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Processing and estimation of nutritional composition of drumstick (*moringa oleifera*) leaf powder for human consumption

Vittal Kamble and Bhuvaneshwari G

Abstract
Drumstick (*Moringa oleifera*) originated in India is one of the most useful tropical tree. With its high nutritive values every part of the tree is used for nutritional or commercial purpose. Moringa leaves are rich source of minerals, vitamins especially vitamin A, vitamin B and vitamin C and it is used as antioxidant, anticancer, anti-inflammatory, antidiabetic, antimicrobial agent and it is widely consumed for self-medication by patients affected by diabetes, hypertension, or HIV/AIDS. The young leaves are edible in some quantities and it can be dried and make into powder for use in some food products. In this study, processing of fresh moringa leaves into dry form for consumption purpose and nutritional composition of dried drumstick leaf powder (Moisture, Protein, Crude Fibre, Ash, Fat, Total Carbohydrate, Calories, Calcium, Magnesium, Iron, Zinc and ß- Carotene) was described.

Keywords: drumstick leaf powder, minerals and noodles

Introduction
Drumstick (*Moringa oleifera)* is an important perennial vegetable crop and is now seen as one way of helping subsistence farmers make better use of their land and improve their living standards. Since the trees can grow in arid and semi-arid areas and are able to withstand temperature up to 40 ˚C, they can offer new income generating opportunities for people living in areas regarded as agriculturally unproductive. A wide variety of nutritional and medicinal virtues have been attributed to its roots, bark, leaves, flowers, fruits and seeds (Kumar *et al.*, 2010) [11]. Drumstick leaves are nutritious and highly perishable in nature. This has been one of the major drawbacks for processing. The crop is mainly grown for its tender pods and very little attention has been paid for the development of processed products from leaves. Phytochemical analyses have shown that its leaves are particularly rich in potassium, calcium, phosphorous, iron, vitamins A and D, essential amino acids as well as antioxidants such as β-carotene, vitamin C and flavonoids (Amaglo *et al.*, 2010; Gowrishankar *et al.*, 2010) [2, 6]. A study on phytochemical and nutritional properties of dried leaf powder of *Moringa oleifera* Lam. was investigated by Isitua *et al.* (2015) [9] and revealed the following nutrients; proteins (24.31%), carbohydrate (55.97%), ash (11.50%), crude fibre (10.28%), total fat (9.22%), moisture (6.12 %), caloric value (404.10 Kcal/100 g) and saturated fatty acids (3.77 %), unsaturated fatty acids (5.45 %), monounsaturated fatty acids (0.87 %), polyunsaturated fatty acids (4.58 %) and trans fatty acid (0.00 %) for fatty acid profile. Thus, for the health conscious genre of the present world, drumstick leaf powder is perhaps one more addition to the proliferating list of healthy foods, owing to its nutritional superiority. It is springtime for potential drumstick leaf powder to be woven in the fabric of daily diet. Drumstick leaf powder has been utilized for formulation of ready to eat items, fermented foods, bakery foods and convenience mixes. There is a need to increase the consumption of drumstick leaf powder by incorporating into food products. The present study was carried to determine the nutritional composition of dried drumstick leaf powder.

Materials and Methods
Processing of raw drumstick leaves into powder
The leaves of KDM-01 (Bhagya) a newly released drumstick variety of University of

Horticultural Sciences, Bagalkot was used for the study. This variety grows best in tropical and subtropical regions. It grows up to 2.5 to 3.0 m height, having average pod length of 65 to 70 cm and leaves are rich source of β- carotene, vitamin C and iron. The twigs containing half matured drumstick leaves were taken to laboratory. The leaves were separated from twigs, washed thoroughly in clean running water, drained and spread on the clean stainless steel tray to remove surface moisture. After removal of surface moisture leaves were weighed and dried under electrical tray drier at 60˚C until they were crisp. Dried drumstick leaf powder was packed separately in LDPE bags (200 gauze) for further use.

