Climate Adaptation Strategy for Cassava Processing and Storage by a Niger Delta Community in Nigeria.

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Citation: Ojimelukwe P. C., Uchechukwu T, Akachukwu D, Daniel L. N., Ubadire-Agua C. and Theodore-Ojinnaka M. (2023) Climate adaptation strategy for cassava processing and storage by a Niger Delta Community in Nigeria. FARA Research Report *Vol 7(31):395-407*. https://doi.org/10.59101/frr072331

Abstract:

Ogwuaniocha is a Niger Delta community in Nigeria facing climate challenges (notably periodic flooding of crop farms), environmental pollution and resource conflicts due to oil exploration activities. The Orashi (Olasi) river serves all purposes for this community (drinking, waste disposal, washing and storage of cassava mash). Preliminary research was conducted to investigate the adaptation of cassava farmers to periodic over flooding of their farms. Climate smart adaptation measures for cassava farming and processing involved: harvesting of cassava before the flooding period; processing the cassava and storing it at the riverbank. Cassava fufu was the most consumed in households (63%). Over 60% of the farmers fermented their cassava tubers in the river for 3-4 days and up to 20% stored their fermented cassava mash at the riverbanks for 6-12 months from where they periodically collect portions for consumption and for commerce. About 2% of the farmers use alum or salt additives for storage. Microbial flora of freshly prepared cassava mash were Enterobacter, Bacillus, Fusarium, Lactobacillus and Trichoderma spp. The major volatile compounds associated with the cassava flour processed from the mash were: hexadecanoic acid methyl ester; 11, Octadecenoic acid, methyl ester; 14-Octadecenoic acid methyl ester; Trans-3-Octadecenoic acid methyl ester.

Keywords: cassava processing and storage, climate smart adaptation strategy, esters, flavour volatiles in cassava flour, microbial flora of cassava mash, Orashi River, over flooding, over flooding.

1. Introduction

Climate change threatens to reverse the progress made so far in the fight against hunger and malnutrition [1]. It decimates the gains being made in food security [2] and breaks down food systems, trade flows and food markets. It may invariably introduce new health risks for humans [3]. Urgent research efforts are needed to respond to climate change challenges in order to safeguard the capacity of food systems and ensure global food security. First, there is need to raise awareness about the impact of climate change on food security and nutrition of vulnerable groups. Knowledge of existing adaptation and coping strategies will provide insights to innovations in climate change adaptation and mitigation measures [4]. The pathways through which climate change impacts food security and the actions that need to be taken need to be clearly defined. This will highlight adaptation and mitigation needs to reduce food insecurity [5]. Rise in Sea-level affects the salinity of surface and groundwater in coastal areas. Droughts, floods and storms in developing countries affect the agricultural sector. **Climate change is profoundly modifying agricultural practices and agricultural production. Gebremichael** et al. [6] stated that accurate precipitation forecast is very important since extreme rainfall could lead to flood disasters. Nnodim and Ezekiel [7] had observed that causes of flooding in rural areas of Orashi region including Ogwuaniocha community were prolonged heavy rainfall, overflow of rivers, and continued release of excess water from artificial reservoirs. The floods submerge farmlands, destroy crops, harvested produce, spread infection

that causes diseases in fishes and other aquatic animals; it causes pollution of rivers and streams, amongst others.

Crude oil pollution and periodic over flooding of the Orashi River accompanied by destruction of farms is experienced by the inhabitants of Ogwuaniocha in Onitsha South and Idemili LGAs in Anambra state. The Orashi River originates from Imo state takes a left turn and flows through Okija while a westerly course flows through Ogwuaniocha. The river splits into two at Egbema in Rivers State and eventually empties into the Gulf of Biafra (officially Bight of Bonny in Nigeria) before emptying into the Ocean [8]. The Orashi River Region has over 35% of the oil wells in the Niger Delta. The present paper describes the adaptation measures of cassava farmers in this community to their climate change challenges (particularly the flooding of their farms) in cassava processing. The microbial quality and flavor volatiles of cassava fufu processed through climate smart practices by rural cassava farmers in response to the flood disaster are investigated.

