CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage, **http,//chimie-biologie.ubm.ro/carpathian_journal/index.html**

EFFECT FERMENTATION ON VOLATILE COMPOUNDS OF PACKAGED CASTOR OIL -MORINGA SEEDS CONDIMENT (*OGIRI*)

Chinyere Nkemakonam Onyekwelu [1] and Eunice Osinachi Uzodinma[2]

[1]Department of Food Technology, Federal Polytechnic Oko, A nambra state
[2]Department of Food Science and Technology, University of Nigeria Nsukka Enugu State
✉*chykems@gmail.com*

https://doi.org/10.34302/crpjfst/2022.14.3.12

Article history,
Received,
20 February 2022
Accepted,
25 August 2022
Published
September 2022

Keywords,
Castor oil seeds;
Moringa seeds;
Fermented condiments;
Packaging;
Volatile compounds.

ABSTRACT
The effect of fermentation on volatile compounds of packaged castor-moringa seeds condiment (*ogiri*) was investigated. Blends of castor oil seeds and moringa seeds were used to produce fermented condiment (*Ogiri'*). A 100% castor *ogiri* (MC_{100}) and 100% moringa *ogiri* (MM_{100}) that served as control were packed in *uma l*eaves and fermented for 48 h. Castor and moringa *ogiri* were blended in ratio 86. 21:13.29, fermented in different fermentation times (46.81 h, 51.99 h, 51.64h and 47.52 h) and packaged in *Uma* leaves, aluminum foil, aluminum foil and plastic containers designated as MMC, FMC, FMC_{64} and Plastic container. The volatile compound of packaged fermented castor- moringa seeds (*ogiri)* were evaluated using Gas –Chromatography / Mass Spectrometry (GC-MS). The result of amino acids showed that only eighteen amino- acids were detected. A total of 162 volatile compounds were identified in packaged castor – moringa *ogiri*. The compound identified were various types of acids, ester, hydrocarbons, aromatic compounds, alcohol, ketones, aldehydes, sterols, among others. The predominant volatile compound found in packaged fermented castor- moringa seeds *were* acids followed by esters. Samples FMC_{64} (86.21: 13. 29 fermented for 51. 64 h) had higher concentration in hydrocarbon (11.52%), ketones (2.40 %), sterols (15.31%) and vitamins (7.48 %.) than other samples..

1. Introduction

Fermented condiments are consumable substances added in small quantities to add flavor, taste, some nutrients and relish to the main food produced from leguminous plant or oil seeds. These fermented condiments include “ogiri” from castor-oil seeds (*Ricinus commumis*), “dawadawa” from African yam beans (*Parkia biglobosa*) and “Ugba” African oil bean (*Pentaclethra macrophyllia*). According to Kalopo *et al.* (2009*)* fermented condiment provided dietary fibre, energy, mineral and vitamins (vitamin A and vitamin B_2). It also has potential uses as protein substitutes and functional ingredients (Achi, 2005). Nigerians spent about $12 million on food flavoring imports between 1983 and 1998, with a projected 15 % annual increase in the future (Essien, 1983; Odunfa and Oyewole, 1998). This emphasizes the importance of fermented vegetable proteins, which have a lot of potential as key protein and micronutrient sources, as well as basic ingredients for dietary supplementation. Most of indigenous condiments are produced through the process of fermentation. Fermentation actually hold a promise as a food processing methods that can be used to diversify the food uses of some under exploit plant food like moringa *olerferia*, among other locally available oil seeds.

Castor oil bean (*Ricinus communis*) is a member of the spurge family, *Euphorbiaceae*. The protein of castor oil seed contains ricin and ricinoleic which are toxic substances; nevertheless, the level is reduced or eliminated during fermentation (Odunfa, 1985). According to Annongu and Joseph, (2008), castor seed is deficient in some indispensable essential amino acids such as lysine, iso-leucine and tryptophan is absent.

Moringa Oleifera Lam belongs to the *Moringaceae genus*, which has fourteen species (Morton, 1991). It is native to the Indian subcontinent, but it has spread throughout the world, including to Nigeria. Ram (1994) and Anhwange *et al.* (2004) indicated that moringa seeds contain all the essential amino acids "lysine, cystine, valine, methionine, isoleucine, leucine, phenylalanine and threonine" in appreciable quantities. These essential amino acids are often in short supply in most legumes and oil seeds. There is need to supplementation of fermented condiment (*ogiri*) with oil seeds that rich in sulphur containing amino acid like moringa seed (Ram, 1994, Gueguen *et al.*, 2016).

Ogiri and other fermented condiment have a very short shelf life, ineffective and unattractive packaging materials that resulted in stickiness and the characteristic putrid odour have caused instability in the commercial status of this traditional condiment (Arogba *et al.*, 1995), thus the need to research how to find good packaging materials that will protect, maintain it in good condition, and preserve the flavor until it reaches consumers in perfect freshness, flavour, appeal, and appearance.

Volatile profile of fermented castor oil bean was investigated by Ojinnaka and Ojimelukwe, (2013), the compounds identified were ester, alcohol, ketones, furan acids and others. Chukeatirote *et al.*, (2017*)* studies the volatile compounds in fermented soybeans prepared by a co-culture of *bacillus substilis and rhizopus oligosporus*, a total of 165 volatile compounds were identified including "alcohol, aldehydes aromatic, ketones, acids, ester, pyrazine, sulphur- containing and miscellaneous". There is little or no information on study of amino acids and volatile compounds of packaged castor – moringa *ogiri.* This present study aims at evaluating effect of fermentation on amino acids and volatile profile of packaged castor moringa *ogiri*

2. Materials and Methods

2.1. Materials

Castor oil seeds were procured from Nwko-- Igboukwu market in Aguata L.G.A in Anambra state and Moringa seeds were purchased from central market Kaduna in Kaduna State. The aluminium foil and plastic container were purchased from Eke –Ekwulobia. An *uma* leaves was also procured from "Amudo" village in Ekwulobia.