Fig 1: Dried drumstick leaf powder

Observations recorded

Moisture (g)

Moisture contents were measured by slightly modifying the hot air oven method (Anon, 1995) [3]. Empty stainless steel moisture dishes with lids were first dried into a pre-heated oven (100 ± 1°C) for 1 h. The dishes and lids were then cooled for 30 min in a desiccator. Approximately 5 g samples were accurately weighed into the pre-weighed dishes and placed into the oven with the lids placed under the respective dishes. These samples were dried at 105°C for 3 h and cooled in a desiccator for 30 min. The process of drying, cooling and weighing was repeated until constant weight obtained. Results were calculated in percentage using the following equation:

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{\text{Weight of the sample}} \times 100$$

Where,

W_1 = Weight of the moisture cup and sample before heating

W_2 = Weight of the moisture cup and sample after heating

Protein (%)

Determination of protein content was carried out by micro kjedhal method which consists of wet digestion, distillation and titration. The protein content was determined by weighing 0.2 g of samples and transfer to a 250 ml Kjeldahl flask care to see that no portion of the sample clings to the neck of the flask. To this 1 to 2 g of catalyst mixture (potassium sulphate 100 g and copper sulphate 20 g) and 10 ml of concentrated H_2SO_4 was added. Flask was placed on the stand in the digestion chamber and continue the process of digestion until the colour of the digest is pale green. The digestion mixture was cooled by adding 30 ml of water. After digestion, distillation was carried out using 40% NaOH and 20% boric acid using methyl orange as an indicator and titrate against 0.1 N H_2SO_4. The protein content was calculated as follows:

$$\text{Nitrogen (\%)} = \frac{14.01 \text{ x ml titrate value of sample x N of } H_2SO_4 \text{ x } 100}{\text{Sample weight (g) x } 1000}$$

Protein content was obtained by converting nitrogen to protein by using conversion factor of 6.25

Protein (%) = 6.25 x Nitrogen (%)

Crude fibre (%)

Crude fibre estimation was done by using Fibra plus-FES-6 instrument**.** About 1 g of the sample was weighed in the crucibles, fixed to the fibra plus instrument and then 100 ml of 1.25% H_2SO_4 was added to all the samples by closing the knobs. The temperature was set to 370˚C and leave the sample for 40 minutes. After 40 minutes the temperature was reduced to 200˚C and open the knobs to remove all H_2SO_4 by suctioning and washed with distilled water by suctioning and the same procedure was repeated by adding of 100 ml of 1.25% NaOH to all the samples. Then crucibles was taken and kept in an oven at 100˚C for 3 hours and the crucibles were cooled in desiccator and weight was taken (W_1). After weighing crucibles were kept in a muffle furnace at 500˚C for 1 hour, allowed to cool and reweighed (W_2). Per cent of crude fibre in the drumstick leaf powder was calculated by using the following formula:

$$\text{Crude fibre (\%)} = \frac{W_1\text{ (g) - }W_2\text{ (g)}}{\text{Weight of the sample (g)}} \times 100$$

Where,

W_1 = Weight of crucibles after drying in an oven

W_2 = Weight of crucibles after ashing in muffle furnace

Ash (%)

Total ash content was determined by burning the samples in pre-weighed crucible in a muffle furnace at 500°C for 6 hours (Rao and Bingren, 2009) [17]. After burning the residue ash weight was recorded and ash content was calculated by using the formula

$$\text{Total ash (\%)} = \frac{\text{Weight of the ash (g)}}{\text{Weight of the sample (g)}} \times 100$$

Fat (%)

Fat content was determined by using the Socs plus-SCS-6 AS instrument as described by Ojure and Quadri (2012) [14]. Initially weight of the beaker was taken (initial weight) and two grams samples were taken in thimbles and place the thimbles in thimble holder and keep the thimble holder in a beaker and to this 80 ml petroleum ether was added. The fat extraction process was carried out for 45 minutes by setting the temperature at 90˚C. After 40 minutes the beakers were kept in an oven at 100˚C for 10-15 minutes to evaporate the petroleum ether. The beakers were then cooled in a desiccator and weighed again (final weight). The fat content was calculated using the following formula:

$$\text{Fat content (\%)} = \frac{\text{Final Weight (g) - Initial weight (g)}}{\text{Weight of the sample (g)}} \times 100$$

Total carbohydrate

The total carbohydrate content was determined 100 minus summing the values of moisture, protein, fat, ash, crude fibre.

