



## GC-MS Characterization of Unsweetened and Sweetened “Kunun-zaki” Beverage and Pulp

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### Authors' contributions

*This work was carried out in collaboration among all authors. Author EEE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AEU and JMN managed the analyses of the study. Authors EHKN managed the literature searches. All authors read and approved the final manuscript.*

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### ABSTRACT

**Aims:** To characterize unsweetened and sweetened “kunun-zaki” drink/pulp using GC-MS.

**Study Design:** The experimental groups were divided into four: unsweetened “kunun-zaki” drink, sweetened “kunun-zaki” drink, unsweetened “kunun-zaki” pulp and sweetened “kunun-zaki” pulp respectively.

**Place of Study:** Department of Biochemistry, Federal University of Lafia, Nasarawa State and Central Diagnostic and Research Laboratory, Ilorin, Nigeria.

**Methodology:** The processes involved sorting, cleaning, soaking, decanting, washing, milling, gelatinization, fermentation, and sieving. Unsweetened “kunun-zaki” beverage was made from millet, sorghum, soybean, dried sweet potatoes, germinated rice, ginger, and cloves. The same process was followed for the sweetened variety, with addition of dried dates. After sieving to collect “kunun-zaki” beverage, the remnant was the pulp. Hydrodistillation and Soxhlet apparatus were

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used to extract the essential oils, and fatty acids respectively. Fatty acid methyl esters of the samples were then analysed using GC-MS.

**Results:** The GC chromatogram identified three constituents in unsweetened “kunun-zaki” drink. The dominant constituents were 9,12-octadecadienoic acid (z,-) (73.36%), and n-hexadecanoic acid (19.31%). Eleven compounds were identified in sweetened “kunun-zaki” drink. The most abundant was 9, 12-octadecadienoic acid (Z,Z)- 54.062%, followed by n-hexadecanoic acid (17.278%). Twenty-one peaks corresponding to eighteen compounds were detected in unsweetened “kunun-zaki” pulp. The dominant constituents were gingerol (20.262%), 1H-3a,7-methanoazulene,2,3,4,7,8,8a-hexahydro-3,6,8,8-teramethyl-,[3R-(3 $\alpha$ ,3a $\beta$ ,7  $\beta$ ,8a $\alpha$ )]- (19.925%), 2-Butanone,4-(4-hydroxy-3-methoxyphenyl)- (15.59%), and cedrene (10.977%). For sweetened “kunun-zaki” pulp, four compounds were detected. The dominant compounds being 9,12-octadecadienoic acid (z,z)- (68.664%), n-hexadecanoic acid (18.654%), and oleic acid (10.199%).

**Conclusion:** The results showed safe fatty acid profile of all samples for different health status. Other components showed bioactivities with significant health benefits. This study identified compounds which validate the medicinal claims of “kunun-zaki.” This is the first documentation of GC-MS profiling of “kunun-zaki” parts.

**Keywords:** “Kunun-zaki”; GCMS; volatile compounds; essential oils; fatty acids; phytochemistry; cereal; multigrain beverage.

## 1. INTRODUCTION

Cereal-based fermented foods contribute immensely to the nutrition, and economy of Africa [1]. Cereals are important sources of food in developing countries, including Nigeria [2]. According to “the UN Food and Agriculture Organization,” by year 2027, consumption of cereals will increase globally [3]. Cereals are high in nutrients, and are processed into ready-to-eat meals, and food drink. One of such food drinks produced from millet, and sorghum or maize is “kunun-zaki” [4-6].

“Kunun-zaki” is a refreshing multi-grain non-alcoholic beverage [7,8]. In addition to cereals, sweet potatoes, sprouted rice, maize, ginger, and other ingredients are added in different proportions [9,10]. “Kunun-zaki” is taken unsweetened, or sweetened with sugar, and other agents like “saccharin, aspartame, cyclamate, and acesulfame K” [11]. The nutritional profile of “kunun-zaki” was reported by [9,12,13]. In addition to results from the previous authors, high calorie, low protein, and fat contents of the drink were documented by [14–19,20].

“Kunun-zaki” is a weaning [17,20,21] and “complimentary food for infants” [10]. It is also consumed by people of different ages, and health status. According to [14], “kunun-zaki” is a purgative, which ameliorates flatulence. It enhances lactation [16], and has antioxidant

properties [10,22]. “Kunun-zaki” is an immune-booster, aids digestion, and absorption of nutrients [21]. These attributes are not unconnected with its bioactive compounds.

After extracting “kunun-zaki” drink, the solid part left is the pulp. This pulp is usually thrown away, used as manure or recycled into animal feed. This discarded pulp could be a food source of compounds with immense health benefits. However, there is no data on the volatile constituents of the drink, and its pulp before/after sweetening with dates. It was proposed that evaluating the volatile constituents of “kunun-zaki” will substantiate the medicinal claims of the drink and bridge the information gap on the pulp metabolites. This study was thus carried out to evaluate the volatile constituents of unsweetened/date-sweetened “kunun-zaki” beverage, and their respective pulps.

## 2. MATERIALS AND METHODS

### 2.1 Raw Materials

Millet (*Pennisetum glaucum L.*), sorghum (*Sorghum bicolor*), soybean (*Gycine max*), dried sweet potatoes (*Ipomoea batates*), germinated rice (*Oryza sativa*), ginger (*Zingiber officinale*), dried dates (*Pheonix dactylifera L.*), cloves (*Syzygium aromaticum*), were used. They were bought from Ta'al Modern market in Lafia Local Government, Nasarawa State- Nigeria.

