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Comparative Study on the Fatty Acid Profile of Three Local Food Condiments (Dawadawa, Ogiri Igbo and Ogiri Okpei) Sold in Aba, Abia State, Nigeria

Nwanisobi Gloria Chinenye[1, *], Aghanwa Charles Ifeanyi[1], Odika Ifeoma Maryrose[1], Ezechi Chigozie Ejikeme[2], Okeke Chinelo Uzoma[2]

[1]Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka, Nigeria

[2]Department of Chemical Sciences, Godfrey Okoye University, Enugu, Nigeria

Email address:

gc.nwanisobi@unizik.edu.ng (N. G. Chinenye)

[*]Corresponding author

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Abstract: In today's society, the risk of cardiovascular disease is steadily rising. The fatty acid composition of three local fermented food condiments (dawadawa, ogiri igbo, and ogiri okpei) purchased from different markets in Aba, Nigeria, was studied using gas chromatography mass spectrometry (GCMS) in order to look for alternative natural fermented food condiments that are absorbed in the body without having many health implications. The fatty acid profiles revealed the presence of caproic acid in all condiments, with dawadawa (0.916%), ogiri igbo (0.767%) and ogiri okpei (6.167%). Linoelaidic acid was observed to be present in the dadwadawa (1.608%) and ogiri igbo (7.050%) condiments only, while oleic acid was present only in ogiri okpei (0.901%). Both ogiri igbo (2.939%) and ogiri okpei (1.419%) showed the presence of palmitoleic acid, while isovaleic acid was also observed to be present in both dawadawa (2.298%) and ogiri igbo (12.307%) condiments. Butanoic acid (35.779%), palmitic acid (4%) and 4-Methyloctanoic fatty acid (1.491%) were found only in the ogiri igbo condiments. The three native condiments were devoid of linoleic acid (omega-6 group) and alpha-linolenic acid (omega-3 group). The lipid profile of the three condiments differed significantly, with the ogiri igbo having a higher fatty acid content than the dawadawa and ogiri okpei.

Keywords: Dawadawa, Fatty Acids, Ogiri Igbo and Ogiri Okpei

1. Introduction

Food condiment market size is expected to grow at a compound annual growth rate of 6.18% from US$105.730 billion in 2019 to US$151.514 billion in 2025, according to the "Global Condiment Sauce Market Forecasts from 2020 to 2025" report [1]. According to a Statista Consumer Market Outlook - Segment Report, the Sauces & Condiments segment, volume is expected to amount to 67,685.3mkg by 2026, with an average volume per person in the Sauces & Condiments segment expected to amount to 7.7kg before the end of 2021 [2]. Imports of mixed condiments and mixed seasonings to Nigeria totalled $107 million in 2020, up from $77 million the previous year, indicating a 39% increase of $30 million in just one year [3].

Condiments (such as table dips and seasonings) are substances that are normally added in small amounts to enhance the flavor of food during cooking and/or eating [4]. They are also herbs that are used to complement foods, and they are usually added in larger quantities than spices, with no toxic effects on the human body [5]. Food condiments can be simple or complex ingredients used in the cooking process. Basic ingredients are condiments that are typically homogeneous in nature and are required for food preparation. Common examples include ingredients such as garlic, onion, pepper, salt, and others. Compound ingredients, on the other hand, are a mixture of two or more edible materials used to achieve a particular flavour. Available condiments include chilli sauce, chutney, horseradish sauce, meat sauce, mint

sauce, prepared mustard, soy sauce, sweet and sour sauce, tomato ketchup, and others [6].

Traditional methods of uncontrolled solid substrate fermentation result in extensive hydrolysis of the protein and carbohydrate components in food condiments, which have been reported to contain a variety of nutritional properties such as protein, fat, and a high calorific value [7]. Local African condiments, particularly those from Nigeria, have been shown to contain all of the natural nutritional components required in a food seasoning. Ogiri [8], bambara nut [9], and dried fermented locust bean and soyabean [10] condiments, for example, have high protein and fat content.

Food condiments made from vegetable proteins may be high in certain B vitamins, but they are low in ascorbate and some fat-soluble vitamins, which are lost during the fermentation process. The content of thiamine, riboflavin, and niacin in the African oil bean increases significantly after fermentation [11]. Furthermore, macroelements (K, Ca, Mg, and Na) and microelements (Fe and Zn) have been discovered in condiments [12]. Fats and oils, which are necessary for the growth of children and the maintenance of good health, have been widely used in condiments due to their physiological role in the nervous system, transportation of fat-soluble vitamins (vitamins A, D, E, and K), and other functions. These fats and oils are primarily made up of unsaturated fatty acids, which help to lower the risk of cardiovascular disease [13]. Lipids serve as electrical and thermal insulators, energy stores, and structural components of membranes in biological systems, and they play a role in the regulation of many cell functions as second messengers, hormones, and membrane receptors [14].

