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Effect of processing on nutritional and anti-nutritional composition of curry leaves (*Murraya koenigii*)

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Abstract
Fresh and dehydrated curry leaves were analyzed for their nutritional and anti-nutritional composition. The moisture content of fresh curry leaves were found to have significantly higher amount i.e. 63.60 percent than that of dehydrated curry leaves i.e. 1.83 percent. The protein, fat, fibre, ash, carbohydrate and energy content of dehydrated curry leaves were found to be significantly higher than that of fresh curry leaves. Calcium and iron content of dehydrated curry leaves were found to be significantly higher i.e. 2111.70 and 10.44 mg/100g. Highest β-carotene content was found in fresh curry leaves i.e. 7427 µg/100g. Vitamin C content was also found to be highest in fresh curry leaves. There was significant increase in methionine and lysine content of dehydrated curry leaves as compared to fresh curry leaves. Curry leaves were also studied for their anti-nutritional components and it was found that dehydrated curry leaves contain highest amount of oxalates and phytate phosphorus.

Keywords: Dehydrated curry leaves, β-carotene, methionine content, anti-nutritional components

1. Introduction
Curry (*Murraya koenigii*) leaf is a fantastic aromatic herb used in many dishes in indian cuisine. Curry leaves known as *Murraya koenigii* is a tropical to sub-tropical tree in the rutaceae family which is a native to India. Curry leaves are called by different names in India like *kariveppilai* (in Tamil), *kariveppaku* (in Telgu) and *karripatta* (in Hindi). The name *kariveppilai* itself says the kari means curry, *veppu* means neem and *ilia* means leaf. Hence the literal translation of curry leaves of the Tamil name means "leaf that is used to make curry". These leaves are almost used or added in almost in almost all dishes to give a nice aroma to the dish. The leaves of *Murraya koenigii* are also used as a herb in ayurvedic medicines. Their properties include much value as an anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, hepatoprotective and anti-hypercholesterolemic. Curry leaves contains good amount of calcium and other minerals. β-carotene content of curry leaves is also high. The incorporation of curry leaf in the foods enhance the nutritive value and provide enormous health benefits.

India is rightfully called as the "Botanical garden of the world". It is the land of several medicinal plants and herbs that are traditionally used to cure ailments. *Murraya koenigii*, is one of such plants and is grown throughout the Indian subcontinent. It has wide culinary use and is one of the main components of formulation in the traditional Ayurvedic system. The ethanobotanical, phytochemical, pharmacological and pharmacognostic characteristics of *Murraya* have been studied in great detail over the past years. Carbazol alkaloids are abundantly present in its stem, leaf and root extracts. These have anti-diabetic, anticancer, antimicrobial, antioxidant and several other beneficial properties (Kamat *et al* 2015) [19]. Handral *et al.* (2012) describe the ethanobotanical properties, pharmacognostic, phytochemical and pharmacological properties of curry leaves plant. The various parts of this plant are widely used by different tribal communities. The leaves of plant are used as tonic, sromachic, carminative, internally in dysentery, vomiting. Used as antihelminthic, analgesic, cures piles, allays heat of the body, thirst inflammation and itching. The bark and roots of curry leaves can be used as a stimulant by physicians. They are also used externally to cure eruptions and the bites of poisonous animals. The green leaves are stated to be eaten raw for curing dysentery and the infusion of the washed leaves stops vomiting. Curry leaves are also used in calcium deficiency. It has Vitamin A, Vitamin B, Vitamin C, calcium and iron in plenty.

People who are suffering from calcium deficiency and osteoporosis can fing an ideal natural calcium supplement in curry leaves. The leaves comprises 18.7 percent carbohydrates, 6.1 percent protein, 1.0 percent fat and 6.4 percent fiber Singh *et al* (2014) [16]. Curry leaves are rich source of natural antioxidant substances such as tocopherol β-carotene, flavonoids and phenolics. The extracts and essential oil of plant exhibit antibacterial and antifungal activities. The curry leaves possess potential anticancer activities because of their strong antioxidative properties in various systems. The nutritional potentiality contained in the plant includes minerals, vitamins, carbohydrates, proteins and fatty acids (Mandal 2016). It is a good source of amino acid lysine (5.32gm/100g), alanine (4.17 gm/100gm), methionine (1.17 gm/100gm), phenylalanine (4.73 gm/100gm) and crude protein (25.67 gm/100gm).

