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GC-MS analyses of biochemical constituents in fruit body of *Agaricus bisporus*

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Fruit body of *Agaricus bisporus* grown in paddy straw-based compost formulation was harvested separately at two different pin head and mature growth stages and ethanolic extract was made for GC-MC analyses. GC-MS-TIC spectrum analyses revealed that the presence of phenolic derivatives, organic acids and essential fatty acids in the ethanolic extract of *A. bisporus* fruit body which are associated with some beneficial health activities like antioxidant. Fumaric acid, acetic acid, malic acid was also detected as organic acids. Pyrazin, a phenolic derivative responsible for antidiabetic activity was detected in this edible mushroom. In pin head stage total 58 compounds were detected which include unsaturated fatty acids, phenolic derivatives, alkaloids, terpenoids, steroids, carbohydrate derivatives while total 69 compounds including terpenoid, alkaloids and organic acids were detected in extract of mature fruit body. Ergosterol derivative was detected as highest peak in both stages of fruit body. Tumeron, a medicinally important compound was also detected only in ethanolic extract of mature fruit body.

Key words: *Agaricus bisporus*, GC-MS, ergosterol, pyrazin, tumeron

INTRODUCTION

Edible mushrooms are a popular and valuable food, low in fats but high in minerals, essential amino acids, unsaturated fatty acids, vitamins and fibres (Afieroho *et al.,* 2013). Mushrooms having potential medicinal effects attributed to the presence of bioactive compounds like terpenoids, steroids, phenolics and alkaloids (Chien*et al.,* 2015; Zhang *et al*., 2016, Meng *et al.,* 2016). There is no doubt that edible mushrooms are nutritionally sound tasteful food source for most people and can be a significant dietary component for vegetarians.

Prior epidemiological studies have shown that the intake of natural antioxidants is allied with reduced risks of several diseases like diabetes and anti-inflammatory disease. Laboratory andclinical studies suggested that the diet supplemented with fruit and vegetables had beneficial effects on diabetes (Adams, 2014). Modern drugs including insulin control blood glucose level only when they are regularly administered but they have several side effects. Hyperglycemia is characterized by the increased level of glucose in blood associated with the alteration of metabolisms (Rushita *et al.,* 2013). Contributory factor in the pathogenesis of diabetes also comprises of oxidative stress (Sonawane *et al.,* 2013). Mushrooms have a history of traditional use in oriental therapies and modern clinical practices continue to rely on mushroom derived preparations (Ferreira *et al.,* 2010). Edible mushrooms and their constitutive active compounds have been described to have beneficial effects on hyperglycemia and hypercholesterolemia. White button mushroom has high content of acidic polysaccharides, dietary fiber, and antioxidants including vitamins C, B12, and D, folate-ergothioneine and polyphenol. It has potential anti-inflammatory, hyperglycemic and hypocholesterolemic effects. Given the high dietary fiber and antioxidants in button mushroom may be advantageous in lowering the dietary glycemic load (Jeong *et al.,* 2010).

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In the present investigation, the biochemical constituents in two growth stages, such as pin head and mature fruit body of *Agaricus bisporus* have been analysed by GC-MS.

MATERIALS AND METHODS

Sample and extract preparation

Fresh mushroom both pin head (3 day old) and mature stage was obtained from the mushroom bed grown in paddy straw-based compost. The sample was cleaned, washed under tap water several times to remove the dirt, dried and powdered using a mixer.The crude extract from the mushroom samples was obtained by means of cold extraction method. About 10 g of the powdered mushroom sample was added to 100 ml of ethanol in a conical flask, covered with aluminium foil and kept on a rotary shaker for 24 h at room temperature. The solution was filtered with the help of Whatman No.1 filter paper and the filtrate obtained was evaporated. The dried parts were then dissolved in ethanol and utilized for GC-MS analysis.

Gas chromatography-mass spectrometry (GC-MS) programming

GC-MS-QP2010 ultra gas chromatograph was equipped with direct injector with linear velocity. A split injection was used for sample introduction and the split ratio was set to 10:0. The oven temperature program was programmed to start at 50^0C, hold for 2 minutes then ramp at 20^0C per minute to 280^0C and hold for 20 minutes. The helium carrier gas was set to 1.21ml/minute flow rate. ACQ top double focusing magnetic sector mass spectrometer operating in electron ionization (EI) mode with TSS-3333 software was used for all analyses. High resolution mass spectra were acquired at a resolving power of 5000 (20% height definition) and scanning the magnet from m/z 40 to m/z 650 at 1 second per scan.

RESULTS

Fruit Body of *A. bisporus* grown in paddy straw-based compost formulations were harvested separately at two different stages (pin head and mature) and ethanolic extract were made as described under materials and methods. These extracts were used for GC-MS analyses. From the GC-MS-TIC spectrum (Fig.1), in ethanolic extract of *A. bisporus* pin head, total 58 compounds were detected which includes unsaturated fatty acids, phenolic derivatives, alkaloids, terpenoids, steroids, carbohydrate derivatives which are very important to drug company. The highest peak was detected as ergosterol derivatives with 33% area in retention time of 48.229 and second highest peak was detected as 2-pyrrolidinone in ethanolic extract of pin head. The detected compounds in pin head stage with their respective retention time and molecular weight and formula are given in Table 1. Major compounds identified from these GC-MS analyses (Figs.2 A-I) include 2-pyrrolidinone,cyclohexanol,5-methyl-2-(1-methylethyl-1,alpha beta), dinanhydromannitol (Fig.2A-C); 2h-yran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-), Ethyl (9z,12z)-9,12-octadecadienoate, Z-6,17-octadecadien-1-ol-acetate (Fig 2 D-F) and 3-cyclopentylpropionic acid, 2-demethylaminoethyl ester, As-indaceno [4,5-b]oxirene, dodecahydro, (1a, alpha), Ergosta-5,7,22-trien-3-ol(3.beta.,22e) (Fig 2 G-I). On the other hand, from total ion Chromatogram (TIC) of GC-MS-TIC spectrum in ethanolic extract of mature fruit body of *A. bisporus* grown in paddy straw-based compost, total 69 compounds including terpenoid, alkaloids and organic acids was detected (Fig.3). Ergosterol derivative was detected as highest peak with 43% area. The detected compounds with their respective retention time and molecular weight and formula are given in Table2. Several other compounds were also detected in ethanolic extracts of mature stage by GC-MS analyses. These were 1,2-ethanediamine, n,n,n',n'-tetramethyl, 2-pyrrolidinone, 2,4,5-trioxoimidazolidine (Fig 4 A-C), N-(2-butyl) cyclopropane-carboxamide, phenol,2,4-bis(1,1-dimethylethyl), Tumerone (Fig.4 D-F), Ar-tumerone, Hexadecanoic acid, ethyl ester, 9,12-Octadecadienoic acid, methyl ester (Fig.4 G-I), Butyl 9,12-Octadecadienoate, 3-Cyclopentyl-propionic acid, 2-Dimethylaminoe- thylester and Ergosta-5,7,22-trien-3-ol (3,beta.,22e) (Fig 4 J-L).

DISCUSSION

GC-MS was conducted using the data base of National Institute Standard and Technology (NIST) having more than 62,000 combinations of different compounds. The GC-MS analysis of the purified mushroom sample was reported to have compounds like alkanes and fatty acids which posses' therapeutic properties (Lakshmi and

