Physicochemical, Micronutrient and Fatty Acid Compositions of Some Selected Mayonnaise Samples in Nsukka, Nigeria

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Abstract

Introduction: The chemical makeup of mayonnaise, a distinctive type of spread and food dressing formed with an oil-in-water emulsion, was examined.

Methods: For this investigation, a total of six distinct mayonnaise samples were used. Standard techniques and GCMS were used to examine the physicochemical, fatty acid, and micronutrient contents of the mayonnaise samples.

Results: The findings indicated that the mayonnaise samples contained the following range of physicochemical characteristics: iodine value (33.1098 ± 0.473 to 35.1022 ± 0.620 g I_2/100g), acid value (27.7824 ± 0.5774 to 29.1121 ± 0.588 mgKOH/g), peroxide value (14.6000 ± 0.5774 to 16.4000 ± 0.5774 meqO2/kg), saponification value (190.9843 ± 0.5774 to 225.1288 ± 3.0550 mgKOH/g), melting point (8.0000 ± 0.5774 to 10.2214 ± 0.5774 C). According to the fatty acid profile, the different mayonnaise samples differ in their proportions of linolenic acid, lauric acid, tetracosapentanoic acid, docosahexaenoic acid, myristic acid, eicosadecanoic acid, oleic acid, and docosapentanoic acid. The mayonnaise samples contained various levels of vitamins A, C, D, E, and K as well as minerals like copper, iron, zinc, and manganese. **Conclusion:** The results of the nutritional features of the various mayonnaise samples, showed that it contained various essential nutrients useful in developing healthy – oriented diets and improve food quality.

INTRODUCTION

Food serves three primary functions; first, it provides sustenance, next it prevents illnesses brought on by a particular lifestyle. In the deployment and systematic analysis of a functional food research project supported by the Ministry of Education, Culture, Sports, Science, and Technology of Japan in 1984, these two functions were principally described. Foodstuffs with health claims (FHCs) were used to define the third function, and rules for extending FHCs were first created in Japan (Mirzanajafı et al., 2019). Numerous food products, including milk, sauces, ice cream, sweets, mayonnaise, salad dressings, and butter, are emulsions in one form or another. The majority of oil-in-water (O/W) emulsions used in the production of food require long-term physical stability to preserve and modify the necessary product qualities (Orgulloso-Bautista et al., 2021). Because of its unique flavor and creamy texture, mayonnaise, an oil-in-water emulsion, is a popular traditional condiment. Its 65–80% fat content enhances both its flavor and texture (Wang et al., 2022). A thick sauce called mayonnaise is formed from an egg yolk-based oil-in-water emulsion. The public has taken a liking to this emulsion product as a side dish. Nowadays, the use of mayonnaise has become extensively prevalent as a result of people's evolving consumption habits as they transition to modern, nutritious diets (Nidhal et al., 2022). Depending on how much oil is used in the recipe, there are two primary categories of mayonnaise. Whereas full-fat mayonnaise has about 75–80% oil, low-fat mayonnaise has about 30–65% oil. The majority of mayonnaise products on the market are low-fat mayonnaises as a result of consumer preferences. The fat percentage of low-fat mayonnaises ranges from 20 to 40%. (Anamaria, 2019). The mayonnaise is prepared by combining vinegar as the dispersion phase, vegetable oil as the dispersed phase, and egg yolk, which serves as an emulsifier (Nidhal et al., 2022). One of the most widely used and favored condiments for enhancing flavor and taste is mayonnaise (Lazar et al., 2022). Due to its structure and composition, mayonnaise—a commonly used food product used as condiment for various types of cuisine—is extremely vulnerable to microbiological and chemical deterioration. Chemical degradation involves the oxidation and hydrolysis of different kinds of fat and oil, which raises the quantity of chemicals such peroxide and causes sourness and changes in colour, taste, and texture (Shaygannia et al., 2021). Due to the quantity of emulsified oil, the stability of mayonnaise is influenced by the type of oil used and is subject to deterioration owing to autoxidation. Due to the physical and chemical processes involved in the creation of emulsions, mayonnaise that is significantly more stable during long-term storage and the creation of products with a wider range of new flavours are now both possible. Thus, a mayonnaise formulation with suitable emulsion qualities and high stability has been created by combining several ingredients, including proteins with different emulsifiers and gums including xanthan and guar gum (Orgulloso-Bautista et al., 2021). Mayonnaise has undergone numerous attempts to be reformulated in recent years to satisfy market requests for a low-fat product with a better lipid profile. Reducing or changing the type of fat that, if taken in excess, may be detrimental, resulting to the initiation and development of chronic diseases, such as yolk cholesterol and salt among others, was the main goal of redesigning the mayonnaise recipe (Raikos et al., 2020). High-fat diets full of nutrient-poor, energy-dense, and highly processed foods are quite popular in the modern world. Processed foods are replacing traditional whole foods, such as numerous higher-fibre meals. Incorporating healthy ingredients into the creation of new dishes is a great way to lessen the harmful effects of ultra-processed food (Mesquita et al., 2020). Given that mayonnaise is a high-fat food that is susceptible to oxidative deterioration as a result of the auto-oxidation of unsaturated fatty acids (Wang et al., 2022) and that it is widely consumed worldwide, this research aims to examine its fatty acid, physicochemical, and micronutrient content to ascertain its health consequences and whether or not it is beneficial to consumers.

