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### Improvement in nutritional quality of commonly consumed products with supplementation of drumstick leaves (*Moringa oleifera* L.)

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#### Abstract

Traditional Indian cuisine is a mixture of various Indian recipes with different taste and method of preparations. With this variety, some of the recipes are commonly prepared in most of the Indian households. Preparation of household recipes with supplementation of nutrients rich food sources can be proven as a substantial method for value addition of Indian diet. Green leafy vegetables act as a very promising tool for value addition as these are rich in vitamins and minerals with an immense variety of non-nutritive health promoting factors. One such underutilized, promising nutritive, phytochemicals and antioxidants rich green leafy vegetable is drumstick (*Moringa oleifera*). Incorporation of pretreated drumstick leaves into *missi roti*, pancake, vegetable *dalia*, *chana dal* and potato leaves vegetable at three levels as 30 % (S1), 45 % (S2) and 60% (S3) were found acceptable with the overall acceptability scores ranging from 7.92 (vegetable *dalia*, S1) to 6.72 (Potato leaves vegetable, S3) on Hedonic Rating Scale. Analysis of 30% drumstick leaves supplemented products showed higher protein and fat content as compared to control. The  $\beta$ -carotene and ascorbic acid content in drumstick leaves supplemented products were ranged between 1322.63-2946.37 $\mu$ g/100g and 12.16-49.32mg/100g respectively. Increase in  $\beta$ -carotene, ascorbic acid and calcium content were significantly high in drumstick leaves supplemented products as compared to control. Thus Supplementation of drumstick leaves into organoleptically acceptable commonly consumed recipes would be a most suitable protocol for Indian dietary diversification and micronutrients enhancement.

**Keywords:** Drumstick leaves, value addition, micronutrients, household recipes

#### Introduction

Indian cuisine is one of the most acknowledged and treasured cuisine in the world due to immense variety and delicious taste. While the eating pattern of Indians are changing according to modernization, but a taste is still alive for traditional recipes. Traditional recipes are commonly prepared and consumed in each Indian household on regularly basis like chapatti, *pulav*, *poha*, *parantha*, *dalia*, *poori*, potato vegetable etc. Addition of nutritious, easily available, cost effective and acceptable food ingredients in these recipes can increase their nutritional value as well as provide healthy approach to consume foods. Green leafy vegetables can be chosen as a valuable food ingredient/supplement to apply this approach in diet. In most of the green leafy vegetable, drumstick leaves are identified as a promising source of nutrients and health promoting factors, but still it is underutilized. Drumstick (*Moringa oleifera*), locally known as *shajana*, belongs to the family *Moringaceae* which is available throughout the year at low cost or no cost (Anwar *et al* 2007) [3]. Drumstick leaves is especially promising as a food source, with a treasure trove of micronutrients and several bioactive compounds which have various biological activity in human body like anticancer, antimicrobial, anti-inflammatory, antiulcer, antispasmodic, antiepileptic, diuretic, antihypertensive, cholesterol lowering, antioxidant, immuno stimulating, antidiabetic and hepatoprotective activities (Chumark *et al* 2008) [6]. Drumstick tree is also referred as an exceptionally precious vegetable tree which is referred as "Miracle Tree" or "Wonder Tree", "Natural Nutrition for Tropics" (Fugile 2001) [8] and "Mother's Best Friend" (Sudhir *et al* 2010) [17] due to its several nutritional, pharmacological and industrial applications. Thus, drumstick leaves are found suitable to provide a biologically metabolized nutritional composition for health, well being and treatment of ailments (Andrews and Andrews 2009) [2].

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However the strategy of synthetic supplementation in the form of pharmaceuticals provide only the specific nutrients whereas the food based approach provides a package of both macro and micro nutrients with addition of antioxidants and nutraceuticals including dietary fibre. Thus, incorporation of drumstick leaves into simple and commonly consumed recipes can be proven as a cost effective and easy approach to combat micronutrient deficiencies and provide protection from various degenerative diseases.

### Materials and Methods

Samples of drumstick (*Moringa oleifera*) leaves and pods (free from blemishes and damage) were procured during mid June to mid November 2011 from the Department of Vegetable Crops, Punjab Agricultural University, Ludhiana, India. For standardization of food products, commonly consumed food items i.e. *wheat flour*, *dalia*, *besan* and *chana dal* were procured from the local market along with other ingredients like oil, spices, sugar, salt and fresh vegetables.

