Trees for Life Journal
a forum on beneficial trees and plants

Open access, freely available online

Research Articles

Standardization and Organoleptic Evaluation of Drumstick (*Moringa oleifera*) Leaves Incorporated Into Traditional Indian Recipes

Vanisha S. Nambiar* and Shilpa Parnami

Department of Foods and Nutrition, a WHO collaborating Center for Anemia Control and Diet Related Chronic Degenerative Disorders, The Maharaja Sayajirao University of Baroda, Vadodara – 390 002, Gujarat, India.
*Corresponding author

Abstract

The competing demands of taste and health pose a dilemma for consumers as well as the food industry. Food-based strategies advocate a diet including easily accessible and inexpensive green leafy vegetables to alleviate micronutrient deficiencies. However, some of the most nutritious green leafy vegetables are underutilized—probably because of their taste. The aim of the present study was to standardize and organoleptically evaluate freshly blanched leaves of the drumstick tree (*Moringa oleifera)* incorporated into three recipes commonly consumed in India: *mung* (*Phaseolus aureus*), *kabuli chana* (*Cicer arietinum*) and *desi chana* (*Cicer arietinum*). One serving of each of these recipes (30 g raw weight of pulses) could incorporate a maximum of 20 g of fresh drumstick leaves. All three recipes were found to be acceptable by the panel of judges (18- to 21-year-old women), with an overall composite score ranging from 3.06-3.53 (on a scale of 1 to 5). The drumstick leaf recipes were micronutrient rich, and each serving could provide 3955 µg β-carotene (665 retinol equivalents or RE), 46 mg ascorbic acid and 1.6 mg iron. Meal planners typically use a benchmark of ⅓ of the RDA, and these recipes could achieve 24%, 341%, 15% and 496% of that level for adult women in energy, vitamin C, iron and β-carotene respectively. Even if only 1/6 of the β-carotene is considered as bioavailable for vitamin A (RE), these recipes would still meet 82.5% to 83.3% of the RDA for adult women. This analysis also suggests that industrial production of ready-to-eat foods incorporating drumstick leaves might also be a useful endeavor.

Abbreviations:

DDL - dehydrated drumstick leaves; DW - dry weight; FW - fresh weight; RW - raw weight; CW - cooked weight; RDA - recommended daily allowance; NGO - non-governmental organization

Introduction

Development of nutritious and organoleptically acceptable recipes with locally available foods is a challenge for the food scientist. However, the benefits of such food-based strategies to prevent micronutrient malnutrition are manifold. They: (a) are preventive, (b) are cost-effective, (c) are sustainable, (d) are income-generating, (e) are culturally acceptable and feasible to implement, (f) promote self-reliance and community participation, and (g) foster the development of environmentally sound food production systems (1). Indian diets provide mostly non-heme iron, which is very poorly absorbed (only 2-20% bioavailability). Thus it has been suggested that vegetarians may be at a greater risk of iron deficiency than non-vegetarians.

Women in developing countries often consume inadequate amounts of micronutrients because of their limited intake of animal products, fruits, vegetables, and fortified foods. Intakes of micronutrients less than the recommended

Contact: Vanisha S. Nambiar
Email: vanisha_nam@yahoo.com
Received: January 26, 2007
Accepted: April 7, 2007
Published: April 22, 2008

The electronic version of this article is the complete one and can be found online at: http://www.tfljournal.org/article.php/20080407133437686

Trees for Life Journal 2008, 3:2

values increase a woman's risk of having micronutrient deficiencies. The adverse effects of deficiencies in vitamin A, iron, and folic acid, including night-blindness in pregnant and lactating women and iron-deficiency anemia, are well known. Low intakes of these and other nutrients, including zinc, calcium, riboflavin, vitamin B6, and vitamin B12, also have consequences for women's health, pregnancy outcome, and the health and nutritional status of breastfed children. Multiple deficiencies coexist, so the benefit of multiple micronutrient supplements is becoming increasingly apparent. These issues need to be discussed, and guidance be provided on the selection of appropriate food for women of reproductive age in developing countries.