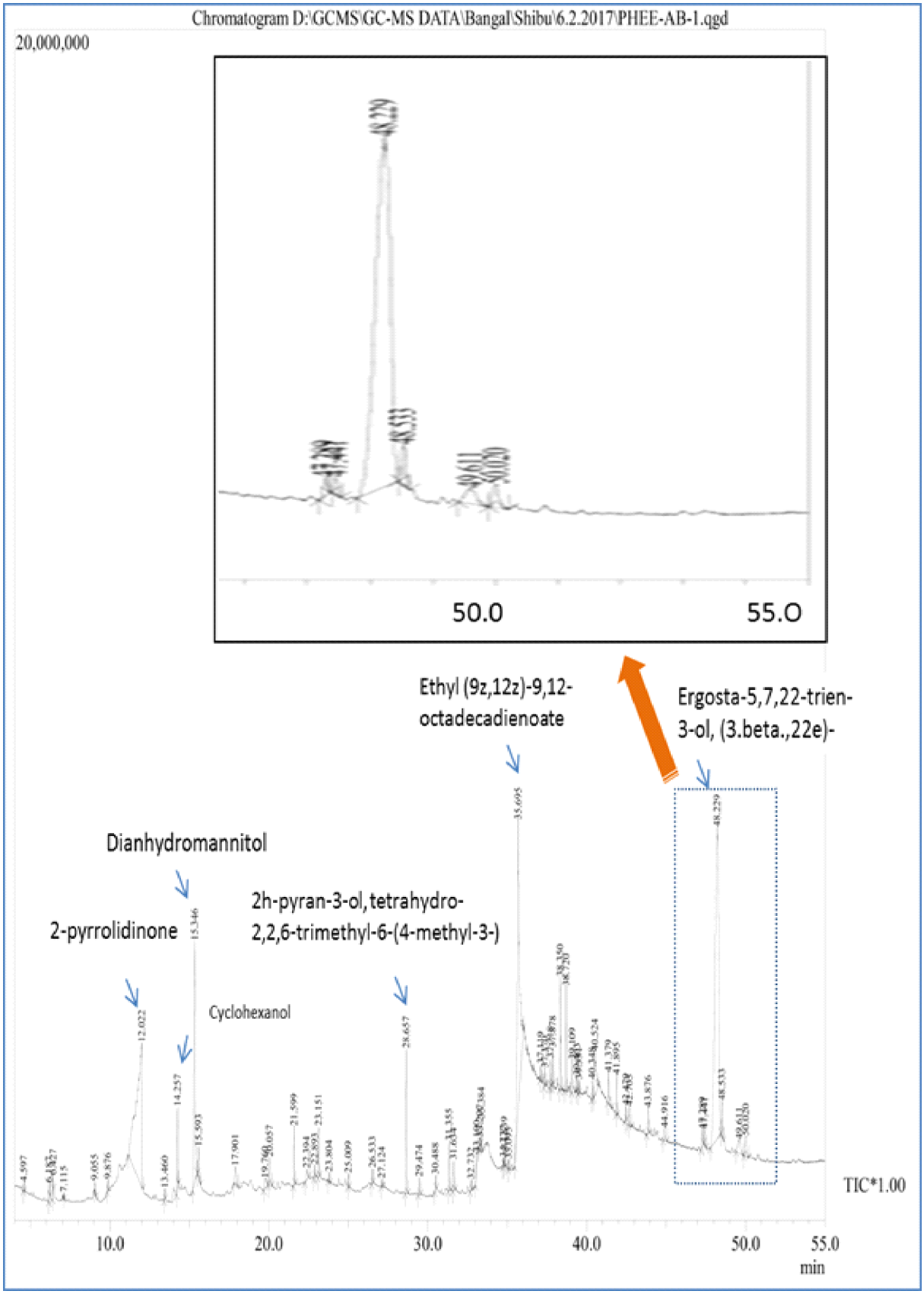

Figure 1: Total ion Chromatogram (TIC) of ethanolic extract of *A. bisporus* (pin head stage) by GC-MS.

Table 1. Compounds detected in Ethanolic extract of *A. bisporus* (pin head stage) GC-MS analysis

Peak	Retention Time	Area (%)	Compounds	Molecular formula	Molecular weight
1	4.597	0.11	1-Propanamine, 2-Methyl-N-(2-Methylpropylidine)	$C_8H_{17}N$	127
2	6.187	0.20	2-Pentanamine, N-Methyl-4-Methyl	$C_8H_{19}N$	129
3	6.427	0.21	2(3H)-Furanone, Dihydro-	C_4H_6O2	86
4	7.115	0.04	Piperidine, 1-Methyl-	$C_6H_{13}N$	99
5	9.055	0.16	2-pentanamine, n-ethyl-4-methyl	$C_8H_{19}N$	129
6	9.876	0.14	1-butamine, 2-methyl-n-(2-methylbutylidene)	$C_{10}H_{21}N$	155
7	12.022	19.73	2-pyrrolidinone (Figure86A)	C_4H_7NO	85
8	13.460	0.16	2,3-dihydro-3,5-dyhiydroxy-6-methyl-4h-pyran	$C_6H_8O_4$	144
9	14.257	1.22	Cyclohexanol, 5 -methyl-2-(1-methylehyl)-, (1. Alpha, beta.) (Figure86B)	$C_{10}H_{20}O$	156
10	15.346	7.36	Dianhydromannitol (Figure86C)	$C_6H_{10}O_4$	146
11	15.593	0.68	4-(1-hydroxy-ethyl), gama. Butanolactone	$C_6H_{10}O_3$	130
12	17.901	0.68	Isosorbid	$C_6H_{10}O_4$	146
13	19.670	0.49	D-mannitol, 1-4-anhydro	$C_6H_{12}O_5$	164
14	20.057	0.92	5-oxo-pyrolidine-2-carboxylic acid methyl	$C_6H_9NO_3$	143
15	21.599	0.84	(E) beta-famesene	$C_{15}H_{24}$	204
16	22.394	0.35	2,4-dihydroxy-5-6-dimethylpyrimidine	$C_6H_8N_2O_2$	140
17	22.893	0.18	1,3,6, 10-dodecatetraene, 3,7,11-trimethyl-	$C_{15}H_{24}$	104
18	23.151	0.74	Phenol, 2,4-bis (1,1-dimethylethyl)	$C_{14}H_{22}O$	206
19	23.804	0.14	N,n-dibutylidene-hydrazine	$C_8H_{16}N_2$	140
20	25.009	0.18	1-hexadecene	$C_{16}H_{32}$	224
21	26.533	0.22	2-furanmethanol, tetrahydro-alpha..alpha…5-trimethyl-5	$C_{15}H_{26}O_2$	238
22	27.124	0.11	Bisabolone oxide	$C_{15}H_{24}O2$	236
23	28.657	2.46	2h-pyran-3-ol, tetrahydro -2,2,6-trimethyl-6-(4-methyl-3-) (Figure86D)	$C_{15}H_{26}O2$	238
24	29.474	0.26	1-nonadecene	$C_{19}H_{38}$	266
25	30.488	0.23	2-pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268
26	31.355	0.82	En-in-dicycloether	$C_{13}H_{12}O_2$	200
27	31.634	0.51	En-in-dicycloether		
28	32.732	0.21	Dibutyl phthalate	$C_{16}H_{22}O_4$	278
29	33.100	0.25	Ethyl 4-isothiocyanatobutyrate	$C_7H_{11}NO_2S$	173
30	33.297	0.23	9-octadecenoic acid (z)-	$C_{18}H_{34}O2$	282
31	33.384	0.34	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284
32	34.777	0.08	1-octadecanol	$C_{18}H_{38}O$	270
33	34.839	0.18	9,12-octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294
34	35.095	0.12	2-hexadecen-1-ol, 3,7,11,15-tetramethyl-	$C_{20}H_{40}O$	296
35	35.695	16.33	Ethyl (9z,12z)-9,12-octadecadienoate (Figure 86E)	$C_{20}H_{36}O_2$	308
36	37.119	0.15	3-Cyclopentylpropionic Acid, 2-	$C_{12}H_{23}NO_2$	213
37	37.370	0.23	Ethyl (9z,12z)-9,12-octadecadienoate	$C_{20}H_{36}O_2$	308
38	37.718	0.27	Oxalic Acid, CyclohexylTetradecyl Ester	$C_{22}H_{40}O_4$	368
39	37.878	0.36	(R)-(-)-14-Methyl-8-Hexadecyn-1-Ol	$C_{17}H_{32}O$	252
40	38.350	1.67	Z-6,17-Octadecadien-1-Ol Acetate (Figure 86F)	$C_{20}H_{36}O_2$	308
41	38.720	1.21	3-Cyclopentylpropionic Acid, (Figure 86G)	$C_{12}H_{23}NO_2$	213
42	39.109	0.75	Eicosane	$C_{20}H_{42}$	282
43	39.403	0.13	1,2-benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390
44	39.531	0.12	(R)-(-)-14-methyl-8-hexadecyn-1-ol	$C_{17}H_{32}O$	252
45	40.348	0.31	3-n-butylthiophene-1,1-dioxide	$C_8H_{12}O_2S$	172
46	40.524	1.94	As-indaceno[4,5-b]oxirene, dodecahydro -, (1a.alpha (Figure86H)	$C_{12}H_{18}O$	178
47	41.379	0.66	9,12-Octadecadienoic Acid (Z,Z)-, Phenylmethyl Ester	$C_{25}H_{38}O2$	370
48	41.895	0.56	Squalene	$C_{30}H_{50}$	410