## 2.2 Preparation of “Kunun-zaki” Beverage and Pulp

Preparation of “kunun-zaki” involved sorting, cleaning, soaking, decanting, washing, milling, gelatinization, fermentation, and sieving [23]. 135 g (millet), 600 g (soybean), and 1500 g (sorghum) were sorted to get rid of debris. They were washed, and soaked in 10 litres of distilled water for 12 hours at room temperature. Water was decanted from the soaked grains, before washing again. The grains were wet-milled with 4 litres of distilled water to form the first paste. 600 g (dried sweet potatoes), 400 g (germinated rice), 120 g (ginger), and 80 g (cloves) were washed, and wet-milled to give the second paste. 3 litres of water at 100°C was poured into the first paste to gelatinize it. The second paste was immediately added to the hot gelatinized paste. The hot mixture of both pastes was stirred till it became thick. This thick paste was heated for 3 minutes to get a thicker consistency, and allowed to ferment overnight at room temperature for 12 hours. The fermented paste was sieved using a 350 µm diameter mesh, to get “kunun-zaki” beverage. The solid remnant was the pulp. The same process was followed to obtain the sweetened samples. However, 500 g of dried dates was added to the second mixture before wet-milling. The four samples (unsweetened/ sweetened “kunun-zaki” beverage and their respective pulps) were stored at 4°C for further analyses.

## 2.3 Extraction of Oils

Exactly 350 g aliquots of each sample were subjected to hydro distillation for 3 hours with a Clevenger-type apparatus to get the essential oil.

## 2.4 Extraction of Fatty Acid Methyl Ester for GC-MS Analysis

Exactly 50 mg of extracted essential oil from the samples were saponified at 95°C for 5 minutes with 3.4 ml 0.5 M KOH in dry methanol. The mixture was neutralized with 0.7 M HCl, then 3 ml of 14% boron trifluoride in methanol was added. For complete methylation, the mixture was heated at 90°C for 4 minutes. Redistilled n-hexane was used thrice to extract fatty acid methyl esters (FAME) from the mixture. 1 ml of the extracted FAME was concentrated for GC analysis, while 1 µL was injected into the injection port of same instrument.

## 2.5 GC-MS Conditions for Analyses of Fatty Acid Methyl Esters (FAME)

Analyses of FAME was done with GC-MS according to the manufacturer’s instruction. The gas chromatography equipment was gotten from Agilent USA. GC was hyperated to a mass spectrophotometer (5975C) with triple axis detector equipped with 10 µL syringe auto injector. Helium was used as the carrier gas. Chromatographic separations were carried out on a capillary column treated with phenyl methyl silox. The column specifications are: 0.2 µm internal diameter, 250 µm thickness, and 30 m length. Other GC-MS conditions were pressure: 16.2 psia, interface temperature: 300°C, ion source temperature (EI): 250°C. Others included out time: 1.8 mm, 1µl injector in Split mode with ratio 1:50 with injection temperature: 300°C. The temperature of the column started at 35°C for 5 mins, and increased to 150°C at 4°C/min. The temperature was then raised to 250°C at 20°C/min, and maintained for 5 minutes. The total elution time was 47.5 mins. This system was controlled. The data was gotten with the MS solution software provided by the supplier. The machine model was 7890A GC system, 5675C Inert MSD with triple- Axis detector. Column; Agilent 19091-433HP-5Ms 5% phenyl methyl silox.

## 2.6 Identification of Compounds

Identification of compounds was done by comparing the mass spectra obtained with that of standard mass spectra from NSIT library (NISTII).

## 3. RESULTS

### 3.1 GC-MS Analysis for Unsweetened “Kunun-zaki” Drink

Fig. 1 represents the GC chromatogram for unsweetened “kunun-zaki” drink. Table 1 shows the retention time, compounds, classification, peak concentration (%), molecular formula (MF), and molecular weight (MW) of constituents. Fig. 2 represents the structures of compounds listed in Table 1. The result revealed three FA, and a FA ester. The compounds included n-hexadecanoic acid, hexadecanoic acid, ethyl ester, 9,12-octadecadienenoic acid (z,-), and oleic acid. The first two were saturated fatty acids (SFA). Others were polyunsaturated fatty acid (PUFA), and monounsaturated fatty acids

(MUFA) respectively. PUFA was the most abundant (73.36%), followed by MUFA (23.44%), and SFA (3.2%).

### 3.2 GC-MS Analysis for Sweetened “Kunun-zaki” Drink

Fig. 3 represents the GC chromatogram for sweetened “kunun-zaki” drink. Table 2 shows details of identified constituents. Fig. 4 shows the structures of compounds presented in Table 2.

Eleven constituents were identified. They belonged to sesquiterpene, FA, esters, acid, and steroid. 9, 12-octadecadienoic acid (Z,Z)- was the dominant compound (54.062%), followed by n-hexadecanoic acid (17.278%), and trans-13-octadecenoic acid (6.665%). Other compounds are presented on Table 2. However, in decreasing order, the identified group of constituents are PUFA>SFA>ester>acid>steroid>MUFA>sesquiterpene.

