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Proximate Nutritive Values and Mineral Components of *Withania Somnifera* (Linn.) Dunal

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Abstract: *Withania somnifera* (Linn.) Dunal is a subtropical shrub with important medicinal properties. The nutritive value and the elemental composition of different parts of plants, *Withania somnifera* which are grown in two distinct geographical regions (Sondekola and Karthikere) of Karnataka have been determined. The investigation revealed that the variation of macro, micro and proximate components varied not only in the plants of different regions but also in the different parts of the same plant. Among the macro elements, Karthikere samples recorded maximum values of nitrogen, phosphorous and magnesium and Sondekola samples recorded maximum values of sodium, potassium and calcium. Among the components of micronutrients, the highest values of iron were recorded both in Sondekola and Karthikere samples. The average values of manganese, copper and zinc were more in the Karthikere samples and comparatively less in the Sondekola samples. Whereas, all the samples of Sondekola recorded maximum values of nutrition. It is believed that the dry climatic condition of the region may contribute the high values of nutrition. Further, the observations are discussed with reference to the geography, elemental composition and nutritional values. The strong and negative observations on herbal drugs and their validity, the study emphasizes the role of elemental composition, proximate components, nutritive value, habitat and geographical features which influence growth and development of *Withania somnifera* and also herbal products of *Withania somnifera* in particular and medicinal plants in general.

Keywords: Heavy metals, Kjeldhal unit, Mineral elements, Nutritive value, Proximate components, Spectrophotometer, *Withania somnifera* (Linn.) Dunal.

Introduction

Withania somnifera (Linn.) Dunal (Figure 1a) which is commonly called Ashwagandha / Indian ginseng /Winter cherry one of the important ingredients in Ayurveda and other traditional systems of medicine. The genus *Withania* belongs to the family Solanaceae and consists of 23 species. Of the 23 species, only two *Withania somnifera* and *Withania coagulans* (Linn.) Dunal have been reported from India[1]. *Withania* Linn. Genus is distributed in the east of the Mediterranean regions and South Asia. *Withania somnifera* is a native of drier part of India and Africa and old world. It is cultivated in large scale as commercial crop in Madya Pradesh, Gujarat and some parts of Rajasthan. *Withania coagulans* is found as a commercial plant in the Punjab region. *Withania somnifera* is known as one of the most useful herbs in pacifying "vata" properties and the plant has been reported to have adaptogenic activity, anticancer, anti-conversant, immunomodelatory, anti oxidative and neurological effects and also used in dietary purposes[1-3]. Human beings require a number of complex organic matters, which includes carbohydrates, fats and proteins for energy and they have dependent on plants for the above requirements. The number of attempts have been made to utilize medicinal plants as food and energy sources[4,5]. Accordingly, attempts are made to narrow down the phytochemical variations and maintenance of compositional uniformity of herbal products under tight regulatory frame works like dietary supplements and heath education act and the new natural health product regulations 2003[6-9]. The number of workers tried to determine the nutritive value and mineral composition of medicinal plants, which are also being used as dietary supplements[5,10].

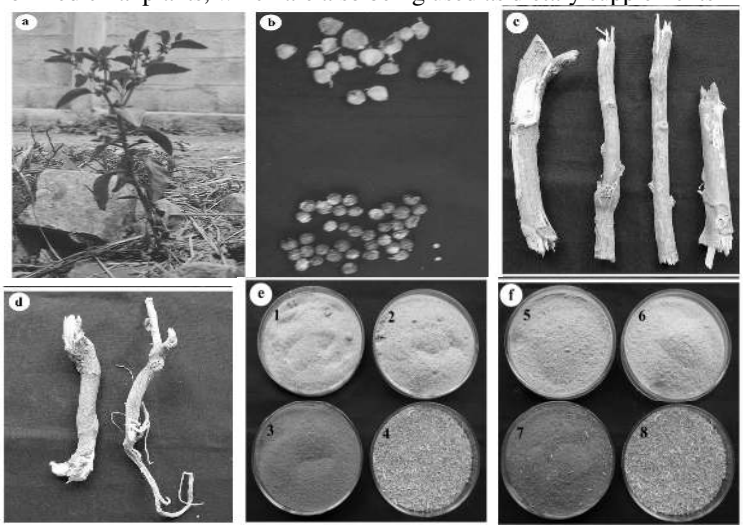

Figure 1 (a). *Withania somnifera* (Linn.) Dunal. (b) Dried fruits and seeds; (c) Dried stems; (d) Dried roots; (e) Powdered samples of Karthikere (1, root; 2, stem; 3, leaf; 4, fruit); (f) powdered samples of sondekola (5, root; 7, leaf; 8, fruit).