Calories (Kcal)

The calorific value was determined by differential method using values of carbohydrate, fat and protein.

Mineral content (Ca, Mg, Fe and Zn) (mg)

Calcium and magnesium was determined by complenomertric titration method involving standard EDTA (Piper, 1966) [16]. Iron and Zinc estimation was done by wet digestion, it involves oxidizing acids like HNO_3: H_2SO_4: $HCLO_4$ tri-acid mixture or HNO_3: $HCLO_4$ Di- acid mixture.

ß- Carotene (mg)

Beta-carotene content was determined by soaking 5 g sample in 15 ml of AR grade acetone for 2hrs at room temperature under dark condition in order to get complete carotene extraction. The carotene layer was separated using petroleum ether through separating funnel. The volume was made up to 100 ml with petroleum ether and then this layer was again passed through sodium sulphate over the funnel in order to remove moisture from the layer. The optical density of the layer was measured at 452nm using petroleum ether as blank (Srivastava and Kumar, 2002) [20].

$$\text{Beta-carotene } (\mu g/g) = \frac{\text{O. D x } 13.9 \text{ x } 10^4 \text{ x } 100}{\text{Weight of the sample x } 560 \text{ x } 1000}$$

Preparation and analysis of noodles incorporated with DLP

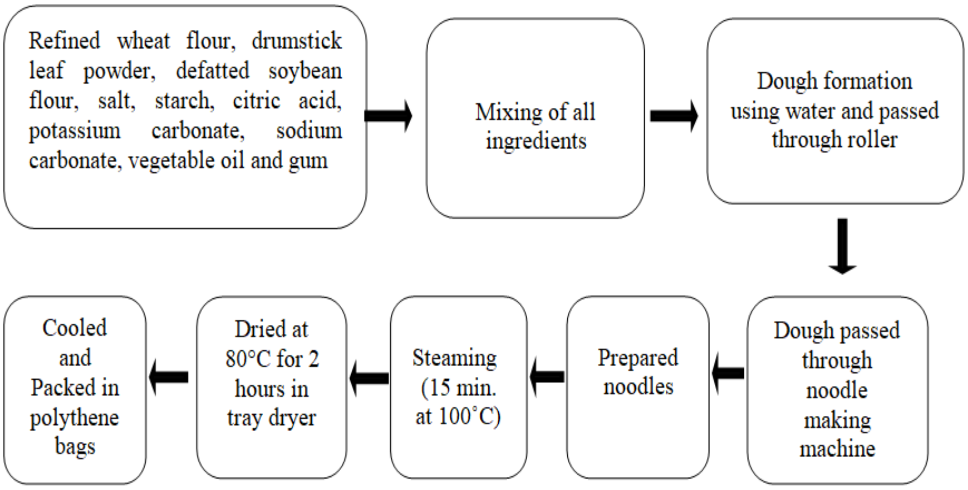

Fig 2: Flow chart for preparation of noodles incorporated with drumstick leaf powder

The prepared noodles were analysed for the nutritional composition like moisture (g), protein (g), crude fibre (g), ash (g), fat (g), Ca (mg), Mg (mg), Fe (mg), Zn (mg), Beta-carotein (mg) by using the above procedure and organoleptic evaluation was carried out by semi-trained students and teachers of college of Horticulture Bagalkot.