2.2. Methods

2.2.1. Traditional processing of fermented castor oil seed "ogiri"

The castor oil seed ogiri was produced according to method described by (Odunfa 1985). The castor oil seeds (1.5 kg) were dehullled mechanically, washed and boiled for 8 h in 9 litres of water. The boiled castor oil seed was fermented for 96 h by natural fermentation. Fermented castor oil seeds were mashed into paste. Subsequently, the paste was distributed into the various packaging materials which comprises of *Uma* leaves, aluminum foil, and plastic containers and was allowed to stand for secondary fermentation and flavor maturation for 48 h.

2.2.2. Traditional processing of fermented moringa seed "ogiri"

The method of Onyekwelu (2016) was adapted to production of fermented moringa seed *ogiri.* Moringa seeds (1.5 kg) were dehullled manually, boiled for 3 h after being washed. The boiled moringa seeds were fermented for 96 h by natural fermentation. Fermented moringa seeds were mashed into paste. Subsequently, the paste was distributed into the various packaging materials which comprises of *uma* leaves, aluminum foil and plastic container and was allowed to stand for secondary fermentation and flavor maturation for 48 h.

2.2.3. Formulation

Castor oil seeds and moringa seeds *ogiri were* blended in ratio, packaging and fermented in different fermentation time in as shown in Table 1 below.

Table 1. Formulation of castor *ogiri* and moringa *ogiri*

Castor seeds *ogiri*	Moringa seed *ogiri*	Packaging	Fermentation time (h)
100		*Uma leaf*	48
	100	*Uma leaf*	48
86.21	13.29	*Uma leaf*	46.8
86.21	13.29	*Foil*	51.99
86.21	13.29	*Foil*	51.64
86,21	13.29	*Plastic*	47.53

2.2.4. Packaging of castor- moringa seeds ogiri

After the primary fermentation, each design points of castor- moringa *ogiri* were distributed in packaging materials comprises *uma* leaves, Aluminum foils and plastic container and kept for further analysis.

2.2.5. Determination of volatile compound profiles

The volatile compounds of Castor – moringa ogiri were determined using gas chromatography/mass spectrometry (GC-MS) analysis. On a Perkin Elmer GC Clarus 500 system with an AOC-20i auto sampler and a gas chromatograph interfaced to a mass spectrometer (GC-MS) apparatus, the following settings were employed to carry out GC-MS analysis, "column Elite-1 fused silica capillary column (30 x 0.25 mm ID x 1 μM df, composed of 100 % Dimethylpolysiloxane), operating in electron impact mode at 70 eV; helium (99.999%) was used as carrier gas at a constant flow of 1 ml /min and an injection volume of 0.5 μI was employed (split ratio of 10,1) injector temperature 250 ºC; ion-source temperature 280 ºC". The oven temperature was set to 110 °C (isothermal for 2 minutes), then increased at a rate of 10°C/min to 200 °C, then 5ıC/min to 280 °C, with a final time of 9 minutes (isothermal at 280 °C). Mass spectra was taken at 70 eV; a scan interval of 0.5 seconds and fragments from 40 to 450 Da. Total GC running time of 36min.

3. Results and discussion

3.1. Percentage composition of volatile compounds of packaged castor moringa *ogiri*

Percentage composition of volatile compounds of packaged castor moringa *ogiri is shown in T*able 2. These volatile compounds are of various type such as acids, ester, hydrocarbon, aromatic compounds, alcohol, indole, ketones, aldehydes, sterols, vitamin and others were identified in packaged castor - moringa *ogiri* acids. Sample MM_{100} had the highest percent **of** acids (91.16%) while sample FMC_{64} had the lowest percentage (1.42 %) of acids. Acids, hydrocarbon, vitamins and Miscellaneous compounds were found present in packaged fermented castor moringa seeds while hydrocarbon and miscellaneous compounds were absent in 100% fermented castor and moringa seeds packed in *uma* leaves

3.2.Identified volatile compounds in packaged fermented castor- moringa seeds (*ogiri*)

The list of the identified compounds and their molecular formula, molecular mass, retention time and percentage concentration of fermented castor- moringa seeds (*ogiri)* packed in different packaging materials are shown in Table 3. The spectrum reveals that 22, 29,38,26,28 and 19 volatile compound were identified in sample MC_{100}, MM_{100}, FMC, MMC FMC_{64} and PMC respectively. Sample PMC had the highest concentration of oleic acid (60.87%) followed by sample MC_{100} (53.32%) while samples MM_{100} and FMC had the lowest concentration of oleic acids 2.70% and 0.70%. Oleic acids were the most abundant compound in samples PMC (60.87%), MC_{100} (53.37%) and FMC (49.92%). In this study acids were most dominant compounds. This was in agreement with Ojinnaka and Ojimelukwe (2013) who found acids to be most dominant volatile compound in fermented castor oil seed. Azokpota *et al.* (2008) found pyrazines to be the major constituent in sonru, aftin, and iru, which contradicts this report. Aldehydes in locust beans *daddawa*, soyabean and melon seeds o*giri*

(Onyenekwe *et al.*, 2012). Adebiyi *et al* (2021) found esters to major constituent in *daddawa* bambara groundnut. According Larcoche *et al* (1999) some acids were synthesis through leucine and isoleucine. Although acids give fermented foods some acidic, fruity, and sour tastes, (Park *et al.*,2013), they have been reported to be undesirable compounds that give unpleasant characteristics such as rancid, sweaty, and pungent flavor (Frauendorfer and Schieberle, 2008).

