.

Another reflux condenser was set up as a blank with everything present except the fat. Both flasks were heated on a boiling water bath for 30minutes. Leave to cool to room temperature and titrate with 0.5mol/litre HCL and phenolphthalein indicator. The differences ($x$ml) between the blank and the test reading gives the number of mils of 0.5mol/litre KOH required to saponify 1gm of fat.

Formula for calculation is shown below;

The molecular weight of KOH is 56. It means that 1ml of KOH = 56mgm.

Mg of KOH = $\frac{56mgm}{xml} \times 1ml$

Since 3 molecules of fatty acid are released from a triglyceride, then;
Saponification value (s) = $3 \times 56 \times 1000/ averagemol.weightoffat$
Average mol. Weight of fat = $3\times 56 \times 1000/s$

3. RESULTS

The enumeration of the total heterotrophic bacterial counts of the samples showed that the self-made margarine had higher bacterial load ($2.6x10^3$ CFU/g) when compared to commercialized blue band margarine ($2.7x10^2$ CFU/g) as presented in Table 1.

The result of the Total Coliform count (Table 2) also revealed that the counts of the self-made product are higher when compared to the commercialized ones.

The Total fungal counts followed the same trend (Tables 3).

Biochemical characterization and identification processes revealed the presence of *Staphylococcus spp., Salmonella* spp*., Escherichia coli, Micrococcus* spp. and *Bacillus* spp as shown in Table 4.

The percentage occurrence of the bacterial isolates obtained showed that *Staphylococcus* species had the highest prevalence of 33.3%, followed by *Escherichia coli* (26.7%)*, Salmonella* species (20%), and then *Micrococcus* species with the lowest value of 6.7% (Table 5).

The result of the isolation and characterization of fungal isolates revealed that *Aspergillus* spp., *Rhizopus* spp. and *Penicillium* spp., were the presumptive fungal organisms as displayed in Table 6.

The percentage occurrence of fungal isolates observed in this study revealed that *Aspergillus* species had the highest percentage occurrence of 50%, with (Table 7).

Table 1. Total Heterotrophic Bacterial (THB) count of margarine produced from palm kernel oil, melon oil and coconut oil samples

Samples	CFU/g
Commercial Margarine (Blue band)	2.7×10^2
Self-made Margarine from palm kernel,elel, melon and coconut oil.	2.6×10^3

Table 2. Total Coliform (TC) count of margarine produced from palm kernel oil, melon oil and coconut oil samples

Samples	CFU/g
Commercial Margarine	1.5×10^2
Self-made Margarine from palm kernel, melon and coconut oil.	2.5×10^2

Table 3. Total Fungal Count of margarine produced from palm kernel oil, melon oil and coconut oil samples

Samples	CFU/g
Commercial Margarine	1.3×10^2
Self-made Margarine from palm kernel, melon and coconut oil.	2.4×10^2

Table 4. Biochemical Characterization and Identification of Isolates Obtained

S/N	Cell shape	Gram reaction	Oxidase	Citrate	Coagulase	Indole	Methyl red	v. p	Catalase	Sucrose	Lactose	Glucose	Butt	Slant	Gas	H_2S	Suspected organisms
1	Rods in singles	-	-	-	-	+	+	-	+	+	+	+	A	A	+	-	*Escherichia coli*
2	Rods in singles	-	-	-	-	+	+	-	+	+	+	+	A	A	+	-	*Escherichia coli*
3	Rods in singles	-	-	-	-	+	+	-	+	+	+	+	A	A	+	-	*Escherichia coli*
4	Cocci in clusters	+	-	+	+	-	-	-	+	+	+	+	A	A	+	-	*Staphylococcus aureus*
5	Rods in chains	+	-	+	-	-	+	-	+	+	+	+	A	A	+	-	*Bacillus species*
6	Rods in pairs	-	-	+	+	+	+	-	+	+	+	+	A	A	+	+	*Salmonella species*
7	Rods in singles	-	-	-	-	+	+	-	+	+	+	+	A	A	+	-	*Escherichia coli*
8	Cocci in clusters	+	-	+	+	-	-	-	+	+	+	+	A	A	+	-	*Staphylococcus aureus*
9	Cocci in clusters	+	-	+	+	-	-	-	+	+	+	+	A	A	+	-	*Staphylococcus aureus*
10	Cocci in singles	+	+	+	-	-	-	-	+	+	+	+	A	A	+	-	*Micrococcus species*
11	Rods in pairs	-	-	+	+	+	+	-	+	+	+	+	A	A	+	+	*Salmonella species*
12	Rods in pairs	-	-	+	+	+	+	-	+	+	+	+	A	A	+	+	*Salmonella species*
13	Rods in chains	+	-	+	-	-	+	-	+	+	+	+	A	A	+	-	*Bacillus species*
14	Cocci in clusters	+	-	+	+	-	-	-	+	+	+	+	A	A	+	-	*Staphylococcus aureus*
15	Cocci in clusters	+	-	+	+	-	-	-	+	+	+	+	A	A	+	-	*Staphylococcus aureus*

