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Nutritional and Neutraceutical potential of some wild edible Russulaceous mushrooms from North West Himalayas, India

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ABSTRACT

Seven wild edible russulaceous mushrooms, namely *R. brevipes* Peck, *R cyanoxantha* (Schaeff.) Fr., *R. heterophylla* (Fr.) Fr., *R. virescens* (Schaeff.) Fr., *Lactarius sanguifluus* (Paulet) Fr., *L. deliciosus* (L.) Gray and *Lactifluus piperatus* (L.) Kuntze were selected for nutritional and nutraceutical evaluation. Their complete nutritional profile with respect to per cent occurrence of protein, carbohydrate, fat, ash, free sugars and energy values present were evaluated. For neutraceutical evaluation, phenolic compounds, flavonoids, ascorbic acid and β carotenoids were evaluated. To evaluate antioxidant activity, reducing power assay was conducted. Nutritional analysis confirmed the presence of good amounts of protein which ranged from 19.84- 37.77%, sufficient carbohydrate content that ranges from 40.81-63.24%, low fat content that ranges from 1.7-5.44%, good ash content ranging from 6.17-16.43 %, moisture 6.89-8.34 % and energy value 253.84- 287.40 Kcal/ 100g of the sample. Mannitol and trehalose occur as the main sugars in all the mushrooms evaluated. Amongst the neutraceutical components phenolic content ranged from 1.78-17.55 mg/g, flavonoid content ranged from 0.14-2.47 mg/g, ascorbic acid content ranged from 0.12-0.31 mg/g, β carotene content ranged from 4.47-32.73µg/g and the reducing power of mushroom methanolic extract was found to range between 0.06-0.77.

Key Words: Wild mushrooms, edibility, neutraceutical potential, reducing power, *Russula*, *Lactarius*, *Lactifluus*

I. INTRODUCTION

Mushrooms are among the largest fungi which belong to class *Agaricomycetes* Doweld. Kirk *et al*. (2008) recognized 17 orders under this class and mushrooms are grouped under orders *Agaricales* Undrew., *Russulales* Krisel ex P.M. Kirk, P.F. Cannon & J.C. David, *Boletales* E.J. Gilbert and *Cantharellales* Gäum. During monsoon season numerous species of wild mushrooms were gathered regularly from the nearby localities in different parts of India for consumption (Thimbal and Kluthe,1998; Gulati *et al*., 2010; Atri *et al*., 1997; 2010a, b). In many countries of Central and Eastern Europe the consumption of wild mushrooms is being preferred over eating of cultivated mushrooms (Kalač, 2009). In Czech Republic mushroom picking is reported to be a National hobby (Šišàk, 2007). In the Indian subcontinent as well, besides consumption of cultivated mushrooms, the wild edible species of *Termitomyces* R. Heim, *Pleurotus* (Fr.)P. Kumm., *Volvariella* Speg., *Lactarius* Pers., *Agaricus* L., *Morchella* Dill. ex. Pers., *Tuber* P. Micheli ex F.H. Wigg., *Calocybe* Kühner ex Donk, *Lycoperdon* Pers., *Podaxis* Desv., *Macrolepiota* Singer, *Cantharellus* Juss., *Boletus* L., *Russula* Pers. etc. are regularly collected in bulk and consumed during rainy season (Atri *et al*., 1997; 2010a, b; 2012; Mridu and Atri, 2015). Some of these including species of *Morchella*, *Termitomyces* and *Podaxis* are being traded as well (Atri *et al*., 2010a, b; Lakhanpal, 1994; Mridu and Atri, 2015). Amongst the russulaceous mushrooms, the edible ones include *Russula cyanoxantha* (Schaeff.) Fr., *R. virescens* (Schaeff.) Fr., *Lactarius deliciosus* (L.) Gray and many others (Atri *et al*., 1997; Verbeken *et al.,* 2000). From North West Himalayas some of the species of *Amanita* Pers., *Astraeus* Morgan, *Cantharellus, Cordyceps* Fr., *Morchella, Termitomyces, Pleurotus, Russula* and *Lactarius* are among the most commonly consumed mushrooms (Semwal *et al.,* 2014). In rural India mushrooms are an important nutrient source (FAO, 2004). Generally the local inhabitant's collect members of the genera *Termitomyces, Lycoperdon, Podaxis, Morchella, Lactarius, Lactifluus* and *Russula,* etc. almost on daily basis during monsoon seasons. There are no known features to differentiate poisonous mushrooms from the edible ones. Every year number of people are reported to suffer from mushroom poisoning in North Western Himalayas as reported by local news papers from time to time. From amongst the russulaceous mushrooms *Russula xerampelina* (Schaeff.) Fr., *R. foetens* Pers., *R. subfoetens* W.G. Sm., *R. emetica* (Schaeff.) Pers., *R. nigricans* Fr., *Lactarius pallidus* Pers., *L. helvus* (Fr.) Fr. are reported to be inedible (Atri *et al*., 1997; Hesler and Smith, 1979). Because wild mushrooms have become an integral part of human diet, interest for knowing their nutritional and neutraceutical profile has started growing with the passage of time and there are number of references from India and abroad in this regard (Crisan and Sands, 1978; Chang and Miles, 2004; Agrahar Murugkar and Subbulakshmi, 2005; Barros *et al*., 2008a, b, c; Pushpa and Purushothama, 2010; Gulati *et al*., 2010; Atri *et al.,* 2013; Sharma and Atri, 2014; Kumar *et al*., 2013; Kumari *et al*., 2011; Kumari and Atri, 2012, 2014; Atri *et al*., 2016). During the present investigation, four edible species of *Russula* (*R. brevipes*, *R. cyanoxantha*, *R. heterophylla* and *R. virescens*), two edible species of *Lactarius* (*L. deliciosus* and *L. sanguifluus*) and one edible species of *Lactifluus* (*Lf. piperatus*) which are commonly collected from the wild sources in North Western Himalayas for consumption purposes have been evaluated for their nutritional and neutraceutical profile.

