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MICRO NUTRIENT COMPOSITION OF UNCONVENTIONAL WILD FRUITS AND VEGETABLES

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ABSTRACT
Micro nutrients perform various direct and indirect physiological functions of the body. Unconventional wild fruits and vegetables may significantly contribute to meet the high nutrient needs specially of the local people.The micro nutrient composition of 42 fruits and vegetables (fruits-11, green leafy vegetables-12, other vegetables- 11 and roots-8) were estimated in terms of minerals viz Calcium, magnesium, Iron, Zinc and Copper and Vitamins viz Beta carotene and Vitamin C. The study concluded that the different fruits and vegetables consumed in tribal areas are rich in micro nutrients can be used in daily diet. Hence these tribal fruits and vegetable can be recommended to achieve food and nutritional security.

INTRODUCTION

Unconventional wild edible plants are those that are neither cultivated nor domesticated, but are available from their natural habitat and are used as food sources (Beluhan and Ranogajee, 2010). Many times theses uncultivated wild edible plants are referred as indigenous, underutilized and neglected plants. They get less importance than conventional agricultural commodities in terms of production and market value due to lack of awareness of their potential in general population (Eleazar and Cesoiv, 2012). It is estimated (FAO, 2010) that the forests and trees outside forests contribute to the livelihoods of more than 1.6 billion people. The unconventional plants play an important role in many food systems, either through direct and indirect provisioning for human nutrition, particularly in developing countries (Vinceti *et al*., 2008; Sunderland, 2011; Bhati and Jain, 2015). Especially unconventional fruits and vegetables are mostly consumed locally or traded in local/regional markets (Akinnifesi *et al*., 2006).

Fruits and vegetables possess micro nutrients such as vitamins, minerals and trace elements in addition to other compounds such as ascorbic acid, carotenoids and flavonoids that may have a positive effect on human health (Bergquist, 2006). Micronutrients play a central part in metabolism and in the maintenance of tissue function. The role of micronutrients in health and well being and synergies with the physiological functions of nutrients is well known (Frison *et al*., 2006; Remans *et al*., 2011).

The conventional energy rich staple crops assure caloric requirement however; they generally contain low amounts of limiting nutrients, including micronutrients per unit of energy, and by themselves are not sufficient to address the problem of "hidden hunger" or micronutrient deficiency. Increasing consumption of micronutrient dense foods (such as a diversity of fruit and vegetables) is a sustainable way to improve nutrient quality (Stephenson *et al*., 2010). The data of the micronutrient composition of unconventional fruits and vegetable is limited.

Considering the valuable contribution of unconventional wild fruits and vegetables in the diet of local community, naturally grown unconventional fruits and vegetables were collected from the forest of Arawali ranges near the Udaipur District of Rajasthan, western India and analysed for micronutrient composition.

MATERIALS AND METHODS

The micro nutrient composition of forty-two fruits and vegetables was analysed. The samples were collected from five tribal blocks situated near the Arawali ranges i.e. Jhdol, Kotra, Kherwada, Sarada and Salumber of Udaipur district of Rajasthan, western India. Selection of samples was on the basis of feasibility and seasonal availability. All the samples were further categories in fruits, green vegetables, other vegetables and roots and tubers and details.

All the samples were washed thoroughly in running tap water to remove dust and dirt etc. and edible parts were collected for analysis purpose. Each sample was further divided into two portions, one fresh sample was stored till final analysis in seal poly begs at - 18 $\pm$ 5ºC for analysis where as another sample was dried at 45 ± 5ºC in hot air oven. They were ground to fine powder and stored in airtight container for analysis.

Dry matter and mineral ash of the samples were determined by using the standard method proposed by NIN, (2003) method. All selected samples were analysed for calcium, magnesium, iron, zinc and copper through Atomic Absorption Spectrophotometer (AAS) suggested by Bishnoi and Brar 1988. Ascorbic acid was analysed by method suggested by the Association of Vitamin Chemist (1966) and â carotene content in the samples was estimated by using HPLC (Chiosa *et al.*, 2005).