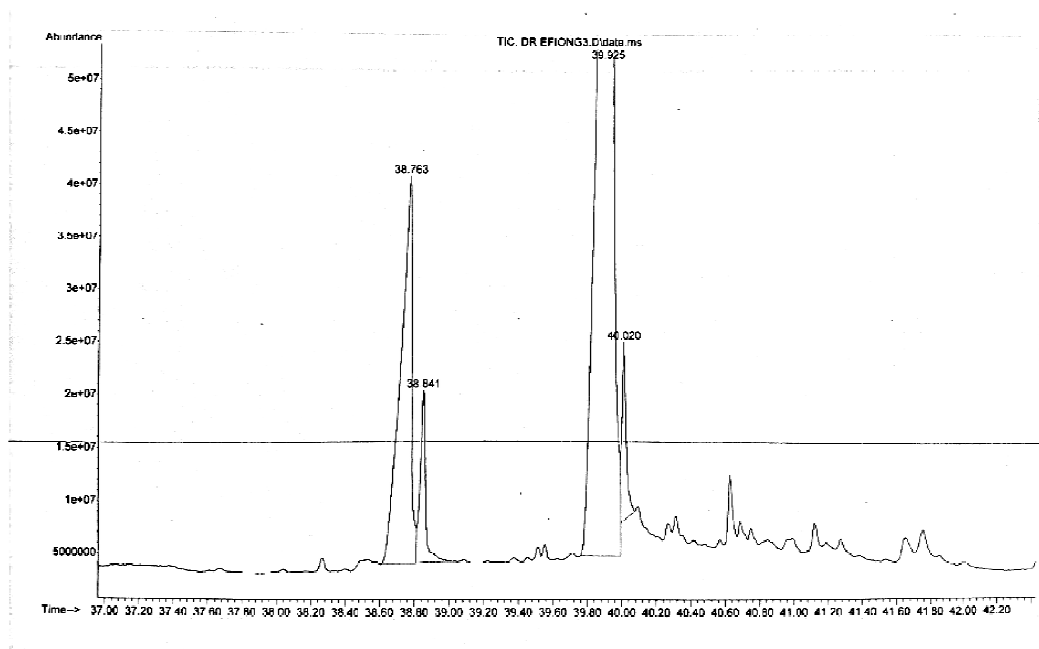


Fig. 1. GC Chromatogram for unsweetened “kunun-zaki” drink

Table 1. GC-MS detail of unsweetened “kunun-zaki” drink

S/ No	RT (min)	Compounds	Class	% Conc	MF	MW
1	38.763	n-Hexadecanoic acid	SFA	19.31	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	256.42
2	38.841	Hexadecanoic acid, ethyl ester	SFA ester	4.13	C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>	284
3	39.925	9,12-Octadecadienoic acid (Z,-)	PUFA	73.36	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280.4
4	40.020	Oleic acid	MUFA	3.20	C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>	282.5