II. MATERIAL AND METHODS

A. Mushroom samples: All the samples of russulaceous mushrooms were collected from various localities of North West Himalayas and then dried at 45˚C and preserved in air tight cellophane bags for further use.

B. Estimation of nutritional component: The amount of protein content was estimated by Bradford dye binding method (Bradford, 1976). The percentage of moisture content, ash and crude fat was calculated according AOAC(1995). Total energy value was calculated according to the equation: Energy (kcal) = 2.62 × (g protein) + 3.48 (g carbohydrate) + 8.37× (g fat) (Crisan and Sands, 1978).

C. Estimation of sugar composition: Soluble sugars were determined by high performance liquid chromatography (HPLC) at 35˚C (Barros *et al*., 2008a). The HPLC system was coupled to a RI detector and equipped with a sugar pack column (6.5 × 300 nm). The mobile phase was acetonitrile/deionised water: 7:3 (v/v) and run at flow rate of 1.25 ml/min. The relative retention times of sample peaks were compared to those of standard's peaks to identify the sugars present. The results were calculated by chromatographic peak areas and expressed as g/100g of dry weight. The sugars used as standards were: D(-) arabinose, D(-) fructose, D(+) fucose, D (+) galactose, D (+) glucose anhydrous, myo-inositol, D(+) mannitol, D(+) mannose, D(+) melibiose monohydrate, L(+) rhamnose monohydrate, D(-) ribose, D(-) sorbitol, D(+) sucrose, D(+) trehalose, and D(+) xylose (Sigma Aldrich Co., Bangalore, India).

D. Estimation of bioactive compounds and antioxidant activity: The methanolic extracts of respective fruiting bodies were used for determining bioactive compounds and antioxidant activity as described by Barros *et al*. (2007a).

E. Statistical analysis: All the experiments were performed in triplicate. The result was expressed as mean values and standard deviation (SD) and the data were analyzed by employing analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