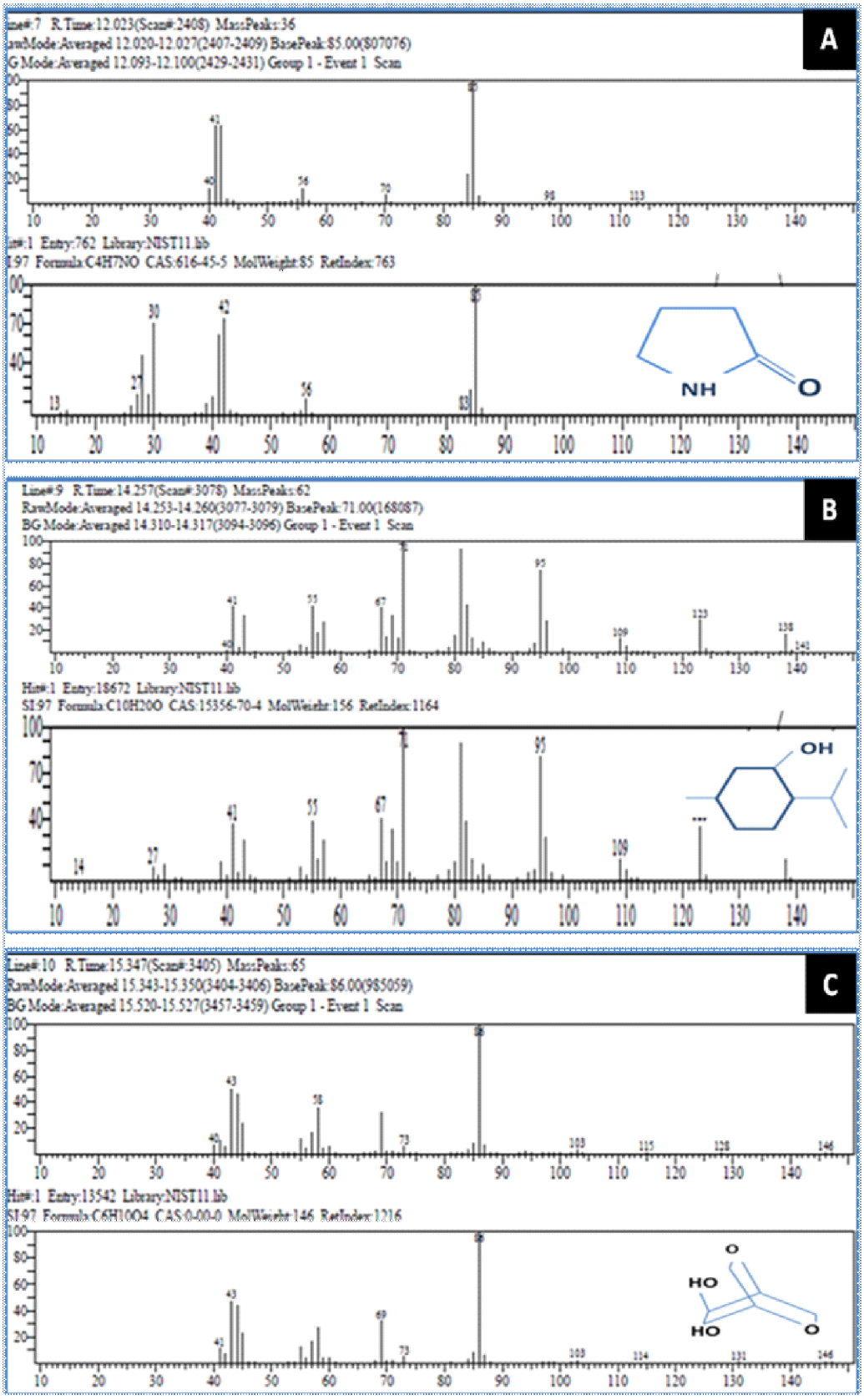

Figure 2 (A-C): Compounds identified in ethanolic extract of *A. bisporus*, (Pin head stage); ***A.*** 2-pyrrolidinone, **B.** Cyclohexanol, 5-methyl-2-(1-methylehyl)-, (1.Alpha, beta), **C.** Dianhydromannitol,

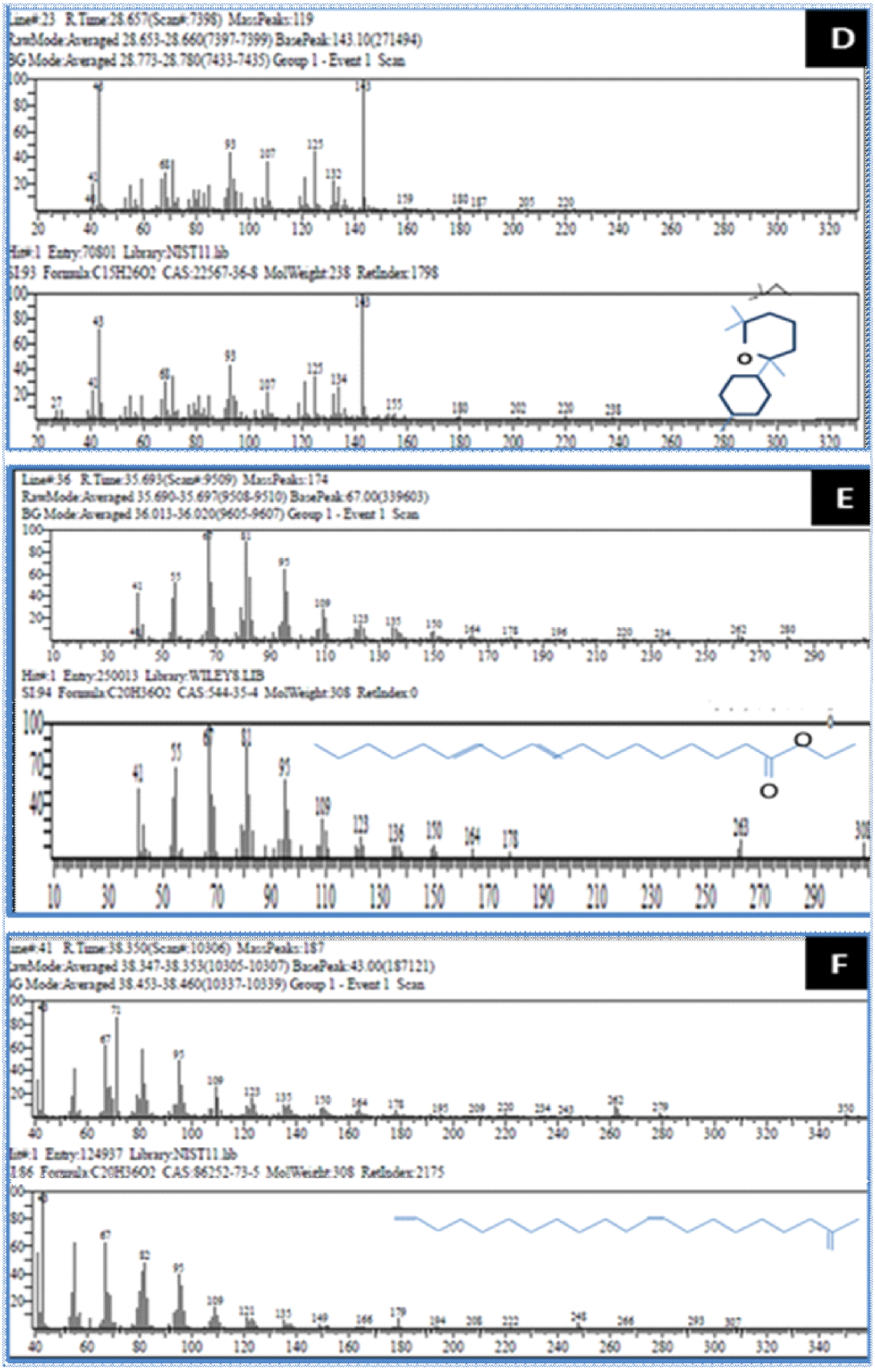

Figure 2 (D-F): Compounds identified in ethanolic extract of *A. bisporus*, (Pin head stage); **D.** 2h-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-), **E.** Ethyl (9z,12z)-9,12-octadecadienoate, **F.** Z-6,17-Octadecadien-1-Ol Acetate.