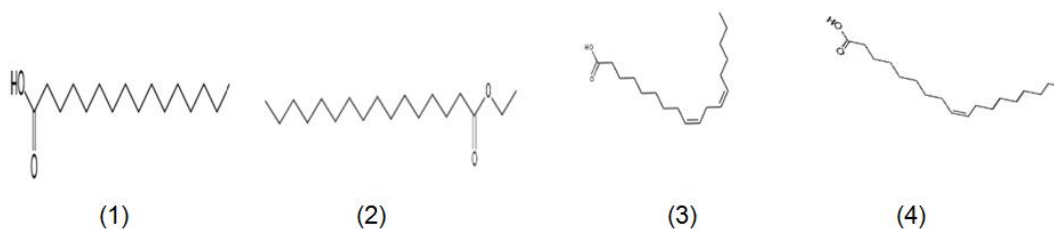


Fig. 2. Structures of compounds identified in Table 1

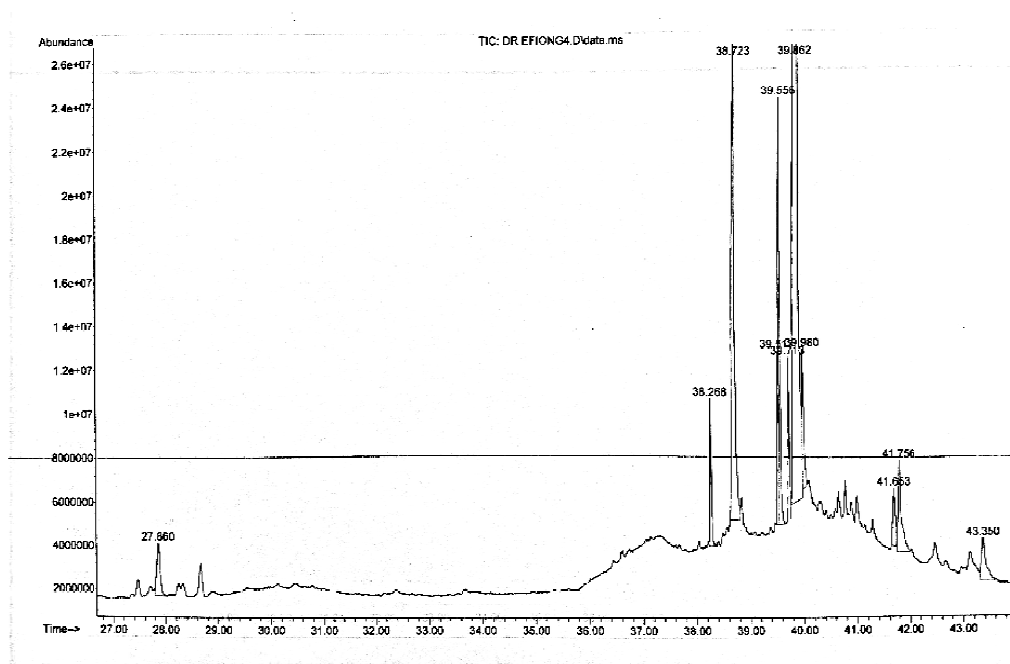


Fig. 3. GC Chromatogram for sweetened “kunun-zaki” drink

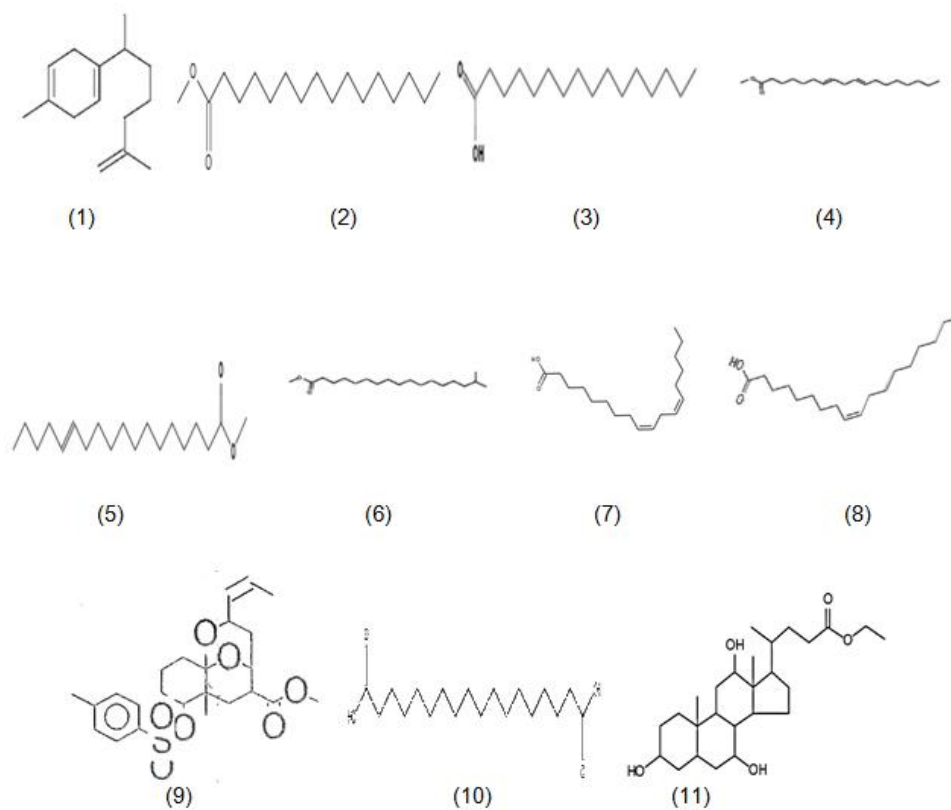


Fig. 4. Structures of compounds identified in Table 2

Table 2. GC-MS details of sweetened “Kunun-zaki” drink

S/No	RT (min)	Compounds	Class	% Conc	MF	MW
1	27.860	$\beta$ -curcumene	Sesquiterpene	2.450	C <sub>15</sub> H <sub>24</sub>	204.35
2	38.268	Hexadecanoic acid, methyl ester	SFA ester	2.977	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>	270.45
3	38.723	n-Hexadecanoic acid	SFA	17.278	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	256.42
4	39.517	7,10- octadecadienoic acid, methyl ester	PUFA ester	2.682	C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>	294.5
5	39.556	Trans-13-octadecenoic acid, methyl ester	MUFA ester	6.665	C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>	296.48
6	39.713	Heptadecanoic acid,-16-methyl-, methyl ester	SFA ester	2.586	C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>	298.5
7	39.862	9,12-Octadecadienoic acid (Z,Z)-	PUFA	54.062	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280.4
8	39.980	Oleic acid	MUFA	2.504	C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>	282.5
9	41.653	6-methyl-11-propenyl-5-(toluene-4-sulfonyloxy)-12,13-dioxatricyclo(7.3.1.0(1.6))tridecane-8-carboxylic acid, methyl ester	Ester	2.039	C <sub>14</sub> H <sub>22</sub> O <sub>5</sub>	270
10	41.756	Octadecanedioic acid	Acid	4.112	C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>	314.5
11	43.350	Ethyl iso-allocholate	Steroid derivative	2.645	C <sub>26</sub> H <sub>44</sub> O <sub>5</sub>	436.3

