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Full Length Research Paper

Effect of dehydration on the nutritive value of drumstick leaves

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Food based strategy' is used as a tool for combating micronutrient deficiencies. It is also referred as dietary modification, which encompasses a wide variety of intervention that aim at increasing the production, availability and consumption of food products, which are rich in micronutrients. One such food products are green leafy vegetables. There are many varieties of green leafy vegetables which are though rich in micronutrients, but are usually discarded or are not used for human consumption. One such leaf, a rich source of micronutrients but still under exploited is drumstick leaf (*Moringa oleifira*). The present study was done with the objective to assess the effect of different methods of drying (sun, shade and oven drying) on the nutritive value of the selected leaf with its fresh counterparts. The results showed significant increase ($p < 0.01$) in all the nutrients in the dried samples of the leaves making them a concentrated source of nutrients. Shade dried samples had highest nutrient retention followed by sun drying and oven dried samples but the difference was not statistically significant ($p > 0.05$).

Key words: *Moringa oleifira*, dehydration, sun drying, shade drying, oven drying, biochemical analysis.

INTRODUCTION

Green leafy vegetables and fruits are a rich source of micronutrients. Though India stands second in vegetables and fruits production, hardly two percent of the produce is processed and 30 - 40 % is being wasted due to lack of processing and preservation infrastructure (Adeyeye, 2002). There are many varieties of green leafy vegetables, which are rich and natural source of iron and other essential micronutrients, but they are discarded and are not used for human consumption. Drumstick leaves (*Moringa oleifira*) is one of them, which is available at no cost and is very rich in all the micronutrients. *M. oleifera*, commonly referred to simply as "*Moringa*", is the most widely cultivated species of the genus *Moringa*, which is the only genus in the family Moringaceae. It is an exceptionally nutritious vegetable tree with a variety of potential uses. The tree itself is rather slender, with drooping branches that grow to approximately 10 m in height. The "*Moringa*" tree is grown mainly in semi - arid, tropical, and subtropical areas, while it grows best in dry sandy soil, it tolerates poor soil, including coastal areas. It is a fast - growing, drought - resistant tree that is native to the southern foothills of the Himalayas in northwestern India. The immature green pods called "drumsticks" are probably the most valued and widely used part of the tree. They are commonly consumed in India and are generally prepared in a similar fashion to green beans and have a slight asparagus taste. The seeds are sometimes removed from more mature pods and eaten like peas or roasted like nuts. The flowers are edible when cooked, and are said to taste like mushrooms. The leaves are highly nutritious, being a significant source of beta - carotene, Vitamin C, protein, iron, and potassium. The leaves are cooked and used like spinach. In addition to being used fresh as a substitute for spinach, its leaves are commonly dried and crushed into a powder, and used in soups and sauces. Murungakai, as it is locally known in Tamil Nadu and Kerala, is used in Siddha medicine. Its leaves are full of medicinal properties. The tree is a good source for calcium and phosphorus. In Siddha medicines, these drumstick seeds are used as a sexual virility drug for treating erectile dysfunction in men and also in women for prolonging sexual activity. The *Moringa* seeds yield 38 - 40% edible oil (called ben oil from the high concentration of behenic acid contained in the oil). The refined oil is clear, odorless, and resists rancidity at least as well as any other botanical oil. The seed cake remaining after

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oil extraction may be used as a fertilizer or as a flocculent to purify water. *Moringa* trees have been used to combat malnutrition, especially among infants and nursing mothers. Three non - governmental organizations in particular - Trees for Life, Church World Service, and Educational Concerns for Hunger Organization - have advocated *Moringa* as “natural nutrition for the tropics.” Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. *Moringa* is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce (Jed and Fahey, 2008).

A large number of reports on the nutritional qualities of *Moringa* now exist in both the scientific and the popular literature. It is commonly said that *Moringa* leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas,” and that the protein quality of *Moringa* leaves rivals that of milk and eggs. Drumstick leaves are also rich sources of flavonols such as kaempferol and 3’-OMequercetin.

A flavone, acacetin and a glycoflavone 4 - OMe Vitexin was also identified. The phenolic acids identified included melilotic acid, p - coumaric acid, and vanillic acid (Nambiar et al., 2005). Quercetin is actually the molecular backbone for the citrus bioflavonoids rutin, quercetin and hesperidin. Quercetin has also been found to inhibit the growth of human prostate cancer cells and human breast cancer cells. Quercetin has antiviral activity against several types of viruses. Our results revealed that maximum poly-phenols were identified in the drumstick leaves, which further enhances its role as an important functional food.