Table 2.Percentage Composition of Volatile Compounds of Packaged Castor- Moring *ogiri*

Volatile Compound group	MC_{100} (%)	MM_{100} (%)	FMC (%)	MMC (%)	FMC_{64} (%)	PMC (%)
Acids	70.65	91.16	67.23	51.77	1.42	77.26
Esters	3.45	4.21	4.86	0.62	3.20	-
Hydrocarbon	4.67	0.10	3.06	3.71	11.52	5.57
Aromatic	-	0.10	-	4.41	0.41	-
Alcohol	-	0.52	-	-	-	0.36
Indole	-	-	5.29	6.89	-	-
Ketones	-	0.25	1.03	1.12	2.40	1.10
Aldehydes	-	0.65	4.56	1.05	1.01	1.80
Sterols	-	1.0	4.07	2.31	15.31	1.10
Vitamins	2.98	0.28	2.84	2.60	7.48	4.04
Others (Miscellaneous compounds)	10.86	2.41	13.60	25.89	22.22	9.06

Key :
MC100= 100% castor *ogiri* package with Uma leaves fermented for 48 h, MM100= Moringa *ogiri* packaged with Uma leaves fermented for 48 h, MMC = 86.21% castorogiri, 13.29 % moringa *ogiri* packed in uma leaves fermented for 46.81 h, FMC = 86.21% castor *ogiri*, 13.29 % moringa *ogiri* packed in aluminum foil fermented for 51.99 h. FMC64 = 86.21% castor *ogiri*, 13.29 % moringa *ogiri* packed in aluminum foil fermented for 51.64h, PMC = 86.21% castor *ogiri*, 13.29 % moringa ogiri packed in plastic container fermented for 47.52 h.

Ester was another major abundant compound in castor – moringa *ogiri* packed in different packaging materials. The most abundant esters were found to be ricinoleic acids methyl ester in sample MC_{100} with concentration of 3.45 %, other esters were octadecenoic acids, ethyl ester, 9, 12 - octadecadienoic acids, ethyl ester and oleyl oleate detected in samples MM_{100}, FMC_{64} and MM_{100}. During fermentation, esters are mostly formed when alcohol is esterified with fatty acids (Sluis *et al.*, 2011). Esters are also produced from chemical reaction between microbial acids and alcohol metabolites (Wittanalai *et al.*,2011), this reaction is catalysed by microbial esterase during fermentation (Eskin, 1990). When compared to their alcohol precursors, esters with few carbon atoms are extremely volatile at room temperature and have a lower perception threshold (Izco and Torre, 2000; Nogueira *et al.*, 2005). It has a fruity floral flavor to it. The sharpness of unpleasant free fatty acids can be reduced or marked by ester. Therefore, esters must have contributed to the flavour of the product.

Table 3. Identified Volatile Compounds in Packaged Fermented Castor- Moringa Seeds (*ogiri*)

Peak	RT (min)	Compound Names	Formula	Molecular MASS	MC_{100}	MM_{100}	FMC	MMC	FMC_{64}	PMC
		Acids								
1	18.792	Oleic acid	$C_{18}H_{34}O_2$	282	53.37	2.70	49.92	39.97	0.70	60.87
2	19.171	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256	4.76	10.95	5.29	4.97	0.72	5.46
3	21.225	9, 12-Octadecadienoic acid	$C_{18}H_{32}O_2$	280	-	-	-	-		O.37
4	21.615	Octadecanoic acid	$C_{18}H_{36}O_2$	284	6.68	10.95	5.60	4.65	-	7.14
5	22.675	trans-delta-9 octadecenoic acid	$C_{18}H_{34}O_2$	282	-	63.96	1.52	-	-	0.80
6	23.391	Ricinoleic acid	$C_{18}H_{34}O_3$	298	5.84	0.14	4.90	2.18	-	2.62
7	23.730	Arachic acid	$C_{20}H_{40}O_2$	312	-	2.56	-	-	-	-
		Esters								
1	20.780	Hexadecanoic acid, propyl ester	$C_{19}H_{38}O_2$	298	-	-	0.12	-	-	-
2	20.858	9-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	-	0.10	0.13	-	-	-
3	21.566	Linoleic acid, ethyl ester	$C_{20}H_{36}O_2$	308	-	-	0.35	-	-	-
4	21.710	oleic acid, ethyl ester	$C_{20}H_{36}O_2$	3.10	-	-	0.85			
5	21.956	Octadecanonic acid ethyl ester	$C_{20}H_{40}O_2$	312		1.41	0.25			
6	22.674	Glyceryl Monooleate	$C_{21}H_{40}O_4$	356				0.62		
7	22.955	Ricinoleic acid, methyl ester	$C_{19}H_{36}O_3$	312	3.45	-	0.56			
8	23.581	9,12-Octadecadienoic acid , methyl ester	$C_{19}H_{34}O_2$	294	-	-	-	-	2.99	-
9	24.485	10-Undecenoic acid, butyl ester	$C_{15}H_{28}O_2$	240	-	-	-	-	0.21	-
10	24.820	Hexadecanoic acid, trimethylsilyl ester	$C_{19}H_{40}O_2Si$	328		0.10				
11	25.280	Oleyl oleate	$C_{36}H_{68}O_2$	532	-	1.38	-	-	-	-
12	26.134	Cinnamic acid, 2-bornyl ester	$C_{19}H_{24}O_2$	684	-	1.22	-	-	-	-
13	26.321	Heptanoic acid, octyl ester	$C_{15}H_{30}O_2$	242						

