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Research Article

Deodorization of Fermented Food Condiment from *Prosopis africana* (African Mesquite) Seeds

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Abstract

Prosopis africana seeds were processed to produce local fermented food condiment called *"Okpehe"* by idoma, igala (*dad*dawa, iru, ogiri) by hausa, yoruba and igbo respectively. However, acceptability of such condiment by the elite consumers is of serious challenge due to the offensive odor associated. The aim was to deodorize laboratory prepared fermented food condiment with potential chemical deodorant; cyclodextrin, and powdered activated carbon. Deodorization was achieved using five different concentrations (0.5, 1.0, 1.5, 2.0 and 2.5g) of the potential chemical deodorants per 100g of the control, CD and PAC treated samples and left for 24 hours, subjected to odor ranking within 24 hours. Odor was observed by snipping and a Panel of fifteen trained panelists was set up and each Panelist was presented with the coded samples and ranked them based on their odor. GC-MS was used to identify the volatile properties. Heterotrophic bacterial counts were determined using pour plate method and the growth increased exponentially from days 1- 6, with peak counts at day 7 (2.24×10^6, 1.54×10^7, 1.16×10^8 and 0.77×10^9) cfu/g and day 8 (2.25×10^6, 1.56×10^7, 1.18×10^8 and 0.78×10^9) cfu/g respectively with steady growth, offensive odor and dark mash sticky cotyledon at days 7 - 9. Cyclodextrin 2.5g/100g and PAC 2.5g/100g treated samples had the least odor (Barely perceived odor) 73.4% and 86.6% respectively. The GC-MS of the control sample had 27 volatile constituents while the sample treated with PAC (2.5g/100g) which achieved 86.6% deodorization had only 10 volatile constituents suggesting that the 17 constituents which had been removed are largely responsible for the offensive odor. The present study depicted the potentiality of CD and PAC as good chemical deodorants for the condiment.

Keywords

Deodorization, Condiment, Cyclodextrin, Powdered Activated Carbon, Prosopis Africana Seeds

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1. Introduction

Prosopis trees are woody unceasing belonging to the family *Leguminosae*. The species have been distributed in North America, Central/South America, Africa, and Asia [30]. In Nigeria, it is predominant in North Central geopolitical zone around Kogi, Benue, Nasarawa, Kaduna, Niger and Plateau states [30]. The pods are used as food for cattle and as fish poison by fishermen. Interestingly, these pods also contain seeds which can be processed to produce local fermented food condiment called "*okpehe*" by Idoma, Igala and other middle belts tribes. It is also called *Daddawa, Iru, Ogiri* in Hausa, Yoruba and Igbo respectively [9].

The high cost of animal protein has also directed interest towards several leguminous seed proteins as potential sources of vegetable protein for human food [18]. Most of the fermented vegetable proteins reported are from leguminous seeds [10]. Quite often, seeds that are used for fermentation are inedible in their raw unfermented or cooked state [15]. The seeds of legumes may account for up to 80% dietary protein and be the only source of protein for some groups of people [12]. Although fermented food condiments have constituted a significant proportion of the diets of many people, Nigerians exhibit an ambivalent attitude in terms of consumer tastes and preferences for such foods [10]. Fermented food condiments remain of interest since they do not require refrigeration during distribution and storage. The traditional fermented condiments have not attained commercial status due to the objectionable packaging materials, stickiness and the characteristic putrid and unpleasant odor [13]. Fermented condiments often have a stigma attached to them despite serving not only as a nutritious non-meat protein, they are often considered as food for the poor due to the off odor [15].

Chemical deodorants are compounds that encapsulate odor components into its cavities, and subsequently deodorize the unpleasant odor [40]. Some deodorants can oxidise into a quinone type structure [33]. The phenolic groups react with compounds containing sulfur or nitrogen and eliminate the odor [40]. This type of reaction is called chemical deodorisation. Some of these deodorants includes; cyclodextrin (CD), tert-butylhydroquinone, butylated hydroxyanisole (BHA), powdered activated carbon (PAC) and polyphenol oxidases (PPO). Cyclodextrins are a family of cyclic oligosaccharides composed of α-(1,4) linked glucopyranose subunits [19].