Map of the location of Orashi River (coloured blue) around Ogwuaniocha in Ogbaru Local Government Area Anambra State (Study Area)

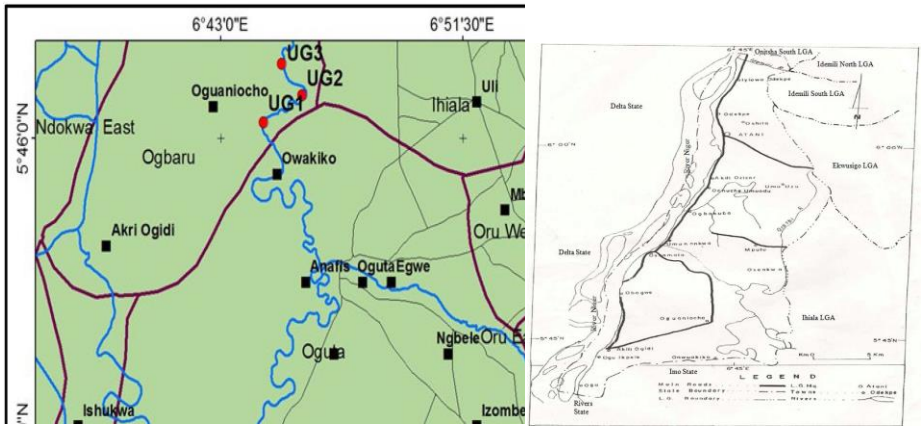

Figure 1: Source: Akachukwu et al., [9]; Ezeokoli et al., [10]

2.0 Materials and methods.

2.1 Questionnaires were administered to rural cassava farmers in order to elicit information on their socio-economic characteristics; practices they use to adapt to periodic flooding of their cassava farms, as well as processing and storage of cassava in the area. Microbial analysis was conducted on the freshly processed cassava mash which were flash dried and stored. The flavour volatiles in the cassava mash were identified.

Figure 2: Research team members being ferried across Orashi River for sample collection and questionnaire administration by female canoe drivers.

Figure 3: Method of cassava processing at the Ogwuaniocha community
Source: Survey and observation, 2022

2.2 Microbial analysis:

2.2.1 Isolation of microorganisms

Processed cassava mash from Ogwuaniocha was used as the sample for microbial analysis. The serial dilution technique was employed in the inoculation of the respective samples on nutrients for microbial growth. Each of the samples was diluted 10-fold as described by Gurung et al. [11]. Dilutions from 10^{-3} and 10^{-4} were inoculated onto freshly prepared Nutrient Agar, MacConkey agar, deMann Rogosa and Sharpe agar as well as Sabouraud Dextrose Agar plates for total heterotrophic bacterial, coliform, lactic acid bacteria and fungi counts respectively. The Spread plate method of inoculation as described by Prescott et al. [12] was used where 0.1ml of the respective dilutions (10^{-3} and 10^{-4}) were plated on various agar plates and evenly spread over the entire plate using a flame sterilized glass rod. The inoculated plates were incubated at 35^{o}C for 24h for bacteria and at room temperature (28±2^{o}C) for 3days for fungi. Nutrient agar was used to enumerate the total bacterial load, de Mann Rogosa and Sharpe agar was used for estimation of LAB count while the total fungal load was enumerated on SDA. The microbial load (bacterial/fungal) expressed in cfu/g was estimated using:

Microbial load = Reciprocal of dilution factor x number of colonies on plate

Where:

Dilution factor (DF) = initial dilution used x subsequent dilution used for inoculation x volume of inoculum.

2.2.2 Biochemical tests for microbial isolates

Isolated organisms were identified by standard microbiology techniques including the gram stain reaction, Catalase test, Citrate, Hydrogen sulphide test, methyl-red test, Voges-Proskauer test as well as the Urease and Indole test, Hydrogen sulphide production (H_2S) test, Oxidase test [13].

2.2.3 Identification of Fungal Isolates:

A smear of the pure culture was made on a microscope slide and stained with Lactophenol cotton blue. Light microscopic examinations were carried out using x10 and x40 objectives. The morphological and cultural features of each fungus were compared with the descriptions given by Barnett and Hunter [14] for identification.

