Applied Biological Research 23(2): 245-254; (2021)
DOI: 10.5958/0974-4517.2021. 00031.8

IDENTIFICATION OF VOLATILE COMPOUNDS IN FERMENTED MILLET BASED BEVERAGES BY GAS CHROMATOGRAPHY-MASS SPECTROSCOPY

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(Received 9 December, 2020; accepted 21 May, 2021)

ABSTRACT

Volatile compounds impart flavour in food and beverages and make the food and food products appealing. The present study involves the development of fermented millet beverages from minor millets *viz*., foxtail millet, little millet, kodo millet, proso millet and barnyard millet, by using an isolate of *Propionibacterium* sp. as fermentation agent. The volatile compounds present in the newly developed fermented millet-based beverages were identified using hexane-extracted samples by gas chromatography-mass spectrophotometry (GC-MS). The results revealed the presence of 21 volatile compounds in foxtail- and proso-millets, 18 compounds in little millet and barnyard millet and 19 compounds in kodo millet. The dominant volatile compounds observed were benzene derivatives, hexadeconoic acid, acetic acid, sitosterol and octadecanoic acid in all five minor millet fermented beverages.

Keywords: Beverages, fermentation, GC-MS, millets, volatile compounds

INTRODUCTION

Millets are known old crops traditionally used for domestic consumption. Millets are specially grown in semi-arid tropics of Asia and Africa for food as they are nutritionally rich, gluten-free and non-acid forming. Being gluten-free food, the millets are consumed by all age groups as its consumption does not lead to any allergic reaction. Millets rank 6th important cereal in the developed countries for the millions of people (Hanafi *et al.,* 2014). In addition to the major nutrients like protein and energy, it contains dietary fibers, minerals especially iron and zinc. The accumulation of phenol, phytic acid and tannins helps to contribute high antioxidant content and impart beneficial impact on overall health and wellbeing (Choi *et al.,* 2007). Millets can be consumed as breakfast cereal in the form of porridge, soups, stews and bread (Singh and Raghuvanshi, 2012). Volatile compounds in food substances impart flavour perception and acceptability of the product by the consumers. Volatile compounds in developed product may vary depending upon the variety used in its preparation (Cramer *et al.,* 2005), preharvest condition (Champagne *et al.,* 2004), type of storage conditions (Wongpomchai *et al.,* 2004) and processing techniques followed (Liu and Yang 2011). Functional character of microbes in fermented food exhibits probiotic properties (Hill *et al.,* 2014), antimicrobial property (Meira *et al.,* 2012), antioxidant activity (Perna *et al.*, 2013), and peptide production (De Meijia and Dia, 2010).

A vast number of volatile compounds have been identified from a range of nutrients such as fatty acids and non-volatile palate constituents like phenolic compounds and alkaloids, etc. (Ludwing *et al.*, 2014). Fermentation of rice and other cereals with single and mixed culture has been reported to produce volatiles predominantly aldehydes, alcohols, hydrocarbons, ketones, etc. (Yi *et al.*, 2009). Several studies have revealed that alcohols, esters, acids, ketones, hydrocarbons, benzene derivatives, and aldehydes are the volatile compounds of millets (Liu *et al.*, 2012). The number of volatile compounds in fermented rice noodles were identified which included alcohol, aldehydes, hydrocarbons and 2,4-di-tert-butylphenol (Gibson *et al.*, 2018). The fermented millet-based beverages from selected minor millets *viz.*, foxtail millet, little millet, kodo millet, proso millet and barnyard millet was developed using GRAS dairy *Propionibacterium* sp. and its quality parameters determined (Sheela *et al.*, 2018). Among the parameters, qualitative identification of volatile compounds in the developed beverages were studied so as to understand the role of fermentation in the production of aroma compounds. This study was undertaken to analyze the changes in volatile-profile characteristics in different minor millets after fermentation by *Propionibacterium* sp. Hence, it is imperative to assess volatile compounds in the developed fermented millet-based beverages (prepared by using isolated *Propionibacterium* sp. from milk) for product quality to the consumers. The objective of this study was to identify the volatile compounds in the developed five minor millet fermented beverages by GC-MS.