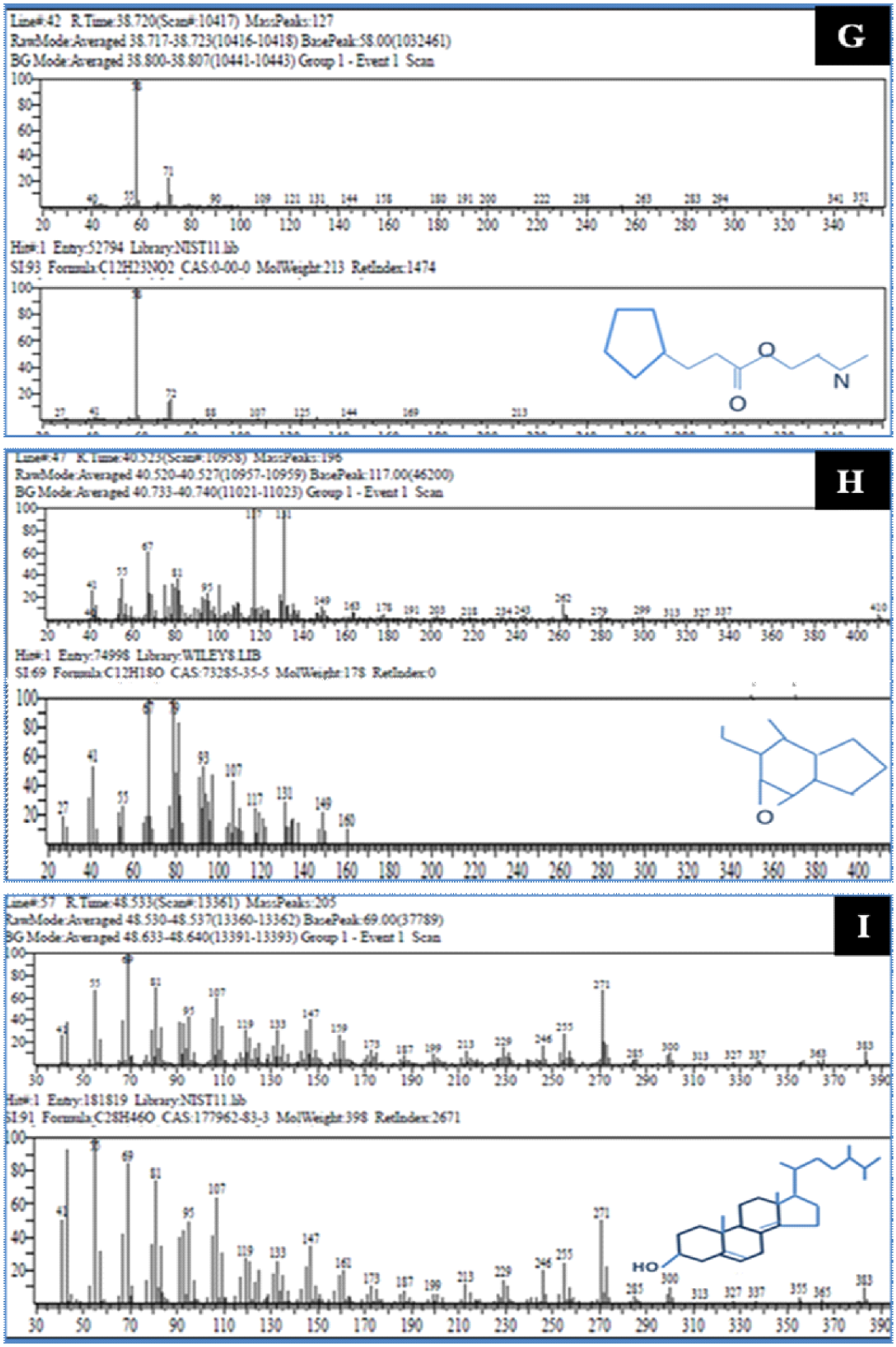

Figure 2 (G-I): Compounds identified in ethanolic extract of *A. bisporus* (Pin head stage), **G.** 3-Cyclopentylpropionic Acid, 2-Dimethylaminoethyl Ester, **H.** As-indaceno [4,5-b]oxirene, dodecahydro, (1a.alpha), **I.** Ergosta-5,7,22-trien-3-ol, (3.beta.,22e)

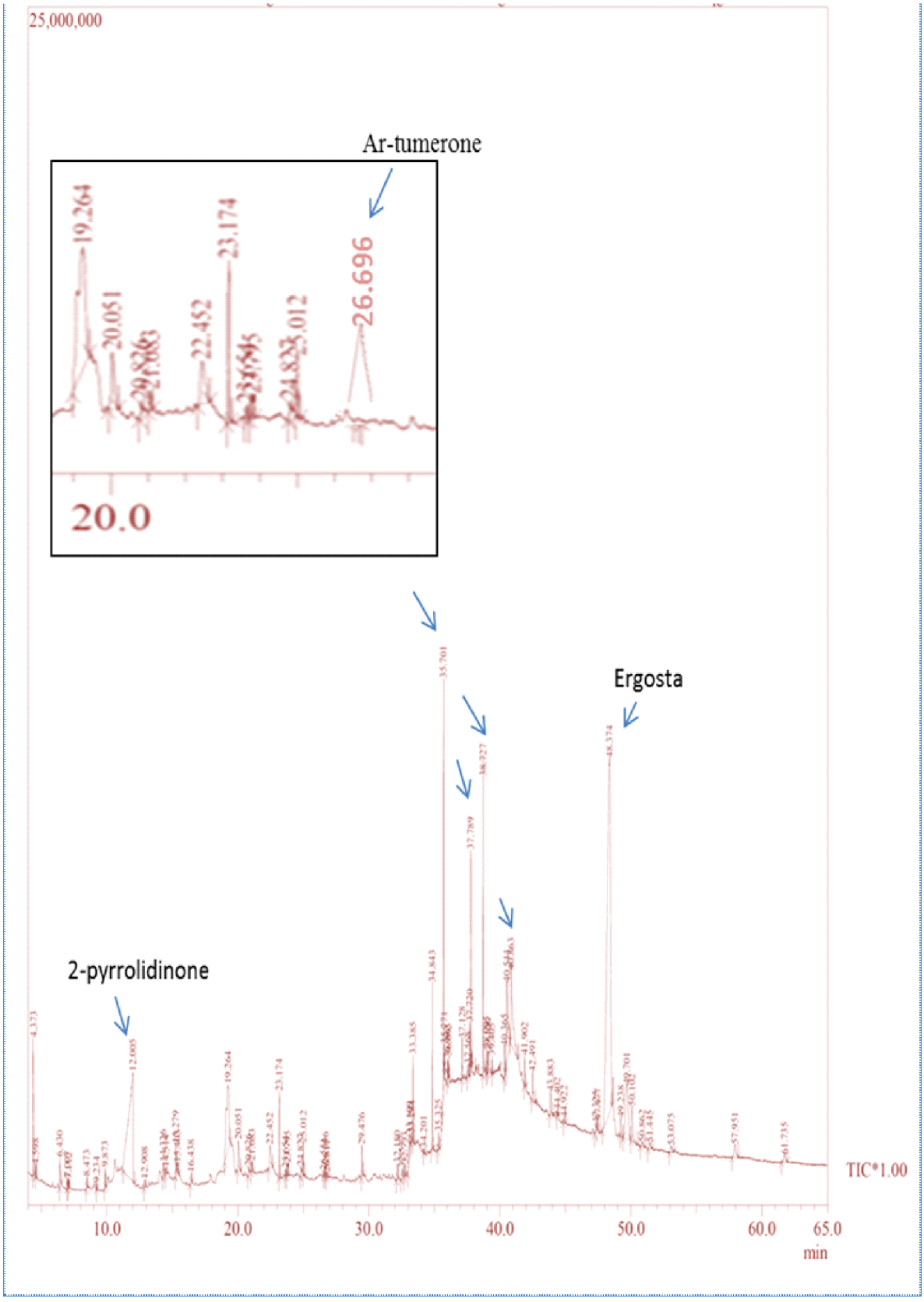

Figure 3: Total ionization Chromatogram (TIC) of GC analysis of ethanolic extract of *A. bisporus* (mature stage).

Table 2. Compounds detected in ethanolic extract of *A. bisporus* (mature fruit body) grown in paddy straw-based compost