MATERIALS AND METHODS

Materials

Mayonnaise

A total of six of the most popular mayonnaise were purchased in Ogige market, Nsukka.

Reagents

Alcoholic potassium hydroxide solution, Chloroform, Diethyl ether, Iodine tetrachloride, Glacial acetic acid, Phenolphthalein, Carbon tetrachloride, HCl, Petroleum ether, Detergent, Iodine, NaOH and Distilled water.

Methods

Quantitative Physicochemical Analysis of Mayonnaises

To quantify the concentrations of physicochemical qualities such iodine value, saponification value, peroxide value, acid value, cloud, specific gravity, melting point, boiling point, and viscosity, several chemical reactions were used (AOAC, 2005).

Micronutrient Composition of Mayonnaise samples

Using the APHA method (1998), mineral contents including copper, iron, zinc, and manganese were estimated. The method outlined by Danka *et al*. (2012) and AOAC (2005) was used to determine the content of vitamins A, C, D, E, and K.

Gas Chromatography (GC) Analysis of fatty acids in mayonnaise samples

In gas chromatography, the process outlined by Amit *et al*. (2020) was implemented with modifications. Briefly, the fatty acids were modified under 0.2M KOH's alkaline conditions and then methylated utilizing a direct trans-esterification process to identify their fatty acid profiles. On an SP2560 column, fatty acid methyl esters (FAMEs) separations were performed. A GC/MS-QP2010 Agilent Plus was then attached after temperature programming at a rate of 2°C per minute was utilized for the necessary portion of the temperature range of 30-260°C. The carrier gas used was helium. Thereafter, FAMEs were measured using FAME standards. Instead of being expressed as mass ratios, individual fatty acid concentrations were expressed as a proportion of the total fatty acids.

Statistical analysis

The statistical analysis was conducted using SPSS 20.0 version (SPSS Inc, Chicago, IL, USA) and the results expressed as means ± standard deviation.

Results and Discussion

Iodine, saponification, acidity, peroxide value, viscosity, cloud, flash point, melting point, and boiling temperatures of the six distinct samples were used to analyze the physicochemical characteristics of the mayonnaises consumed in Nsukka (Table 1). Iodine content in the various brands of mayonnaise ranged from 33.10 ± 0.47 to 34.19 ± 0.57 g I_2/100g, with sample 3 having the lowest value and sample 5 having the highest, as shown in Table 1. This value is lower than 43.27 reported by Chukwu and Adgidzi, (2008) on shea butter and higher than 26 reported on groundnut oil (Hui, 1996). The level of oil unsaturation is determined by the iodine value. The degree of unsaturation and shelf life increase with increasing iodine values.