MATERIALS AND METHODS

Millet beverages were standardized using five minor millets *viz.*, little millet (*Panicum sumatrense*), foxtail millet (*Setaria italica*), kodo millet (*Paspalum setaceum*), barnyard millet (*Echinochola utilis*) and proso millet (*Panicum miliaceum*). Millet milk was extracted as per the method described by Sheela *et al.* (2018), then filtered, pasteurized, cooled, inoculated with 1% commercial curd culture NCDC 261 (procured from National Dairy Research Institute, Karnal, Haryana) and incubated at 30ºC for 6 h for fermentation. The isolated *Propionibacterium* culture strain MM21 (1 mL, 10^8 CFU mL^{-1}) [isolated from milk] was added to develop millet-based beverages (Fig. 1). The prepared millet fermented beverages were stored under refrigerated conditions before analysis.

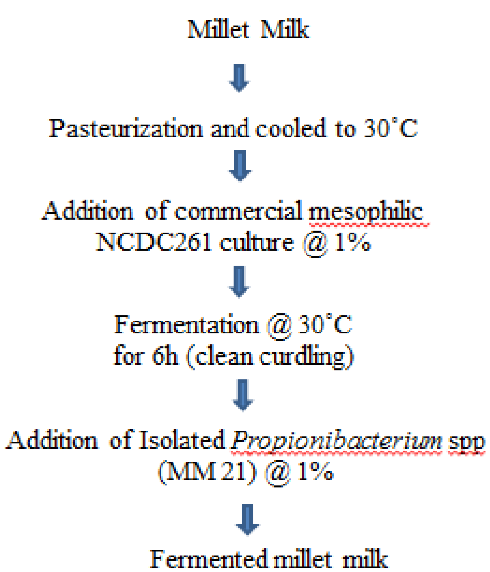

Fig. 1: Flowchart for the preparation of fermented millet milk

Sample preparation

The millet beverages samples were prepared following the method of Janes *et al.* (2009). The liquid samples (10 g) were extracted with 100 mL HPLC grade hexane in ultrasonic bath for 30 min at 27ºC, followed by continuous shaking in a shaker for 6 h at 300 rpm at room temperature. Then, it was transferred to separating funnel and shaken for a few minutes before separation. The supernatants collected were filtered through 0.22 µm membrane filters and directly injected into GC-MS system (Shimadzu QP 2020, Japan).

Sample analysis

GC-MS analysis were carried out in a Shimadzu QP 2020 GC-MS System, fitted with Rxi-5 Sil MS fused silica column cross bonded with 1, 4-bis (dimethyl-siloxy) phenylene dimethyl polysiloxane. The column length was 30 m, inner diameter 0.25 mm and film thickness 0.25 µm. The maximum temperature limit for column was 320ºC. Ultra-high purity helium (99.99%) was used as carrier gas at a constant flow rate of 1.0 mL min^{-1}. The injection, transfer line and ion source temperatures were 290, 280 and 200ºC, respectively, and the ionizing energy was 70eV. Electron multiplier voltage was obtained from auto tune. The oven temperature was programmed from 80ºC (hold for 2 min) to 285ºC at a rate of 4ºC min^{-1}. One microliter of samples was injected into the system in split mode with the split ratio of 1:10 and the solvent cut off times was 4 min. All data were obtained by collecting the full-scan mass spectra within the scan range 35-500 m/z. The identification and characterization of chemical compounds in various crude extracts was based on GC retention time. The obtained mass spectra were matched with the standards available in NIST mass spectrum libraries (Karthika, *et al.*, 2013). The samples were taken as triplicates for each analysis.

RESULTS AND DISCUSSION

The quality of fermented products arises by aroma, flavour and appearance. The chromatograms of hexane extract of fermented millet beverage samples are displayed in Fig. 2-6. The results revealed that the presence of volatile compounds in prepared sample varied in number, retention time and peak area. The major volatile compounds identified in each sample on the basis of percentage peak area are given in Tables 1-5. The major volatile compounds in the foxtail millet beverage were mesitylene (13.19%), hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester (10.23%), stigmasta-3,5-diene (9.34%), cyconanasiloxane (7.98%), benzene, 1-ethyl-3methyl (7.52%), octa decanoic acid, 2,3-digydroxypropyl ester (5.90%), 3-trifluoroacetoxypentadecane (3.55%) [Table 1; Fig. 2]. Apart from these, the other notable volatile compounds identified were acetic acid, butyl