Peak	Retention Time	Area (%)	Compounds	Molecular formula	Molecular weight
1	4.373	2.03	1,2-ethanediamine, n,n,n',n'-tetramethyl-(Figure90A)	$C_6H_{16}N_2$	116
2	4.598	0.18	1-propanamine, 2-methyl-n-(2-methylpropylidene)-	$C_8H_{17}N$	
3	6.430	0.55	2(3h)-furanone, dihydro-	$C_4H_6O_2$	86
4	7.007	0.10	2-butyl-(2-methylbutylidene)-amine	$C_9H_{19}N$	141
5	7.112	0.17	Piperidine, 1-methyl-	$C_6H_{13}N$	99
6	8.473	0.15	Cyclohexanamine, n,n-dimethyl-	$C_8H_{17}N$	127
7	9.234	0.07	1-butylpyrrolidine	$C_8H_{17}N$	127
8	9.873	0.24	1-butanamine, 2-methyl-n-(2-methylbutylidene)-	$C_{10}H_{21}N$	155
9	12.005	14.05	2-pyrrolidinone(Figure90B)	C_4H_7NO	85
10	12.908	0.13	N,n-dimethylhomoserine lactone	$C_6H_{11}NO_2$	129
11	14.326	0.20	2-hexene, 3,4,4-trimethyl-	C_9H_{18}	126
12	14.514	0.17	Cyclohexane, eicosyl-	$C_{26}H_{52}$	364
13	15.279	0.57	Dianhydromannitol	$C_6H_{10}O_4$	146
14	15.403	0.15	Isosorbide	$C_6H_{10}O_4$	146
15	16.438	0.22	Glutamine	$C_5H_{10}N_2O_3$	146
16	19.264	5.17	2,4,5-Trioxoimidazolidine(Figure90C)	$C_3H_2N_2O3$	114
17	20.051	0.99	Pyrrolidin-2-Carboxylic Acid Amide, N -T-Butyloxycarbonyl-N'-2-1-Pyrrolidyl	$C_{16}H_{29}N_3O_3$	311
18	20.826	0.10	Bicyclo[7.2.0]undec-4-ene, 4,11,11 -trimethyl-8-methylene	$C_{15}H_{24}$	204
19	21.083	0.16	Acetamide, n-[4-(chlorodifluoromethoxy)phenyl	$C_{13}H_{15}ClF_2N_2O_2$	304
20	22.452	1.06	N-(2-butyl)cyclopropanecarboxamide(Figure90D)	$C_8H_{15}NO$	141
21	23.174	1.22	Phenol, 2,4-bis(1,1-dimethylethyl)- (Figure90E)	$C_{14}H_{22}O$	206
22	23.654	0.09	Phosphoric acid, diethyl octyl ester	$C_{12}H_{27}O_4P$	266
23	23.795	0.18	1,2-butanediol, 1-(2-furyl)-	$C_8H_{12}O_3$	156
24	24.827	0.10	3-methyl-4-phenyl-1h-pyrrole	$C_{11}H_{11}N$	157
25	25.012	0.42	1-hexadecene	$C_{16}H_{32}$	224
26	26.551	0.07	Tumerone(Figure90F)	$C_{15}H_{22}O$	218
27	26.696	0.16	Ar-tumerone(Figure90G)	$C_{15}H_{20}O$	216
28	26.811	0.07	Tumerone	$C_{15}H_{22}O$	218
29	29.476	0.50	1-octadecene	$C_{18}H_{36}$	252
30	32.180	0.24	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270
31	32.537	0.21	5h,10h-dipyrrolo[1,2-a:1',2'-d]pyrazine-5,10-dione, octahydro	$C_{14}H_{22}N_2O_2$	250
32	32.733	0.17	1,2-benzenedicarboxylic acid, dibutyl ester	$C_{16}H_{22}O_4$	278
33	33.109	0.40	Hexadecanoic acid	$C_{16}H_{32}O_2$	256
34	33.284	0.16	Tetradecanoic acid	$C_{14}H_{28}O_2$	228
35	33.385	1.05	Hexadecanoic acid, ethyl ester (Figure 90H)	$C_{18}H_{36}O_2$	284
36	34.201	0.05	Hexadecanoic Acid, 2-Hydroxy-, Methyl Ester	$C_{17}H_{34}O_3$	286
37	34.843	1.89	9,12-Octadecadienoic Acid, Methyl Ester (Figure90I)	$C_{19}H_{34}O_2$	294
38	35.325	0.24	9,12-Octadecadienoyl Chloride, (Z,Z)-	$C_{18}H_{31}ClO$	298
39	35.701	4.56	Ethyl (9z,12z)-9,12-octadecadienoate #	$C_{20}H_{36}O_2$	308
40	35.771	0.21`	9-octadecenoic acid (z)-, ethyl ester	$C_{20}H_{38}O_2$	310
41	36.002	0.23	Hexadecanoic acid, butyl ester	$C_{20}H_{40}O_2$	312
42	36.095	0.17	Octadecanoic acid, ethyl ester	$C_{20}H_{40}O_2$	312
43	37.128	0.38	Octanoic Acid, 2-Dimethylaminoethyl Ester	$C_{12}H_{25}NO_2$	215
44	37.568	0.23	7,10,13-eicosatrienoic acid, methyl ester	$C_{21}H_{36}O_2$	320
45	37.720	0.32	Oxalic Acid, CyclohexylTetradecyl Ester	$C_{22}H_{40}O_4$	368
46	37.789	2.00	Butyl 9,12-Octadecadienoate(Figure90J)	$C_{22}H_{40}O_2$	336
47	38.727	3.01	3-Cyclopentylpropionic Acid, 2-Dimethylaminoethyl Ester(Figure90K)	$C_{12}H_{23}NO_2$	213
48	38.995	0.21	Octanoic Acid, 2-Dimethylaminoethyl Ester	$C_{12}H_{25}NO_2$	215
49	39.106	0.36	2-Ethylbutyric Acid, Eicosyl Ester	$C_{26}H_{52}O_2$	396
50	39.405	0.14	1,2-benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390
51	40.365	0.48	.Beta.-Eudesmol, Trimethylsilyl Ether	$C_{18}H_{34}OSi$	294
52	40.544	3.29	As-indaceno[4,5-b]oxirene, dodecahydro-, (1a.alpha.,1b.alpha	$C_{12}H_{18}O$	178
53	40.863	4.11	9,12-Octadecadienoic Acid (Z,Z)-, 2,3-Dihydroxypropyl Ester	$C_{21}H_{38}O_4$	354
54	41.902	0.39	Squalene	$C_{30}H_{50}$	410
55	42.491	0.61	Hexadecanoic Acid, 2-Hydroxy-, Methyl Ester	$C_{17}H_{34}O3$	286
56	43.883	0.54	9(11)-Dehydroergosteryl Benzoate	$C_{35}H_{46}O_2$	498

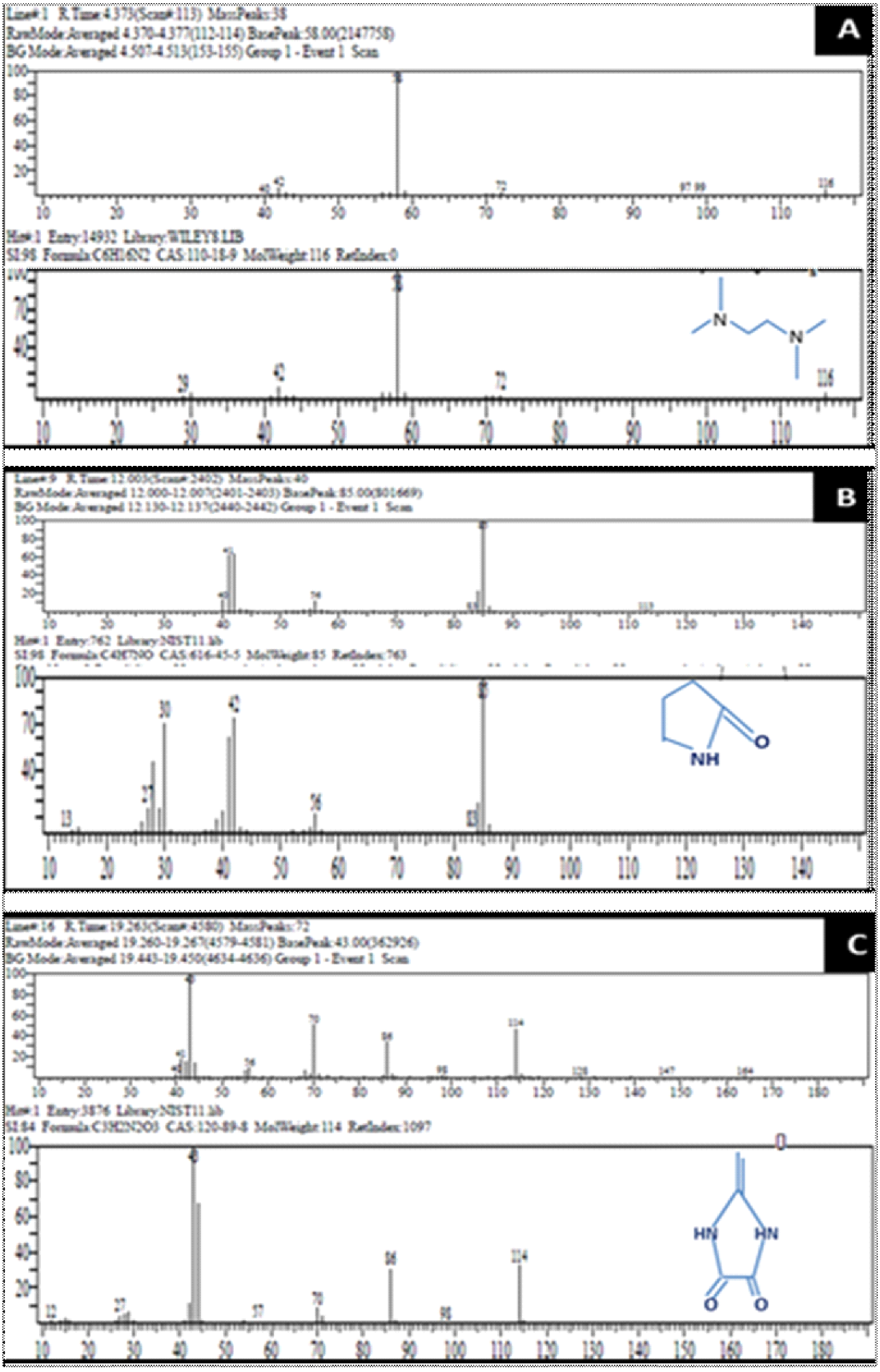

Figure 4 (A-C): Compounds identified in ethanolic extract of *A. bisporus* (mature stage). **A.** 1,2-ethanediamine, n,n,n',n'-tetramethyl, **B.** 2-pyrrolidinone, **C.** 2,4,5-Trioxoimidazolidine,