Table 1: Physicochemical properties of some locally consumed mayonnaise in Nsukka.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Iodine (g I_2/100g)	34.10±0.57	34.19±0.57	33.10±0.47	33.19±0.47	35.10±0.62	34.10±0.57
Saponification (mgKOH/g)	225.12±3.05	190.98±0.57	202.14±0.55	200.11±0.57	195.97±0.57	198.74±0.55
Acid (mgKOH/g)	28.48±0.57	27.78±0.57	28.48±0.57	29.01±0.57	29.11±0.58	28.45±0.57
Peroxide (meqO_2/kg)	14.80±0.57	16.40±0.57	14.60±0.57	14.80±0.57	15.81±0.58	14.74±0.56
Viscosity (m Pa s)	64.89±0.57	69.72±0.57	66.74±0.57	64.89±057	72.84±0.57	64.77±0.57
Specific gravity	0.92±0.05	0.9336±0.07	0.93±0.05	0.91±0.05	0.92±0.57	0.93±0.05
Cloud	7.06±0.88	6.30±0.57	6.50±0.66	6.51±0.66	6.51±66	6.86±0.77
Melting point (C)	8.00±0.57	10.00±0.57	10.00±0.57	10.22±0.57	9.52±0.57	9.51±0.57
Boiling point (C)	332.66±0.88	349.00±0.57	329.00±0.86	328.14±0.86	344.22±0.57	332.66±0.88

Values are presented in mean ± standard deviation.

One of the crucial chemical components of salad sauces and dressings like mayonnaise is acidity. Acidity and time spent in storage are directly correlated. Yet, a rise in acidity imparts a disagreeable flavour to the sauce (Shaygannia *et al*., 2021). Since mayonnaise is a relatively acidic food, its pH is the primary factor influencing its shelf life and consumer acceptance (Wang *et al*., 2022). The range of the acid value in this study was 27.78 ± 0.57 to 29.01 ± 0.57mgKOH/g. According to a prior work by Shaygannia *et al*. (2021), the coated microencapsulated mayonnaise's acid values significantly (P<0.05) increased over the course of storage, reaching their peak after 30 days. Acidity of mayonnaise rose with storage due to the release of free fatty acids, hydrolysis of lipids, and double bond oxidation of unsaturated fatty acids. This caused the pH to drop from 14.60 ± 0.57 to 16.40 ± 0.57 meqO2/kg. The findings regarding the oxidative stability of mayonnaise were in line with those of Wang *et al*. (2022), who examined the oxidative stability of whole and SOB-substituted mayonnaise stored at four different temperatures (4°C, 25°C, and 35°C) and found that storage time and temperature significantly increased the peroxide value (PV) and thiobarbituric acid reactants (TBARS) of all mayonnaise samples (p<0.05). This may also justify the highest boiling points obtained from samples 2 and 5 (349.00 ± 0.57 ∘C, 344.22 ± 0.57 ∘C) of mayonnaise consumed in Nsukka with increased boiling points (temperatures) thereby accelerating the peroxide values of samples 2 and 5 (16.40 ± 0.57 meqO_2/kg, 15.81 ± 0.58 meqO_2/kg) respectively. As a result, the two samples (2 and 5) have considerably greater values for their respective boiling points (temperatures) and peroxides than the other samples. However, Lazar *et al*. (2022) noted that peroxide readings under 10 suggested that both enriched and basic mayonnaise samples are thought to be secure when stored in the refrigerator. According to Hermund *et al* (2019), the capsules' major oxidation product composition was stabilised throughout storage by antioxidants. The capsules were found to have a PV of 5–12 meq/kg oil after manufacture, with a lag period of roughly 8 days. After this time, the PV of the capsules significantly rose, ranging from 20.0 ± 4.5 to 34.6 ± 0.5 meq/kg oil in the final PV. Since the pH level found was in the range of 4.02–4.28 and the titratable acidity was between 0.40 and 0.48, Orgulloso-Bautista *et al*. (2021) reported that the results of the pH and titratable acidity analyses indicated that the mayonnaise-type sauces are considered acidic. Likewise, the results of the peroxide index analysis were between 12.5–20 meq.