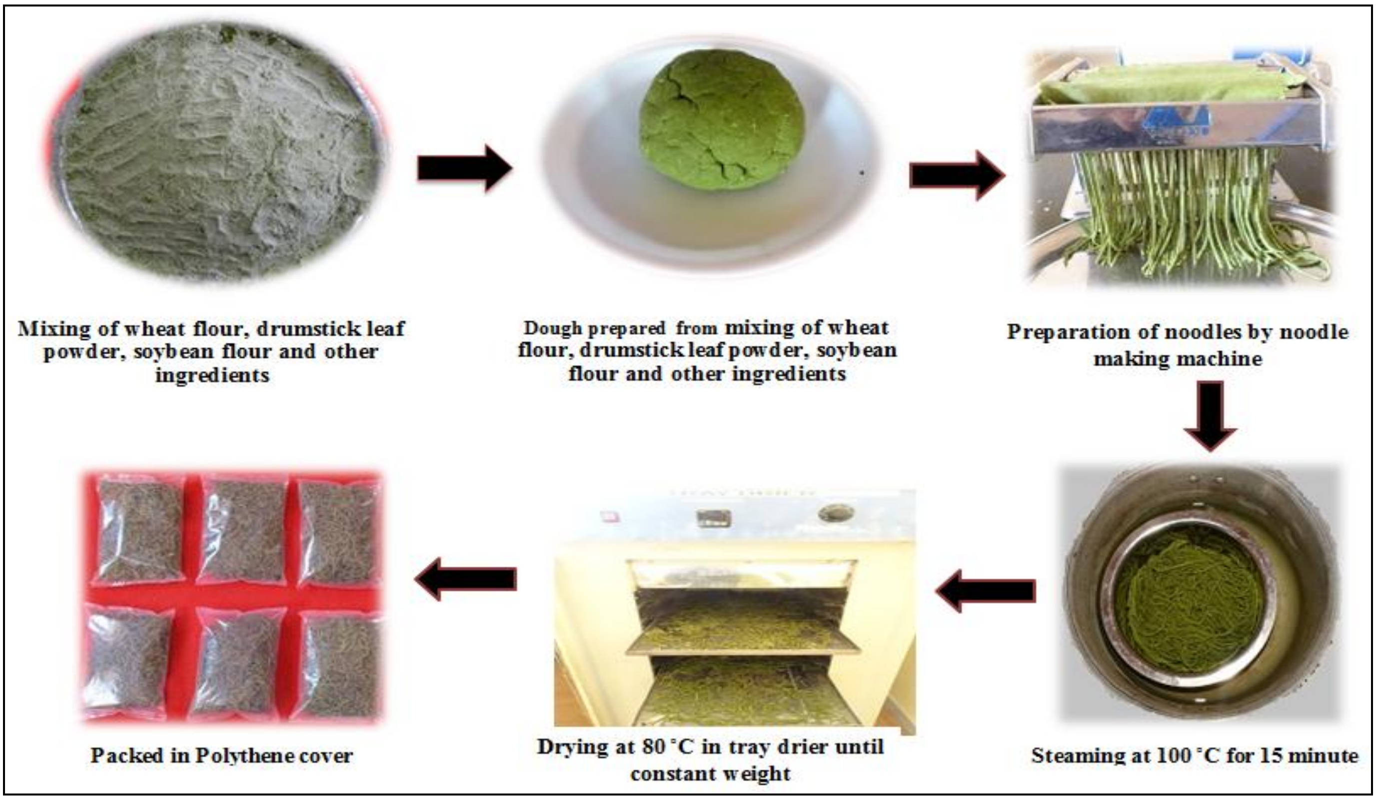

Fig 3: Preparation method of drumstick leaf powder and other ingredients incorporated noodles