Nutritionists are now trying to encourage cultivation and incorporation of GLVs in various recipes with minimum effort and little cost, yielding a great benefit. Devising several simple and acceptable micronutrient rich recipes rich recipes containing GLVs would not only bring variety to the diet and but also help in combating vitamin A deficiency along with other micronutrient deficiencies. In developing countries where most of the people are engulfed in poverty and can not afford the expensive food products and suffer from various deficiency diseases, a need to identify cheap and easily available source rich in micronutrients is essential. Through this study the less utilized leaves of *M. oleifira,* which are rich in micronutrients but are mostly discarded or go waste was researched on and the effect of different methods of drying (sun, shade and oven) on their nutritive value was assessed.

METHODOLOGY

The leaves of *M. oleifira* were collected at a time from the same tree to avoid the effect of soil variation on the micronutrient content of the leaves.

Preparation of the leaves for drying

Sorting

Fresh, green, un-damaged, non - insect infested, bruised, dis-colored, decayed and wilted leaves were discarded before washing the leaves, as decayed and wilted leaves give a bad flavor to the whole batch. Besides decayed and wilted leaves can lead to loss of nutrients too (Adeyeye and Otokiti, 1999).

Washing

The stalks of the leaves were cut from the main branches and the leaves were washed thoroughly three to four times with plenty of water to remove all the adhering dust, dirt particles. The Drumstick leaves grow on number of thin branches attached to the main branch. The thin branches were kept intact during washing for the easy handling of the leaves. After washing the stems of the leaves were tied together in small bunches and was hung in an airy space to drain away extra water and to air - dry the leaves. The residual moisture was evaporated at a room temperature, before the actual drying process on a clean paper with constant turning over to avert fungal growth. After air drying, all the stems and branches of the leaves were removed and only the leaves of drumstick were used for drying. The leaves were then weighed and they were equally distributed in three batches for sun drying, shadow drying and oven drying.

Drying

The techniques used in the present study for dehydration were (i) Sun drying; (ii) Shadow drying and (iii) Oven drying.

Sun drying: The air - dried leaves were placed on cotton sheets and then covered with the cheesecloth to keep off dust and insects. The cotton sheets were placed in a direct sunlight on a roof away from animals, traffic and dust and turned occasionally to assure even drying. The leaves were brought indoor at nights as the temperature during night falls down. Sudden temperature change could put moisture back into the leaves and lengthen the drying time. The leaves took four days to dry in the sun.

Shadow drying: In shadow drying also, the air - dried leaves were spread on cotton sheets but instead of keeping them on the roofs the leaves were kept in the room only. The room selected for shadow drying was well ventilated. Natural current of air was used for shadow drying the leaves. It took about six days for the leaves to dry completely and become crisp and brittle to touch.

Oven drying: The leaves were loaded on the trays forming one single layer of the dehydrator and were dried in the dehydrator by forced air technique. The oven was preheated to 60°C and then the loaded tray was added each time, until all the leaves were done. The temperature was maintained at 60°C and the leaves were left for 1 h for their drying. Vegetables were sufficiently dried till they became crisp and brittle to touch. The leaves took four to five hours for complete drying. The dried leaf samples were then analyzed for (i) Proximate composition (Protein, fat, fiber, carbohydrate and energy). (ii) Vitamin (Beta-carotene and vitamin C). (iii) Minerals (Iron, phosphorus and calcium). (iv) Anti nutritional factor (Oxalate), using the standard procedure of AOAC (2004).

Table 1. Proximate composition of dehydrated *Moringa* leaf (per 100 g leaf powder).

Nutrient	Fresh leaves#	Sun dried sample (%)	Shadow dried sample (%)	Oven dried sample (%)
Moisture (%)	75.9	6	6	6
Energy (Kacl)	92	268.56 (65.74)	271.83 (66.15)	271.54 (66.12)
Protein (g)	6.7	23.42 (71.39)	23.66 (71.68)	23.78 (71.82)
Carbohydrate (g)	12.5	27.98 (55.33)	28.476 (56.10)	28.323 (55.86)
Fat (g)	1.7	6.987 (75.66)	7.032 (75.81)	7.014 (75.76)
Fiber (g)	0.9	11.3 (92.04)	12.1 (92.56)	11.8 (92.37)

*Figure in bracket represents percent increase in the nutrient content after dehydration. #The values for fresh leaves have been taken from the nutritive value of Indian food.