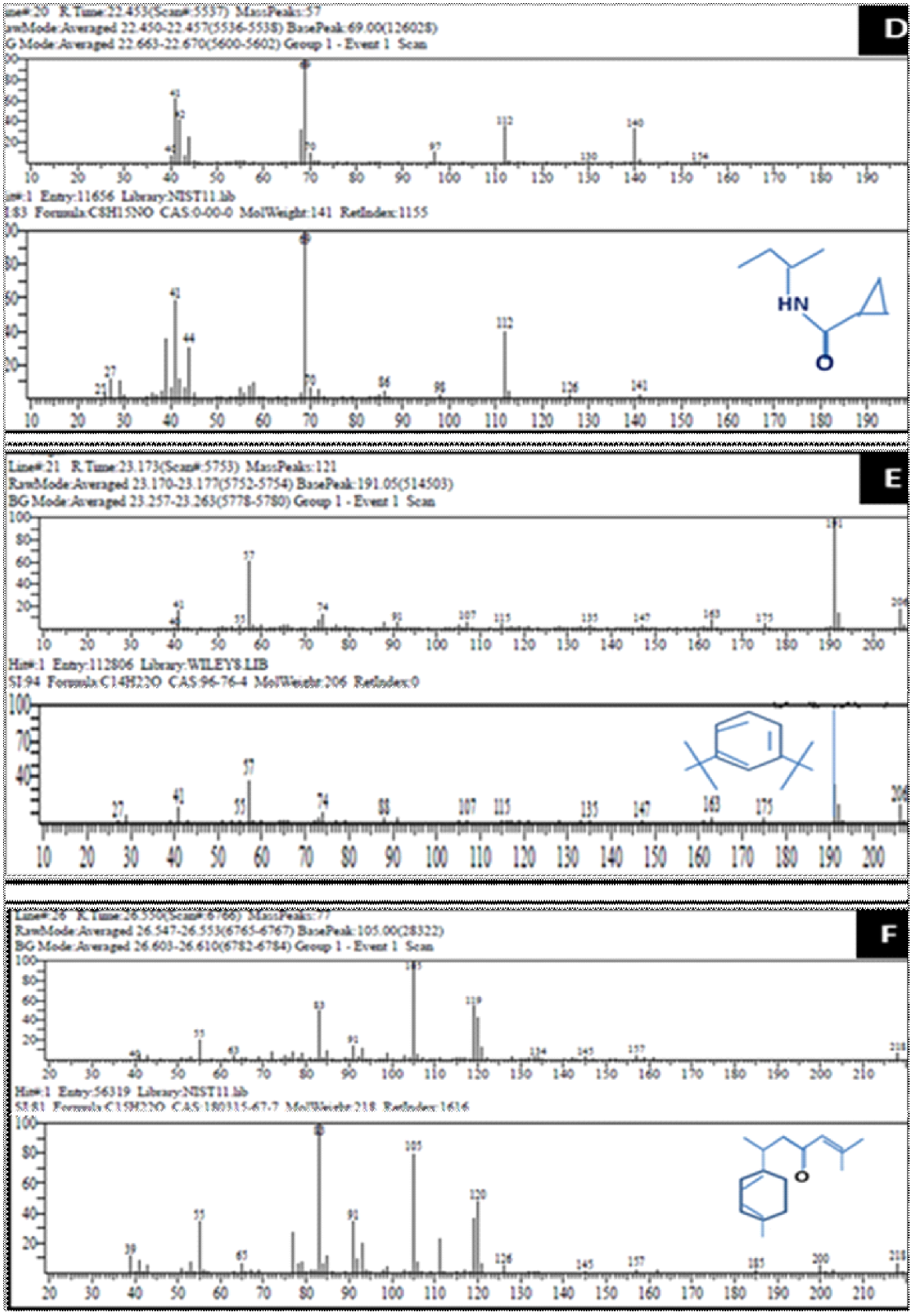

Figure 4 (D-F): Compounds identified in ethanolic extract of *A. bisporus* (mature stage), **D.** N-(2-butyl) cyclopropane-carboxamide, **E.** Phenol, 2, 4-bis (1,1-dimethylethyl), **F.** Tumerone

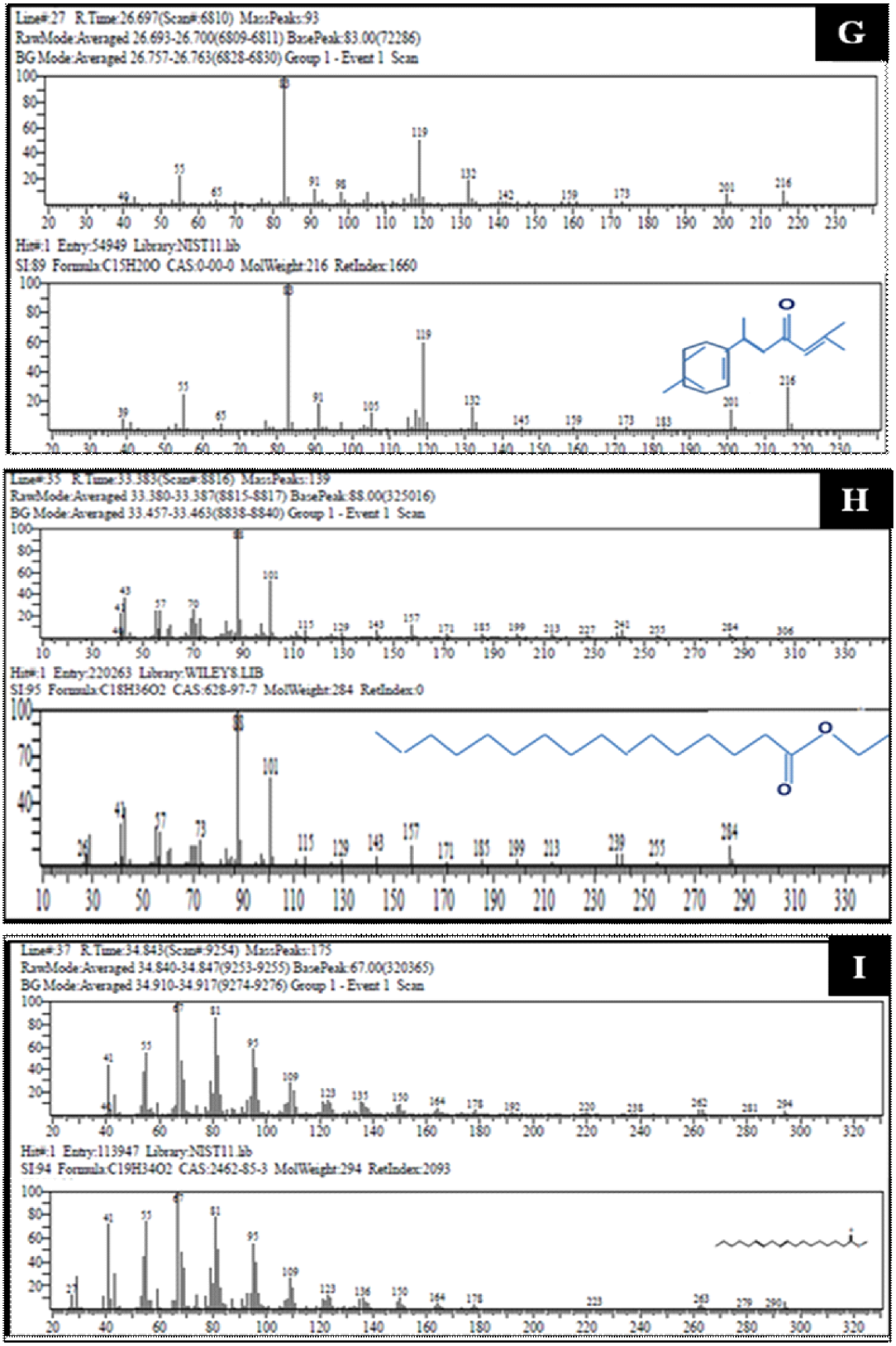

Figure 4 (G-I): Major Compounds identified in ethanolic extract of *A. bisporus,* (mature fruit body) **G.** Ar-tumerone, **H.** Hexadecanoic acid, ethyl ester, **I.** 9,12-Octadecadienoic Acid, Methyl Ester**,**