		Hydrocarbon								
1	3.595	2-pentene, 2-4 dimethyl	C_7H_{14}	96					0.43	
2	10.075	Tridecane	$C_{13}H_{28}$	184					1.20	
3	27.370	Squalene	$C_{30}H_{50}$	410	4.67	0.10	3.06	3.71	9.89	5.57
		Aromatic compounds								
1	3.795	Phenol	C_6H_6O	94				4.41	0.41	
2	27.754	Benzene, (1-methylnonadecyl)- (2-Phenyleicosane)	$C_{26}H_{46}$	358		0.10				
		Alcohol								
1	15.215	11-Tetradecen-1-ol, acetate,	$C_{16}H_{30}O_2$	254						0.36
2	24.186	Phytol	$C_{20}H_{40}O$	296		0.52				
		Indole								
1	9.985+	Indole	C_8H_7N	117			5.29	6.89		
		Ketones								
1	20.465	13-Hexyloxacyclotridec-10-en-2-one	$C_{18}H_{32}O_2$	280		0.22	1.03	1.12	2.40	1.10
2	26.192	1-Penten-3-one, 4,4-dimethyl-1-phenyl-	$C_{13}H_{16}O$	188		0.03				
		Aldehydes								
1	23.455	Cis-9-Hexadelenal	$C_{16}H_{30}O$	238			1.28			1.22
2	23.606	9-Tetradecenal, (Z)	$C_{14}H_{26}O$	210		0.65	3.13			
3	24.675	Cis- 13-Octadecenal	$C_{18}H_{34}O$	266			0.15	1.05	1.01	0.58
		Sterol								
1	25.071	Stigmasterol	$C_{29}H_{48}O$	412		0.23	0.82	0.89	4.38	
2	26.590	Gamma-sitosterol	$C_{29}H_{50}O$	414		0.77	3.25	1.42	10.35	1.10
3	26.904	26-Hydroxycholesterol	$C_{18}H_{46}O_2$	402					0.58	

		Vitamins								
1	28.334	delta Tocopherol	$C_{27}H_{46}O_2$	402	1.11		1.12	1.07	3.01	1.54
2	29.167	Gamma Tocopherol	$C_{28}H_{48}O_2$	416	1.87		1.72	1.53	4.47	2.50
3		Vitamin E (2H-1-Benzopyran-6-ol, 3,4-dihydro-)	$C_{29}H_{50}O_2$	430		0.28				
		Others (miscellaneous compound)								
1	7.692	2-piperidinone	C_5H_9NO	99			1.13			
2	9.870	Benzeneethanamine, N-(1-methylethylidene)-	$C_{11}H_{15}N$	161			3.06	10.56		2.50
3	20.461	Cyclooctasiloxane, hexadecamethyl-	$C_{16}H_{48}O_8Si_9$	596	0.49					
4	21.767	Octadecanamide	$C_{18}H_{34}NO$	283					1.61	
5	21.801	Silane, (cyclohexyloxy) trimethyl-	$C_9H_{20}OSi$	172	3.31		3.23	2.80		3.43
6	22.049	Cyclononasiloxane, octadecamethyl-	$C_{18}H_{34}O_9Si_9$	666	4.23		0.30		3.19	
7	23.005	2-Palmitoylglycerol,2trimetlylsilyl ether	$C_{25}H_{54}O_4Si_2$	474			0.14			
8	23.630	Palmitoyl chloride	$C_{16}H_{31}ClO$	274		0.32				
9	23.659	9-Octadecenamide	$C_{18}H_{35}NO$	281			5.32	6.44	15.73	3.13
10	24.670	1,3-Dipalmitin trimethylsilyl ether	$C_{38}H_{76}O_5S_i$	640		0.14				
11	25.170	Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	290			0.10		0.83	
12	25.521	Dodecanamide, N,N-diethyl-	$C_{16}H_{33}NO$	255			0.73	3.84		
13	26.260	Octadec-9Z-enol trimethylsilyl ether	$C_{21}H_{44}OS_1$	340		0.82				
14	26.385	Acetamide,N,N-dioctyl-	$C_{18}H_{37}NO$	283			0.19			
15	27.821	N-Hexadecylacetamide	$C_{18}H_{37}O$	283			0.51	2.25	0.86	

Key: MC100= 100% castor ogiri package with *Uma* leaves .fermented for 48 h, MM100= Moringa ogiri packaged with *Uma* leaves fermented for 48 h, MMC = 86.21% castor ogiri, 13.29 % moringa ogiri packed in *uma* leaves fermented for 46.81 h, FMC = 86.21% casto rogiri, 13.29 % moringa ogiri packed in aluminum foil fermented for 51.99 h. FMC64 = 86.21% castor ogiri, 13.29 % moringa ogiri packed in aluminum foil fermented for 51.64h, PMC = 86.21% castor ogiri, 13.29 % moringa ogiri packed in plastic container fermented for 47.52 h