2.3 Determination of Volatile compounds profile by headspace GC-MS

Flash dried cassava flour samples (3.0 g) were stored in hermetically sealed vials and analyzed in a Headspace injector (HS, model Perkin Elmer Turbo Matrix 16) coupled to a GC-MS equipment (Perkin Elmer, Model Clarus 500 MS). The extraction was carried out at 100 ºC/60 min with the needle and transfer line at 150 °C, a pressurization time of 3 min and an injection time of 1 min. The injection was performed at 150 °C in a splitless vaporization chamber with a 2-mM internal diameter. The separation was performed on an HP-FFAP column (50 m x 0.2 mM x 0.33 µm) at 50 °C/20 min, followed by increments of 3 °C/min to 200 °C and 10 °C/min to 230 °C (maintained for 7 min), in a total of 80 min. Helium at 1 mL/min was used as the carrier gas. The molecules were fragmented by electron impact (EI 70 eV). The peaks of volatiles present in the samples were identified by comparison of their mass spectra with the spectra of the reference at the National Institute of Standards and Technology (NIST) database and results expressed as peak areas.

3.0 Results.

3.1 Socio-economic characteristics of cassava farmers at Ogwuaniocha

Table 1 shows the socio-demographic characteristics of respondents. Eleven (11%) of the respondents were male cassava farmers, while 89% were females. Twenty-nine (29%) of the farmers were less than 20 years old; 25% were 41-50 years old; 33% were between 21 and 40 years old and only 2% were above 60 years old. Seventy-three (73%) of the cassava farmers were married; 12% were single or widows while few (3%) were divorced. Many of the farmers were uneducated (43%); 38% had primary education while 19% had secondary education. Most of the respondents had moderate household sizes (6-10) (63%), while 6% had very large household sizes (16-25). Two (2) % of the surveyed population had up to 25 people in their household.

Table 1. Distribution of Cassava farmers according to their socio-economic characteristics.

Variables	Frequency/Percentage (n=100)	Highlights
Sex		
Male	11	
Female	89	The cassava farmers were mostly females (over 80%)
Age		
≤ 20	29	They were less than 20 years old followed by 41-50 years old
21-30	15	
31-40	18	
41-50	25	
51-60	11	
>60	2	
Marital status		
Single	12	
Married	73	The cassava farmers are mostly married women (over 70%)
Divorced	3	
Widow	12	
Widower	0	
Level of Education		
Not educated	43	Majority of the farmers are uneducated and most, had primary education
FSLC	38	
WAEC or Equivalent	19	

Household size		
1-5	18	
6-10	63	6-10 people in most households
11-15	13	
16-20	4	
21-25	2	
Major Occupation		
Farming	98	Almost all the respondents were farmers
Fishing	1	
Petty Trading	1	
Others (transportation; civil servant; politician)	0	

Source: Field survey, 2022

3.2 Processing of harvested cassava

The cassava farmers in Ogwuaniocha community prefer to soak their peeled cassava tubers for fermentation in Orashi River than to soak them in plastic containers at home (only 3% of the farmers soaked at home for fermentation). The peeled tubers are stacked in propylene bags and put near the riverbank for 3 days (51%) and 4 days (49%) by the farmers after which the softened tubers are washed, manually mashed and the mash is packed into polyethylene lined propylene or polyolefin bags and stored back in the river.

3.3 Storage of cassava mash in Urashi River

The processed cassava mash is stored back in the river by only those who have enough to eat and can store and those involved in commerce. Forty-four (44) % of the farmers indicated that they store their cassava mash for 0-9 months. Fifty (52) % indicated that they store for 10-12 months, while only 4% indicated that they store for more than 12 months.

