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Nutritional value of wild edible mushroom *Cantharellus* of North-West Himalayas, India

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Four wild edible *Cantharellus* species viz. *C. applanatus*, C. *appalachiensis*, *C. minor*, *C. subamethysteus* collected from different localities of North West Himalayas and studied for their chemical composition and nutritional value. In the present study, proximate composition viz., moisture, ash, protein, carbohydrates, crude fat, fibre, minerals and vitamins were estimated. All the species investigated contain high nutritional value.

Key words: *Cantharellus*, nutrition, minerals, vitamins.

INTRODUCTION

Our health depends on the quality and quantity of the food we consume. The food is needed to supply the minimum requirement of the six groups of nutrients viz., proteins, carbohydrates, fats, mineral elements, vitamins and water. During the early days of civilization, mushrooms were collected and eaten mainly for their palatability and unique flavours. The consumption of wild edible mushrooms is high, even in the developed world, due to their taste, in many traditional cuisines (Chudzyñski *et al*. 2011). Now a day, a number of research investigations done on the chemical composition of mushrooms have revealed that mushrooms can be used as a part of balanced diet. Research reports described the nutritional composition of mushrooms as attractive, being good source of nutrition (Jiskani 2001; Mattila *et al*. 2001; Nakalembe *et al*. 2015).

More than 2,000 species of mushroom existing in nature are edible and eaten, but less than 25 species are accepted as food and only a few of them (*Agaricus bisporus*, *Pleurotus* spp., *Lentinula edodes*, *Volvariella volvacea*, etc.) have attained the level of an item of commerce (Barros *et al*. 2007). Wild edible mushrooms, however, are seasonally consumed by local people, enthusiasts and gourmets and are becoming more and more important in our diet for their nutritional, organoleptic and pharmacological characteristics (Diéz and Alvarez 2001).

Cantharellus is naturally and widely occurring macrofungi with worldwide distribution. It is a seasonal mushroom that occurs during rainy season from July to September. A number of *Cantharellus* species are collected in large quantity by mushroom hunters from forests during rainy periods and sell in the local markets. This is an important source of income and also valuable food due to its nutritional properties. The present study is intended to investigate the nutritional value namely chemical composition, minerals, heavy metal and vitamin composition of four *Cantharellus* species viz**.** *C. applanatus*, C. *appalachiensis*, *C. minor*, *C. subamethysteus* collected from forests of Himachal Pradesh.

MATERIALS AND METHODS

Four species of wild edible *Cantharellus* mushrooms have been analyzed for the presence of proteins, carbohydrates, fat, fibre, moisture content, ash content, vitamins, mineral elements and heavy metals following the standard

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biochemical techniques. To assess the nutritive values, fruit bodies were oven dried at 40°C to constant weight and then ground into fine powder and stored for further studies.

Moisture, ash (AOAC 17th Edition 2003) and fibre content (AOAC 13th Edition 1980) were determined according to already standardised method. Estimation of fat was done by extraction through Soxlet apparatus using petroleum ether (James 1995). Total carbohydrate was calculated by subtracting the ash, fat, and protein from the dry weight (Raghuramulu *et al*. 2003). Estimation of energy was done in Kcal (Barros *et al.* 2007). Mineral and heavy metal estimation was done using WD-XRF (wavelength dispersive X-ray fluorescence, for 20min.Vitamin B1 (Thiamine), B2 (Riboflavin), B3 (Niacin), B9 (Folic acid) and C (Ascorbic acid) were determined using HPLC by following standard methods. Each value represents the average of three analyses ($P^3 0.05$)

RESULTS

Chemical composition

In the present investigation moisture content, proteins, carbohydrates, fat, crude fibre, ash and energy was estimated (Table 1). The average moisture content recorded in dried samples was highest in *C. subamethysteus* (7.80%) followed by *C. minor* (7.4%), *C. appalachiensis* (6.07%) and minimum in *C. applanatus* (5.27%). Amongst the worked-out species maximum protein content has been found in *C. appalachiensis* (41.93%) followed by *C. subamethysteus* (38.33%), *C. applanatus* (34.87%) and lowest amount of total protein was estimated in *C. minor* (30.07%). Presently, crude fat was determined by extraction through Soxhlet apparatus using petroleum ether. It was found to be maximum in *C. subamethysteus* (2.67%) followed by *C. appalachiensis* (2.57%), *C. applanatus* (1.90%) the lowest amount of crude fat was observed in *C. minor* (1.83%) per 100g of dry sample.Maximum percentage of fibre has been documented in *C. subamethysteus* (7.43%) followed by *C. appalachiensis* (6.67%) and (5.13%) in C*. minor* while the minimum quantity of fibre was estimated in *C. applanatus* (4.3%). Ash content was highest in *C. applanatus* (11.53%), followed by *C. subamethysteus* (9.93%), *C. appalachiensis* (9.6%) and significantly minimum amount of ash has been recorded in *C. minor* (8.47%).The maximum carbohydrates content has been reported in *C. minor* (47.1%) followed by*C. applanatus* (42.13%), and (33.83%) in *C. subamethysteus* while the minimum amount of carbohydrates was estimated in *C. appalachiensis* (33.17%).The energy value has been calculated based on the content of fibre, moisture, ash, protein, carbohydrate and fat. The maximum percentage of estimated energy has been observed in *C. minor* (325.17%) followed by *C. applanatus* (325.1%), *C. appalachiensis* (323.5%) and least amount of energy was observed in *C. subamethysteus* (312.67%).

