RESULTS AND DISCUSSION

Ethnobotanical study:

The information of three potential wild edible tuberous plants under study were collected from different area of Satara and Kolhapur district by taking interviews of eight villagers.

Table 1: Ethnobotanical information

Sr. No.	Place/Area	Informant Name	Male/ Female	Age (Yr.)	Caste
1.	Kartikswami ghat	Ramdas Patole	M	50	Ramoshi
2.	Pateshwar	Abaji Budhawale	M	60	Kaikaris
3.	Wai	Dharma Shinde	M	40	Mang
4.	Shindewadi	Sulabai Pawar	F	35	Beldar
5.	Katyani	Gajabai Chavan	F	60	Maratha
6.	Ramling	Tanaji Gawade	M	50	Dhangar
7.	Nesari	Malubai Mhasute	F	50	Jain-chatur
8.	Tarewadi	Subhash Buchade	M	45	Koli

1) Brachystelma edulis:

Family- Asclepiadaceae,

Common Name- Singati Galya.

Local Name- Galya, Hanuman batata.

Place: Kartikswami ghat.

Use: Raw tubers are eaten as food supplement.

Place: Pateshwar.

Use: Tubers are cooked as vegetable with salt and spices.

Place: Shindewadi.

Use: Decoction of tubers taken 1 cup daily once for 7-8 days as a tonic for bodily discomfort.

Place: Nesari.

Use: 1-2 tablespoon of fresh tubers decoction given to childrens in cough and cold for 4-5 days.

Place: Tarewadi.

Use: Tubers are eaten boiled or sometimes eaten by mixing with milk.

2) Ceropegia bulbosa:

Family- Asclepiadaceae, Common Name- Kandwel.

Local Name- Kharpudi, Khartundi.

Place: Ramling.

Use: Tubers are cooked and eaten by ladies to enhance fertility and vitality.

Place: Nesari.

Use: 1 cup decoction of fresh tubers is taken daily once for 8-10 days to get rid of urinary bladder stone.

Place: Tarewadi.

Use: Decoction of tubers is taken 1 cup daily once as a source of energy and for digestion.

Place: Kartikswami ghat.

Use: 3-4 fresh leaves are eaten early morning for 10-15 days in empty stomach to cure stomachache.

Place: Pateshwar.

Use: Tuber powder 1 tablespoon + 5 ml water and prepared a paste applied on the inflammation of skin.

Place: Wai.

Use: Tubers are eaten as a boiled and mixed with milk and sugar or salt and spices.

Plate 5

Rural Informants

Collection Locality

3) *Ceropegia hirsuta:*

Family- Asclepiadaceae, Common Name- Hairy *Ceropegia.*

Local Name- Hamana, Khapparkadu.

Place: Katyani.

Use: Warm tubers paste in hot water is applied twice daily on viral infection for 5-6 days.

Place: Kartikswami ghat.

Use: 1 cup decoction of whole plant is taken daily once for 4-5 days in fever. Also tuber rubbed on rock with pinch of lime is applied on affected area of scorpion bite.

Place: Pateshwar.

Use: Tubers are eaten as raw or boiled and also it eaten by making vegetable.

Place: Wai.

Use: 1-2 tablespoon root powder in warm water are given twice daily for 3-4 days in dysentery and diarrhea.

Place: Ramling.

Use: The powder of tuber with lime is applied over infected area of scorpion bite.

Place: Nesari.

Use: Fresh tubers and leaves are given daily for 4-5 days for treating stomach disorders.

Table 2: Proximate nutrient composition of wild edible tuberous plants.

Sr. No.	Plant Name→ Paramaters ↓	*B. edulis*		*C. bulbosa*		*C. hirsuta*	
		Tuber	Leaves	Tuber	Leaves	Tuber	Leaves
1	Moisture (%FW)	80.84 ±2.5	85.26 ±3.1	78.24 ±1.9	90.10 ±2.6	75.82 ±1.4	87.06 ±1.8
2	Dry Matter (%FW)	19.26 ±1	14.74 ±1.3	21.76 ±2.1	9.90 ±1.27	24.18 ±1.12	12.94 ±1.6
3	Ash (%DW)	11.5 ±1.0	7.5 ±0.89	10.2 ±1.32	6.0 ±1.2	10.6 ±0.9	7.8 ±1.0
4	Crude fibre (%DW)	8.0 ±1.02	9.4 ±0.96	8.7 ±0.81	9.9 ±0.88	9.1 ±0.02	14.4 ±2.1
5	Crude fat (%DW)	0.12 ±0.03	0.08 ±0.02	0.1 ±0.01	0.07 ±0.00	0.11 ±0.01	0.09 ±0.01
6	Crude protein (g/100g DW)	3.93 ±0.91	5.23 ±0.72	4.62 ±0.81	7.87 ±0.70	4.82 ±1.02	8.08 ±0.19
7	Reducing sugar (g/100g DW)	2.108 ±0.42	0.126 ±0.01	1.948 ±0.32	0.241 ±0.008	1.727 ±0.00	0.290 ±0.001
8	Total sugar (g/100g DW)	2.212 ±0.25	0.278 ±0.01	2.138 ±0.12	0.526 ±0.008	1.840 ±0.27	0.310 ±0.005
9	Starch (g/100g DW)	17.50 ±2.63	1.149 ±0.81	14.23 ±3.12	0.973 ±0.87	15.46 ±3.10	1.283 ±0.62
10	Energy (Kcal/100g DW)	302.39 ±27.23	173.13 ±12.01	286.40 ±18.08	183.97 ±11.04	256.14 ±20.25	173.34 ±10.08

The data are mean value± Standard deviation (SD) of three replicates.

Table 3: Mineral composition of wild edible tuberous plants.

Sr. No.	Plant Name→	*B. edulis*		*C. bulbosa*		*C. hirsuta*	
	Elements↓	Tuber	Leaves	Tuber	Leaves	Tuber	Leaves
1	N (g/100g DW)	0.63 ±0.008	1.59 ±0.04	0.74 ±0.001	1.41 ±0.02	0.66 ±0.00	1.79 ±0.01
2	K (mg/100g DW)	416.3 ±10.0	815.2 ±15.3	400.23 ±2.5	819.40 ±0.5	440.07 ±10.2	816.80 ±0.4
3	Ca (mg/100g DW)	464.8 ±6.8	956.2 ±10.2	437.2 ±4.5	1012.4 ±12.4	428.0 ±3.2	980.5 ±11.5
4	Mg (mg/100g DW)	186.66 ±2.1	212.0 ±0.2	148.36 ±2.0	248.1 ±2.6	152.48 ±0.8	251.0 ±2.4
5	Na (mg/100g DW)	9.54 ±0.7	27.8 ±2.10	12.32 ±0.9	36.48 ±2.4	10.42 ±0.8	29.09 ±2.21
6	Fe (mg/100g DW)	40.3 ±2.4	13.06 ±0.5	49.04 ±2.6	18.4 ±0.8	45.6 ±2.0	15.78 ±0.4
7	Mn (mg/100g DW)	3.27 ±0.1	6.17 ±0.2	3.31 ±0.9	4.91 ±0.21	3.33 ±0.8	4.84 ±0.08
8	Zn (mg/100g DW)	1.07 ±0.1	1.96 ±0.2	1.5 ±0.8	1.60 ±0.1	1.22 ±0.6	1.8 ±0.1
9	Cu (mg/100g DW)	0.94 ±0.03	0.82 ±0.01	0.83 ±0.04	0.78 ±0.00	0.89 ±0.02	0.70 ±0.01
10	P (mg/100g DW)	143.4 ±0.31	203.3 ±0.426	155.0 ±0.20	234.7 ±0.26	150.4 ±0.35	221.3 ±0.22

The data are mean values ± Standard deviation (SD) of three replicates.

Table 4: Antioxidant composition of wild edible tuberous plants.

Sr. No.	Plant Name→	*B. edulis*		*C. bulbosa*		*C. hirsuta*	
	Paramater↓	**Tuber**	**Leaves**	**Tuber**	**Leaves**	**Tuber**	**Leaves**
1	Polyphenol (mg/100g FW)	146.8 ±1.21	418.32 ±1.04	131.4 ±0.86	448.1 ±0.81	140.1 ±0.75	434.24 ±0.39
2	AscorbicAcid (mg/100g FW)	2.04 ±0.32	3.18 ±0.27	2.23 ±0.11	2.95 ±0.13	2.27 ±0.23	3.86 ±0.21
3	Peroxidase (unit $min^{-1}.mg^{-1}$protein)	8.43 ±0.085	4.07 ±0.096	7.37 ±0.087	3.28± 0.11	7.28 ±0.13	4.12 ±0.01
4	Catalase (unit $min^{-1}.mg^{-1}$protein)	0.3 ±0.03	0.39 ±0.01	0.24 ±0.001	0.32 ±0.02	0.20 ±0.02	0.37 ±0.05
5	Superoxide dismutase (unit $min^{-1}.mg^{-1}$protein)	0.21 ±0.004	0.35 ±0.001	0.30 ±0.005	0.46 ±0.03	0.26 ±0.01	0.39 ±0.006
6	Carotenoid (mg/100g FW)	0.9 ±0.44	10.8 ±1.03	0.6 ±0.002	17.36 ±0.98	0.8 ±0.001	15.72 ±1.43

The data are mean values ± Standard Deviation (SD) of three replicates.

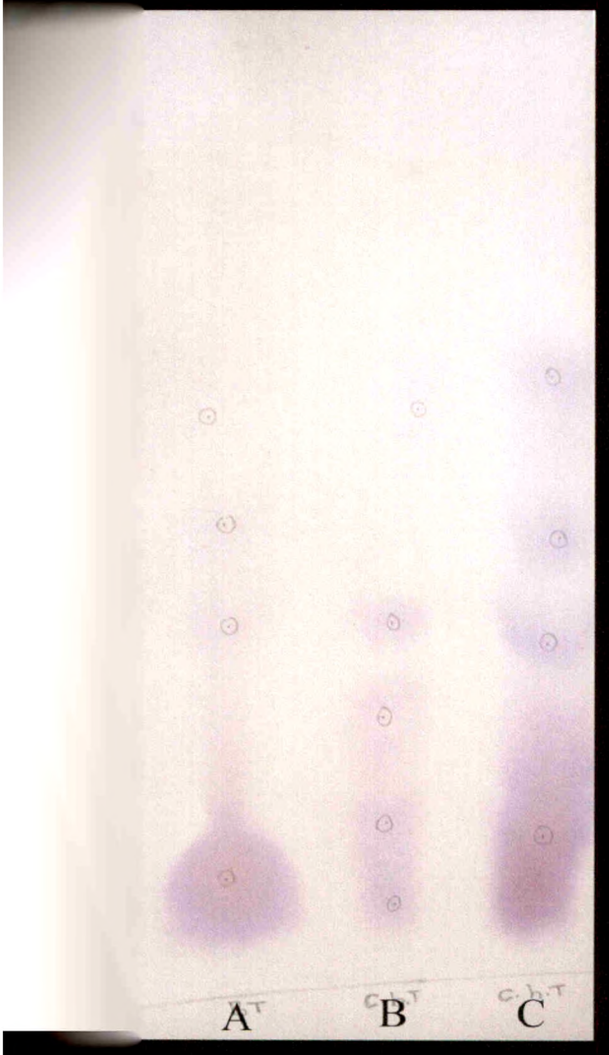
Table 5: Free amino acid composition of wild edible tuberous plants.

