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Standardization and nutritional quality evaluation of an uncultivated green leafy vegetable (*Aerva lanata)* incorporated instant chutney powders

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ABSTRACT

Uncultivated green leafy vegetables (UCGLVs) play a significant role in socio socio-economic, cultural, nutritional and ethnomedicinal status of tribal and rural people of underdeveloped and developing countries. However, scientific studies on the nutritional, pharmaceutical activities and value addition of these UCGLVs are limited. Hence, the present study dealt with the standardization and nutritional quality evaluation of Aerva lanataincorporated instant chutney powders. Aerva lanata is a seasonal, naturally grown underutilised green leafy vegetable used in Nalgonda district, Telangana state, India. Consumption of instant chutney powders with rice and some breakfast items is a common practice in rural areas of Nalgonda district. And so, the freshly collected Aerva lanata leaves were washed, shade-dried, and incorporated into instant chutney powders. The developed products along with its control were analyzed for organoleptic and nutritional quality. The results of the study found that 50% leaf powder incorporated chutney powder was best accepted. The incorporation of leaf powder significantly ($p \leq 0.01$) increased the protein, crude fiber, ash, total and beta carotenoid content of instant chutney powders. When compared to the control (ICC), calcium (25.49%), iron (48.31%), zinc (43.05%), copper (36.49%), manganese (97.86%), phosphorus (3.13%), sodium (38.01%) and potassium (46.27%) content as well as antioxidants activity of selected chutney powder was highly increased. The study found that instant chutney powders developed from Aerva lanatawere are not only attractive in sensory parameters due to the color, but they are also beneficial in maximizing the health benefits due to the rich source of nutrients, antioxidants and radical scavenging activity present in the products.

Keywords: *Aerva lanata, Instant chutney powder, Dehydration, Antioxidants, Uncultivated green leafy vegetables, Nutritional security, Sensory evaluation, Nutritional quality*

INTRODUCTION

According to the FAO [1], green leafy vegetables (GLVs) are a crucial part of healthy diets all over the world, and their consumption is expected to rise as a result of growing consumer knowledge of the advantages of including green leafy vegetables in one's diet [2]. More than 400gms of vegetables per person per day were recommended by WHO to protect from diet-related chronic diseases [3]. Green leafy vegetables provide an adequate amount of dietary fiber, phytochemicals, vitamins, and minerals. Some of leafy vegetables like spinach, amaranth, coriander, and fenugreek are commonly consumed, and the nutritive values of which have been reported in food composition tables [4,5].

In addition to these, there are several underutilised green vegetables that are seasonal and very less information is known about the nutrients and antinutrients they contain. Finding these nourishing green leafy vegetables could contribute to obtaining nutritional security [6]. Each region of India has its own distinctive traditional eating customs that are rooted in its cultural heritage and highly acceptable to the population because the recipes are passed down from generation to generation with little alteration. Thus, enhancing traditional dishes with micronutrient-rich, nutrient-dense green vegetables could pave a way for sustainable utilization in routine diets and to attain good micronutrient levels in diet [7].

Recognizing the significance of underutilized food crops, the ICUC (International Centre for Underutilized Crops) promotes the cultivation, usage, and marketing of these crops. These crops are also important for sustaining floral biodiversity, require less economic input, and maintenance, are well adapted to local agroecology, and do not require much agricultural inputs such as irrigation, fertilizers, pesticides, and so on. They also possess systemic resistance against biotic and biotic stresses [8].

Aerva lanata (L.) Juss Ex. Schult, a member of the Amaranthaceae family, is also called as a stone breaking plant in English. It is contemplated as a medicinal plant and also widely accepted to be a principal source of nutrition and some chemical properties have potential of therapeutic effects [9,10]. It contains a variety of phytoconstituents, including tannins, terpenoids, alkaloids, saponins, steroids, flavonoids, amino acids, and cardiac glycosides. Every part of the plant, including the stem, leaves, and flowers, has medicinal properties that include antimicrobial, antiparasitic, diuretic, anti-urolithiasis, anti-asthma, anti-infertility, antihyperglycemic, anti-diabetic, hypolipidemic, hepatoprotective, immunomodulatory, antitumor, anti-diarrheal and antioxidant activity [11,12,9,10,13].