Minerals and heavy metals

In the present study, essential elements and heavy metal detection was done for three samples of *Cantharellus*: *C. appalachiensis*, *C. applanatus* and *C. subamethysteus* (Table 2&3 and Figs. 1–3). In all the three samples K is present in highest amount among all the studied minerals. The amount of K was maximum in *C. subamethysteus* (6020 mg/100g) followed by *C. applanatus* (5520 mg/100g) and least quantity in *C. appalachiensis* (5390 mg/100g). The quantity of P was maximum in *C. appalachiensis* (770 mg/100g) followed by *C. applanatus* (650 mg/100g) and minimum in *C. subamethysteus* (490 mg/100g). Ca was detected (140 mg/100g) in *C. applanatus* and *C. subamethysteus* and minimum in *C. appalachiensis* (100 mg/100g). Maximum amount of Mg (160 mg/100g) was recorded in *C. subamethysteus* and in other two samples it was (130 mg/100g). Like Mg, S was detected maximum in *C. subamethysteus* (120 mg/100g) and other two species possessed the same amount of S (110 mg/100g). Al was maximum in *C. subamethysteus* (240 mg/100g) followed by *C. appalachiensis* (170 mg/100g) whereas minimum quantity of Al (50 mg/100g) was recorded in *C. applanatus*. Maximum amount of Fe (110 mg/100g) was recorded in *C. subamethysteus* followed by *C. appalachiensis* (80 mg/100g) whereas minimum quantity was documented in *C. applanatus* (30 mg/100g). Si was maximum in *C. subamethysteus* (650 mg/100g) followed by *C. appalachiensis* (400 mg/100g) whereas minimum quantity of this element was detected in *C. applanatus* (110 mg/100g). Na was detected only in *C. subamethysteus* (30 mg/100g). It was not recorded in the other two samples. Zn was maximum in *C. applanatus* (10 mg/100g) followed by *C. subamethysteus* (9.6 mg/100g) and minimum amount of Zn (3.9 mg/100g) was

Table 1: Chemical composition (g/100g) and energy value (kcal/100g) of wild *Cantharellus* species (on dry weight basis).

Chemical composition	Species			
	C. applanatus.	*C. subamethysteus.*	*C. minor.*	*C. appalachiensis*
Moisture (%)	5.27±0.4b	7.80±0.3a	7.4±0.3a	6.07±0.3b
Protein (%)	34.87±2.2bc	38.33±1.4ab	30.07±2.9c	41.93±3.3a
Fat (%)	1.90±0.3a	2.67±0.6a	1.83±0.3a	2.57±0.3a
Fibre(%)	4.3±0.6b	7.43±0.2a	5.13±0.4b	6.67±0.4a
Ash (%)	11.53±0.6a	9.93±0.3b	8.47±0.3c	9.6±0.4b
Carbohydrate (%)	42.13±3.02a	33.83±2.4b	47.1±2a	33.17±3.1b
Energy (kcal/100 g)	325.1±5.6a	312.67±1.5b	325.17±1.6a	323.5±2.1a

The values in the same column followed by the same letter (viz. a, b, or c) are not significantly different at $P<0.05$. Each value is expressed as mean ± standard deviation (SD) (n = 3).

Table2: Mineral elements (mg/100g) of wild *Cantharellus* species (on dry weight basis).

Mineral elements (mg/100g)	Species		
	C. applanatus	*C. subamethysteus*	*C.appalachiensis*
Na	ND	30	ND
K	5520	6020	5390
P	650	490	770
Ca	140	140	100
Mg	130	160	130
S	110	120	110
Al	50	240	170
Fe	30	110	80
Si	110	650	400
Zn	10	9.6	3.9
Cu	5.8	5.1	2.7
Mo	1.4	ND	1.3

recorded in *C. appalachiensis*. Maximum amount of Cu (5.8 mg/100g) was reported in *C. applanatus* followed by *C. subamethysteus* (5.1 mg/100g), while minimum quantity (2.7 mg/100g) was recorded in *C. appalachiensis*. There was no much difference in the amount of Mo in the *C. applanatus* and *C. appalachiensis.* It was 1.4 and 1.3 mg/100g respectively and not detected in *C. subamethysteus*.

The determination of heavy metal concentration in mushrooms is essential in dietary intake. Some

Table 1: Chemical composition (g/100g) and energy value (kcal/100g) of wild *Cantharellus* species (on dry weight basis).

Chemical composition	Species			
	C. applanatus.	*C. subamethysteus.*	*C. minor.*	*C. appalachiensis*
Moisture (%)	5.27±0.4b	7.80±0.3a	7.4±0.3a	6.07±0.3b
Protein (%)	34.87±2.2bc	38.33±1.4ab	30.07±2.9c	41.93±3.3a
Fat (%)	1.90±0.3a	2.67±0.6a	1.83±0.3a	2.57±0.3a
Fibre(%)	4.3±0.6b	7.43±0.2a	5.13±0.4b	6.67±0.4a
Ash (%)	11.53±0.6a	9.93±0.3b	8.47±0.3c	9.6±0.4b
Carbohydrate (%)	42.13±3.02a	33.83±2.4b	47.1±2a	33.17±3.1b
Energy (kcal/100 g)	325.1±5.6a	312.67±1.5b	325.17±1.6a	323.5±2.1a

The values in the same column followed by the same letter (viz. a, b, or c) are not significantly different at $P<0.05$. Each value is expressed as mean ± standard deviation (SD) (n = 3).