Cyclodextrins are cyclic oligosaccharides consisting of six α-cyclodextrin, seven β-cyclodextrin, eight ϒ-cyclodextrin or more glucopyranose units linked by α-(1,4) bonds [19]. These compounds having supramolecular structures carry out chemical reactions that involve intramolecular interactions where covalent bonds are not formed between interacting molecules, ions or radicals [19]. Compared to all the supramolecular hosts mentioned above, cyclodextrins are most [40]. As a result of molecular complexation phenomena. CDs are widely used in many industrial products, technologies and analytical methods. The negligible cytotoxic effects of CDs are an important attribute in applications such as food and flavours, cosmetics, packing, textiles, separation processes, environment protection, fermentation, odor control and catalysis [40].

Powdered activated carbon is considered as crude form of graphite, but unlike graphite structure, it has random imperfect structure with macro and micro pores [11, 19]. The graphite structure gives the activated carbon it's very large surface area. Activated carbon has the strongest physical adsorption forces, the adsorbility of activated carbon increases with increasing molecular weight, higher number of functional group compounds, increasing polarizability. The surface area of activated carbon varies from 500 m^2/g to 2000 m^2/g [44]. The effectiveness of activated carbon is increased with increase of total pore volume [44]. It is expressed in milliliters per gram (ml/g). The significance of activated carbon is its unique distribution of pore sizes.

2. Method

2.1. Collection of Seed Samples

The *Prosopis africana* seeds and leaves were purchased from the new Monday market, popularly known as Kasuwan Amaru/new Katafawa market in Zaria city and identified with voucher number; V/N 06919 in Botany Department, Faculty of Life Sciences, Ahmadu Bello University, Zaria, Nigeria.

2.2. Laboratory Preparation of Food Condiment

The boiling step in the traditional process is long, tedious and wasteful; it also requires more volume of water. Thus boiling by fuel (kerosene) or fire wood was replaced by boiling in an autoclave in the laboratory. Two kilograms (2kg) of *Prosopis africana* seeds were boiled in 2000ml of water at 12℃ for 2h in an autoclave and later dehulled [2]. The cotyledons were separated from the coats and later rinsed in sterile water, before boiling again in an autoclave for about 30 min to soften the cotyledons. The cotyledons were drained through a sterile sieve and cooled to about 35℃, then wrapped in paw-paw leaves already disinfected with alcohol and wrapped in a foil. The wrapped cotyledons were then incubated in an incubator for 5-9 days to produce the fermented mash of food condiment. A modified method [10, 28].

2.2.1. Serial Dilution

Serial dilution was carried out by weighing 1g of laboratory fermented condiment and dissolved into 90ml of diluents water to form a stock culture ratio (1:90). From the stock solution 1ml was transferred into 9ml sterile distilled water, 1ml diluents from the stock culture ratio (1:90) was transferred into 9ml sterile distilled water (1:9) making it to dilution factors of 10^1,

10^2, 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, and 10^9 respectively. Also 1ml each from dilution factors of 10^1, 10^2, 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, and 10^9 were inoculated in nutrient agar plates and incubated at 37˚C for 24h. The stock preparation and process were repeated every day for nine consecutive days.

2.2.2. Microbial Counts Determination

The bacterial populations of the fermented condiment were estimated using a pour plate method before deodorization [33].

$$\text{Colony Forming Unit Per gram (cfu/g)} = \frac{\text{Total number of Colony counted x Dilution Factor}}{\text{Volume of Inocula}}$$

2.3. Deodorizing Process

A varying amount of (0.5, 1.0, 1.5, 2.0, and 2.5g) of deodorizing agents: cyclodextrin and powdered activated carbon in 100g of fermented condiment each of the deodorizing agents were mixed with the sample fermented condiment and deodorized the off odor separately for 24h at room temperature [23, 29, 33]. Fermented condiments were grouped as follows: GROUP 1: Fermented condiment without treatment (Negative control), GROUP 2: Fermented condiment mixed with cyclodextrin, GROUP 3: Fermented condiment mixed with powdered activated carbon. All the deodorizing agents were retained in the condiment.

2.3.1. Odor Ranking Test

Descriptive word category scale method was applied and it determines how the samples differ on the basis of intensity of the off odor. Odor was observed by sniffing; odor testing was conducted within a nominal 24h time period after deodorization. A panel of fifteen (15) trained panelists was set up; each panelist was presented with coded samples and asked to rank according to their preference. Judging was done individually, this assures independent judgments and communication between panel members was not allowed except for consultation with the panel observer on any point of doubt. Descriptive word category scale was used to give the assessors to rate the odor on a scale, using 5-point scale as follows:

1) Odorless
2) Barely perceives odor
3) Mild off odor
4) Moderate odor
5) Strong odor

A score card was developed for this experiment. All score cards contain date and name of the judge as described [21].