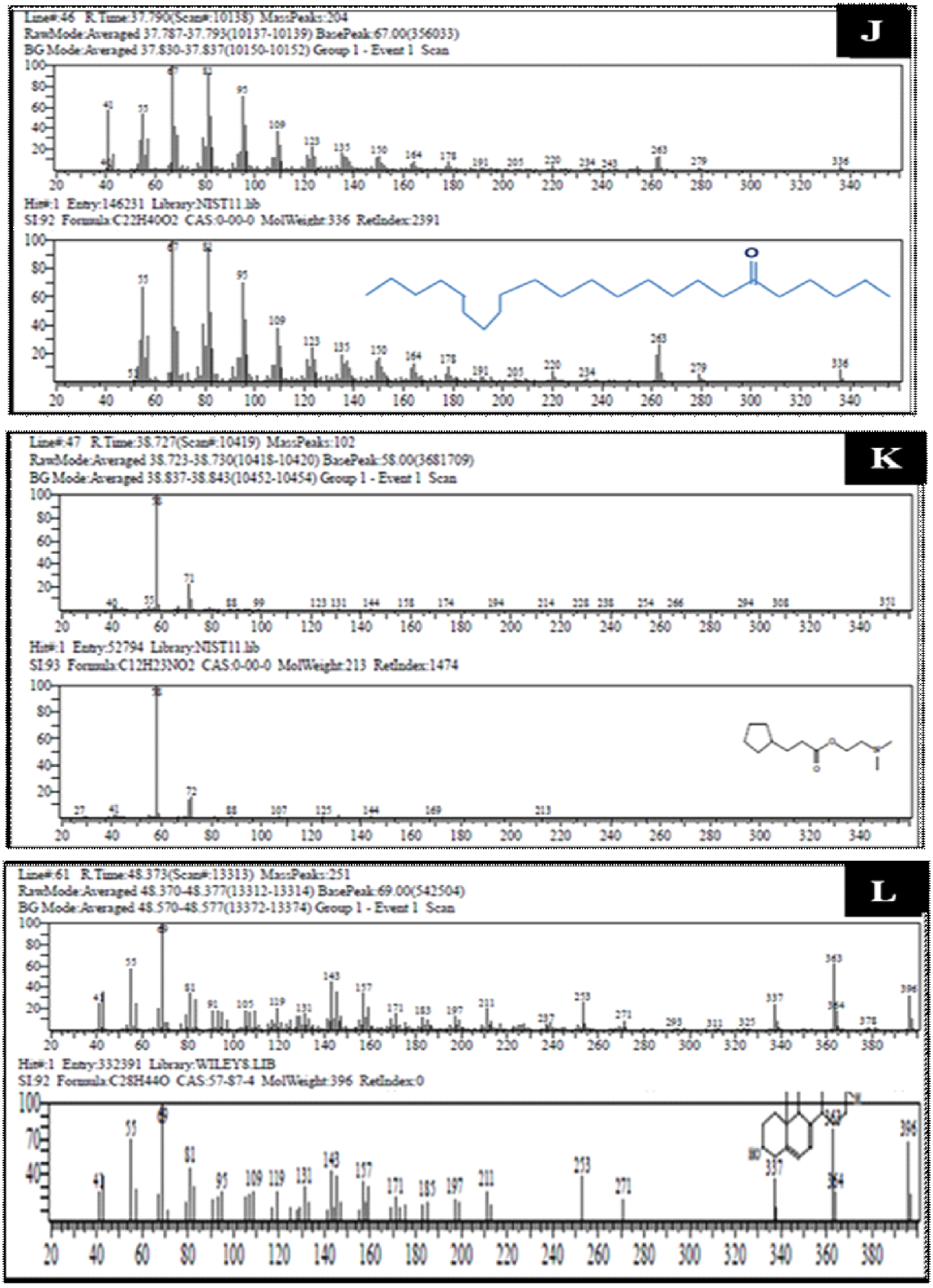

Figure 4 (J-L): Major Compounds identified in ethanolic extract of *A. bisporus* (mature fruit body), **J.** Butyl 9,12-Octadecadienoate, **K.** 3-Cyclopentylpropionic Acid,2-DimethylaminoethylEster, **L.** Ergosta-5,7,22-trien- 3-ol, (3.beta.,22e).

Rajalakshmi, 2011, Dhakad *et al.,* 2017). But Shao *et al.,* (2010) investigated different parts of button mushrooms at various development stages and found different fatty acid and detected non esterified ergosterol. In our study, maximum unsaturated fatty acids as octadec-9-enoic acid were detected and moderate amount of steroids as ergosta was detected. The present study regarding the GC-MS analysis revealed the presence of volatile compounds which were identified majorly as fatty acids ester and some non-polar and volatile compounds in these mushrooms' species give the chemistry of the aroma. Bhupathi and Subbiah (2017) carried out the GC-MS analysis of milky mushroom in fresh and dry form and the results revealed the presence of increased levels of ergosterol indicates the availability of antioxidants and anticancer biomolecules and stated that milky mushroom contains many volatile compounds and phenolics which are potent antioxdant. Mohamed and Fatma, (2014) used GC-MS analysis and reported 5 alkohol, 27 alkane, 3 amides 27 esters, 8 fatty acids, 4 terpenoid, 29 heterocyclic and 2 phenols in ethanolic extract of *Pleurotus ostreatus*. Jananie *et al*., (2012) used GC-MS analysis for detection of bioactive compounds in hydro alcoholic extract of *A. bisporus* and he recorded that 2-non-bornanone and methano-benzocyclodecene as prevailing compound. Ragasa *et al.,* (2016b) reported the presence of sterols and lipids in dichloromethane extract of *A. bisporus* detected in GC-MS analysis. Some essential amino acids such as lysine, leucine, threonine and isoleusine and fatty acids identified by GC-MS analysis by Ravikrishnan *et al*., (2017). Aromatic tumerone is a bioactive compound found in ethanolic extract of *A. bisporus* plays an important role in self-repair and recovery of brain function in neurodegenerative diseases. In adult brains of humans and mammals, the sub ventricular zone and hippocampus are the two key areas where growth of new neurons occurs when subjected to the powerful impact of Ar-tumerone (Liao *et al.,* 2013). Researchers are thinking that it may be able to get one step closer in treating neurological diseases, including Alzheimer's. This new finding is an incredible one in the scientific community. The presence of sterol and lipids was detected by GCMS in *P. florida* (Ragasa *et al*., 2015) and *P. djamor* (Ragasa *et al*., 2016a).

One of the compounds Ergosterol can be present either in free form or esterified with fatty acids (that is ergosteryl esters). Being an important factor for membrane fluidity in fungi and yeast, free ergosterol is located predominantly in cell membranes. Several researchers have already investigated the ergosterol content of cultivated and wild mushrooms (Villares *et al.,* 2014). Shao *et al.,* (2015) investigated different parts of button mushrooms at various development stages but did not detect any esterified ergosterol in these samples. Organisms are well protected against free radical damage by enzymes such as superoxide dismutase and catalase or compounds such as ascorbic acid, tocopherols and glutathione. Ergosterol has been linked with antioxidative activity and is the natural precursor of vitamin D2, which is formed from the former under UV light irradiation (Shao *et al.,* 2010; Phillips and Rasor, 2016).

The presence of linoleic and oleic acid derivatives as the major unsaturated fatty acids is in line with earlier reported on mushrooms (Kalac, 2013). Linoleic acid is an essential omega-6 polyunsaturated fatty acid involved in the biosynthesis of arachidonic acid and prostaglandins. The GC-MS analysis of the purified mushroom sample was reported to have compounds like alkanes and other fatty acids and was also reported to possess numerous therapeutic properties (Chen *et al*., 2016, Zhang *et al*., 2016, Chakraborty et al., 2020). Sharma and Gautam, (2016) stated that *A. bisporus* has the antimicrobial, antioxidant and anticancer potential and they identified some phytochemicals from mushroom sample such as alkaloids, flavanoids, terpenoids, phenols and tannins that exhibit a wide range of medicinal properties. *Agaricus bisporus* and *Pleurotus spp* are also found to be a rich source of amino acids such as leucine, valine, glutamine and other essential amino acids. Several studies have been conducted to evidence the bioactive properties of mushroom extracts as well as of their secondary metabolites such as antioxidant (Heleno *et al.,* 2015), antitumour (Ferreira *et al.,* 2010), antimicrobial (Alves *et al.,* 2013), immunomodulator, antiatherogenic, hypoglycemic and anti-inflammatory (Choi *et al.,* 2014; Taofiq *et al.,* 2016) activities. Mushrooms are also considered as functional foods because they elicit their positive effect on human being (Patel *et al.,* 2012). *A. bisporus*, thus can be used for deriving biologically active metabolites or compounds in order to design or develop therapeutically

important drugs without any side effects and also helps in combating life threatening diseases.