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Furthermore, due to their perishable nature, greens degrade very quickly after harvesting, making them unfit for consumption. Dehydrating these greens allows to preserve them for a longer period of time and nutrients can be attained in concentrated forms. Later these dehydrated greens can used to make a variety of ready-to-eat food adjuncts. In the current study, an effort has been made to make ready-to-eat quick chutney powders incorporated with dehydrated *Aerva lanata*leaves.

MATERIALS AND METHODS

The fresh leaves of *Aerva lanata*was collected from the farm fields of Nalgonda district, Telangana state. The edible portions of selected leaves were washed, blanched, and shade dried until samples became crisp and brittle to the touch. After drying the samples were powdered and used for product development. All the raw materials required for the product are procured from the local markets of Hyderabad, India.

Process description of *Aerva lanata* incorporated instant chutney powders

All the individually weighted and roasted ingredients (black gram, Bengal gram, cumin seeds, coriander seeds, garlic, tamarind, chili powder, and salt) were powdered and mixed together in blender, with salt and five different proportions of leaf powder is added.

Table-1 Proportions of the ingredients used in standardization of Aerva lanataincorporated chutney powder

Ingredients	Control	F1	F2	F3	F4	F5
Aerva lanata powder	0.0	5.0	10.0	15.0	20.0	25.0
Black gram dhal	6.5	6.5	6.5	6.5	6.5	6.5
Bengal gram dhal	5.0	5.0	5.0	5.0	5.0	5.0
Cumin powder	3.5	3.5	3.5	3.5	3.5	3.5
Coriander seeds	6.5	6.5	6.5	6.5	6.5	6.5
Garlic	5.5	5.5	5.5	5.5	5.5	5.5
Tamarind powder	7.0	7.0	7.0	7.0	7.0	7.0
Chili powder	10.0	10.0	10.0	10.0	10.0	10.0
Common salt	6.0	6.0	6.0	6.0	6.0	6.0

Note: *All formulae were repeated three times.*
All ingredients were measured in grams

Sensory evaluation of instant chutney powder

The sensory assessments were conducted in a purpose-built sensory evaluation laboratory. The panel of 15 members consisted of staff and graduate students of the Department of Foods and Nutrition, Professor Jayashankar Telangana State Agricultural University, Hyderabad. All the products prepared with *Aerva lanata*powder along with control were coded using random three-digit numbers and served with the order of presentation counter-balanced. Panelists were provided with a glass of water and instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for acceptability based on its color, texture, taste, flavor, leafy odor and overall acceptability using a nine-point hedonic scale (0=Dislike extremely to 9=Like extremely) [14].

Physical-functional properties: Bulk density [15], tapped density [16], flowability and cohesiveness [17], titratable acidity [18], color [19], chroma and hue [20], total color difference [21] and water activity [22].

Nutritional analysis: Moisture, ash, protein [23], fat [24], crude fiber [25], carbohydrate and energy [26], free fatty acids [27], starch [28], total carotenoids [29], β-carotene [30], ascorbic acid [18], calcium, iron, magnesium, manganese, copper, zinc, sodium, potassium, phosphorus was analyzed by the standard procedures [31] bioavailable calcium, zinc [32] and iron [33] content was analyzed.

Antioxidant properties: Antioxidant screening [34], flavonoid content [35], total phenols [36], antioxidant activity by DPPH [37,38], tannins [39], oxalate content [40].

Statistical analysis: All experiments were performed in triplicates and the data were analyzed and presented as mean values with standard deviations.

