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Forensic Chemical Profiling of Hazardous Additives and Contaminants alongwith their harmful Effects & Source discrimination of seized Moonshine samples: A study on New Emerging Crisis in Punjab

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Abstract

Moonshine an illegally produced alcoholic beverage has caused several times "hooch tragedies" in various states of India. Punjab which is already facing Drug addiction hitch, has also not been untouched by hooch tragedies since 2020 when 120 people in Punjab died due to consumption of hooch. To curb hooch tragedies, Govt. of Punjab showed the very urgency for the inclusion of death penalty in Punjab & Excise Act, 1914. However, owing to shortfalls in quality control norms and non availability of a reliable facility to identify additives & contaminants in moonshine, avaricious manufacturers are still intentionally adding large number of hazardous additives and ignoring contaminants while manufacturing moonshine to make the brew strong and aromatic. More surprisingly, at present people are still considering methanol a root cause of hooch tragedies. Investigating agencies are more inquisitive to know the presence of methanol in seized samples to qualify them as 'unfit for drink'. It is crystal clear that merely the presence of methanol in any sample does not prove it lethal as it has also been studied that many alcoholic beverages contain methanol naturally at low level without causing harm. At present, a study on hazardous additives and contaminants in moonshine alongwith their harmful effects & source discrimination has not yet been reported. Henceforth, a forensic attempt is made to secure public health by chemically profiling various hazardous additives and contaminants detected in seized moonshine samples alongwith enlightening their harmful effects on body so as to make public aware of the hidden health hazards of moonshine. In this study, 31 samples of moonshine seized by Punjab Police from various districts of Punjab were extracted, sonicated and analysed by GCMS technique for the detection of hazardous additives and contaminants. For comparison & discrimination of source of these samples, grouping of detected chemicals was done using Principal Component analysis (PCA) a cluster analysis method. Our research outcome led to successful chemical profiling of 187 detected chemicals and among these 187 chemical compounds, 73 chemical compounds were found hazardous as these can cause severe health problems viz. eye, nose & throat irritation, inflammation to monocytes, birth defects, CNS disorder, cancer & death. Hence through this research an effort is made to secure public health and to alert govt. agencies regarding these health hazardous additives and contaminants.

Keywords: Moonshine; Hooch; Forensic; Additives; Contaminants; Death; Hazardous; Public health

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INTRODUCTION

Alcoholic beverages have been used in Indian societies since the Vedic era (1500-700 BCE). It can be produced locally or industrially with the available resources across the world. The raw materizals generally used for the production of alcohol are fruits, palm wine, sugar cane etc. and the basic method used for its production is fermentation & simple distillation. At present alcohol is all pervasive and the mode of its intake has been constantly evolving. In India, alcohol consumption is widespread across all the states & the union territories and an estimated 160 million people consume alcohol.[1] The Indian Govt. has made multiple efforts to limit the availability of alcohol in pursuit of various public health objectives. But the problem does not cease here as most of the bootleggers are selling "moonshine" also known as 'hooch', a cheap alcoholic drink manufactured in small unregulated shanties to the poor population and in states that have imposed a full ban on liquor.

It is evident that the presence of methanol 'a toxic alcohol' in hooch has caused several times "hooch tragedies" in village population and urban poor in several states of India. A bar chart showing mortality v/s states due to hooch tragedies in India since 2008 to 2020 is depicted in fig. 1.

Mortality v/s States

Surprisingly, it has been observed that in the last

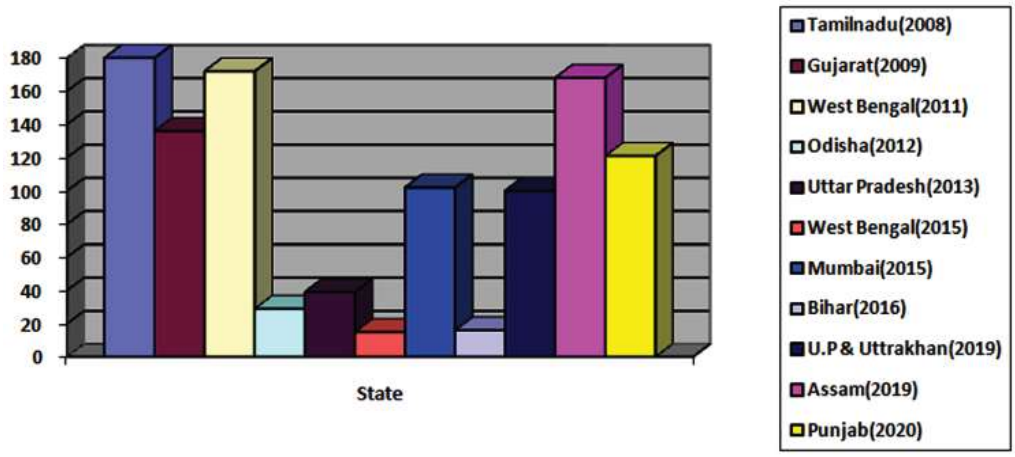


Fig. 1: Bar chart depicting Mortality due to hooch tragedies in various states of India.

few years, Punjab is disgraced having rise of **drug addled** persons especially youth. It has also not been untouched by hooch tragedies and has been facing new crisis "***Moonshine illicit liquor***". Most of the drug peddlers in Punjab have changed their business from drug smuggling to "bootlegging". Such mafias have no longer apprehension for prosecution and are now more intrepid in adding large number of harmful adulterants to make brew stronger i.e. lizard skins, alprazolam tablets and Iodex.[2] The year, **2020 was the pandemic year** for the people of Punjab when 120 people in the districts of Amritsar, Gurdaspur and Tarn Taran died due to consumption of hooch. To occlude this, Punjab police have raided different places in Punjab and large amount of hooch was seized. This incident trembled the Govt. of Punjab and showed the very urgency for the inclusion of ***death penalty***[3] in Punjab & Excise Act, 1914 in the year 2021 to curb hooch tragedies. Besides, the Hon'ble Punjab & Haryana High Court ordered an iron-hand approach for dealing these cases[4]; Punjab police added Section 302 (murder) of IPC in cases against all the kingpins of hooch tragedies and Punjab Excise Commissioner issued guidelines for transportation of Ethyl Neutral Alcohol, Ethanol, Specially Denatured Spirit, Denatured Spirits, and Rectified Spirit. Despites tightening its noose against bootleggers, the cases of hooch tragedy have not been ceased in Punjab. However, owing to shortfalls in quality control norms and non availability of a reliable facility to identify additives & contaminants in moonshine, avaricious manufacturers are still intentionally adding large number of hazardous additives and ignoring contaminants while manufacturing moonshine to make the brew strong and aromatic. These hazardous additives includes organic solvents & flavouring chemicals and pesticides like contaminants. The intake of organic solvents can cause severe health problems viz. eye, nose & throat irritation, CNS disorder, seizures & death.[5] Flavouring additives can cause inflammation to monocytes, cancer, birth defects, neurotoxic, CNS disorder & allergic reactions.[6] Pesticides additives have effect on reproduction, immune or nervous system, can cause cancer.[7] It

has also been studied that the solution obtained after distillation with a minimum ethanol content contains trace amount of methanol, esters, aldehydes, higher alcohols, acetates, acetic acid and fusel oil. Like methanol, some of these chemical compounds are also harmful. More surprisingly, at present people are still considering methanol a root cause of hooch tragedies. Investigating agencies are more inquisitive to know the presence of methanol in seized samples to qualify them as moonshine 'unfit for drink'. It is crystal clear that merely the presence of methanol in any sample does not prove it lethal as it has also been proven that many alcoholic beverages contain methanol naturally at low level without causing harm.[8] Its maximum legal concentration in different alcoholic beverages has already been defined by Food Safety and Standards (Alcoholic Beverages) Regulations, 2018. Till date only determination of methanol and its percentage in moonshine have been published so far. Several methods like spectroscopic, colorimetric etc. have been used for determination of methanol content in alcoholic drinks.[9-11] A study on hazardous additives and contaminants in moonshine alongwith their harmful Effects and source discrimination has not yet been reported.

Henceforth, a forensic attempt is made to secure public health by chemically profiling various hazardous additives and contaminants detected in seized moonshine samples alongwith enlightening their harmful effects on body so as to make public aware of the hidden health hazards of moonshine. In this study, 31 samples of moonshine were subjected to forensic chemical analysis. These samples were seized during raids conducted in different parts in Punjab by Punjab police under Excise Act and were submitted at Central Forensic Science Laboratory, Chandigarh, for the detection of Methanol. Various laboratory examinations such as Physical tests, Chemical tests, Gas Chromatography analysis and Gas Chromatography Mass Spectrometric analysis (GC-MS) were carried out with these samples. Ethanol was detected in 05 seized samples while Methanol was detected in 24 seized samples. The percentage of ethanol and methanol was determined using specific gravity and calibration graph method respectively. Apart from this, 187 additives including contaminants were identified by mass spectral chemical profiling. For comparison and discrimination of source of these samples, grouping of 187 detected chemicals was done using ***Principal Component analysis (PCA)*** a cluster analysis method.

MATERIALS AND METHODS

In this research paper, thirty one (31) seized samples of various moonshine samples were subjected to forensic chemical analysis. These samples were seized (under Excise Act) during a regular search in various district of Punjab u/s 61/78(2) Punjab Excise Act,1914 & 420/468/471 IPC 1860 by Punjab Police and submitted at Central Forensic Science Laboratory, Chandigarh for chemical analysis. All of the submitted plastic nips (quarters) were found without printed label of any brand.