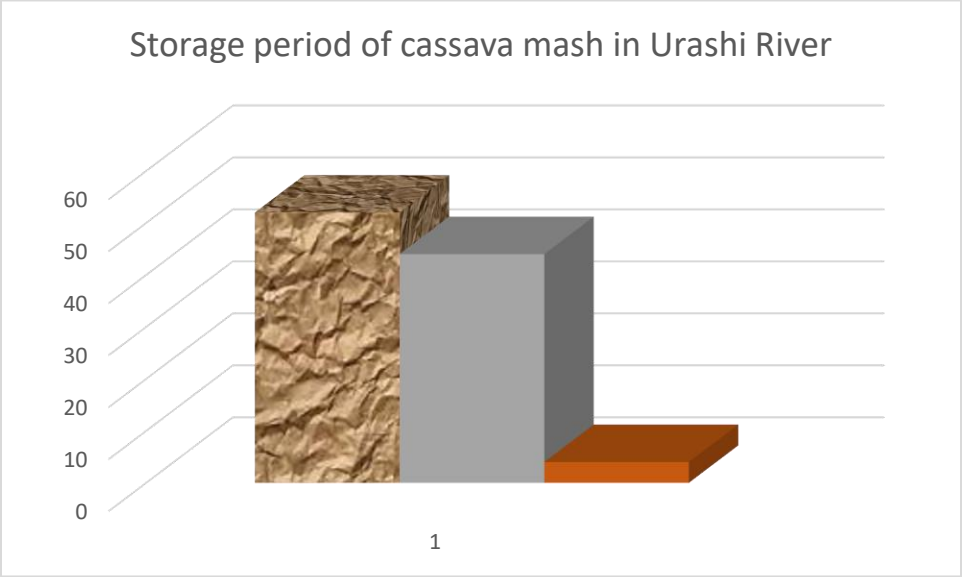

Figure 4: Storage period of cassava mash by Ogwuaniocha farmers in the Orashi River

3.4 The major volatiles from the cassava flour were esters (11, Octadecenoic acid, methyl ester; 14-Octadecenoic acid methyl ester; Trans-3-Octadecenoic acid methyl ester; Hexadecanoic acid methyl ester and Tridecanoic acid methyl ester) (Table 2). Although the identified volatile compounds were up to 21 (see supplementary materials), only five compounds had peak areas of ≥ 5% suggesting that they contributed significantly to the flavour of the processed cassava flour. Some alkanes also contributed to the flavour.

Table 2. Selected volatile compounds (peak area ≥ 5%) from flash-dried cassava flour obtained from cassava mash processed by stakeholders at Ogwuaniocha community.

Peak Number	Retention time	% Area (cm^2)	Identified compound

3	29.23	18.88	Hexadecanoic acid methyl ester; Tridecanoic acid methyl ester
4	30.89	6.67	9,12-octadecadienoic acid (Z,Z)- methyl ester; 9,12, Octadecanoic acid , methyl ester (E,E)-
5	30.91	35.74	11, Octadecenoic acid, methyl ester; 14-Octadecenoic acid methyl ester; Trans-3-Octadecenoic acid methyl ester
6	31.130	7.48	Heptadecanoic acid, 16-methyl-methyl ester Methyl stearate
19	33.505	6.70	Trimethylsilyl-di (trimethylsiloxy) –silane Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,-dodecamethyl-2,2,3,5,6,6,7-Heptamethyl [1,4,2,3,5,6,7] dioxapentasilepane

Microbial flora of cassava mash processed in Orashi River.

The probable organisms identified from the freshly prepared cassava mash were: Enterobacter spp; coagulase negative Staphylococcus (CONs), Bacillus spp and Lactobacillus spp.

The fungal isolates found were *Fusarium solani* and *Trichoderma* species. Table 2a shows the Bacterial and fungal loads of the cassava mash obtained from stakeholders in Ogwuaniocha community using their climate smart processing method.

Table 3a: Total Heterotrophic Bacterial and Fungal Load (cfu/g & cfu/ml) of the Samples

Samples	THBC	TFC	LAB Count	TCC
A	1.4×10^5	NG	NG	7.0×10^3
B	5.2×10^5	4.0×10^3	NG	2.0×10^3
S	1.8×10^5	2.0×10^3	4.0×10^3	2.0×10^3

THBC= Total Heterotrophic Bacterial Count; TFC= Total Fungal Count; cfu/g= colony forming unit per gram for the solid sample; LAB: Lactic acid bacteria count; TCC= total coliform count; cfu/ml: colony forming unit per milliliter for the water sample.