Table2: Mineral elements (mg/100g) of wild *Cantharellus* species (on dry weight basis).

Mineral elements (mg/100g)	Species		
	C. applanatus	*C. subamethysteus*	*C.appalachiensis*
Na	ND	30	ND
K	5520	6020	5390
P	650	490	770
Ca	140	140	100
Mg	130	160	130
S	110	120	110
Al	50	240	170
Fe	30	110	80
Si	110	650	400
Zn	10	9.6	3.9
Cu	5.8	5.1	2.7
Mo	1.4	ND	1.3

recorded in *C. appalachiensis*. Maximum amount of Cu (5.8 mg/100g) was reported in *C. applanatus* followed by *C. subamethysteus* (5.1 mg/100g), while minimum quantity (2.7 mg/100g) was recorded in *C. appalachiensis*. There was no much difference in the amount of Mo in the *C. applanatus* and *C. appalachiensis.* It was 1.4 and 1.3 mg/100g respectively and not detected in *C. subamethysteus*.

The determination of heavy metal concentration in mushrooms is essential in dietary intake. Some

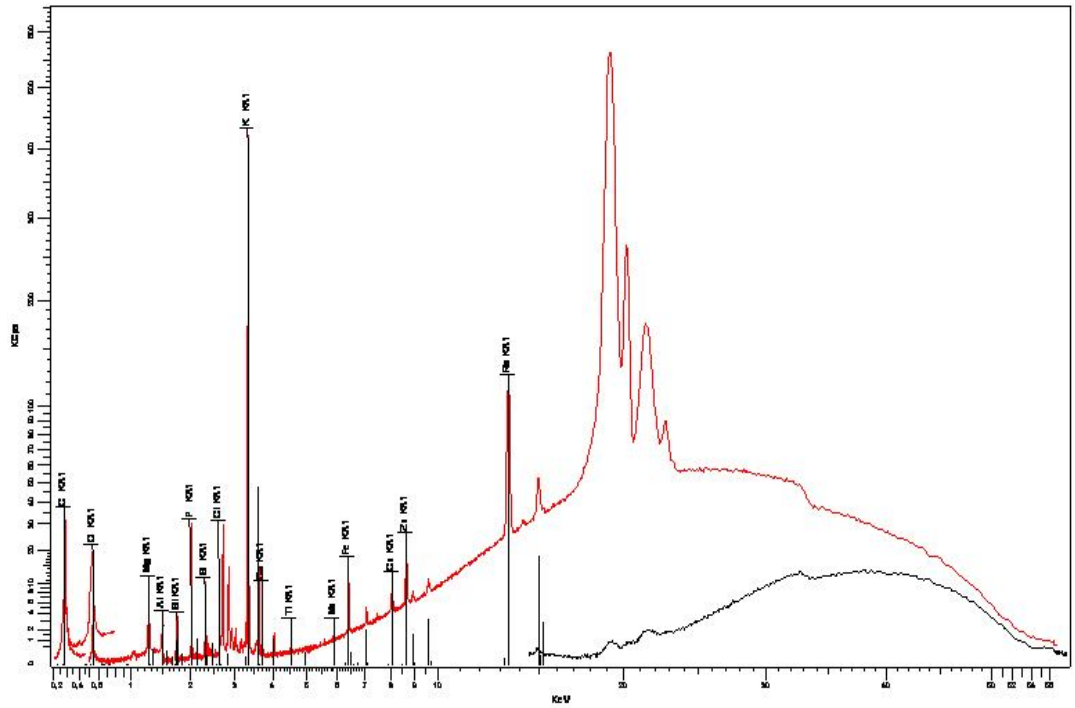

Fig. 1: Chromatogram showing presence of different essential elements and heavy metals in *C. applanatus*.