2.3.2. Identification of Volatile Components of Deodorized Fermented Condiment from *Prosopis Africana* Seeds

The volatile constituents were analyzed by gas chromatography using the PDMS-SPME head space technique [6, 7]. To extract the volatile constituents, 5g of the mashed deodorized fermented condiment was transferred into capped glass and 100% Dimethylsulfuroxide (DMSO) was added for extraction. The mixture was incubated in an oven for 30 min at a temperature of 37 ℃. The constituents of the extract were analysed using GC-MS by direct injection method in the split mode with (split ratio 20:1) under the following conditions; Hewlett – Packard 6890 GC equipped with an ionization detector and a quartz capillary column; 30 m x 0.25 nm x 0.25 nm, nitrogen was used as carrier gas, hydrogen pressure and compressed air were 28 and 35 psi, respectively [1, 5]. A digital integrator was then used to integrate the area of the signal from the detector [1, 8]. The integrated area, retention time and constituents were printed automatically at the end of each peak. The identification of the different constituents in the extract was performed by the comparison of their retention times and mass spectra with those of the database of National Institute Standard and Technology (NIST) having more than 32,000 patterns. The spectrum of the unknown component was compared with the spectrum of the known components stored in the NIST library. The names of the components of the test materials were ascertained [34].

3. Result

Heterotrophic bacterial count of laboratory fermented *Prosopis africana* seeds is presented in Figure 1. The microbial counts increased exponentially from days 1- 6, with peak count at day 7 (2.24×10^6, 1.54×10^7, 1.16×10^8 and 0.77×10^9) cfu/g and day 8 (2.25×10^6, 1.56×10^7, 1.18×10^8 and 0.78×10^9) cfu/g observed with steady growth, offensive odor and dark mash sticky cotyledon was observed at days 7 – 9 (Figure 1).

Changes in physical sensory parameters of laboratory fermented *Prosopis africana* seeds are presented in Table 1. The fermentation period was nine days and there was no change observed in colour of creamy cotyledon from Days 1 – 3, but at days 4 - 6 a slight change in colour was observed from creamy brownish to brown colour and a persisted dark brown colour was observed at days 8 – 9 (Table 1). At day 1 of the fermentation, there was no odor observed, but a slight change from odorless to barely perceived odor at days 2 – 4 as presented in Table 1. Mild odor was observed at day 5, moderate odor at day 6 and persisted strong odor was observed at days 7 – 9. At days 1 - 4 of the fermentation, there was no change observed in the texture of mash cotyledon, but a stick mash cotyledon was observed at day 5, and persisted mashy sticky cotyledon was observed at days 6 – 9.

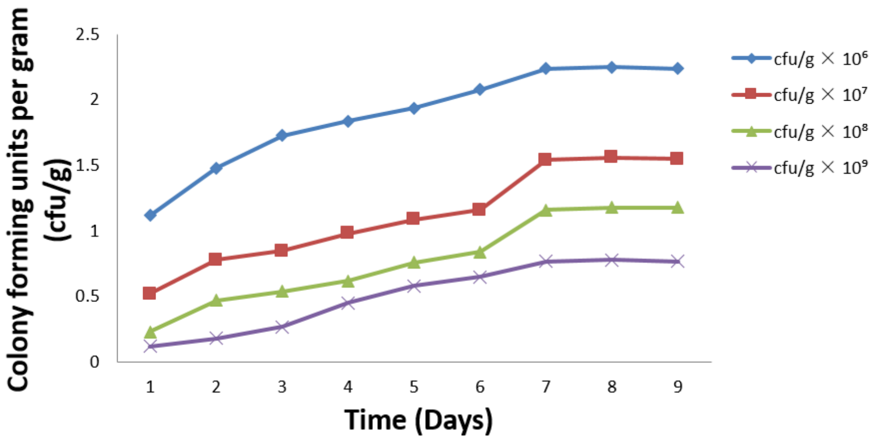

Figure 1*. Heterotrophic Bacterial Count of Laboratory Fermented Prosopis africana Seeds before Deodorization (cfu/g).*