RESULTS AND DISCUSSION

Sensory quality characteristics of *Aerva lanata* leaves incorporated instant chutney powders: Sensory analysis involves the inspection of quality attributes of a food products like appearance, color, flavor, aroma, taste, texture, and sound by the senses viz. sight, smell, taste, and touch [41]. It is an essential concept in food product development as it reduces the risk of product failure and depicts the consumer perception about the quality of food [42]. Sensory evaluation was conducted for instant chutney powders prepared with *Aerva lanata*at various incorporation levels and their mean sensory scores were presented in Figure-1. The mean sensory scores for color, appearance, flavor, taste, flavor and overall acceptability of all formulations of*Aerva lanata* leaf powder incorporated chutney powders were ranged from 6.60 (ICA_4) to 8.10 (ICC), 6.80 (ICA_4, ICA_5) to 8.00 (ICC, ICA_1), 6.70 (ICA_4) to 8.00 (ICC), 6.80 (ICA_4) to 8.10 (ICC), 7.20 (ICA_4) to 8.20 (ICC) and 6.40 (ICA_5) to ICC (8.20) respectively. Among all the samples, control (ICC) scored highest in all attributes. Overall acceptability scores for developed products showed that, as leaf powder percentage increased scores decreased significantly($p<0.05$) when compared to the control sample. The results of the highest leaf powder incorporated instant chutney powder (50%) were in the acceptable range and so, it was selected for further study.

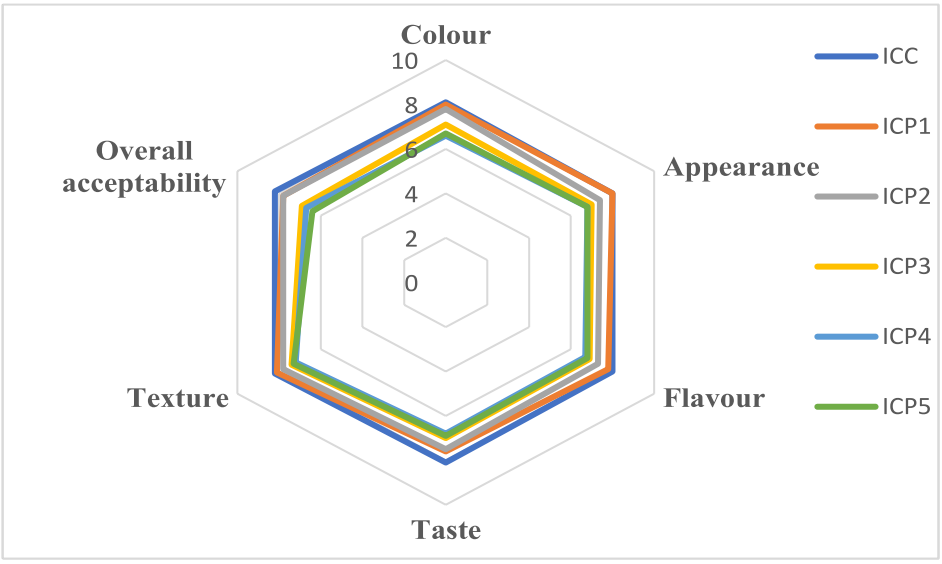

Figure-1: Mean sensory scores of Aerva lanataleaves incorporated chutney powders

Physical properties of *Aerva lanata* incorporated chutney powder

To improve production methods, and efficiency and to reduce losses in the process line, it is necessary to characterize the physical, chemical, and behavioral properties of foods. It is also useful to build efficient processing machinery for the food business. Due to the complicated structure of powdered goods made from food materials, it is required to regulate properties such as size, shape, physicochemical structure and particle cohesion in order to achieve the desired properties and quality in the finished product. To lower processing costs and to improve equipment design, a better understanding of powder mass flow, resistance to flow, cake forming potential, and adhesion strength onto surfaces is needed [43].