The representative samples taken from 31 seized moonshine samples were tested for the detection of ethanol, methanol, copper, iron & furfural. Specific gravity method was used for estimating ethanol percentage and calibration graph method was used for methanol concentration. For complete chemical profiling of hazardous additives and contaminants in representative samples of seized moonshine samples were then analyzed by gas chromatography mass spectrometry (GC-MS) technique.

The Solvent used for extraction was of LC grade (Merck, German).

Fig. 2: Samples sized from various district of Punjab

Extraction of seized moonshine samples for additives and contaminants

10 ml of each seized samples were extracted three times with 10 ml chloroform by liquid-liquid extraction procedure. These chloroform extracts were combined in china dish, was concentrated and stored at 40^0C.

Equipment

Shimadzu Nexis GC2030 coupled with Shimadzu QP2020 NX MS and Shimadzu autosampler AOC-20i Plus were used.

INSTRUMENTATION CONDITIONS

Shimadzu, QP-2020NX

Shimadzu Nexis GC2030 coupled with Shimadzu QP2020 NX MS and Shimadzu autosampler AOC-20i Plus were used for chemical profiling. The GC-column was a 30m SH-Rxi-5Sil MS with 0.25 mm I.D. & 0.25µm film thickness. Helium was used as a carrier gas at a constant flow of 1 ml/min. Splitless injection was used with a splitless time of 60s. The injector & interface line temperature were held at 250^0C & 330^0C respectively. Oven initial temperature was set at 60^0C for 2 minute; increased to 80^0C at the rate of 6^0C/min & hold at this temperature for 4 minutes and then increased to 250^0C at the rate of 10^0C & held at this temperature for 2 min.

The MSD conditions: - Ionisation energy 70 eV, ion source temperature 200^0C, mass range 50-500 amu, electron multiplier voltage (Auto tune + 200V).

Sample injection volume: - 1 µl.

Compound Identification.

MS Real Time Analysis software was used for data acquisition & processing and the result(s) were scrutinized via MS-library of National Institute of Standard and Technology..

RESULTS

Various laboratory examinations such as Physical tests, Chemical tests and Specific gravity measurements were carried out with the 31 seized samples and are summerised in Table 1.

In addition to physical and chemical analysis, percentage of ethanol was calculated in sample 27

Table 1: Tests performed with seized samples

Sample No.	Physical Tests			Chemical Tests				
	Volume (approx)	Colour	Odour/ Aroma	Iodoform test for Ethanol	Dichromate test for Ethanol	Aniline test for Furfural	Chromo-tropic acid test for Methanol	Potassium ferrocyanide test for Copper and Iron
1 to 24	Each 180 ml	all having colourless liquid	all having pungent odour	-VE in all samples	-VE in all samples	-VE in all samples	+VE in all samples	-VE in all samples
25	180 ml	Colorless liquid	Sweet aroma	-VE	-VE	-VE	-VE	-VE
26	180 ml	Yellow coloured liquid	Sweet fruity aroma	-VE	-VE	-VE	-VE	-VE
27	180 ml	Caramel coloured liquid	Sweet fruity aroma	+VE	+VE	-VE	-VE	-VE
28	180 ml	Light yellowish liquid comprising with oil type suspension	Sweet fruity aroma	+VE	+VE	-VE	-VE	-VE
29	180 ml	Slight yellowish liquid comprising two immiscible liquid layers.	Sweet fruity aroma	+VE	+VE	-VE	-VE	-VE
30	180 ml	Dark brown coloured thick viscous material	Burnt molasses odour	+VE	+VE	-VE	-VE	-VE
31	180 ml	Dark brown coloured thick liquid	odour alike of medicinal syrup	+VE	+VE	-VE	-VE	-VE

to 29 using specific gravity method, methanol was quantified in sample 1 to 24 by calibration graph method using GC technique and for identification of various hazardous compounds, chloroform extracts of seized moonshine samples were analyzed by GC-MS technique. The percentage of methanol in Exhibit-1 to Exhibit-24 was found as 0.77, 0.81, 0.93, 0.69, 0.57, 0.8, 0.77, 0.77, 0.77, 0.77, 0.79, 0.78, 0.76, 0.77, 0.8, 0.77, 0.78, 0.73, 0.76, 0.75, 0.82, 0.78, 0.81, 0.83 respectively; percentage of ethanol in Exhibit-27 to Exhibit 29 was found as 0.07, 0.26 & 0.07 respectively (ethanol detected in traces in Exhibit 30 & Exhibit 31) and 187 chemical compounds were detected and identified in seized sample 1 to 31. These detected chemicals according to their nature were categorized as Phytochemical compounds; Pyrolysis byproducts; Fermentation byproducts; Pesticides; Organic solvent; Flavouring substances/ Essential oils & Antioxidant compound. The resulting total ion chromatograms (TICs) are depicted in Fig. 3 the detected chemicals are tabulated alongwith Rt & molecular structure in table 2.

Grouping study by statistical methods using identification of chemicals detected in seized moonshine's samples

For comparison and discrimination of source of these detected chemicals, grouping was done using cluster analysis methods namely ***Principal Component analysis (PCA)*** as depicted in Fig. 4.

DISCUSSION

Table 2: Chemical profiling of chemical compounds detected compounds in seized moonshine samples.

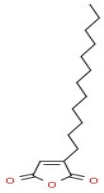
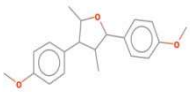
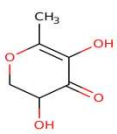
S.No.	Chemical compounds	Exhibits	Molecular structure	Rt
1.	**Phytochemical compounds**			
I.	**Heterocyclic compound**			
(i)	1,3,5,7-Tetroxane	4, 6, 9 to12, 14 to 18 and 20 to 24.		2.155, 2.910, 2.865, 2.130, 2.42, 2.750, 2.045, 2.880, 2.045, 2.22, 2.110, 2.045, 2.605, 2.405, 2.930, 2.020, 2.515
(ii)	2H-Pyran,2-(2,5-hexadiynyloxy) tetrahydro	13, 17 and 18		1.770, 1.665, 1.650
(iii)	3-Dodecyl-2,5-furandione	26		26.67
(iv)	Furan, tetrahydro-2,4-bis(4-methoxyphenyl)-3,5-dimethyl	26		17.955
(v)	4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl	30		12.490

Table contt...

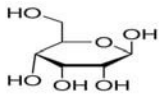
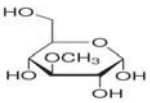
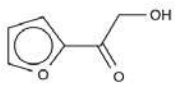
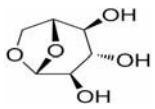
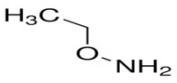
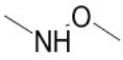
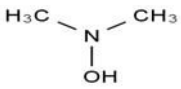
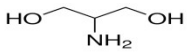
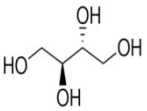
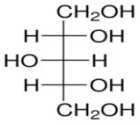
II.	**Bicyclic compound**			
(i)	Thujene	28		6.725
III.	**Monosaccharide**			
(a)	**Aldohexoses**			
(i)	D-Allose	30		19.435
(ii)	3-O-Methyl-d-glucose	30		16.140
IV.	**Hydroxy Ketone/ Hydroxyacetone/ Acetol**			
(i)	Furyl Hydroxymethyl ketone	30		10.430
2.	**Chemical compounds formed during pyrolysis of carbohydrates, such as starch and cellulose**			
a.	**Cyclic Ketohexoses**			
(i)	1,6-Anhydro-.beta.-Dglucofuranose/ Levoglucosan (furanose)	30 &31		20.920 & 20.730
3.	**Chemical compounds formed during fermentation**			
I.	**Nitrogen compound**			
a.	**Amine: Amines occur in liquor due to the biochemical degradation of amino acids, which may begin during malting and then continues during fermentation.**			
(i)	O-Ethylhydroxylamine	1, 4 to 7, 9 to 12, 14 to 22 and 24.		2.345, 1.82, 2.955, 3.09, 2.93, 2.385, 2.56, 2.055, 2.625, 2.235, 2.31, 2.45, 2.485, 3.005, 2.555, 2.495, 2.825, 2.010, 2.170
(ii)	Methanamine N-methoxy	1, 2, 8, 15, 20 and 22 to 24 & 31		4.495, 1.62, 1.905, 1.940, 1.945, 2.095, 2.480, 3.710, 13. 500
(iii)	Methanamine, N-hydroxy-N-methyl/ N,N-Dimethylhydroxylamine	20, 22 and 23.		2.375,2.39, 2.35
II	**Amino alcohol**			
(i)	Serinol/aminoglycerin/ 2-amino-1,3-propanediol	23		3.840
III	**Sugar alcohol**			
(i)	Erythritol	1, 2 and 4 to24		4.630, 4.790, 5.12, 13.55, 4.72, 4.57, 4.615, 4.845, 4.695, 4.975, 4.605, 4.575, 3.52, 4.925, 5.205, 4.9, 4.970, 4.650, 4.460, 4.87, 5.770, 4.820, 5.020 , 4.720
(ii)	Xylitol	7		3.300

Table contt...