Curry leaves, an inevitable part of spicing up dishes are not a part of mere garnishing. They are rich in medicinal, nutraceuticals properties and have even cosmetic uses. But from the age old days it is customary to pick up curry leaves from dishes and throw it out first before even tasting it. Indian cuisine experts, especially in South India made it a habit to include curry leaves in their daily diet. More than adding to the multi-hued look and spicy taste, there was definitely some other reason why the wise Indian ladies included curry leaf necessary ingredient in all our dishes. Though it is customary to remove these deep green leaves from dishes we are truly unaware of its health benefits.

2. Material and methods

2.1 Procurement and processing of curry leaves

The fresh curry leaves (*Murraya koenigii*) have been procured from the Department of Agronomy, Punjab Agricultural University (PAU), Ludhiana, India. The leaves were cleaned and rendered free of dust, dirt and other impurities. Processing had been applied under controlled conditions in the Food Laboratory of the Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. The samples were taken in triplicate.

2.1.1 Sorting and washing of curry leaves

The curry leaves sorted with healthy leaves were washed thoroughly by dipping in water for one to two minutes. The procedure was repeated till the leaves were devoid of dirt and soil.

2.1.2 Blanching and dehydration of fresh leaves

Fresh leaves were blanched for 2 minutes at 80 ºC. These were cooled and the excess water was drained off. Leaves were dried in hot air oven at 60± 5ºC for 8 hours and cooled at room temperature.

2.1.2.3 Storage of dehydrated leaves

The dehydrated leaves were powdered and packed in low density polythene bags and stored in air tight container for further use. Effect of dehydration on curry leaves has been studied by comparing chemical composition of fresh and dehydrated curry leaves. All the analytical chemicals and solvents used were supplied by Himedia (Mumbai, India)

2.2 Nutritional and anti-nutritional analysis of fresh and dehydrated curry leaves.

2.2.1 Proximate composition

Proximate composition viz. moisture, crude protein, crude fat, crude fibre, ash was analyzed by standard methods (AOAC 2000) [2]. The moisture content of samples was determined by air-oven drying at 105 °C for 8 hrs. Protein content was calculated by determining total nitrogen employing Microkjeldhal method (Kel plus Classic, Pelican Equipments Inc., India). Crude fat was extracted with petroleum ether, using Socs Plus and for fibre, acid and alkali washing was given in Fibra Plus Apparatus (Pelican Equipments Inc., India). Available carbohydrate was calculated by subtracting the sum of percentage value of crude protein, crude fat, ash and crude fibre from 100 on dry matter basis. Gross energy was computed with the help of formula mentioned below

Gross Energy = (Crude Protein×4) + (Crude Fat×9) + (Carbohydrate×4)

2.2.2 Amino acid analysis

Extraction of amino acids was done by hydrolyzing the samples in autoclave for 6h at 15lb pressure. After filtration, hydrolyzed samples were used for the determination of methionine (Horn, Jones, & Blum, 1946) [10]. Lysine was assessed by method of Carpenter, 1960 modified by Booth, 1971

2.2.3 Mineral content

For minerals, the samples were wet digested on hot plate using nitric acid and perchloric acid mixture in 5:1 ratio (v/v) and used for the determination of total amount of calcium and iron by atomic absorption spectrophotometer (AOAC, 2000) [2].

2.2.4 Vitamin content

For β-carotene content the individual carotenoids were separated on a column of calcium hydroxide of alumina and determined spectrophotometrically (Rangana, 2002) [13]. The vitamin C content of fresh and dehydrated curry leaves were determined using method of AOVC (1996) [3]. The blue colour produced by the reduction of 2, 6-dichlorophenolindophenol dye by ascorbic acid and was estimated colorimetrically in spectrophotometer at 500 nm.