However, many people prefer international seasoning products like maggi cubes, which contain trans fats, which cause stroke and heart attacks by clogging arteries that supply sensitive organs like the brain and heart [15]. In addition, an increase in the intake of industrially produced Trans Fatty Acids (iTFA), which are abundant in vegetable oils, fried and baked foods, popcorn, chin-chin, bean cake, noodles, and plantain chips, has been linked to an increase in cases of heart attacks and sudden deaths in Nigeria and around the world [16]. Elaidic acid (trans-9 C18: 1) is one of the major TFAs, as are Octadecadienoic acid (trans-9), Linoelaidic acid (trans-12C18: 2), and 16-Dimethyldihydropyrene (trans-15). Foods containing hydrogenated oils have a higher TFA content than foods without hydrogenated oils [17].

Humans consume a wide range of fatty acids, which are found in their diets, bloodstreams, and cells and tissues. Fatty acids are both an energy source and a component of membranes. They have biological activities that affect the metabolism, function, and responsiveness of cells and tissues to hormonal and other signals. Regulation of membrane structure and function, regulation of intracellular signaling pathways, transcription factor activity, gene expression, and regulation of the production of bioactive lipid mediators are some of the biological activities [18]. Saturated fatty acids, like all other fats, play an important role in the body. On the other hand, the most important fats, on the other hand, are those that the body cannot produce and must therefore be obtained from food. These essential fatty acids (EFAs) are made up of linoleic acid (omega-6 group) and alpha-linolenic acid (omega-3 group) [19]. Omega-3 fatty acids have been linked to a lower risk of age-related macular degeneration (AMD) and vision loss, as well as coronary heart disease and rheumatoid arthritis. Their anti-inflammatory properties may also reduce the risk of Alzheimer's disease, dementia, depression, and asthma [20]. Prostaglandin formation, phospholipid membrane integrity, energy storage, and proper lamellar granule formation are just a few of the structural and synthetic functions of EFAs. They account for between 13% and 30% of the fatty acids in the skin [21]. Low fat intake can cause deficiencies in total energy and essential fatty acids (EFAs). Neurological (dementia, poor neurological development), visual, inflammatory, gastrointestinal (elevated hepatic enzymes), hematological (hemolytic anemia and thrombocytopenia), and endocrine system deficits are all symptoms of essential fatty acid deficiency. In addition, fatty acid (FFA) deficiency causes poor growth and development [22]. In a research, it was reported that the major fatty acids in cress and mustard were linolenic acid (48.43%) and erucic acid (29.81%), respectively [23]. The linoleic acid was the major fatty acid in black cumin, fenugreek, black pepper and clove oils at 68.07%, 34.85%, 33.03% and 44.73%, respectively. Total unsaturated fatty acids were 83.24, 95.62, 86.46, 92.99, 81.34 and 87.82% for cress, mustard, black cumin, fenugreek, black pepper and clove, respectively. Other fatty acids found in local African condiments include lauric acid, myristic acid, palmitoleic acid, palmitic acid, oleic acid, stearic acid, and lignoceric acid [24, 25]. Fatty acids such as caprylic, capric, lauric, myristic, palmitic, margaric, stearic, oleic linoleic and linolenic fatty acids were also found in fermented and non-fermented melon seeds (Citrullus vulgaris), a local African seasoning [26]. The presence of fatty acids in local food condiments, particularly essential fatty acids, contributes significantly to the overall nutritional value of the diet after cooking. Another point of view guides dietitians in determining which local condiments may contain some essential fatty acids, which will be an added bonus to the overall nutritional quality of food provided for people who have a deficiency or require daily availability of the fatty acids. The study's goal was to compare the fatty acid profiles of local African condiments like dawadawa, okpei, and ogiri obtained in Aba, Abia State, Nigeria in order to provide the necessary information on the availability of fatty acids, particularly essential ones, for improving the nutritional value of the total diet.