NG: No Growth; A = Water sample; B = Water sample from another location; S = Cassava sample; A and B: Water samples; S: Cassava sample

Table 3b. Macroscopic and Microscopic characteristics of the Fungal Isolates

Macroscopic features	Microscopic Characteristics	Fungal Isolate
White coloured colonies with cottony growth showing yellow pigments, raised mycelium	Long aerial unbranched conidiophores, slightly narrow towards the apex; oval septate producing conidia	*Fusarium solani*
Rapidly growing white colonies turning blue green with age	Septate hyphae, with conidia bearing heads borne on branched conidiophores. Conidiophores are large and branched.	*Trichoderma* species

Sample source	Associated Microorganisms
A	*Enterobacter* sp., *Bacillus* sp., CONs
B	*Enterobacter* sp., *Bacillus* sp., CONs, *Fusarium* sp
S	*Lactobacillus* sp., *Enterobacter* sp., *Bacillus* sp., CONs, *Trichorderma* sp., *Fusarium* sp

CONs: Coagulase Negative Staphylococcus: A = Water sample; B = Water sample from nearby location; S = Cassava sample

Colonial Morphology and Biochemical Features of the isolates
CONs: Coagulase Negative Staphylococcus; Na: Not Applicable

Colonial Description	Gram Status	Cell shape	Catalase test	Coagulase	Citrate	Oxidase	Indole	MR test	VP Test	H_2S	Likely Organisms
Lactose fermenting (pink) colonies on MCA plates	-ve	Rod	+ve	Na	-ve	-ve	-ve	-ve	+ve	+ve	*Enterobacter* species
Smooth yellow colonies on MSA plates	+ve	Cocci in clusters	+ve	-ve	na	Na	Na	Na	Na	-ve	CONs
Flat irregularly shaped creamy colonies on NA	+ve	Rods	-ve	Na	+ve	-ve	-ve	-ve	-ve	-ve	*Bacillus subtilis*
White mucoid slimy colony on MRS agar plate	+ve	Long Rod	-ve	Na	-ve	-ve	-ve	-ve	-ve	-ve	*Lactobacillus* sp

+ve: Positive; -ve: Negative; H_2S: Hydrogen sulphide Production; MR: Methyl Red test; VP: Voges-Proskauer Test

4.0 Discussion

4.1 Socio-economic status of cassava farmers in Ogwuaniocha community of the Niger Delta, Nigeria.

Most cassava farmers in Ogwuaniocha community of the Niger Delta region were uneducated females and were engaged in subsistence agriculture. They were relatively young and middle-aged married women with moderate household sizes of 6-10 people. Some had large family sizes which may be responsible for the inability of many families to store their cassava mash for a long time. This implies that they may have limited knowledge (based on their level of exposure to formal education) about improved varieties, adaptation and mitigation measures to improved agricultural practices. Opportunities for skills acquisition will enhance their adaptation measures and expose them to alternative coping strategies for climate change adaptation in the region.

4.2 Cassava processing and storage by famers in Ogwuaniocha community of the Niger Delta.

Results indicated that cassava farmers in this community depend very much on the Orashi River for their major processing operation (fermentation). Only very few farmers fermented their cassava tubers at home. Sieving the cassava mash after fermentation was undertaken by more farmers, but a significant number (up to 40%) still further processed their cassava into products without sieving the fermented mash. Before fermentation, the peeled cassava tubers were stacked in plain polypropylene bags and after fermentation the washed hand pulverized fermented mash were stacked in polyethylene lined propylene or polyolefin bags (suggesting improved protection for the fermented cassava product). Few farmers used HDPE bags.

4.3 Flavour compounds in fermented cassava mash and flour

Numerous aldehyde flavor compounds have been identified in dried cassava products. Non-fermented cassava flour had numerous acids. An undried cassava product (Inyange) had numerous esters that were not found in the dried product. 1,3-butanediol, 2-butanol, acetone, 2-butanone and acetic acid were relatively more abundant than other components in fresh cassava. 2-3 butanediol, benzeneethanol, nonanal, hexanal, acetoin and acetic acid were abundant in non-fermented cassava flour. 2-butanol, 1-hexanol, ethanol, hexanal, 2-butanone and acetic acid predominated after fermentation [15]. 1-pentanol, 1-hexanol, ethanol, nonanal, hexanal, decanal, octanal, 2-octenal and acetic acid dominated after drying. The major compounds depended on the cassava variety as well as the processing method. Processing cassava roots by soaking, heap fermentation and drying gave cassava products with different flavor compounds [16]. The drying process affects the flavour of cassava flour [17]. The volatile compounds 2-octenal, 3, 5-octadien-2-one, nonanal and 2-decenal are associated with the green, fat, aldehyde and waxy flavors, (respectively), in flour [18]. Aldehydes and ketones are common flavour compounds associated with cassava starch [18] and are lipid degradation products. The type of food product and the processing operations determine the flavour volatiles obtainable [19-21].