Table 1*. Changes in Physical Sensory Parameters of Laboratory Fermented Prosopis africana Seeds.*

DAYS	COLOUR	ODOR	TEXTURE
1	Creamy	Odorless	Mash cotyledon
2	Creamy	Non offensive Odor	Mash cotyledon
3	Creamy	Non offensive Odor	Mash cotyledon
4	Creamy/brownish	Barely odor	Mash cotyledon
5	Brownish	Mild odor	Stick mash cotyledon
6	Brown	Moderate odor	Mashy sticky cotyledon
7	Brown	Offensive odor	Mashy sticky cotyledon
8	Dark brown	Very offensive odor	Mashy sticky cotyledon
9	Dark brown	Very offensive odor	Mashy sticky cotyledon

The recommended fermentation period is 7 day.

3.1. Odor Evaluation of Deodorized Fermented Condiment from *Prosopis Africana* Seeds

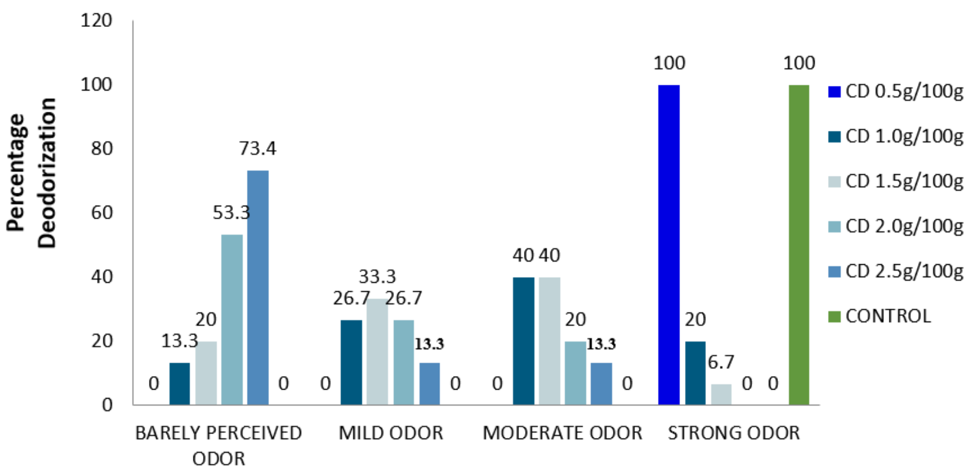

Figure 2*. Odor Evaluation of Deodorized Fermented Condiment from Prosopis africana Seeds Treated with Cyclodextrin (CD).*

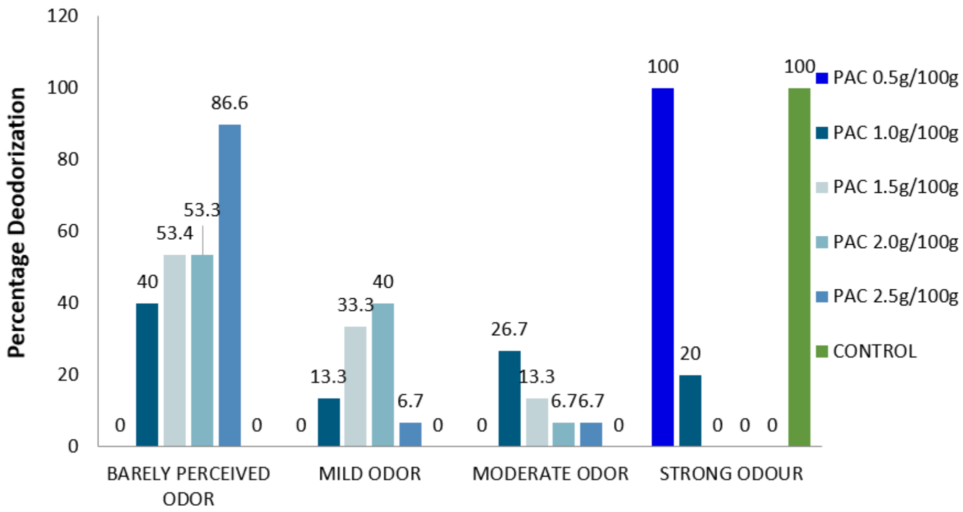

Figure 3. *Odor Evaluation of Deodorized Fermented Condiment from Prosopis africana Seeds Treated with Powdered Activated Carbon (PAC).*