Sr. No.	Plant Name→ Amino acid↓	*B. edulis*		*C. bulbosa*		*C. hirsuta*	
		Tuber	**Leaves**	**Tuber**	**Leaves**	**Tuber**	**Leaves**
1.	Lysine*	-	-	++	-	-	-
2.	Valine*	+	-	-	-	-	+
3.	Methionine*	-	+	++	-	++	-
4.	Isoleucine*	+	++	-	-	++	++
5.	Leucine*	+	+++	+	-	+	+++
6.	Tyrosine*	-	+	++	-	-	+
7.	Glycine	+++	-	++	-	+++	-
8.	Alanine	-	+	-	+	++	+
9.	Proline	-	-	-	+	-	-

* Essential amino acids.

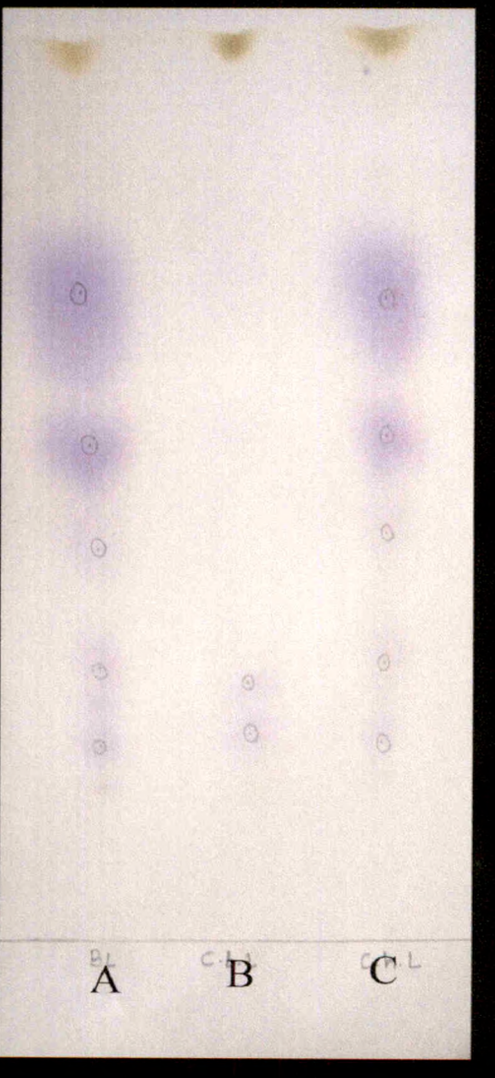
- Absent, + Low, ++ Medium, +++ High.

ate 6 Free amino acid composition of wild edible tuberous plants by paper chromatography



A: *Brachystelma edulis*
B: *Ceropegia bulbosa*
C: *Ceropegia hirsuta*

Tubers



Leaves

I. Ethnobotanical Studies:

Plants may be used as both food and medicine so it is often difficult to draw a line between these two groups. In the past decade, the food–medicine has come to the forefront of ethnobotanical and nutritional research. Many studies have stressed the ethnobotanical and food aspects of wild plants. In the present study it is observed the *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta* plants are eaten as a food and used as a medicine at different places of Satara and Kolhapur district.

The studies in Asclepiadaceae genus: *Ceropegia* and *Brachystelma* were carried out by Patil (1990). He reported that the tubers of *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta* are eaten by people as a food in Satara and Kolhapur district. In the present study *B.edulis, C.bulbosa* and *C.hirsuta* tubers and leaves are eaten as a vegetable and used on different aliments. The present study of wild edible tuberous plants has got similar information as reported by previous authors.

Mahekar (2006) has carried out the botanical and pharmacognostical studies on medicinal plants of south western Maharashtra. She reported that the 474 wild species are known for their medicinal properties. *Ceropegia bulbosa* is one of them. Its tubers are used in inflammation and given as a tonic. In the present study *C.bulbosa* tubers decoction were given as a source of energy. In present work is also giving similar information as above reported by Mahekar (2006).

Kamble (2007) worked on Asclepiadaceae and Periplocaceae of Maharashtra. Among these *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta* three of them are economically important due to their edible tubers. In the present study, the tubers of *B.edulis, C.bulbosa* and *C.hirsuta* are eaten as a food supplements as well as

to cure some ailments. The earlier reported information is some what similar to the present study.

The supplementary and emergency food plants of West Africa are studied by Irvine (1952). He reported that *Ceropegia,* consumed by the French Guinea with several species of edible tubers. Others of the genus from the Nile and Abyssinia were said to taste like *Jerusalem artichokes* when cooked. Several species of *Brachystelma* with edible tubers occur in South Africa and Abyssinia, while in *Brachystelma bingeri* is being eaten raw after the milky resinous outer layer of the tuber is removed. In the present study *Ceropegia bulbosa, Ceropegia hirsuta* and *Brachystelma edulis* are eaten as a food and medicine. The present information was similar but working place is different.

The survey on ethnomedicobotanical uses of endemic and RET plants utilized by Korku tribe of Amaravati district, Maharashtra was carried out by Jagtap *et al.* (2008). They reported the tubers of *Ceropegia bulbosa* consumed as vegetable by tribals. In present work also it is seen that wild edible tuberous plants, *C.bulbosa* are cooked with salt and spices and eaten. The present information proved the food value of plants.

Ethnobotanical survey of Rajasthan was carried out by Chaudhary *et al.* (2008). They have documented the therapeutic properties of plants to cure various diseases of human and pets. The *Ceropegia bulbosa* was one of them containing high nutritive value so that it is used as food and widely used to cure various ailments of ear and urinary systems in the tribals. Similarly, *Ceropegia hirsuta* tubers are used as a food as well as antidote by tribals. In the present work *C.bulbosa* is used as source

of energy and decoction of tubers and leaves is given in kidney stone and tubers of *C.hirsuta* are applied over infected area of scorpion bite.

Reddy *et al.* (2007) in their study documented 156 plants which are used as a food by tribal people in Andhra Pradesh. Among these, *Ceropegia bulbosa* and *Ceropegia hirsuta,* boiled tubers are eaten as a food by local communities. In the present study the fresh as well as boiled tubers are eaten by rural peoples as a food.

Upadhyay *et al.* (2010) worked ethnomedicinal and ethnopharmaco-stastical studies of eastern Rajastan, India. They reported the *Ceropegia bulbosa* tubers were eaten raw for relieving stomachache and dried tuber is rubbed on stone and applied against scorpion bite. In present study *C.bulbosa* leaves are eaten in empty stomach to cure stomachache. So *C.bulbosa* has got the medicinal importance.

II. Proximate Nutrient analysis:

In these experiments moisture, dry matter, ash, crude fibre, crude fat, crude protein, reducing sugar, total sugar, starch and energy content of tubers and leaves of the wild edible tuberous plants were analysed. The result are shown in table 2.

Moisture:

The Moisture content of tubers and leaves were recorded in table 2 and depicted in fig.1. It is clear from the fig. that moisture level is highest in tuber of *Brachystelma edulis* (80.84±2.5%) and lowest in *Ceropegia hirsuta* (75.82±1.41%). Similarly moisture level is highest in leaves of *Ceropegia bulbosa* (90.10±2.6%) and lowest in *Brachystelma edulis* (85.26±3.1%). On the basis of whole plant, the leaves contained higher moisture than the tubers.

Odhav *et al.* (2007) carried out preliminary assessment of nutritional value of traditional leafy vegetables in Kwazulu-Natal, South Africa including their mineral

elements and antioxidant levels. They studied twenty vegetables and reported the moisture content ranged from 75-95 g/100g of fresh weight of leaves. In the present work also moisture level in leaves of *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta* is reported to the higher.

Moisture content is the quantity of water contained in a material. The amount of moisture (water) in the food has an important influence on the calorific value. Water is an essential constituent of many foods. Nuts and grains have a low water content (5 to 10%) and therefore high energy value, while tubers and fruits have high water content (80 to 90%) and thus have lower energy value.

Dry matter:

The dry matter of tubers and leaves of wild edible tuberous plants are recorded in table 2 and depicted in fig.2. It is clear from the fig.2 that the dry matter content is highest in tubers of *Ceropegia hirsuta* (24.18±1.12%) and lowest in *Brachystelma edulis* (19.26±1%). Similarly dry matter level is highest in leaves of *B.edulis* (14.74±1.3%) and lowest in *Ceropegia bulbosa* (9.90±1.27%). By considering the whole plant tubers contained higher dry matter than the leaves.

Agrahar-Murugkar and Subbulakshmi (2005) studied the nutritive value of wild edible fruits, berries, nuts, roots and spices consumed by the Khasi tribes of India. They reported *Flemingia vestita* tubers contained 30.7% dry matter. Present work showed low dry matter than the tubers of *F.vestita*, it might be due to climatic change.

The work on nutritional components of some non conventional leafy vegetables consumed in Cameroon carried out by Ejoh *et al.* (2007). They reported that the dry matter level in four species of *Vernonia calvoana* ranged from 10 to 21%

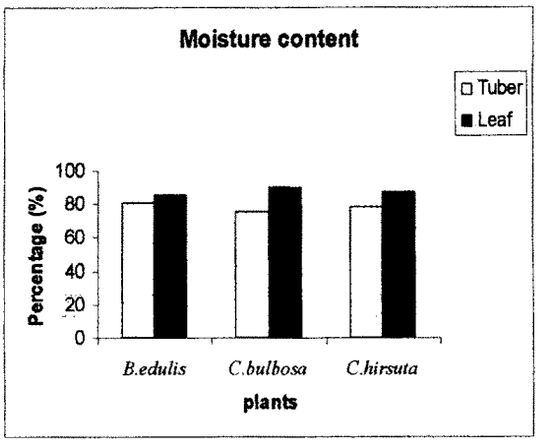


Fig.1. Moisture content of three wild edible tuberous plants.

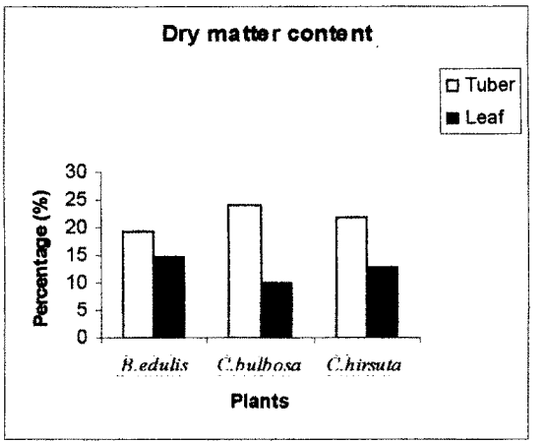


Fig.2. Dry matter content of three wild edible tuberous plants.