Pretreated (pressure cooked for 2 Min.) Drumstick leaves were supplemented into *Missi roti*, Pancake, *Vegetable Dalia*, *Chana dal* and Potato Leaves Vegetable at three levels as 30g, 45g and 60g levels per 100g of main raw ingredient of product (Table 1). The developed products were organoleptically evaluated on 9 point Hedonic Rating Scale by a trained panel of 10 judges from Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. After the development of products, the highly acceptable product along with its corresponding control were weighed, homogenized and oven dried at 60°C. Dried samples were stored in air tight plastic bags for further chemical analysis of proximate composition, iron and calcium (AOAC 2000) [5],  $\beta$ -carotene (Rangana 1995) [16] and ascorbic acid (AOAC 1996) [4] of samples were analyzed on fresh weight basis. Antinutrients such as phytates (Haug and Lantzsch 1983) [11], polyphenols (AOAC 2000) [5] and oxalates (Abeza *et al* 1968) [1] were also analyzed.

### Results and Discussion

#### Organoleptic evaluation

The mean scores of acceptability trials of drumstick leaves supplemented products by expert panel of judges using 9 point hedonic rating scale are presented in Table 2. All the products developed by using drumstick leaves were found acceptable at all three levels of supplementation. The 30g level of drumstick leaves supplementation was found highly acceptable in all the products with overall acceptability scores ranging from 7.92 to 7.29 being highest for vegetable *dalia* and lowest for potato leaves vegetable. The overall acceptability of S1 sample was comparatively higher than control in all products except potato leaves vegetable. The control of potato leaves vegetable was highly accepted with the overall acceptability score of 7.87 compared to S1 sample i.e. 7.20. The 45g level of supplementation and control were found comparable in vegetable *dalia*, *chana dal* and *missi roti* which were liked moderately. The scores of overall acceptability for S3 sample in all products ranged from 6.72 to 7.34 which were lower to other samples which liked slightly. This indicates that increasing the level of drumstick leaves supplementation to 60g decreased the overall acceptability scores of developed products due to development of dark green color, bitter taste, strong flavor and rough fibrous texture. A significant ( $p \leq 0.05$ ,  $p \leq 0.01$ ) difference was observed for all the sensory attributes of all products except in flavor and texture parameter of vegetable

*dalia* and color for potato leaves vegetable. It may be due to mixing of flavors and softening of drumstick leaves during pressure cooking of *dalia*. The 30g level of supplementation was most liked in *dalia*, *missi roti* and pancake with the overall acceptability scores of 7.92, 7.91 and 7.90 respectively followed by *chana dal* (7.75) and potato leaves vegetable (7.56). Dachana *et al* (2010) [7] found that increasing amount of drumstick leaves from 0-15% in cookies, increased water absorption and decreased dough stability which decreases the acceptability of cookies at higher level. Kushwaha *et al* (2013) [13] reported that 15% drumstick leaves powder supplementation was acceptable for *missi roti* and chapatti whereas 10% level for vegetable.

#### Proximate composition

The proximate composition of test sample (S1) and control of all developed products supplemented with drumstick leaves are given in Table 3. The proximate composition of fresh drumstick leaves was found as 74.32g moisture, 6.3g crude protein, 1.53g fat, 0.6g fibre, 1.66g ash, and 15.59g carbohydrate and 102Kcal/100 g energy. Among drumstick leaves supplemented products, pancake showed maximum protein, fat and ash content as 20.38, 16.92 and 2.80g/100g respectively on dry matter basis. Maximum fiber content was found in vegetable *dalia* as 2.29g/100g with a non significant difference from control. The highest energy content was found in pancake (457Kcal) followed by potato leaves vegetable as 415Kcal/100g. A significant increase in moisture, protein and ash content was found in S1 sample as 3.39, 2.88 and 3.33g respectively in 100g potato leaves vegetable. Kushwaha *et al* (2013) [13] also found a significant increase in protein and fat content in *missi roti* and chapatti with 15% supplementation of drumstick leaves.

#### Vitamin content

##### $\beta$ -carotene

The  $\beta$ -carotene content in the developed products using drumstick leaves is presented in Table 4 and Fig. 1. A significant ( $p \leq 0.01$ ) increase in the  $\beta$ -carotene content with 30g drumstick leaves supplementation, which increased more than 19-267 fold  $\beta$ -carotene of all products on fresh weight basis for *chana dal* and potato leaves vegetable respectively. This significant ( $p \leq 0.01$ ) increase in the  $\beta$ -carotene content of the preparations may be attributed to the high  $\beta$ -carotene content of drumstick leaves ((16794.40 $\mu$ g/100g). The maximum content in S1 sample was found in potato leaves vegetable (2946.37 $\mu$ g) and minimum in pancakes (1322.63 $\mu$ g). Maximum percentage increase was found to be in potato leaves vegetable as the  $\beta$ -carotene is more soluble in fat as compared to water. The increase in  $\beta$ -carotene content in S1 sample of pancake was lowest as compared to other preparations which may be due to the loss of  $\beta$ -carotene on direct heating of pancake. The  $\beta$ -carotene content of S1 sample of *dalia*, *chana dal* and *missi roti* was found to be 2067.38, 2428.96 and 2402.04 $\mu$ g/100g respectively. Nambiar and Pranami (2008) [14] also reported 3995 and 3966 $\mu$ g/30g  $\beta$ -carotene in 20g fresh drumstick leaves supplemented desi *chana* and mung *dal* in which 3938 $\mu$ g  $\beta$ -carotene is contributed by drumstick leaves.