At the same time extensive works have been carried out on *Withania somnifera* and a few medicinal plants with reference to their pharmacological activity, composition of herbal products variation, species diversity, genomic composition and techniques and markers which have been used to analyze genetic variations[2-5,10] However little studies have been carried out on nutritional values, mineral elemental composition and impact of habitats on variation of nutritional values and elemental composition within the different parts of the plants. Sangwan *et al*.[4] reported that the phytochemical variations in commercial herbal products and preparation of *Withania somnifera.*

Hence in the present study an attempt has been made to determine nutritional values and variations of macro and microelements in different parts of the plants, *Withania somnifera*, which are grown in two different habitat of Karnataka, India.

Experimental

The plants were collected from two separate regions, which are differing in their habitat and climatic conditions. The first locality is Sondekola, which is in the Chitradurga district of Karnataka, the region is dry and receives moderate rainfall and harbours scurby vegetation. The second location is at Karthikere, which comes under the Chikmagalur district of Karnataka. The region comes under malnad region, receives the maximum rain during the South West Monsoon. Climatic condition is cool throughout the year. The whole plants were collected from the above localities and the entire plants were washed with water and dried in shade. The different parts of the plants were separated (fruit, Figure 1b; stem, Figure 1c; root, Figure 1d and leaf). The dried plant parts were grind to powder (Figure 1e and Figure 1f). The powder was used for the determination of mineral composition and nutritive values. However the separated plant material were used to determine the moisture contents as outlined below. The analysis was made at the Department of Applied Botany, Kuvempu University, Shankaraghatta and the Central Coffee Research Institute (CCRI) Balehonnur, Chikamagalure district of Karnataka, India[5].

Preparation of plant samples for mineral analysis

One gram of powdered dried plant material was taken in Kjeldhal flask, 25 mL of concentrated H_2SO_4 was added and digestion was carried out on a low flame initially for 10 to 15 min until frothing stops. The digestion at high temp was carried out for 1 to 1½ hours or till the contents of Kjeldhal flask become clear, then the flask was cooled and content was transferred quantitatively to 100 mL volumetric flask and the final volume was adjusted to 100 mL by adding distilled water. The solution was used for determination of mineral elements through the atomic absorption spectroscopy (AAS) and the flame photometry (FPM). Standard solution of each element was prepared and calibration curves were drawn for each element using AAS/FPM.

Determination of nutritive value

For the determination of nutritive value, the various parameters were estimated using the crushed plant material.

Determination of ash content

10 g of each sample was weighed in a silica crucible. The crucible was heated first over a low flame till all the material was completely charred, followed by heating in a furnace for about 3-5 h at 600 ^{o}C. It was cooled in a desiccator and weighed to ensure the completion of ashing. To ensure completion of ashing it was heated again in the furnace for half an hour, cooled and weighed. It was repeated till the weight become constant (ash become white or grayish white). Weight of the ash gave the ash content[5].

Determination of moisture content

The samples materials were taken in a flat bottom dish and kept overnight in a hot air oven at 100-110 ^{o}C and weighed. The loss in weight was regarded as a measure of moisture content[5].

Determination of crude fat

Crude fat was determined by extracting 2 g moisture free samples with petroleum ether in a soxhlet extractor, heating the flask on sand bath for about 6 h till a drop taken from the drippings left no greasy stain on the filter paper. After boiling with petroleum ether[11],

the residual petroleum ether was filtered using Whatman No. 40 filter paper and the filtrate was evaporated in a pre-weighed beaker. Increase in weight of beaker gave the crude fat[5].