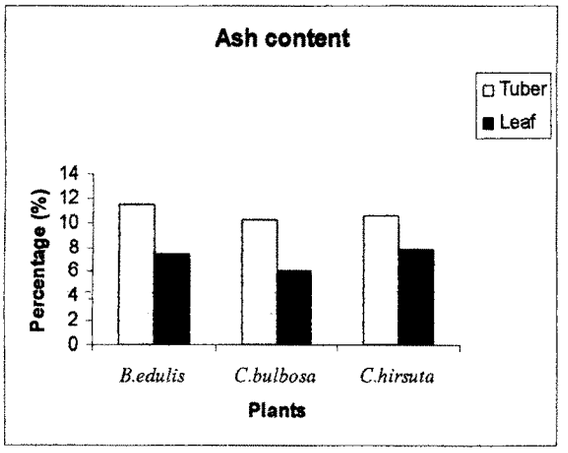


Fig.3. Ash content of three wild edible tuberous plants.

per 100g of fresh weight. In present work dry matter values in leaves of *Brachystelma edulis* and *Ceropegia hirsuta* are within same range of previously reported values and slightly less in *Ceropegia bulbosa.*

The dry matter content of the plants varies due to lot of factors such as, plant species growing condition, soil and environment. The high value of dry matter indicates good source of minerals.

Ash:

The ash value of tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.3. It is clear from the fig.3 that it is highest ash value in tubers of *Brachystelma edulis* (11.5±1.0%) and is lowest in *Ceropegia bulbosa* (10.2±1.32%) of dry weight. Similarly highest ash value in leaves of *Ceropegia hirsuta* (7.8±1.0 %) and lowest in *C.bulbosa* (6.0±1.2 %) leaves. By considering the whole plant tubers contained higher ash value than the leaves.

Aberoumand (2009) worked on the preliminary assessment of nutritional value of plant based diets in relation to human nutrients. Ash values of tubers of *Chlorophytum comosum* and *Eulopia ochreata* contained 10.38±5.17 g/100g and 9.1±5.17 g/100g respectively. In present work tubers of wild edible tuberous plants showed higher ash value than above reported values. It indicates the present plants are nutritionally important for human.

The study on mineral content of commonly consumed leafy vegetables in Assam carried out by Borah *et al.,* (2009). They reported the ash contained within the range of 6.21 to 8.60 g %. In the present work, leaves of *Brachystelma edulis* and *Ceropegia hirsuta* showed ash values within the range of commonly consumed leafy vegetables in Assam.

Ash contains inorganic material of the plant because ashing destroys all the organic matter present in sample. Determining the ash content is the first step in analyzing the amount of individual minerals that are found in a food. The high value of ash observed in all species of wild edible tuberous plants is indicated the good sources of minerals.

Crude fibre:

The crude fibres of tubers and leaves of wild edible tuberous plants are recorded in table 2 and depicted in fig.4. It is clear from the fig.4 that the crude fibre are highest in tubers of *Ceropegia hirsuta* (9.1±0.02%) and lowest in *Brachystelma edulis* (8.0±1.02%). Similarly crude fibre content highest in leaves of *C.hirsuta* (14.4±2.1%) and lowest in *B.edulis* (9.4±0.96%). On the basis of whole plant, leaves contained higher crude fibers than the tubers.

Hassan *et al.* (2007) assessed the nutritive value, phytochemical constituents and antifungal activity of leaf, root and stem extract of *Pergularia tomentosa* (Asclepiadaceae). They reported the fiber content of leaf and root were 16.33±0.29% and 20.83±2.47 % respectively. Present work showed lower content of crude fibre than above mentioned. It may be due to different genera of same family.

The study on proximate evaluation of Chufa (*Cyperus esculantus*) tubers was carried out by Arafat *et al.* (2009). They reported that *C. esculantus* tubers contained 6.50±0.90% of crude fibre. The present work on tubers of wild edible plants showed higher value of crude fibres than the tubers of C. *esculantus*.

Irawan *et al.* (2006) studied the ethnobotanical and nutrient potency of local traditional vegetables in central Kalimantan. They observed crude fiber content in traditional vegetables within ranged of 0.80-7.93 g/100g wet basis. In present work

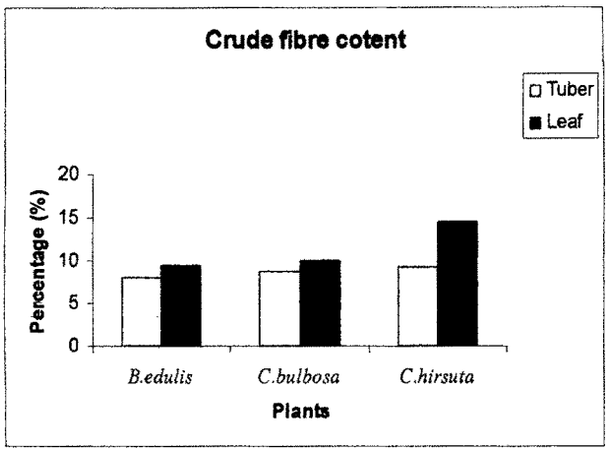


Fig.4. Crude fibre content of three wild edible tuberous plants.

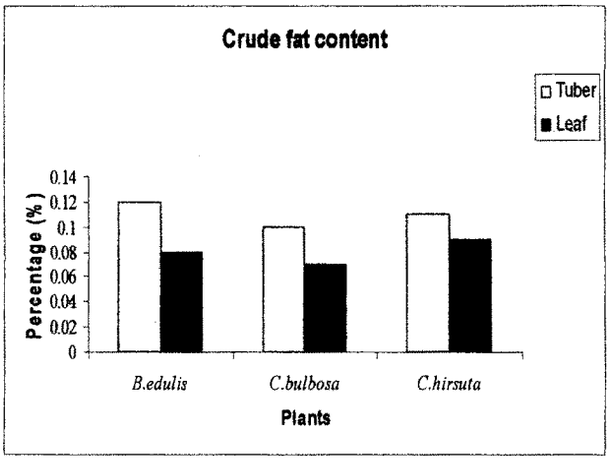


Fig.5. Crude fat content of three wild edible tuberous plants.

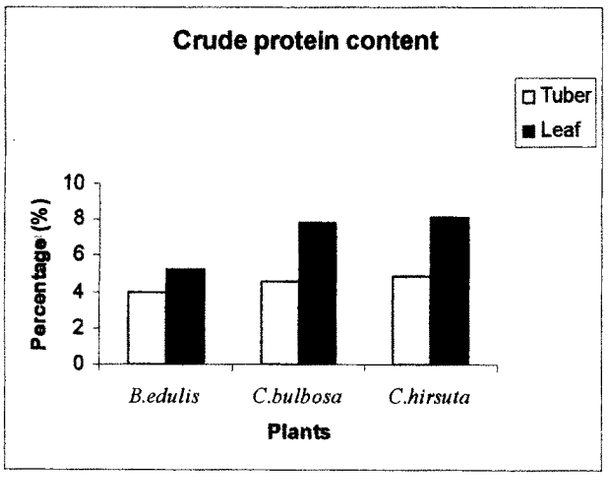


Fig.6. Crude protein content of three wild edible tuberous plants.

leaves of wild edible tuberous plants showed higher crude fibre than the above reported values.

The higher level of crude fibers are observed in leaves of *Ceropegia hirsuta* of wild edible tuberous plants. It is advantageous for their active role in the regulation of intestinal transit due to their ability to absorb water. Also it might have a good nutrient value in them.

Crude fat:

The crude fat in tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.5. It is clear from the fig.5 that crude fat level is highest in tubers of *Brachystelma edulis* (0.12±0.03%) and lowest in *Ceropegia bulbosa* (0.1±0.01%). Similarly crude fat is highest in leaves of *Ceropegia hirsuta* (0.09±0.01%) and lowest in *C.bulbosa* (0.07±0.00%) leaves. As a whole plant, tubers contained higher crude fat than the leaves.

The composition of wild tubers used by Hadza foragers of Tanzania is studied by Schoeninger *et al.* (2000). They observed crude fat contents in tubers of *Vigna frutescens, Eminia entennulifa, Vatoraea pseudolablab* and *Vigna macrorhyncha* which were 1.3±1.1, 0.6, 2.6±1.8 and 3.4 g /100g dry weight respectively. In present work also tubers of wild edible tuberous plants showed lower crude fat than the above reported wild tubers.

The study on nutritive value of some wild edible leaves in Mozambique carried out by Oliveira and Carvalho (1975). They reported the crude fat contained in wild edible leaves within the range of 2.07 to 4.81% of dry weight. In present work leaves of wild edible tuberous plants contained very low crude fat as compare to the wild edible leaves.

The crude fat analysis showed that wild edible tuberous plants are deficient in fats so this makes them good for health.

Crude Protein:

The crude protein in tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.6. It is clear from the fig.6 that crude protein content is highest in tubers of *Ceropegia hirsuta* (4.82±1.02%) and lowest in *Brachystelma edulis* (3.93±0.91%). Similarly crude protein is highest in leaves of *C.hirsuta* (8.08±0.19%) and lowest in *B.edulis* (5.23±0.72%). As a whole plant, leaves contained higher crude protein than the tubers.

Yildirim *et al.* (2001) studied the nutritional contents of the wild plants used as vegetable in upper Coruh valley. They reported protein content in vegetable within range of 3.50-6.75 g/100g dry weight. In the present work leaves of *Ceropegia hirsuta* and *Ceropegia bulbosa* showed higher protein than the wild vegetables. The leaves with high protein values are recommended for patient with protein deficiency. Proteins are organic nitrogenous substances which most essential for human body.

Carbohydrate:

Reducing Sugar:

The reducing sugar in tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.7. It is clear from the fig.7 that reducing sugar is highest in tubers of *Brachystelma edulis* (2.108±0.42 g/100g) and is lowest in *Ceropegia hirsuta* (1.727±0.00 g/100g). Similarly reducing sugar is highest in leaves of *C.hirsuta* (0.290±0.001%) and is lowest in *B.edulis* (0.126±0.01%) leaves. As a whole plant, reducing sugar was highest in tubers and lowest in leaves. A reducing

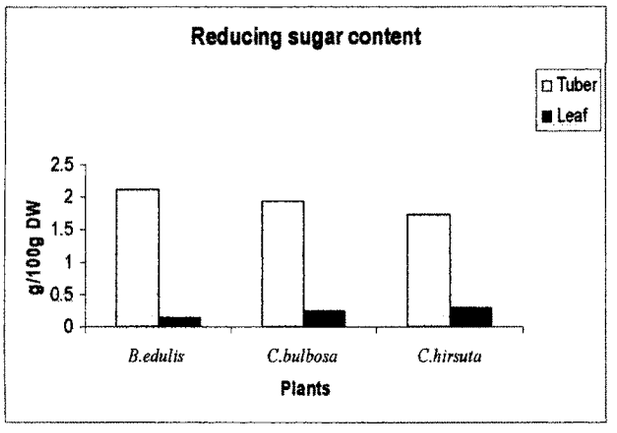


Fig.7. Reducing sugar content of three wild edible tuberous plants.