##### Ascorbic acid

The results presented in Table 4 and Fig. 2 revealed that the ascorbic acid content in S1 samples was found to be significantly ( $p \leq 0.01$ ) higher than control, for *missi roti*, pancake and *dalia*. The ascorbic acid content of fresh

drumstick leaves was found as 208.33mg/100g. The means score of ascorbic acid content for *chana dal* was 3.33mg/100g in control which significantly ( $p \leq 0.05$ ) increased in test sample as 39.33mg/100g. Among S1 samples, maximum increase in ascorbic acid content was observed in pancake (46 fold) followed by *missi roti* (40 fold) and minimum in potato leaves vegetable (2 fold). It may be due to that wheat flour and bengal gram flour are poor sources of ascorbic acid as compared to potatoes (Gopalan *et al* 2007) <sup>[10]</sup>.

### Mineral content

#### Iron

The iron content of the developed products has been presented in the Table 5 and Fig. 3. The iron content of drumstick leaves was found as 1.35mg/100g on dry weight basis. Addition of 30g drumstick leaves in control sample resulted in non significant increase in iron content of developed products except potato leaves vegetable. The control sample of potato leaves vegetable was found to contain 0.59mg/100g iron which significantly ( $p \leq 0.05$ ) improved to 1.32mg/100g. The iron content of control sample of *missi roti* was 4.47mg/100g which improved to 4.96 mg/100g in S1 sample. The iron content of control *dalia*, *chana dal* and pan cake was found to be 6.39, 5.08 and 4.49mg/100g respectively with supplementation of 30% drumstick leaves. Nambiar and Parnami (2008) <sup>[14]</sup> reported the iron content in drumstick leaves supplemented *kabuli channa* as 1.6mg per 30g raw weight.

#### Calcium

The results of the calcium content of the developed products as shown in Table: 5. indicated that the 30g level of drumstick leaves supplementation, significantly ( $p \leq 0.05$ ) improved the calcium content of *missi roti*, *dalia* and pancake as compared to control sample. In all preparations, the calcium content increased from 84% (*missi roti*) to 1000% (potato leaves vegetable) in test samples as compared to corresponding control. The potato leaves vegetable was found to contain minimum calcium content in control as 10mg/100g which significantly ( $p \leq 0.01$ ) increased to 1000% in S1 sample with the value of 110mg/100g. It was observed that the percentage increase was higher for those products which were originally poor sources of calcium. The calcium content of *chana dal* was 53mg/100g which significantly ( $p \leq 0.01$ ) improved to 130.5mg/100g in S1 sample. The 30g level of drumstick leaves supplementation in pancake and *dalia* was found to result in 156% and 114% increase of calcium content as compared to control. Nambiar and Parnami (2008) <sup>[14]</sup> gave a value of 151mg of calcium per 30g raw weight of drumstick leaves supplemented *kabuli channa*. Mineral content of depends on maturity level and seasonal variation which have a profound effect on mineral profile of green leafy vegetables. Pant *et al* (2012) <sup>[15]</sup> reported the calcium content of 25% supplemented *mathi* and *pakora* as 94.25 and 144 mg/100g with 25% drumstick leaves supplementation.

### Antinutritional factors

#### Phytates:

The phytate content of control samples in various cooked preparations ranged from 14.01 to 189.26 mg/100g being minimum in potato leaves vegetable and maximum in *missi roti* (Table 6). Addition of 30g drumstick leaves in control samples non-significantly improved the phytate content of all developed products except *chana dal* ( $p \leq 0.05$ ). This increase

may be due to addition of drumstick leaves at end point of cooking. However, *dalia* contain 157.36mg/100g phytates in control which also increased to 165.63mg/100g non-significantly. The reason of more increase in phytate content in *dalia* and *chana dal* may be due to the less availability of free components in cooking as both are cooked by wet cooking methods. A non significant increase in phytate content was observed in *missi roti*, pan cake and potato leaves vegetable. The reason may be attributed to the formation of insoluble complexes between phytates and other components of foods. Another reason may also be the high ascorbic acid content of the green leaves, which may stimulate the activity of phytase enzyme thus causing reduction in phytate content of the products. As compared to present study, Pant (2013) <sup>[13]</sup> reported very less amount of phytate content in 25g drumstick leaves supplemented *missi roti*, *kabuli chana*, *dalia* and pancake as 113, 106, 102.3 and 100.5mg/100g on dry matter basis.