Results for odor evaluation of deodorized fermented condiment from *Prosopis africana* seeds are presented in Figures 2 and 3. Cyclodextrin (CD) treated sample (2.5g/100g) and powdered activated carbon (PAC) treated sample (2.5g/100g) were observed to have the least odor (Barely perceived odor) with 73.4% and 86.6% respectively (Figures 2 and 3). The (0.5g/100g) of both CD treated sample and PAC treated sample were observed to have 100% strong odor when compared with control (NC). The samples treated with PAC (1.5g/100g), CD (2.0g/100g) and PAC (2.0g/100g) were observed to have 53% barely perceived odor, while samples treated CD (1.0g/100g) and PAC (1.0g/100g) were observed to have 10% and 40% (barely perceived odor) and CD treated sample (1.5g/100g) have 20% (barely perceived odor) as indicated in Figures 2 and 3.

3.2. Volatile Constituents of Deodorized Fermented Condiment from *Prosopis Africana* Seeds

Table 2. *Volatile Constituents of Deodorized Fermented Condiment from Prosopis africana Seeds.*

S/N	CONTROL		CD		PAC	
	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents
1	8.177	Hexadecanoic acid, methyl ester	8.146	Hexadecanoic acid, methyl ester, Pentadecanoic acid, 14-methyl-, methyl ester	11.593	9-Octadecenoic acid, methyl ester Dodecahydropyrido[1,2b]iso quinolinone, Cyclopentene, carboxylic acid
2	8.548	n-Hexadecanoic acid	9.821	Oleic Acid, 6-Octadecenoic acid	14.418	1,2-Benzisothiazol-3-amine, 5-Methyl-2-phenylindolizine
3	9.275	Docosyl propyl ether, Hexaco-sylpropyl ether, Propyltriac-ontylether	10.987	Heptadecanolide	14.695	1,2-Benzisothiazol-3-amine, isopropyl ester
4	9.853	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester, 11-Octadecenoic acid, methyl ester	11.589	Oxirane, tetradecyl-6-Octadecenoic acid	14.983	2'-Hydroxy-5'-methylacetop henone, 2-Ethylacridine
5	10.257	Oleic Acid, cis-13-Octadecenoic acid	11.740	Oleic Acid, Fumaric acid, 4-heptyl tridecyl ester, 11-Hexadecenoic acid	15.213	Benzendehyde
6	10.452	Octadecanoic acid	11.890	6-Octadecenoic acid, Oleic	15.438	Octasiloxane

S/N	CONTROL		CD		PAC	
	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents
				Acid		
7	11.740	Oleic Acid, Fumaric acid, 4-heptyl tridecyl ester, 11-Hexadecenoic acid	11.930	Benzenamine, 4-(2-phenylethenyl)-N-(3,5-dimethyl-1-pyrazolylmethyl)-l-(+)-Ascorbic acid	16.025	1,5-hexadecamethyl-acetic acid
8	11.930	Benzenamine, 4-(2-phenylethenyl)-N-(3,5-dimethyl-1-pyrazolylmethyl)-l-(+)-Ascorbic acid	14.192	3,5-bis(1,1-dimethylethyl)-Heptasiloxane	16.249	13,13,15,15-hexadecamethyl-1,2-Benzisothiazol-3-amine
9	14.918	Anthracene, 9,10-dihydro-9,9,10-trimethyl-Benzo[h]quinolone	14.725	1,5-hexadecamethyl-2,4-Cyclohexadienone	16.769	2-Ethylacridine, Benzo[h]quinoline, 2,4-dimethyl-1,2-Benzisothiazol-3-amine
10	15.044	1H-Indole-2-carboxylic acid, 6-(4-ethoxyphenyl)-3-methyl-4oxo-4,5,6,7-tetrahydro-, isopropyl ester	14.881	2-Ethylacridine, Cyclotrisiloxane	16.892	1-methyl-2-phenyl-5-Methyl-2-phenylindolizine
11	15.213	Benzendehyde 2,4-Cyclohexadienone	15.156	2,4-Cyclohexadienone		
12	15.438	Octasiloxane, 1,5-hexadecamethyl-acetic acid	15.366	2'-Hydroxypropiophenone,		
13	15.552	2-Ethylacridine, 2-Methyl-7-phenylindole	15.438	Octasiloxane		
14	15.737	1,2-Benzisothiazol-3-amine, Benzeneacetaldehyde	16.016	1,2-Benzisothiazol-3-amine, 1,2-Benzenediol, 3,5-bis(1,1-dimethylethyl)-Derivative		
15	16.302	2-Ethylacridine, Benzo[h]quinoline, 2,4-dimethyl-Thymol	16.312	1H-Indole-2-carboxylic acid, isopropyl ester, 1,2-Benzisothiazol-3-amine		
16	16.777	2,4-Cyclohexadienone, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-Thymol,	16.550	2,4-Cyclohexadienone, 2,4-dimethyl-2-Methyl-7-phenylindole		
17	16.923	2,4-Cyclohexadienone, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-Benzo[h]quinolone	16.713	isopropyl ester, acetic acid, 2-[bis(methylthio)methylene]-1-phenylhydrazide		
18	17.774	1,2-Benzenediol, 3,5-bis(1,1-dimethylethyl)-1H-Indole-2-carboxylic acid, isopropyl ester	17.066	1,2-Benzisothiazol-3-amine, 13,13,15,15-hexadecamethyl-5-Methyl-2-phenylindolizine		
19	17.971	1H-Indole, 1-methyl-2-phenyl-1H-Indole-2-carboxylic acid	17.616	1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl-1H-Indole		
20	18.259	2-methyl-3-phenyl-4-pentanone,				
21	18.120	Heptanal				
22	18.391	Acetophenone				
23	22.313	Nonadecanone, 2-Butyl-octenal, 2,4-Nonadienal				