2.2.5 Anti-nutritional factors

The fresh and dehydrated curry leaves were analyzed for oxalates and phytate phosphorus content. The oxalate content of curry leaves was analyzed through the method given by Abeza *et al* (1968) [1]. The phytate phosphorus content of fresh and dehydrated curry leaves were analyzed spectrophotometrically through method given by Haug and Lantzsch (1983) [9].

2.2.6 Statistical analysis

The data were analyzed statistically by using various statistical tools such as mean and standard error. To test the significance difference between samples of fresh and dehydrated curry leaves, ANOVA and two tail t-test was applied using SPSS 16 software.

3. Results and Discussion

3.1 Proximate composition

The proximate composition of fresh and dehydrated curry leaves has been given in the table 1. The moisture content of fresh curry leaves was found to be 63.60 percent and 1.83 percent for dehydrated curry leaves with a significant difference. The protein content of dehydrated curry leaves was found to be significantly higher i.e. 10.33 percent, whereas in fresh curry leaves it was found to be 5.63 percent. The fat content of fresh curry leaves was found to be 0.67

which was significantly lower than dehydrated curry leaves. The crude fibre content of dehydrated curry leaves was also higher than that of fresh curry leaves i.e. 9.23 and 6.30 percent in fresh curry leaves. There was a significant increase in ash content of dehydrated curry leaves (10.33%) than that of fresh curry leaves (3.96%). Sudha *et al* (2014) [17] found 69.9 percent moisture content in fresh curry leaves and 6.4 percent in dehydrated leaves, the ash content were ranged between 9.9 to 13 percent and the protein content was found to be in the range of 16.9 to 24.4 percent on dry weight basis. The carbohydrate content of fresh curry leaves was found to be 19.73 g/100g and that of dehydrated was 62.94 g per 100g. The energy content was found to be 107.47 Kcal for fresh curry leaves and 341.05 Kcal for dehydrated curry leaves.

Gopalan *et al* (2011) [8] reported the moisture content of curry leaves to be 63.8 percent, protein content 6.1 percent, crude fat 1.0 percent, total ash 4.0 percent, crude fibre 6.4 percent, carbohydrate 18.7 g/100g and 108 Kcal energy. Jain *et al* (2012) [11] revealed that mature curry leaves contains 63.2 percent moisture, 1.15 percent total nitrogen, 6.15 percent fat, 18.92 percent carbohydrates, 6.8 percent crude fiber and 13.06 percent ash. Khatoon *et al* (2011) [12] performed the comparative study of fresh and dehydrated curry leaves. The results revealed that protein content of fresh curry was 6 g and 12 g/100 g for dehydrated curry leaves. The crude fat content of fresh and dehydrated curry leaves were ranged between 1 g to 5.4 g/100g. The carbohydrate content of fresh curry leaves was found to be 18.7g and for dehydrated leaves it was 64.31g per100 g. Sharangi and Guha (2013) [15] analyzed the curry leaves (*Murraya koenigi*) for their proximate composition and it was found that curry leaves contain moisture 66.3 percent, protein 6.1 percent, fat (ether extract) 1.0 percent, carbohydrates 16.0 percent, fiber 6.4 percent and mineral matter 4.2 percent.

3.2 Mineral content

The results of mineral content of fresh and dehydrated curry leaves has been given in Table 2. The dehydrated curry leaves contain significantly higher amount of iron than that of fresh curry leaves i.e. 10.44 mg/100 g in dehydrated curry leaves and 0.93 mg/100 g in fresh curry leaves. The dehydrated curry leaves also contain higher amount of calcium as compared to fresh curry leaves i.e. 2111.70 mg/100 g calcium in dried curry leaves and 819 mg/100 g in fresh curry leaves. The calcium content and iron content of curry leaves was found to be 830 mg/100 g and 0.93 mg/100 g respectively (Gopalan *et al* 2011) [8].

Singh *et al* (2014) [16] conducted a comparative study on nutrient content of fresh and dehydrated curry leaves and it was found that the calcium content of fresh curry leaves 830mg/100g and for dehydrated leaves was 2040mg/100g. The iron content of dehydrated leaves was found to be 12mg/100g which was significantly higher than that of fresh curry leaves i.e. 0.93mg/100g.