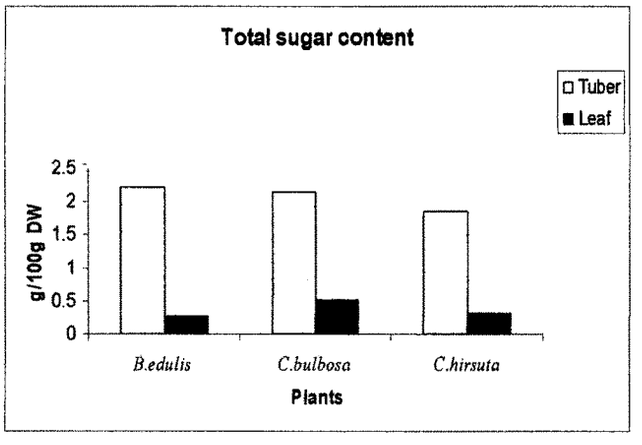


Fig.8. Total sugar content of three wild edible tuberous plants.

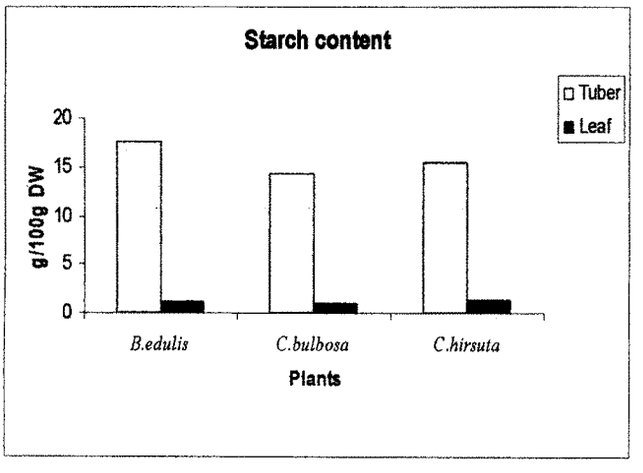


Fig.9. Starch content of three wild edible tuberous plants.

sugar is an aldehyde or a ketone group. This allows the sugar to act as a reducing agent.

Total Sugar:

The total sugar in tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.8. It is clear from the fig.8 that total sugar level is highest in tubers of *Brachystelma edulis* (2.212±0.25 g/100g) and is lowest in *Ceropegia hirsuta* (1.840±0.27 g/100g). Similarly total sugar is highest in leaves of *Ceropegia bulbosa* (0.526±0.008%) and is lowest in *B.edulis* (0.278±0.002%). As a whole plant, total sugar was highest in leaves and lowest in tubers.

Starch:

The starch content in tubers and leaves of wild edible tuberous plants were recorded in table 2 and depicted in fig.9. It is clear from the fig. 9 that starch content is highest in tubers of *Brachystelma edulis* (17.50±2.63 g/100g) and is lowest in *Ceropegia bulbosa* (14.23±3.12 g/100g). Similarly starch is highest in leaves of *B.edulis* (1.149±0.81%) and is lowest in *C.bulbosa* (0.973±0.87%). As a whole plant, starch content is highest in tubers and lowest in leaves.

The pharmacognostical study of *Tylophora dalzellii* (Asclepiadaceae) carried out by Najafi and Deokule (2010). They reported the leaves of *T. dalzellii* contained reducing sugar 0.036 %/g of dry weight and starch 0.076 %/g of dry weight. In present work leaves showed lower reducing sugar and starch than the above mentioned values.

A study on nutritional evaluation and elimination of toxic principle in wild yam (*Dioscorea spp.*) in Nepal was carried by Shanthakumari *et al.* (2008). They reported the wild yams contained total sugar within range of 1.19±0.11 to

6.02±0.049g/100g dry weight and starch were 42.86±1.13 to 64.29±2.23 g/100g. In present work of wild edible tuberous plants tubers showed total sugar within range of above reported values and starch contained low than the wild yam tubers. The main function of sugars in the body is to provide energy. It is necessary for good health, growth, and proper body function and activity.

Energy:

The energy content in tubers and leaves of wild edible tuberous plants are recorded in table 2 and depicted in fig.10. It is clear from the fig. 10 that is higher energy in tubers of *Brachystelma edulis* (302.39±27.23%) and is lower in *Ceropegia hirsuta* (256.14±20.25%) tubers. Similarly there is higher energy in leaves of *Ceropegia bulbosa* (183.97±11.04%) and lower in *B.edulis* (173.13±12.01%). As a whole plant, higher energy contained in tubers than the leaves.

The nutritional evaluation of wild yam (*Dioscorea spp.*) tubers of Nepal was carried out by Bhandhari *et al.* (2003). They reported tubers of *Dioscorea bulbifera, D.deltoidea, D.versicolor* and *D.triphylla* contained energy 119, 78, 79 and 91 kcal/100g fresh weight respectively. The present work on tubers of wild edible plants showed higher energy level than the above reported values.

Nile and Khobragade (2009) studied the nutritive value and mineral element of some important medicinal plants from western part of India. They reported the *Gymnema sylvester* (Asclepiadaceae) energy content 363.02 cal/100 g nutritive values. The present work showed leaves contained quite lower energy than the *G.sylvester*. It might be possible due to generic difference.

Aberoumand and Deokule (2009) studied the proximate and mineral composition of wild coco (*Eulophia ochreata*) tubers in Iran. They reported the

E.ochreata contained 288.25±5.31 kcal/100g energy on wet basis. In the present work, tuber showed slightly similar energy contained with the *E.ochreata.*

The energy value depends on the moisture content and a combination of carbohydrates, fats and proteins. Vitamins and minerals are present in small amounts and are important in maintaining specific functions in the body. High calorific content could be attributed to high carbohydrates and protein contents.

III. Mineral Analysis:

Living organism requires a continuous supply of large number of substances from food to complete their life cycle. This supply is called as nutrition. The mineral nutrition is an important aspects and it play pivoted role in human life for healthy growth. Such type of mineral is easily available in wild edible plants. Thus it is through worth to study the mineral nutrition of *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta.* Minerals may be broadly classified as macro and micro elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur (Eruvbetine, 2003).

Along with several organic compounds, it is now well established that many trace elements play a vital role in general well-being as well as in the cure of diseases. Minerals are chemical constituents used by the body in many ways. Although minerals not provided energy, but they play important roles in many activities in the body (Malhotra, 1998). About 14 elements are essential to human health. Their deficiency causes diseases; where as their presence in excess may result in toxicity.

Nitrogen (N):

The nitrogen content of tubers and leaves were recorded in table 3 and depicted in fig.11. It is evident from the fig. 11 that nitrogen content is highest in tubers of *Ceropegia bulbosa* (0.74±0.001 g/100 g of dry weight) and is lowest in *Brachystelma edulis* (0.63±0.008 g/100 g of dry weight) tubers. Similarly nitrogen content is highest in leaves of *Ceropegia hirsuta* (1.79±0.01g/100 g dry weight) and is lowest in *C.bulbosa* (1.41±0.02 g/100g of dry weight) leaves. On the whole plant basis, the leaves contained higher nitrogen than the tubers.

Turan *et al.* (2003) studied the macro and micro mineral content of some wild edible leaves consumed in Eastern Anatolia. They reported the nitrogen content in *Beta vulgaris, Chenopodium album, Falcarica vulgaris, Ferula communis, Scorzonera cana, Mentha arvensis* were 0.87, 0.54, 0.79, 0.92, 1.09, 1.13 g/100g respectively. In our work leaves showed higher nitrogen contained than the previously reported author. It might be the due to the different genera.

Sekeroglu *et al.* (2006) studied the wild vegetables used in Eastern black sea region of Turkey. They reported the leaves of *Ornothogalum umbellatum* a bulbous plant contained 0.2±0.0 % of dry weight nitrogen. In present work leaves showed higher nitrogen than the above mentioned wild vegetables.

In our work leaves of *Ceropegia hirsuta* is good source of nitrogen than the tubers. Therefore, the total nitrogen contents of present study are in simultaneously equal with the previously reported studies. The nitrogen play vital role in digestion of food and growth but in excess it is harmful to the living body (Cooper, 1984).

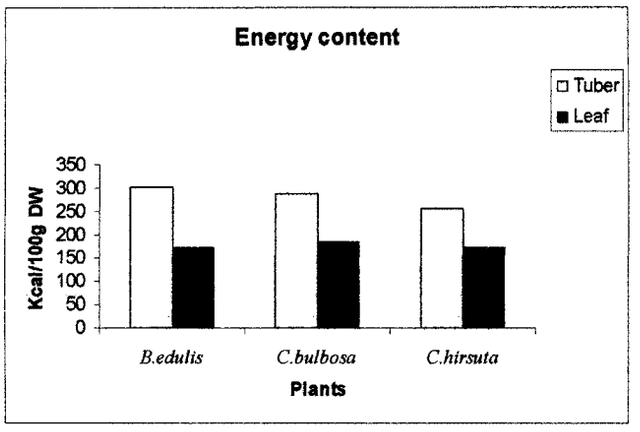


Fig.10. Energy content of three wild edible tuberous plants.

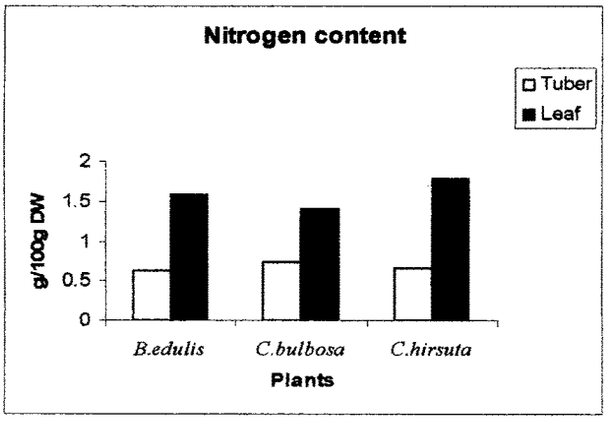


Fig.11. Nitrogen content of three wild edible tuberous plants.

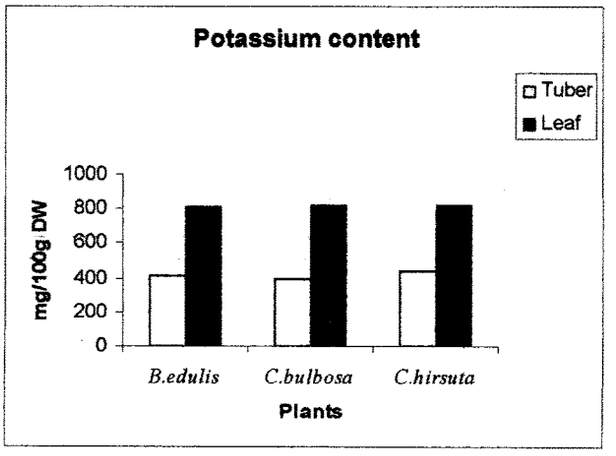


Fig.12. Potassium content of three wild edible tuberous plants.

Potassium (K):

The potassium content of tubers and leaves are recorded in table 3 and depicted in fig.12. It is evident from the fig. 12 that potassium content is highest in tubers of *Ceropegia hirsuta* (440.07±10.2 mg/100 g dry weight) and is lowest in *Ceropegia bulbosa* (400.23±2.5 mg/100 g dry weight) tubers. Similarly there is highest potassium content in leaves of *C.bulbosa* (819.40±0.5mg/100 g dry weight) and lowest in *Brachystelma edulis* (815.2±15.3 mg/100g dry weight). On the whole plant basis, the leaves contained higher potassium than the tubers. Potassium is one of most important and the most essential macronutrient.