#### Polyphenols

The polyphenol content of the control samples of all the products ranged from 45.04 for potato leaves vegetable to 251.80 mg/100g for pancake (table 6). Polyphenolic compounds in foods are mostly responsible for their pungent and bitter taste, but these also improve photochemical properties of foods. The polyphenols content in *dalia*, pancake and *channa dal* was observed to be 179.51, 251.80 and 172.09mg per 100g respectively. With supplementation of 30g drumstick leaves, the polyphenol content increased significantly ( $p \leq 0.05$ ) in *dalia* from 179.51mg/100g in control to 215.33mg/100g in test sample (S1) which may be due to fact that more release of phenolic compounds in pressure cooking of *dalia*. The polyphenol content in S1 samples of *missi roti* and pancake were found to be 264.98 and 253.62mg/100g respectively while 181.42mg/100g for *chana dal*. The reason of non significant increase may be the lesser difference in polyphenol content of green leafy vegetables as compared to the cereals and pulses. Gitanjali (2004) <sup>[9]</sup> reported the total phenolic content of wheat *roti*, malted ragi flour porridge and sprouted green gram *dal* as 89.41, 53.35 and 214.85mg/100g as gallic acid equivalents on fresh weight basis.

#### Oxalates

The oxalates content of the developed products using drumstick leaves has been presented in Table 4.19. and Fig. 4-5. The oxalates content of the control samples of all the products was found to be ranged between 2.7mg/100g for pancake to 16.2mg/100g in *dalia*. Control sample of *missi roti* and *dalia* were found to contain more oxalates as compared to other preparations. Supplementation of drumstick leaves into products significantly increased the oxalate content of all developed products, due to its high oxalates (111.75mg/100g in fresh drumstick leaves). The oxalate content in pretreated drumstick leaves supplemented *missi roti* and *dalia* was found to be 35.3 and 26.8mg per 100g respectively, which was significantly ( $p \leq 0.05$ ) higher from their corresponding controls. The oxalate content of control samples of *chana dal* and potato leaves vegetable was found to be 1.8 and 9.9mg/100g respectively. Kachhawa *et al* (2013) <sup>[12]</sup> also reported that application of pressure cooking as pretreatment on drumstick leaves can reduce 47.3% oxalates content on dry weight basis.

**Table 1:** Recipes of the developed products using drumstick leaves

Product	Ingredients used		Description of recipe	Cooked weight	No. of serving
	Name	Amt.			
Missi roti	Wheat flour	100g	Prepare the dough with wheat flour, bengal gram flour and drumstick leaves. Make and roll dough balls into roti and cook it. Apply ghee.	190g	3
	Bengal gram flour	25g			
	Drumstick leaves	30g			
	Ghee	25g			
	Salt	3g			
	Ajwain	5g			
	Water	30ml			
Pancake	Bengal gram flour	100g	Prepare batter with onion, ajwain, salt and drumstick leaves into bengal gram flour. Spread batter on heated pan and apply oil. Cook it till done.	240g	6
	Drumstick leaves	30g			
	Onion	20g			
	Ajwain	3g			
	Salt	3g			
	Water	150ml			
	Oil	20ml			
Chana dal	Chana dal	100g	Pressure cook <i>chana dal</i> with spices. Put finely chopped vegetables in heated oil with boiled <i>dal</i> . Add drumstick leaves and water and cook it till done.	330g	3
	Drumstick leaves	30g			
	Onion	50g			
	Tomato	30g			
	Salt	3g			
	Turmeric powder	5g			
	Garam masala	5g			
	Water	300ml			
Oil	10ml				
Vegetable Dalia	Broken wheat	100g	Roast broken wheat in heated oil with chopped vegetables. Add drumstick leaves spices and water and pressure cook it till done.	320g	3
	Drumstick leaves	30g			
	Onion	25g			
	Tomato	20g			
	Capsicum	10g			
	Potato	25g			
	Oil	5g			
	Salt	3g			
Water	250ml				
Potato Leaves Vegetable	Potato	100g	Wash and cut potato. Fry spices, add potato and drumstick leaves with water and cook it till done.	150g	3
	Drumstick leaves	30g			
	Oil	10g			
	Red chilli powder	2g			
	Garam masala	2g			
	Turmeric powder	2g			
	Salt	3g			
	Cumin seeds	2g			
Water	300ml				