Bulk and tapped densities determine the heaviness of powders and it is affected by the size of the particle and density of the powder. Bulk density is an important parameter in determining packing requirements, handling and its applications in wet processing in the food industry [44]. The results physical properties of *Aerva lanata* incorporated chutney powder is given in Table 2. When compared to the control (ICC), the bulk and tapped density of ICA was decreased by 56.6% and 27.71% respectively due to the incorporation of leaf powder. According to the Carr index, the flowability of ICA has very bad flowability due to its high cohesiveness as classified by the hausner ratio (HR). The titratable acidity of ICA was decreased (28.7) whereas its pH was increased by 17.6% than ICC (control). Estimation of a_w is an important parameter as it greatly affects the shelf life of the powders.Water activity, is the physicochemical state of water and is a measure of water availability for the growth of various microorganisms. Water activity is a major issue in relation to chemical stability of dry food products and has already been identified as an intrinsic factor in determining shelf-life [45,46]. The water activity of ICC and ICA was less than 0.5 which indicates that the developed products can be stored at room temperature for longer duration.

Colour is an important quality parameter as it influences the acceptability of the food product. The results of colour scores of selected products were presented as L*, a*, b*, C*, h* values and mentioned in Table-2. The L* is the indication of lightness ranged from 0 (black) to 100 (white), a* component ranged from green to red and b* ranged from blue to yellow. The E* is the difference between two colours. In the colour space C* represents chroma and h* indicates hue. These colour units were often used in food research studies because of uniform distribution of colours and are very close to human perception of colour [47]. The study found that color valuesL*, a*, E* were significantly ($p \leq 0.05$)decreased in ICA whereas the values of b*, C* and h* were increased when compared to the control sample due to the addition of leaves powder.

Table-2 Physical properties of Aerva lanata incorporated products

Physical properties of *Aerva lanata* incorporated instant chutney powders							
Sample	**BD (g/cm³)**	**TD (g/cm³)**	**CI (%)**	**HR**	**TA (%)**	**PH**	**aw**
ICC	$0.53^{b}\pm0.00$	$0.83^{b}\pm0.00$	$36.33^{a}\pm0.58$	$1.57^{a}\pm0.01$	$0.014^{b}\pm0.00$	$4.07^{a}\pm0.01$	0.46b±0.01
ICA	$0.30^{a}\pm0.01$	$0.60^{a}\pm0.00$	$51.76^{b}\pm0.49$	$2.05^{b}\pm0.01$	$0.010^{a}\pm0.00$	$4.79^{b}\pm0.01$	$0.39^{a}\pm0.00$
t-value	67.80	86.70	35.20	73.38	6.07	95.70	20.00
p-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Sample	**L***	**a***	**b***	**E***	**C***	**h***	
ICC	$-61.16^{b}\pm1.53$	$9.63^{b}\pm0.88$	$25.59^{a}\pm0.09$	$67.61^{b}\pm1.47$	$27.35^{a}\pm0.32$	$58.50^{a}\pm1.20$	
ICA	$-54.76^{a}\pm0.28$	$7.45^{a}\pm0.43$	$27.86^{b}\pm0.79$	$63.16^{a}\pm1.86$	$28.83^{b}\pm0.76$	$62.65^{b}\pm0.80$	
t-value	7.11	3.85	4.93	3.25	3.13	4.99	
p-value	0.00**	0.02*	0.01**	0.03*	0.04*	0.01**	

(BD: Bulk density, TD: Tapped density, CI: Carr index, HR: Hausner ratio, TA: Titratable acidity, L*- lightness, a*- green to red, b*- blue to yellow, E*- total colour difference, h*- hue angle, C*- chroma)

Note: Values are expressed as mean ± standard deviation of three determinations; NS: not significant; ** significant at ($p \leq 0.01$); * significant at ($p \leq 0.05$)

ICC: Instant chutney powder control

ICA: Instant chutney powder with 50% incorporation of dried *Aerva lanata* leaf powder