Two volatile compounds were detected as ketones in castor – moringa *ogiri* packed in different packaging materials, which are 13-Hexyloxacyclotridec-10-en-2-one and 1-Penten-3-one, 4,4-dimethyl-1-phenyl-. Sample FMC_{64} had highest concentration of 13-Hexyloxacyclotridec-10-en-2-one (2.40%). This ketone is found present in sample MM_{100}, FMC, MMC and PMC. Ketone was not detected in sample MC_{100} (100% castor *ogiri* packed in *uma* leaves). 1-Penten-3-one, 4,4-dimethyl-1-phenyl- was found present in sample MM_{100} This may be as a result of the longer fermentation and effect of packaging materials. "The high concentration of ketone in sample FMC_{64} might be due to partial oxidation of the alcohols as well as synthesis through several metabolic pathways, especially reduction of methyl ketone" (Curioni and Bosset, 2002; Akkad *et al.*, 2019). This is contradicting the report of Ojinnaka and Ojimelukwe (2013) that identified oxacyclotetradecan-2-one in fermented castor seed with 3 % lime. Ketones are derived from the breakdown of amino acids and lipids, with the presence of compounds that affect food flavor (Adebo *et al*., 2018). Ketones contribute to flavour of castor- moringa *ogiri.*

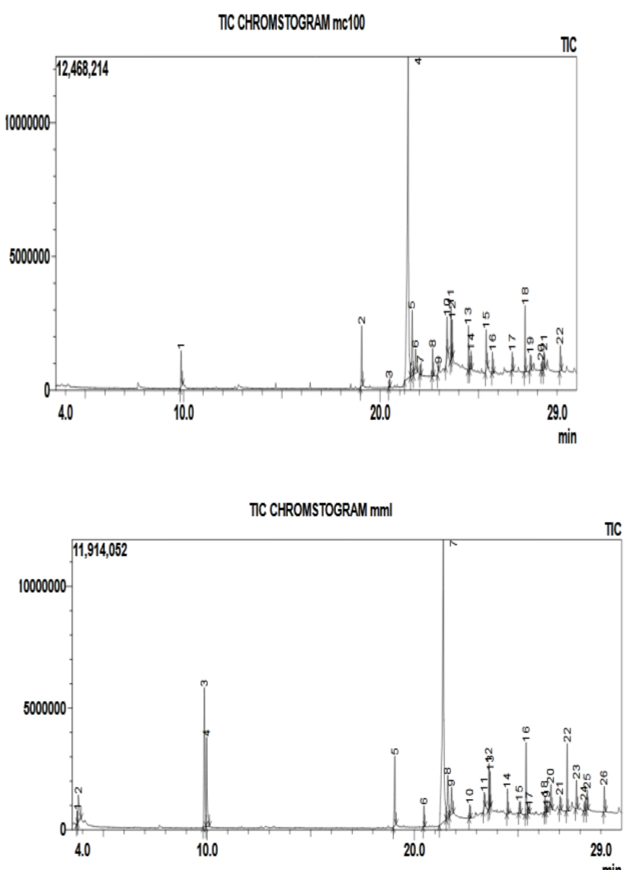
Alcohol identified in castor –moringa *ogiri* were 11-Tetradecen-1-ol, acetate, and phytol in samples PMC and MM_{100} but absent in other samples. Reduction of corresponding aldehydes and oxidation of acids were used to produce alcohols (Pham *et al*.,2008). Aldehydes and ketones are relatively unstable intermediate compounds that can be easily reduced to alcohol, according to Estrella *et al*., (2004). Low concentration of alcohol in fermented condiments possibly as a result of the thermal treatment used during processing (Cho *et al.*,2017; Wang *et al.,* 2019) alcohol present in fermented condiment help to prevent this condiment from spoilage, this is known to acts as antifungal and prevent food spoilage (Onyenekwe *et al.,* 2012). Alcohol related compound could be contributed to the aroma of castor – moringa *ogiri.*

The aldehydes detected in castor- moringa *ogiri* packed in different packaging materials were cis-9-hexadecenal, 9-Tetradecenal and cis-13-Octadecenal found present in almost all samples but absent in sample MC_{100} (100% castor *ogiri* packed in *uma* leaves). Similar trends were reported by Ojinnaka and Ojimelukwe (2013) that aldehdyes was not detected in castor seed ogiri. The presence of aldehydes may be due to presence of moringa *ogiri* present in samples.

The oxidation of fatty acids, as well as oxidation catalyzed by lipoxygenases and hypo-oxidase enzymes, produces aldehydes, which are important flavor compounds (Nzigamasabo, 2012). Aldehydes are also known as a key component in the formation of heterocyclic compounds (Ziegleder, 2009). The presence of aldehydes in the fermented condiments is probable associated with variable factors such as Millard reaction, streckers degradation or microbial metabolism occurs during the fermentation.

Sterols are a group of compounds found in abundance in Sample FMC64.with highest concentration of stigmasterol (4.38 %) and gamma sitesterol (10.35 %). The 26-hydroxycholestrol was identified only in sample FMC_{64}. None of these Sterols was detected in sample MC_{100}. Sterols were detected in sample contain proportion of moringa ogiri. This is in agreement with Gupta *et al.* (2014) that found stigmasterol and β- sitosterol present in moringa seed, these sterol possess medicinal properties. Stigamsterol and β- sitosterol function as antioxidant, hypoglycemic, hyroid inhibiting properties and effective against cardiovascular disease anti-inflammatory and anti –diabetic properties among others (Kris *et al*., 2002, Singh, 2006; Jamal *et al.*,2008; Gupta *et al.*, 2014). Natural occurring plant cholesterol, according to Ogbe *et al.* (2015), may benefit animal and human health when taken as food supplements or organically in food on a regular basis for a suitable amount of time.