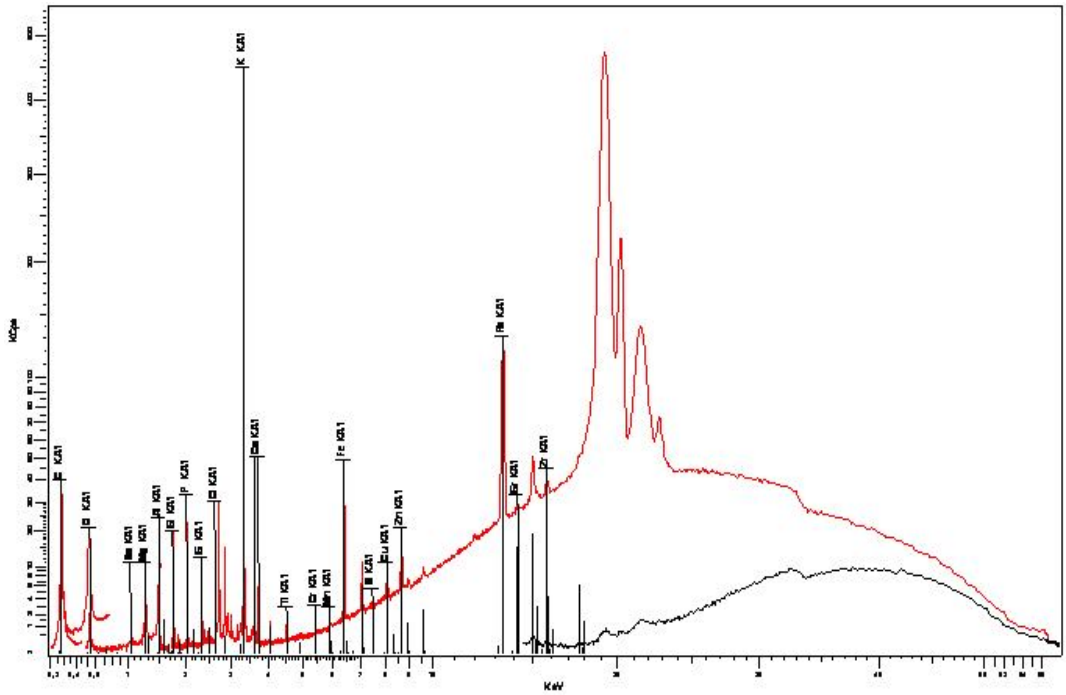

Fig. 2: Chromatogram showing presence of different essential elements and heavy metals in *C. subamethysteus*.

Vitamins

Wild edible *Cantharellus* spp. collected from forests of Himachal Pradesh were evaluated for different vitamins (B1, B2, B3, B9 and C), presented in Table 4. The maximum thiamine (B1) was found in *C. subamethysteus* (5.45 mg/100g) followed by *C. appalachiensis* (1.48 mg/100g), *C. minor* (0.92 mg/100g) and least quantity was observed in *C. applanatus* (0.51 mg/100g). Riboflavin (vitamin B2) was maximum in *C. applanatus* (7.91 mg/100g) followed by *C. subamethysteus* (4.29 mg/100g), *C. minor* (3.37 mg/100g) and *C. appalachiensis*

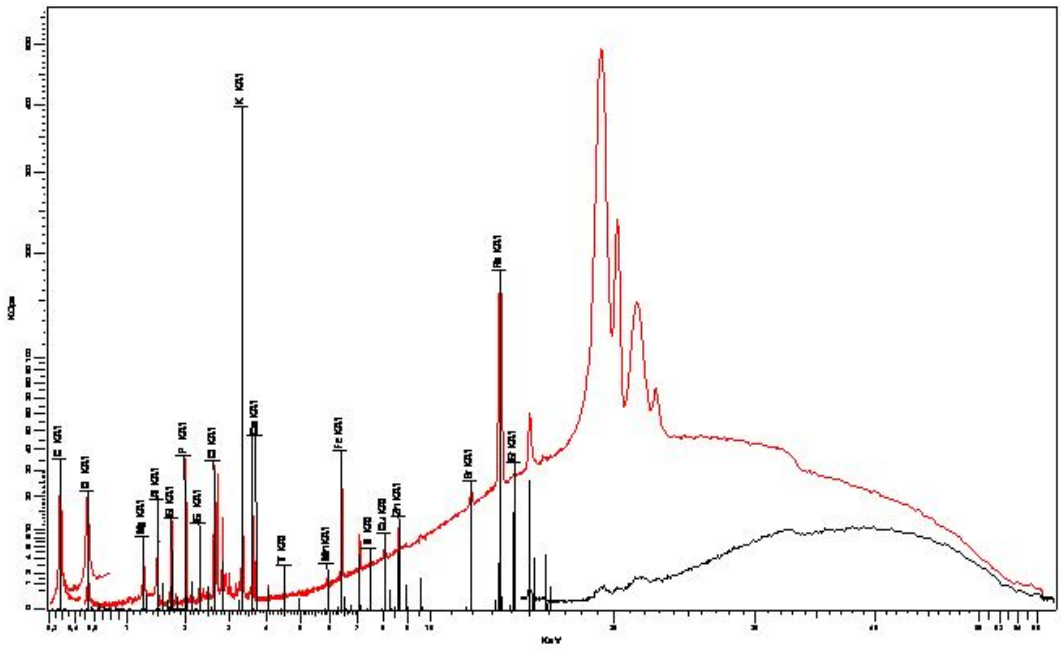

Fig. 3: Chromatogram showing presence of different essential elements and heavy metals in *C. appalachiensis*

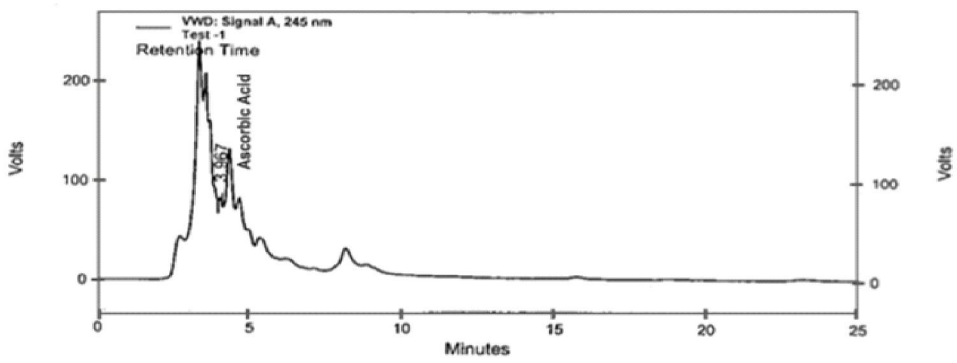

Fig. 4: HPLC chromatogram of ascorbic acid in *C. applanatus*.