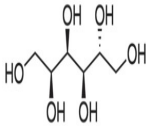
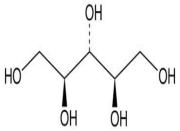
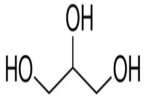
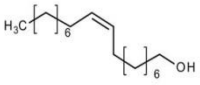
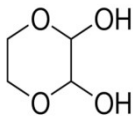
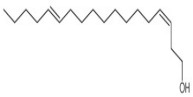
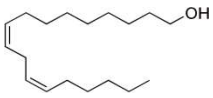
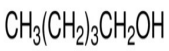
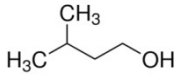
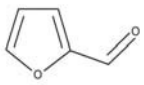
(iii)	Sorbitol	13		2.95
(iv)	Ribitol	23		5.820
(v)	Glycerin	1, 2 and 4 to 24 & 31		3.22, 4.945, 5.455, 5.47, 5.27, 2.725,3.195, 2.265, 2.265, 2.24, 2.425, 2.03,2.07, 2.105, 1.67, 2.260, 2.385, 5. 675,5.895, 5.42, 5.145, 5.495, 4.895
IV.	**Alcohol: Alcohols produced by reduction of acids/ fermentation**			
(i)	9-Octadecen-1-ol, (Z)	3		22.57
(ii)	Dioxanediol/ 2,3-Dihydroxy-1,4-dioxane	1, 3 to 7, 9 to 22 and 24		4.82, 1.585, 1.615, 1.65, 1.62, 1.615, 2.265, 1.655, 3.175, 3.275, 3.055, 2.215, 3.995, 2.895, 3.905, 2.35, 3.015, 2.245, 2.895, 5.115, 2.210, 2.040, 2.120
(iii)	E,E-3,13-Octadecadien-1-ol	2		23.77
(iv)	9,12-Octadecadien-1-ol, (Z,Z)/ Linoleyl alcohol	6		25.065
(v)	1-Butanol	27		1.93
(vi)	1-Pentanol/ n-Butylcarbinol/ amyl alcohol	27		4.15
(vii)	Isoamyl alcohol/ Fermentation amyl alcohol/ Fusel oil	27		3.095
V	**Hydrocarbon**			
(i)	8-Heptadecene	2 and 8		21.45 & 21.45
VI.	**Aldehyde**			
(i)	Furfural	30		3.850

Table contt...

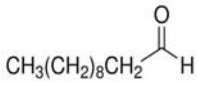
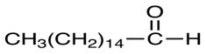
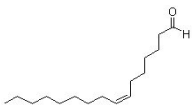
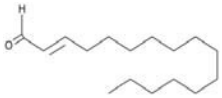
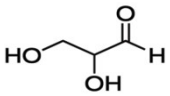
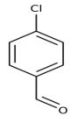
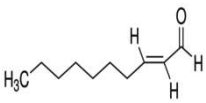
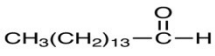
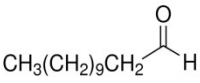
(ii)	Undecanal	28		16.050
(iii)	Hexadecanal	1 to 4 and 19		23.115, 23.115, 23.12, 23.12, 23.115, 23.130
(iv)	7-Hexadecenal (Z)	2, 3, 7,8, 10, 16 and 19		22.865, 23.83, 25.085, 22.865, 27.385, 25.105 & 25.08
(v)	9-Hexadecenal(Z)	2 & 28		26.500
(vi)	E-Hexadec-2-enal/ trans-2-Hexadecenal	8 and 20		17.025, 17.055
(vii)	Glyceraldehyde	10, 15, 20 and 22 to 24 & 30		2.53, 1.655, 3.405, 2.295, 2.540, 5.680, 1.905
(viii)	Myristaldehyde	2		20.645
(ix)	Benzaldehyde, 4-chloro	1		15.195
(x)	9-Octadecenal	1, 8 and 19.		23.83, 23.825, 24.005
(xi)	9-Tetradecenal	1 and 3		26.820 & 27.365
(xii)	2-Decenal(E)-/ trans-2-Decenal	19		15.14
(xiii)	Pentadecanal	2, 8 and 20		21.915, 21.915 & 25.325
(xiv)	Dodecanal/ Lauraldehyde	28		17.745

Table contt...

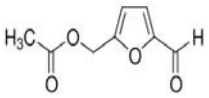
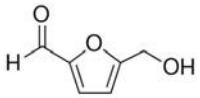
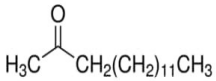
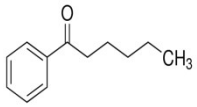
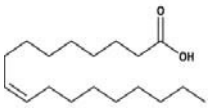
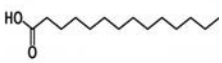
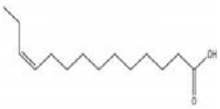
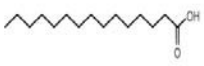
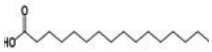
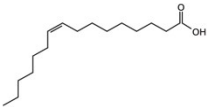
(xv)	5-Acetoxymethyl-2-furaldehyde	30		15.995
(xvi)	5-Hydroxymethylfurfural / HMF	30 & 31		14.745 & 14.490
VII.	**Ketone**			
(i)	Methyl tridecyl ketone/ Pentadecan-2-one	2		21.705
(ii)	Linoleyl methyl ketone	3, 4 and 19		25.665, 25.665 & 25.730
(iii)	Hexanophenone	2		18.585
VIII.	**Acids/volatile acids**			
(i)	Oleic acid/ 9-Octadecenoic acid(Z)	1 to 21 & 30		26.485, 26.7, 26.74, 26.59, 24.745, 26.57, 26.595, 26.595, 26.545, 26.57, 26.555, 26.595, 24.77, 26.6, 26.585, 26.615, 26.64, 26.670, 26.625, 26.630, 26.74, 26.410
(ii)	Elaidic acid / 9-octadecenoic acid(E)	1 & 2		26.53 & 26.7
(iii)	Acetic acid	1 & 23		4.825 & 2.075
(iv)	Dodcanoic acid	2		20.015
(v)	Tetradecanoic acid	2		22.495
(vi)	Z-11-tetradecenoic acid	2		22.365
(vii)	Pentadecanoic acid	2		23.62
(viii)	n-Hexadecanoic acid	1, 2, 29 & 30		24.665, 24.83, 24.735 & 27.67
(ix)	9-Hexadecenoic acid,(Z)/ Palmitoleic acid	2		24.565

Table contt...

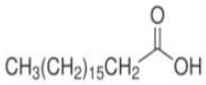
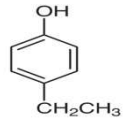
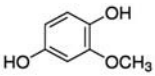
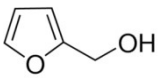
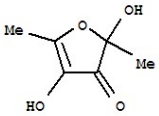
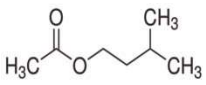
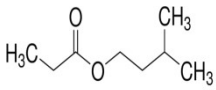
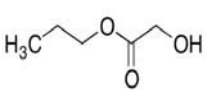
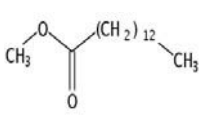
(x)	Octadecanoic acid	1		26.72
IX.	**Phenolic compound**			
(i)	p-Ethylphenol	31		13.135
(ii)	2-Methoxyhydroquinone	30		15.820
X	**Furans**			
(i)	Furfuryl alcohol	30		4.150
(ii)	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furanone	30		6.765
XI.	**Ester: These are formed by the reactions of organic acids and alcohols created during fermentation.**			
a.	**Acetate ester**			
(i)	Linoleyl acetate	3, 4 & 9		25.065, 25.065 & 25.05
(ii)	7-Dodecen-1-yl-acetate	2 & 8.		21.355 & 21.36
(iii)	Isopentyl alcohol, acetate/ Isoamyl acetate	27		4.615
b.	**Propionate ester**			
(i)	Isopentyl alcohol, propionate/ Isoamyl propionate	27		6.645
c.	**Glycolate ester**			
(i)	Propyl glycolate	3		2.01
d.	**Fatty acid methyl ester**			
(i)	Methyl tetradecanoate/ Myristic acid, methyl ester /Tetradecanoic acid, methyl ester	2 and 3		22.0 & 22.01
(ii)	Methyl Palmitoleate/ 9-Hexadecanoic acid, methyl ester (Z)	2, 3 and 8		24.055, 24.06 & 24.05

Table contt...