REFERENCES

Adams, M.R. 2014. Antimicrobial properties of fungi. *Encyclopaedia of Food Microbiology*, **5:** 717-721.

Afieroho, O.E., Lawson, L., Adedokunand, O.M., Emenyonu, N. 2013. Antituberculosis and Phytochemical investigation of the dichlomethane extract of *Pleurotus tuber-regium* (Fries) Singer sclerotium. *India Research journal of Phamacy*, **4:** 255-257**.**

Alves, M.J.,Ferreira, I.C.F.R., Froufe, H.J.C.,Abreu, R.M.V.,Martins, A., Pintado, M. 2013. Antimicrobial activity of phenolic compounds identified in wild mushrooms, SAR analysis and docking studies. *Journal of Applied Microbiology,***115:** 346-357**.**

Bhupathi, P., Subbiah, K.A. 2017. Volatilomes of milky mushroom (*Calocybe indica* P&C) estimated through GCMS/ MS.*International Journal of Chemical Studies*, **5:** 387-381**.**

Chakraborty, B.N., Barman, S., Chakraborty, U. 2020. Evaluation of antioxidant activity of *Calocybe indica* P&C and analysis of its chemical constituents by GC-MS. *Journal of Mycopathological Research*, **57**: 229-236.

Chen, X., Wu, J.Y., Gui, X.T. 2016. Production and characterization of exopolysaccharides in mycelial culture of *Cordyceps sinensis* fungus CS-HK1 with different carbon sources. *Chin. J. Chem. Eng*., **24:** 158-162.

Chien, R.C., Yen, M.T., Tseng, Y.H., Mau, J.L. 2015. Chemical characteristics and anti-proliferation activities of *Ganoderma tsugae* polysaccharides. *Carbohydr. Polym.*, **128:** 90-98.

Choi, H.W., Chung, I.M., Sin, M.H., Kim, Y.S., Sim, J.B. 2014. The effect of spent mushroom sawdust compost mixes, calcium cyanamide and solarization on basal stem rot of the cactus *Hylocereus trigonus* caused by *Fusarium oxysporum. Crop Protection*, **26:** 162-168.

Dhakad, P.K., Chandra, R., Yadav, M.K., Patar, U.R. 2017. Comparative study on nutraceuticals of five strains of milky mushroom (*Calocybe indica*).*International Journal of Current Microbiology and Applied Sciences,* **6:** 645-648**.**

Ferreira, I.C.F.R., Vaz, J.A., Vasconcelos, M.A., Martins, A. 2010. Compounds from wild mushrooms with antitumor potential. *Anti Cancer Agents Medicinal Chemistry*, **10:** 424-436**.**

Heleno, S.A., Ferreira, R.C., Antonio, A.L., Queiroz, M.J.R.P., Barros, L., Ferreira, I.C.F.R. 2015. Nutritional value, bioactive compounds and antioxidant properties of three edible mushrooms from Poland. *Food Biosci II.,* **11:** 48-55.

Jananie, R.K., Priya, V., Vijayalakhmi, K. 2012. Gas chromatography- mass spectrum analysis of bioactive compounds of *Agaricus bisporus.* A*sian journal of Pharmaceutical and Clinical Research,* **5(2):** 168-169**.**

Jeong, S.C., Jeong, Y.T., Yang, B.K., Rezuanul, I., Koyyalamudi, S.R., Pang, G., Cho, K.Y., Song, C.H. 2010**.** White button mushroom (*Agaricus bisporus*) lowers blood glucose and cholesterol levels in diabetic and hypercholesteromic rats. *Nutrition Research*, **30:** 49-56**.**

Kalac, P. 2013. A review of the chemical composition and nutritional value of wild-growing and cultivated mushrooms. *J Sci Food Agric.,* **93:** 209-218**.**

Lakshmi, P.T.V., Rajalakshmi, P. 2011. Identification of phytocomponents and its biological activites of *Aloe vera* through the Gas chromatography-Mass spectrometry. *International Research Journal of Pharma*, **2:** 247-249.

Liao, J.C., Tsai, J.C., Liu, C.Y., Huang, H.C., Wu, L.Y., Peng, W.H. 2013. Antidepressant-like activity of turmerone in behavioral despair tests in mice. *BMC Complementary and Alternative Medicine*, **13:** 299.

Meng, X., Liang, H., Luo, L. 2016. Antitumor polysaccharides from mushrooms: a review on the structural characteristics, antitumor mechanisms and immunomodulating activities. *Carbohydrate Research* **424**: 30-41**.**

Mohamed, E.M., Fatma, A. F. 2014. Bioactive compounds of fresh and dried *Pleurotus ostreatus* mushroom. *International Journal of biotechnology for Wellness Industries,***3:** 4-14**.**

Patel, Y., Naraian, R., Singh, V.K. 2012**.** Medicinal properties of *Pleurotus* species (oyster mushroom) : A review . W*orld Journal of Fungal and Plant Biology***, 3:** 1-12.

Phillips, K.M., Rasor, A.S. 2016. A mixed mushroom control material to facilitate inter-laboratory harmonization of mushroom composition analyses. *J. Food Compos. Anal.,* **48:** 48-66.

Ragasa, C.Y., EbajoJr, V.D., Reyes, R.G., Brkljaca, R., Urban, S. 2015**.** Sterol and lipids from *Pleurotus florida. Der Pharmachemical,* **7:** 331-336**.**

Ragasa, C.Y., Reyes, J.M.A., Tan, M.C.S., Brkljaca, R., Urban, S. 2016a**.** Sterol and lipids from *Agaricus bisporus. International journal of Pharmaceutical and Clinical Research.* **8:** 1451-1453**.**

Ragasa CY, Tan MCS, Ting J, Reyes RG, Brkljaca R, Urban S.2016b. Chemical constituents of *Pleurotus djamor*. *Der Pharma chemiscal*, **8:** 343-346.

Ravikrishnan, V., Sanjeev, G., Madaiah, R. 2017**.** Compositional and nutritional studies on two wild mushrooms from Western Ghat forests of Karnataka, India. *International Food Research Journal*, **24:** 679-684**.**

Rushita, S., Vijayakumar, M., Noorlodah, A., Abdulla, M.A., Sabaratnam, V.2013. Effect of *Pleurotus citrinopileatus* on blood glucose, insulin, and catalase of streptozotocin induced type 2 diabetes rats. *Journal of Animal and plant science*, **23:** 1566-1571**.**

Shao, H. J., Jeong, J.B., Kim, K.J., Lee, S.H. 2015. Anti-inflammatory activity of mushroom-derived hispidin through blocking of NF-kB activation. *Journal of the Science of Food and Agriculture*, **95:** 2482-2486.

Shao, S., Hernandez, M., Kramer, J.K., Rinker, D.L., Tsao, R. 2010. Ergosterol profiles, fatty acid composition, and antioxidant activities of button mushrooms as affected by tissue part and developmental stage. *J. Agric. Food Chem.,* **58:** 11616-11625**.**

Sharma, S.K., Gautam, N. 2016**.** Evaluation of nutritional, nutraceutical and antioxidant composition of eight wild culinary mushrooms from the northeast Himalayas. *International Journal of Medicinal Mushroom*, **18:** 539-546.

Sonawane, H.B., Ghole, V.S., Garad, S., Bapat, G., Bhosle, S., Apte, K. 2013. Hypoglycemic effect of Phansomba (*Phellinus badius* Berk Ex Cooke) G. Cunn, on alloxan induced diabetic rats. *J. Nat. Remed*, **13 :** 29-34**.**

Taofiq, O., Martins, A., Barreiro, M. F., Ferreira, I.C.F.R. 2016. Anti-inflammatory potential of mushroom extracts and isolated metabolites. *Trends in Food Science & Technology*, **50:** 193-210.

Villares, A., García-Lafuente, A., Guillamon, E., Ramos, A. 2012. Identification and quantification of ergosterol and phenolic compounds occurring in *Tuber* spp. truffles. *J. Food Compos. Anal,* **26:** 177-182**.**

Villares, A., Mateo-Vivaracho, L., García-Lafuente, A., Guillamoìn, E. 2014. Storage temperature and UV-irradiation influence on the ergosterol content in edible mushrooms. *Food Chem.,***147:** 252-256**.**

Zhang, J.J., Li, Y., Zhou, T., Ping, X.D., Zhang, P., Sha, Li, Hua-Bin, L.2016. Bioactivities and Health Benefits of Mushrooms Mainly from China Molecules, **21:** 938-944**.**