Nutritional composition of *Aerva lanata*incorporated instant chutney powder:

Nutritional parameters such as moisture, ash, crude fat, crude fiber, protein, starch, carbohydrate and energy content of ICA and ICC were assessed and the results are given in Table-3**.** The moisture content of ICC and ICA was 7.41 and 7.88% respectively. The moisture content of both products is less than 8%, which do not support microbial growth in dehydrated food (Luh and Woodroof, 1975). Due to high ash (31.2%) and crude fiber (6.75%) content of *Aerva lanata* (Omeyeni and Adeyene, 2009), ICA ash and crude fiber content was increased by 8.42 and 16.68% respectively. The protein content of ICA was estimated to be 22.69% and in ICC was 15.32%. The high protein content of ICA was due addition of protein-rich (22.6g/100g) *Aerva lanata* leaf powder [48]. The protein content *Aerva lanata* powder was quite higher in comparison to regularly consumed cereals and falls in the protein content of pulses. So, this can be used as a cheap source of protein.The fat content of ICC and ICA was 8.41 and 8.81% respectively (Figure-2). The carbohydrate (24.41%), energy (2.14%), starch (21.04%) content of ICA was significantly (p≤0.01)decreased, as green leafy vegetables are not a good source of these compounds [49].

Vitamins and minerals are essential to humans as they play essential roles in a variety of basic metabolic pathways that support fundamental cellular functions such as energy-yielding metabolism, oxygen transport, DNA synthesis, and neuronal functions making them critical for brain and muscular function [50]. Green leafy vegetables contain a wealth of nutrients. Carotenoids, like beta-carotene, are found in plant foods and have to be converted by the body into vitamin A. Green leafy vegetables are abundant sources for beta-carotene [51]. The vitamin C, beta-carotene, and total carotene content of ICA is significantly increased (p≤0.01)by 457%, 560.58%, and 1223.63% respectively when compared to the control sample (ICC).

Calcium, sodium and potassium are some of the important macro minerals whereas iron and zinc are micro minerals that are necessary for body's normal functioning. The calcium, iron and zinc content increased from 486.3 to610.3mg, 7.22mg to 11.43, and 1.44mg to2.06mg respectively in *Aerva lanata* powder incorporated chutney powder (ICA) than the control. Calcium functions as a constituent of bones and teeth, regulation of nerve, muscle and blood clotting functions [52,53]. Iron is an important constituent of haemoglobin, myoglobin, and cytochromes and helps in normal bodily functions. Zinc performs various functions in the body including protein synthesis, cellular differentiation, replication and immunity functions of the body [53].

Dehydrated *Aerva lanata* leaves are good sources of minerals like calcium (51.7mg/100gm), sodium (39.4mg/100gm), potassium (47.9mg/100gm), magnesium (41.50mg/100gm), zinc (44.7mg/100gm), iron (11.0mg/100gm), phosphorus (187mg/100gm) and manganese (1.04mg/100gm) [54]. Therefore, value addition of chutney powders with *Aerva lanata* leaves powder significantly increased the calcium (25.49%), iron (48.31%), zinc (43.05%), copper (36.49%), manganese (97.86%), phosphorus (3.13%), sodium (38.01%) and potassium (46.27%) content. Sodium and potassium are important intracellular and extracellular cations respectively, which are involved in the regulation of plasma volume, acid-base balance, and nerve and muscle contraction [5] . The absorption of mineral nutrients in green leafy vegetables is adversely affected by the presence of inhibitors like oxalate and phytates and many other anti-nutritional factors [55]. Hence, the bioavailability of calcium, iron, and zinc content of chutney powders are estimated and the results showed that ICA bioavailable calcium, iron and zinc content was increased by 23.82%, 15.86%, and 46.55% respectively than the control sample (ICA) (Figure-3).