The average molecular weight of all the fatty acids contained in the sample in the form of triglycerides is measured by the saponification value. The samples under study had a saponification value that ranged from 190.98 ± 3.05 to 225.12 ± 3.05mgKOH/g. It is higher than 185.00 mgKOH/g (Saba *et al*., 2018) and lower than the 208.371 mgKOH/g reported on chemically extracted shea butter (CSB) (Ofoegbu-Chibuzor *et al*., 2022). The melting points of the mayonnaise samples used in this investigation ranged from 8.00±0.57 to 10.22 ± 0.57 C. It is more than that of groundnut (0–3 C) (Hui, 1996). The temperature at which a transition from a solid state is noticed is known as the melting point.

The average viscosity of mayonnaise as shown in Table 1 ranged from 64.89 ± 0.57 m Pa s to 72.84 ± 0.57 m Pa with samples 1 and 4 having the least values and sample 5 having the highest value. The findings of the analysis of variance revealed that the addition of watermelon rind flour raised the viscosity of the reduced-fat mayonnaise significantly (P< 0.01), but the values were lower than the observed values of Evanuarini *et al*. (2021). His research revealed that viscosity values ranging from 3177.5 to 3805 cP were produced by a larger amount of watermelon rind flour. In a similar vein, gums may cause a gel-like structure that traps oil droplets, slowing their mobility and raising viscosity, according to Gaikwad *et al*. (2019). Contrary to Anamaria (2019) reports, the quality of mayonnaise is not affected by the speed of mixing, the number of eggs, the type of eggs, or the amount of oil in the mixture. Moreover, the emulsification process alters the mayonnaise's quality, bringing out the best in the traditional recipe. Long-term exposure to high speed causes the egg yolk protein to irrevocably be degraded, which reduces the viscosity of the mayonnaise. Nonetheless, the texture, moisture content, and droplets of mayonnaise were all impacted by the viscosity of the mayonnaise. In order to increase the viscosity of the reduced fat mayonnaise, soybean oil—which made up 50% of the original recipe—was substituted with components high in carbohydrates. Viscosity and textured liquid can both be lessened by reducing the oil (Evanuarini *et al.,* 2021). Low viscosity can also be considered a drawback since it can speed up oxygen transport and allow prooxidants, such as metal ions, to flow from the aqueous phase to the interface, where they can interact with lipids and cause lipid oxidation. On the other hand, the delivery emulsion's (Des) ability to have a lower viscosity could be advantageous for the manufacturing of less viscous but still physically stable food products like soups and salad dressings (Yesiltas *et al*., 2021). As a result, the condiments used to make the mayonnaise that is locally consumed in Nsukka have an impact on the composition and viscosity of the dish. As correctly noted by Nidhal *et al*. (2022), who reported that reduced-fat mayonnaise with additional pumpkin flour had an average viscosity rise. He claimed that reduced-fat mayonnaise with additional pumpkin flour had an average viscosity value that ranged from 3985 to 4443 cP. Reduced-fat mayonnaise may become more viscous if pumpkin flour is added. The viscosity ranged from 4443 cP at P3 treatment to 3985 cP at P0. Due to the addition of pumpkin flour, the viscosity of the reduced-fat mayonnaise increased. Hence, the usage of egg yolk as an emulsifier, vinegar as a dispersion media, oil as a dispersed medium, and stabiliser are elements that affect viscosity. The viscosity of the emulsion system depends on how much vegetable oil is utilized. Vegetable oils of various sorts were used, and this led to variations in viscosity that ranged from 3700 to 5513 cP (Nidhal *et al.,* 2022).