Nutritional analysis confirmed the presence of good amount of protein which ranged from 19.84-37.77%. Out of seven russulaceous mushrooms evaluated, *Lactarius sanguifluus* (37.77%) contained maximum amount of protein followed by *R. virescens* (34.97%), *R. brevipes* (31.63%) *Lactraius deliciosus* (27.49%), *Russula heterophylla* (26.36%) and minimum percentage was documented in *R. cyanoxantha* (19.84%). Almost comparable amount of protein content has been reported in *Russula brevispora* (24.1%) and *R. integra* (21.1%) by Agrahar Murugkar and Subbulakshmi (2005) and R. delica (26.25% and 27.69%) by Konuk *et al*. (2006) and Pushpa and Purushothama (2010). Amongst the species of *Lactarius*, *L. deliciosus* is one of the most preferred edible mushrooms. Kalač (2009) reported 29.8% protein in this species, while Konuk *et al*. (2006) reported 28.2% protein on dry weight basis which is almost comparable to the percentage (27.49%) of proteins detected in the Indian samples of *L. deliciosus* collected from the North West Himalayas during the present study. In comparison, much less protein percentage (14.71-17.31%) has been reported in the literature by Sharma *et al*. (1988) and Agrahar Murugkar and Subbulakshmi (2005). There are few other species like *L. sanguifluus* (15.20-18.87%) and *L. quieticolor* (19.0%), which have been evaluated for their proximate composition including protein (Sharma *et al*., 1988; Agrahar Murugkar and Subbulakshmi, 2005). The Indian sample of *L. sanguifluus* (37.77%) has been evaluated to contain substantially high amount of protein than documented (15.20 18.87%) by Sharma *et al*.(1988). From amongst the species of *Lactifluus*, *Lf. piperatus* was estimated to contain 24.23% protein on dry weight basis, which is much more in comparison to 16.85% as reported by Ayaz *et al.* (2011) in this species. *Lactarius quietus* is another russulaceous mushroom evaluated for protein percentage (12.55%) by Ayaz *et al.* (2011). All the Indian species of *Russula*, *Lactarius* and *Lactifluus* evaluated presently, contained much more percentage of protein (19.84-37.77%) in comparison.

The carbohydrate content has been reported to account for 50-65 % of the total mushroom on dry weight basis (Thatoi and Singdevsachan, 2014). However, Manikandan (2011) documented it to vary from 26-82%. Amongst the seven wild russulaceous mushrooms evaluated presently, the percentage of carbohydrates detected ranges from 40.81-63.24%, which is well within the total range of carbohydrate percentage reported in different edible mushrooms (Thatoi and Singdevsachan, 2014; Manikandan, 2011). In the presently evaluated samples maximum percentage of carbohydrate has been detected in *Russula cyanoxantha* (63.24%) followed by *Lactifluus piperatus* (57.05%), *Lactarius deliciosus* (55.23%), *Russula heterophylla* (46.11%), *Lactarius sanguifluus* (42.45%), *Russula virescens* (42.16%) and *R. brevipes* (40.81%). In an earlier report 62.9% of carbohydrate has been estimated in *L. deliciosus*, (Barros *et al*., 2007b), which is almost near to the net amount of carbohydrate detected in the Indian sample of this mushroom (55.23%) during present study. The percentage of carbohydrates estimated in *Lactifluus piperatus* (57.05%) during the present study is much more than documented for this species (42.50%) by Ayaz *et al*.(2011). In *Lactarius quietus* (67.65%), it is on the higher side in comparison to the range of carbohydrate percentage detected (42.45-57.05%) in all the species of *Lactarius* and *Lactifluus* evaluated presently. Amongst the *Russula* species evaluated presently, the carbohydrate content varied from 40.81% in *R. brevipes* to 63.24% in *R. cyanoxantha*. Konuk *et al.* 2006 estimated the carbohydrate percentage in *R. delica* to be 53.17%, which is much more in comparison to the value achieved (34.88%) for the same species by Pushpa and Purushothama (2010).

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 1.75-44%, which is in conformity with the observations of other workers (Kalač, 2009; Atri *et al*., 2012; Barros *et al*., 2007b; Barros *et al*., 2008a,b; Kumari and Atri, 2014). Amongst the presently evaluated *Russula* species, maximum fat percentage was recorded in *Russula heterophylla* (5.44%) followed by *R. brevipes* (3.46%), *R. virescens* (2.93%) and *R. cyanoxantha* (1.7%). In *R. heterophylla* the amount of fat detected (5.44%) is comparable to the percentage of fat documented in *R. delica* (5.38%) by Pushpa and Purushothama (2010), while in *R. cyanoxantha* (1.7%) it is comparable to *R. brevispora* (1.3%) as documented by Agrahar Murugkar and Subbulakshmi

(2005). Amongst the species of *Lactarius* and *Lactifluus* evaluated, maximum fat content has been documented in *Lactarius deliciosus* (2.77%) followed by *Lactifluus piperatus* (2.41%) and *Lactarius sanguifluus* (1.78%). All these values achieved for the percentage of fat in the presently evaluated species of *Lactarius* and *Lactifluus* is comparable to the percentage of fat reported by Ayaz *et al*. (2011) in *Lactarius quietus* (2.30%). In comparison, higher fat percentage has been reported by Ayaz *et al*. (2011) in *Lactifluus piperatus* (5.80%).