Table 1: The volatile compounds found in foxtail millet beverage

S. No.	Volatile compounds	Molecular weight (g mol^{-1})	Formula	Retention time (min)	Peak area (%)
1.	Acetic acid, butyl ester	116	$C_6H_{12}O_2$	3.098	1.88
2.	Benzene, propyl-	120	C_9H_{12}	4.286	1.33
3.	Benzene, 1-ethyl-3-methyl-	144	C_9H_{12}	4.345	7.52
4.	Benzene, 1,2,3-trimethyl-	120	C_9H_{12}	4.505	2.46
5.	Mesitylene	120	C_9H_{12}	4.639	13.19
6.	Benzene, 1,4-diethyl-benzene	134	$C1_0H_{14}$	5.138	1.03
7.	1,2-oxathiane,	304	$C_{16}H_{32}O_3S$	26.714	1.87
8.	Hydrazine carboxamide	155	$C_7H_{13}N_3O$	32.450	3.54
9.	Stigmasta-3,5-diene	396	$C_{29}H_{48}$	32.526	9.34
10.	Glycidol stearate	340	$C_{21}H_{40}O_3$	34.420	2.09
11.	Cyclononasiloxane,	666	$C_{18}H_{54}O_9Si_9$	39.884	7.98
12.	Hexadecanoic acid, 2-bromo-alpha.-bromopalmitic acid	334	$C_{16}H_{31}BrO_2$	39.990	1.37
13.	3-Trifluoroacetoxypentadecane	324	$C_{17}H_{31}F_3O_2$	3.020	3.55
14.	Glycidol stearate	340	$C_{21}H_{40}O_3$	34.420	2.09
15.	Octane	114	C_8H_{18}	3.030	3.15
16.	Nonane	128	C_9H_{20}	3.745	1.85
17.	Undecane	156	$C_{11}H_{24}$	5.424	3.20
18.	Dodecane	170	$C_{12}H_{26}$	6.294	2.07
19.	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	330	$C_{19}H_{38}O_4$	32.362	10.23
20..	Docosanoic acid, n.-octyl ester	452	$C_{30}H_{60}O_2$	34.482	3.30
21.	Octadecanoic acid, 2,3-dihydroxypropyl ester	358	$C_{21}H_{42}O_4$	36.305	5.90

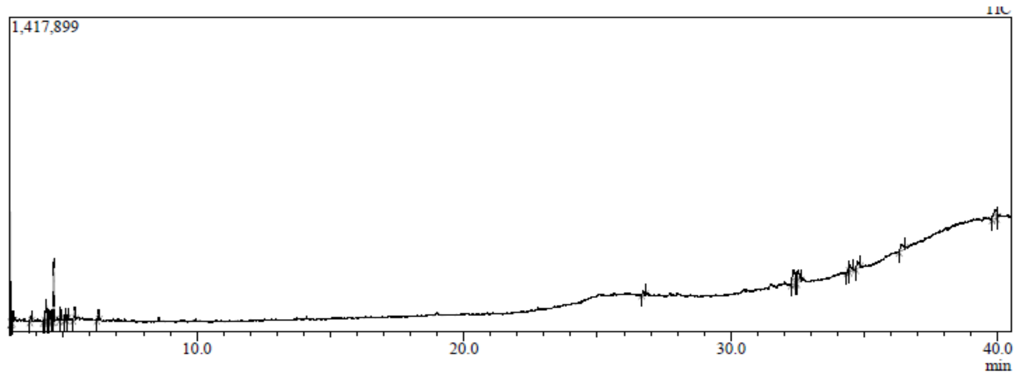

Fig. 2: Chromatogram of volatile compounds in foxtail millet beverage; X axis - time; Y-axis - relative abundance