Determination of crude protein

Crude protein was determined by using Kjeldhal method. One gram of powdered dried plant material was taken in Kjeldhal flask, 25 mL of diacid mixture was added. The digestion was carried out on low flame initial for 10 to 15 minutes until frothing stops. Then digestion at 1 to 1½ h or till the content in Kjeldal flask become clear the flask was cooled and the contents was transferred quantitatively to the 100 mL volumetric flask and final volume was adjusted to 100 mL by adding distilled water, 10 mL of diluted acid digested samples was taken in a micro Kjeldhal distillation assembly. The boric acid mixed indicator solution was kept ready at the receiving end to trap ammonia, 30 mL of 40% NaOH was added and distillation was carried out till the colour of the mixture changes and was further continued for some time to trap the all ammonia released. No changes in colour of the red litmus paper indicate the completion of distillation. The quantity of ammonia distilled was estimated by titrating against 0.01N H_2SO_4 or HCl till the colour changes to purple.

The percentage (%) of N was calculated with the help of following formula.

$$\text{Percentage of Nitrogen} = \frac{\text{Titrate value x N.}H_2SO_4\text{ x 0.014 x dilution factor x 100}}{\text{Weight of the plant sample}} \text{ x 100}$$

The percent of crude protein was estimated by multiplying the percent of Kjeldhal nitrogen into 6.25 (standard factor) it was calculated by using the following formula. Crude protein= Percentage of Kjeldhal nitrogen x 6.25

Determination of crude fibre

The estimation was based on treating the moisture and fat free material with 1.25% dilute acid, then with 1.25% alkali, thus initiating the gastric and intestinal action in the process of digestion. Then 2 g of moisture and fat free material was treated with 200 mL of 1.25% H_2SO_4. After filtration and washing, the residue was treated with 1.25% NaOH. It was filtered, washed with hot water and then 1% HNO_3 and again with hot water. The residue was ignited and the ash was weighed. Loss in weight gave the weight of crude fibre[11].

Percentage of carbohydrate was calculated by using the formula,

100-(Percentage of ash +Percentage of moisture + Percentage of fat + Percentage of protein)[5].

Nutritive value

Nutritive value was finally determined by:

Nutritive value = 4 x Percentage of protein + 9 x Percentage of fat + 4 x Percentage of carbohydrate[5].

Results and Discussion

The result of the macro elements, micro elements, components of nutritional value and nutritive value are given (Table 1 - 3). The values of percentage nitrogen of Karthikere ranged between 0.09 and 1.76 from the root and fruit samples respectively. The samples of stem and leaf recorded moderate values of 0.88% and 0.85% nitrogen respectively. Similarly the samples of root and fruits of Sondekola also recorded minimum and maximum values of 0.26% and 0.49% nitrogen respectively. However the samples of stem and leaf recorded same values of 0.39% of nitrogen. The maximum of 1.76% of nitrogen was recorded in fruits samples of

Karthikere and also the minimum values of 0.09% nitrogen was recorded in the root samples of Karthikere (Table 1, Figure 2). Nitrogen is an essential element for structural proteins. It is found in purines, pyrimidines, porphyrins and coenzymes[12]. When nitrogen is supplied in excess the plant shows dark green leaves with abundance of foliage and reduced growth of root system and as a result the plant shows high shoot to root ratio[13]. The excess of nitrogen causes hormone imbalance and it is reported that tomato fruit were split due to excess of nitrogen supply in addition excess of nitrogen retarded flowering and formation of seeds in may commercial crops. However, when nitrogen become deficit, the plant shows chlorosis in the older leaves and the younger leaves remain green as they obtain nitrogen from older leaves. Nitrogen deficiency also causes accumulation of anthocyanin pigment.