**Table 2:** Organoleptic scores of developed products using drumstick leaves

Levels	Color	Flavor	Texture	Taste	Overall acceptability
<i>Missi roti</i>					
S1	8.05±0.13	7.90±0.14	7.65±0.13	8.05±0.11	7.91±0.11
S2	7.42±0.16	7.40±0.10	7.42±0.11	7.40±0.10	7.47±0.13
S3	6.80±0.13	6.80±0.13	7.05±0.13	7.05±0.12	6.95±0.10
Control (S4)	7.45±0.15	7.45±0.13	7.55±0.13	7.60±0.13	7.55±0.10
F-ratio	11.74**	10.97**	4.17*	11.51**	10.74**
CD	0.420	0.384	0.367	0.347	0.341
<i>Pancake</i>					
S1	7.65±0.23	8.05±0.14	8.05±0.16	7.85±0.19	7.90±0.11
S2	7.55±0.16	7.15±0.13	7.00±0.15	7.00±0.17	7.17±0.14
S3	6.85±0.19	6.80±0.29	6.85±0.18	6.80±0.21	6.82±0.12
Control (S4)	7.65±0.21	7.45±0.24	7.50±0.19	7.50±0.15	7.52±0.15
F-ratio	5.87**	11.33**	10.55**	7.72**	9.17**
CD	0.449	0.443	0.471	0.483	0.429
<i>Chana dal</i>					
S1	7.90±0.16	7.70±0.14	7.65±0.16	8.05±0.15	7.75±0.14
S2	7.50±0.11	7.40±0.11	7.42±0.11	7.47±0.16	7.35±0.10
S3	7.05±0.14	7.00±0.22	7.05±0.24	7.10±0.17	6.97±0.18
Control (S4)	7.50±0.16	7.65±0.15	7.45±0.21	7.60±0.16	7.53±0.14
F-ratio	6.85**	5.64**	3.52*	11.06**	7.38**
CD	0.374	0.379	0.376	0.338	0.346
<i>Vegetable dalia</i>					
S1	7.95±0.11	7.85±0.13	7.85±0.11	7.90±0.12	7.92±0.11
S2	7.8±0.13	7.6±0.11	7.55±0.19	7.50±0.15	7.60±0.11
S3	7.50±0.16	7.40±0.16	7.60±0.18	7.20±0.17	7.34±0.16
Control (S4)	7.45±0.13	7.70±0.12	7.70±0.14	7.50±0.15	7.60±0.14
F-ratio	2.90*	1.53	0.52	3.58*	3.08*
CD	0.397	NS	NS	0.428	0.386
<i>Potato leaves Vegetable</i>					
S1	7.77±0.15	7.55±0.20	7.50±0.19	7.56±0.22	7.29±0.20
S2	7.54±0.20	7.29±0.23	7.12±0.20	6.92±0.26	7.20±0.21
S3	7.31±0.19	6.86±0.24	6.76±0.23	6.44±0.28	6.72±0.23
Control (S4)	7.86±0.11	7.68±0.17	7.90±0.10	7.92±0.07	7.87±0.12
F-ratio	2.13	2.75*	6.43**	8.41**	3.10*
CD	NS	0.617	0.543	0.640	0.757

Values are given as Mean±SE, n=20

\* Significant at 5% level of significance

\*\* Significant at 1% level of significance

NS-non significant

S1- 30g drumstick leaves per 100g of main raw ingredient of product

S2- 45g drumstick leaves per 100g of main raw ingredient of product

S3- 60g drumstick leaves per 100g of main raw ingredient of product

S4- Control

**Table 3:** Proximate composition of developed products using drumstick leaves

Products	Moisture %	Protein %	Fat %	Fiber %	Ash %	CHO %	Energy (Kcal/100g)
Fresh drumstick leaves (on fresh weight basis)	74.32±1.11	6.30±0.28	1.53±0.12	0.60±0.07	1.66±0.13	15.59	102
<i>Missi roti</i> (on dry weight basis)							
C	2.36±0.01	6.91±0.18	1.33±0.71	1.59±0.05	1.62±0.04	86.19	386
S1	3.56±0.25	7.52±0.74	1.75±0.05	1.79±0.01	2.09±0.19	83.54	384
F-ratio	11.00	0.32	0.18	5.88	2.89		
CD	NS	NS	NS	NS	NS		
<i>Pancake</i>							
C	2.54±0.09	18.28±0.31	15.50±0.23	1.32±0.01	2.38±0.01	59.98	455
S1	3.45±0.14	20.38±0.06	16.92±0.53	1.38±0.06	2.80±0.06	55.07	457
F-ratio	15.43	22.45*	3.00	0.34	11.92		
CD	NS	1.907	NS	NS	NS		
<i>Potato Leaves Vegetable</i>							
C	2.07±0.01	0.69±0.13	5.66±0.47	1.06±0.02	1.32±0.05	90.2	415
S1	3.39±0.05	2.88±0.19	6.92±0.17	1.19±0.02	3.33±0.05	84.29	411
F-ratio	297.84**	47.56*	3.12	8.58	357.49**		
CD	.329	1.36	NS	NS	.457		
<i>Chana dal</i>							
C	3.80±0.27	16.27±0.25	5.91±0.06	1.75±0.06	2.37±0.04	74.9	373
S1	4.98±0.10	19.86±1.42	6.74±0.41	1.81±0.07	2.42±0.04	69.19	372
F-ratio	8.34	13.10*	1.97	0.27	.04		
CD	NS	0.386	NS	NS	NS		
<i>Vegetable Dalia</i>							
C	3.03±0.08	12.59±0.25	1.33±0.00	2.28±0.08	3.36±0.13	77.41	372
S1	3.85±0.17	13.65±0.37	2.58±0.17	2.29±0.06	4.07±0.12	73.56	372
F-ratio	9.38	2.80	25*	0.00	8.22		
CD	NS	NS	1.075	NS	NS		