Table 2. Mineral composition of dehydrated *Moringa* leaf (per 100 g leaf powder).

Nutrient	Fresh leaves#	Sun dried sample (%)	Shadow dried sample (%)	Oven dried sample (%)
Iron (mg)	0.85	21 (95.95)	24 (96.45)	19 (95.52)
Calcium (mg)	440	3382 (87.44)	3405 (82.88)	3467 (82.06)
Phosphorus (mg)	70	203 (65.51)	218 (67.89)	215 (67.44)

*Figure in bracket represents percent increase in the nutrient content after dehydration. #The values for fresh leaves have been taken from the nutritive value of Indian food.

RESULTS

Moisture content

The moisture content in the three samples of the dehydrated leaves was in the range of 6 - 7%. Maximum moisture content (7.39%) was in the shadow - dried sample and minimum was in the sun dried sample. The moisture content was in the range mentioned by BIS (1978) (Table 1).

Protein content

The protein content in the three samples of the dehydrated leaves was in the range of 23.42 - 23.78 g per 100 g. Maximum protein content (23.78%) was in the oven - dried sample and the minimum was in the sun dried sample. The protein content in the dehydrated powder increased by 71 - 72% from the fresh sample of drumstick leaves. The fresh drumstick leaves contain 6.7% protein. The difference in the protein content of the three samples of the leaves compared to the fresh leaves was statistically significant ($p < 0.05$).

Fat content

Fat content of the three dehydrated leaf samples was in the range of 6.987 - 7.03%. The fat content was again highest in the shadow - dried sample and was lowest in sun - dried samples. The fresh sample of drumstick leaves contain 1.7 g per 100 g of fat while it increased by 75% in the dehydrated sample.

Fiber content

The fiber content in the three samples was in the range of 11.3 to 12.1% with the highest level in shadow dried sample followed by oven dried and the minimum values of fiber were found in sun dried sample. The fiber content in the dehydrated powder increased by 92% from the fresh sample of drumstick leaves, which contain 0.9% of fiber. The leaf sample was a rich source of fiber, which is in line with the statement that vegetables are the natural broom for the body as they are rich in fiber.

Carbohydrate content

Calculation of carbohydrate content of the leaf samples was in the range of 27.98 - 28.476%. The carbohydrate content in the dehydrated powder increased by 55.33 - 56.10% from the fresh sample of drumstick leaves.

Energy content

Calculation of the energy content of the leaf samples was in the range of 268.56 - 271.83%. The energy content in the dehydrated powder increased by 65.74 - 66.15% from the fresh sample of drumstick leaves.

Mineral composition

Mineral composition of dehydrated *Moringa* leaf (per 100 g leaf powder) is given in Table 2.

Table 3. Vitamin composition of dehydrated *Moringa* leaf (per 100 g leaf powder).

Nutrient	Fresh leaves	Sun dried sample (%)	Shadow dried sample (%)	Oven dried sample (%)
Beta-carotene (μg)	6780	36000 (87.44)	39600 (82.88)	37800 (82.06)
Vitamin C (mg)	220	92 (-139.13)	140 (-57.14)	56 (-292.85)

*Figure in bracket represents percent increase in the nutrient content after dehydration. #The values for fresh leaves have been taken from the nutritive value of Indian food.

Table 4. Anti nutritional factor of dehydrated *Moringa* leaf (per 100 g leaf powder).

Nutrient	Fresh leaves#	Sun dried sample	Shadow dried sample	Oven dried sample
Oxalate (mg)	101	430	500	450

#The values for fresh leaves have been taken from the nutritive value of Indian food.

Iron

Fresh drumstick leaves have an iron content of 0.085 mg / 100 g of fresh leaves where as the iron content of the leaf powder prepared by different methods of dehydration was in the range of 19 - 24 mg/ 100 g leaf powder which was 95 to 96% more than their fresh counter parts. Maximum amount of iron content was in the shadow dried sample (24 mg/ 100 g leaf powder) followed by sun dried sample (21 mg/ 100 g leaf powder) and it was lowest in oven dried sample (19 mg/ 100 g leaf powder). The difference in the iron content of the three samples was statistically significant.