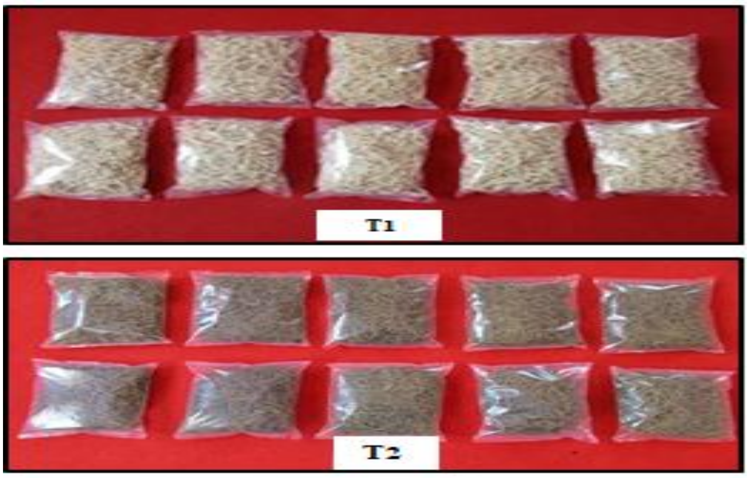

Fig 4: Noodles incorporated without drumstick leaf powder (T_1) and with drumstick leaf powder (T_2)

Statistical analysis

The data were analysed according to unpaired 't' test to compare the variation among the treatments. The level of significance used in F and t test was at one per cent level of significance.

Results and Discussion

The nutrient compositions of dried drumstick leaf powder were as follows. The moisture, protein, crude fibre, ash, fat, total carbohydrate and calorific values were 6.55±0.36 %, 24.71±0.33 %, 11.03±0.73%, 11.71±0.21%, 9.41±0.22 %, 36.56±1.29% and 329.00±2.98 K. Cal/100 g, respectively. Calcium (2.80±0.08 g), magnesium (835.10±8.77 mg/100 g), iron (32.89±0.44 mg/100 g), zinc (2.54±0.10 mg/100 g) and ß- Carotene (16.53±0.18 mg/100 g) content was found to be higher in dehydrated drumstick leaves powder. These results are agreement with Isitua *et al.* (2015) [9]; Titi *et al.* (2012) [21] and Ibok *et al.* (2008) [8].

Table 1: Nutrient composition of dried drumstick leaf powder (Per 100 g)

Sl. No.	Nutrients	Mean ±SD*
1	Moisture (g)	6.55±0.36
2	Protein (g)	24.71±0.33
3	Crude fibre (g)	11.03±0.73
4	Ash (g)	11.71±0.21
5	Fat (g)	9.41±0.22
6	Total carbohydrates (g)	36.56±1.29
7	Calories (Kcal)	329.00±2.98
8	Calcium (mg)	2.80±0.08
9	Magnesium (mg)	835.10±8.77
10	Iron (mg)	32.89±0.44
11	Zinc (mg)	2.54±0.10
12	ß- Carotene (mg)	16.53±0.18

*****Values are the mean of five replications

Large amount of the vitamins are lost during drying and storage, the leaf powder still constitutes a very rich nutritional supplement, since it is a concentrate of the leaves. Moringa leaf powder can be stored for some time before it is consumed. If so, the leaf powder has to be stored in a water- air- and light-proof container to preserve as much vitamins as possible and avoid microbial contamination. In storage, the protein and mineral contents will be preserved for up to six months, whereas a loss of up to 50% of vitamins can be reached after six months of storage. Once the container is opened, the leaf powder should be consumed quickly (within one week) since its water content will increase and it will be exposed to microbial contamination. For this reason, it is advised to package leaf powder in rather small containers. Moringa Leaf Powder can be added to any food or beverage and it will increase the vitamin, mineral and protein content. For healthy individuals, a few spoonful's of moringa leaf powder can be added to any meal to make it more nutritious. Since the nutrient content of moringa leaf powder decreases if exposed to heat, add the powder after the food or drink has been prepared, just before serving. Moringa leaf powder has the greatest impact on those who are more vulnerable: malnourished children, pregnant or lactating women, children at weaning age, HIV/AIDS patients, and the elderly. Malnourished children ages 1-3 years should consume three rounded tablespoons (25g) of moringa leaf powder each day. Pregnant or lactating women should consume six rounded tablespoons (50g) of moringa leaf powder each day. Promotion of moringa leaf powder incorporated foods would help not only for alleviating micro nutrient deficiencies but also to develop entrepreneurship which could provide an additional source of income, employment and exports to the farmers, entrepreneurs and processors.