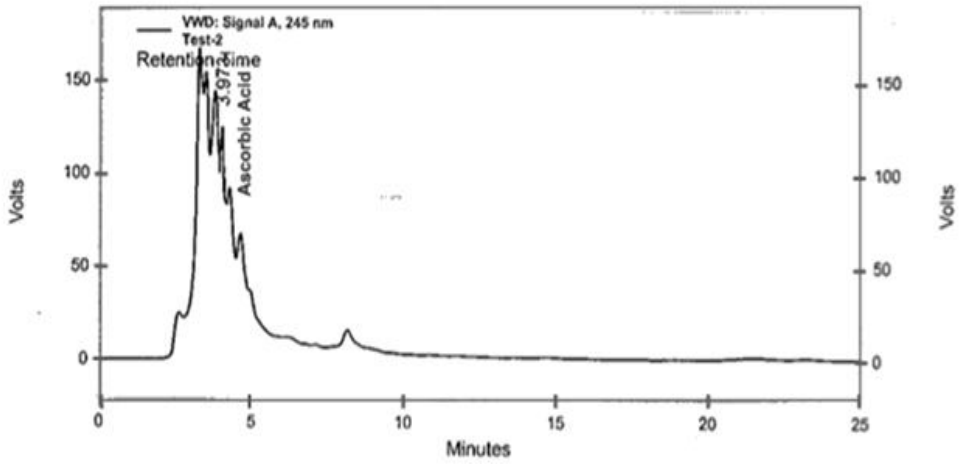

Fig. 5: HPLC chromatogram of ascorbic acid in C. *subamethysteus*.