Table 3. GCMS Details of Unsweetened “Kunun-zaki” Pulp

S/ No	RT (min)	Compound	Class	% Conc	MF	MW
1	18.606	Decanal	Aldehyde	1.252	C <sub>10</sub> H <sub>20</sub> O	156.26
2	27.357	β-copaene	Sesquiterpene	2.551	C <sub>15</sub> H <sub>24</sub>	204.35
3	27.475	6-(p-Tolyl)-2-methyl-2-heptenol,trans-	Sesquiterpene	4.252	C <sub>15</sub> H <sub>22</sub> O	218
4	27.710	Benzene,1-(1,5-dimethyl-4-hexenyl)-4-methyl- or α-Curcumene	Sesquiterpene	3.261	C <sub>15</sub> H <sub>22</sub>	202.33
5	27.875	1H-3a,7-methanoazulene,2,3,4,7,8,8a-hexahydro-3,6,8,8-teramethyl-,[3R-(3α,3aβ,7 β,8α)]- or α-cedrene	Sesquiterpene	19.925	C <sub>15</sub> H <sub>24</sub>	204.35
6	28.244	β-Bisabolene	Sesquiterpene	4.352	C <sub>15</sub> H <sub>24</sub>	204.35
7	28.331	α-Farnesene	Sesquiterpene	3.855	C <sub>15</sub> H <sub>24</sub>	204.35
8	28.676	Cedrene	Sesquiterpene	10.977	C <sub>15</sub> H <sub>24</sub>	204.35
9	31.473	β-Guaiene	Sesquiterpene	0.604	C <sub>15</sub> H <sub>24</sub>	204.35
10	32.321	2-Butanone,4-(4-hydroxy-3-methoxyphenyl)- or zingerone	Ketone	15.590	C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>	194.23
11	36.705	Propanoic acid,2-methyl,(dodecahydro-6a-hydroxy-9a-methyl-3-methyene-2,9-dioxoazuleno[4,5-b]furan-6-yl) methyl ester	Sesquiterpene	0.862	C <sub>19</sub> H <sub>26</sub> O <sub>6</sub>	350.4
12	37.655	Fenretinide or Cedren-13-ol, 8-	Retinoid derivative	0.967	C <sub>26</sub> H <sub>33</sub> NO <sub>2</sub>	391.5
13	38.260	Hexadecanoic acid, methyl ester	SFA ester	2.183	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>	270.45
14	39.517	Cyclopropanebutanoic acid,2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cyclopropyl]methyl]cyclopropyl]methyl]-,methyl ester	PUFA ester	1.263	C <sub>25</sub> H <sub>42</sub> O <sub>2</sub>	374.59
15	39.556	Hexadecanoic acid, 14-methyl, methyl ester	SFA ester	0.828	C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>	284.5
16	39.713	Methyl stearate	SFA	0.794	C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>	298.5
17	40.271	Gingerol	Ketone	5.723	C <sub>17</sub> H <sub>26</sub> O <sub>4</sub>	294.4
18	40.624	Gingerol	Ketone	11.935	C <sub>17</sub> H <sub>26</sub> O <sub>4</sub>	294.4
19	41.127	Gingerol	ketone	2.604	C <sub>17</sub> H <sub>26</sub> O <sub>4</sub>	294.4
20	41.756	Ethyl iso-allocholate	Steroid derivative	3.034	C <sub>26</sub> H <sub>44</sub> O <sub>5</sub>	436.3
21	43.358	Ethyl iso-allocholate	Steroid derivative	3.187	C <sub>26</sub> H <sub>44</sub> O <sub>5</sub>	436.3

### 3.3 GC-MS Analysis for Unsweetened “Kunun-zaki” Pulp

Fig. 5 shows the chromatogram for unsweetened “kunun-zaki” pulp. Twenty-one peaks were detected from the chromatogram peaks. Details of the detected compounds are on Table 3. Fig. 6 shows structure of constituents listed on Table 3. These compounds are grouped in decreasing abundance as sesquiterpene>steroid derivative>esters>aldehyde>retinoid derivative>SFA. Their corresponding concentrations are (50.639, 35.852, 6.221, 4.274, 1.252, 0.794, and 0.967)% respectively. The most abundant constituent was gingerol (20.262%), followed by 1H-3a,7-methanoazulene,2,3,4,7,8,8a-hexahydro-3,6,8,8-teramethyl-,[3R-(3 $\alpha$ ,3 $\alpha$  $\beta$ ,7  $\beta$ ,8 $\alpha$ )]- or  $\alpha$ -cedrene (19.925%).

### 3.4 GC-MS Analysis for Sweetened “Kunun-zaki” Pulp

Fig. 7 shows the chromatogram for sweetened “kunun-zaki” pulp. Four peaks were detected

from the chromatogram. The compounds in decreasing order of their abundance are 9, 12-octadecadienoic acid (Z,Z)- (68.664%), n-hexadecanoic acid (18.654%), oleic acid (10.199%), and 6-(p-Tolyl)-2-methyl-2-heptenol, trans- (2.484%). The details for these compounds are on Table 4, while their structures are shown in Fig. 8.

## 4. DISCUSSION

9, 12-octadecadienoic acid (z,-) the most dominant compound from Table 1 prevents cardiovascular diseases, ulcerative colitis, rheumatoid arthritis, and reduces cholesterol [24]. The antimicrobial [25], hepato-protective [26], anti-inflammatory, and anti-arthritis properties have been reported [27]. The compound also possesses anti-cancer [28], antioxidant, anti-arteriosclerotic, anti-androgenic, anti-acne, anti-eczemic, anti-histaminic, inhibitor of 5-alpha reductase, anti-prostatic, anti-anaphylactic, insectifuge, nematicide [29], and hepato-protective potentials [26].