Sample preparation for beta carotene estimation

Five grams of samples of selected fruits and vegetables were extracted with acetone: hexane (4:6). After the extraction, the solvent was evaporated to dryness under a stream of nitrogen and the residue was reconstituted with 1 ml of eluent solution and was collected in a screw-cap vial for HPLC analysis Chiosa *et al.* (2005). All used chemicals were of analytical or HPLC grade. Ultra-pure water generated by the Milli-Q system was used. All standards compounds were purchased from Sigma. All used chemicals were of analytical or HPLC grade.

Statistical analysis

All analyses were performed in triplicate (n = 3) and the data was presented as means and standard deviation.

RESULTS AND DISCUSSION

Results of all analysed fruits, green leafy vegetables, other vegetables and roots and tuber are presented under Table 1a, 1b, 1c and 1d respectively. Wide variation was observed in minerals content among all the fruits analysed in present study.

The micronutrients in studied wild fruits were appreciably high (Table 1 a). Dry matter and mineral ash was ranged from 10.87 to 97.82 g/100g and 3.47 to 7.38 g/100g respectively. Dry matter is inversely proportional to the moisture content in the sample. The highest Maximum calcium was noted for *Ficus benghalensis* followed by *Feronia limonia, Ficus recemosa*. Over all the analysed fruits were containing less calcium content as compare to the common fruits. The magnesium content among all the analysed fruits was ranging 61.07 to 75.65 mg/100g. Result of iron was noted maximum in *Nelumbo nucifera* (32.85 mg/100g) followed by *Pithecellobium dulce* (13.73 mg/100g)*, Holoptelea integrifolia* (8.43 mg/100g) and *Tribulus terrestris* (6.98 mg/100g). *Holoptelea integrifolia* was containing higher amount of iron and zinc content.

Cordia gharaf (768.90 μg/100g) was containing maximum â-carotene followed by *Manilkara hexandra* (560.72 μg/100g). However, *Feronia limonia* and *Holoptelea integrifolia* recorded nil beta carotene content. The â-carotene in the *Feronia limonia* was found to be similar to Joshi and Jain, (2005). Vitamin C content found maximum in *Citrus medica* i.e. 123.01 mg/100g. The vitamin C content in *Manilkara hexandra* and *Pithecellobium dulce* was similar to the values obtained by Gopalan and *et al.* (2007).

Maximum dry matter in green leafy vegetable was recorded in *Marsilea minuta* (29.86 per cent) followed by *Medicago sativa*

Table 1a: Micro-nutrient composition of fruits (per 100g)

S. No.	Botanical Name	Local name	Dry matter (%)	Mineral Ash (%)	Minerals (mg) Calcium	Magnesium	Iron	Zinc	Copper	Vitamins â-Carotene (μg)	Vitamin-C (mg)
1	*Citrus medica*	Bijura	10.87 ±0.4	5.17 ±0.01	176.43 ±1.15	68.74 ±0.93	2.64 ± 0.56	9.60 ±1.20	1.80 ± 0.18	18.33 ±0.06	123.01±0.61
2	*Cordia gharaf*	Gundi	43.71 ±0.27	4.62±0.08	15.85 ±1.60	64.69 ± 0.21	6.76 ±0.86	3.34± 0.33	1.13 ±0.26	768.90±1.64	39.52±0.97
3	*Diospyros melanoxylon*	Timru	37.43± 1.55	3.75 ±0.06	118.05 ±1.08	61.70 ±1.53	3.40±0.18	1.28 ±0.18	0.20 ±0.11	260.75 ±0.77	49.01±0.43
4	*Feronia limonia*	Kotambadi	29.66 ±0.87	5.2 ±0.07	493.75 ±1.14	71.73 ±0.68	14.64 ±0.38	2.65 ±0.21	0.35 ±0.20	Nil	9.38 ±1.50
5	*Ficus benghalensis*	Bad	27.00± 1.39	6.06 ±0.04	795.02 ±0.88	75.25 ± 0.79	6.06 ±0.67	3.61 ±0.34	5.53 ±0.63	26.04 ±0.15	47.47±1.02
6	*Ficus recemosa*	Gullar	18.68 ± 1.58	7.38 ±0.04	217.77 ±0.63	72.60 ±0.98	6.70 ±0.95	2.48 ±0.26	0.58 ±0.05	17.52 ± 1.17	47.78 ± 0.85
7	*Holoptelea integrifolia*	Bandar Batti	97.82 ±0.05	3.76 ±0.04	77.42 ±0.32	71.07 ±0.87	8.43 ±0.56	11.09±0.48	3.80 ±0.21	Nil	Nil
8	*Manilkara hexandra*	Rayna	52.12 ±1.8	3.47 ±0.06	149.28 ±0.65	67.93 ±0.48	2.41 ±0.27	2.20 ±0.20	Nil	560.72 ±0.70	12.53± 0.77
9	*Nelumbo nucifera*	Kamal Kokari	17.07 ±1.84	6.47± 0.13	68.69 ±0.91	72.38±1.12	32.85 ±0.70	13.46 ±0.71	2.13 ±0.10	92.47 ± 1.10	47.84 ± 0.75
10	*Pithecellobium dulce*	Jangal Jalebi	15.3 ±0.35	5.07 ±0.11	Nil	65.73 ±0.97	13.73 ±0.50	5.02 ±0.75	0.73 ±0.09	19.20 ±0.14	95.68±0.95
11	*Tribulus terrestris*	Gokhru	91.48 ±0.36	6.38 ±0.02	65.85 ±1.60	75.65±0.74	6.98 ±1.38	6.73 ±0.18	1.06 ±0.21	16.41 ±1.15	1.73 ±0.39

