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Effect of different drying treatment on composition, nutritional and phytochemical content of curry leaves

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Abstract
The present work was proposed to development technology for drying of curry leaves *(Murraya koenigii*) and carried out by using sun drying (30-35^{0}C for 8 Hr.), shade drying (27-32^{0}C for 15 days) and cabinet oven drying (60^{0}C for 2 hr.). The obtained result was evaluated of dried curry powder with respect to chemical composition, nutritional and phytochemical properties. The moisture was reduced from 65.50% to 3.90%, fat, protein carbohydrate, crude fibre and ash increased from 0.80% to 5.82%, 6.10% to 10.75%, 6.60% to 59.48%, 6.30% to 12.95% and 4.65% to 11.10% respectively. Related to mineral content, the calcium, potassium, iron, magnesium, zinc and phosphorus raised from 455.55 to 475.05 mg/100g, 416.13 to 432.60 mg/100g,18.30 to 19.55 mg/100g,129.72 to 156.57 mg/100g, 2.09 to 2.43 mg/100g and63.25 to 68.50 mg/100grespectively. The variation in the concentration of such compounds as alkaloids, flavonoids, total phenol and β-Carotene and found more concentration in shade dried curry powder TC2 had values 9.74, 8.12, 0.99 and 1.50 respectively. Finally energy consumption and time taken more in shade drying method but end-dried product is superior in all respect compared to other dried products.

Keywords: Drying methods, curry powder, composition, nutritional and phytochemical component

Introduction
Curry leaves (*Murraya koenigii*) belongs to the Rutaceae family and is an aromatic, pubescent, deciduous shrub or tiny tree. It is widespread throughout Southeast Asia, Australia and the Pacific Islands. In India, it occurs in cultivated and wild forms. The curry leaf tree is native to India, Bangladesh, Sri Lanka and the Andaman Islands. Later spread by Indian migrants, they now grow in other areas of the world where Indian immigrants resided. The leaves are widely cultivated and are particularly associated with South Indian cuisines (Mubeen *et al.*, 2009) [1]. The curry leaves are aromatic in nature, deciduous shrub or tree up to 6 metres in height and about 15-40 cm in diameter with short trunk.

Several processes can achieve drying of the plant material, including sun drying, shade drying, microwaves drying, cabinet drying, hot air oven drying, and freezes drying. While drying can be used to avoid heat damage, it is considered a costly and time-consuming method to produce a product with superior physical and chemical qualities (Ratti, 2001) [2].

Curry leaves powder are rich in carbohydrate, fibres, minerals like phosphorus, calcium, iron, zinc, potassium and manganese and vitamins like thiamine, niacin and ascorbic acid and retinol. Curry leaves contain various phytochemical substances including alkaloids, flavonoids, tannins and terpenoid. Some bioactive substances such as mahanimbilyl acetate, girinimbilyl acetate and bicyclomahanimbiline have been isolated and antimicrobial and antioxidant activity has been reported (Ganesan *et al.*, 2013) [3].

Curry leaves possess extensive food and pharmacological applications in its original state. Due to the high influence beneficial effects, there is a growing market for this leafy spice, if appropriate and viable methodologies for the processing as well as preparation of bioactive preserve (antioxidant / radical scavenging) created. This could identify potential uses / applications in food systems. However, curry leaves are the main ingredient in many processed food products, its biological importance has been known and the applications or industrial processes due to various technological constraints have not been fully explored. For example, use is limited to fresh leaves only, although in some places the sun-dried leaves are used which have the disadvantage of being unhygienic and deemed inferior due to reasons such as loss of volatile oil and colour etc. Curry leaves are primarily used for cooking in the southern parts of India in order to provide flavour to the curries, vegetables, pickles, chutneys, soups, butter milk, southern indian sambar preparation as well as non-vegetarian products, but mostly used