ester, benzene-propyl, benzene-1,2,3-trimethyl, oxathiane and glycidol stearate. During fermentation volatile compounds from lactic acid bacteria impart particular flavours to the fermented milk (Beshkova *et al.*, 1998). The acceptable flavour of fermented product is molded by these volatile compounds. The compounds like carbonyl compounds and organic acids including acetaldehyde, diacyl and acetic acid plays a crucial role in imparting flavor and can be used to evaluate the flavour quality of dairy products (Zha *et al.*, 2015). Ott *et al.* (1997) reported that acetaldehyde provided typical flavor to dairy products such as yogurt and buttermilk. Erkus *et al.* (2013) also reported that diacetyl contributed the characteristic sour buttery to some fermented dairy products. Hammed *et al.* (2015) found n-hexadecanoic acid compound possess antioxidant, anti-inflammatory, antimicrobial, pesticide and cancer preventive, hypocholesterolemic, lubricant activities and hemolytic property (reductase inhibitor). Mathew (2011) revealed that octadecadienoic acid has hypocholesterolemic, antiarthritic, hepatoprotective anti androgenic, antihistaminic, antieczemic and diuretic properties and also benzene derivatives exhibit antioxidant, anti-inflammatory, anti-thrombotic and hypo-lipidemic effects. Dan (2017) identified a number of aromatic compounds in the fermented milk consisting of 3-methyl-1-butanol, 3-methyl-butanol, acetoin, 2-heptanone, acetic acid and butanoic acid etc., at different percentage of peak area and

Table 2: The volatile compounds identified in little millet beverage

S. No.	Volatile compounds	Molecular weight (g mol^{-1})	Formula	Retention time (min)	Peak area (%)
1.	Heptane, 2,4-dimethyl	128	C_9H_{20}	3.193	3.85
2.	Octane, 4-methyl	128	C_9H_{20}	3.493	1.76
3.	Benzene, 1-ethyl-3-methyl	144	C_9H_{12}	4.343	5.59
4.	Mesitylene	120	C_9H_{12}	4.415	1.89
5.	Nonane, 2,5-dimethyl	156	$C_{11}H_{24}$	4.740	1.61
6.	Benzene, 1,2,3-trimethyl	120	C_9H_{12}	4.881	2.21
7.	Benzene, 1,3-bis	190	$C_{14}H_{22}$	6.855	8.15
8.	3-Trifluoroacetoxypentadecane	324	$C_{17}H_{31}F_3O_2$	3.020	3.14
9.	Octane	114	C_8H_{18}	3.046	1.60
10.	Decane	142	$C_{10}H_{22}$	4.593	3.10
11.	Undecane, 5-methyl	170	$C_{12}H_{26}$	5.055	5.63
12.	Decane, 3,7-dimethyl	170	$C_{12}H_{26}$	5.097	1.99
13.	Undecane, 3,7-dimethyl	184	$C_{13}H_{28}$	5.421	4.82
14.	Dodecane	170	$C_{12}H_{26}$	6.289	9.41
15.	2,4-Dimethyldodecane	198	$C_{14}H_{30}$	6.900	2.03
16.	Hexadecane	226	$C_{16}H_{34}$	7.041	4.79
17.	Tetradecane	198	$C_{14}H_{30}$	8.559	8.79
18.	Eicosane	282	$C_{20}H_{42}$	14.092	5.93

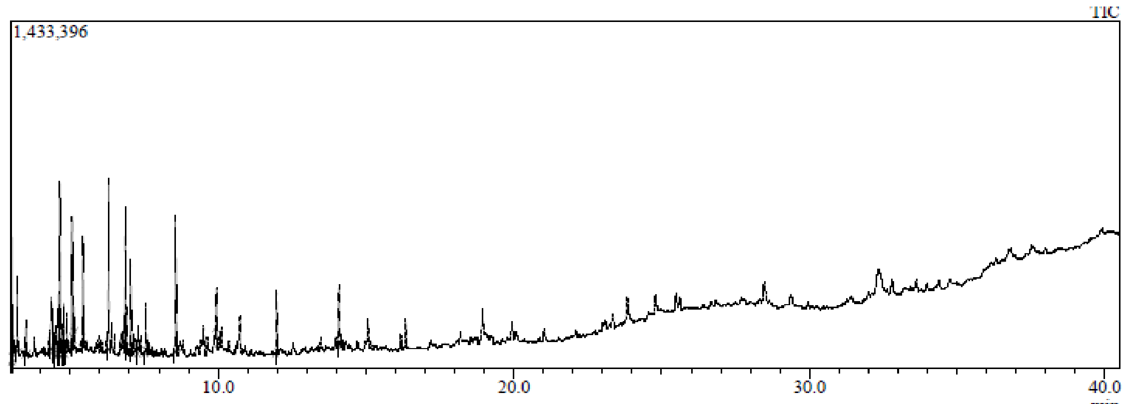

Fig. 3: Chromatogram of volatile compounds in little millet beverage; X axis - Time; Y-axis - Relative abundance

also found six hydrocarbons by *Lactobacillus delbrueckii* ssp. *bulgaricus*. Cheng (2010) reported that hexanal and heptanal are important aroma compounds contributes as flavour enhancers in fermented milk products.