Values are presented as Mean±SE

\*Significant at 5% level of significance

\*\*Significant at 1% level of significance

NS non significant

**Table 4:** Vitamin content of developed products using drumstick leaves (on fresh weight basis)

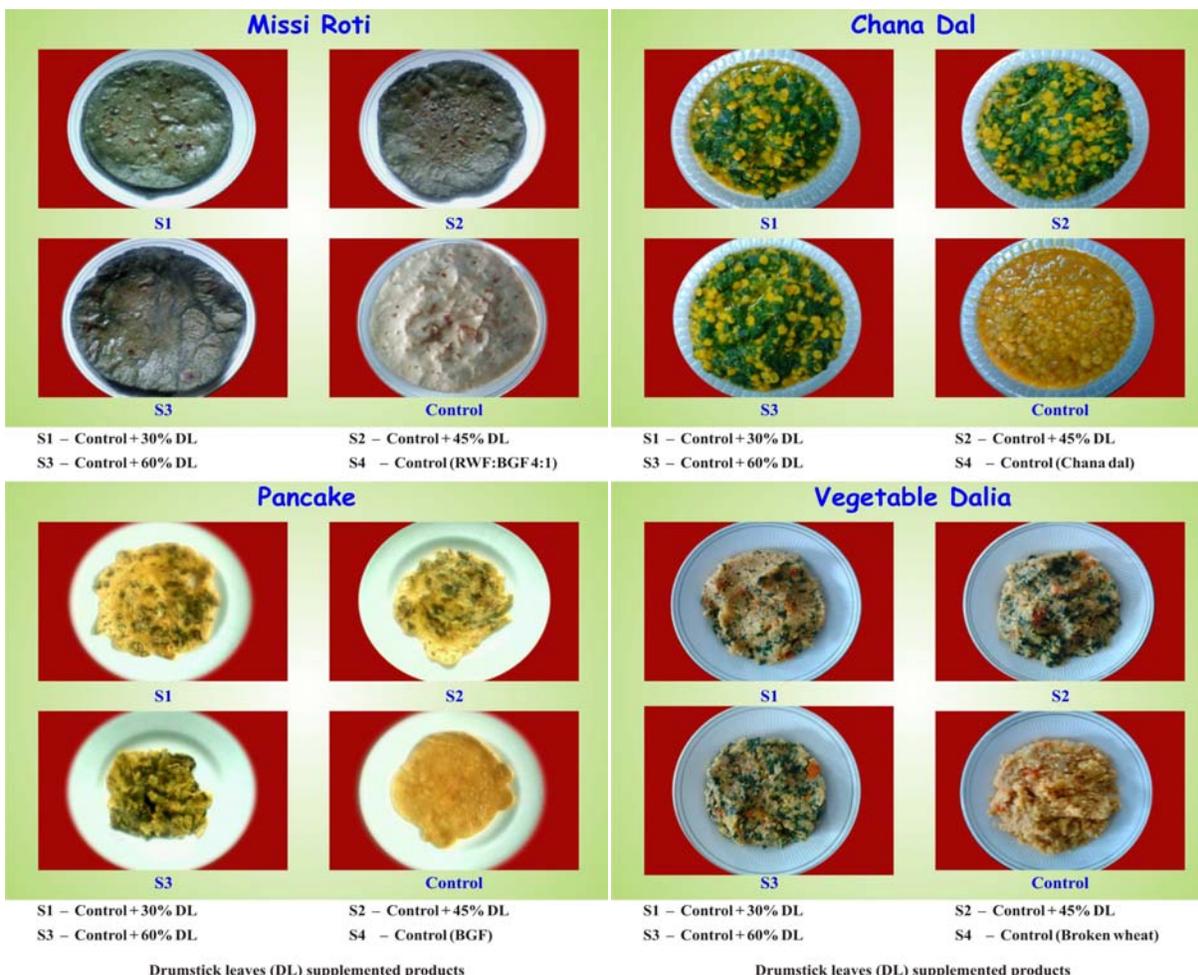
Products	$\beta$ -carotene ( $\mu\text{g}/100\text{g}$ )	Ascorbic acid ( $\text{mg}/100\text{g}$ )
Drumstick leaves	16794 $\pm$ 0.16	208.33 $\pm$ 2.36
<i>Missi roti</i>		
C	61.10 $\pm$ 0.79	1.20 $\pm$ 0.17
S1	2402.04 $\pm$ 15.4	49.32 $\pm$ 0.93
F-ratio	115.47**	1286.37**
CD	937.007	5.771
Pancake		
C	17.81 $\pm$ 1.09	0.37 $\pm$ 0.13
S1	1322.63 $\pm$ 3.55	17.29 $\pm$ 0.66
F-ratio	2697.24**	115.26**
CD	108.055	6.781
<i>Chana dal</i>		
C	124.11 $\pm$ 0.79	3.33 $\pm$ 0.47
S1	2428.96 $\pm$ 5.48	39.33 $\pm$ 2.59
F-ratio	883.54**	31.98*
CD	333.513	27.376
Vegetable <i>Dalia</i>		
C	11.66 $\pm$ 0.21	2.16 $\pm$ 0.59
S1	2067.38 $\pm$ 11.75	47.16 $\pm$ 0.35
F-ratio	152.82**	686.98**
CD	715.268	7.384
Potato leaves vegetable		
C	11.04 $\pm$ 0.26	4.33 $\pm$ 0.23
S1	2946.37 $\pm$ 16.94	12.16 $\pm$ 2.00
F-ratio	150.15**	4.15
CD	1030.333	NS