* Dry matter, â-Carotene and Ascorbic acid on fresh weight basis; * Mineral ash and mineral elements on dry weight basis; * ± standard deviation

Table 1b: Micro-nutrient composition of green leafy vegetables (per100g)

S. No.	Botanical Name	Local name	Dry Matter (%)	Mineral Ash (%)	Minerals (mg) Calcium	Magnesium	Iron	Zinc	Copper	Vitamins â-Carotene (μg)	Vitamin-C (mg)
1	*Asphodelus tenuifolius*	Piyagi	10.79 ±0.17	10.1 ±0.1	853.32 ± 1.26	63.23 ±0.96	44.33 ±0.84	11.21 ± 0.70	0.91 ±0.03	849.38 ±1.58	67.84±2.23
2	*Cassia tora*	Puariya	15.08 ±0.05	11.69 ±0.81	976.63 ± 0.56	72.09 ±0.82	53.90 ±0.62	9.73 ±0.49	0.92 ±0.03	6300.74 ±1.54	38.33±0.19
3	*Centella asiatica*	Brahami Buti	14.29 ±0.31	18.27 ±0.21	893.40 ±1.49	72.82 ±0.86	59.03 ±0.81	23.74 ±1.04	1.32 ±0.16	2890.75 ±1.57	69.38±0.39
4	*Cicer arietinum*	Liliya	22.92 ±0.12	12.12 ±0.03	1019.57 ±0.12	77.63 ±0.91	97.23 ±1.28	8.13 ±1.39	1.11 ±0.79	590.17 ±1.02	67.84±2.95
5	*Cordia dichotoma*	Gunda ka More	21.52 ±1.35	13.39 ±0.09	185.67±0.93	58.03 ±0.28	14.32 ±0.57	11.06 ±1.14	2.09 ±0.39	661.21 ±1.80	43.89±1.88
6	*Euphorbia royleana*	Thour	6.47 ±0.64	14.15 ±0.05	793.93 ±0.98	81.53 ±0.98	17.00 ±0.41	13.95 ±0.63	2.78 ±0.16	850.71 ±0.70	68.02±1.93
7	*Marsilea minuta*	Jhalod Ri Bhaji	29.86 ±1.82	8.32 ±0.13	66.53 ±0.67	54.06 ±0.38	28.10 ±1.43	4.54 ±0.15	0.42 ± 0.05	491.59 ±1.54	33.70±2.36
8	*Medicago sativa*	Rajka	27.34 ±0.97	11.59 ±0.05	647.17 ±2.02	76.88 ±1.48	59.18 ±0.10	10.89 ±0.22	1.01 ±0.03	680.35 ±1.49	58.83 ±1.13
9	*Melilotus indica*	Pili Sangi	20.43 ±0.69	10.58 ±0.06	755.52 ± 1.00	71.12 ±0.81	43.41 ±0.72	9.85 ±0.94	1.11 ±0.08	960.31 ±1.12	88.15±0.56
10	*Polygonum glabrum*	Pani vala	15.14 ±0.83	12.44 ±0.54	719.53 ±1.70	75.90 ±0.91	53.16 ±1.38	6.12 ±0.30	0.25 ±0.08	849.71 ±0.59	40.43 ±2.47
11	*Portulaca oleracea*	Lunakiya	9.06 ±0.26	26.37 ±0.51	799.10 ±0.53	134.30 ±0.61	97.06 ±0.79	42.85 ±1.09	2.54 ±0.24	940.64 ±0.65	61.91 ±1.50
12	*Tribulus terrestris*	Gokhru Leaves	17.84 ±0.36	16.55 ±0.33	1935.50 ±1.00	93.55 ±1.87	47.91 ±1.04	9.73 ±0.49	0.92 ± 0.03	2100.35 ±1.15	42.16 ±1.66