The present study reveals that the fruit samples contained highest value of nitrogen and it is due to accumulation of nitrogen in the stored products. The changes in amount of total nitrogen in the root, stem, leaf and seeds of a broad been (Vincofaba) plant from the seedling stage until maturity was investigated and study reported that the highest percentage of nitrogen was recorded in the seed samples[13]. Present observation is in accordance with the above investigation. The percentage of phosphorus ranged between 0.12 and 0.44 at Karthikere samples, whereas it values ranged between 0.13% and 0.37% at Sondekola samples. The roots samples of both recorded minimum values of 0.12% and 0.13% phosphorus respectively. The highest % of phosphorus was recorded in the leaf samples of Karthikere and fruit samples of Sondekola (Table 1, Figure 2). Phosphorus is easily redistributed in most plant from one organ to another and is from older leaves accumulating in younger leaves and in developing flowers and seeds[13]. The study is in accordance with the above observation and as a result the highest percentage of phosphorus was recorded in the fruit samples of Sondekola and leaf samples of Karthikere. In contrast to that of nitrogen, the highest concentration of phosphorus abundant speeds the maturity. The phosphorus is an essential part of many sugar involved in photosynthesis, respiration and other metabolic processes. It is also part of nucleotides as in RNA and DNA and of the phospholipids present in the membranes[13]. The percentage of sodium was ranged between 0.40 and 0.54; 0.40 and 0.76 at Karthikere and Sondekola samples respectively. The leaf samples of both recorded maximum values of 0.54% and 0.76% of sodium. It is also clear from the results that the difference between maximum and minimum values of percentage sodium was narrow for different parts of the plants (Table 1, Figure 2). Allen and Arnon[14] conformed that the requirement of sodium to several blue green algae and higher plants. It was reported that sodium may partially substitute for potassium in both higher[15] and lower plants[16]. Devlin and Witham[12] included sodium under other essential elements which are required for the normal growth of certain plants along with aluminum, silicon, chlorine, galinium and cobalt. Brownell and Crossland investigated[17] and reviewed the sodium nutrition of thirty two species and concluded that those having the C-4 photosynthesis pathway probably do require Na^+. The percentage of potassium varied between 1.73 and 3.80 at Karthikere and 0.87 and 2.82 at Sondekola samples respectively. The minimum values of potassium of 1.73% were recorded in the fruit samples of Karthikere and 0.87% of potassium in the stem samples at Sondekola. The highest percentage of potassium was recorded in the leaf samples and it was 3.80% for Karthikere samples and 2.82% for Sondekola samples (Table 1, Figure 2). Potassium and commercial fertilizer were applied in the combination of N, P & K. As with nitrogen and phosphorus, K^+ is easily redistributed from mature to younger organs, so deficiency symptoms first appear on older leaves. The present data is also in accordance with the previous reports that potassium serve an activator of many enzymes that are essential for photosynthesis, respiration and it also activates, enzymes need to form starch and proteins[13]. It is worth to mention that potassium and sodium take part in ionic balance of

the human body and maintain tissue excitability. Because of the solubility of salts sodium place an important role in the transport of metabolites. Potassium is of importance as a diruretic[5]. The percentage of calcium was more in the stem samples of both Karthikere (1.23%) and Sondekola (1.12%) respectively. The minimum percentage of calcium was recorded in the root samples of Karthikere (0.157%) and fruit samples of Sondekola (0.12%) respectively. The moderate values were recorded in the leaf samples of Karthikere and Sondekola respectively (Table 1, Figure 2).

Table 1. Comparative account of macro elements (in percentage) of the root, steam, leaf and fruits samples of *Withania somnifera* (Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

Samples	Karthikere, Chickmagalore District						Sondekola, Chitradurga District					
	N	P	Na	K	Ca	Mg	N	P	Na	K	Ca	Mg
Root	0.098	0.12	0.54	2.20	0.157	0.184	0.261	0.13	0.40	1.38	0.15	0.179
Stem	0.883	0.22	0.40	2.99	1.232	0.214	0.392	0.15	0.40	0.87	1.122	0.309
Leaf	0.850	0.44	0.54	3.80	0.2	0.319	0.392	0.15	0.76	2.82	0.197	0.374
Fruit	1.767	0.38	0.50	1.73	0.163	0.078	0.490	0.37	0.74	1.70	0.12	0.192