The main effect of vitamin A is to maintain adequate levels of iron in plasma to supply the different body tissues including the bone marrow with proper amounts of this essential mineral which may be the mechanism by which the hemopoeitic tissue becomes flavored with more available iron. A significant association of serum retinol with hematocrit, serum iron and serum ferritin has been reported by Bloem et al (1989) in a cross sectional study of children in north east Thailand (2).

Use of green leafy vegetables to eradicate underlying micronutrient deficiencies has been advocated for a long time. The leaves of the drumstick tree (*Moringa oleifera*) have one the highest known contents of total carotene (~40,000 μg/100 g FW) and β-carotene (~19,000 μg/100 g FW). They are also an excellent source of a variety of other nutrients and phytochemicals (phytonutrients), which have been shown to have positive health effects (Table 1) (3,4,5,6). Drumstick leaves may have an unacceptably bitter taste to some people, due to the presence of polyphenols (5). However, these polyphenols have also been reported to have multiple beneficial biological effects, including antioxidant activity, anti-inflammatory action, inhibition of platelet aggregation, antimicrobial activities and anti-tumor activities, and are therefore a much-researched topic in recent years (7,8,9,10).

Promotion, development, and even engineering of plant foods with enhanced concentrations of chemopreventive phytonutrients are promising new strategies for promoting health. However, any meaningful inclusion of phytonutrients must also consider the taste of these substances. Consumer and marketing studies invariably show that taste, as opposed to perceived nutrition or health value, is the key influence on food selection. Thus, organoleptically acceptable recipes with drumstick leaves would be a most suitable protocol for dietary diversification or improvement, as these leaves are storehouses of both the classic nutrients (carbohydrate, protein, oil, vitamins and minerals) as well as beneficial non-nutrients (typically referred to as phytochemicals or phytonutrients). Several studies using dehydrated drumstick leaves (DDL) in traditional Indian recipes have been carried out in recent years, evaluating the recipes for their acceptability among children. However, the threshold for acceptability may vary since drumstick leaves have a slightly bitter taste to many people. This distinctive taste is compounded by innate taste preferences, sex and age, thus adding an extra layer of complexity to the acceptance of bitter plant foods by the consumer.

The present study aims to modify three boiled and sautéed pulse-based recipes with the inclusion of freshly blanched drumstick leaves, and to organoleptically evaluate those recipes using a test panel composed of representatives of the main target group: young women.

Methods and Materials

Fresh drumstick leaves (*Moringa oleifera*) were obtained from trees around the city of Vadodara, Gujarat. Three pulse-based recipes were selected which are consumed frequently by young adult women, namely ***mung*** (*Phaseolus aureus*), ***kabuli chana*** (*Cicer arietinum*) (Figure 2) and ***desi chana*** (*Cicer arietinum*) (Figure 3). Different amounts of freshly blanched drumstick leaves were added at the point of sautéing the boiled pulses, and thereafter the required spices were added. For initial range-finding trials, drumstick leaves were added in amounts ranging from 6 g to 25 g fresh weight (FW) for every 30 g raw weight (RW) of pulses (i.e. one serving of each recipe). Final evaluations were performed on recipes containing 20 g FW of blanched drumstick leaves for every 30 g RW of pulses in each recipe.

Sensory evaluation of recipes

Sensory evaluation provides an index of overall acceptability of foodstuffs, which depends on its appearance, flavor, taste, texture, aftertaste, and overall acceptability. To ensure the acceptability of the modified recipes, they were subjected to evaluation by composite scoring for their sensory qualities. All recipes were prepared fresh and presented to a panel of 12 untrained judges (young girls, all first- or second-year students at The Maharaja Sayajirao University of

Baroda, ranging from 18 to 21 years of age, and not in the Foods and Nutrition Department).