Table-2 Nutrient and antioxidant composition of Aerva lanata incorporated instant chutney powders per 100gm

Sample	Moisture (%)	Ash (g)	Fat (g)	Crude fiber (g)	Protein (g)	Carbohydrate (g)	Energy (kcal)	Starch (g/100g)
ICC	7.41^{a}±0.05	15.33^{a}±0.15	8.41^{a}±0.12	13.06±0.02	15.32±0.01	40.47b±0.02	298.84^{b}±0.00	25.71^{b}±0.32
ICA	7.88^{b}±0.05	15.70^{b}±0.09	8.81^{b}±0.02	14.34b±0.04	22.69b±0.00	30.59a±0.01	292.39a±0.00	20.30a±0.23
t-value	10.13	3.70	5.65	47.95	2412.73	893.68	313.90	23.66
p-value	0.00**	0.02*	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Mineral content of instant chutney powders								
Sample	Calcium (mg)	Iron (mg)	Zinc(mg)	Copper(mg)	Manganese (mg)	Phosphorus (mg)	Sodium (mg)	Potassium (mg)
ICC	486.00±0.30	7.22^{a}±0.17	1.44^{a}±0.00	0.74^{a}±0.00	1.87^{a}±0.00	207.12^{a}±0.00	5829.97^{b}±0.27	592.55^{a}±0.05
ICA	610.25b±0.19	11.43^{b}±0.24	2.06b±0.00	1.01b±0.00	2.70b±0.00	213.63b±0.70	3614.47^{a}±0.14	866.84b±0.09
t-value	613.59	24.64	5594.54	292.19	751.67	16.13	12709.05	4516.09
p-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Vitamin and antioxidant composition of developed products								
Sample	Vitamin C (mg)	Beta carotenoids (µg)	Total carotenoids (µg)	Phenols (mg GAE)	Flavonoids (mg RE/gm)	Tannins (mg TAE)	Oxalates (mg)	Antioxidant activity (%)/0.5ml
ICC	1.07^{a}±0.02	13.87^{a}±0.16	150.25^{a}±0.32	203.07^{a}±0.00	8.44a±0.12	16.29a±0.02	1506.84^{a}±0.39	31.09a±0.00
ICA	5.96b±0.03	91.90b±0.01	1989.23b±1.35	248.16b±0.03	80.68b±0.02	34.24b±0.01	3766.55b±0.04	56.03b±0.00
t-value	256.57	845.55	2297.44	2552.90	652.81	1363.73	10092.26	86981.60
p-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

Note: Values are expressed as mean ± standard deviation of three determinations; NS: not significant; ** significant at (p≤0.01); * significant at (p≤0.05)
ICC: Instant chutney powder control
ICA: Instant chutney powder with 50% incorporation of dried *Aerva lanata* leaf powder

Antioxidant composition of developed chutney powders

Antioxidants are directly associated with the reduction of stress, anxiety, and life style disorders like cancer, diabetes, neurodegenerative and cardiovascular diseases [56]. Initial antioxidants screening of methanolic extracts of chutney powders identified the presence of proteins, amino acids, carbohydrates, phenols, flavonoids, tannins, alkaloids, terpenoids, saponins, glycosides, phlobatinins and steroids.

The antioxidant activity of phenolic compounds is due to the capacity to scavenge of free radicals, donating hydrogen atoms, electrons, or chelate metal cations. For the determination of TPC, Gallic acid was used as a reference compound. The total phenols were expressed as mg/g Gallic acid equivalent (mg GAE/gm). The amount of total flavonoid was determined with the Rutin as standard and the total flavonoids were expressed as mg/g Rutinequivalent (mg QE/gm). Tannins content was estimated with tannic acid as a reference compound and the results were expressed as Tannic acid equivalents (mg TAE/100gm). The total phenol, flavonoid, tannin and oxalate content of ICA was significantly increased ($p \leq 0.01$) by 22.02%, 855.92%, 110.44%, and 150.13% respectively than ICC (Figure-4).