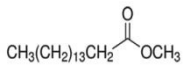
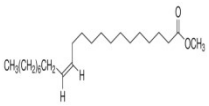
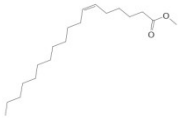
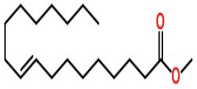
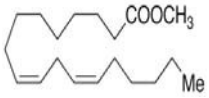
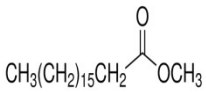
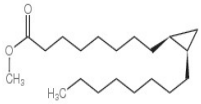
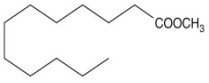
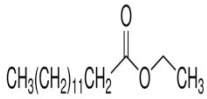
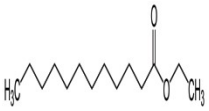
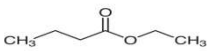
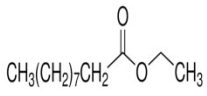
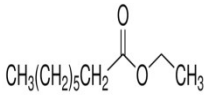
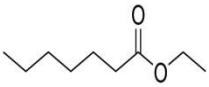
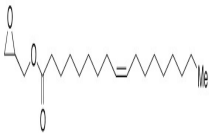
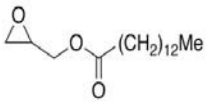
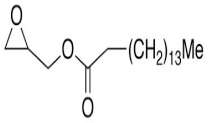
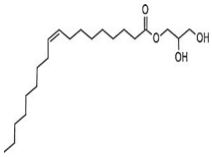
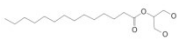
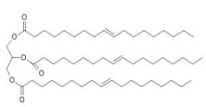
(iii)	Palmitic acid, methyl ester/ Hexadecanoic acid, methyl ester	1 to 4, 8, 10 and 19.		24.28, 24.28, 24.28, 24.28, 24.28, 24.285 & 24.280
(iv)	13-Docosenoic acid, methyl ester/ methyl, 13-docosenoate	1, 3, 4, 7 and 8.		25.96, 25.95, 25.945, 25.95 & 25.945
(v)	6-Octadecenoic acid, methyl ester (Z)	1		25.33
(vi)	9-Octadecenoic acid methyl ester (E)/ Methyl elaidate	1 to 4, 6, 8 to 14, 17 and 19 to 21		26.1, 26.105, 26.1, 26.1, 26.1, 26.15, 26.1, 26.11, 26.115, 26.125, 26.115, 26.115, 26.11, 26.105, 26.100, 26.110
(vii)	9, 12-Octadecadienoic acid (Z,Z)-, methyl ester/ Methyl linoleate	2 to 4, 8, 9 and 15		26.035, 26.035, 26.035, 26.03, 26.98 & 26.985
(viii)	Methyl stearate/ Octadecanoic acid, methyl ester	2 to 4, 8 and 17		26.345, 26.345, 26.345, 26.34 & 26.36
(ix)	Cis-9,10-Methyleneoctadecanoic acid, methyl ester	3		25.95
(x)	Dodecanoic acid, methyl ester/ Metholene 2296	27		19.405
e.	**Fatty acid ethyl ester**			
(i)	Myristic acid, ethyl ester/ Ethyl myristate	27		22.795
(ii)	Dodecanoic acid, ethyl ester/ Ethyl laurate	27		20.355
(iii)	Ethyl butanoate /Butanoic acid, ethyl ester	26 & 27		3.075 & 3.165
(iv)	Ethyl caprate/ Decanoic acid, ethyl ester	27		17.5

Table contt...

(v)	Ethyl caprylate/ Octanoic acid, ethyl ester	27		13.775
(vi)	Ethyl enanthate/ Heptanoic acid, ethyl ester	27		11.085
f.	**Fatty acid glycidal ester**			
(i)	9-octadecenoic acid(Z)-oxiranylmethyl ester/ glycidol oleate/ glcidyl octadecenoate/ oleic acid, glycidyl ester	1 to 6, 8 to 14, 17 and 20		25.225, 28.02, 25.225, 25.215, 25.215, 25.215, 25.205, 25.22, 25.21, 25.21, 25.215, 25.23, 25.22, 25.22, 25.23, 25.20
(ii)	Tetradecanoic acid, 2-oxiranylmethyl ester/ Myristic acid glycidyl ester	4, 5 and 8		25.875, 25.89 & 25.895
(iii)	Hexadecanoic acid, 2-oxiranylmethyl ester/ Glycidyl palmitate/ Oxiran-2-ylmethyl palmitate	3, 4, 6, 8 and 13		25.875, 28.235, 28.235, 28.235 & 25.895
g.	**Fatty acid glycerol ester**			
(i)	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester/ Palmitin, 2-mono	3, 4, 6, 8, 9, 10, 13,14, 17, 19, 20		27.66, 27.66, 27.665, 27.67, 27.66, 27.680, 27.67, 27.69, 27.675, 27.66 & 27.65
(ii)	9-Octadecenoic acid (Z)-,2,3-dihydroxypropyl ester/ Glyceryl monooleate	3, 4, 5, 8, 10, 13, 14, 17, 19		23.67, 23.575, 27.445, 23.67, 23.68, 23.67, 23.68, 23.69, 23.695, 23.695 & 23.69
(iii)	Tetradecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester/ Myristin, 2-mono	4		25.55
(iv)	9, 12-Octadecadienoic acid (Z,Z)-, 2-hydroxy-1-(hydroxymethyl) ethyl ester/ Linolein, 2-mono	3 & 4		23.395 & 23.44
(v)	9,12-Octadecadienoic acid (Z,Z)-, 2,3 dihydroxypropyl ester/ Alpha-glyceryl linoleate	3		23.44
(vi)	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)/ glycerine trioleate	4 & 5		24.555 & 26.58

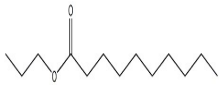
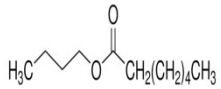
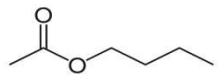
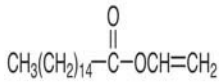
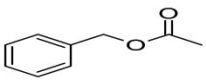
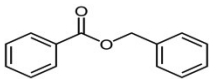
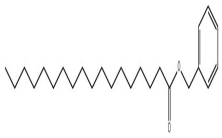
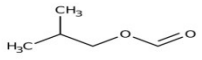
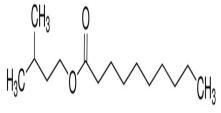
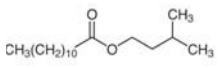
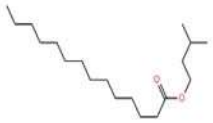
h.	**Fatty acid propyl ester**			
(i)	Dodecanoic acid, propyl ester/ Propyl decanoate	21		4.900
i.	**Fatty acid butyl ester**			
(i)	Oleic acid, butyl ester	19		1.495
(ii)	Butyl heptanoate/ Heptanoic acid, butyl ester	27		15.685
(iii)	Butyl ethanoate/ acetic acid, butyl ester	27		3.42
j.	**Fatty acid vinyl ester**			
(i)	Palmitic acid vinyl ester/ Hexadecanoic acid ethenyl ester	2 to 4		27.6, 27.58 & 27.58
k.	**Fatty acid benzyl ester**			
(i)	Acetic acid,phenylmethyl ester / Benzyl ethanoate / Benzyl acetate	19 & 27		12.93 & 12.945
(ii)	Benzyl Benzoate	1, 25 & 26		22.665, 23.8 & 22.65
(iii)	Octadecanoic acid, phenylmethyl ester/ Benzyl stearate	27		27.815
l.	**Fatty acid isobutyl ester**			
(i)	Formic acid, 2-methylpropyl ester	23		1.685
m.	**Fatty acid isoamyl ester**			
(i)	Pentadecanoic acid, 3-methylbutyl ester/ Isopentyl decanoate	27		21.01
(ii)	Dodecanoic acid, 3-methylbutyl ester/ Isopentyl laurate	27		23.385
(iii)	Tetradecanoic acid, 3-methylbutyl ester/ 3-Methylbutyl tetradecanoate	27		25.505

Table contt...

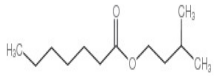
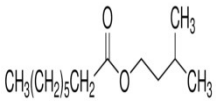
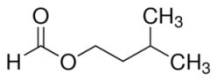
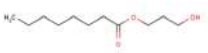
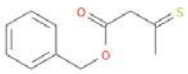
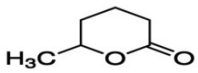
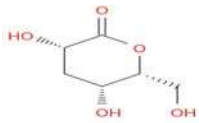
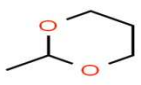
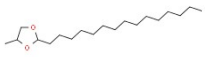
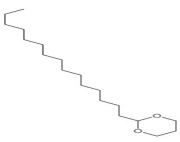
(iv)	Hexadecanoic acid, 3-methylbutyl ester/ 3-Methylbutyl hexadecanoate	27		27.555
(v)	Heptanoic acid, 3-methylbutyl ester/ Isopentyl heptanoate	27		16.745
(vi)	Octanoic acid, 3-methylbutyl ester/ Isoamyl caprylate	27		118.3
(vii)	Isoamyl formate	27		3.005
n.	**Fatty acid sabinyl acetate**			
(i)	Sabinyl linoleate/ Linoleic acid, sabinyl acetate	26		23.655
o.	**Fatty acid monohydroxy propyl ester**			
(i)	Octadecanoic acid, 3-hydroxypropyl ester	26		27.79
p.	**Fatty acid monohydroxy aryloxy ester**			
(i)	tert-Butyl 3-hydroxy-3-(4-methoxyphenyl) propanoate/ Propanoic acid, 3-hydroxy-3-(4-methoxyphenyl)-,t-butyl ester	25 & 26		19.155 & 22.965
q.	**Keto acids benzyl ester**			
(i)	Acetoacetic acid, 3-thio-,benzyl ester/ Benzyl 3-thioxobutanoate	26		12.43
r.	**Cyclic ester**			
(i)	delta.-Caprolactone	27		3.615
(ii)	3-deoxy-d-mannoic lactone	30		21.42
XII.	**ACETALS**			
(i)	1,3-Dioxane, 2-methyl	25		2.020
(ii)	1,3-Dioxolane, 4-methyl-2-pentadecyl	26		18.875
(iii)	1,3-Dioxane, 2-pentadecyl	26		26.01

Table contt...