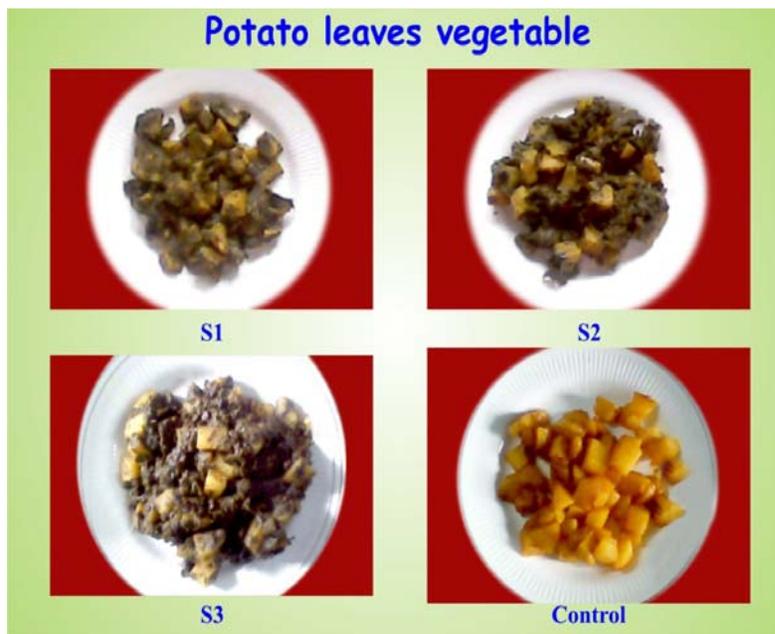
Values are presented as Mean $\pm$ SE

\* Significant at 5% level of significance

\*\*Significant at 1% level of significance

NS-non significant.





S1 – Control+30% DL  
 S2 – Control+45% DL  
 S3 – Control+60% DL  
 S4 – Control (Potato)