in vegetarian foods. In addition to the food value, they add to the smell and taste of the food (Kulkarni 1994) [4].
Curry Leaves are rich in several bioactive compounds such as polyphenols, alkaloids and flavonoids that exhibited multiple bioactive functions such as antioxidant, anticancer, antimicrobial, antidiabetic and hepatoprotective The two carbazole alkaloids found in these leaves, namely mahanimbine and koenigine, showed higher antioxidant activity (Ganesan *et al*., 2013) [3]. Due to its free radical scavenging activity, phenolic antioxidants are very important components of plants. Different pharmacological experiments persuading demonstrated antioxidants, antimicrobial, hepatoprotective and pro-thrombic activities of curry leaves. Curry leaves contribute great promise against cardiovascular disorders, hypertension and obesity. Curry leave contains large quantities of phenolic and flavonoid compounds that are responsible for lipid reduction and anti-obesity activities due to high antioxidant capacity (Schieber *et al*., 2001) [22].
Therefore, the work deals with the application of different drying methods, quantitatively analysis of proximate composition, mineral composition and phytochemicals content in dried curry leaves powder

Material and methods

Materials: The raw material used during the experiment white wheat flour, sugar, linseed, aniseed, turmeric, sesame, salt, sugar and other minor ingredients were obtained from the market area of Parbhani.

Chemicals and glassware: Chemicals of analytical grade and sufficient glassware required were available in the laboratory, Department of Food Chemistry and Nutrition, College of Food Technology. V.N.M.K.V. Parbhani.

Analytical equipment's: Electronic weighing balance, soxhlet extraction apparatus, steam distillation unit, hot air oven, incubator, spectrophotometer, Gas chromatography-mass spectrometry, Baking oven and muffle furnace available from the Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani

Method of Drying and preparation of powder

Sun shade drying: Conventional sun drying techniques have been used. Separate the leaves from the stalks and wash them with running water. Washed leaves then spread over the floor and held those leaves at 30-35^{0}C temperature for 8 hours for sun drying. Once the dried leaves are collected, the dried leaves are grinded in grinder to make the fine powder, weighed and packed into a polyethylene container. Such powders were used for trials (Sathiya *et al*., 2015) [5].

Shade drying: Conventional shade-drying methods have been used. Separate the leaves from stalks and wash with running water underneath. Washed leaves then spread over the floor and kept those leaves at a temperature of 27-32^{0}C for 15 days for shade drying. Once the dried leaves are collected, the dried leaves are grinded in grinder to make the fine powder, weighed and packed into a polyethylene container. Such powders were used for trials (Sathiya *et al*., 2015) [5].

Cabinet oven drying: Segregate the leaves from stalks and wash with running water underneath. Washed leaves then spread over the tray and put the tray in the oven. Drying was performed two hrs. at 60^{0}C. To achieve the required temperature, the dryer was switched on for 30 min before each run. Once the desired temperature was achieved, samples were placed into a layer onto the tray. The trays have been removed from the dryer, the dried leaves have been collected, finely grinded, weighed and packed into a polyethylene bag. These powders were used for trials (Sathiya *et al*., 2015) [5].

Different drying treatments given to curry and mint leaves
Curry and mint leaves given various drying treatment like sun, shade and cabinet oven drying and converted dried leaves into fine powder. The treatments and dried samples was mentioned below.

Table 1: Drying treatments given to curry and mint leaves

S. No.	Treatment	Sample
1.	TC0	Fresh curry leaves
2.	TC1	Sun dried curry leaves powder
3.	TC2	Shade dried curry leaves powder
4.	TC3	Cabinet oven dried curry leaves powder

Proximate composition of dried curry and mint leaves powder
Fresh curry and mint leaves and its prepared powder were analysed for proximate composition including moisture, fat, protein, total carbohydrate, crude fibre, ash and mineral composition was carried out as per the methods given by (AOAC, 2005).