S/N	CONTROL		CD		PAC	
	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents	RT (min)	Volatile Constituents
24	22.505	Ethyl hexanone				
25	22.202	Ethyl heptanone, 2,4-Undecadienal, 2,4,6-Dodecatrienal				
26	22.255	5-methyl-2-phenyl-2,4-Cyclohex adienone,				
27	23.213	Ethyl octanone, 2,4-Decadienal, Hendecanal, 2-Nonenal				

RT: Retention Time, CD: Cyclodextrin and PAC: Powdered Activated Carbon.

Volatile constituents of deodorized fermented condiment from *Prosopis africana* Seeds are presented in Table 2. The predominant compounds responsible for the offensive odor are the carbonyl compounds aldehydes and acetones as well as amines and amides. These includes compounds such as anthracene, 9,10-dihydro 9,9,10-trimethyl-benzo[h]quinolone, 1,5-hexadecamethyl-2,4-cyclohexadienone, 2,4-cyclohexadienone, 2'-hydroxypropiophenone, 3,5-bis(1,1-dimethylethyl)-4-hydroxybenzo[h]quinolone, 2-methyl-3-phenyl-4-pentanone, acetophone, heptanal, acetophenone, nonadecanone, 2-butyl-octenal, 2,4-nonadienal, ethyl hexanone, ethyl heptanone, 2,4undecadienal, 2,4,6-dodecatrienal, 5-methyl-2-phenyl-2,4-cyclohexadienone, ethyl octanone, 2,4-decadienal, hendecanal and 2-nonenal. Powdered activated carbon (PAC) was observed to have the highest deodorization potential with 63% deodorization of the volatile constituents while cyclodextrin (CD) with least deodorization potential with 30% deodorization of the volatile constituents respectively.

4. Discussion

In this study, the laboratory prepared fermented food condiment from *Prosopis africana* seeds was deodorized with potential chemical deodorants β-Cyclodextrin (CD), and powdered activated carbon (PAC). Heterotrophic bacterial count of laboratory prepared fermented *Prosopis africana* seeds increased exponentially from day 1 - 6, with peak count at day 7 and steady growth were observed from day 7 – 9. Also, changes in physical sensory parameters of laboratory fermented *Prosopis an africana* seeds *was* observed during the fermentation period. The fermentation period was nine days. There was no change observed in colour of creamy cotyledon during the first three days of fermentation, but subsequently a slight change from odorless to non-offensive odor with mash cotyledon was observed. At day 4 and 5, a slight change from creamy-brownish to brownish colour and barely odor to mild odorous stick mash cotyledon were observed. At day 6 – 9, brown to dark brown colour was observed with increased offensive odor and mashy sticky cotyledon. The result obtained corroborates with the study reported by Akubor, P. I. [3]. that demonstrated some changes in physical sensory parameters of fermented condiments as a result of microbial activities and related environmental factors [4, 32]. It is expected that the longer the period of fermentation (5 - 7) days, the better the product due to more activities of the fermenting bacterial flora but period of fermentation is another major factor to assess the quality of production of fermented condiments [10, 37].