2. Material and Methods

2.1. Sample Collection

The three fermented food condiments samples were purchased from different food vendors in Aba, Abia state: ogiri-igbo from Castor seed Ricinus comminis, Dawa dawa from African locust bean (Parkia biglobosa), and Ogiri-Okpei from Prosopis Africana.

2.2. Fatty Acid Methyl Esters (FAME) Analysis

In a 50ml extraction beaker, 10g of fermented local African condiments (dawadawa, okpei, and ogiri) were transferred and a 1:1 20ml methanol and dichloromethane solution was added. The extract was allowed to settle after being thoroughly shaken for 5 minutes, after which 2g of anhydrous sodium sulphate was added to a filter paper during filtration to remove water content. The fatty acid methyl esters were measured using an Agilent 7890A GC System and a G3935A 240 Ion Trap GC/MS with a flame ionization detector and Agilent ChemStation software. As a carrier gas, nitrogen was used. The initial temperature of the column was 40°C, rising at a rate of 10°C per minute to a final temperature of 310°C, while the injection port and detector were kept at 270°C and 320°C, respectively. A non-polar (30m, 0.25 micrometre) capillary column (Agilent DB-5) was used for the separation of the esters [27].

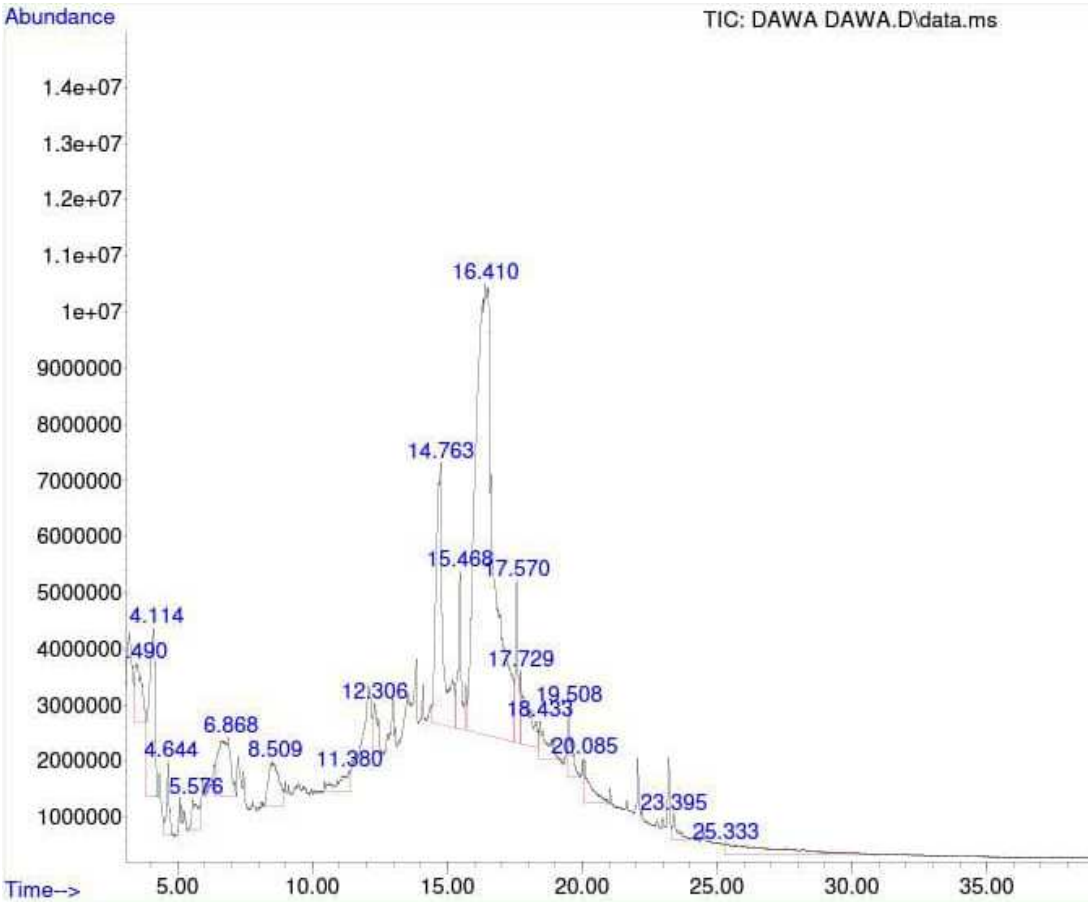

Figure 1. *Peaks of the chromatogram obtained from extract of fermented food condiment prepared from Parkia biglobosa.*