In the presently investigated russulaceous mushrooms, the ash content has been evaluated to range from 6.17-16.43%, which is almost comparable to the amount of ash reported in other mushrooms (Kalač, 2009; Barros *et al*. ,2008 a). Amongst the presently evaluated *Russula* species, *R. brevipes* (16.43%) contained maximum amount of ash that is almost comparable to the percentage (17.92%) of ash documented in *R. delica* by Pushpa and Purushothama (2010). *R. heterophylla* (15.20%) and *R. virescens* (12.47%) possesses comparatively lesser percentage of ash content. Minimum ash content has been documented in *R. cyanoxantha* (7.83%). Comparable amount of ash was detected in *R. brevispora* (10.9%) and *R. integra* (11.5%) by Agrahar Murugkar and Subbulakshmi (2005). The percentage of ash evaluated in *Lactarius sanguifluus* (10.07%), *Lactifluus piperatus* (8.13%) and *Lactarius deliciosus* (6.17%) is comparatively on the lower side. The variable amount of constituents within the species are reported to be largely influenced by various factors like stage of development of the carpophore and pre and post-harvest conditions under which the mushroom is growing (Manzi *et al*., 1999). Values of moisture were also taken into consideration while calculating the proximate proportions of different nutritional attributes evaluated during the present investigations. In the dry samples of the investigated mushrooms, the moisture content was found to range from 6.89 to 8.34%. This has been done to reach the near exact proportions of nutritionally important components in the evaluated samples. Energy value of different mushrooms is also quite variable. In different *Pleurotus* species, it has been reported to range between 295-367 Kcal, while in *Agaricus* between 283-413 Kcal (Crisan and Sands, 1978). Amongst the presently evaluated species of russulaceous fungi, the energy value has been calculated to range between 253.84 Kcal/100g in *R. brevipes* to 287.4 Kcal/100g in *Lactarius deliciosus*. In comparison, Singer (1961) evaluated energy value of fresh samples of *L. deliciosus* to be 371 Kcal/100g which is much more than the energy value obtained for the dry sample of *L. deliciosus* during the present investigation. For all other species evaluated including *Russula cyanoxantha* (286.28 Kcal/100g), *Lactarius sanguifluus* (261.59 Kcal/100g) and *R. brevipes* (253.84 Kcal/100g), the energy value obtained is comparable to some of the canned samples of *Agaricus bisporus* (Adriano and Cruz, 1993; Watt and Merill, 1963) and fresh samples of *Tuber melanosporum* (Singer, 1961) (**Table 1; Fig 1**).

Mannitol and trehalose occur as the main sugars in all the seven mushrooms evaluated presently. Maximum mannitol content has been evaluated in *Russula cyanoxantha* (4.94%) followed by *Lactarius sanguifluus* (4.26%), *R. brevipes* (3.93%) and minimum content was found in *R. Heterophylla* (1.67%), *Lactifluus piperatus* (1.36%) and *Russula virescens* (1.14%). The presently documented value of mannitol in various russulaceous mushrooms is well within the range (0.07-6.09%) documented in large varieties of mushrooms (Barros *et al*., 2007b; Barros *et al*., 2008a,b). The percentage of mannitol detected in *L. deliciosus* (1.76%) during current study is slightly higher as compared to 1.36%, detected by Barros *et al*. (2007b).

Amongst the investigated species, maximum trehalose content was documented in *Russula brevipes* (0.51%) followed by *R. cyanoxantha* (0.30%), *Lactifluus piperatus* (0.27%), *R. heterophylla* (0.22%), *Lactarius sanguifluus* (0.20%), *R. virescens* (0.16%) and minimum in *L. deliciosus* (0.12%). Barros *et al*. (2008b) while working on wild samples of *L. deliciosus* from Portugal investigated substantially high amount (1.36%) of trehalose in comparison to the presently worked out sample of this mushroom (0.12%) from North West Himalayas. Inositol is another important sugar present in mushrooms (Ikawa *et al*., 1968). Out of the seven

Table 1. Proximate chemical composition (g/100g) and energy value (kcal/100 g) of seven Russulaceous mushroom species (on dry weight basis) (mean ± SD; *n* = 3)