The study on element profile of some wild edible plants carried out by Aberoumand and Deokule (2008). They reported the tubers *Chlorophytum comosum* contained 4.29 mg/g potassium. In our work the tubers of wild edible tuberous plants showed slightly higher potassium than the *C.comosum.*

In present study *Ceropegia bulbosa* showed higher potassium content so there was an increasing possibility of its use in food and medicine. Potassium ions play an important role in the diseases related to renal disorders (Rajurkar and Damame, 1998). Potassium-rich food is generally used to treat or cure rheumatoid arthritis (Boruh *et al.* 2009). The Recommanded Dietary Allowances of potassium for adults is 1.3 to 3.3 g per day (Venkatesh-Iyengar *et al.,* 2002). In our work potassium content in leaves provided partially requirement of RDA.

Calcium (Ca):

The calcium content of tubers and leaves were recorded in table 3 and depicted in fig.13. It is evident from the fig. 13 that calcium content is highest in tubers of *Brachystelma edulis* (464.8±6.8 mg/100 g dry weight) and is lowest in

Ceropegia hirsuta (428.0±3.2 mg/100 g dry weight) tubers. Similarly it is highest in leaves of *C.bulbosa* (1012.4±12.4mg/100 g dry weight) and is lowest in *B.edulis* (956.2±10.2 mg/100g dry weight). On the whole plant basis, the leaves contained higher potassium than the tubers. The RDA of calcium for adults is 800 mg per day (NRC, 1989). In the present work leaves meet the sufficient amount of calcium RDA and tubers are with low calcium.

The nutritive value of some wild edible plants from different regions was compiled by Sundriyal and Sundriyal (2001). They reported the calcium contained in tubers of *Colocasia esculenta* (0.06%), *Nelumbo nucifera* (0.37%) and leaves of *Amaranthus gangeticus* (0.50%), *A.hybridus* (2.78%). In present study tubers contained higher calcium than the tubers *N.nucifera* and *C.esculenta*. Similarly leaves of wild edible tuberous plants showed higher calcium than the *A. gangeticus* and *A.hybridus* leaves. The differences of these values are due to the different environment conditions.

Sheela *et al.* (2004) carried out study on proximate composition of under utilized green leafy vegetables in southern Karnataka. They reported the calcium in green leafy vegetables within the range of 73 to 740 mg/100g. In present work leaves contained higher calcium than the green leafy vegetables on southern Karnataka.

Calcium play important role in building and maintaining strong bones and teeth also large part of human blood and extra cellular fluids. So it is necessary for normal functioning of cardiac muscles, blood coagulation, milk clotting and regulation of cell permeability (Heaney, 1994). The calcium deficiency causes the rickets, back pain, osteoporosis, indigestion, irritability, premenstrual tension and

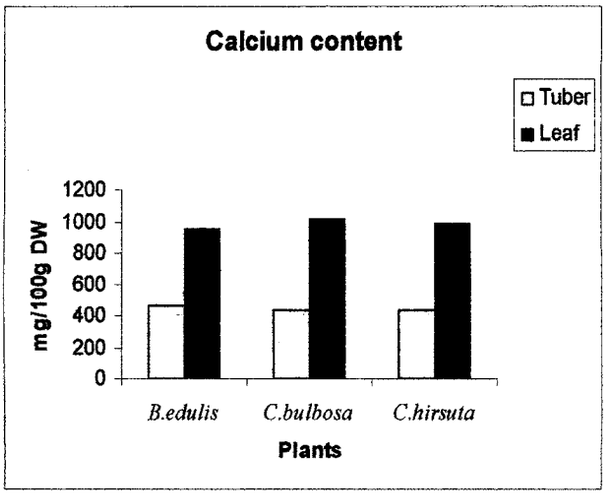


Fig.13. Calcium content of three wild edible tuberous plants.

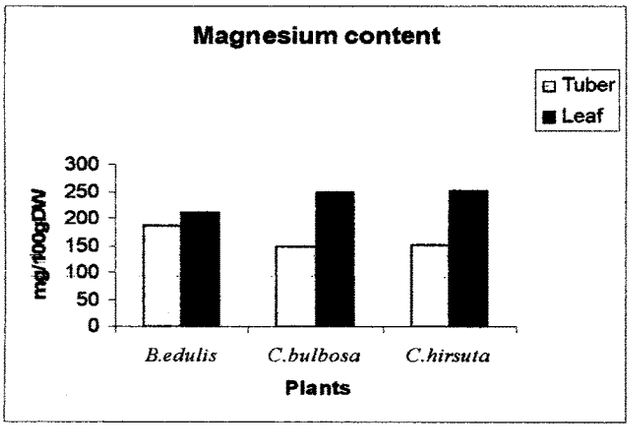


Fig.14. Magnesium content of three wild edible tuberous plants.

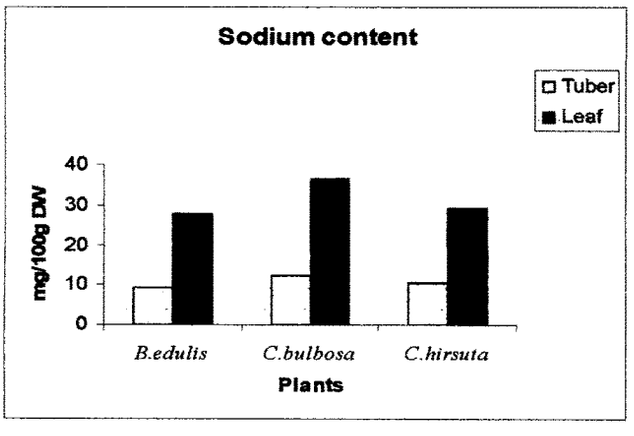


Fig.15. Sodium content of three wild edible tuberous plants.

cramping of the uterus (Hasling *et al.*, 1994). Excess quantity of calcium ions in the extracellular fluids acts as a mental depressant.

Magnesium (Mg):

The magnesium content of tubers and leaves were in recorded in table 3 and depicted in fig.14. It is evident from the fig.14 that magnesium content is highest in tubers of *Brachystelma edulis* (186.66±2.1 mg/100 g dry weight) and is lowest in *Ceropegia bulbosa* (148.36±2.0 mg/100 g dry weight) tubers. Similarly it is highest magnesium content in leaves of *Ceropegia hirsuta* (251.0±2.4mg/100 g dry weight) and is lowest in *B.edulis* (212.0±0.2 mg/100g dry weight). On the whole plant basis, the leaves contained higher magnesium than the tubers. The daily consumption of magnesium should amount to 120 mg (NRC, 1989). The present work, magnesium of wild edible tuberous plants showed satisfied amount of the RDA.

Mensah *et al.* (2008) studied the nutritional properties of some leafy vegetables consumed by Edo people of Nigeria. They reported the magnesium contained in leaves with in range of 0.30 to 2.53 mg/100g. In present work leaves showed higher magnesium than the above mentioned green vegetables.

Magnesium is an antioxidant micronutrient and its presence may boost to the immune system and it is the second most abundant intracellular cation (Talwar *et al.*, 1989). The magnesium plays important role in formation and function of bones, Muscles and prevents high blood pressure, depression, enzyme activity (Smith and Hammarsten, 1958). The magnesium deficiency can affect a wide variety of disorders including high blood pressure, asthma, angina pectoris, coronary artery disease, cardiac arrhythmias, chronic fatigue syndrome, all types of musculoskeletal disorders, epilepsy, anxiety, panic disorder, and many other medical and psychiatric conditions

(Schachter, 1996; Scelig, 1989). The dietary deficiency of magnesium which is linked with ischemic heart disease (Seeling and Heggtveit, 1974). Magnesium has the ability to compete with calcium for binding sites on proteins and membranes (Swaminathan, 2003).

Sodium (Na):

The sodium content of tubers and leaves are recorded in table 3 and depicted in fig.15. It is clear from the fig.15 that is highest sodium content is in tubers of *Ceropegia bulbosa* (12.32±0.9 mg/100 g dry weight) and is lowest in *Brachystelma edulis* (9.54±0.7 mg/100 g dry weight) tubers. Similarly highest sodium content in leaves of *C.bulbosa* (36.48±2.4 mg/100g dry weight) and is lowest in *B.edulis* (27.8±2.10 mg/100g dry weight) leaves. On the whole plant basis, the leaves contained higher sodium than the tubers. The lower content of sodium in *B.edulis* might be added advantage due to the direct relationship of sodium intake with hypertension in human. The RDA for sodium is 300 mg (NRC, 1989). However excessive intake of sodium can result in high blood pressure (Jaworska and Kmiecik, 1999).

The vitamin and mineral content of fruits and vegetables grown in Israel were studied by Halevy *et al.* (1957). They reported the sodium content in tubers of *Ipomoea batatas* (37.0±1.05), *Solanum tuberosum* (5.1±0.66) mg/100 g and leaves of *Brassica oleracea* (11.3±0.51), *Beta vulgaris* (155.0±20.00) mg/100g. In our study tubers of wild edible plants showed lower sodium than the *I.batatas* and slightly higher than the *S.tuberosum*. Present study in leaves showed slightly equal sodium with *B.oleracea* and lower than the *B.vulgaris* leaves.

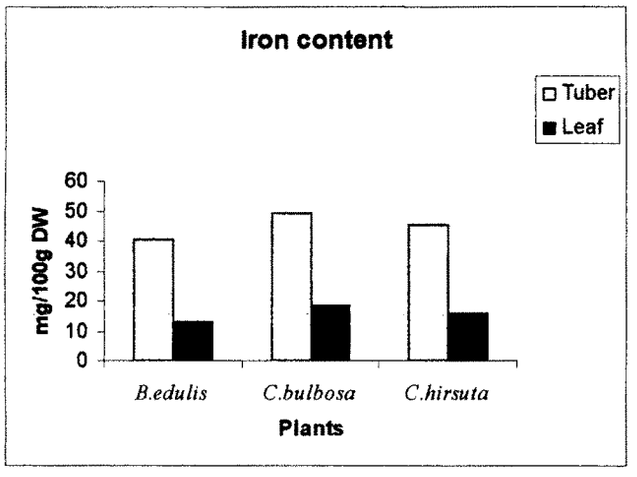


Fig.16. Iron content of three wild edible tuberous plants.

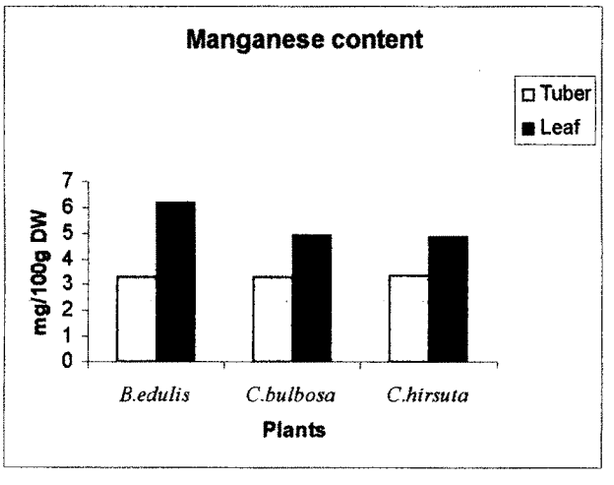


Fig.17. Manganese content of three wild edible tuberous plants.