* Dry matter, â-Carotene and Ascorbic acid on fresh weight basis; * Mineral ash and mineral elements on dry weight basis; * ± standard deviation

Table 1c: Micro-nutrient composition of other vegetables (per 100g)

S. No.	Botanical Name	Local name	Dry matter (%)	Mineral Ash (%)	Minerals (mg) Calcium	Magnesium	Iron	Zinc	Copper	Vitamins â-Carotene (μg/100)	Vitamin-C (mg/100)
1	*Acacia nilotica*	Babul Fali	37.57 ±0.12	3.77 ±0.04	128.45 ±0.57	65.58 ±0.59	17.00±0.78	6.87±0.35	0.58 ±0.05	23.80±0.36	27.04 ±2.41
2	*Aloe barbadensis*	Sinduri	10.48 ±0.63	6.2 ±0.09	105.93 ±0.99	72.95 ±0.54	12.05 ±0.22	13.27 ±0.34	0.44 ±0.06	182.43±0.46	63.21 ±1.02
3	*Averrhoea carambola*	Kamrakh	8.04 ± 0.64	4.35 ±0.02	Nil	61.88 ±0.53	4.94 ±0.22	8.96±0.40	11.18 ±0.60	240.38 ±1.11	45.37 ±1.11
4	*Bombax ceiba*	Samble Dodi	23.1 ±0.37	6.76 ±0.07	455.28 ±1.27	82.87 ±1.20	20.58 ±0.67	5.20 ±0.19	1.09 ±0.05	20.38 ±1.13	22.28±0.70
5	*Carissa congesta*	Jangli Karonda	18.42 ±0.33	4.75 ±0.08	107.15 ±1.55	72.45±0.82	48.10 ±0.79	8.71 ±0.26	1.06 ±0.30	12.98±0.12	105.93 ±0.93
6	*Cissus quandrangula*	Hadjood	8.13 ±0.03	15.13 ± 0.28	1403.44 ±0.60	78.55 ±0.57	105.67 ±0.81	4.01±0.20	1.33 ±0.21	622.61 ±1.48	62.53 ±1.95
7	*Crotalaria juncea*	San	24.8 ±0.75	7.08 ±0.07	728.00 ±0.45	67.92 ±0.58	11.88 ±0.42	8.45 ±0.53	1.21 ±0.12	503.77 ±0.52	5.56 ±1.85
8	*Dendrocalamus strictus*	Bans/ Karel	8.46 ±0.29	12.08 ±0.15	424.29 ±0.88	71.48±1.26	92.77 ±0.43	12.75±0.58	1.39 ±0.28	21.52 ±0.34	39.32 ±1.34
9	*Dioscorea* Sp.	Alitha Fruit	27.92 ±0.9	3.01 ± 0.01	8.29±0.42	64.96 ±0.90	3.98 ±0.90	3.46±0.75	0.61 ±0.11	57.33±1.45	0.43 ±0.21
10	*Leptedenia reticulate*	Shani Dhodi	11.56 ±0.4	5.53 ±0.08	118.64 ±0.75	70.57 ±0.66	6.62 ±0.34	5.32 ±0.09	1.06 ±0.08	152.40 ±1.42	98.46 ±2.34
11	*Phoenix sylvestris*	Khazoor Root	17.21 ±0.07	8.01 ±0.01	163.33 ±0.93	70.10 ±0.25	16.84 ±0.68	7.51±0.23	0.99 ±0.18	472.53 ±0.82	4.02 ±0.54