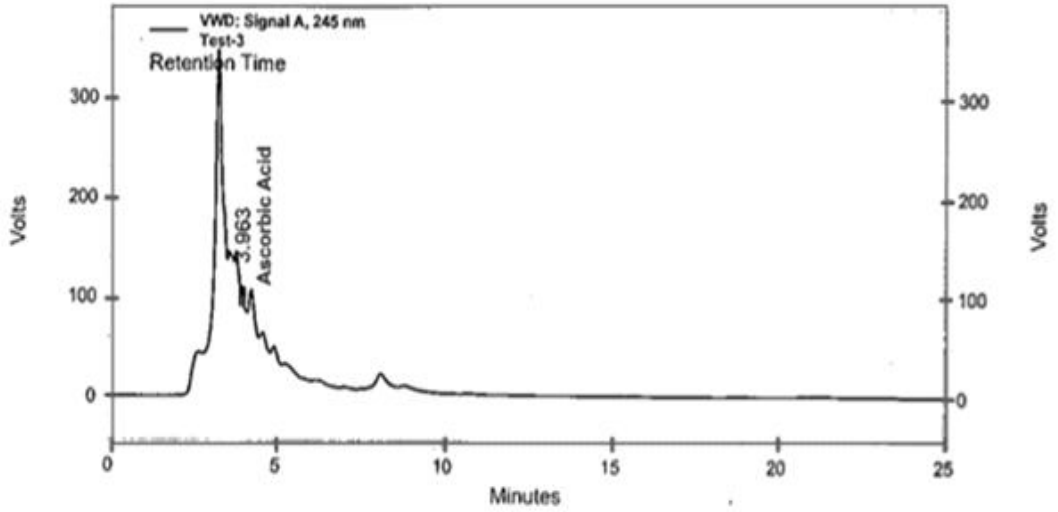

Fig. 6: HPLC chromatogram of ascorbic acid in *C. minor.*

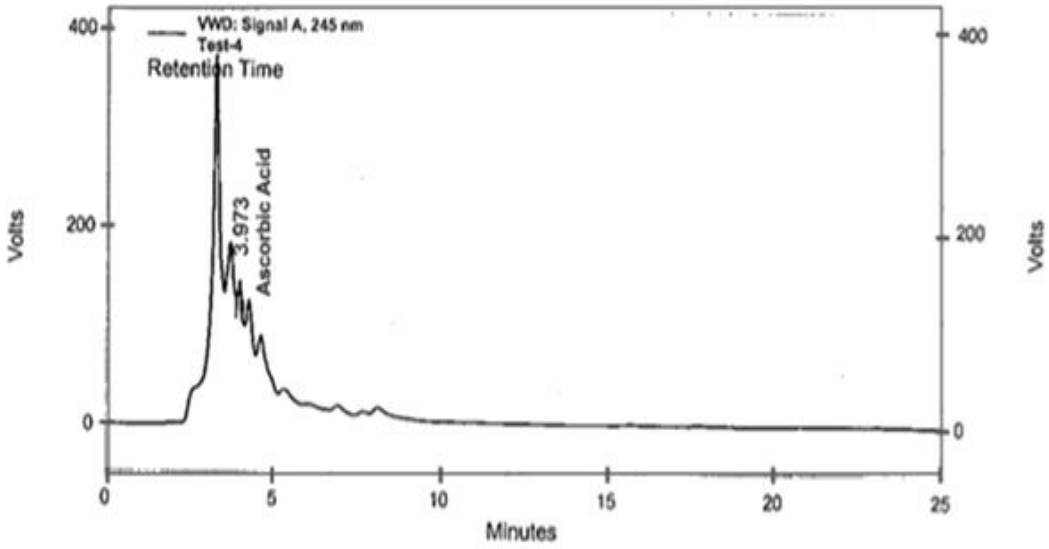

Fig. 7: HPLC chromatogram of ascorbic acid in *C. appalachiensis*

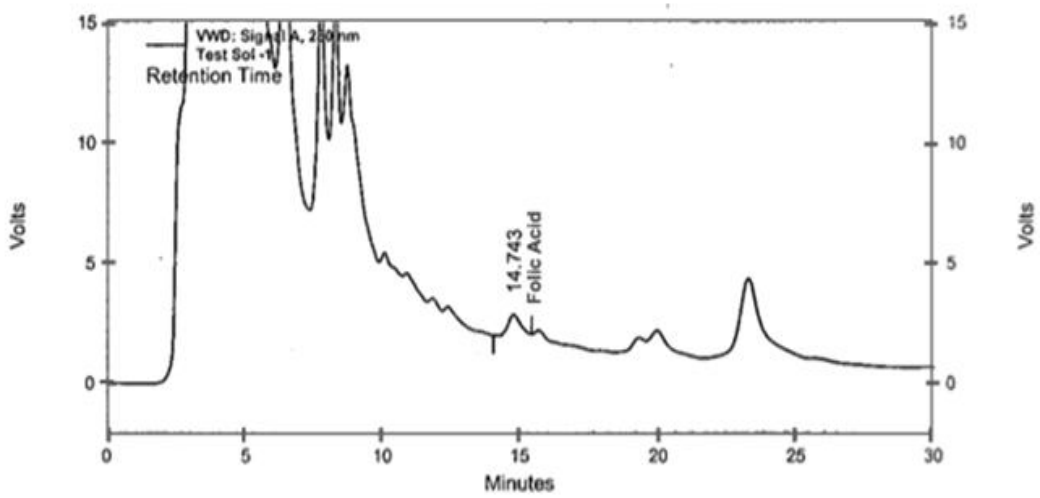

Fig. 8: HPLC chromatogram of folic acid in *C. applanatus.*

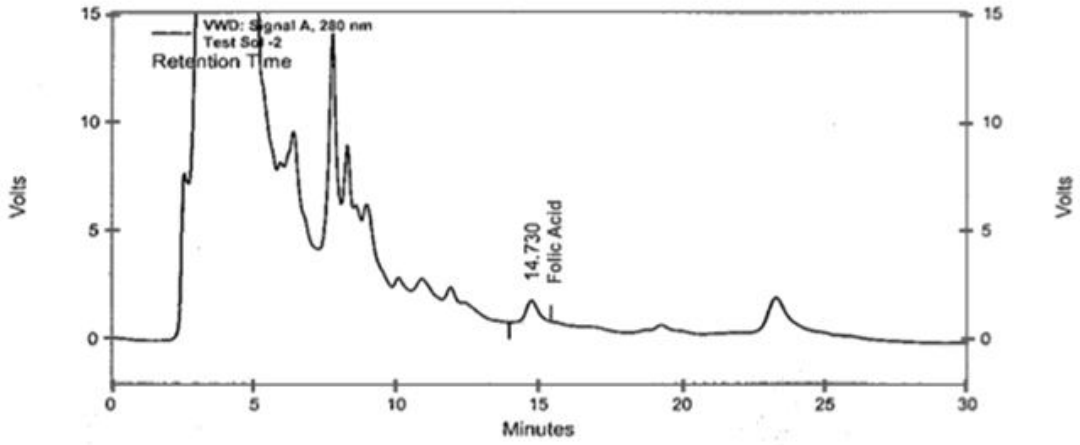

Fig. 9: HPLC chromatogram of folic acid in *C. subamethysteus*

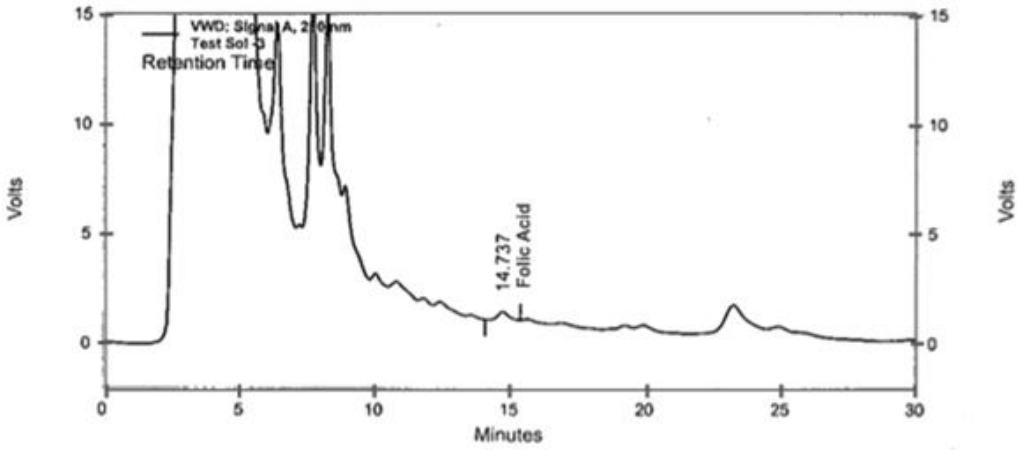

Fig. 10: HPLC chromatogram of folic acid in *C. minor.*