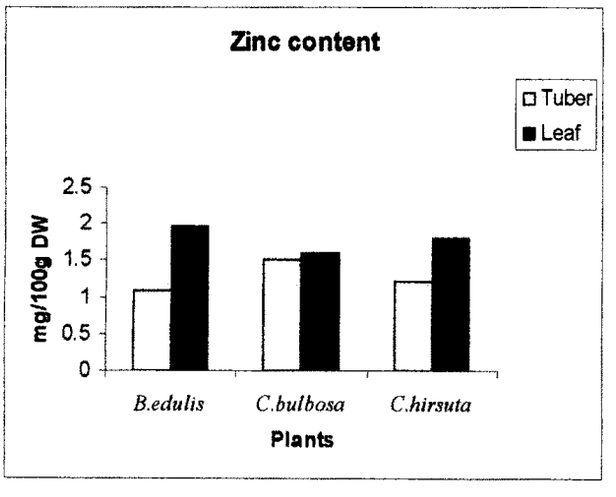


Fig.18. Zinc content of three wild edible tuberous plants.

Sodium is used as an electron carrier in the body. Sodium ions play an important role in the diseases related to renal disorders (Rajurkar and Damame, 1998). The insufficient sodium in the body may lead to low blood pressure, muscle weakness, paralysis, mild fever, respiratory problems. The excessive amounts in the body may lead to de-hydration and hypertension. Sodium and potassium take part in ionic balance of the human body and maintain tissue excitability, carry normal muscle contraction, help in formation of gastric juice in stomach (Brody, 1998).

Iron (Fe):

The iron content of tubers and leaves are recorded in table 3 and depicted in fig.16. It is clear from the fig.16 that highest iron content is in tubers of *Ceropegia bulbosa* (49.04±2.6 mg/100 g dry weight) and lowest is in *Brachystelma edulis* (40.3±2.4 mg/100 g dry weight) tubers. Similarly highest iron content is in leaves of *C.bulbosa* (18.4±0.8mg/100 g dry weight) and lowest is in *B.edulis* (13.6±0.5 mg/100g dry weight) leaves. On the whole plant basis, tubers contained higher iron than the leaves. The RDA for iron is 10 mg per day for adults (NRC, 1989). The tubers were contained high iron so it can satisfy the iron requirement of the RDA for adults.

Barminas *et al.* (1998) worked on mineral composition of six non-conventional leafy vegetables consumed largely by the rural people of Nigeria. They reported the iron content in *Colocasia esculenta* which was 12.4±2.4 mg/100g dry weight. In present work leaves showed higher iron than the leaves of *C. esculenta.*

Vishwakarma and Dubey (2009) worked on nutritional potential of *Ipomoea aquatica.* They reported the iron content in leaves of *Ipomoea aquatica* which was

35.4 mg/100g dry sample. In our study leaves contained lower iron level than the leaves of *I.aquatica.*

The iron is an important micronutrient. It is required for hemoglobin formation, normal functioning of the central nervous system, for the optimal immune function and for oxidation of carbohydrates, protein and fats (Adeyeye and Otokiti, 1999; Alessandra and Robert, 2005). It forms an integral part of cytochromes, haemoglobin, myoglobin and certain enzymes such as catalase and peroxidases. About 15% of the body's iron is stored for future needs and mobilized when dietary intake is inadequate (Aberoumand and Deokule 2008). There is a relatively high prevalence of iron deficiency, anemia among all age groups in the rural populations (Glew *et al.*, 2005; Reddy *et al.,* 1987).

Manganese (Mn):

The manganese content of tubers and leaves are recorded in table 3 and depicted in fig.17. It is evident from the fig.17 that highest manganese content is in tubers of *Ceropegia hirsuta* (3.33±0.8 mg/100 g of dry weight) and lowest is in *Brachystelma edulis* (3.27±0.1 mg/100 g of dry weight) tubers. Similarly highest manganese content is in leaves of *B.edulis* (6.17±0.2mg/100 g of dry weight) and lowest is in *C.hirsuta* (4.84±0.08 mg/100g of dry weight) leaves. On the whole plant basis, leaves contained higher manganese than the tubers. The RDA for manganese is 7 mg per day for adults (NRC, 1989). The leaves of wild edible tuberous plants meet more than 50% of the daily recommended manganese.

The study on profile of heavy metal in some medicinal plants from Ghana carried out by Annan *et al.,* (2010). They reported the leaves of *Pegularia daemia*

(Asclepiadaceae) contained 102 ± 0.001 µg/g manganese. In our work the leaves of wild edible tuberous plants showed slightly lower manganese than the *P.daemia.*

The manganese is an essential element required for various biochemical processes. Also it is part of the enzyme copper-zinc superoxide dismutase (CuZn SOD) system. Its deficiency causes diseases and excess of it causes poisoning of central nervous system absorption, ingestion, inhalation or skin contact may cause manganic pneumonia (Underwood, 1977). The deficiencies of manganese are unusual but may lead to bone deformities, rashes, reduced hair growth and retarded growth in children. It helps in eliminating fatigue and reduces nervous irritability (Prasad, 1993; Hamilton *et al.*, 1994).

Zinc (Zn):

The zinc content of tubers and leaves are recorded in table 3 and depicted in fig.18. It is evident from the fig. 18 that highest zinc content is in tubers of *Ceropegia bulbosa* (1.5±0.8 mg/100 g of dry weight) and lowest is in *Brachystelma edulis* (1.07±0.1 mg/100 g of dry weight) tubers. Similarly highest zinc content is in leaves of *B.edulis* (1.96±0.2mg/100 g of dry weight) and lowest is in *C.bulbosa* (1.60±0.1 mg/100g of dry weight) leaves. On the whole plant basis, leaves contained higher zinc than the tubers. The RDA for zinc is 10 mg per day for adults (NRC, 1989). Thus the plants do not meet the RDA. The poor zinc status is widespread, especially amongst populations that consume cereal based diet (Brown and Wuehler, 2000).

Tayie and Asibey-Berko (2001) worked on mineral content of some indigenous vegetables of Ghana. They reported the zinc content in leaves of *Corchorus tridens* (1.76±0.18) and *Ipomoea batatas* (0.95±0.10) mg/100 g. In present

work leaves of wild edible tuberous plants showed higher zinc than the *C.tridens* and *I.batatas*.

The study on nutrient content of 300 species of edible wild plants of Southern Africa carried out by Wehmeyer (1984). They reported *Brachystelma sp.* contained 0.18 mg/100g zinc and in *Ceropegia sp.* 0.10 mg/100g. In present work tubers contained higher zinc than the previously reported values.

Zinc, a trace mineral that is especially important for the normal functioning of the immune system was relatively abundant in *Brachystelma edulis* leaves. The zinc plays a vital role in an enormous number of biological processes. It is also cofactor in the antioxidant enzyme superoxide dismutase (SOD) and is in a number of enzymatic reactions involved in carbohydrate and protein metabolism. The zinc maintain various reactions of the body which help to construct and maintain DNA, required for growth and repair of body tissues, important element of ligaments and tendons (Diaz-Gomez *et al.*,2003). The zinc deficiency causes clinical consequences, including growth delay, skin lesions, diarrhea, pneumonia, distributed neuropsychological performance and abnormalities of fetal development (Hambiadge, 2000; Chatterjee and Shinde, 1995). Zinc is relatively nontoxic (Prasad, 1982). Zinc is necessary for the growth and multiplication of cells, skin integrity, bone metabolism, and functioning of taste and eyesight (Thunus and Lejeune, 1994). The lower amount of Zn accumulation in the plants is due to its less absorption from the soil.

Copper (Cu):

The copper content of tubers and leaves are recorded in table 3 and depicted in fig.19. It is evident from the fig.19 that highest copper content is in tubers of *Brachystelma edulis* (0.94±0.03 mg/100 g dry weight) and lowest is in *Ceropegia*

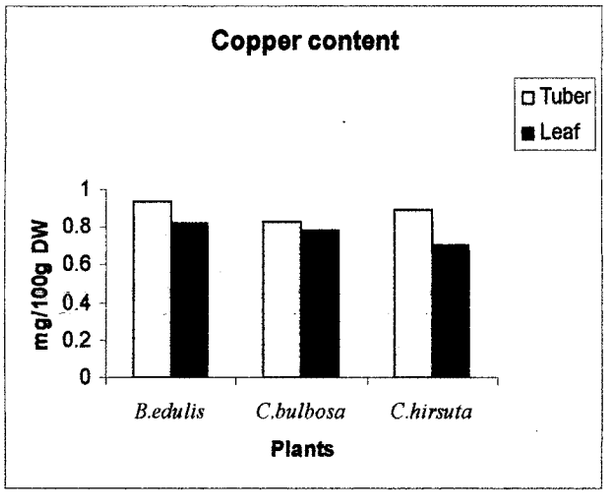


Fig.19. Copper content of three wild edible tuberous plants.

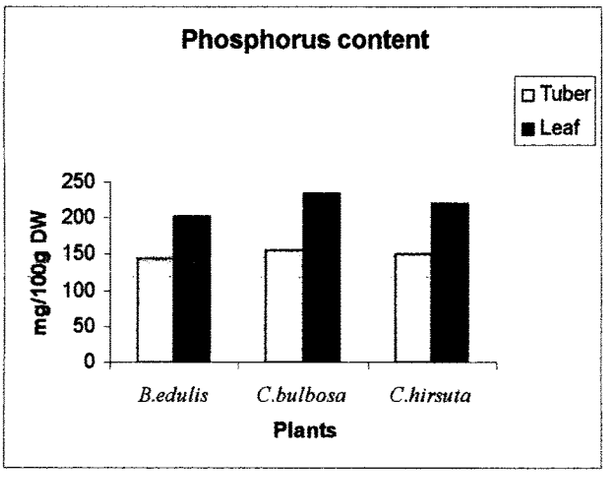


Fig.20. Phosphorus content of three wild edible tuberous plants.

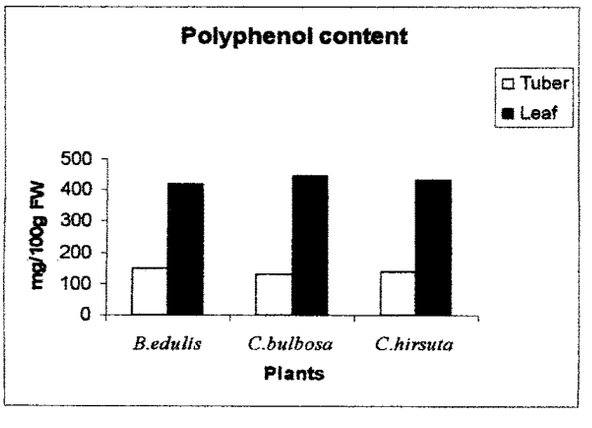


Fig.21. Polyphenol content of three wild edible tuberous plants.

bulbosa (0.83±0.04 mg/100 g dry weight) tubers. Similarly highest copper content is in leaves of *B.edulis* (0.82±0.01mg/100 g dry weight) and lowest is in *Ceropegia hirsuta* (0.70±0.01 mg/100g dry weight) leaves. On the whole plant basis, tubers contained higher copper than the leaves. According to the National Research Council, the daily requirement for copper is 2 mg per day (NRC, 1989). Plants which have high copper concentrations could be useful in preventing a deficiency of copper which normally results in anemia and bone problems (Arntzen and Ritter, 1984). Therefore, it could be declared that copper concentration of the present worked plants have sufficient quantities.