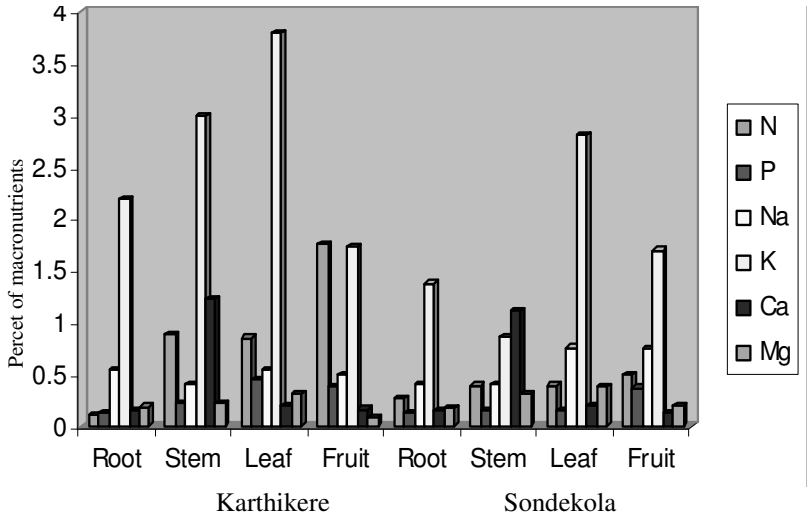

Figure 2. Variation of macro elements of the root, steam, leaf and fruit samples of *Withania somnifera* (Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

The calcium is absorbed as divalent Ca^{2+}. In contrast to Mg^{2+}, Ca^{+} is almost immobile in phloem and as a result deficiency symptoms are always more pronounced in young tissues. The meristematic zones of roots, stems and leaves where cell divisions are occurring, are most susceptible, perhaps because calcium is required to bind pectate polysaccharides that form a new middle lamellae in the cell plate that arises between the daughter cells or because calcium is needed to form microtubules of the mitotic spindle apparatus. The calcium deficiencies result in the formation of twisted and deformed tissues and death of meristematic areas[13]. Much of the calcium is bounded in small soluble protein called calmodulin[18], which activates several enzymes. Calcium constitutes a large proportion of bone, human blood and extracellular fluid; it is necessary for the normal functioning of cardiac muscles, blood coagulation and milk clotting and also in the regulation of cell permeability. Calcium plays an important role in nerve impulse transmission and

in the mechanism of neuromuscular system. The percentage of magnesium was highest in the leaf samples of both the sites and it was 0.31% for Karthikere and 0.37% for Sondekola samples respectively. The minimum values of 0.07% of magnesium were recorded in the fruit samples of Karthikere and 0.17% for root samples of Sondekola. It is also clear from the values that the accumulation of magnesium in different parts of the plant is more or less same (Table 1, Figure 2). The deficiency of magnesium causes chlorosis of the older leaves and it is usually in the interveinal. In addition to presence of Mg in chlorophyll, it is also required for ATP formation. Magnesium activates many enzymes which are needed in photosynthesis, respiration and formation of DNA & RNA[13]. The magnesium values were more in the leaves samples of both Karthikere and Sondekaola. It is due to the mobility of magnesium from older region to the meristematic region of the plant. Magnesium is required in the plasma and extracellular fluid, where it helps to maintain osmotic equilibrium. The lack of magnesium associated with abnormal irritability of muscle and convulsions and excess magnesium with depression of the central nervous system, magnesium is participated in the nucleotide reactive as Mg ATP[5]. The micronutrients like zinc, manganese, copper and iron were estimated and the values are given in Table 2.

Table 2. Comparative account of micro elements (in ppm) of the root, steam, leaf and fruits samples of *Withania somnifera* (Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

Samples	Karthikere, Chickmagalore district				Sondekola, Chitradurga district			
	Zn	Mn	Cu	Fe	Zn	Mn	Cu	Fe
Root	44.1	59.0	33.0	349.5	31.0	26.0	17.0	945.0
Stem	36.4	19.0	18.0	617.0	17.6	49.0	21.0	280.0
Leaf	52.9	34.0	35.0	740.0	11.3	32.0	16.0	485.0
Fruit	49.2	37.0	42.0	602.0	17.3	15.0	14.0	370.0