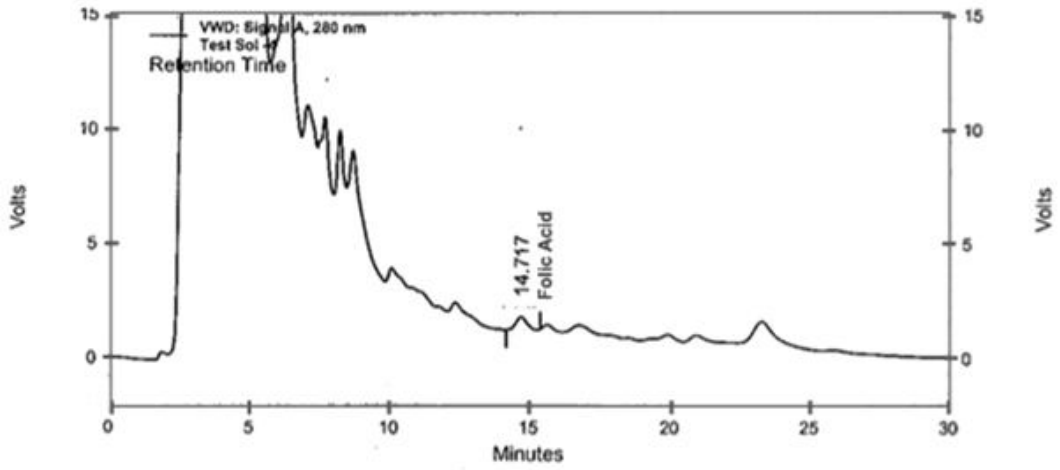

Fig. 11: HPLC chromatogram of folic acid in *C. appalachiensis*

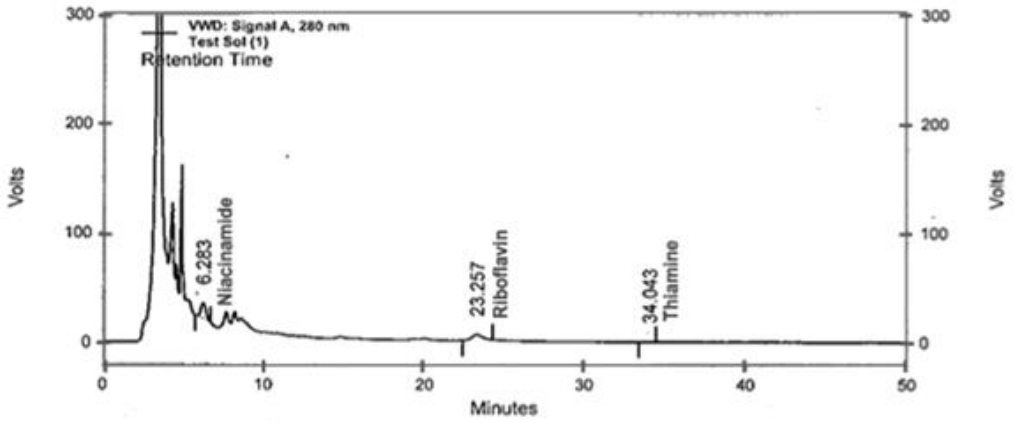

Fig. 12: HPLC chromatogram of niacin, riboflavin and thiamine in *C. applanatus*.

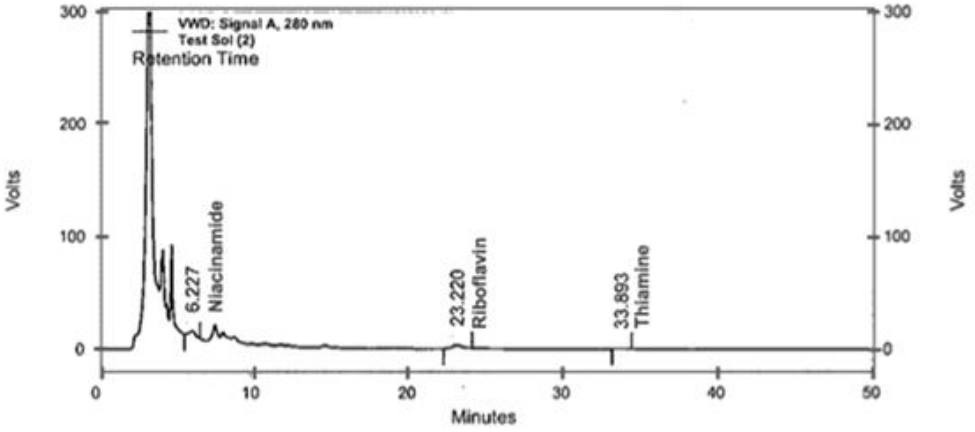

Fig. 13: HPLC chromatogram of niacin, riboflavin and thiamine in *C. subamethysteus*.

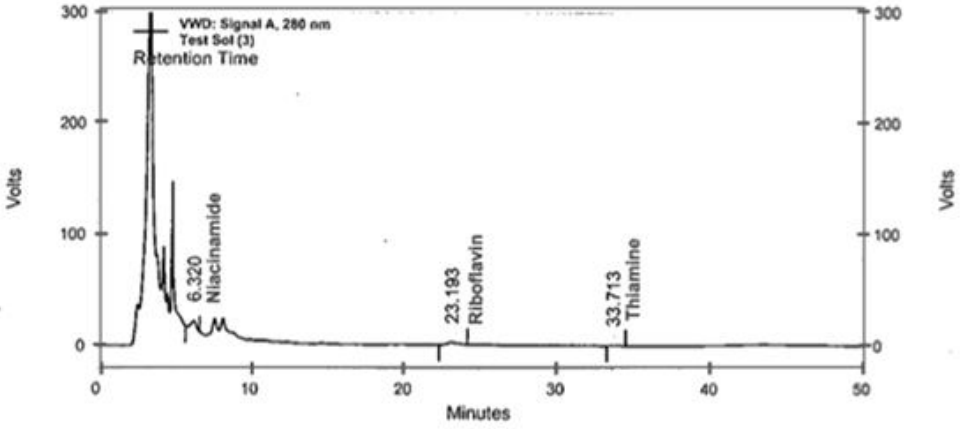

Fig. 14: HPLC chromatogram of niacin, riboflavin and thiamine in *C. minor*.