Vitamin –related compound was detected in all the samples of castor- moringa *ogiri.* delta tcopherol and gamma tocopherol were identified in samples $MC_{100,}$ FMC, MMC, FMC_{64} and PMC but found absent in sample MM_{100} (100 % moringa *ogiri* packed in *uma* leaves). Vitamin E (2H-1-Benzopyran-6-ol) was detected only in sample MM_{100}.Sample FMC_{64} had highest concentration in delta tocopherol (3.01 %) and gamma tocopherol (4.47 %). The highest concentration of vitamin in aluminum foil may be as result of aluminum is a good moisture and oxygen barrier therefore retard oxygen in the products (Ima *et al.*, 2016; Kubik and Zeman, 2014). This vitamin related compounds are nutritional and dietary important. It also acts as an antioxidant, preventing lipid peroxidation from spreading (Frei, 2004).



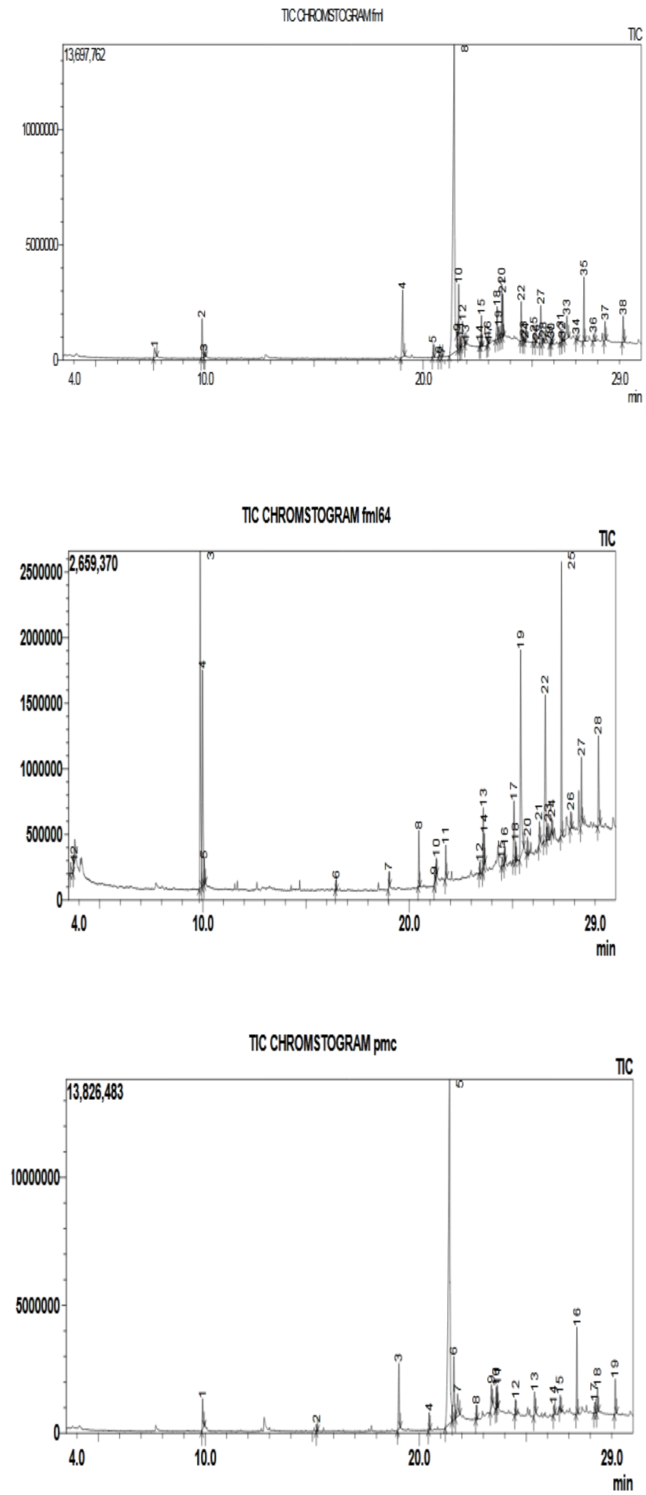


Figure 1. Chromatograms of the volatile compounds of packaged feremtned castor moringa seeds

Aromatic, hydrocarbon, and N- containing compounds were identified which found to be minor groups. Phenol was detected in sample

MMC and FMC_{64}. Adebiyi *et al.* (2021) identified phenol in *dawadawa* bambara groundut while Ojinnaka and Ojimelukwe (2013) found no phenol in fermented castor seed. Phenol is contected to benzene ring of phenol moiety. According to Koleva *et al*. (2018), phenols are a major class of antioxidants with significant biological and free radical scavenging properties.

Other volatile compounds identified were Benzeneethanamine, N-(1-methylethylidene)- and Silane, (cyclohexyloxy)trimethyl- found in presence in samples MC_{100}, FMC, MMC and PMC while Palmitoyl chloride, 1,3-Dipalmitin trimethylsilyl ether and Octadec-9Z-enol trimethylsilyl ether were identified in sample MM_{100}. This result agrees with report of many researchers that diversity of aroma volatile compounds in fermented food condiments such as Burkinaso, *soumbala*, Ghanaian soy-*dawadawa*, Beninese *afitin*, *iru* and *sonru*, fermented castor oil seed, *dawadawa* bambara groundut (Tanaka *et al*., 1998; Leejeerajumnean *et al.*, 2001, Azokpota *et al*., 2008, Ojinnaka and Ojimelukwe,2013, Adebiyi *et al.*, 2021).