* Dry matter, â-Carotene and Ascorbic acid on fresh weight basis; * Mineral ash and mineral elements on dry weight basis; * ± standard deviation

Table 1d: Micro-nutrient composition of roots and tubers (per 100g)

S. No.	Botanical Name	Local name	Dry matter (%)	Ash (%)	Minerals (mg) Calcium	Magnesium	Iron	Zinc	Copper	Vitamins â-Carotene (μg)	Vitamin-C (mg)
1	*Amorphophallus paeoniifolius*	Suran	24.22 ±0.87	6.75 ±0.04	47.29 ±0.88	73.40 ±0.43	14.10± 0.74	4.57± 0.28	0.64 ±0.03	83.10 ±0.11	Nil
2	*Dioscorea esculanta*	Aamchai	18.91 ±0.31	3.73 ± 0.06	29.58± 0.64	67.60± 0.75	12.76±0.78	3.48± 0.80	0.47 ±0.09	289.93 ±0.87	0.49 ± 0.11
3	*Dioscorea hispida*	Kandu	17.72 ±1.4	3.35 ± 0.06	Nil	63.78± 1.10	9.25±0.46	3.93± 0.49	0.63 ±0.10	98.55 ±1.42	0.56 ±0.19
4	*Dioscorea petaphylla*	Suwari	17.45 ±0.76	4.74 ±0.12	110.39±0.53	69.33± 0.55	11.18±0.80	8.65± 0.81	2.14 ±0.09	41.13 ±0.17	Nil
5	*Dioscorea tomentosa*	Jangli Kanda	24.01 ±0.25	3.64 ± 0.01	Nil	66.65±1.31	1.45±0.13	5.39±0.52	0.78 ±0.05	96.29±0.44	Nil
6	*Dioscorea* I-Sp.	Alitha Kand	15.32 ±0.27	4.25 ± 0.1	Nil	51.14± 1.12	37.93±1.03	2.82±0.57	0.68 ±0.05	50.98±0.33	4.51 ±0.57
7	*Dioscorea* II-Sp.	Amaliya Kand	34.97 ±0.71	3.88 ± 0.02	Nil	50.87±1.11	17.02±0.96	2.80±0.12	4.91 ±0.12	72.34 ±0.59	2.78 ±0.96
8	*Pueraria tuberose*	Modi	19.54 ±0.03	8.55 ± 0.2	56.72± 1.01	69.30 ±0.78	2.83±0.11	3.28±0.24	5.01 ±0.50	23.98 ±0.07	0.86 ±0.28

* Dry matter, â-Carotene and Ascorbic acid on fresh weight basis;* Mineral ash and mineral elements on dry weight basis;* ± standard deviation

(27.34 per cent), *Cicer arietinum* (22.92 per cent) and *Cordia dichotoma* (21.52 per cent). Mineral ash content was ranged 8.32 (*Marsilea minuta*) to 26.37 per cent (*Portulaca oleracea*). Mineral composition of analyzed green leafy vegetable was lower in calcium content than the conventional green leafy vegetable. The calcium content was ranged from 66.53 to 1935.50 mg/100g on dry weight basis. Iron was found to be similar in *Cicer arietinum* (97.23 mg/100g) and *Portulaca oleracea* (97.06 mg/100). Iron plays numerous biochemical roles in the body, including oxygen blinding in hemoglobin and acting as an important catalytic centre in many enzymes as the cytochrome oxydase. Thus, the selected leaves of this study could be recommended in diets for reducing anaemia (Trowbridge and Martorell, 2002). Zinc is one of the other micronutrient helps in various function of the body. In present study the maximum zinc content among green leafy vegetables was recorded in *Portulaca oleracea* followed by *Centella asiatica*, *Euphorbia royleana*, *Asphodelus tenuifolius* and *Cordia dichotoma*. Copper content was ranged from 0.25 to 2.78 mg/100g on dry weight basis (Table 1b).