Table 1. *Result of Gas Chromatography-Mass Spectrometric analysis on fermented food condiment prepared from Parkia biglobosa.*

S/N	RT	COMPONENT	FORMULAR	MW	%
1	3.209	Hexanoic acid (Caproic acid)	$C_6H_{12}O_2$	116	0.916
2	3.490	Butanoic acid, 3-methyl- (Isovaleric acid)	$C_5H_{10}O_2$	102	2.298
3	4.114	Hexanamide	$C_6H_{13}NO$	115	6.091
4	4.326	Mannosamine	$C_6H_{13}NO_5$	179	0.730
5	4.644	L-Glucose	$C_6H_{12}O_6$	180	1.110
6	6.614	Diglycerol	$C_6H_{14}O_5$	166	2.995
7	6.868	5-Aminovaleric acid	$C_5H_{11}NO_2$	117	1.518
8	7.239	Propanedioic acid, phenyl-	$C_9H_8O_4$	180	0.692
9	8.509	10-Octadecenal	$C_{18}H_{34}O$	266	2.842
10	12.084	Limonen-6-ol, pivalate	$C_{15}H_{24}O_2$	236	4.738
11	12.306	Ethyl iso-allocholate	$C_{26}H_{44}O_5$	436	1.337
12	12.989	Dodecanoic acid, 3-hydroxy-	$C_{12}H_{24}O_3$	216	0.770
13	13.535	1-Hexadecanol, 2-methyl-	$C_{17}H_{36}O$	256	1.852
14	13.847	Cyclopropanedodecanoic acid, 2-octyl-, methyl ester	$C_{24}H_{46}O_2$	366	0.981
15	14.763	1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	$C_{21}H_{38}O_2$	322	9.307

S/N	RT	COMPONENT	FORMULAR	MW	%
16	15.176	Linoelaidic acid	$C_{18}H_{32}O_2$	280	1.608
17	15.468	1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	$C_{21}H_{38}O_2$	322	2.393
18	16.410	Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cyclopropyl]methyl]cyclopropyl]methyl]-methylester	$C_{25}H_{42}O_2$	374	47.675
19	17.570	7-Methyl-Z-tetradecen-1-ol acetate	$C_{17}H_{32}O_2$	268	2.308
20	17.729	1-Heptatriacotanol	$C_{37}H_{76}O$	536	1.545
21	18.846	Sulfuric acid, 5,8,11-heptadecatrienyl methyl ester	$C_{18}H_{32}O_3S$	328	0.840
22	19.508	1,3-Dioxocane, 2-pentadecyl-	$C_{21}H_{42}O_2$	326	1.847
23	20.085	Glutaric acid, tridec-2-yn-1-yl but-2-en-1-yl ester	$C_{22}H_{36}O_4$	364	1.618
24	22.060	2,6,10-trimethylundecanoic Acid, 2,2,2- trifluoroethyl ester	$C_{16}H_{29}F_3O_2$	310	1.256
25	23.209	Ethyl iso-allocholate	$C_{26}H_{44}O_5$	436	0.734

3. Results and Discussion

The GCMS chromatogram results revealed the presence of three fatty acids in the dawadawa condiments, as shown in Table 1 and Figure 1 above. Hexanoic and isovaleric acid, both saturated fatty acids, had percentage compositions of 0.916% and 2.298%, respectively, while lineolaidic acid, an unsaturated trans fatty acid, had a percentage composition of 1.608%. These results revealed the absence of saturated fatty acids such as myristic, palmitic, stearic, arachidic, and lignoceric fatty acids, as well as unsaturated fatty acids such as palmitoleic, oleic, and eicosenoic fatty acids, as reported [28] from local food fermented seeds obtained in Ghana. In dawadawa harvested in Auchi, Edo State, it was discovered to contain oleic, lauric, myristic, palmitic, and stearic fatty acids [29]. The absence of some essential fatty acids in the dawadawa samples could be due to the fermentation process used by the producer or the storage method used by the dawadawa seeds [30]. It would be premature to declare categorically that the condiment obtained from the sample site does not contain some of the reported fatty acids without taking into account the aforementioned factors.