Quantitative determination of phytochemicals in prepared powder

Total alkaloid: Five grams of the sample were weighed in a 250 ml beaker and 200 ml of 10 percent ethanol acetic acid was added and allowed to stand for 4 minutes, filtered and diluted to one quarter of the original volume in a water bath. Concentrated ammonium hydroxide added drop wise to the extract every time the precipitation was over. The entire solution was allowed to settle, and dilute ammonium hydroxide was used to absorb, wash, and filter the precipitate. Dried and weighed the residue, was alkaloid (Harbone, 1973) [6].

$$\text{Alkaloid (\%)} = \frac{W3 - W2}{W1} \times 100$$

Where,
W1 = Initial weight of sample, W2 = Weight of the extract and W3 = Final weight of the residue

Total flavonoid content: The total flavonoid content of cold and hot powder extracts was determined by a slightly changed method stated by Meda *et al.*, (2005) [7]. A 0.5 ml of sufficiently diluted sample was combined with 0.5 ml methanol, 50 µl 10% $AlCl_3$, 50 µl 1 mol L^{-1} potassium acetate and 1.4 ml water, and allowed to incubate at room temperature for 30 minutes. Afterwards the absorbance of the reaction mixture was measured at 415 nm. The total flavonoid was determined using quercetin formula as standard.

$$TFC = \frac{A \times DF}{A1\%\ 1cm \times (w - ld)}$$

Where, A = Absorbance, DF = Dilution Factor, A1% 1cm = Specific absorption by $AlCl_3$
w = Mass of plant material, ld = Loss on drying

Total phenolic content: The total phenolic content (TPC) of the powder extracts was measured using the process of Folin – Ciocalteu (Pinelo *et al.,* 2005) [8]. Next to 5 ml Folin - Ciocalteu reagent was added into 1 ml sample tube. Then introduced to the mixture of 4 ml of 7.5 per cent (w/v) of sodium carbonate. The absorbance was read at 765 nm against blank after 60 min of room temperature incubation (32 ± 1^0C) The results were presented as an equivalent mg of gallic acid per gram of dry weight basis for the fresh sample (mg GAE / g dw base). The overall phenolic content of all the samples was estimated using the formula,
Total phenolic contents (TPC) from the powder extracts were quantified using

$$C = c\ V/m$$

where,
C = total phenolic content mg GAE/g dry extract, c = concentration of Gallic acid obtained from calibration curve in mg/mL, V = volume of extract in ml, m = mass of extract in gram.

β- Carotene: Carotene was extracted from vegetables using the Khalil and Varananis (1996) [9] method for "Reversed phased HPLC system." 10 g of the sample was homogenized to 30 ml of acetone, and 0.1% BHT solution in the acetone solution was used as an antioxidant. The resulting extract has been pumped through Buchner funnel. The residue was treated with acetone twice, until it was colourless. The excess was discarded and 20gm of anhydrous sodium sulphate was added to the filtrate. The anhydrous sodium sulfate was extracted by filtration, and rotatory evaporator reduced the amount of extract. The extract was quantitatively transferred to 100ml volumetric flask, and the amount was made with acetone and water up to the limit, so that the final extract contains 80 percent of acetone.

Standard preparation of beta carotene standard of beta carotene

1 g wrapped in a vial received from merck. Stock beta-carotene solution was prepared by taking 10 mg in 100ml n-hexane. The stock solution concentration was = 100 ppm. The stock solution was diluted to different known concentrations e.g. 20, 40 and 60 ppm, dilutions in 5 ml of each n-hexane solution were obtained. Each working standard solution was injected into the HPLC system and chromatographic condition was the Perkin Elmer HPLC program with the LC-1000 pump (Isocratic) column and the LC 250 UV / VIS detector was connected. The "CSW 32 program" for the HPLC method allowed peak detection and quantification. HPLC was measured at a rate of 2ml per minute by running the mobile process (acetonitrile, dichloromethane, and methanol 70:20:10. respectively. The wavelength was 452 nm. Column pressure was holding from 1800-2000 PSI. Each standard beta carotene solution (20µl) was injected at the time the injector was in load mode. The normal beta-carotene peak was reached at 4.7 minute retention time (Rt = 4.7). To get a straight line, the concentrations of the beta-carotene standards were plotted against the peak point.

Sample assay
A sample of beta-carotene extract was used as usual in 80 percent acetone for HPLC assay; a sample of vegetables (20µl) was taken by micro liter syringe. The peak was immediately identified and quantified by comparing its sample retention time to the standard retention period.