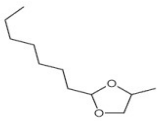
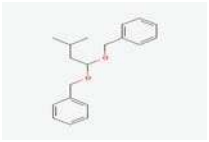
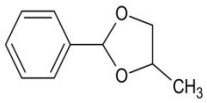
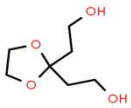
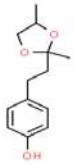
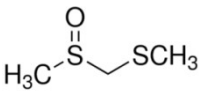
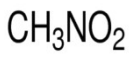
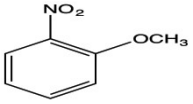
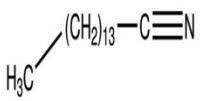
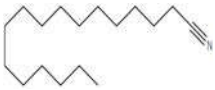
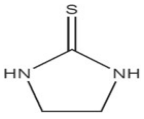
(iv)	1,3-Dioxolane, 2-heptyl-4-methyl	28 & 29		17.350 & 17.335
(v)	Isovaleraldehyde dibenzyl acetal	27		21.76
(vi)	Benzaldehyde propylene glycol acetal/ 1,3-Dioxolane, 4-methyl-2-phenyl	27		15.285
(vii)	1,3-Dioxolane-2,2-diethanol	26		28.22
(viii)	4-[2-(2,4-Dimethyl-1,3-dioxolan-2-yl) ethyl]phenol/ 4-(4-Hydroxyphenyl)-2-butanone propyleneglycol	26		22.77
XIII.	**Sulphur compound**			
(i)	Formaldehyde dimethyl mercaptal S-oxide	1, 2 and 4 to 24		1.665, 3.325, 2.045, 2.18, 2.02, 1.97, 1.645, 1.66, 2.05, 1.59, 2.275, 2.475, 2.945, 2.715,1.58, 2.23,1.99, 4.8, 1.875, 1.690, 1.875, 1.570 & 1.585
4.	**Pesticides/contaminants**			
I.	**Nitrogen compounds**			
a.	**Nitro: Pesticides/fuel additive/ agricultural products/explosive**			
(i)	Methane nitro	1 to 24 & 31		2.22, 1.545, 3.895, 1.915, 1.805 , 1.88, 2.055, 1.565, 2.2, 1.875, 2.105, 1.86, 2.35, 1.605, 1.59, 1.925, 1.970, 1.955, 1.780, 1.770, 1.765, 1.740, 1.765, 2.035 & 2.035
(ii)	Anisole, o-nitro/ Benzene, 1-methoxy-2-nitro/ o-Nitrophenyl methyl ether	16		3.790
b.	**Nitrile-agricultural products/pesticides**			
(i)	Pentadecanenitrile	1		22.88
(ii)	Heptadecanenitrile	1		25.125
c.	**Amide-** Fungicides/ Herbicides (contaminats)			
(i)	Ethylenthiourea	10 to 12, 18 and 20		5.520, 5.735, 5.425, 5.485 & 2.76

Table contt...

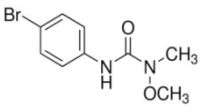
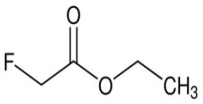
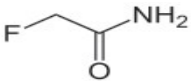
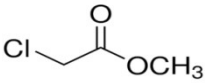
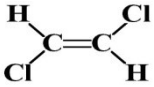
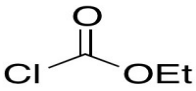
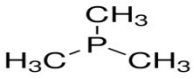
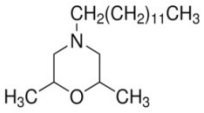
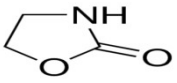
(ii)	Metobromuron/ Urea,N-(4-bromophenyl)-N-methoxy-N-methyl	13 and 20		3.775 & 2.76
II.	**Organofluorine compound: Rodenticide (contaminant)**			
(i)	Acetic acid, fluoro-, ethyl ester/ Ethyl monofluoroacetate/ Ethyl fluoroacetate	1, 3, 5 to 7, 9 to 14, 16, 17, 19 to 21 and 23		11.625, 4.995, 3.645, 17.135, 4.78, 2.505, 7.135, 3.58, 7.03, 3.685, 3.135, 3.705, 2.71, 4.245, 16.545, 5.18, 5.280
(ii)	Acetamide, 2-fluoro	5		7.375
III.	**Organochlorine compound (Pesticides/ Agrochemicals)**			
(i)	Methyl chloroacetate/ Acetic acid, chloro-, methyl ester	27		10.090
(ii)	Ethene,1,2-dichloro-,(E)/Trans-Di-1,2-Chloroethylene	30		3.795
(iii)	Carbonochloridic acid, ethyl ester/ Cathyl chloride/ Formic acid, chloro-, ethyl ester	30 & 31		1.405 1.385
IV.	**Organophosphorus compound (pesticide)**			
(i)	Trimethylphosphine	28, 29 & 31		2.615, 2.720, 2.905
V.	**Morpholine compound (Fungicide)**			
(i)	Tridemorph	30		10.525
VI.	**Oxazolidinones (Antimicrobials)**			
(i)	2- Oxazolidinone	28		17.550
(ii)	N-Nitroso-2,4,4-trimethyloxazolidine	30		16.275
5.	**Organic Solvent (Health hazardous chemical compounds)**			
I.	**Glycol ether**			
(i)	Carbitol/ Diethylene Glycol ethyl ether/ Ethanol, 2-(2-ethoxyethoxy)	25		11.165
(ii)	Diethyl carbitol	25		11.41

Table contt...

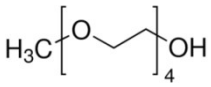
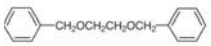
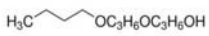
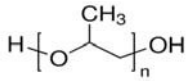
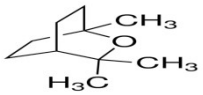
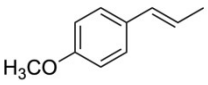
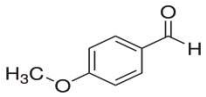
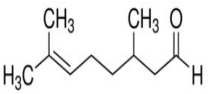
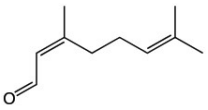
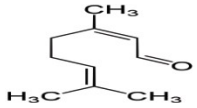
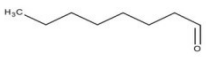
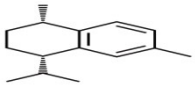
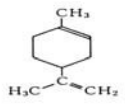
(iii)	Tetraethylene glycol, monoethyl ether	25		12.78,
(iv)	Ethane, 1,2-bis(benzyloxy)/ Ethylene Glycol Dibenzyl Ether/ Dibenzyl Glycol	25		24.82
(v)	Dipropylene glycol, butyl ether	28		11.650
(vi)	Ethylethylene glycol	28 and 29		6.275 & 10.030
(vii)	Polypropylene glycol/ 1-Propanol, 2-(2-hydroxy propoxy)	29		10.605 & 10.715
6.	**Flavouring substances/ Essential oils/Terpenoids**			
I.	**Ether**			
(i)	Eucalyptol	25		8.655
(ii)	Anethole	1 and 8 and 25		15. 695, 15.68 & 16.52
II.	**Aldehyde**			
(i)	p-Anisaldehyde	25		13.71
(ii)	Citronellal	28		12.650
(iii)	Citral	28 and 29		15.220, 15.180
(iv)	Neral	28 and 29		14.605 & 14.680
(v)	Caprylaldehyde/ Octanal	8 & 28		7.7007
III.	**Hydrocarbon**			
(i)	Cis-Calamenene	25		17.525
(ii)	D-Limonene	26, 28 & 29		10.12, 8.640 & 8.795

Table contt...

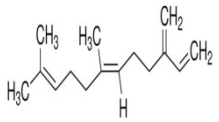
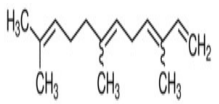
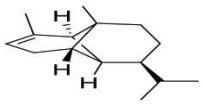
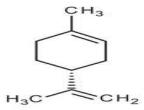
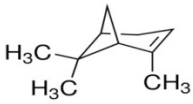
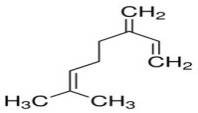
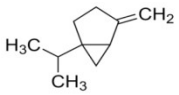
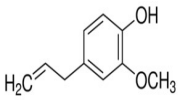
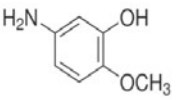
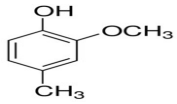
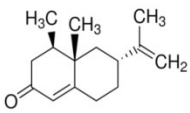
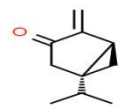
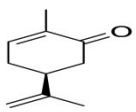
(iii)	(E)-.beta.-Farnesene	26		21.705
(iv)	alpha.- Farnesene	26		22.36
(v)	Copaene	26		17.305
(vi)	Limonene	27		8.530
(vii)	2-Pinene	28		5.675
(viii)	Myrcene/ beta-Myrcene	28 and 29		7.075 & 7.090
(ix)	Sabinene	28		6.725
(x)	n-Hexane	28 and 29		
IV.	**Phenolic compound**			
(i)	Eugenol	26 & 31		16.94 & 16.855
(ii)	o-Guaiacol/o-Methoxyphenol	31		10.645
(iii)	Creosol	31		13.595
V.	**Ketone**			
(i)	Nootkatone	26		23.17
(ii)	Sabinone	29		14.455
(iii)	D-Carvone	29		14.825

Table contt...