Table 2 and Fig. 3 show the volatile compounds of little millet beverage. The high peak area observed in undecane, 3,7-dimethyl- (9.41%) followed by tetradecane (8.79%), benzene, 1,3-bis (8.15), eicosane (5.93%), undecane, 5-mehyl (5.63%), benzene, 1-ethyl-3-methyl (5.59%), hexadecane (4.82%) and heptane, 2,4-dimethyl (3.85%). The low amounts compounds were octane and decane. Even at low concentrations, the esters compounds contribute to the "fruity and floral" aromas and flavours like dairy product and yogurt (Guler and Stupp, 2007).

The volatile compounds in kodo millet beverage are depicted in Table 3 and Fig. 4. Nineteen compounds were identified in kodo millet beverage. The peak area percentage volatile compounds were mesitylene (12.38%), dodecane (8%), dodecane, 4,6-dimethyl (7.38%), tetradecane (6.28%), eicosane (5.63%), undecane, 3,7-dimethyl (5.16%) and dodecane, 4-methyl (4.31%). The rest were

Table 3: The volatile compounds identified in kodo millet beverage

S. No.	Volatile compounds	Molecular weight (g mol^{-1})	Formula	Retention time (min)	Peak area (%)
1.	Decanal	156	$C_{10}H_{20}O$	3.020	3.80
2.	Heptane, 2,4-dimethyl	128	C_9H_{20}	3.197	3.56
3.	Benzene, 1-ethyl-3-methyl	144	C_9H_{12}	4.347	4.41
4.	Benzene, 1,2,3-trimethyl	120	C_9H_{12}	4.417	2.48
5.	Mesitylene	120	C_9H_{12}	4.640	12.38
6.	Dodecane, 4-methyl	184	$C_{13}H_{28}$	4.780	1.89
7.	Benzene, 1,3-bis	190	$C_{14}H_{22}$	6.862	7.38
8.	Dodecane, 4,6-dimethyl	198	$C_{14}H_{30}$	7.047	4.31
9.	Octane	114	C_8H_{18}	3.050	3.43
10.	Octane, 4-methyl	128	C_9H_{20}	3.497	1.70
11.	Decane	142	$C_{10}H_{22}$	4.597	2.96
12.	Decane, 4-methyl	156	$C_{11}H_{24}$	4.780	1.89
13.	Undecane, 3,7-dimethyl	184	$C_{13}H_{28}$	5.058	5.16
14.	Dodecane	170	$C_{12}H_{26}$	6.293	8.00
15.	2,4-Dimethyldodecane	198	$C_{14}H_{30}$	6.905	1.84
16.	Nonane, 3-methyl-5-propyl	184	$C_{13}H_{28}$	7.299	1.70
17.	Hexadecane	226	$C_{16}H_{34}$	7.543	2.42
18.	Tetradecane	198	$C_{14}H_{30}$	8.566	6.28
19.	Eicosane	282	$C_{20}H_{42}$	14.102	5.63