The iron values were highest (740.0 ppm) in the leaf samples of Karthikere and in the root samples (945.0 ppm) of Sondekola. The lowest values of 349.5 ppm and 280.0 ppm were recorded in the root and stem samples of Karthikere and Sondekola respectively. The moderate values of 602.0 and 370.0 ppm were recorded in the fruits samples of Karthikere and Sondekola respectively (Figure 3). The average values of zinc were higher in the Karthikere samples when compared with Sondekola samples. At Karthikere zinc values ranged between 36.4 ppm and 52.9 ppm. At Sondekola, its values varied between 11.3 ppm and 31.0 ppm. The highest values of 52.9 ppm of zinc were recorded in the leaf samples of Karthikere and 31.0 ppm in root samples of sondekola. The stem samples of Karthikere (36.4 ppm) and leaf samples of Sondekola (11.3 ppm) recorded minimum values of zinc (Figure 3). Manganese values varied between 19.00 ppm and 59.00 ppm at Karthikere and between 15.00 ppm and 49.00 ppm at Sondekola samples respectively. The average values of manganese were highest in the samples of Karthikere than the samples of Sondekola. The highest value of 59.00 ppm was recorded in the root samples of Karthikere and minimum values of 15.00 ppm was recorded in the fruit samples of Sondekola (Figure 3). The copper value was highest in the fruit (42 ppm) samples of Karthikere and minimum values (14.00 ppm) was also recorded in the fruit samples of Sondekola. Its values differ moderately in the different plant part at different regions (Figure 3). Salisbury and Ross[13] listed 16 elements which are believed to be essential to all higher plants. These elements are classified in to trace elements, micro elements and macro elements depending on their requirements, the elements like zinc, manganese, copper and iron are included under the trace elements. The deficiency of iron causes chlorosis, chlorosis of interveinal of the younger leaves. It is believed that iron deficiency results in a rapid inhibition of chlorophyll formation.

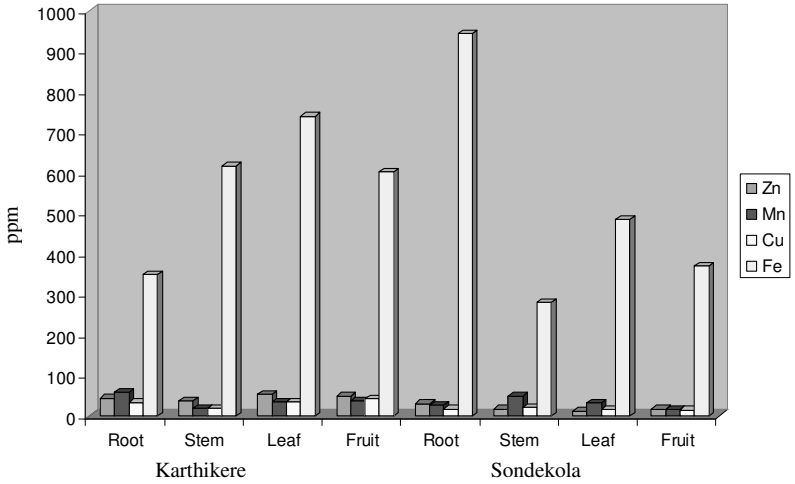

Figure 3. Variation of micro elements of the root, steam, leaf and fruit samples of *Withania somnifera* (Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

Iron is stored in the leaves as an iron protein complex are called phytoferritin. Iron is essential because it forms part of certain enzymes and part of number of proteins that carry electrons during photosynthesis and respiration. Iron was more in the leaf samples of Karthikere and the root samples of Sondekola respectively. When compared to the concentration of micronutrients, iron was the highest which is followed by zinc, manganese and copper[13]. The deficiency of zinc causes disorders which include "little life" and "rosette". It is characterized by the reduction of growth of young leaves and stem internodal regions. Leaf margin are often distorted and puckered in appearances. Zinc bounds to many essential enzymes of organisms. The value of zinc was more in the leaves samples of Karthikere and root samples of Sondekola. It is similar to that of iron values. Manganese causes disorders like "gray specks", marsh spots" and "speckled yellows". The deficiency of manganese causes interveinal chlorosis on younger or older leaves. The highest concentration of manganese was recorded in the root samples of Karthikere and the stem samples of Sondekola. Manganese plays in a structural role in the chloroplast membrane system and that one of its important role is, like that of chloride, in the photosynthetic split of water. The manganese in the form of Mn^{2+} ions activates numerous enzymes[13]. The plants are rarely deficit in copper and copper is required in a little quantity. The copper is also available sufficiently in all soils and deficiency symptoms are largely unknown. The deficiency of copper causes dark greening of younger leaves with necrotic spots. Copper is present in several enzymes or proteins involved in oxidation and reduction. Two notable examples are cytochrome oxidase and plastocyanin. In addition, copper is also a component of lysyloxidase and ceruloplasmin, an iron-oxidizing enzyme in blood[18]. The observation of anemia in copper deficiency may probably be related to its role in facilitating iron absorption and in the incorporation of iron into haemoglobin[20]. Further, copper plays a major role in Fe metabolism and its deficiency results in fragile bone cortices and spontaneous rupture of major vessels from which most of the plants could be prescribed[21,22].