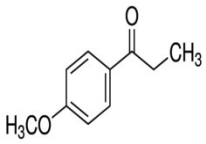
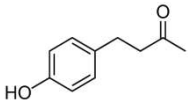
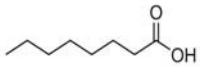
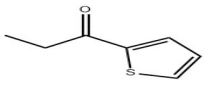
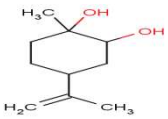
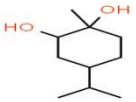
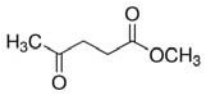
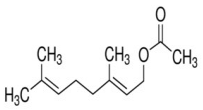
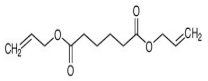
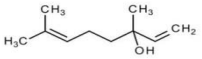
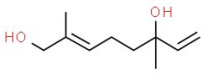
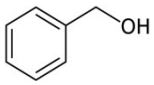
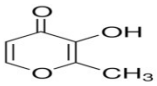
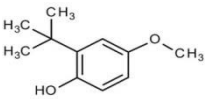
(iv)	1-Propanone, 1-(4-methoxyphenyl)/ Propiophenone,4-methoxy/ p-Methoxy propiophenone	25		18.510
(v)	2-Butanone, 4-(4-hydroxyphenyl) / raspberry Ketone	26		20.07
VI.	**Epoxide**			
(i)	Limonene oxide, trans	26		20.205
VII.	**Acids**			
(i)	n-Heptoic acid	27		11.81
(ii)	Oleic acid	26 , 27 & 30		26.470, 26.525 & 26.410
(iii)	n-Hexadecanoic acid/Palmitic acid	26, 27, 29 & 30		24.675, 24.700, 24.615 & 24.600
(iv)	D-Campholic acid	29		18.725
(v)	Octanoic acid	29, 30 & 31		13.685, 13.285 &13.305
VIII.	**Thienyl**			
(i)	Ethyl-2-thienylketone	30		12.645
IX.	**Cyclic vicinal glycol**			
(i)	1,2-Cyclohexanediol,1-methyl-4-(1-methylethenyl)/Limonene glycol	26 & 29		16.87 & 16.995
(ii)	Isocarvomenthol,1-hydroxy/ p-Menthane-1,2-diol	26		21.115

Table contt...

X.	**Keto acid**			
(i)	3-Methyllevulinic acid/ Pentanoic acid, 3-methyl-4-oxo	27		1.685
XI.	**Acetate ester**			
(i)	Acetic acid, geraniol ester/ Geranyl acetate	28		17.195
XII.	**Fatty acid geranyl ester**			
(i)	Geraniol butyrate/ Geranyl butyrate	28		16.900
XIII.	**Allyl Ester**			
(i)	Adipic acid, dially ester	30		20.425
XIV.	**Alcohol**			
(i)	Linalool	28 & 29		10.745 & 10.465
(ii)	alpha-Terpineol	28 & 29		13.335 & 13.865
(iii)	8-Hydroxylinalool			14.00
(iv)	Benzenemethanol/ Benzyl alcohol	31		8.730
XV.	**Hydroxypyranone**			
(i)	Maltol	30		11.430
7.	**Antioxidant compound**			
(i)	2-tert-Butyl-4-methoxyphenol/ 2-BHA	29		18.955