Specific sensory characteristics of each recipe (appearance, color, flavor, taste, texture and overall acceptability) were rated separately on a scale of 1 to 5. Scores were defined as follows: 1 - dislike extremely, bad; 2 - like only slightly, tolerable; 3 - like, good; 4 - like very much, very good; 5 - like extremely, excellent. Numerical averages were then calculated for a composite test score.

For the range-finding trials, all judges were served each of the 3 recipes and then the recipes were modified and improved based upon their suggestions. The final tests were conducted by incorporating 20 g of fresh drumstick leaves into each serving of each recipe, since this level of addition received the highest initial ratings from the judges.

Results

Sensory Attributes of the Drumstick Leaves Incorporated Recipes

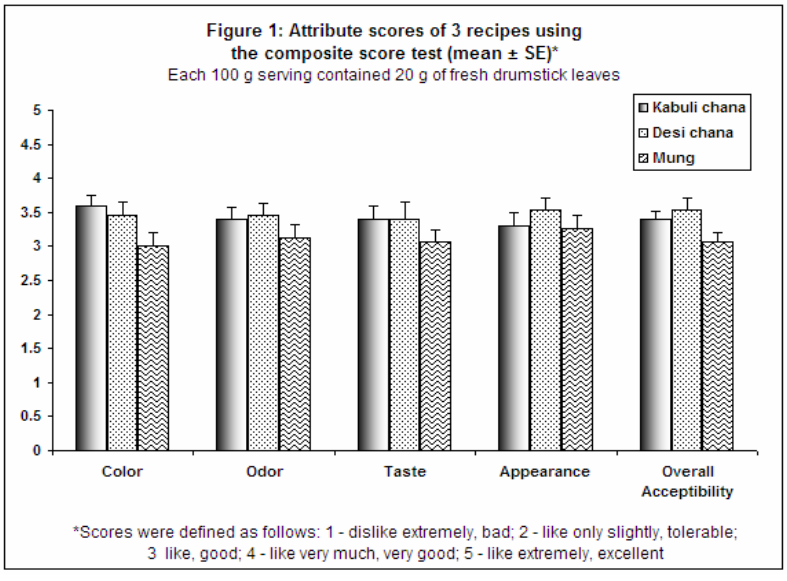
The recipes which were determined to be the most acceptable in the range-finding trials utilized 20 g of freshly blanched drumstick leaves per serving of the pulse (30 g RW; in the case of pulses, this is equivalent to approximately 100 g cooked weight). The overall composite score for *desi chana* (*Cicer arietinum*) was highest at 3.53 ± 0.71. This score was followed by *kabuli chana* (*Cicer arietinum*) at 3.4 ± 0.49, and *mung* (*Phaseolus aureus*) at 3.06 ± 0.57 (Figure 1). Scores for each of the individual attributes for the three test recipes ranged from 3.0 to 3.53.

Despite the variations in the individual attribute scores, all of the recipes were rated as "good" by the panel of untrained judges.

Several investigators have reported the use of Composite Scores to evaluate foods products. Dehydrated drumstick leaf (DDL) powder incorporated into *dhebra* (shallow fried *rotis*, or flatbreads), *muthia* (steamed cereal-pulse-vegetable traditional snacks of Gujarat, Western India) and *dal* soup (boiled lentils) have been evaluated using composite scores (8). We have also used this methodology to evaluate the incorporation of other green leafy vegetables, such as coriander leaves, radish leaves, colocasia leaves, fenugreek leaves, spinach and amaranth, into a variety of food products (1,11,12,13).