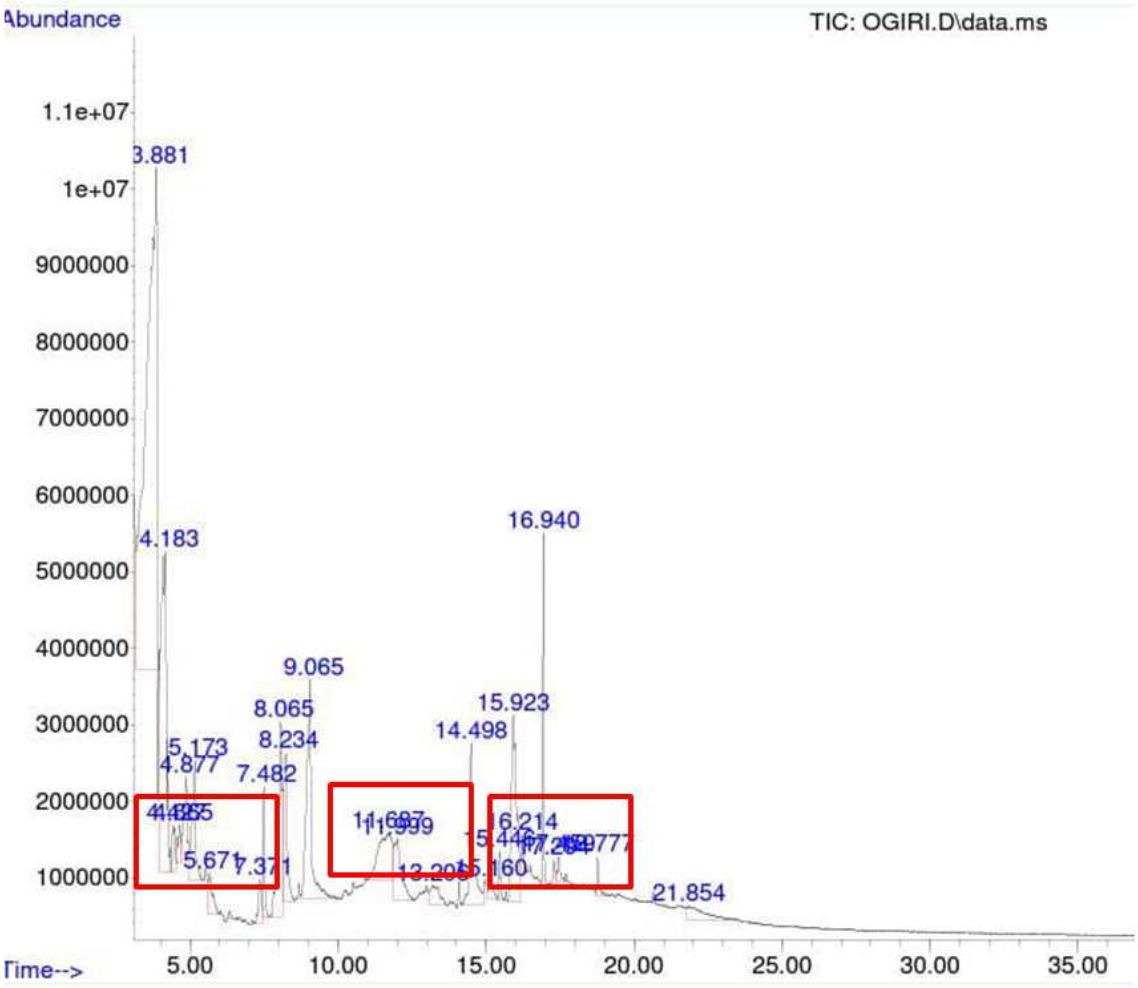

Figure 2. *Peaks of the chromatogram obtained from extract of fermented food condiment prepared from Ricinus comminis.*

Table 2. *Result of Gas Chromatography-Mass Spectrometric analysis on fermented food condiment prepared from Ricinus comminis.*