Species↓	Proteins (g/100g)	Carbohydrates (g/100g)	Crude fat (g/100g)	Ash (g/100g)	Moisture (g/100g)	Energy (kcal/100g)
1. *Russula brevipes*	31.63±0.16(c)	**40.81±0.40 (f)**	3.46±0.01 (b)	**16.43±0.42 (a)**	7.67±0.55 (ab)	**253.84±0.11 (f)**
2. *R. cyanoxantha*	**19.84±0.12(g)**	**63.24±0.49 (a)**	**1.7±0.02 (g)**	7.83±0.15 (d)	7.39±0.41 (ab)	286.28±0.40 (a)
3. *R. heterophylla*	26.36±0.42 (e)	46.11±0.83 (d)	**5.44±0.02 (a)**	15.20±0.72 (a)	**6.89±0.61 (b)**	275.05±0.25 (c)
4. *R. virescens*	34.97±0.13(b)	42.16±0.39 (ef)	2.93±0 (c)	12.47±0.80 (b)	7.47±0.59 (ab)	262.85±0.18 (d)
5. *Lactarius deliciosus*	27.49±0.21(d)	55.23±0.32 (c)	2.77±0.01 (d)	**6.17±0.80 (e)**	**8.34±0.64 (a)**	**287.40±0.54 (a)**
6. *L. sanguifluus*	**37.77±0.30 (a)**	42.45±0.78 (e)	1.78±0.01 (f)	10.07±0.25 (c)	7.93±0.45 (ab)	261.59±0.61 (e)
7. *Lactifluus piperatus*	24.23±0.73(f)	57.05±0.64 (b)	2.41±0.05 (e)	8.13±0.65 (d)	8.18±0.28 (ab)	282.18±0.70 (b)

Values bearing different letters in the same column are significant at P<0.05. All values are Mean ± SD (n = 3).

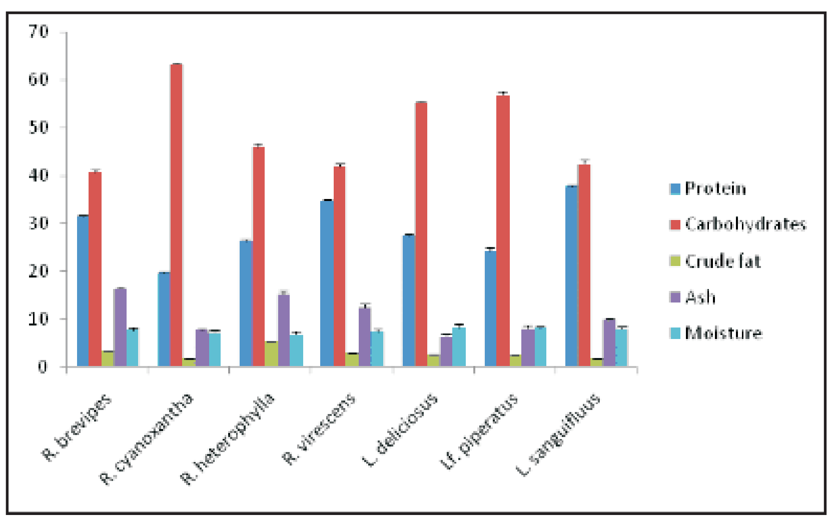

Fig. 1: Histogram depicting respective level of various nutritional component and moisture in seven Russulaceous mushrooms

Table 2: Sugar composition of seven Russulaceous mushrooms (Mean ± SD; n=3)