Fig 1: Drumstick leaves (DL) supplemented products

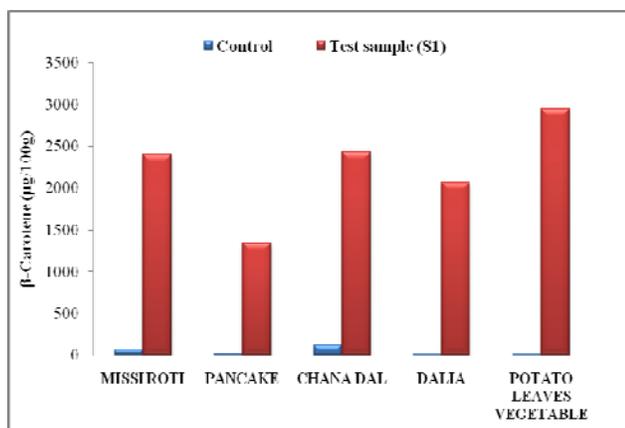


Fig 2: β-carotene content of developed products using drumstick leaves

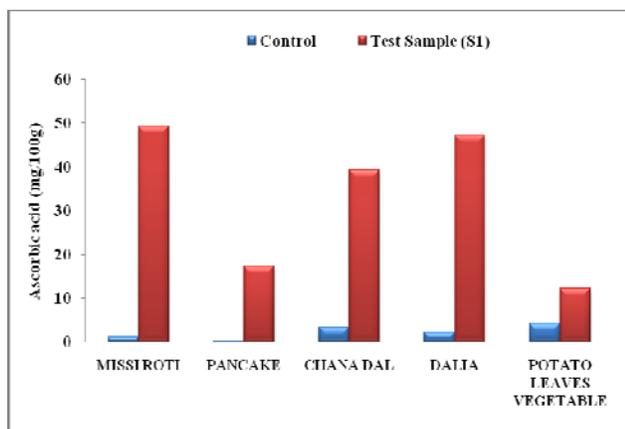


Fig 3: Ascorbic acid content of developed products using drumstick leaves

Table 5: Mineral content of developed products using leaves products (on dry matter basis)

Products	Iron (mg/100g)	Calcium (mg/100g)
Drumstick leaves	2.31±0.02	40±0.27
<i>Missi roti</i>		
C	4.47±0.17	85±0.19
S1	4.96±0.04	156±0.21
F-ratio	3.72	28.01*
CD	NS	57.706
<i>Pancake</i>		
C	4.02±0.02	40±0.14
S1	4.47±0.08	102.5±0.26
F-ratio	17.18	24.53*
CD	NS	54.278
<i>Vegetable dalia</i>		
C	6.17±0.02	80.5±0.35
S1	6.39±0.06	172±0.52
F-ratio	6.58	34.00*
CD	NS	67.495
<i>Chana dal</i>		
C	4.78±0.05	53±0.19
S1	5.08±0.12	130.5±0.42
F-ratio	2.87	133.24**
CD	NS	28.692
<i>Potato leaves vegetable</i>		
C	0.59±0.01	10±0.09
S1	1.32±0.06	110±0.14
F-ratio	59.52*	206.19**
CD	0.415	29.954

Values are presented as Mean±SE  
 \*Significant at 5% level of significance  
 \*\*Significant at 1% level of significance  
 NS-non significant

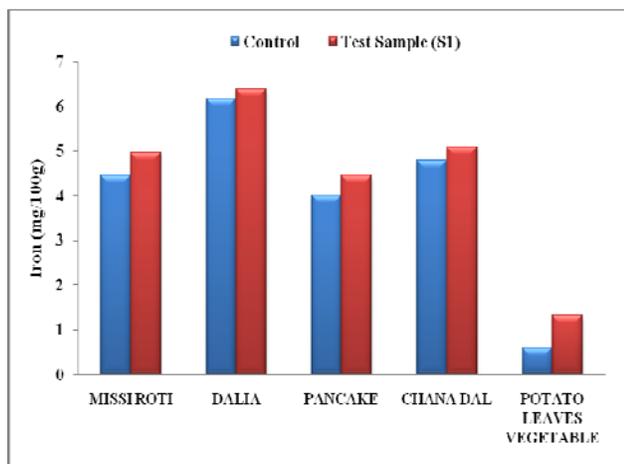


Fig 4: Iron content of developed products using drumstick leaves

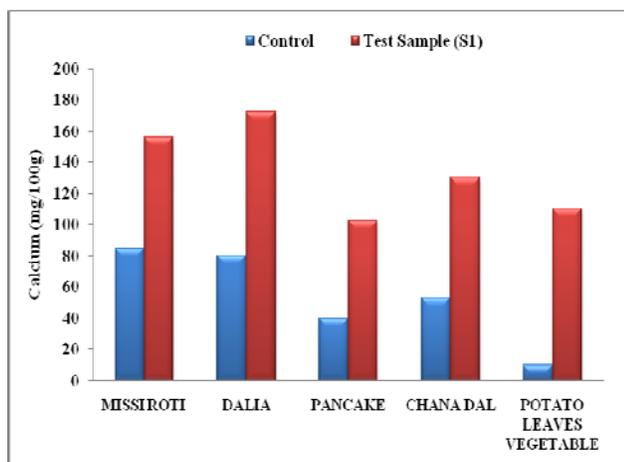


Fig 5: Calcium content of developed products using drumstick leaves

### Conclusion

Drumstick leaves are cost effective and easily available greens all over the India. Incorporation of fresh drumstick leaves at a level of 30% in traditional recipes; enhance the protein, fat,  $\beta$ -carotene, ascorbic acid and calcium content of preparations. Thus the Value addition with drumstick leaves into commonly consumed products at the homestead level is suitable protocol to improve the nutritional composition of Indian traditional recipes. People should also be encouraged to grow these trees and use them in diets to improve their nutritional status.

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