4. Conclusions

Fermented condiment of strong aroma and flavor can produced from castor and moringa seeds based on evaluation of volatile compounds. Packaging material and fermentation time had an influence on volatile compound. Castor-moringa *ogiri* packed in aluminum foil had highest concentration in ester, hydrocarbon, ketones, aldehydes and sterol and vitamins. The volatile compound of various types such as acids, esters, aldehydes, flavour - related compound and constituent could be responsible for organoleptic properties and nutritional quality.

5. References

Achi, O. K. (2005). The upgrading of traditional fermented foods through biotechnology. *African Journal of Biotechnology* 4, 375-380.

Adebiyi, J.A., Njobeh, P. B., Adebo, O.A and Kayitesi, E (2021). Metabolite profile of Bambara groundnut (Vigna subterranea) and dawadawa (an African fermented condiment) investigation using gas chromatography high resolution time-of-flight mass spectrometry (GC-HRTOF-MS). Heliyon 7, 1-10.

Adebo, O.A., Njobeh, P.B., Desobgo, S.C.Z., Pieterse, M., Kayitesi, E. and Ndinteh, D.T. (2018).Profiling of volatile flavor compounds in nkui (a Cameroonian food) by solid phase extraction and 2D gas chromatography time of flight mass spectrometry (SPMEGC_GC-TOF-MS). *Food Science and Nutrition.* 6, 2028–2035.

Akkad, R., Kharraz, F., Han, J., House, J.D. and Curtis, J.M., (2019). Characterisation of the volatile flavour compounds in low and high tannin faba beans (Vicia faba var. minor) grown in Alberta, Canada. *Food Research International Journal* 120, 285–294.

Anhwange, B .A., Ajibola, V.O. and Oniye, S. J.(2004).Amino acid composition of the seeds of *Moringa oleifera* (Lam), *Detarium microcarpum* (Guill & Sperr) *and Bauhinia monandra (*Linn.*). Food chemistry*, 100(7),449-455.

Annongu, A. A. and Joseph, J. K.(2008). Proximate Analysis of Castor Seeds and Cake Journal of Applied Science for Environmental Management, 12(1), 39 – 41.

Arogba, S. S., Ademola, A. and Elum, M. (1995). The effect of solvent treatment on thechemical composition and organoleptic acceptability of traditional condiments from Nigeria. *Journal of Plant Food for Human Nutrition,* 48, 31-38. 162.

Azokpota, P., Hounhouigan, D.J., Annan, N.T., Odjo, T., Nago, M.C., Jakobsen, M. (2010). Volatile compounds profile and sensory evaluation of Beninese condiments produced by inocula of *Bacillus subtilis*. *Journal of Science Food. Agriculture* 90, 438-444.

Choi, U. K., Kim, M. H., Kwon, O. J., Lee, T. J., and Lee, N. H. (2017). Characterization of aroma components in barley bran sauce using statistical analysis. *Food Science Biotechnology*, 16, 23-28.

Chukeatirote, E., Eungwanichayapant, P.D. and Kanghae A (2017).Determination of volatile components in fermented soybean prepared by a co-culture of *Bacillus subtilis* and *Rhizopus oligosporus*. *Food Research* 1(6), 225 – 233.

Curioni, P.M.G. and Bosset, J.O., (2002). Key odorants in various cheese types as determined by gas chromatography-olfactometry. *International Dairy Journal*, 12, 959–984.

Essien, N. (1983). Survey of the food seasonings in Nigeria. Business Concord. 1, 22.

Eskin, N. A. M. (1990). *Biochemistry of Foods* (2nd ed.). Academic Press, San Diego, CA. pp. 444.

Estrella, F.G., Carboell, M., Gaya, P., Nunze, M., 2004. Evolution of the volatile components of ewes raw milk Zamorano cheese, seasonal variation. *International Dairy Journal*, 14, 701–711.

Frei, B. (2004). Efficacy of dietary antioxidants to prevent oxidative damage and inhibit chronic disease. *Journal of Nutrition* 134, 3196–3198.

Gueguen, J., Walrand, S. and Bourgeois, O. (2016). Plant protein, Context and potential in human nutrition , Notebooks of Nutrition and Dietetics 5(4),177 185.

Gupta, J., Gupta, A. and Gupta, A. K (2014). Phytochemical studies and isolation of sterols from seeds of *Moringa oleifera* Lam. *Journal der Pharmazie Forschung*. 2(4), 1-5.

Izco, J. M., and Torre, P. (2000). Characterization of volatile flavour compounds in Roncal cheese extracted by thepurge and trap' method and analysed by GC-MS. *Food Chemistry*, 70, 409-417.

Ima, W,Titi,S. Aperi, D. A and Eko, S (2016) Effect of Different packaging pn Proximate and Lysine content of Milkfish [*Chanos chanos (Forsskal,1775)*] Floss during storage. Aquatic *Procedia*, 7, 118-124.

Jamal, A K, Yacoob, W. A and Din, L.B. (2008) A Chemical study on *Phyllanthus reticulates*. *Journal of Physical Science*. 19(2),45-50.

Kris, E.P. M, Hecker, K. D., Bonanome. A, Coval, S. M, Binkoski, A.E, Hilpert, K.F, Griel, A.E and Etherton, TD. (2002). Bioactive compounds in foods, their role in the prevention of cardiovascular disease and cancer. *American Journal of medicine*, 113(9B),71-88.