DPPH is a stable free radical and accepts an electron or hydrogen radical to become a stable diamagnetic molecule. A freshly prepared DPPH solution is of deep purple color and in the presence of antioxidant this color disappears due to the quenching of DPPH free radicals and convert them into a colorless product i.e 2,2-diphenyl-1-hydrazine, mechanism performed by providing hydrogen atoms or electron [57]. The percentage of DPPH radical scavenging activity of 0.5ml methanol extract was increased from 31.09 to 56.03% in ICA. IC_{50} values were calculated and the 50% inhibition was found at 0.8 and 0.44ml of extract for ICC and ICA respectively. Phenolic compounds are the major antioxidant constituents in herbs, vegetables and fruits and there are direct relationships between their antioxidant activity and TPC [58].

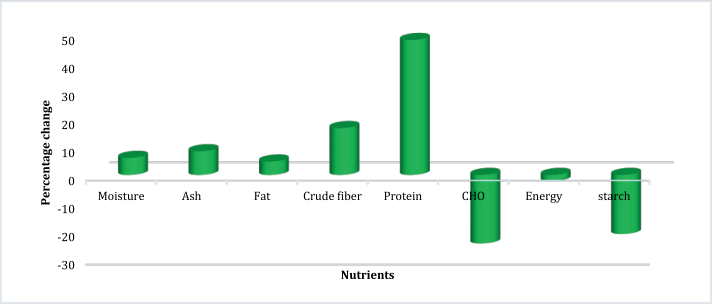

Figure-2: Percentage change in nutritional composition of Aerva lanataincorporated instant chutney powder when compared to the control

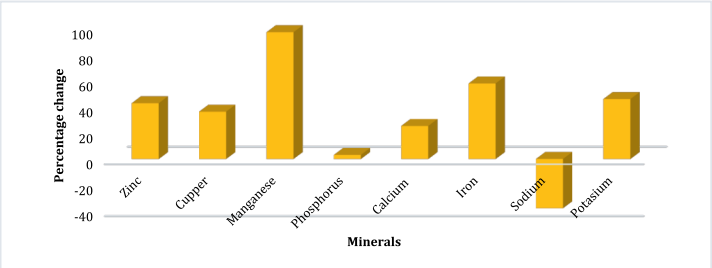

Figure-3: Percentage change in mineral composition of Aerva lanataincorporated instant chutney powder when compared to the control

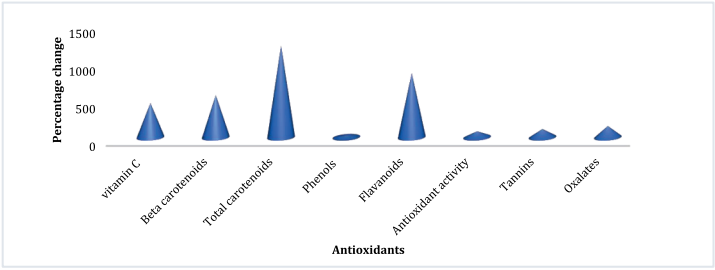

Figure-4: Percentage change in vitamins and antioxidant composition of Aerva lanataincorporated instant chutney powder than the control

Conclusion

Green leafy vegetables are an excellent source of vitamins, minerals, fibers, and other bioactive compounds like phenols, flavonoids, ascorbate, antioxidant activity, and radical scavenging activity.*Aerva lanata* is a seasonal underutilized green leafy vegetable with potential nutritional and health benefits. Value addition of instant chutney powders with *Aerva lanata* was well accepted in all sensory parameters. Overall nutrient content of the developed was excellent when compared to the control sample. As *Aerva lanata* is a seasonal leafy vegetable, sensitive to deterioration even when stored under refrigerated conditions; therefore, dehydration and development of value-added products from these is an effective way to preserve these kinds of leafy vegetables.

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