S/N	RT	COMPONENT	FORMULAR	MW	%
1	3.881	Butanoic acid	$C_4H_8O_2$	88	35.779
2	4.183	Butanoic acid, 3-methyl- (Isovaleric acid)	$C_5H_{10}O_2$	102	12.307
3	4.427	Phenol	C_6H_6O	94	0.893
4	4.665	Pentanoic acid, 4-methyl- (Isocarporic acid)	$C_6H_{12}O_2$	116	0.767
5	4.877	4-Methyloctanoic acid	$C_9H_{18}O_2$	158	1.491
6	5.173	Methenamine	$C_6H_{12}N_4$	140	3.086
7	5.671	Benzene, (isocyanomethyl)-	C_8H_7N	117	1.096
8	7.371	Benzenepropanoic acid, α-(hydroxyimino)-	$C_9H_9NO_3$	179	0.868
9	7.482	Benzeneacetic acid	$C_8H_8O_2$	136	1.314
10	8.065	Hydrocinnamic acid	$C_9H_{10}O_2$	150	4.433
11	8.234	3-O-Benzyl-d-glucose	$C_{13}H_{18}O_6$	270	3.711
12	9.065	L-Arginine, N2-[(phenylmethoxy)carbonyl]-	$C_{14}H_{20}N_4O_4$	308	7.181
13	11.687	N-Guanyl-l-tyrosine	$C_{10}H_{13}N_3O_3$	223	4.461
14	11.999	Desulphosinigrin	$C_{10}H_{17}NO_6S$	279	2.836
15	13.206	Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cyclopropyl]methyl] cyclopropyl]methyl]-methyl ester (1.290%)	$C_{25}H_{42}O_2$	374	1.290
16	14.498	n-Hexadecanoic acid (palmitic acid)	$C_{16}H_{32}O_2$	256	4.000
17	15.160	9-Octadecenoic acid, (2-phenyl-1,3-dioxolan-4-yl)methyl ester, trans-	$C_{28}H_{44}O_4$	444	0.475
18	15.446	1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	$C_{21}H_{38}O_2$	322	0.549
19	15.923	9,12-Octadecadienoic acid (Z,Z)- (Linoeladic acid)	$C_{18}H_{32}O_2$	280	7.050
20	16.214	Methyl 12-hydroxy-9-octadecenoate	$C_{19}H_{36}O_3$	312	0.441
21	16.940	9-Hexadecenoic acid (Palmitoleic acid)	$C_{16}H_{30}O_2$	254	2.939
22	17.294	Oxiraneoctanoic acid, 3-octyl-, cis-	$C_{18}H_{34}O_3$	298	0.456
23	17.459	9-Octadecenamide, (Z)-	$C_{18}H_{35}NO$	281	0.432
24	18.777	9,10-Secocholesta-5,7,10(19)-triene-3,24,25-triol, (3β,5Z,7E)-	$C_{27}H_{44}O_3$	416	0.527
25	21.854	Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy-	$C_{30}H_{52}O_2$	444	1.620

According to the GCMS Chromatogram results, the castor seed condiment (Ogiri Igbo) contained seven fatty acids (table 2 and figure 2). The fatty acids found were butanoic acid (35.779 percent), isovaleric acid (12.307 percent), isocarproic acid (0.767%), 4-methyloctanoic acid (1.491%), palmitic acid (4%), linoeladic acid (7.050%), and palmitoelic acid (2.939%), with butanoic acid having the highest composition. Ricinoleic, oleic, linoleic, stearic, palmitic, and linolenic fatty acids were found in castor seed from India, China, Brazil, Ethiopia, Pakistan, Saudi Arabia, Nigeria, and Tanzania [31]. The authors also reported that castor seed oil from Nigeria, on the other hand, lacked linoleic, stearic, and linolenic fatty acids. This however appears to contradict a study [32], which found linoleic (0.5%), stearic (1.3%), and linolenic (7.5%) fatty acids in castor seed collected in Enugu State, Nigeria.

Table 3. *Result of Gas Chromatography-Mass Spectrometric analysis on fermented food condiment prepared from Prosopis Africana.*