Sr. No.	Species	Trehalose (g/100g)	Mannitol (g/100g)	Sorbitol (g/100g)	Ribose (g/100g)	Glucose (g/100g)	Inositol (g/100g)	Total sugar (g/100g)
1.	*Russula brevipes*	**0.51 ± 0.01(a)**	3.93 ± 0.03(c)	0.13 ± 0.00(b)	0.13 ± 0.0(b)	**0.04 ± 0.00**(b)	nd	4.74 ± 0.02(c)
2.	*R. cyanoxantha*	0.30 ± 0.01(b)	**4.94 ± 0.04**(a)	**0.06 ± 0.01**(c)	**0.16 ± 0.0**(a)	nd	nd	**5.46 ± 0.02**(a)
3.	*R. heterophylla*	0.22 ± 0.02(d)	1.67 ± 0.04(d)	nd	**0.03 ± 0.00**(d)	**0.21 ± 0.04**(a)	nd	2.13 ± 0.03(d)
4.	*R. virescens*	0.16 ± 0.02(e)	**1.14 ± 0.02**(f)	nd	nd	0.19 ± 0.06(a)	nd	**1.5 ± 0.03**(f)
5.	*Lactarius deliciosus*	**0.12 ± 0.0**(f)	1.76 ± 0.03(d)	**0.16 ± 0.03**(a)	0.14 ± 0.0(b)	nd	nd	2.18 ± 0.03(d)
6.	*L. sanguifluus*	0.20 ± 0.0(d)	4.26 ± 0.02(b)	0.12 ± 0.01(b)	0.09 ± 0.0(c)	nd	0.32 ± 0.0(a)	4.99 ± 0.02(b)
7.	*Lactifluus piperatus*	0.27 ± 0.0(c)	1.36 ± 0.01(e)	nd	nd	nd	nd	1.63 ± 0.01(e)

Values bearing different letters in the same column are significant at $P<0.05$. All values are Mean ± SD (n = 3).

russulaceous mushrooms evaluated, inositol was detected only in *L. sanguifluus* (0.32%), which is almost comparable to the percentage of inositol documented in *Boletus edulis* (0.12%), *Amanita muscaria* (0.20%) and *Agaricus bisporus* (0.58%) by Ikawa *et al*.(1968) (**Table 2**). Sorbitol, ribose and glucose are other sugars which were documented in variable proportions in some of the investigated mushrooms.

Among the bioactive compounds, phenolic content ranged from 1.78-17.55 mg/g. This is within the range of 0.88-20.32 mg/g documented in number of mushrooms including *Agaricus bisporus, A. silvaticus, A. silvicola, A. arvensis, Boletus edulis, Calocybe gambosa, Craterellus cornucopiodes, Cantharellus cibaricus, Leucopaxillus giganteus, Sarcodon imbricatus, Ramaria botrytis, Tricholoma acerbum* and *Marasmius oreades* (Barros *et al*., 2008a, b; Barros *et al.*, 2007a). Highest phenolic content has been estimated in *Lactarius sanguifluus* (17.55 mg/g) followed by *Russula cyanoxantha* (14.39 mg/g), *Lactarius deliciosus* (12.28 mg/g), *Lactifluus piperatus* (4.41 mg/g) and *Russula brevipes* (1.78 mg/g). The flavonoid content ranged from 0.14-2.47 mg/g. The maximum amount was found in *Lactarius sanguifluus* (2.47 mg/g) followed by *Russula heterophylla* (2.01 mg/g), *R. cyanoxantha* (1.59 mg/g), *Lactifluus piperatus* (1.37 mg/g), *Russula virescens* (0.78 mg/g), *R. brevipes* (0.19 mg/g) and *Lactarius deliciosus* (0.14 mg/g). The proportion of flavonoid has been reported to range from 0.40-16.56 mg/g in various mushroom taxa (Barros *et al*., 2008a, b; Barros *et al*., 2007d). In *Macrolepiota* species, the flavonoid content has been reported to range between 1.36-1.76 mg/g by Kumari and Atri (2014). The amount of flavonoid detected in *Russula brevipes* (0.19 mg/g) during present study is comparable to the proportion (0.16 mg/g) of this antioxidant detected by Gursoy *et al*. (2010) in *R. delica.* Ascorbic acid content ranged from 0.12-0.31 mg/g, which is in line with the proportion of ascorbic acid content (0.03-0.52mg/g) documented in various edible mushrooms including *Lactarius deliciosus* (0.24 mg/g) (Barros *et al*., 2007d; Barros *et al*., 2007c). Presently, maximum ascorbic acid amount has been detected in *L. deliciosus* (0.31 mg/g) followed by *Russula virescens* (0.23 mg/g), *R. cyanoxantha* (0.17 mg/g), *R. brevipes* (0.14 mg/g), *Lactifluus piperatus* (0.13 mg/g), *Russula heterophylla* (0.12 mg/g) and *Lactarius sanguifluus* (0.12 mg/g). β carotene is yet another antioxidant detected in all the mushroom samples evaluated presently. Its content ranged from 4.47-32.73µg/g. The maximum amount of β-carotene content has been evaluated in *Lactarius deliciosus* (32.73 µg/g) followed by *Lactifluus piperatus* (27.83 µg/g), *Lactarius sanguifluus* (19.17 µg/g), *Russula brevipes* (11.63 µg/g), *R. heterophylla* (8.17 µg/g), *R. virescens* (5.91 µg/g) and *R. cyanoxantha* (4.47 µg/g). The β- carotene proportions reported in the presently evaluated samples is much less in comparison to β-carotene content reported in *Tricholoma acerbum* (75.58 µg/g) (Barros *et al*., 2007a). In the available literature, there is no information about the presence of β- carotene in russulaceous mushrooms with which the presently evaluated data could be compared. In *Macrolepiota* species, β-carotene content has been documented to range between 0.12-0.29 µg/g (Kumari and Atri, 2014) which is much less in comparison to the proportion of β- carotene (4.47-32.73 µg/g) evaluated in the presently evaluated samples of russulaceous mushrooms (**Table 3**). These mushrooms also showed good antioxidant properties (**Fig. 2**). The reducing power of mushroom methanolic extract at 1mg/ml in the presently evaluated mushrooms has been evaluated between 0.06-0.77, which is almost comparable to the value of reducing power