3.3 Vitamin content

The results of vitamin C and β-carotene content of fresh and dehydrated curry leaves has been given in Table 3. Vitamin C content in fresh curry leaves was observed as 3.83 mg/100 g while in dehydrated curry leaves it was significantly decreased and found to be 0.42 mg/100g. The β-carotene content of fresh curry leaves was found to be 7427µg/100 g which is significantly higher than that of dehydrated curry leaves i.e. 5206.33µg/100 g.

Bonde *el al* (2007) [5] reported that fresh curry leaves contain 7560 µg/100 g and dehydrated curry leaves contain 5292 µg/100 g of β-carotene. Salikutty *et al.* (2012) [14] found that vitamin C content of curry leaves is 4mg/100g of curry leaves. Verma (2015) [19] reported vitamin C content of fresh and dehydrated garden cress leaves to be 0.7 mg/100 g and 0.9 mg/100g. The β-carotene content of fresh and dehydrated garden cress leaves was found to be 2551 µg/100g and 17625 µg/100g respectively. The β-carotene content of curry leaves was found to be 7560µg/100g and the vitamin C content of curry leaves was found to be 4mg/100g (Gopalan *et al* 2011) [8]. Singh *et al* (2014) [16] found that β-carotene content of fresh curry leaves to be 7560µg/100g and in dehydrated curry leaves it was found to be 5292µg/100g.

3.4 Amino acid composition

Amino acid composition of fresh and dehydrated curry leaves has been presented in table 5. The fresh and dehydrated curry leaves were evaluated for methionine and lysine content and it was found that methionine content of dehydrated curry leaves was significantly higher than that of fresh curry leaves i.e. 1.17 mg/100 g in dehydrated curry leaves and 0.84 mg/100 g in fresh curry leaves. The lysine content of dehydrated curry leaves was found to be 5.12 mg/100 g which was significantly higher than that of fresh curry leaves i.e. 1.20 mg/100 g. Aremu *et al* (2011) [4] found that curry leaves contained lysine (5.32 mg/100 g), alanine (4.17 mg/100 g), methionine (1.17 mg/100 g) and phenylalanine (4.73 mg/100 g of protein) respectively.

3.5 Anti- nutritional factors

The curry leaves were evaluated for oxalates and phytate phosphorus and results has been given in Table 6. It was observed that dehydrated curry leaves significantly contained higher amount of phytate phosphorus (86.52 mg/100 g) than that of fresh curry leaves (40.90 mg/100 g). The dehydrated curry leaves also contained higher amount of oxalates than that of fresh curry leaves i.e. 501.55 mg/100 g in dehydrated curry leaves and 225.34 mg/100 g in fresh curry leaves

Curry leaves are observed to have the highest levels of anti-nutrients prior to heating i.e. tannins (427.16mg/100gm), phytate (41.27mg/100gm), HCN (231mg/100gm) and total oxalates (246.40mg/100gm). A remarkable and significant decrease in levels of the phytate is seen when the samples were heated at 90 °C. At 50 °C, the levels of phytates reduced to 7.7 percent and 74.6 percent at 90 °C. Cyanide levels reduced significantly after heating the samples for 15 minutes at 50 °C. Heating the samples further did not cause much reduction in the cyanide levels. The effective condition for reduction of these anti-nutrients would be heating at a temperature of 90 °C for 15 minutes (Udousoro *et al* 2013) [8].

Table 1: Proximate composition of fresh and dehydrated curry leaves (on dry weight basis).

Sample	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	CHO (g)	Energy (Kcal)
Fresh leaves	63.60±0.05	5.63±0.005	0.67±0.005	6.30±0.005	3.96±0.005	19.73±0.005	107.47±0.30
Dehydrated leaves	1.83±0.005	10.33±0.005	5.33±0.005	9.23±0.005	10.33±0.005	62.94±0.005	341.05±0.005
t-value	10.65**	575.63**	570.73**	50.49**	780.16**	744.70**	763.20**

Values are expressed as Mean ± SE

** Significance at 1% level of significance

Table 2: Mineral content of fresh and dehydrated curry leaves (mg/100g on dry weight basis)