S/N	RT	COMPONENT	FORMULAR	MW	%
1	3.574	N-Acetylethylenediamine	$C_4H_{10}N_2O$	102	0.643
2	3.934	Emylcamate	$C_7H_{15}NO_2$	145	1.641
3	4.009	Dimethyl trisulfide	$C_2H_6S_3$	126	1.064
4	4.268	Hexanoic acid (Caproic acid)	$C_6H_{12}O_2$	116	6.167
5	5.062	Phenyl-β-D-glucoside	$C_{12}H_{16}O_6$	256	0.777
6	5.915	1-Methyl-2-pyrrolidineethanol	$C_7H_{15}NO$	129	1.391
7	7.392	4-Aminobutanoic acid	$C_4H_9NO_2$	103	0.779
8	8.541	4,4-Ethylenedioxy-pentanenitrile	$C_7H_{11}NO_2$	141	1.002
9	9.431	S-[2-[2-Hydroxy-3-isopropoxypropylamino]ethyl]thiophosphate	$C_8H_{20}NO_5PS$	273	1.165
10	10.522	Benzenepropanoic acid, α-(hydroxyimino)-	C9H9NO3	179	0.756
11	11.390	Propanedioic acid, phenyl-	C9H8O4	180	1.310
12	11.486	Dithiocarbamate, S-methyl-, N-(2,3-dimethyl-4-oxo-2-pentyl)-	$C_9H_{17}NOS_2$	219	0.577
13	12.132	N-(1-Hydroxy-4-oxo-1-phenylperhydroquinolizin-3-yl)carbamic acid, benzyl ester	$C_{23}H_{26}N_2O_4$	394	0.550
14	12.460	12,15-Octadecadiynoic acid, methyl ester	$C_{19}H_{30}O_2$	290	1.489
15	14.790	Deoxyspergualin	$C_{17}H_{37}N_7O_3$	387	9.663
16	15.468	Desulphosinigrin	$C_{10}H_{17}NO_6S$	279	1.743
17	15.748	10-Octadecenal	$C_{18}H_{34}O$	266	2.326
18	16.421	Melezitose	$C_{18}H_{32}O_{16}$	504	51.182
19	17.554	Glycine, N-(N-glycyl-L-leucyl)-	$C_{10}H_{19}N_3O_4$	245	1.552
20	17.702	tert-Hexadecanethiol	$C_{16}H_{34}S$	258	3.803
21	19.995	Oxiraneoctanoic acid, 3-octyl-, cis-	$C_{18}H_{34}O_3$	298	3.145
22	22.060	9-Hexadecenoic acid (Palmitoleic acid)	$C_{16}H_{30}O_2$	254	1.419
23	23.225	Oleic Acid	$C_{18}H_{34}O_2$	282	0.901
24	23.395	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O_2$	280	3.344
25	28.203	Ursodeoxycholic acid	$C_{24}H_{40}O_4$	392	1.612

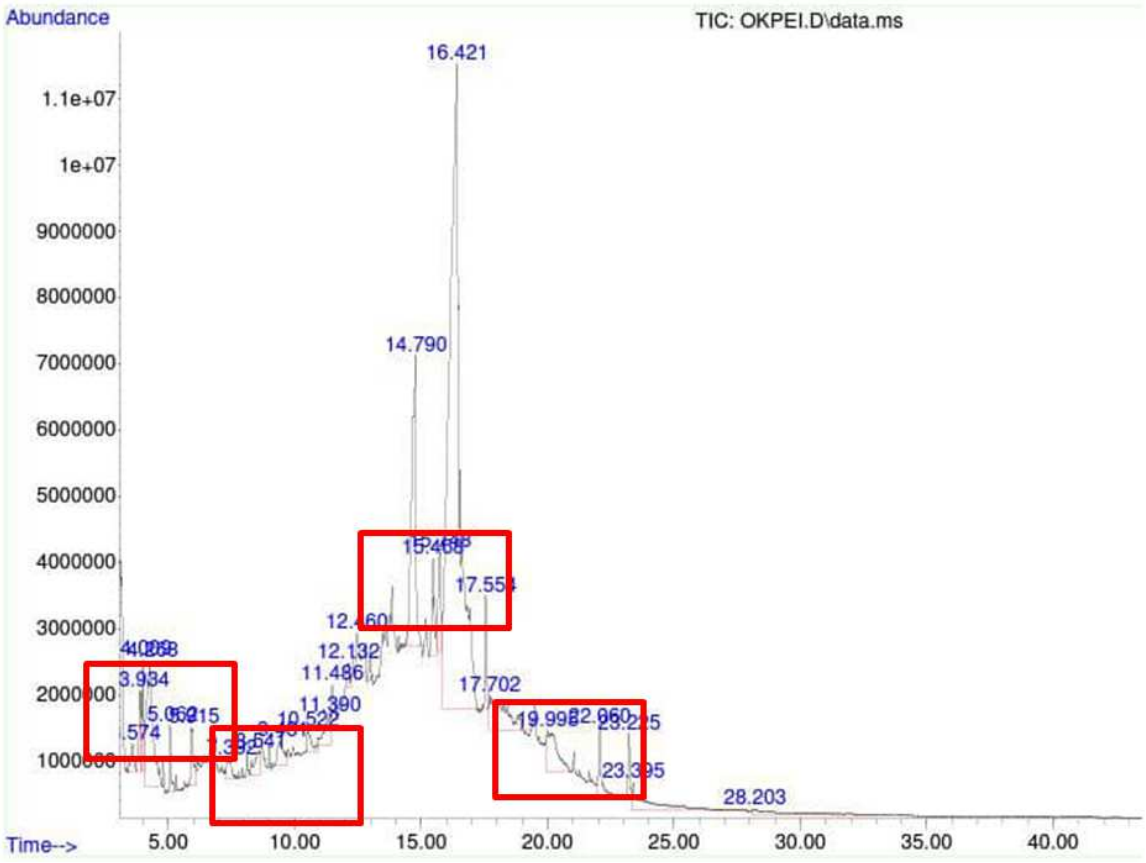

Figure 3. *Peaks of the chromatogram obtained from extract of fermented food condiment prepared from Prosopis Africana.*