With a methyl group at one end and a carboxyl group at the other, fatty acids are hydrocarbon chains of varying length. Unsaturated fatty acids have more double bonds than saturated fatty acids, which have no double bonds in the acyl chain (Gramlich *et al*., 2019). The three types of fatty acids are saturated, monounsaturated, and polyunsaturated. Fatty acids are a class of volatile molecules like aldehydes and ketones that are produced via chemical processes like enzymatic and fat oxidation. Based on fatty acid reactions, the volatile molecules that make up fatty acids are made up of alcohol, aldehyde, and ketone (Nidhal *et al*., 2022). As indicated in Table 2, the analysis of the fatty acids discovered in some locally consumed mayonnaise in Nsukka revealed the presence of numerous saturated and unsaturated fatty acids in a range of amounts. The highest concentration of fatty acids across all the samples was -linoleic acid found in sample 2 (41.63 ± 0.57 %), sample 5 (41.63 ± 0.57 %) and sample 6 (41.66 ± 0.57 %) followed by sample 3 (40.52 ± 0.56%) and sample 4 (40.73 ± 0.56 %) respectively. However, moderate but varied concentrations of linolenic acid across all the samples were observed (Table 2). Thus, the most abundant unsaturated fatty acid is -linoleic acid present in all the samples. This has demonstrated that the mayonnaise consumed locally in Nsukka is a rich source of essential fatty acids (EFA), such as linoleic acid (LA; 18:2n-6, an n-6 fatty acid) and -linolenic acid (ALA; 18:3n-3, an n-3 fatty acid), which the human body is unable to produce and must therefore be consumed through diet. Because humans lack the desaturase enzymes necessary to catalyse double bond formation at the n-6 or n-3 position of the hydrocarbon chain (counting from the methyl carbon), these two polyunsaturated fatty acids, linoleic acid (LA; 18:2n-6, an n-6 fatty acid) and -linolenic acid (ALA; 18:3n-3, an n-3 fatty acid), cannot be synthesised by them. Hence, the two fatty acids are regarded as essential fatty acids (EFAs) because they can only be obtained through diet (Gramlich *et al*., 2019). According to the fatty acid profile, mayonnaise contains both saturated and unsaturated fatty acids. The quantity of fatty acids reveals the level of antioxidant activity in mayonnaise (Nidhal *et al*., 2022). Changes in fatty acid consumption can have a significant impact because they are crucial to so many physiological functions. It is not difficult to achieve these requirements under these typical circumstances because essential fatty acid deficit (EFAD) is prevented if 2%-4% of total energy comes from LA and 0.25%- 0.5% from ALA (Gramlich *et al*., 2019). As a result, EFAD will be uncommon among healthy kids and adults who eat a varied diet that includes mayonnaise in Nsukka and get enough EFAs.

Long-chain (LC) omega-3 (n-3) polyunsaturated fatty acids (PUFAs), such as eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3), have been linked to a variety of health advantages, including the preservation of normal brain, eyesight, and cardiac function (Hermunda *et al*., 2019; Yesiltas *et al*., 2020). As a result, the food industry makes foods like mayonnaise, milk, bread, and others that are fortified with omega-3 fatty acids. Yet, these omega-3 PUFA are extremely vulnerable to oxidation, and adding plain fish oil—which is high in EPA and DHA—to food products reduces their oxidative stability (Hermunda *et al.,* 2019).

Table 2: Fatty acid composition of some selected locally consumed mayonnaise in Nsukka

Fatty Acids	Sample 1(%)	Sample 2(%)	Sample 3(%)	Sample 4(%)	Sample 5(%)	Sample 6(%)
Lauric acid	14.35±0.60	15.45±0.57	15.55±0.57	14.81±0.56	15.45±0.57	14.82±0.55
Tetracosapentanoicacid	0.94±0.57	1.03±0.57	1.13±0.57	1.13±0.57	0.98±0.56	1.02±0.57
-Linoleic acid	42.36±0.57	41.63±0.57	40.52±0.56	40.73±0.56	41.63±0.57	41.66±0.57
Linolenic acid	10.49±0.57	13.83±0.57	11.83±0.57	11.84±0.57	12.81±0.56	13.73±0.57
Docosahexanoic acid	8.73±0.57	8.44±0.57	8.32±0.57	8.40±0.57	8.41±0.56	8.43±0.57
Myristic acid	0.67±0.057	0.67±0.05	0.69±0.05	0.67±0.05	0.67±0.05	0.67±0.05
Eicosadienoic acid	7.85±0.57	1.68±0.57	1.66±0.57	1.76±0.58	1.74±0.58	1.71±0.57
Oleic acid	6.13±0.57	8.68±0.57	8.61±0.57	8.66±0.55	5.51±0.57	8.43±0.52
Stearic acid	6.77±0.57	10.78±0.57	11.44±0.57	10.23±0.53	10.88±0.57	11.22±0.58
Docosapentanoic acid	4.62±0.57	4.47±0.57	4.45±0.57	4.45±0.57	4.51±0.56	4.47±0.57
Dihano- -Linolenic acid	1.06±0.57	0.89±0.05	0.91±0.57	0.93±0.57	0.91±0.57	0.89±0.57

Values are presented in mean ± standard deviation.