The esters, many of which have attractive aromas, emanate from chemical reactions between microbial acidic and alcoholic metabolites which are probably produced by microbial esterases [22]. Alkanes and alkenes are readily formed from lipid hydroperoxides by the β-scission of alkoxy radicals to give alkyl radicals [23]. 1,3-butanediol, 2-butanol, acetone, 2-butanone and acetic acid were relatively more abundant than other components in fresh cassava. In another research on the volatiles of cassava flakes and garri, guaiacol, 3-methylbutanal, methylpropanal, and butyric acids contributed intensely to the characteristic aroma of the two products. Twenty-one odourants were identified. They exhibited an array of odour notes such as malty, rancid/buttery, popcorn, balsamic, mushroom, ammonia-like, chocolate, cocoa-like, and fatty. Odorants such as 2-acetylpyrroline and 1-octen-3-one, were found in high concentrations in the products, but produced relatively low odour volatiles, suggesting that they did not contribute significantly to the overall aroma of cassava flakes and garri [24]. The volatiles produced by the flavor compounds rather than their concentrations determine their contribution to the overall aroma of the product.

4.4 Microbial quality of the cassava mash processed in Urashi River by cassava farmers.

The terminology Coagulase negative Staphylococci (CONs) is used to clinically differentiate between S*taphylococcus aureus* from the less pathogenic strains of Staphylococci. *S. epidermidis* and *S. haemolyticus* are the most important CONs species. CONs account for many foreign bodies related food infections. *S. saprophyticus* has been associated with urethritis, *S. lugdunensis* (which resembles *S. aureus* in some respects) is associated with infectious endocarditis. Many strains of CONs are methicillin-resistant and are not very susceptible to glycopeptides [25]. Trichoderma species are considered not harmful but offer protection against some other bacteria and fungus. *Trichoderma harzianum* Rifai (Strain T-39) is a naturally occurring fungus that is used to protect crops from the harmful gray mold, *Botrytis cinerea*. It has not been observed to cause disease or any adverse health effects to humans. It is not also harmful to the environment. However, Trichoderma spp. are common pathogenic fungi for edible mushrooms. They can grow on mushroom beds and finally cover the entire substrate [26]. Water samples from some locations at the

Urashi River did not indicate any growth of Lactic acid Bacteria and Fungus while water samples from other locations (nearer the bank of the river) housed Lactic acid Bacteria and fungus. WHO standards stipulates that the heterotrophic bacterial load of potable water should not be more than 100cfu/ml (WHO, 2006). Water from Orashi River is therefore unsuitable for use as potable water.

Conclusion

The Ogwuaniocha cassava farmers have an interesting adaptation strategy to combat periodic over-flooding of their farms by modifying their processing and storage methods and periods. The quality of the cassava mash they produce is acceptable compared to other local standards. However, the product contains less pathogenic strains of Staphylococcus species, which although not as virulent as *Staphylococcus aureus*, may be associated with incidences of urethritis and infectious endocarditis. They need more accurate prediction of precipitation data and need to diversify their coping strategies for improved climate change adaptation.

Funding. This research did not receive any funding.

Informed consent statement. Informed consent was obtained from all subjects involved in the study.

Data Availability Statement. The data presented in this study are available in the supplementary materials document titled 'Supplementary materials for FULL PAPER-FARA CONFERENCE'.

Philippa C Ojimelukwe conceptualized the research and prepared the manuscript. Doris Akachukwu designed the questionnaire and validated it. Doris Akachukwu, Uche Tasie and Nkechi Louisa Daniel participated in sample collection and questionnaire administration. Chinechendu Ubadire-Agua and Maureen Theodore-Ojinnaka assisted with analyses.

Acknowledgments: We acknowledge the support of Mrs Patricia Esiobu and Mr Collins Nwabugwu in facilitating our research activities in this community.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix

Supplementary materials

Volatile compounds from flash dried cassava flour processed by stakeholders at Ogwuaniocha community.