The GCMS results revealed the presence of hexanoic acid (caproic acid), a saturated fatty acid, palmitoleic acid, and oleic acid, both mono unsaturated fatty acids, with percentage compositions of 1.419% and 0.901%, respectively, in the ogiri okpei condiment. The fatty acid content of the ogiri okpei was found to be extremely low. In Prosopis africana, which is used to make ogiri-okpei [33] we discovered stearic > arachidic > linolenic > linoleic fatty acids in the stated order. Omega-3 and omega-6 polyunsaturated fatty acids (PUFAs) appear to be the most important of these fatty acids, owing to their numerous biological functions, including influencing the inflammatory cascade, reducing oxidative stress, providing neuroprotection, and providing cardiovascular protection [34]. The human body, with the exception of two essential polyunsaturated fatty acids (PUFAs), can synthesize many of these fatty acids: linoleic acid (LA) and α-linolenic acid (ALA). These two are found in a variety of vegetable oils, but their metabolites are mostly found in fish oil. Linoleic acid is nature's most abundant fatty acid and the precursor to other omega-6 fatty acids. -Linolenic acid is used to produce omega-3 fatty acids [35]. This essential fatty acid was discovered in the condiments dawadawa and ogiri igbo, but not in ogiri okpei. The absence of some essential polyunsaturated fatty acids (PUFAs) such as stearidonic acid (SDA; 18:4-3), eicosapentaenoic acid (EPA; 20:5–3), docosapentaenoic acid (DPA; 22:5–3), and docosahexaenoic acid (DHA; 22:6-3), which were observed to be absent in the three food condiments [36]. The fatty acids caproic and isocaproic were found in all three condiments (Figures 1-3). Caproic acid can be used directly as a feed additive, antimicrobial, plant growth promoter, and a precursor to a variety of commodities such as lubricants, fragrances, paint additives, and pharmaceuticals [37].

Only the dawadawa and ogiri igbo condiments were found to contain isovaleic acid. Isovaleic acid has been shown to protect against cancer, inflammation, and a variety of metabolic disorders in vitro, though there haven't been many human studies to date [38]. According to one animal study, Isovaleric acid, on the other hand, activates protein kinase A (PKA) signalling in the colon, resulting in smooth colon muscle cell relaxation. This suggests that branched chain fatty acids, which isovaleic is part of, are involved in colon health and motility [39]. Insulin sensitivity, cholesterol metabolism, and hemostasis have all been shown to benefit from palmitoleic acid. Palmitoleic acid has been proposed to prevent beta-cell apoptosis caused by glucose or saturated fatty acids [40]. Palmitic acid (16:0) is the most abundant saturated fatty acid in the human body, and it can be obtained from food or synthesized in the body from other fatty acids, carbohydrates, and amino acids [41]. The fatty acid was discovered to only be present in ogiri igbo condiments. The properties of oils from various sources are largely determined by their compositions, and no single oil can be used for all purposes [42]. The presence of some essential fatty acids required for proper human system functioning can be seen in the fatty acid composition of the three food condiments.

Although it was observed that the presence of some other essential fatty acids such as stearic, lauric, mystic acid, and others in soil from African bean locust and shea nut oil is used in local food condiments [29].

4. Conclusion

The fatty acid profiles of the three condiments revealed that only a few fatty acids were present, as well as the absence of some essential fatty acids required by the human body. The lipid profile of the three condiments differed significantly, with the ogiri igbo having a higher fatty acid content than the dawadawa and ogiri okpei. Local fermented condiments play an important role in enhancing nutritional value in the human system as well as spicing up meals. Because there has been little research on the fatty acid composition of local fermented condiments in Nigeria, this study will serve as a baseline source of fatty acid information, especially on essential fatty acids in local food condiments prepared and sold in the country.

Conflict of Interest

The authors declare that they have no competing interests.

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