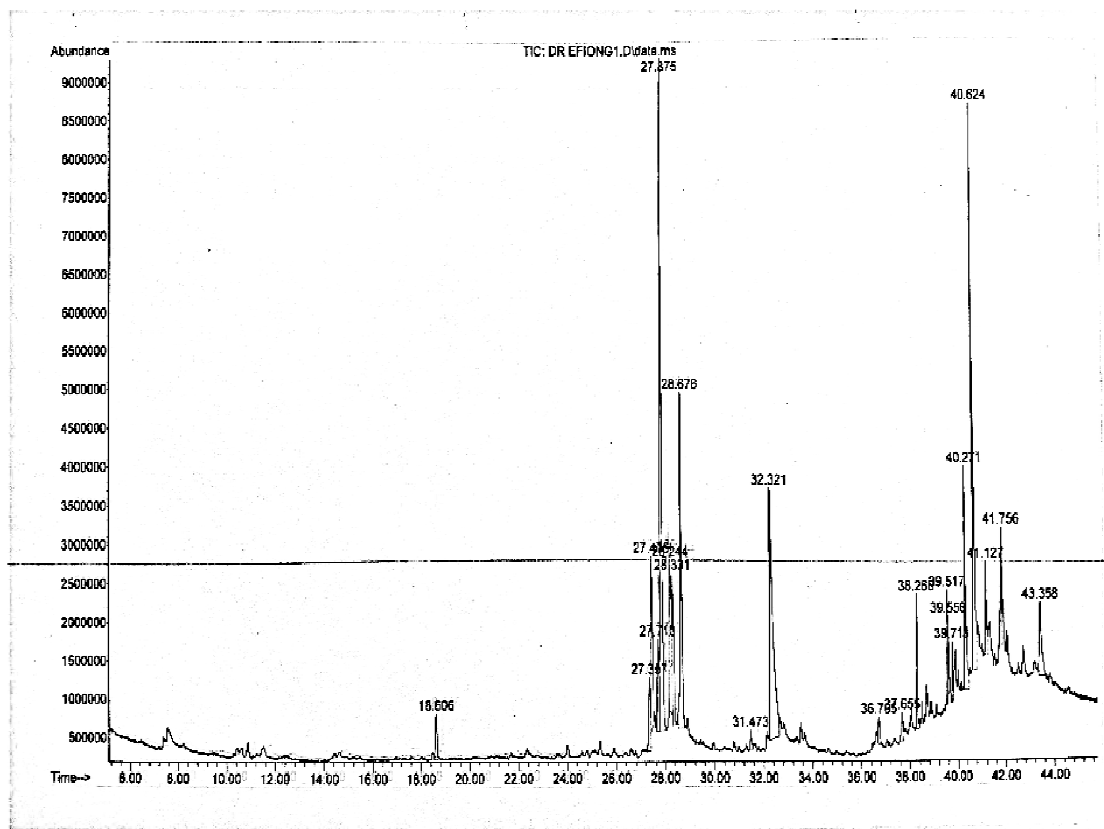
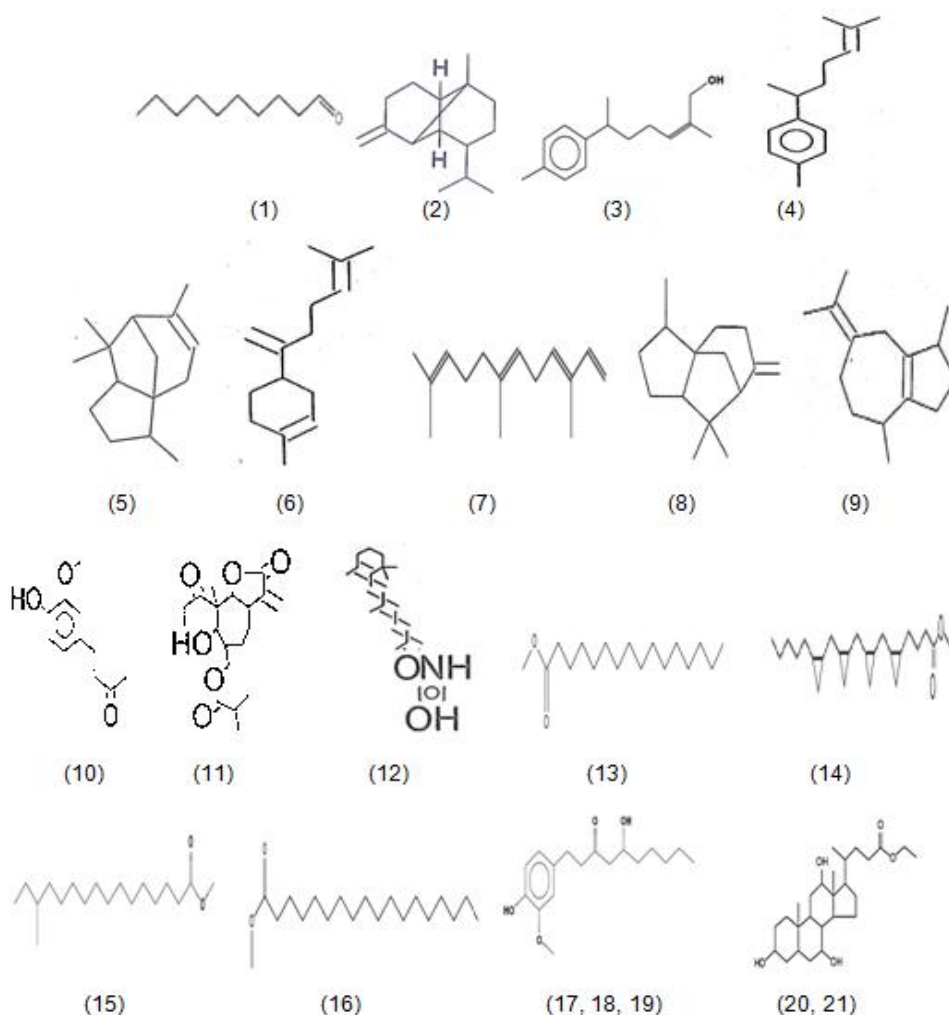


Fig. 5. GC Chromatogram for unsweetened “kunun-zaki” pulp





**Fig. 6. Structures of compounds identified in Table 3**

$\beta$ -curcumene detected in sweetened “kunun-zaki” drink was reported to possess antifungal activity [34] (Table 2). Hexadecanoic acid, methyl ester is a flavouring agent, with hypocholesterolemic, antioxidant [35], anti-fungal [36], anti-inflammatory, anti-cancer, hepatoprotective, anti-androgenic, anti-acne, anti-eczemic, insectifuge, nematocide, antihistaminic, alpha reductase inhibitor, anti-arthritis, and cardio-protective effects [37]. Heptadecanoic acid, -16-methyl-, methyl ester was observed to have antimicrobial, antioxidant, anti-inflammatory [29], and anti-fungal activities [36]. According to [38,39], the compound also fights the protein of skin cancer.