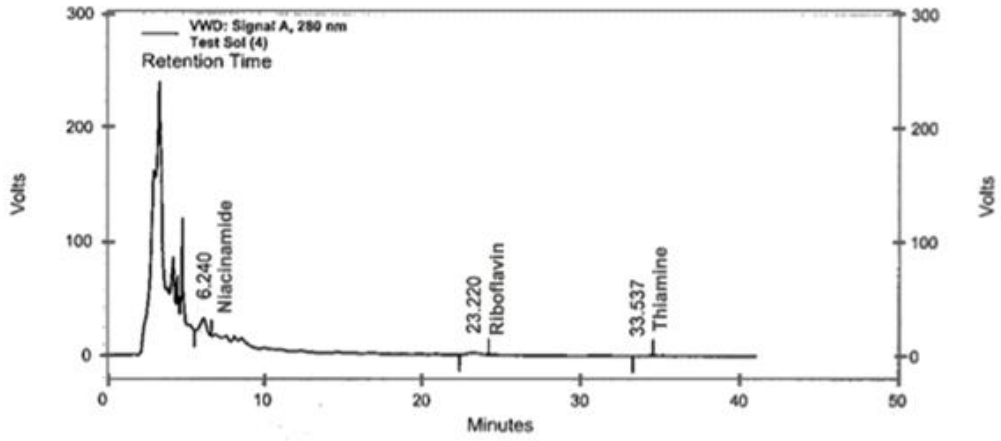

Fig. 15: HPLC chromatogram of niacin, riboflavin and thiamine in *C. appalachiensis*.

(2.84 mg/100g). Niacin content was found to be highest among vitamin B complex studied it was maximum in *C. appalachiensis* (17.90 mg/100g) followed by (16.41 mg/100g) in *C. applanatus*, (8.92 mg/100g) in *C. minor* and (6.52 mg/100g) in *C. subamethysteus*. Folic acid content was highest in *C. applanatus* (0.70 mg/100g) followed by *C. subamethysteus* (0.69 mg/100g), *C. appalachiensis* (0.30 mg/100g) and minimum in *C. minor* (0.24 mg/100g). Ascorbic acid (vitamin C) was maximum in *C. appalachiensis* (11.35 mg/100g) followed by *C. subamethysteus* (9.43 mg/100g), *C. minor* (2.58 mg/100g) and least was observed in *C. applanatus* (2.08 mg/100g). The results have been expressed in mg/100g for all vitamins of dry weight. Representative chromatograms are shown in Figs. 4–15.

DISCUSSION

Edible wild mushrooms are characterized by high contents of proteins, vitamins and minerals elements and low calories; they are valuable health-promoting foods (Kula *et al*. 2011). The consumption of wild edible mushrooms is high, due to their unique taste (Chudzyñski *et al*. 2011). These species can be regarded as healthy foods in well-balanced diets due to the presence of minerals and nutrients contents (Kalaè 2009).

Among all the studied *Cantharellus* species, protein was the principal macronutrient. The total protein content is based on the determination of nitrogen content by Kjeldahl method. The proteins from fungal origin are considered to be at par with those of animal origin. Protein content is usually very high in the majority of the wild mushrooms (Sanmee *et al*. 2003; Adejumo and Awosanya 2005; Chye *et al*. 2008; Colak *et al*. 2009; Palazzolo *et al*. 2012) which is quite useful for vegetarians or malnutrition persons.

Beside proteins, mushrooms were also found to contain good amount of carbohydrates ranging from 50–65% of the total dry weight (Thatoi and Singdevsachan 2014). In the present study percentage of carbohydrates varies from 33.17–47.1%, which is well within the total range of carbohydrate percentage reported in different edible mushrooms (Thatoi and Singdevsachan 2014).

Mushrooms are valued for their low fat content which is reported to range from 1.1–8.3% (Chang and Miles 2004). In the presently evaluated species the fat content has been found to range between 1.83-2.67%, which is in conformity with the observations by (Kalaè 2009; Barros *et al*. 2007; Atri*et al*. 2012; Kumari and Atri 2014). The low fat or lipid contents also suggest that persons suffering from heart or weight problems can consume mushrooms.

As compared to agricultural crop plants, vegetables or fruits, mushrooms have significantly higher concentrations of trace element (Kalyoncu *et al*. 2010). Elements can be divided into two groups, i.e. major elements and trace elements. Major elements include Na, K, Ca, Cl, Mg, S and P and their recommended daily intake is more than 50 mg/day. Trace elements Fe, Mn, Zn, Cu, Mo, Co, Se, Ni are needed in less quantity (<50 mg/day) (Ismail *et al*. 2011). Despite the fact that mushrooms contain a wide spectrum of essential

elements and organic substances, they also contain problematic heavy metals present in the environment. Wild edible mushrooms are mainly collected from lawns and parks, roadside forests and industrial sites (Falandysz *et al*. 2001). These sites are exposed to pollution with various elements, thus the mushrooms collected from these areas are not suitable for human consumption (Falandysz *et al*. 2001; Chudzyñski *et al*. 2011).

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