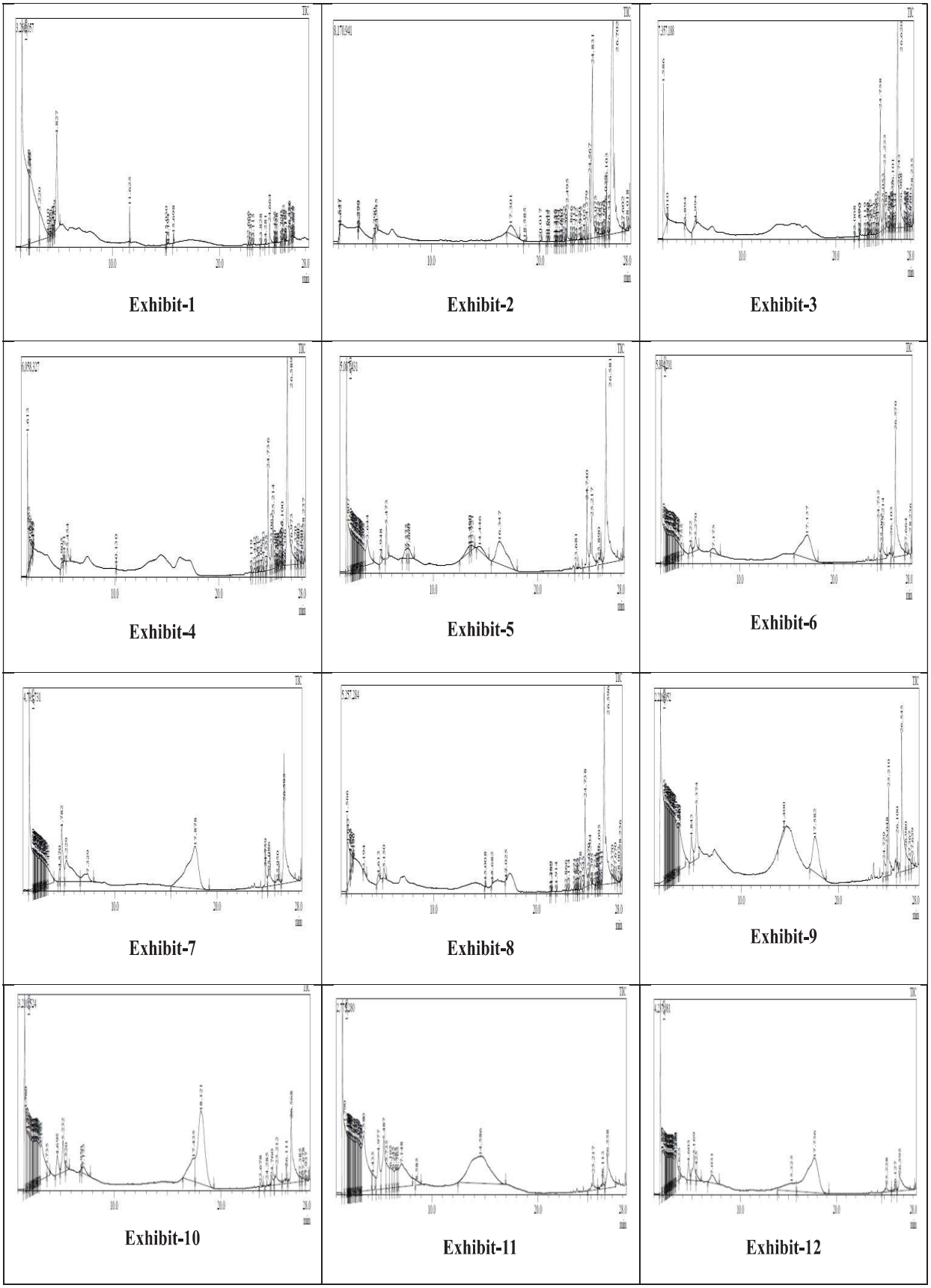


Exhibit-1

Exhibit-2

Exhibit-3

Exhibit-4

Exhibit-5

Exhibit-6

Exhibit-7

Exhibit-8

Exhibit-9

Exhibit-10

Exhibit-11

Exhibit-12

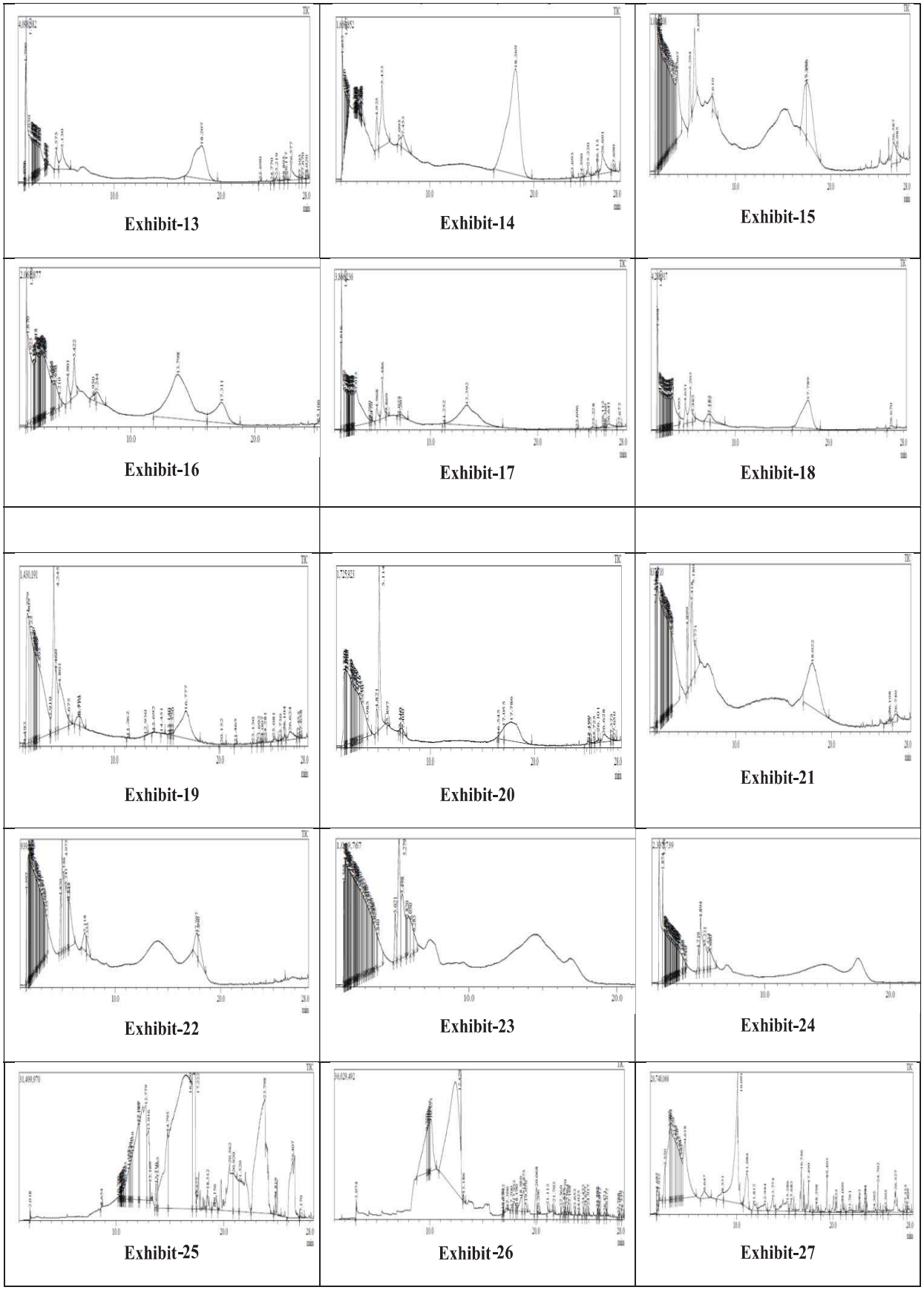


Exhibit-13

Exhibit-14

Exhibit-15

Exhibit-16

Exhibit-17

Exhibit-18

Exhibit-19

Exhibit-20

Exhibit-21

Exhibit-22

Exhibit-23

Exhibit-24

Exhibit-25

Exhibit-26

Exhibit-27

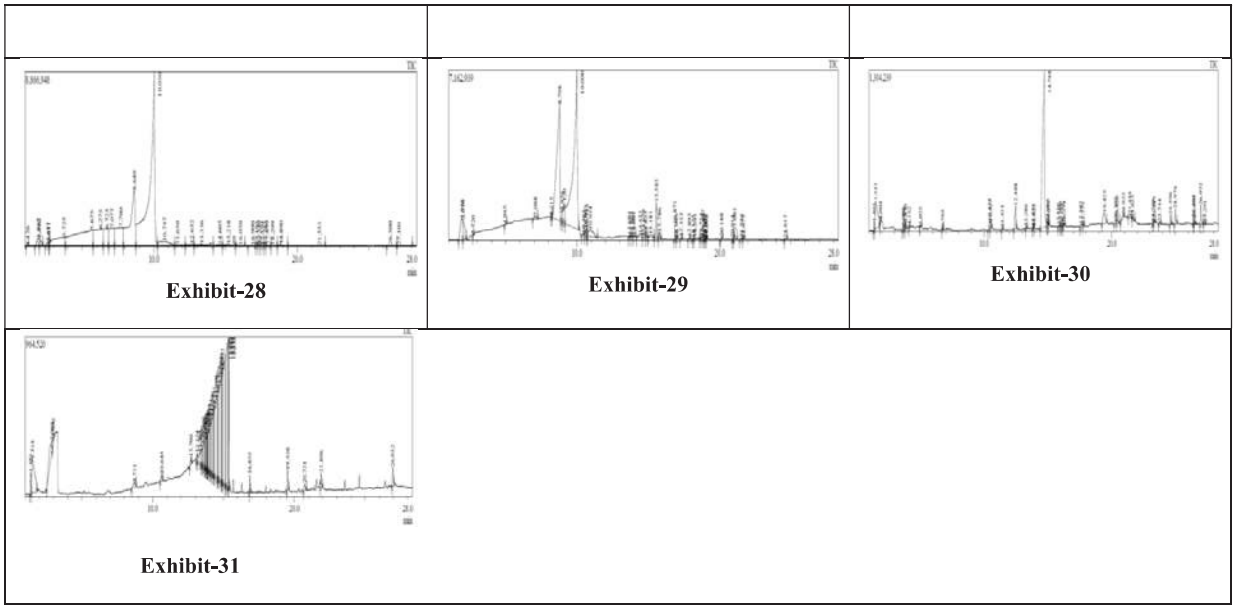


Fig. 3: Total Ion Chromatograms of Seized Samples (1- 31)

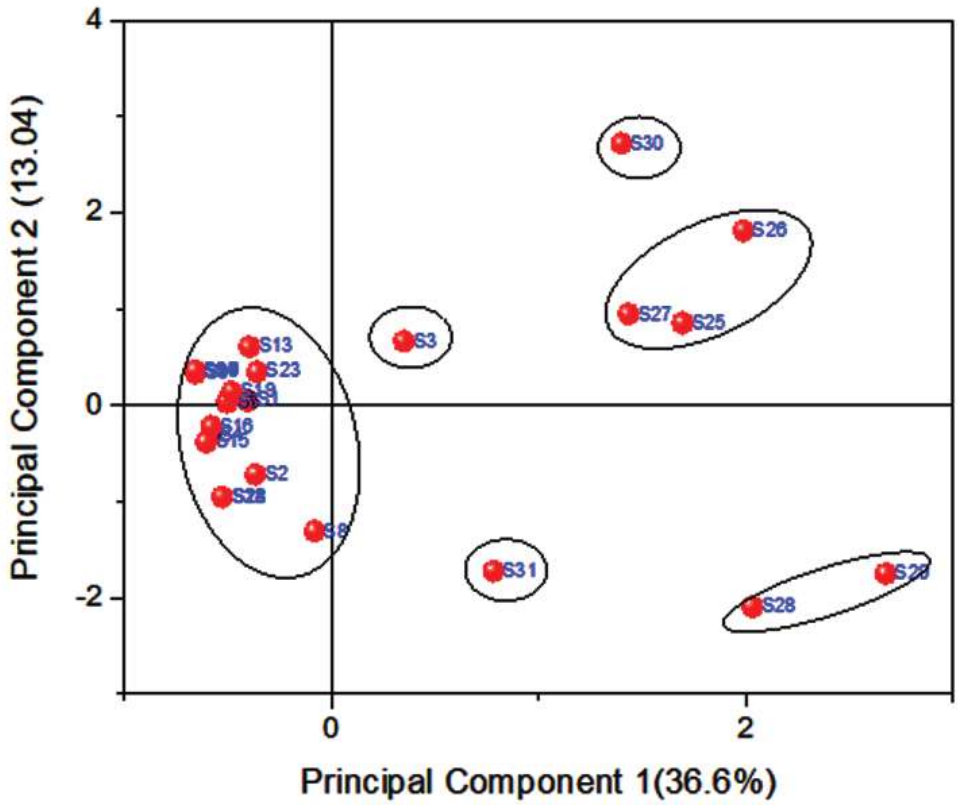


Fig. 4: Principal Component Analysis (PCA) using chemicals detected in seized moonshine's samples

One hundred eighty seven (187) chemical compounds were detected and identified by GC-MS technique in 31 moonshine's seized samples. These were categorised as Phytochemical compounds; Pyrolysis byproducts; Fermentation byproducts Pesticides; Organic solvent; Flavouring substances/ Essential oils and Antioxidant compound as depicted in table 2. The composition of these

samples were found quite different from recorded country liquor as the homemade producers might had use their own traditional methods.

Among these detected 187 chemical compounds, 73 chemical compounds were found health hazardous. The hazard statement of these 73 harmful chemicals are tabulated in table 3.