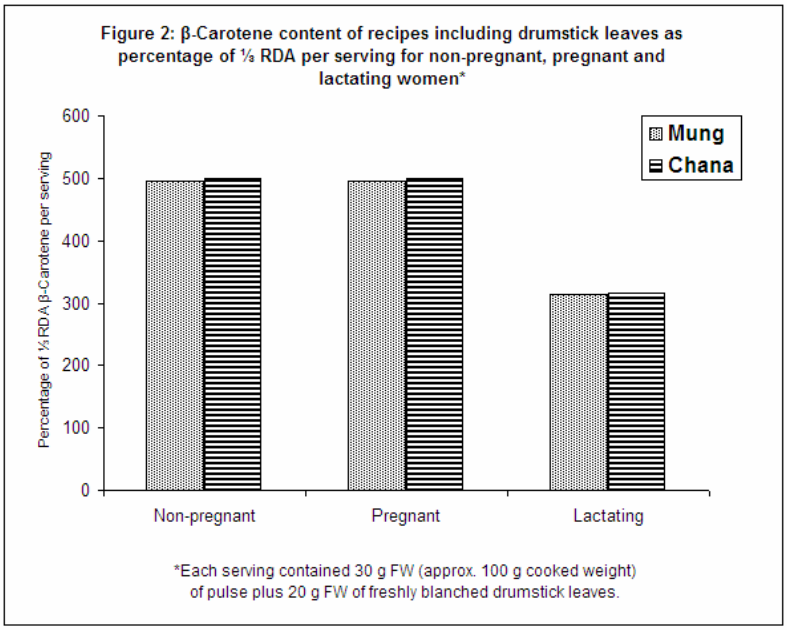
Nutritive Value of 3 Traditional Recipes with Drumstick Leaves

The nutritive value of the recipes supplemented with drumstick leaves was calculated using standard values for Indian foods (Table 2) (14). The three recipes provided similar amounts of energy (147-155 Kcal), protein (6.5-8.6 g), calcium (112-150 mg), vitamin C (45-47 mg), iron (1.5-1.6 mg) and β-carotene (3966-3995 µg). When the nutritive values were compared with the common meal-planning benchmark of ⅓ RDA for non-pregnant, pregnant and lactating women, it was found that these recipes meet 18-24% of ⅓ RDA for energy, 27-52% of ⅓ RDA for protein, 38-113% of ⅓ RDA for calcium, 171-349% of ⅓ RDA for vitamin C, 12-16% of ⅓ RDA for iron and 313-499% of ⅓ RDA for β-carotene (indicating that they are excellent sources of vitamin A) (Table 3).



Twenty grams of drumstick leaves provided 3938 µg of β-carotene, which is equivalent to 656 µg retinol equivalents (RE) [1 RE = 6 µg β-carotene]. The three recipes prepared from fresh drumstick leaves had a β-carotene content ranging from 3966 µg to 3995 µg per serving, which is equivalent to 661-669 µg RE (Figure 2). According to the most recent consensus on bioavailability and processing losses for β-carotene, even if there are 50% losses during cooking the β-carotene content of the final recipes would be 1980 µg or 330-333 RE, which meets 82.5% of the RDA for adult women (15). These results have an important implication, as food-based approaches to combat vitamin A deficiency have

generally considered green leafy vegetables to be poor sources of vitamin A due to low bioavailability.



Discussion

Drumstick leaves have been advocated by several NGOs as well as some food and nutrition experts as an excellent source of vitamins and minerals. Their nutrient and phytochemical constituents have been studied extensively in recent years. Although deficiency of iron in the diet is regarded as the most important factor in the etiology of nutritional anemia, certain human and animal studies have shown that supplementation of diets with both iron and vitamin A may increase the iron status as measured by hematological indices like hemoglobin and hematocrit (2). Beta-carotene-rich drumstick leaves can thus be an important source of vitamin A, can be used for releasing the bound iron stores and can thus help in reducing anemia as well as prevalence of vitamin A deficiency in vulnerable sections of the society.