Having estimated, the percentage of moisture, ash, crude protein, carbohydrate, crude fiber and crude fat, the nutritive value of the different plant parts of the different regions are determinates and the values are given in Table 3. The comparative details of variations of nutritional components

are given in Figure 4. The percentage of moisture content of the plant parts of Karthikere is always greater than that of the plant parts of Sondekola. The stem and leaf samples of Karthikere contained highest percentage of moisture and it was 80.07% and 74.30% respectively.

Table 3. Comparative account of components of nutritive values and nutritive values of the root, steam, leaf and fruits samples of *Withania somnifera* (Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

Samples	Karthikere, Chickmagalore District							Sondekola, Chitradurga District						
	Mois-ture, %	Ash, %	Crude protein, %	Carbo hydrate, %	Crude fibre, %	Crude Fat ,%	Nutritive value Cal/100 g	Mois-ture, %	Ash, %	Crude protein, %	Carbo hydrate, %	Crude fibre, %	Crude Fat, %	Nutritive value Cal/100 g
Root	70.73	3.17	0.612	24.34	5.00	1.138	107.97	28.00	6.66	1.631	63.37	4.00	0.328	262.97
Stem	80.07	12.87	5.518	0.17	1.96	0.75	29.538	25.60	9.66	1.790	61.91	5.95	1.631	273.56
Leaf	74.30	8.65	5.312	66.76	11.38	2.34	78.513	44.20	1.22	2.45	51.55	0.92	3.67	236.60
Fruit	67.20	9.15	11.04	55.89	4.00	2.90	109.10	28.00	5.00	3.062	63.03	4.00	0.90	322.50

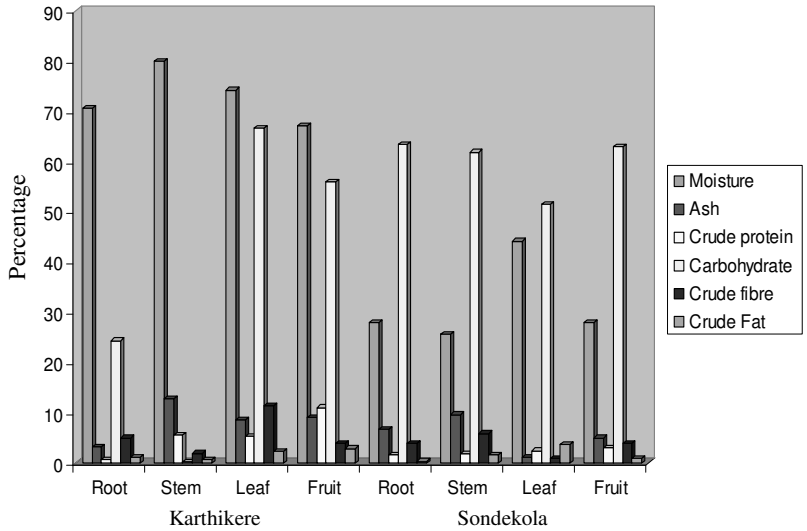

Figure 4. Variation of nutritional components (in percent) of the root, steam, leaf and fruit samples of *Withania somnifera (*Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

The plant parts of Sondekola recorded lowest moisture values. The maximum values of 44.20% and minimum values of 25.60% were recorded in the leaf and stem samples of Sondekola. The ash percentage of Karthikere varied between 3.17% and 12.87%. The maximum values were recorded in the stem samples and minimum values recorded in the root samples. At Sondekola, the plant parts recorded minimum and maximum values of 1.22% and 9.66% in the leaf and stem samples respectively. The percentage of crude protein values varied between 0.61% and 11.04%; 1.63% and 3.06% from the Karthikere and Sondekola samples respectively. It is interesting to note that the highest percentage of crude protein was recorded in the fruit samples of both Karthikere and Sondekola samples. The percentage of carbohydrate values was highest in the leaf samples of Karthikere and the root samples of Sondekola. The percentage carbohydrate values varied between 0.17% and 66.7%