Table 5. Frequency of occurrence of bacterial isolates

Isolates	No. of Occurrence	Percentage of Occurrence
Escherichia coli	4	26.7
Staphylococcus sp.	5	33.3
Bacillus sp.	2	13.3
Salmonella sp.	3	20
Micrococcus sp.	1	6.7
Total	15	100

Table 6. Characterization and Identification of fungal isolates obtained from the margarine

S/N	Macroscopic Characteristics	Microscopic characteristics	Presumptive Organism
1	Rapidly growing on SDA starting with a white to yellowish mat of mycelia. Reverse side of plate is white.	Septate	*Aspergillus spp*
2	Typical blue-green mycelia with white edges. White on the reverse side of plate.	Septate	*Aspergillus spp*
3	Cottony irregular shape with purple edge. Mycelia became green-yellow as they aged. White on reverse side.	Septate	*Aspergillus spp*
4	Bluish-green mycelia with a white border. Reverse is white.	Septate	*Penicillium spp*
5	Dense white filamentous hyphae covering entire plate later turn grey or yellowish-brown. White on reverse plate.	Septate	*Rhizopus spp*
6	Fine white cotton, wool-like hyphae slightly raised. Reverse side is odd white.	Septate	*Fusariums spp*

Table 7. Frequency and percentage of occurrence of fungal isolates

Isolates	No of Occurrence	Percentage of Occurrence
Aspergillus sp.	3	50
Penicillium sp.	1	16.7
Rhizopus sp.	1	16.7
Fusarium sp.	1	16.7
Total	6	100

Table 8. Proximate composition of margarine produced from melon coconut and palm kernel oil

Parameters	Percentage composition (%)
Moisture content	15.0±0.05
Ash content	35.0±0.05
Crude fibre	17.50±0.025
Lipid (fat) content	22.50±0.03
Protein content	2.218±0.01
Carbohydrate	7.782±0.01

Values represented in mean ± standard deviation of triple determination

Table 9. Physicochemical analysis of melon, coconut and palm kernel oil extract

Components	Proportion in (mgKOH/g)
Acid value	1.159
Saponification value	22.103
Iodine value	0.372

The results of the proximate analysis as contained in Table 8 revealed that the moisture content was determined as 15.0±0.05%, Ash content 35.0±0.05%, Lipid (fat) content 22.50±0.03%, Crude Fibre 17.50±0.025%, Crude Protein 2.218±0.01%, and carbohydrate content 7.782±0.01%.

The result of the physicochemical analysis of the produced margarine revealed that it has an acid value of 1.159mgKOH/g, Saponification value of 22.103mgKOH/g, and Iodine value of 0.372mgKOH/g as shown in Table 9.