Wide variation was recorded for â-carotene content among all the analysed green leafy vegetables and ranged from 491.59 to 6300.74 μg/100g. Maximum â-carotene was noted in *Cassia tora* leaves. All the analysed green leafy vegetables were containing a good amount of vitamin C content. Vitamin C was found maximum in *Melilotus indica* (88.15 mg/100g) and minimum in *Marsilea minuta* (33.70 mg/100g). Intake of 100g of these vegetables may meet the half of daily requirement of vitamin C.

Averrhoea carambola and *Cissus quandrangula* was containing almost similar dry matter i.e. 8.04 and 8.13 per cent respectively (Table 1c) however *Acacia nilotica* (37.57 per cent) was noted maximum dry matter. Mineral ash content was found to be maximum in *Cissus quandrangula* followed by *Dendrocalamus strictus* and *Dioscorea* I Sp. Among all the analysed other vegetable it was noted that all the analysed other vegetables were fair source of minerals. Calcium and magnesium was found highest in *Cissus quandrangula* and *Bombax ceiba* respectively. Iron content was widely varied and maximum was ranged 4.94 mg/100g (*Averrhoea carambola*) to 105.67 mg/100g (*Cissus quandrangula*). Highest zinc was noted in *Aloe barbadensis* followed by *Dendrocalamus strictus, Averrhoea carambola, Carissa congesta* and *Crotalaria juncea*. Beta carotene was ranged from 12.98 to 622.61 μg/100. The analysed other vegetables were containing good amount of vitamin C as compared to conventional other vegetables. Maximum vitamin C was observed in *Carissa congesta* followed by *Leptedenia reticulate* and *Aloe barbadensis*

Dry matter among all the analysed roots and tubers were ranged 15.32 to 34.97 per cent. Higher the moisture, lower the dry matter hence moisture content is inversely proportional to the dry matter. Mineral ash was recorded maximum in *Pueraria tuberose* followed by *Amorphophallus paeoniifolius*, *Dioscorea petaphylla* and *Dioscorea* I-Sp. Wide variation was noted among all the minerals (Table 1d). Calcium content was found nil for *Dioscorea hispida*, *Dioscorea tomentosa*, *Dioscorea* I-Sp. and *Dioscorea* II-Sp. Magnesium was ranged from 50.87 to 73.40 mg/100g for *Dioscorea* II-Sp. and *Amorphophallus paeoniifolius* respectively. Wide variation was recorded for iron content among all the analysed roots and tubers ranged between 37.97 to 1.45 mg/100g. Beta carotene was recorded maximum 289.93 (*Dioscorea esculanta*), followed by 98.55 (*Dioscorea hispida*), 96.29 (*Dioscorea tomentosa*) and 83.10 (*Amorphophallus paeoniifolius*). Vitamin C was ranged from nil to 4.51 mg/100g. The analysed roots were containing good amount of iron and zinc with respect to common conventional other vegetables.

Study conducted by Pal *et al.* (2013) on underutilized horticultural crops and found that underutilized fruits and vegetables are valuable source of natural antioxidant, which can be applied in both healthy medicine and food industry. Fruit and vegetables contain significant amounts of bioactive compounds, which provide a wide range of health benefits beyond basic nutrition. Although the biosynthesis and metabolism of different nutrients in plants can significantly affect by the differences in growing environment, such as temperature, nutrient availability, soil, intensity of sunlight and stage of harvesting (Mukhim *et al.*, 2015; Cazzonelli and Pogson, 2010)

The unconventional fruits and vegetables are locally available, easy to access, affordable and potentially more acceptable especially to the local communities. Such fruits and vegetables may help to meet the high nutrient needs of women and children whose diets are founded predominantly based on cereals and legumes. Still more researches are required to find out the bioavailability of nutrients.

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