Sample	Iron (mg/100g)	Calcium (mg/100g)
Fresh leaves	0.93±0.005	819.00±0.57
Dehydrated leaves	10.44±0.005	2111.70±0.005
t-value	11.65**	22.39**

Values are expressed as Mean ± SE
** Significance at 1% level of significance

Table 3: Vitamin content of fresh and dehydrated curry leaves (on fresh weight basis)

Sample	β-Carotene (µg/100g)	Vitamin C (mg/100g)
Fresh leaves	7427±0.57	3.83±0.005
Dehydrated leaves	5206.33±0.005	0.42±0.005
t-value	38.46**	417.63**

Values are expressed as Mean ± SE
** Significance at 1% level of significance

Table 4: Amino acid composition of fresh and dehydrated curry leaves (mg/100g protein)

Sample	Methionine (mg)	Available Lysine(mg)
Fresh leaves	0.84±0.005	1.20±0.005
Dehydrated leaves	1.17±0.005	5.12±0.005
t-value	40.41**	67.55**

Values are expressed as Mean ± SE
** Significance at 1% level of significance

Table 5: Anti-nutritional factors of fresh and dehydrated curry leaves

Sample	Oxalates (mg/100g)	Phytate Phosphorus (mg/100g)
Fresh	225.34±0.005	40.90±0.05
Dehydrated leaves	501.55±0.005	86.52±0.005
t-value	33.83**	786.24**

Values are expressed as Mean ± SE
** Significance at 1% level of significance

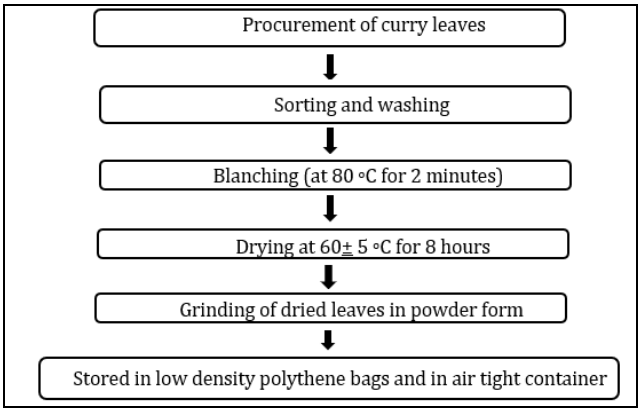

Fig 1: Schematic presentation of dehydration process of curry leaves

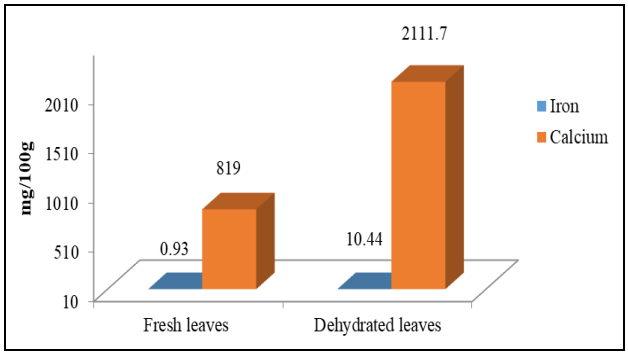

Fig 2: Iron and calcium content of fresh and dehydrated curry leaves

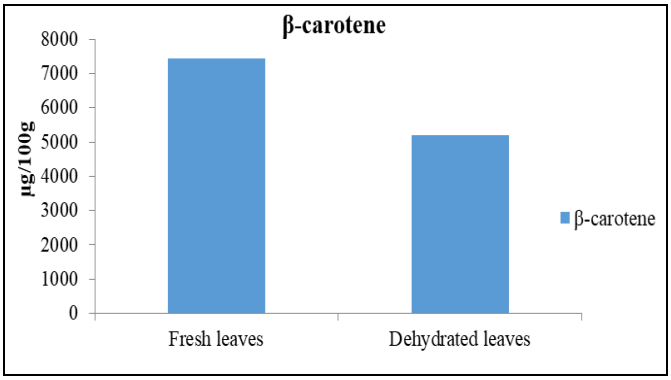

Fig 3: β-carotene content of fresh and dehydrated curry leaves

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