It is evident from table 3 that among 187 chemical compounds, 73 chemical compounds are

Table 3: Hazard identification of detected chemical compounds

S.No.	Chemical compounds	Detected in Exhibit No.	Hazards Identification								
			Irritant				Corrosive	Toxic	Flammable	carcinogenic	Toxic to aquatic Life
			Skin	Eyes	Respiratory	Digestive					
											
1	O-Ethylhydroxylamine	1, 4 to 7, 9 to 12, 14 to 22 & 24	✓	✓	✓	✓	-	✓	✓	✓	✓
2	Methanamine N-methoxy	1, 2, 8, 15, 20, 22 to 24 & 31	✓	✓	✓	✓	-	-	-	-	-
3 to 11	Methanamine, N-hydroxy-N-methyl/ N,N-Dimethylhydroxylamine	20, 22 & 23	✓	✓	-	-	-	-	-	-	-
	Dioxanediol/ 2,3-Dihydroxy-1,4-dioxane	1, 3 to 7, 9 to 22 & 24									
	Myristaldehyde	2									
	9-Tetradecenal	1 & 3									
	2-Decenal(E)-/ trans-2-Decenal	19									
	Pentadecanal	2, 8 & 20									
	Tetradecanoic acid	2									
	Pentadecanoic acid	2									
	n-Hexadecanoic acid	29 & 30									
12 to 14	Furfural	1 to 24 & 30	✓	✓	✓	✓	-	-	-	✓	-
	Furfuryl alcohol	30									
	BHA	29									
15	1,3-Dioxane, 2-methyl	25	✓	✓	✓	-	-	-	-	✓	-
16	Serinol/ aminoglycerin/ 2-amino-1,3-propanediol	23	✓	✓	✓	-	✓	-	-	-	-
17 to 31	Erythritol	1, 2 & 4 to 24	✓	✓	✓	✓	-	-	-	-	-
	Xylitol	7									
	Sorbitol	13									
	Ribitol	23									
	p-Ethylphenol	31									
	Methyl stearate/ Octadecanoic acid, methyl ester	2 to 4, 8 & 17									
	Glyceraldehyde	10, 15, 20, 22 to 24 & 30									
	Glycerin	1, 2, 4 to 24									
	Ethyl butanoate /Butanoic acid, ethyl ester	26 & 27									
	Isopentyl alcohol, acetate/ Isoamyl acetate	27									
	9-Octadecenoic acid methyl ester (E)/ Methyl elaidate	1 to 4, 6, 8 to 14, 17, 19 to 21									
	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)/ glycerine trioleate	4 & 5									

	Oleic acid, butyl ester	19									
	Isovaleraldehyde dibenzyl acetal	27									
	Benzaldehyde propylene glycol acetal/ 1,3-Dioxolane, 4-methyl-2-phenyl	27									
32 to 36	1-Butanol	27	✓	✓	✓	✓	-	-	✓	-	-
	1-Pentanol/ n-Butylcarbinol/ amyl alcohol										
	Isoamyl alcohol										
	Octadecanoic acid	1									
	Methyl Palmitoleate/ 9-Hexadecanoic acid, methyl ester (Z)	2, 3 & 8									
37to 46	Hexadecanal	1 to 4, 8 & 19	✓	✓	✓	-	-	-	-	-	-
	9-Hexadecenal(Z)	2 & 28									
	Hexanophenone	2									
	Elaidic acid/ 9-octadecenoic acid(E)	1 & 2									
	Butyl heptanoate/ Heptanoic acid, butyl ester	27									
	Octanoic acid, 3-methylbutyl ester/ Isoamyl caprylate	27									
	Dodecanoic acid, propyl ester/ Propyl decanoate	21									
	Formaldehyde dimethyl mercaptal S-oxide	1, 2, 4 to 24									
	Methyl tridecyl ketone /Pentadecan-2-one	2									
	1,3-Dioxane, 2-methyl	25									
47 & 48	Benzaldehyde, 4-chloro	1	✓	✓	✓	✓	-	-	-	-	✓
	Dodecanoic acid	2									
49 to 51	Dodecanal/ Lauraldehyde	28	✓	✓	-	-	-	-	-	-	✓
	Acetoacetic acid, 3-thio-, benzyl ester/ Benzyl 3-thioxobutanoate	26									
	Octanoic acid	29 to 31									
52	Acetic acid	1 & 23	✓	✓	✓	✓	✓	✓	✓	-	-
53 & 54	9-Hexadecenoic acid,(Z)/ Palmitoleic acid	2	✓	✓	✓	-	-	-	✓	-	-
	Myristic acid, ethyl ester/ Ethyl myristate	27									
55	Ethyl heptanoate/ Heptanoic acid, ethyl ester	27	✓	✓	✓	✓	-	-	✓	✓	-
56 & 57	Propyl glycolate	3	✓	✓	-	✓	-	✓	-	-	-
	9-Octadecenoic acid (Z)-,2,3-dihydroxypropyl ester/ Glyceryl monooleate	3, 4, 5, 8, 10, 13, 14, 17 & 19									
58 to 60	Methyl tetradecanoate/ Myristic acid, methyl ester Tetradecanoic acid, methyl ester	2 & 3	✓	-	-	-	-	-	✓	-	-

	Isopentyl alcohol, propionate/ Isoamyl propionate	27									
	Oleic acid/ 9-Octadecenoic acid(Z)	30									
61	Palmitic acid, methyl ester/ Hexadecanoic acid, methyl ester	1 to 4, 8, 10 & 19	✓	-	-	-	-	-	-	-	-
62 & 63	13-Docosenoic acid, methyl ester/ methyl, 13-docosenoate	1, 3, 4, 7 & 8	-	-	-	-	-	-	✓	-	-
	Butyl ethanoate/ acetic acid, butyl ester	27									
64	9, 12-Octadecadienoic acid (Z,Z)-, methyl ester/ Methyl linoleate	2 to 4, 8, 9 & 15	✓	✓	✓	✓	-	-	✓	-	✓
65 & 66	Dodecanoic acid, methyl ester/ Metholene 2296	27	-	-	-	-	-	-	-	-	✓
	Acetic acid, phenylmethyl ester/ Benzyl ethanoate/ Benzyl acetate	19 & 27									
67	Ethyl caprylate/ Octanoic acid, ethyl ester	27	✓	✓	-	-	-	-	✓	-	-
68	Benzyl Benzoate	1	-	-	-	✓	-	-	-	-	✓
6 9	Formic acid, 2-methylpropyl ester	23	-	✓	✓	-	-	-	✓	-	-
70	Pentadecanoic acid, 3-methylbutyl ester/ Isopentyl decanoate	27	✓	-	✓	-	-	-	-	-	-
71	Isoamyl formate	27	-	✓	✓	-	-	-	-	-	-
72	Octadecanoic acid, 3-hydroxypropyl ester	26	-	✓	-	-	-	-	-	-	✓
73	delta.-Caprolactone	27	-	✓	-	-	-	-	-	-	-

found potential harmful to human health. These are categorized into six categories viz. Irritant, Corrosive, Toxic, Flammable, Carcinogenic & Toxic to aquatic life and among these 73 harmful chemical compounds, 40 chemical compounds are found only irritant, 2 are only flammable, 2 are only toxic to aquatic life; 13 are irritant & flammable; 7 are irritant & toxic to aquatic life; 4 are irritant & carcinogenic; 1 is irritant & corrosive; 2 are irritant & toxic; 1 is irritant, flammable & carcinogenic; 1 is irritant, corrosive, toxic & flammable and 1 is irritant, toxic, flammable, carcinogenic & toxic to aquatic life.

As per the table, it has also been observed that the most commonly present Irritant are O-Ethylhydroxylamine; Methanamine N-methoxy; Dioxanediol; Furfural; Glycerin; Methyl elaidate & Formaldehyde dimethyl mercaptal S-oxide; most commonly corrosives chemicals are Serinol & Acetic acid and the most commonly present toxic chemicals are O-Ethylhydroxylamine; Acetic acid & Glyceryl monooleate.

Further, it is also found that among 31 samples, sample marked as 1 to 25 and 27 and 30 are highly potential health hazardous samples as these samples are containing carcinogenic chemical compounds i.e. Furfural (in sample 1 to 24 & 30); Furfuryl alcohol (in sample 30); 1,3-Dioxane, 2-methyl (in sample 25); Ethyl heptanoate (in sample 27); BHA (in sample 29) & O-Ethylhydroxylamine (in sample 1, 4 to 7, 9 to 12, 14 to 22 & 24).

It is unequivocal that the coalesce presence of Methanol & carcinogenic chemicals (furfural, O-Ethylhydroxylamine) alongwith other harmful hazardous chemicals in sample 1 to 24 constitutes ***the most*** deadly chemical's combination drink and so, this make hooch lethal (toxic brew) to the vital organs.

Moreover, the presence of detected chemicals in myriad combination with statistical tools like principal component analysis as depicted in Fig. 4 are found to be advantageous in terms of interpreting the sources with adequate reliability. From these statistical analysis it is found that sample 1 to sample 24 (except sample 3) are from the same source; sample 25 to sample 27 are from same source; sample 28 & sample 29 are from same source; sample 30 & sample 31 are from different source.

CONCLUSION

Incidences of hooch tragedies have been increased in Punjab since 2020 and the main reasons observed for this tragedies are presence of hazardous

contaminants and additives besides methanol in hooch. The presence of these contaminants are mainly caused due to the ignorance of moonshiners towards public health in distillation process such as use of heads & tails in hooch; not using multiple distillation process; utilizing large containers of hazardous chemicals/organic solvents/pesticides; improper cleaning of raw materials for production of liquor and lack of facility to control the fermentation which causes oxidation of the ethyl alcohol into acetic acid. Moreover, to make brew strong and aromatic, moonshiners also add multiple harmful flavouring substances. The intake of these hazardous additives and contaminants in hooch can cause severe health problems viz. eye, nose & throat irritation; inflammation to monocytes; birth defects; allergic reactions; effect on reproduction, immune or nervous system; cancer & even death. The aforementioned health hazards in lieu of hazardous additives and contaminants besides methanol need utmost attention and stringent action by Govt. authorities/ law agencies for determining the cause of death/grievous hurt and in deciding the quantum of punishment. Further, the excise department should disposed off seized liquor laced with hazardous chemicals appropriately to protect other life as "what kills humans, can kill animal as well as aquatic life".

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