Organoleptic evaluation

Organoleptic evaluation of noodles incorporated with drumstick leaf powder was carried out. The highest score for colour and appearance was found in control (8.00) and more mean score for flavour (7.91), taste (7.91), texture (8.17) and overall acceptability (8.21) was recorded in T_2 (Table 2). The scores for all sensory characters of noodles were found to more in T_2 except for colour. The drumstick leaf powder added noodles shows the light green colour these are not accepted by the panelist (Fig 4). The noodles prepared by using drumstick leaf powder were scored more it may be due to good taste and flovour. The bitter taste of drumstick leaf powder was lost during the drying process of noodles. These findings are similar with Wani *et al.*, 2013 [22] revealed that, sensory score for noodles incorporated with cauliflower is more compared to the control.

Nutritional composition of noodles incorporated with DLP

The moisture content of any food material is of significance to shelf life, packaging and general acceptance. In the present study, the significant difference was found to exist in the mean moisture content of noodles (Table 3). The highest moisture content was recorded in control T_1 (6.73%) and lowest moisture content was recorded in T_2 (5.09%). This might be due to incorporation of drumstick leaf powder which did not hold more water. It is also possible that the low lipid content of drumstick leaf powder added noodles resulting in decreased water holding capacity when compared to wheat flour noodles. Low moisture content is important in the shelf life of noodles. Ritthiruangdej *et al.* (2011) reported that the moisture content of dried noodles decreased when the level of banana flour in the noodles was increased. These results are in agreement with Eyidemir and Hayta (2009) [4] who reported that adding of apricot kernel flour (AKF) led to decrease in the moisture contents of noodles.

The highest protein content was recorded in the T_2 (17.13%) and it might be due to incorporation of defatted soybean flour and DLP (Table 3). These results are similar with Wani *et al.* (2013) [22] who reported that the protein content (13.42) of noodles was increased with the incorporation of cauliflower leaf powder. Similar increase in protein content were also observed by Mridula *et al.* (2006) [13] when noodles were incorporated defatted mustard flour (DMF).

The highest mean score for crude fibre (1.34%) was recorded in T_2 and lowest was found in control (0.39%) (Table 3). Significant increase in crude fibre content was observed in drumstick leaf powder incorporated noodles as drumstick leaf powder is rich source of crude fibre when compared refined wheat flour. More crude fibre content was noticed in vegetable noodles possibly because of vegetables being rich in crude fibre (Ganiyu, 2005) [5].

Significantly low fat content was observed in drumstick leaf powder incorporated noodles (Table 3) *i.e.*, T_2 (4.59%) when compared to control (5.07%). These results are in conformity to the results of Moss *et al.* (1987) [12] and Park and Baik (2004) [15] who suggested that lower fat content in noodles was due to a more compact structure as a result of strong adherence between protein and wheat starch as that found in instant noodles with higher protein content.

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents which provides the measure of total amount of minerals within the food (Shahnawaz *et al.*, 2009) [19]. In the present study significant difference was found to exist in the mean ash content of treatments. The highest ash content was recorded in T_2 (4.48%) and the lowest ash content was recorded in control T_1 (2.91%) (Table 3). This might be due to incorporation of drumstick leaf powder in T_2 which is a rich source of minerals. Wani *et al.* (2013) [22] observed that the noodles incorporated with 20 per cent cauliflower leaf powder recorded the highest value of 1.01 per cent 15 per cent cauliflower leaves with an ash content of 0.96 per cent.