Peak Number	Retention time	% Area (cm2)	Identified compound
1	20.64	0.08	Undecanoic acid, 10 methyl-1-ester; Methyl 8 methyl-nonanoate; Methyl tetradecanoate
2	25.32	0.64	Nonanoic acid methyl ester; Octanoic acid methyl ester Tetradecanoic acid, 12-methyl methyl esters
3	29.23	18.88	Hexadecanoic acid methyl ester;Tridecanoic acid methyl ester
4	30.89	6.67	9,12-octadecadienoic acid (Z,Z)- methyl ester; 9,12, Octadecanoic acid , methyl ester (E,E)-
5	30.91	35.74	11, Octadecenoic acid, methyl ester; 14-Octadecenoic acid methyl ester; Trans-3-Octadecenoic acid methyl ester
6	31.130	7.48	Heptadecanoic acid, 16-methyl-methyl ester Methyl stearate
7	31.568	1.19	9,12, Octadecanooic acid (Z,Z)-methyl ester; Methyl-11 – (12-cyclopenten-1-yl) undecanoate 4-undecyne
8	32.251	2.09	Octadecanenitrile; 10-Heneicosene (c,t) 3-Octadecene (E)-
9	32.303	0.55	Octasiloxane 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl Ethyl-2-butyramido-3,3,3-trifluoro-2- (4-fluoroanilino) propionate
10	32.396	2.81	Estradiol, 2 TMS derivative L-Hydroxyproline 3TBDMS derivative

11	32.427	1.08	Thiosemicarbazide,4- (-1-adamantyliccarbonyl)- 3,4-seco-5.alpha-cholestan-3-oic acid, 4-hydroxy-4-methyl-, epsilon-lactone (4R) Acetamide, N- (adamantan-1-yl) propyl 1-2- (-5—phenyltetrazol-2-yl) -
12	32.460	1.48	1,3-Bis (dimethylamino) -2,2,4,4-tetraki 5(trifluoromethyl) -1,3-diazacryclobutane Alizarin yellow GG,OO′ di (trimethylsilyl)-3,4-Seco-5.alpha.cholestan-3-oic acid, 4 hydroxy-4-methyl-epsilon-lactone (4R)
13	32.548	1.26	Octasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl- Furazo[3.4.-6] pyrazine-5 (4H) –one,6- (1-pyrrolidinyl)-3,4- Methylenedioxyphenyllactic acid OO′-bis (trimethylsily)-
14	32.567	1.36	Oleic acid; Octadec-9-enoic acid 2-Methyloctadeca-7,8-diol bis (trifluoroacetate)
15	32.737	1.61	2,4,6 Trimethylalanine, N, N-di (trifluoroacetyl) Ethyl 5- (furan-2-yl) -1,2 - - oxazole-3-carboxylate 1- (Pyrrolidin-1-yl) cyclopentane-1-carbonitrile
16	32.935	2.49	Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11-dodecamethyl- Heptasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13 tetradecamethyl- Succinic acid, 4-chloro-3-methylphenyl 2methoxy phenyl ester
17	33.033	1.17	Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11-dodecamethy- Octasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15, hexadecamethyl-3-Isopropoxy) tetrasiloxane
18	33.103	4.11	Norcodeine, 2TMS derivative 9-chloro-4,5-dihydro-4[4[trifluoromethy] phenyl] 3-H-isoxalo [3,4,5-k]acridin-6-yl acetate Norcodeine, N-trimethylsilyl-di (trimethylsiloxyy)-silane
19	33.505	6.70	Trimethylsilyl-di (trimethylsiloxy) –silane Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,-dodecamethyl-2,2,3,5,6,6,7-Heptamethyl [1,4,2,3,5,6,7] dioxapentasilepane
20	33.668	1.75	1,4-Phthalazinedione,2,3-dihydro-6-nitro-4H-1,2,4-triazole-3,5-diammine, N3 (4-fluorophenyl)-N5-methyl-Trimethylsilyl-di (trimethylsiloxy)-silane
21	34.358	0.52	Furazanol [3.4-6] pyrazine-5 (4H) – one,66-(1-pyrroidinyl)-Phenytoin, 2TBDMS derivative 1,4-Cyclohexadiene, 1,3,6-tris (trimethylsilyl)-
22	34.917	0.32	4-Acetyloxyimino-6,6-dimethyl-3-methylsulfonyl-4,5,6,7-tetrahydro-benzo[c] thiophene-1-carboxylic acid methyl ester Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11, dodecamethyl- Heptasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13-tetradecamethyl-

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