Table 3: Micronutrient composition of some selected locally consumed mayonnaise

Nutrients	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Copper (ppm)	0.08±0.00	0.06±0.00	0.06±0.00	0.06±0.00	0.06±0.00	0.06±0.00
Iron (ppm)	0.23±0.05	0.27±0.05	0.26±0.05	0.27±0.05	0.23±0.05	0.26±0.05
Zinc (ppm)	0.24±0.05	0.33±0.05	0.33±0.05	0.34±0.06	0.34±0.06	0.33±0.05
Manganese (ppm)	0.87±0.05	0.98±0.05	0.97±0.05	1.11±0.05	0.97±0.05	0.92±0.05
Vitamin A (mg/kg)	1.72±0.02	1.91±0.12	1.92±0.12	1.92±0.12	1.91±0.12	1.9±0.12
Vitamin C (mg/kg)	68.05±0.57	66.13±0.57	66.13±0.53	66.13±0.57	67.12±0.59	66.22±0.57
Vitamin D (mg/kg)	3.29±0.57	5.46±0.57	5.56±0.58	5.56±0.57	5.56±0.56	5.46±0.57
Vitamin E (mg/kg)	4.33±0.57	9.11±0.57	9.22±0.57	7.11±0.57	9.22±0.57	9.14±0.57
Vitamin K(mg/kg)	3.36±0.57	2.84±0.57	2.92±0.55	2.82±0.57	2.82±0.57	2.84±0.57

Values are presented in mean ± standard deviation.

The results in Table 3 demonstrate that the quantities of micronutrients in the various mayonnaise samples varied. The health effects of consuming various mayonnaise brands primarily depend on the unique roles played by the micronutrient makeup of each brand. According to various studies and research, the micronutrients present in these mayonnaise samples as shown in Table 3 be extremely beneficial for several biological processes, including (but not limited to): bone formation (Balenchia *et al.*, 2013), anti-oxidation processes (Sindab *et al.*, 2019), immunity (Bono *et al.*, 2016), potential cancer prevention activity (Lokman *et al.*, 2019; Diarrasouba *et al.*, 2015), vision propagation

(Carazo *et al.*, 2020), neuro-transmission and enzyme activation (Erikson *et al.*,2019), cell growth and development, neuro-generative and cognitive processes (Altarelli *et al.*, 2019), cell growth and development (Chasapis *et al.*, 2020).

Conclusion

Due to the quality of its physicochemical properties (acidity, PV, viscosity, boiling points etc.), the presence of a considerable amount of micronutrients (minerals and vitamins), and high-fat content, locally consumed mayonnaise in Nsukka can be considered a microbially stable product rich in essential nutrients with functional properties and can be stored at room temperature. However, more studies should be carried out on the risk of its quality loss due to the autoxidation of unsaturated fatty acids.

Declarations

Authors Contribution

Conceptualization: Chinelo Chinenye Nkwocha, Joshua Ogah Felix; resources: Chinelo Chinenye Nkwocha, Raphael Ekeanyanwu; **writing – original draft preparation:** Chinelo Chinenye Nkwocha, Joshua Ogah Felix, Raphael Ekeanyanwu; **results and interpretation:** Chinelo Chinenye Nkwocha, Joshua Ogah Felix, Raphael Ekeanyanwu; review and editing: Chinelo Chinenye Nkwocha, Joshua Ogah Felix, Raphael Ekeanyanwu; **statistical analyses** were done by Chinelo Chinenye Nkwocha; **supervision**: Chinelo Chinenye Nkwocha. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

Authors have declared no conflict of interest.

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Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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