at Karthikere and 51.55% and 63.37% at Sondekola respectively. However, the stem samples of Karthikere recorded lowest value of 0.17% of carbohydrate. The percentage of crude fibre of plant parts of Karthikere is higher than that of plant parts of Sondekola. The highest values of 11.38% crude fibre was recorded in the leaf samples of Karthikere and minimum of 0.92% of crude fibre was recorded in the leaf samples of Sondekola. The stem samples and the leaf samples of both Karthikere and Sondekola recorded low values of crude fibre. The fruit samples of Karthikere recorded highest values of 2.90% of crude fat and lowest values of 0.75% in stem samples. The crude fat values of Sondekola ranged between 0.32% and 3.67% respectively. The lowest values were recorded in root samples and the highest values were observed in the fruit samples. Finally, the nutritive values ranged between 29.53 cal/100 g and 109.10 cal/100 g in the samples of Karthikere and 236.60 cal/100 g and 322.50 cal/100 g in the samples of Sondekola respectively. In both the cases the nutritive values were recorded highest in the fruit samples. It was 109.1 cal/100 g for Karthikere and 322.5 cal/100 g for Sondekola samples respectively (Figure 5). The minimum nutritive value was recorded in the stem samples of Karthikere and leaf samples of Sondekola. However, when whole plant is considered, the plants of Sondekola are more nutritive than that of Karthikere. The Sondekola, which is located in the dry region, may cause higher nutritive values.

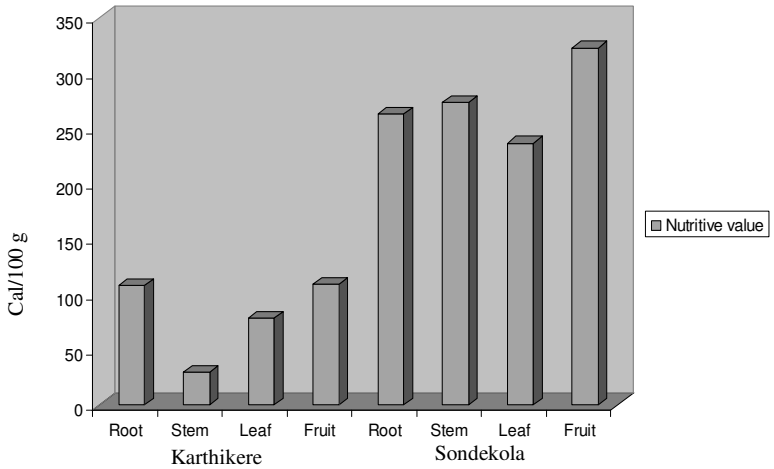

Figure 5. Variation of nutritive values of the root, steam, leaf and fruit samples of *Withania somnifera (*Linn.) Dunal at Karthikere and Sondekola of Karnataka, India.

Indrayan *et al.*[5] analyzed mineral elements and nutritive value in different medicinal plants of Uttaranchal and reported that the accumulation of mineral elements was differed in different parts of the plant. The results of present investigation are also in accordance with the observation of Indrayan *et al.*[5] and Deepak Dayani *et al*[10]. Ndiokwere[23] analyzed elements in ten Nigerian medicinal plants and he used different parts of the plant. It was well established that the total mineral dosage and pH have positive effects on accumulation of the alkaloids hyoscyamine and scopolamine in *Datura stramonium* L.[23] and Demeyer[24] observed that at a pH 5.0 alkaloid accumulation in the leaves and stem was significantly decreased as compared with plants grown at pH 6.0 or 7.0, suggesting a decreased synthesis of alkaloids in plants grown at low pH and further increases in mineral concentration of the culture media produced a concomitant increase in alkaloid content and yield. However, excess mineral

supply produced a temporal decrease in alkaloid production[24]. The present study serves as baseline data for the systematic and distribution of wild edible plants. It also involves the studies perspectives of establishment organic food and nutriceutical industries to solve the rural and economic problems of people who are in the middle of the Western Ghats and they are associated with plants for their regular activities.

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