A total of 27 volatile constituents were identified in this study. The alkanols present in the condiment may help prevent them from spoilage since alkanols are known to act as antifungal and prevent food spoilage [39]. Most of these alkanols had been reported present in other fermented leguminous products [14, 33]. Alcohols also contribute to the flavour of the condiments. This is consistent with previous work where alcohol was reported in soy sauce, Miso [24], and Korea doenjang as an important contributor of flavor [36]. Eight ketones were identified in the sample in this study [41]. Ketones are usually derived from lipid and amino acid degradation during microbial fermentation and have a high impact on food odor [35, 42]. Ketones contribute to the odor of *okpehe*. The result corraborates with the study reported by Wittanalai, S., Rakariyatham, N. that identified 17 ketones in soya beans condiment [44].

The ester constituents of the condiment may be responsible for the ‘fruitiness’ associated with *okpehe*. The acetates of higher alcohols and the ethyl ester of fatty acids had been suggested to be the most desirable compounds to enhance the aroma of the finished products and are responsible for the fruity tinge of freshly prepared miso [18, 31]. The majority of benzene derivatives present in the fermented food condiment are the most important flavor constituents of daddawa (fermented locust bean seeds) after aldehydes [16]. Microbial fermentation of legumes is known to increase the free amino acids content by five folds [38], and some of these amino acids are precursors of pyrazines. Threonine could be the precursor of 2, 5 – dimethyl pyrazine while tetramethyl pyrazine can be produced from different amino acids such as glycine, alanine, valine, isoleucine and leucine via Strecker degradation and deamination [20, 38]. This coupled with the fungicidal and bactericidal activities of other constituents may be responsible for non-spoilage of this condiment no matter how long it is stored without refrigeration [17]. Other volatile constituents present in the fermented food condiment include anthracene, fumaric acid, 1h-Indole and 5-Methyl-2-phenylindolizine [41].

Powdered activated carbon (PAC) treated sample had the highest deodorization potential which deodorized 63% of the volatile constituents while Cyclodextrin (CD) treated sample had the least deodorization potential which deodorized only 30% of the volatile constituents. This is consistent with the study conducted by Tamaki *et al.* [40], who reported that, PAC has higher deodorization potential in sweet potato juice while CD treated sample showed least effect in reducing the off-flavour of the sweet potato juice. It is expected that all the odor component molecules are small enough to enter the microspores of the PAC [43]. However, PAC differed in its adsorption removal ability for individual odor components. It is thought that the odor removal ability depends on the difference in physical and/or chemical interactions between the PAC surface and the odor components [25, 27]. Since, several kinds of coexisting odor components in water were removed by the PAC adsorption, it is difficult to evaluate the potential physical and/or chemical interactions between the PAC surface and the respective odor components [26, 40].

Cyclodextrin removed only a small amount of acetone although acetone being small in size could be enveloped easily in its cavity; the inner hydrophobic environment prevents hydrophilic acetone from being adsorbed [40]. Ethyl acetate, with a relatively high hydrophobicity, showed a higher value and the peak intensity remained high after activated carbon treatment. When treated with apple polyphenols AP deodorant, the peak intensity for ethyl acetate was approximately four times larger than that for acetone [22]. On the contrary, the peak intensity for acetone was slightly larger than that for ethyl acetate during PAC treatment [43].

5. Conclusion

In conclusion, the present study depicted the potentiality of cyclodextrin and powdered activated carbon as good chemical deodorants for the deodorization of fermented food condiment from *Prosopis africana* seeds. Powdered activated carbon exhibited the highest deodorization potential.

Abbreviations

CD	Cyclodextrin
GC-MS	Gas Chromatography and Mass Spectroscopy
NC	Negative Control
PAC	Powdered Activated Carbon

Author Contributions

Suleiman Ubangida: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft

Danladi Amdu Ameh: Conceptualization, Supervision, Writing – review & editing

Muawiya Abarshi Musa: Conceptualization, Supervision, Writing – review & editing

Clement Myah Zaman Whong: Conceptualization, Supervision, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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