The study on nutritional and antinutritional factors of green leafy vegetables carried out by Gupta and Wagale (1988). They reported the copper contents in chickpea (1.667), Chenopodium (1.667), Spinach (0.833), Mustard (1.250) and in Couliflower (1.667) mg/100g. In present study, leaves of *Brachystelma edulis* showed equal copper to the Spinach and *Ceropegia bulbosa* and *C. hirsuta* showed lower copper than the above mentioned values.

The copper is a most essential nutrient. It converts iron to hemoglobin and is necessary for the utilization of vitamin C and stops the degeneration of the nervous system. It is necessary for normal biological activities of amino-oxides and tyrosinase enzymes. The deficiency of copper has been associated with cardiac abnormalities in human and animal causes anemia and neutropenia (Mills, 1981). The ingestion of 15-75 mg of copper causes gastrointestinal disorders. The continuous ingestion of copper from food induces chronic copper poisoning in man (Hashmi *et al.*, 2007).

Phosphorus (P):

The phophorus content of tubers and leaves were recorded in table 3 and depicted in fig.20. It is evident from the fig.20 that highest phophorus content is in tubers of *Ceropegia bulbosa* (155.0±0.20 mg/100 g of dry weight) and lowest is in *Brachystelma edulis* (143.4±0.31 mg/100 g of dry weight) tubers. Similarly highest phophorus content is in leaves of *C.bulbosa* (234.7±0.26mg/100 g of dry weight) and lowest is in *B.edulis* (203.3±0.426 mg/100g of dry weight) leaves. On the whole plant basis, leaves contained higher phophorus than the tubers. The RDA for phosphorus is 800 mg for adults (NRC, 1989). However the plants analyzed in this study had very low phosphorus concentration.

Ndlovu and Afolayan (2008) carried out the nutrient analysis of the South African vegetable *Corchorus olitorius*. They reported the leaves of *C.olitorius* contained 0.258± 0.03 g/kg phosphorus. In present work leaves showed slightly lower phosphorus than the *C.olitorius.*

Phosphorus is needed for healthy bones and teeth, energy metabolism, and acid-base balance in the body. It maintains blood sugar level and normal heart contraction and also important for normal cell growth, bone growth, kidney function and cell growth (Linder and Manria, 1991). Insufficient phosphorous may lead to Anaemia, demineralization of bones, nerve disorders, respiratory problems, weakness, weight loss. It is also a constituent of bone tissue and forms compounds needed for energy conversion reactions. It helps in the process of ossification of bones by getting deposited in the form of Calcium phosphate (Indrayan *et al.*, 2005).

IV. Antioxidant Analysis:

In recent years much attention has been devoted to natural antioxidant and their association with health benefits (Moon and Shibamoto, 2009). Wild plants are potential sources of natural antioxidants. Antioxidants are compounds that protect cells against the damaging effects of reactive oxygen species, such as singlet oxygen, superoxide, peroxyl radicals and hydroxyl radicals. An imbalance between antioxidants and reactive oxygen species results in oxidative stress, leading to cellular damage (Cheng *et al.*, 2003). Antioxidants have become synonymous with good health. Several plants and vegetables used in traditional medicine can provide diverse secondary metabolites with antioxidant potentials in that most of which are isolated phenolic compounds (Ramarathnam *et al.*, 1997). The continued search among plant secondary metabolites for natural antioxidants has gained importance in recent years because of the increasing awareness of herbal remedies as potential sources of antioxidants.

Polyphenols, ascorbic acid, enzyme peroxidase, catalase, superoxide dismutase, and carotenoid content of tubers and leaves of the wild edible tuberous plants examined in this study are shown in table 4.

Polyphenols:

The polyphenols content of tubers and leaves are recorded in table 4 and depicted in fig.21. It is clear from the fig.21 that polyphenols content is highest in tubers of *Brachystelma edulis* (146.8±1.21 mg/100 g of fresh weight) and is lowest in *Ceropegia bulbosa* (131.4 ±0.86 mg/100 g of fresh weight) tubers. Similarly polyphenol content is highest in leaves of *C.bulbosa* (448.1±0.81 mg/100 g fresh

weight) and is lowest in *B.edulis* (418.32±1.04 mg/100g of fresh weight) leaves. On the whole plant basis, the leaves contained higher polyphenols than the tubers.

Marwah *et al.* (2006) carried out the antioxidant capacity of some edible and wound healing plants in Oman. They reported the total phenolics in tubers of *Dorstenia flava* (26.5±1.6 mg/g of ethanol extract) and *Remusatia vivipara* (14.9±1.6 mg/g of ethanol extract). Also they concluded the total phenolics of the wound healing plants were directly proportional to the antioxidant activity. In our work tuber of *Brachystelma edulis* showed slightly equal polyphenols to the *Remusatia vivipara* and *Ceropegia bulbosa and C. hirsuta* showed lower polyphenol than the above mentioned plants.

Simopoulous (2004) found out antioxidant in edible wild plants. He reported the total phenols content in leaves of certain wild edible plants with in the range of 6.736±0.52 to 102.56±3.13 mg/100g wet weight. In our work the leaves showed higher total polyphenols than the above reported wild edible plants.

Polyphenols were the most abundant antioxidant in the diet. Their total dietary intake could be 1g/day which much higher than the all known dietary antioxidant (Scalbert *et al.,* 2005). The phenolic compounds are increasingly of interest in the food industry because they retard oxidative degradation of lipids and thereby improve the quality and nutritional value of food (Kahkonen *et al.*, 1999). The importance of natural phenolic compounds from plants materials is also raising interest among scientists, food manufacturers, and consumers due to functional food with specific health effects (Loliger, 1991). Polyphenol constitute a major group of compounds that act as primary antioxidants (Hatano *et al.*, 1989). Recent researches report that the phenolic compound is the main human dietary antioxidant and has a decreased

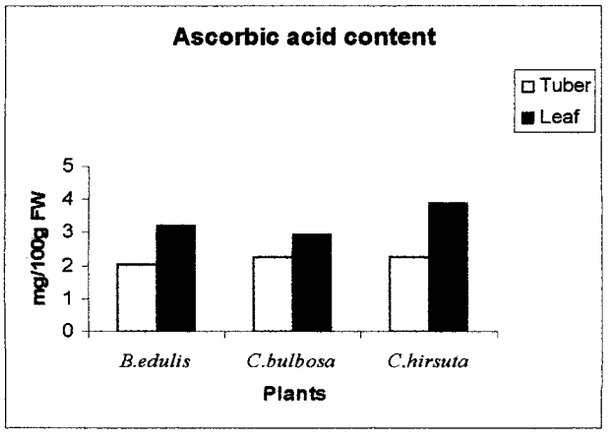


Fig.22. Ascorbic acid content of three wild edible tuberous plants.

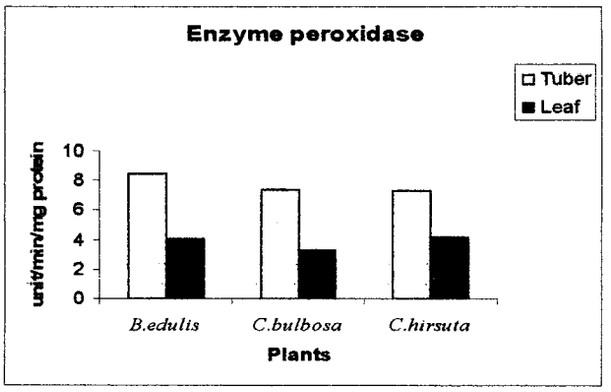


Fig.23. Enzyme peroxidase activity in three wild edible tuberous plants.

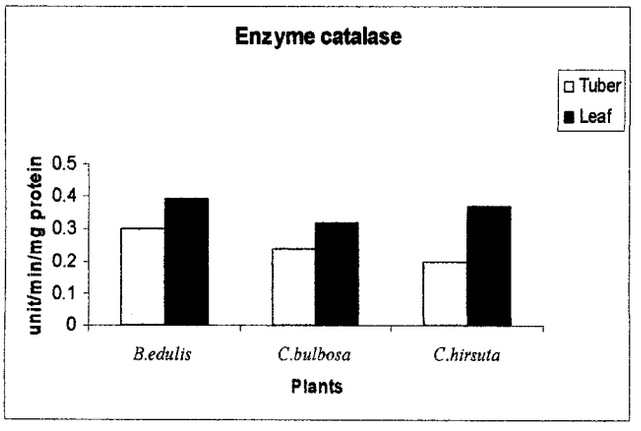


Fig.24. Enzyme catalase activity in three wild edible tuberous plants.

incidence of chronic diseases Under the present nomenclature phenols fall under the category of nutraceuticals, offering many nutritional advantages to man (Padmaja *et al.*, 2005). Especially polyphenols, are receiving increasing attention because of interesting new findings regarding their biological activities (Cho *et al.*, 2003). The total phenolic compounds prevent from damage of nutrients contain double bonds such as fatty acids flavor compounds even proteins and amino acids and other compounds (Aberoumand and Deokule, 2008).

Ascorbic acid:

The ascorbic acid content of tubers and leaves are recorded in table 4 and depicted in fig.22. It is clear from the fig.22 that ascorbic acid content is highest in tubers of *Ceropegia hirsuta* (2.27±0.23mg/100 g of fresh weight) and lowest is in *Brachystelma edulis* (2.04 ±0.32mg/100 g of fresh weight) tubers. Similarly ascorbic acid content is highest in leaves of *C.hirsuta* (3.86±0.21mg/100 g fresh weight) and lowest is in *Ceropegia bulbosa* (2.95±0.13mg/100g of fresh weight) leaves. On the whole plant basis, the leaves contained higher ascorbic acid than the tubers. According to the Food and Nutrition Board, the RDA for Vitamin C is 60 mg per day. The wild edible tuberous plants studied do not meet the daily allowance standard set for Vitamin C by the Food and Nutrition Board (NRC, 1989).

Odukoya *et al.* (2007) analysed antioxidant activity of selected Nigerian green leafy vegetable. They reported that the leaves of *Gongronema latifolium* (Asclepiadaceae) contained 187.11±0.98 mg/100g dry weight. In our work the leaves of wild edible tuberous plants showed very low amount of ascorbic acid than the *G.latifolium.*

Zennie and Ogzewalla (1977) evaluated ascorbic acid and vitamin A content of edible wild plants of Ohio and Kentucky. They reported the ascorbic acid content in leaves with in range of 19-130 mg/100g. In present work the leaves showed lower ascorbic acid than the above reported values.