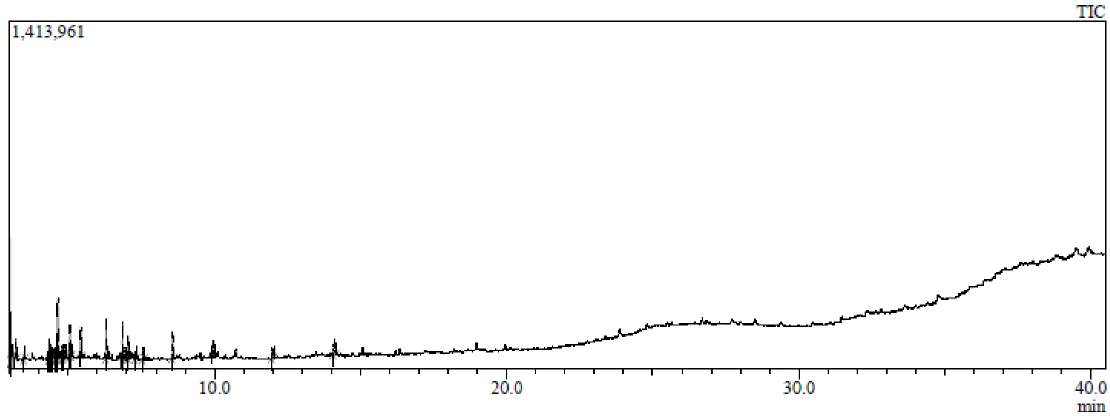

Fig. 4: Chromatogram of volatile compounds in kodo millet beverage; X axis - Time; Y-axis - Relative abundance

decanal, heptane, dodecane and octane. Chaughtai *et al.* (2015), analyzed volatile profile of pearl millet variety MB-87 and Bajra in Pakistan and reported aldehydes as dominant amine compounds present in both the varieties. Aldehydes improve the flavour of the fermented milk products. In fermented milk samples, bacterial cultures play significant role in producing aromatic compounds. Liang (2012) identified hexane formation as a result of the oxidation of unsaturated fatty acids in dairy products such as fermented milk.

Amongst the volatile compounds in proso millet, the higher peak area was occupied by several compounds *viz.*, dodecane (8.85%), tetradecane (8.24%), benzene, 1,3-bis (1,1-dimethyl-ethyl) (7.72%), benzene, 1-ethyl-3-methyl (6%), octane, 5-ethyl-2-methyl (5.16), eicosane (5.07%), heptadecane (4.65%) and dodecane, 4,6-dimethyl (4.52%) [Table 4 and Fig. 5]. The other compounds present in lesser amounts were 3-trifluroacetoxypentadecae, mesityleme, heptane,

Table 4: The volatile compounds found in proso millet beverage

S. No.	Volatile compounds	Molecular weight (g mol^{-1})	Formula	Retention time (min)	Peak area (%)
1.	Heptane, 2,4-dimethyl	128	C_9H_{20}	3.197	3.45
2.	Benzene, 1-ethyl-3-methyl	144	C_9H_{12}	4.350	6.00
3.	Mesitylene	120	C_9H_{12}	4.425	1.80
4.	Benzene, 1,2,3-trimethyl	120	C_9H_{12}	4.417	2.48
5.	Benzene, 1,3-bis(1,1-dimethylethyl)	190	$C_{14}H_{22}$	6.865	7.72
6.	Cycloheptasiloxane, tetradecamethyl	518	$C_{14}H_{42}O_7Si_7$	9.394	3.67
7.	Cyclooctasiloxane, hexadecamethyl	592	$C_{16}H_{48}O_8Si_8$	12.407	2.62
8.	3-Trifluoroacetoxypentadecane	324	$C_{17}H_{31}F_3O_2$	3.020	1.50
9.	Octane	114	C_8H_{18}	3.050	1.91
10.	Octane, 4-methyl	128	C_9H_{20}	3.497	1.63
11.	Decane, 4-methyl	156	$C_{11}H_{24}$	4.782	1.06
12.	Octane, 5-ethyl-2-methyl	156	$C_{11}H_{24}$	5.060	5.16
13.	Decane, 3,7-dimethyl	170	$C_{12}H_{26}$	5.104	1.78
14.	Dodecane	170	$C_{12}H_{26}$	6.298	8.85
15.	Gamma Sitosterol	414	$C_{29}H_{50}O$	6.910	1.89
16.	Dodecane, 4,6-dimethyl	198	$C_{14}H_{30}$	7.051	4.52
17.	Eicosane	282	$C_{20}H_{42}$	14.111	5.07
18.	Decane	142	$C_{10}H_{22}$	4.599	2.49
19.	Dodecane, 4,6-dimethyl	198	$C_{14}H_{30}$	7.567	2.48
20.	Tetradecane	198	$C_{14}H_{30}$	8.571	8.24
21.	Heptadecane	240	$C_{17}H_{36}$	11.992	4.65