Our previous papers have discussed the nutritional and sensory qualities of dehydrated drumstick leaves (DDL) incorporated into salty recipes used in the schemes presented by the Integrated Child Development Services (ICDS) of India. Results indicated that in spite of high losses, there is enough β-carotene retained in DDL powder to help in the eradication of several micronutrient deficiencies (16). The results of feasibility and acceptability studies of introducing DDL into salty recipes (in the supplementary feeding program of ICDS) along with nutrition communication indicated that these practices were feasible and could be endeavored for a longer duration in existing national programs (17).

Although the primary function of food is to provide nutrients, its secondary function concerns sensory attributes such as taste and flavor. The tertiary function, said to be independent of the previous two, is to prevent disease at the molecular level. The recipes developed in the present study require no extra effort or modification of the usual, traditional recipes beyond simple inclusion of the drumstick leaves. Food industries involved in the preparation of ready-to-eat foods as well as national feeding programs such as India's ICDS Scheme and Mid-day meal programs may thus initiate the task of fortifying existing menus with such foods.

The present study recommends the prospect of more aggressive introduction and utilization of drumstick leaves by the food sector. It also implies that it may be worthwhile for industry to take up the production of drumstick leaf powder. Such promotion of drumstick leaf incorporation into the diet in India and other countries could go a long way towards not only alleviating micronutrient deficiencies, but also towards the development of functional foods for several chronic degenerative disorders. These efforts could also be an additional source of income generation, employment and exports.

Figure 3: *Kabuli chana* — plain and with drumstick leaves

Figure 4: *Desi chana* — plain and with drumstick leaves

Figure 5: *Mung* — plain and with drumstick leaves

Table 1: Nutrient Composition of Drumstick (*Moringa oleifera*) Leaves (6)

Nutrient	**Content**
Moisture	79.2%
Total Carotenoids	40,139 μg / 100 g FW
β-Carotene	19,210 μg / 100 g FW (47.8% of total carotenoids)
Ascorbic Acid	6.6 mg / g DW
Total Iron	0.26 mg / g DW
Calcium	22.4 mg / g DW
Phosphorus	6.3 mg / g DW
Ca : P	3.6 : 1
Oxalic acid	11.2 mg / g DW
Fiber	0.9 g / 100 g FW

Table 2: Nutritive value of drumstick leaf incorporated recipes per serving (30 g raw pulse = 100 g cooked pulse)

Nutrient	***Desi chana* or *kabuli chana*** (per 30 g RW)	***Mung*** (per 30 g RW)	**Contribution from drumstick leaves** (per 20 g FW)
Energy (Kcal)	155	147	18
Protein (gms)	6.5	8.6	1.3
Calcium (mg)	151	127	88
Phosphorous (mg)	108	112	14
Vitamin C (mg)	46.5	45.5	44
Iron (mg)	1.6	1.5	0.2
β-Carotene (μg)	3995	3966	3938
Oxalates (mg)	20.8	21.1	20.2
Phytates (mg)	56.2	53.2	8.8
Cost per serving (Indian Rupees)	2 (*Desi chana*) 1.5 (*Kabuli chana*)	1.25	-

Nutritive values calculated as per Ref. 6; β-Carotene calculated as per Refs. 5,6

Table 3: Per-serving nutritive value of drumstick leaf recipes (100 g cooked weight) as percentage of ⅓ RDA for adult non-pregnant, pregnant and lactating women

Nutrient	*Mung* recipe			*Chana* recipes		
	Non-pregnant	Pregnant	Lactating	Non-pregnant	Pregnant	Lactating
Energy (Kcal)	24% (625)*	20% (725)	19% (783)	25% (625)	21% (725)	20% (783)
Protein (g)	51% (17)	40% (22)	36% (24)	39% (17)	30% (22)	27% (24)
Calcium (mg)	95% (133)	38% (333)	38% (333)	113% (133)	45% (333)	45% (333)
Vitamin C (mg)	341% (13)	341% (13)	171% (27)	349% (13)	349% (13)	174% (27)
Iron (mg)	15% (10)	12% (13)	15% (10)	16% (10)	13% (13)	16% (10)
β-Carotene (µg)	496% (800)	496% (800)	313% (1270)	499% (800)	499% (800)	315% (1270)

*Figures in parentheses indicate ⅓ of the RDA as established by National Institute of Nutrition, Hyderabad, India (6).