The human body cannot produce ascorbic acid, so it must be obtained entirely through diet. Ascorbic acid is an important micronutrient necessary for a significant number of metabolic reactions (Oguntibeju, 2008). Ascorbic acid (Vitamin C) prevents scurvy disease and also aids in the formation of folic acid derivatives, which are essential for DNA synthesis (Chatterjea and Shinde, 1998). Ascorbic acid is an antioxidant which helps to protect the body against cancer, blood pressure, immunity and drug metabolism and other degenerative diseases such as arthritis and type II diabetes mellitus (Mensah *et al.*, 2008).

Enzymes:

Peroxidase:

Peroxidase activity of tubers and leaves were recorded in table 4 and depicted in fig.23. It is clear from the fig.23 that peroxidase activity is highest in tubers of *Brachystelma edulis* (8.43 ±0.085 unit min^{-1}.mg $^{-1}$protein) and is lowest in *Ceropegia hirsuta* (7.28±0.13 unit min^{-1}.mg $^{-1}$protein) tubers. Similarly peroxidase activity is highest in leaves of *C.hirsuta* (4.12 ±0.01 unit min^{-1}.mg $^{-1}$protein) and is lowest in *Ceropegia bulbosa* (3.28±0.11 unit min^{-1}.mg $^{-1}$protein) leaves. On the whole plant basis, the tubers contained peroxidase activity higher than the leaves.

Peroxidase catalyses the oxidation of various electron donor substrates. In food, the reaction products of these enzymes may not only affect taste, bitterness, astringency and colour, but when interacting with proteins, these products may hinder

digestibility and desirability, thereby reducing the nutritional value of foods. Peroxidase is utilized in neurodegenerative diseases (Ursini *et al.*, 1995).

Dogan *et al.* (2007) found out the partial characterization of peroxidase from the leaves of *Thymbra spicata.* They reported the peroxidase enzyme controlling the specific flavour of thymbra leaves and observed activity 3580 EU $ml^{-1}.min^{-1}$ in leaves. Peroxidase catalyzes oxidation of phenolic compounds and it may be considered to be an important enzyme controlling the specific flavour of thymbra. In present work leaves of *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta* showed lower peroxidase activity than the thymbra leaves.

Catalase:

Catalase activity of tubers and leaves are recorded in table 4 and depicted in fig.24. It is clear from the fig. 24 that enzyme catalase activity is highest in tubers of *Brachystelma edulis* (0.3±0.03 unit $min^{-1}.mg^{-1}$protein) and is lowest in *Ceropegia hirsuta* (0.20±0.02 unit $min^{-1}.mg^{-1}$ protein) tubers. Similarly catalase activity is highest in leaves of *B.edulis* (0.39 ±0.01 unit $min^{-1}.mg^{-1}$protein) and is lowest in *Ceropegia bulbosa* (0.32±0.02 unit $min^{-1}.mg^{-1}$protein) leaves. On the whole plant basis, the leaves contained catalase activity higher than the tubers.

Catalases are ubiquitous antioxidant enzymes irrespective of their origin, catalyze the same basic reaction, the breakdown of hydrogen peroxide into water and oxygen (Chelikani *et al.,* 2005). Catalase is an unusual enzyme since, although hydrogen peroxide is its only substrate. Catalases are utilized in cancer and diabetic retinopathy.

Superoxide dismutase:

Superoxide dismutase activity of tubers and leaves are recorded in table 4 and depicted in fig.25. It is clear from the fig.25 that enzyme superoxide dismutase activity is highest in tubers of *Ceropegia bulbosa* (0.30±0.005 unit min^{-1}.mg $^{-1}$protein) and is lowest in *Brachystelma edulis* (0.21±0.004 unit min^{-1}.mg $^{-1}$protein) tubers. Similarly enzyme superoxide dismutase activity is highest in leaves of *C.bulbosa* (0.46±0.03unit min^{-1}.mg $^{-1}$protein) and is lowest in *B.edulis* (0.35±0.001 unit min^{-1}.mg $^{-1}$protein) leaves. On the whole plant basis, the leaves contained enzyme superoxide dismutase activity higher than the tubers.

Enzyme superoxide dismutase is a group of enzymes important for removing biologically generated superoxide anion radical. Superoxide dismutase is a class of enzymes that catalyze the dismutation of superoxide into oxygen and hydrogen peroxide, and their action helps to protect cells from oxidation of lipids, proteins and DNA (Powers *et al.*, 2008). As such, they are an important antioxidant defense in nearly all cells exposed to oxygen. The superoxide dismutase enzyme mostly is utilized in neurodegenerative diseases.

Stajner *et al.* (2007) studied the antioxidant properties of wild growing and cultivated *Allium* species. They reported superoxide dismutase, catalase and peroxidase activities in bulbs and concluded that the cultivated *Allium* species had better antioxidant properties compared with wild growing species. Work showed higher enzyme activities than the above reported wild growing *Allium* plants. The superoxide dismutase plays important role in therapeutic approaches for treatment of various diseases.

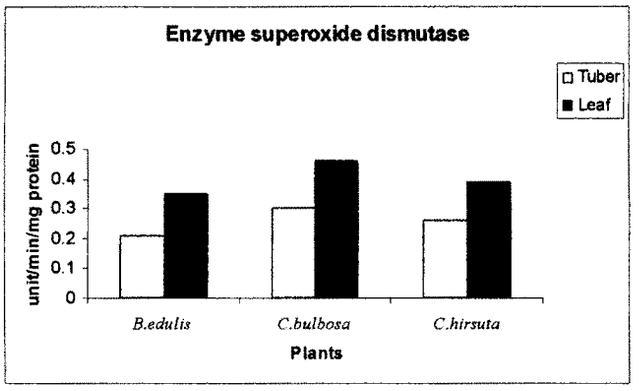


Fig.25. Enzyme superoxide dismutase activity in three wild edible tuberous plants.

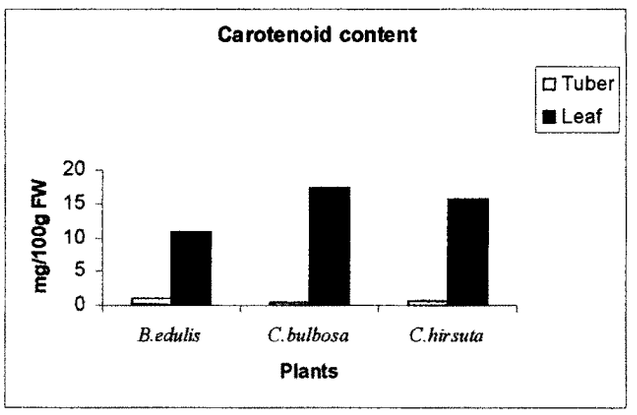


Fig.26. Carotenoid content of three wild edible tuberous plants.

Carotenoid:

The carotenoid content of tubers and leaves are recorded in table no.4 and depicted in fig.26. It is clear from the fig. that carotenoid content is highest in tubers of *Brachystelma edulis* (0.9±0.44 mg/100 g of fresh weight) and is lowest in *Ceropegia bulbosa* (0.6±0.002 mg/100 g of fresh weight) tubers. Similarly carotenoid content is highest in leaves of *C.bulbosa* (17.36±0.98 mg/100 g of fresh weight) and is lowest in *B.edulis* (10.8±1.03 mg/100g of fresh weight) leaves. On the whole plant basis, the leaves contained higher carotenoids than the tubers.

The study on screening of antioxidant activity and antioxidant compounds of some edible plants of Thailand was carried out by Chanwitheesuk *et al.* (2005). They reported the carotenoid contents in leaves of *Dregea volubilis* (6.14±0.07 mg %), *Gymnema inodorum* (1.31±0.03 mg %), *Marsdenia glabra* (8.92±0.04 mg %). In our work the leaves of wild edible tuberous plants showed higher carotenoid than the earlier mentioned values.

Rajyalakshmi *et al.* (2001) analyzed the total carotenoid and β - carotene contents of forest leafy vegetables consumed by tribals of south India. They reported the total carotenoid in leafy vegetables with in range of 6.36 to 36.13 mg %. The earlier reported values of carotenoids are somewhat similar with present work.

Carotenoid is important powerful antioxidant present in chloroplasts in the leaves of dark green leafy vegetables, which are not readily digested in the body. It is believed that the fibre of vegetables entraps the beta-carotene, reducing its availability to be incorporated into micelles prior to absorption from the intestines. Hence, cooking of the vegetables before eating increases its bioavailability (Odukoya, *et al.*, 2007).

V. Qualitative analysis of free amino acid:

We know that the amino acid analysis of foodstuffs is an important index of its food quality and can elucidate useful information on the nutritional quality of the food. The free amino acid composition of the ethanol soluble fraction in tubers and leaves of wild edible tuberous plants are depicted in the plate 6 and recorded in table 5. The qualitative analysis of amino acids in ethanol soluble fraction reveals that about 8 to 9 amino acids are detectable in paper chromatography. The amino acids are found in varying proportional in tubers and leaves of *Brachystelma edulis, Ceropegia bulbosa* and *Ceropegia hirsuta.*

In wild edible tuberous plants, there are significant amounts of leucine, isoleucine with smaller amount of valine, lysine and tyrosine present. Similarly in leaves *Brachystelma edulis* and *Ceropegia hirsuta* found essential amino acids leucine, isoleucine prominent with methionine, tyrosine and alanine in low amount. In *Ceropegia bulbosa* only non essential amino acid alanine and proline are observed. The nutritional quality of amino acids of tubers is poor in comparison to other major root crops due to the predominant nonessential amino acids.

Walter *et al.* (1986) carried out the compositional study of *Apios priceana* tubers. They recorded significant amount of arginine and aspartic acids with smaller amount of glutamic acid and praline in tubers. Among the essential amino acids only valine and aromatic amino acids were present in tubers in levels exceeding the FAO recommendation. In our work, tubers observed similar essential amino acids in low amount as compared to the tubers of *A.priceana.*

The study on amino acid composition of *Dioscorea dumetorum* varieties carried out by Alozie *et al.* (2009). They reported wild variety contained the essential

amino acids: tryptophan, phenylalanine, threonine and valine in levels that compared favourably with the FAO/WHO provisional pattern (FAO/WHO, 1973). In present work tubers showed maximum essential amino acids as similar to the *D.dumetorum.*

Kubmarwa *et al.* (2009) studied the proximate composition and amino acid profile of two non conventional leafy vegetables (*Hibiscus cannabinus* and *Haematostaphis barteri*). They reported the essential amino acids in both vegetables had a ranking above 100% for threonine, leucine, tyrosine and phenylalanine in comparison to the WHO standard. In our work leaves observed high amount of leucine and low amount of tyrosine except in *C.bulbosa* leaves.

Amino acid profile of two non-conventional leafy vegetables, *Sesamum indicum* and *Balanites aegyptiaca* was studied by Kubmarawa *et al.* (2008). They found seventeen amino acids in varying proportions in both vegetables. Glutamic acid had the highest value for both vegetables, while the limiting amino acid in both samples was cysteine. In present work maximum essential amino acids are present in leaves of wild edible tuberous plants except in *Ceropegia bulbosa* leaves.