Mineral composition and beta-carotene content of noodles incorporated with DLP

The mineral contents (calcium, magnesium, zinc and iron) of noodles produced in this study were significantly affected by incorporation of drumstick leaf powder. The data revealed that the mineral content of noodles was significantly influenced among the treatments and all the minerals increased with the incorporation of drumstick leaf powder. The highest mineral contents Ca (33.00mg/100g), Mg (32.80mg/100), Fe (32.42mg/100g) and Zn (9.66mg/100g) were recorded in T_2 (5% DLP) it might be added drumstick leaf powder (Table 4). Wani *et al.* (2013) [22] revealed that, the iron content of noodles was significantly influenced by different treatments and increased with the incorporation of cauliflower leaf powder. Himabindu and Devanna (2015) [7] revealed that minerals like calcium and iron are significantly increased in sample because kodo millet and spinach are rich in iron and calcium. As the amount of nettle leaves flour increased in the proportion with wheat flour, the amount of calcium, iron and zinc were significantly increased. Similar results were observed in cookie produced from wheat: moringa blends, quality protein maize based complementary food and wheat: soybean cookie (Alemayehu *et al.*, 2016) [1].

The highest value of beta-carotene content was observed in T_2 (1.73µg/g) and the minimum value was obtained in T_1 (0.48µg/g). Incorporation of drumstick leaf powder which is a rich source of beta-carotene may enhance the beta-carotene content in T_2 noodles (Table 4). These findings are similar to Wani *et al.* (2013) [22], who reported that beta carotene content was highest in cauliflower leaf powder incorporated noodles. Karnjanawipagul *et al.* (2010) [10] showed that β-carotene content was higher in noodles supplemented with carrot flour and it varied from 1.02-7.11µg /100 g.

It conclude that, use of drumstick leaf powder as direct or indirect provides number of health benefits to human body and it also creates job opportunities in rural and urban areas because it needs some manpower to convert fresh leaves into dry powder and making of value added products of drumstick leaf powder.

Table 2: Organoleptic evaluation of noodles incorporated with drumstick leaf powder.

Treatments	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
T_1:DLP(0 g)	8.00	7.05	7.33	6.96	6.83
T_2:DLP (5 g)	7.11	7.91	7.91	8.17	8.21
Mean	7.56	7.48	7.62	7.56	7.52
SD	0.56	0.69	0.35	0.60	0.53
t-value	2.83*	2.94*	3.26*	3.07*	5.28*

* Significant at 1% of level

Note: DLP: Drumstick Leaf Powder, T_1: Control

Table 3: Nutritional compositions of noodles prepared by using drumstick leaf powder.

Treatments	Moisture (%)	Protein (%)	Crude fibre (%)	Fat (%)	Ash (%)
T_1:DLP(0 g)	6.73	11.76	0.39	5.07	2.91
T_2:DLP (5 g)	5.09	17.13	1.34	4.59	4.48
Mean	5.91	14.44	0.86	4.83	3.69
SD	0.80	0.40	0.22	0.10	0.29
t-value	3.76*	33.41*	12.63*	5.78*	16.26*
% increase/decrease over control	24.36	45.66	5.22	9.46	53.95

* Significant at 1% of level

Table 4: Mineral composition and beta-carotene content of noodles incorporated with drumstick leaf powder.

Treatments	Ca (mg/100g)	Mg (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)	Beta-carotene (μg/ g)
T_1:DLP(0 g)	24.00	23.60	22.38	6.50	0.48
T_2:DLP (5 g)	33.00	32.80	32.42	9.66	1.73
Mean	28.50	28.20	27.40	8.08	1.10
SD	2.70	2.69	8.65	5.31	0.01
t-value	9.10*	8.98*	3.06*	3.86*	19.22*
% increase/decrease over control	27.27	38.98	44.86	48.61	8.30

* Significant at 1% of level

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