References

1. Nambiar V, K Sharma and H Gandhi (2005) Food based approach to combat vitamin A deficiency. *UGC-DSA Monograph Series No. 3*. Department of Foods and Nutrition, M.S. University of Baroda, Vadodara 390002.
2. Bloem MW (1989) Iron metabolism and vitamin A deficiency in children in Northeast Thailand. *American Journal of Clinical Nutrition* 50: 332-8.
3. Nambiar V and S Seshadri (2001) Bioavailability of beta carotene from fresh and dehydrated drumstick leaves in a rat model. *Journal of Plant Foods for Human Nutrition* 56(1): 83-95.
4. Nambiar VS, R Mehta and M Daniel (2005) Polyphenol content of three Indian green leafy vegetables. *Journal of Food Science and Technology* 42(6): 312-315.
5. Nambiar V and S Seshadri (1998) Beta carotene content of selected green leafy vegetables of western India by high performance liquid chromatography. *Journal of Food Science and Technology* 35(4): 351-355.
6. Seshadri S and V Nambiar (2003) Kanjero (*Digera arvensis*) and drumstick leaves (*Moringa oleifera*): nutrient profile and potential for human consumption. In: Simopoulos AP, C Gopalan (eds): Plants in Human Health and Nutrition Policy. *World Review of Nutrition and Dietetics* 91: 41-56.
7. Ames BN, MK Shigenaga and TM Hagen (1991) Oxidants, antioxidants, and the degenerative diseases of aging. *Proceedings of the National Academy of Sciences of the USA* 90: 7915-7922.
8. Clarkson PM and HS Thompson (2000) Antioxidants: what role do they play in physical activity and health? *American Journal of Clinical Nutrition* 72(2): 637S-646S.
9. Key TJA, M Thorogood, PN Appleby and ML Burr (1996) Dietary habits and mortality in 11,000 vegetarians and health conscious people: results of a 17 year follow up. *BMJ* 313: 775-779.
10. Singhal S, R Gupta and A Goyle (2001) Comparison of antioxidant efficacy of vitamin E, vitamin C, vitamin A and fruits in coronary heart disease: a controlled trial. *Journal of the Association of Physicians of India* 49: 327-31.

11. Nambiar V, M Daxini and K Bhadalkar (2003) Nutritional and sensory evaluation of shade dried beta-carotene rich drumstick leaf (*Moringa oleifera*) recipes. *Indian Food Packer* 57(6): 156-161.

12. Nambiar VS and S Seshadri (2001) Retention of total and beta carotene from fresh radish leaves in steamed, sautéed and baked products of western India. *Journal of Food and Science and Technology* 38(5): 458-461.

13. Nambiar V and M Sharma (2000) Study on β-carotene content of fresh processed and dehydrated carotene rich foods of Western India. Department of Foods and Nutrition, MS University of Baroda, India (Unpublished).

14. Gopalan C, BV Rama Sastri and SC Balasubramanian (1983) *Nutritive Value of Indian Foods.* National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.

15. McLaren DS and M Frigg (2001) *Sight and Life manual on vitamin A deficiency disorders (VADD), 2nd edition*. Task Force Sight and Life, Switzerland.

16. Seshadri S, M Jain and D Dhabhai (1997) Retention and storage stability of B-carotene in dehydrated drumstick leaves (*Moringa oleifera*). *International Journal of Food Sciences and Nutrition* 48: 373-379.

17. Nambiar V, K Bhadalkar and M Daxini (2003) Drumstick leaves in the ICDS-SFP. *Indian Journal of Peadiatrics* 70(5): 11-15.