Also identified in sweetened “kunun-zaki” drink from Table 2, was Octadecanedioic acid. Although, there is scanty documentation on its

biological activity, [40] observed its anti-tumour activity when “monoconjugated to paclitaxel (PTX).” Additionally, Ethyl iso-allocholate also detected in the sweetened drink showed antimicrobial activity [41,42]. The biological function of n-Hexadecanoic acid, 9,12-Octadecadienoic acid (Z,Z)- and oleic acid also identified in the sample was discussed above. However, the biological role of three constituents have not been recorded. They are 7, 10-octadecadienoic acid, methyl ester, Trans-13-octadecenoic acid, methyl ester, and 6-methyl-11-propenyl-5-(toluene-4-sulfonyloxy)-12,13-dioxatricyclo(7.3.1.0(1.6))tridecane-8-carboxylic acid, methyl ester.

Compounds detected in unsweetened “kunun-zaki” pulp are documented on Table 3. Decanal has antioxidant, and anti-Salmonella activity [43].

$\beta$ -copaene was observed to have anti-inflammatory, antioxidant, anti-hyperglycemic, anti-fungal, anti-parasitic, anti-viral, antimicrobial, anti-allergenic, anti-cancer, immune modulatory, and anti-spasmodic activities [44–46]. They are also involved in production of steroid hormones, cholesterol, pharmaceutical agents, vitamin D, and cosmetics [37]. 6-(p-Tolyl)-2-methyl-2-heptenol,trans- is an antioxidant [47]. Benzene,1-(1,5-dimethyl-4-hexenyl)-4-methyl- or  $\alpha$ -Curcumene possess anti-inflammatory, antimicrobial [43], insect repellent, and inhibitory

effects on acetylcholinesterase [47]. 1H-3a,7-methanoazulene,2,3,4,7,8,8a-hexahydro-3,6,8,8-teramethyl-,[3R-(3 $\alpha$ ,3 $\alpha\beta$ ,7  $\beta$ ,8 $\alpha\alpha$ )]- or  $\alpha$ -cedrene is larvicidal [48], and hepato-protective [49]. It is involved in maintenance of muscle mass, and strength [50]. Its anti-leukaemic, trypanocidal, anti-obesity effects were also observed [51].  $\beta$ -Bisabolene is a flavouring agent [52] with antimicrobial activity [53].  $\alpha$ -Farnesene, Cedrene, and  $\beta$ -Guaiene have antioxidant [46], anti-cancer [31], and anti-inflammatory properties [54] respectively.

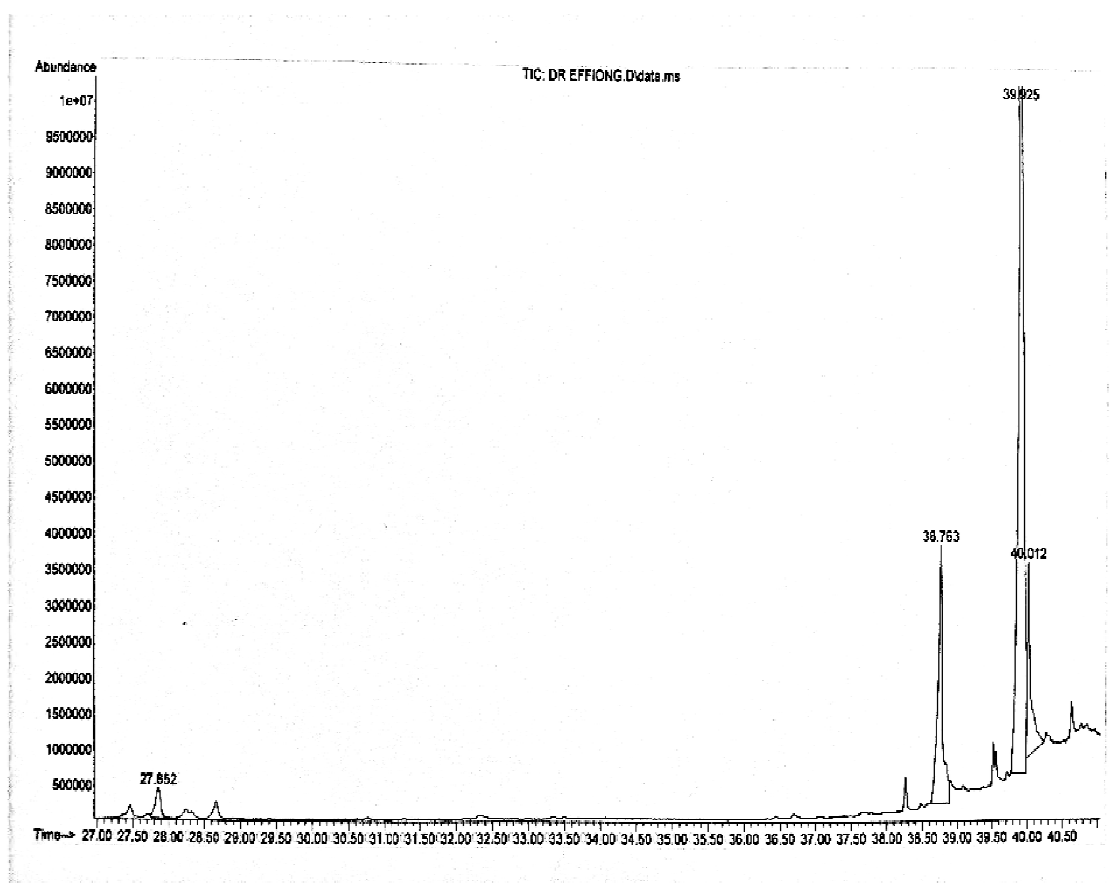
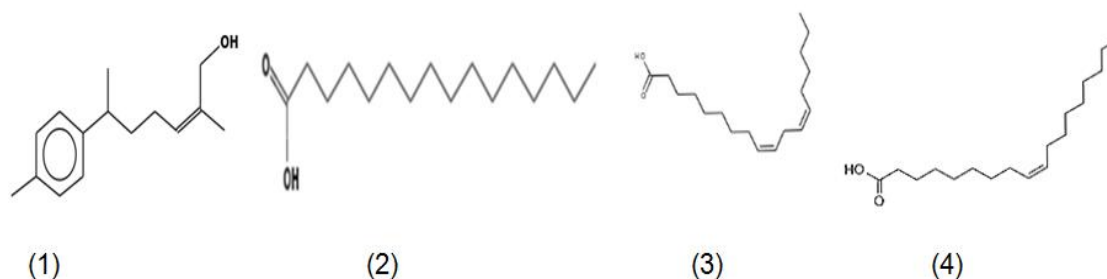