Calcium

Fresh drumstick leaves have a calcium content of 440 mg / 100 g fresh leaves where as the calcium content of the leaf powder prepared by different methods of dehydration was in the range of 3382 mg to 3467 mg / 100 g leaf powder which was 86 - 87% higher than the fresh leaves. The difference in the calcium content of the three samples was statistically significant.

Phosphorus

Fresh drumstick leaves have a calcium content of 70 mg/ 100 g fresh leaves where as the calcium content of the leaf powder prepared by different methods of dehydration was in the range of 203 mg to 218 mg/ 100 g leaf powder which was 65.51 to 67.89% increased from the fresh leaves. The difference in the calcium content of the three samples was statistically significant.

Vitamin composition

Vitamin composition of dehydrated *Moringa* leaf (per 100 g leaf powder) is given in Table 3.

Beta – carotene

The maximum retention of beta - carotene was in shadow dried sample, (39600 μg) was followed by oven dried sample, (37800 μg) and a minimum level of 36000 μg / 100 g leaf powder in sun dried sample. Shadow drying though took longer than sun and oven drying, lead to lower carotene losses. The difference between the three samples of drumstick leaves was statistically significant.

Vitamin C

Vitamin C content of the dehydrated leaves was less than the fresh sample. This was the only nutrient, which reduced after dehydration as it is oxidized rapidly on exposure to heat and air. The maximum amount of vitamin C was in shadow - dried sample as in this technique the leaves were not exposed to direct heat and air.

Anti nutritional factors

Anti nutritional factor of dehydrated *Moringa* leaf (per 100 g leaf powder) is given in Table 4.

Oxalates

Oxalate content of the leaf samples was in the range of 430 to 500 mg per 100 g.

DISCUSSION

The results of the biochemical analysis showed that the leaf samples after dehydration became a concentrated source of all the nutrients. The results are in agreement with the studies done by Lakshmi and Vimla (2000) which showed that the leaves retained good amounts of protein, fiber and calcium in the various samples of the leaves dried by sun drying and cabinet drying. Similar findings were reported by Kowslya and Vidhya (2004) and Jemina Beryl and Bhavani 2004 in the dehydrated green leafy vegetables of cauliflower. The protein content of the leaf powder was equivalent to the protein content of many pulses such as Moth beans, soybeans, rajmah etc. which contain (22 - 24%) protein. Thus, becoming a good source of protein. Pulses though rich in protein are not affordable by the poor community of the developing countries thus *M. oleifira* in its dehydrated form can serve the role of pulses. The protein content of the leaf samples was higher than many of the commonly consumed green leafy vegetables, spinach (2%), and mint (4.8%). The fat content of the leaf samples were also higher than their fresh counter parts but it could not be considered as a rich source of fat, which is in agreement with the fact that green leafy vegetables are 'Heart friendly food'. As far as carbohydrate is concerned, green leafy vegetables are not considered as a good source of carbohydrate but after dehydration the carbohydrate content of the leaves was comparable with many of the carbohydrate rich cereals and vegetables. Wheat (69.4%), Potato (22.6%), turnip (9.4%). There was a significant increase in the mineral and vitamin content of the leaf samples after dehydration. Micronutrient deficiency also referred as hidden hunger is a major problem in the developing countries which leads to severe consequences affecting the human resources, the major power of the developing countries. Iron, calcium and phosphorus increased manifolds in the dehydrated samples. Carotene losses were lowest in the shadow dried samples. Studies have also shown that the carotene losses were directly dependent on the method of drying. Loss of beta carotene from green leafy vegetables such as mint, curry, gogu and amaranth, after drying was found to range from 24 to 40% in sun dried leaves and 6 to 255 in oven dried leaves (Aletor and Adeogun, 1995). Vitamin C content showed a decrement as vitamin c is a heat labile vitamin and is destroyed when exposed to direct sunlight and heat due to oxidation.

Conclusion

Dehydration technique resulted in concentration of nutrients. Dehydration is one of the most possible strategies for preservation of green leafy vegetables, which are highly seasonal and perishable too. The abundantly available inexpensive leaves of *M. oleifira* can serve as a pool house of nutrients and can be used in the developing countries to combat micronutrient deficiencies.

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