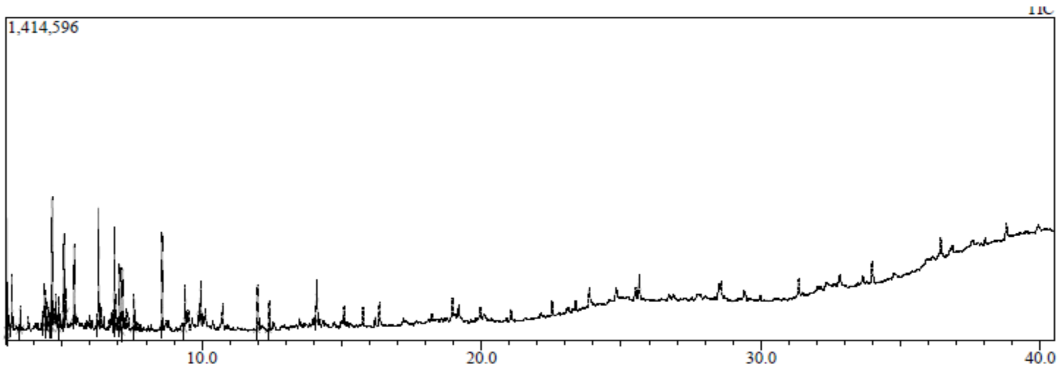

Fig. 5: Chromatogram of volatile compounds in proso millet beverage; X axis - Time; Y-axis - Relative abundance

cycloocta-siloxane and hexadecamethyl. Hexadecanoic acid present in almost all millets is used as flvouring and fragnance agent. The results are in line with Khan *et al.* (2017) who in pearl millet genotypes identified n-hexadecanoic acid as major volatile compound in cultivated variety 'RHB-177' (18.17%) followed by 'RHB-173' (16.36%), 'HHB-67' (15.57%), 'GHB-558' (13.09%) and 'HB-538' (8.07%). Liu *et al.* (2012) analyzed volatile compounds in brown millet, milk millet by GC-MS and reported aldehydes and benzene derivatives (hexanal, hexadeconoic acid and 2-methyl-naphthalane) as the most frequently occurring volatile compounds. Acetaldehyde is produced by various LAB including *S.thermophlus* and *L. delbrueckii* ssp. *bulgaricus*. (Bodyfelt and Potter, 2008; Akyol *et al.,* 2015; Gezginc *et al.,* 2015). Heptane and heptanol are important aroma compounds that contribute 'green and sweet' flavour to yogurt (Cheng, 2010). Even at low levels heptanol contributes the flavour precursor of dairy products (Siek *et al.,* 2006).

Eighteen volatile compounds were identified in barnyard millet (Table 5 and Fig. 6) which included cyclohexasiloxane, dodecamethyl (7.22%), cycloheptasiloxane, tetradecamethyl (5.82%), benzene, 1,3-bis-1,1-dimethylethyl (5.65%), dodecane (5.52%), eicosane (4.61%) and cycloocta-siloxane, hexadecamethyl (4.55%). The notable amount present in the form of decanal, heptanes, 2,4-dimethyl, benzene, 1-ethyl-3-methyl and mesitylene etc., Fuchs (2008) identified aromatic

Table 5: The volatile compounds identified in barnyard millet beverage

S. No.	Volatile compounds	Molecular weight (g mol^{-1})	Formula	Retention time (min)	Peak area (%)
1.	Decanal	156	$C_{10}H_{20}O$	3.020	2.67
2.	Heptane, 2,4-dimethyl	128	C_9H_{20}	3.196	2.75
3.	Benzene, 1-ethyl-3-methyl	144	$C9H_{12}$	4.348	2.90
4.	Mesitylene	120	C_9H_{12}	4.380	2.24
5.	Benzene, 1,2,3-trimethyl	120	C_9H_{12}	4.889	2.02
6.	Gamma Sitosterol	414	$C_{29}H_{50}O$	39.840	7.79
7.	Benzene, 1,3-bis(1,1-dimethylethyl)	190	$C_{14}H_{22}$	6.866	5.65
8.	Cyclohexasiloxane, dodecamethyl	444	$C_{12}H_{36}O_6Si_6$	7.152	7.22
9.	Cycloheptasiloxane, tetra-deca-methyl	518	$C_{14}H_{42}O_7Si_7$	9.391	5.83
10.	Cyclooctasiloxane, hexadecamethyl	592	$C_{16}H_{48}O_8Si_8$	12.405	4.55
11.	Cyclononasiloxane, octadecamethyl	666	$C_{18}H_{54}O_9Si_9$	33.978	2.90
12.	Octane	114	C_8H_{18}	3.048	2.75
13.	Decane	142	$C_{10}H_{22}$	4.599	2.09
14.	Undecane, 5-methyl	170	$C_{12}H_{26}$	5.059	3.77
15.	Dodecane	170	$C_{12}H_{26}$	6.298	5.52
16.	Dodecane, 4,6-dimethyl	198	$C_{14}H_{30}$	7.051	3.21
17.	Tetradecane	198	$C_{14}H_{30}$	8.572	4.48
18.	Eicosane	282	$C_{20}H_{42}$	14.110	4.61