4. DISCUSSION

The result of the microbiological evaluation revealed that the suspected bacterial isolates are *Staphylococcus* Spp, *Escherichia coli, Bacillus* spp, *Salmonella* spp, *Micrococcus* spp., while the fungal isolates are Aspergillus spp, Fusarium spp, Rhizopus spp. This agrees with the findings of Zaeroomali et al. [15] which identified similar organisms from the investigation of physicochemical, microbial and fatty acid profile of table margarine. The observation of a low microbial load could be due to high temperature the sample were exposed to during the oil extraction. However, the isolation of Staphylococcus, Salmonella and *Escherichia coli* remains a concern to human health. The result of this study shows that margarine produced from oil extracted from palm kernel, melon and coconut could be good for consumption but hygienic conditions must be adhered to in order to avoid contamination.

The result of the proximate composition of margarine revealed the presence of nutritious compounds. The margarine has a moisture content of 15.0±0.05. "The moisture content is a widely used parameter in processing and of testing of many food, it is an index of the water activity of many food products" [16].

The major aim of processed food item is to keep its moisture content low so that it can be stored or preserved for long period of time. The Ash content was 35.0±0.05. Ashing helps in analyzing the mineral content of the melon, coconut and palm kernel oil. Lipid (fat) content (22.50±0.03) is high and therefore agrees with the earlier report of Borger et al. [17], who reported that fat is important in diets as it promotes fat soluble vitamins absorption. It is a high energy nutrient and does not add to the bulk of the diet. The crude fibre was found to be 17.50±0.025, it helps in maintenance of internal distention for a normal peristaltic movement of the intestinal tract. Okon (2005) reported that a diet low in fibre is undesirable as it could cause constipation and that such diets have been associated with diseases of colon like piles, appendicitis and cancer. The protein content is low, 2.218±0.01. The low protein indicate that the palm kernel nuts are not very suitable for animal feeds or to improve nutritional values. The finding of Carbohydrate of 7.782±0.01 (by difference) is an indication that the melon, coconut and palm kernel oil have a low source of energy.

The physicochemical analysis of the melon, coconut and palm kernel oil showed that the acid value was low, 1.159. Acid value determination is often used as a general indication of the condition and edibility of the oil. This is because an increase in acid value is accompanied by development of objectionable flavours and odours. The maximum acceptable level of acid in the oil that can find application in cooking or consumed is 4 mg KOH/g [18]. This proves that the margarine produced from melon, coconut and palm kernel oil is good for consumption as it did not exceed the acceptable range. Acid value measures the free fatty acids (FFA) present in lipid. Increment in FFA in a sample of oil or fat indicates hydrolysis of triglycerides. Since such reaction results from the action of lipase enzyme [19], high acid value can be used as an indicator of inadequate processing and storage conditions. The low and slight increase of the acid value of the margarine samples may be attributed to the effective destruction or inhibition of enzymes activity and indicates adequate processing [20].

"Saponification value is an indication of the amount of fatty saponifiable materials in oil or fat. It gives information concerning the characteristics of the fatty acid of the oil and in particular regarding the solubility of their soaps in water. The higher the saponification number, the more soluble the soap that can be made from it" [21]. "The saponification value obtained from the melon, coconut and palm kernel oil indicates that the oil may be used industrially for the production of soap and other products. Iodine value of the oil extract analyzed was very low. Iodine value is an indicator of double bonding in the molecular structure, which influences the long-term stability properties of the oil. It has been reported that lowering the iodine value improves the stability and good yield of the liquid oil" [22,23].

5. CONCLUSION

This study has shown that coconut, palm kernel and melon oil have suitable microbial quality, physicochemical characteristics and composition for production of margarine that is within acceptable standards and can be optimized as alternatives in the edible oil and industrial oil use. The favorable iodine values of the oils suggest beneficial health possibilities, the high saponification values reveal the soap-making ability, while the lightness, fluidity and non-greasy properties indicate the suitability of the oil for consumption. This indicates that melon, coconut and palm kernel oil extract have greater potential as industrial raw material beyond been consumed directly or indirectly as ingredient in food.

ACKNOWLEDGEMENT

We appreciate the efforts of Mr Donald Idoko and Mr Obinna H. Sylvanus during the laboratory work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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