Fig. 7. GC Chromatogram for sweetened “kunun-zaki” pulp

Table 4. GCMS details of unsweetened “kunun-zaki” pulp

S/ No	RT (min)	Compound	Class	% Conc	MF	MW
1	27.852	6-(P-Tolyl)-2-methyl-2-heptenol,trans-	Sesquiterpene	2.484	C <sub>15</sub> H <sub>22</sub> O	218
2	38.762	n-Hexadecanoic acid	SFA	18.654	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	256
3	39.925	9,12-Octadecadienoic acid (Z,Z)-	PUFA	68.664	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280
4	40.012	Oleic acid	MUFA	10.199	C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>	282



**Fig. 8. Structures of compounds identified in Table 4**

Other compounds identified in unsweetened “kunun-zaki” pulp (Table 3) include 2-Butanone,4-(4-hydroxy-3-methoxyphenyl)- or zingerone (a flavouring agent) with known hypoglycemic, antioxidant, hypocholesterolemic, anti-inflammatory [55], and hepato-protective effects [56]. The antibiotic activity of Propanoic acid,2-methyl,(dodecahydro-6a-hydroxy-9a-methyl-3-methyene-2,9-dioxoazuleno[4,5-b]furan-6-yl) methyl ester was documented [57]. Also detected in unsweetened “kunun-zaki” pulp was Fenretinide or Cedren-13-ol, 8- with reported anti-cancer, anti-tumour, and antineoplastic activities [43]. The function of Hexadecanoic acid, methyl ester was discussed above. There is no reported activity for Cyclopropanebutanoic acid, 2-[[2-[(2-pentylcyclopropyl)methyl]cyclopropyl]methyl]cyclopropyl]methyl]-,methyl ester. The compound Hexadecanoic acid, 14-methyl, methyl ester is a flavouring agent with hypocholesterolemic, antioxidant [35], anti-inflammatory, anti-cancer, hepato-protective, anti-androgenic, anti-acne, anti-eczemic, insectifuge, nematicide, anti-histaminic, 5-alpha reductase inhibitory, anti-arthritis, cardio-protective effects [37]. Others include antifungal, antibacterial, anti-fibrinolytic, hemolytic, lubricant, and antiallo-pecic properties [29]. The antibacterial [58], and antifungal properties [59] of Methyl stearate was documented. Gingerol is a flavouring agent found in ginger. Its antioxidant, anti-inflammatory [35,43,60], analgesic, antibacterial, anti-cancer, antipyretic, sedative activities [52] were reported. The biological role of Ethyl iso-allocholate was mentioned above. Noteworthy is the low FA composition of 0.967 % in unsweetened “kunun-zaki” pulp. This result suggest that the pulp could make a useful dietary addition for people who have hypertension, diabetes, cardiovascular diseases, as well as for maintaining healthy weight.

The result for sweetened “kunun-zaki” pulp (Table 4) showed the presence of 6-(P-Tolyl)-2-methyl-2-heptanol,trans-, n-Hexadecanoic acid, 9,12-Octadecadienoic acid (Z,Z)- and Oleic acid. The biological activity of these compounds was discussed above.

## 5. CONCLUSION

The constituents identified validates the health benefits of “kunun-zaki.” The mechanism of action of these compounds, are unconnected with their cumulative synergistic effects. Some volatile constituents detected in appreciable concentrations in the samples have unidentified activities. The success of the nutrition, pharmaceutical, cosmetic, and other chemical industries lie on identification of compounds with novel activities, and safe profiles. Thus, further research should be directed at targeting these compounds for their bioactivities.

FA profile of the samples comprised mainly of PUFA, followed by MUFA. SFA was low in the samples. Although SFA have been linked with adverse health effects, the ones identified in this work have immense benefits. Hence, should be utilized to curb malnutrition in developing countries. This further supports the non-disposal of “kunun-zaki” pulp, after extraction of the drink. Particularly, the FA of unsweetened “kunun-zaki” pulp was appreciably low. Thus, should be useful for maintenance of healthy weight, and management of blood sugar/lipid profile.

This is the first report on GC-MS characterization of volatiles in “kunun-zaki” parts. This work has bridged the knowledge gap, and substantiates the medicinal claims associated with consumption of “kunun-zaki” in folklore. Overall, these bioactive components in “kunun-zaki” may present new sources for developing novel products with immense health benefits.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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