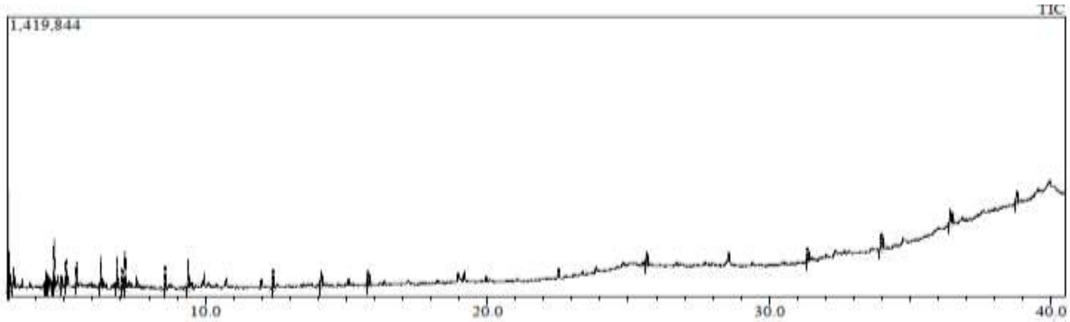

Fig. 6: Chromatogram of volatile compounds in barnyard millet beverage; X axis - Time; Y-axis- Relative abundance

hydrocarbon in fermented milk at low concentration, *viz*., toluene (0.23-5.13 µg L^{-1}), 2,4-dimethyl-hexane (1.13-7.39 µg L^{-1}) and 2-heptane (0-4.84 µg L^{-1}).

Hydrocarbon and benzene derivatives were the common volatile compounds identified in cereals. Jingke Liu *et al.* (2016) found several hydrocarbons *viz*., tridecane, pentadecane, hexadecane and heptadecane in different varieties of foxtail millet. These hydrocarbons possibly are formed as a result of decarboxylation and splitting of carbon-carbon chains of higher fatty acids. Dan *et al.* (2017) identified 10 ketone compounds including 2,3 butanedione, acetoin, 2-hepaone and 2-nonaone in *Streptococcus thermophiles* fermented milk. Butanedione and acetoin compounds were obtained from pyruvate, which comes from lactose and are known to influence the aroma and flavoring qualities of fermented milk (Chaves *et al.*, 2011; Pan *et al.*, 2014). Dan (2017) reported that heptanal was produced in higher amounts (2-heptaone and 2-nonaone touched 25.56 and 10.67 µg L^{-1}, respectively) by *L. delbrueckii* subsp. *bulgaricu*s during storage period. These compounds were reported in dairy products, including milk, fermented milk and cheese (Bok *et al.*, 2011).

Conclusions: Minor millets have many health benefits due to their nutritional attributes and fermentation process improves vitamin and mineral availability in food. Beneficial bacteria in gut promote vitamin B & K production. Volatile component availability in fermented millet beverages is generally low. In this study, 97 volatile compounds were identified in 5 minor millet beverages. All millet beverages had similar volatile compounds but varied in their content. The volatile compounds identified at different peak area and percentages were acetic acid, butyl ester, diethyl, triethyl ester, eicosane, hexadecanoic acid mesitylene, heptanol, hexane, octane, decane, dodecane and γ-sitosterol. Acetic acid, hexanoic acid, γ-sitosterol and benzene derivatives were present in millet fermented beverages and categorized as essential volatile components for human health.

Acknowledgement: The present research was supported by GOI-DST-SERB (Science and Engineering Research Board), New Delhi, India under Early Career Research Award 2016-2019.

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