Table 3: Phenolic compounds (mg/g), Flavonoids (mg/g), Ascorbic acid (mg/g) and β-Carotene (ug/g) in *seven* wild Russulaceous mushrooms (on dry weight basis) (mean ± SD; *n* = 3)

Species↓	Total Phenolics (mg/g)	Flavonoids (mg/g)	Ascorbic Acid (mg/g)	β-Carotene (µg/g)
1. *Russula brevipes*	**1.78±0.15 (g)**	0.19±0.02 (f)	0.14±.01 (d)	11.63±0.50 (d)
2. *R. cyanoxantha*	14.39±0.13 (b)	1.59±0.02 (c)	0.17±.00 (c)	**4.47±0.39 (f)**
3. *R. heterophylla*	9.43±0.15 (d)	2.01±0.02 (b)	**0.12±.00 (d)**	8.17±0.50 (e)
4. *R. virescens*	7.39±0.13 (e)	0.78±0.01 (e)	0.23±.00 (b)	5.91±0.85 (ef)
5. *Lactarius deliciosus*	12.28±0.15 (c)	**0.14±0.03 (f)**	**0.31±.02 (a)**	**32.73±2.26 (a)**
6. *L. sanguifluus*	**17.55±0.15 (a)**	**2.47±0.02 (a)**	**0.12±.00 (d)**	19.17±1.56 (c)
7. *Lactifluus piperatus*	4.41±0.13 (f)	1.37±0.02 (d)	0.13±.01 (d)	27.83±1.10 (b)

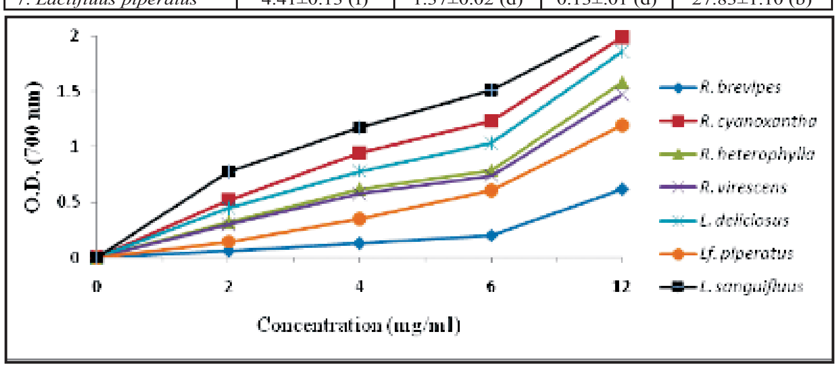

Fig. 2: Reducing power of the methanolic extracts of seven wild Russulaceous mushrooms at different concentrations

reported in *Leucopaxillus giganteus, Sarcodon imbricatus* and *Agaricus arvensis* (Barros *et al*., 2007a). The present data indicate russulaceous fungi to be equally good in this regard.

IV. CONCLUSION

Nutritional value of russulaceous mushrooms is comparable with vegetables and meat. Edible russulaceous mushrooms compare well with the nutritional and neutraceutical qualities of commonly cultivated mushrooms and are much better because of low fat and the presence of neutraceutically important constituents in comparison to many of the commonly consumed vegetables**.**

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