Kolapo, A.L., Popoola, T.O.S., Sanni, M.O., Afolabi, R.O. (2007). Preservation of Soy bean Daddawa Condiment with Dichloromethane Extract of Ginger. *Research Journal of Microbiology*, 2, 254-259.

Koleva, L., Angelova, S., Dettori, M.A., Fabbri, D., Delogu, G. and Kancheva, V.D., (2018.) Antioxidant activity of 3-hydroxyphenol, 2,2'-biphenol, 4,4'-biphenol and 2,2',6,6'-biphenyltetrol, theoretical and experimental studies. Bulgarian Chemical Communnication 50.

Kubík, L. and Zeman, S. (2014). Determination of Oxygen Permeability and Mechanical Properties of the Aluminium Paper Foils. *Research Agric Engineering*, 60(4), 172–179.

Larroche, C., Besson, I. and Gros, J.B. (1999). High pyrazine production by Bacillus subtilisin solid substrate fermentation on ground soybeans. Process *Biochemistry*, 34, 667–674 .

Leejeerajumnean, A., Duckham, S.C., Owens, J.D. and Ames, J.M. (2001). Volatile compounds in *Bacillus*-fermented soybeans. *Journal of the Science of Food and Agriculture*, 81, 525–529.

Nogueira, M. C. L., Lubachevsky, G., and Rankin, S. A. (2005). A study of the volatile composition of Minas cheese. *Lebensm-Wiss. Technol., 38*, 555-563.

Nzigamasabo, A. (2012). Volatile compounds in Ikivunde and Inyange, two Burundian cassava products. *Global Advance research Journal of Food Science and Techenology* 1,1-7

Odunfa, S.A. (1985). Microbiological and toxicological aspects of fermentation of castor oil seeds for *ogiri* production. *Journal of Food Science*, 50(6), 1758-1759.

Odunfa S. A. and Oyewole, O. B. (1998). African fermented foods In Microbiology of Fermented Foods; Wood, B.J.B. (ed)

Blackie Academic and Professional, London, U.K., pp 713-746.

Ogbe, R.J., Ochalefu, D.O., Mafulul, S.G. and Olaniru, O.B. (2015). A review on dietary phytosterols, their occurrence, metabolism and health benefits. *Asian Journal Plant Science and Research*, 5 (4), 10–21.

Ojinnaka and Ojimelukwe (2013) Study of the Volatile Compounds and Amino Acid Profile in BacillusFermented Castor Oil Bean Condiment. *Journal of Food Research*; 2 (1);191-202

Onyenekwe, P.C, Odeh, C, and Nweze, C.C(2012). Volatile constituents of ogiri, soybean daddawa and locust bean daddawa three fermented Nigerian food flavour enhancers. Electron. Journal of Environmental Agricultural Food Chemistry; 11(1),115-21.

Onyekwelu, C. N. (2016) Chemical Composition, Microbial Quality and acceptability of castor –morinag *ogiri* M.SC Dissertation ,Department of Food Science and Technology, University of Nigeria Nsukka .50-56.

Pham, A.J., Schilling, M.W., Mikel, W.B., Williams, J.B., Martin, J.M. and Coggins, P.C.(2008). Relationships between sensory descriptors, consumer acceptability and volatile flavour compounds of American dry-cured ham. Meat Science 80, 728–737.

Park, H.J., Lee, S.M., Song, S.H. and Kim, Y.S., (2013). Characterization of volatile components in makgeolli, a traditional Korean rice wine, with orwithout pasteurization, during storage. Molecules 18 , 5317–5325.

Petkova, D. O., Vodenicharov, E., Hadjieva, B., Koleva, N., Petkova, E. and Dimitrov, M., (2013). Essential Amino Acids - Review of Some of the Contemporary Analytical Methods for Detection. World, *Journal of Pharmacy and Pharmaceutical Sciences*, 2, 658–666.

Ram, J. (1994) Moringa , A Highly Nutritious Vegetable Tree. Tropical Rural and Island. A Toll Development Experiment Station (TRIADES) Techanical Bulletin No.2/

Sluis, C. V. D., Tramper, J., & Wijffels, R. H. (2001). Enhancing and accelerating flavour formation by salt tolerant yeasts in Japanese soy-sauce processes. *Trends Food Science Technology 12*, 322-327.

Singh, A P. (2006) Distribution of steroid like compounds in plant flora. Pharmacog Mag.2(6), 87-88.

Tanaka, T., Muramatsu, K., Kim, H., Watanabe, T., Takeyasu, M., Kanai, Y. and Kiuchi, K. (1998). Comparison of volatile compounds from Chungkuk-Jang and Itohiki-Natto. *Bioscience, Biotechnology, and Biochemistry*, 62, 1440–1444.

Wang, S., Tamura, T., Kyouno, N., Liu, X., Zhang, H., Akiyama, Y., Chen, J.Y.,(2019). Effect of volatile compounds on the quality of Japanese fermented soy sauce. LWT – Food Science and Technology 111, 594–601.

Wittanalai, S., Rakariyatham , N. and Richard L. Deming, R. L (2011). Volatile compounds of vegetarian soybean kapi, a fermented Thai food condiment. African *Journal of Biotechnology*, 10(5), 821-830.

Ziegleder, G. (2009). Flavour development in cocoa and chocolate. In, Beckett, S.T. (Ed.), Industrial Chocolate Manufacture and Use, 4. ed. Wiley, New Jersey, pp. 169–191.