Result and discussion
In the present investigation efforts have been taken for qualitative and quantitative determination of chemical composition, mineral composition and phytochemical content of curry leaves powder given as following

Percent yield and drying parameters for curry leaves
The present finding with respect to drying curry leaves was carried out using different drying techniques by various drying conditions with respect to time & temperature and drying yield presented in table 2.

Table 2: Drying condition and yield of dried curry leaves

S. No.	Drying methods	Conditioned employed	Time (hrs/days)	Drying yield /100 gm
1	Sun drying	$30\text{-}35^0$ C	8 h	43.50
2	Shade drying	$27\text{-}32^0$ C	15 days	44.20
3	Cabinet oven drying	60^0 C	2 h	41.90

Drying of curry leaves with sun, shade and cabinet oven was performed by varied conditions i.e. $30\text{-}35^0$C, $27\text{-}32^0$C and 60^0C respectively. Results reported that the drying yield of dried curry leaves was varied significantly from among the drying methods and reported to be 43.50%, 44.20% and 41.90% in respective drying methods. The shade drying method showed significantly higher value (44.20) as compared to other drying methods.
The results showed that in all these methods the quality of dried products were found to be superior and retained green colour, which performed in a single trial. In all these methods, the energy consumption and time taken for drying found to be more in shade drying method but produce quality of end-dried product is superior as compare to other dried products. These results are comparable with those reported by (Rajkumar *et al.*, 2006) [10]

Proximate composition of curry leaves powder
Proximate composition generally represents the nutritional quality of product. It is necessary to determine the proximate composition of curry leaves powder to judge its effect on final product after utilization as a novel ingredient. The present finding of proximate composition of curry leaves powder with respect to moisture, fat, protein, carbohydrate, crude fibre and ash was conducted and obtained results were presented in Table 3

Table 3: Effect of drying methods on proximate composition of curry leaves powder

Treatments	Values (g /100g)					
	Moisture	Fat	Protein	Carbohydrate	Crude fibre	Ash
TC0	65.50	0.80	6.10	16.60	6.30	4.65
TC1	4.10	5.33	10.75	58.47	10.25	11.10
TC2	4.85	5.10	10.38	55.87	12.95	10.85
TC3	3.90	5.82	8.80	59.48	11.10	11.90
SE+	0.3679	0.0431	0.1443	0.4508	0.2391	0.1031
CD at 5%	1.5200	0.1781	0.5962	1.8622	0.9878	0.4259

*Each value is average of three determinations

TC0 Fresh curry leaves
TC1 Sun dried curry leaves powder
TC2 Shade dried curry leaves powder
TC3 Cabinet oven dried curry leaves powder

The table 3 sought to provide information on the effect of different drying methods (sun, shade and cabinet drying) on proximate composition of curry leaves powder and determine the best method for drying of curry leaves powder. The proximate composition of curry leaves dried using different drying methods revealed variations in the composition. The moisture content of the dried samples was significant difference and it was drastically reduced as compared to fresh curry leaves samples TC0 (65.50). The samples (TC1, TC2 and TC3) subjected to drying until the final moisture content reaches to 4.10, 4.85 and 3.90 per cent respectively. The maximum moisture content in dried powder TC2 (4.85%) and minimum was in the TC3 (3.90%).

The fat content of curry leaves powder was increased after drying. The TC3 powder retained the highest fat content with a value of 5.82 per cent. The TC1 and TC2 sample had fat content 5.33 and 5.10 per cent. It shows that TC3 was significant with TC1 and found at par with TC2. It represents a good index of storability as it reduces the susceptibility of the powder to lipid oxidation.

The TC1 had highest protein content in all the drying treatments with a value of 10.75% which was significantly higher than other drying methods. The protein content of TC2 and TC3 powder was 10.38 and 8.80 per cent. The result shows that TC1 was significant with TC2 and TC3 with respect to protein content. The change in protein content could be attributed to mild heating effect associated with all the drying conditions which could result in the unzipping of hydrophobic forces leading to a partial distribution of the primary, secondary, tertiary and quaternary structure of the protein molecule (Ihekoronye and Ngoddy, 1985) [11].

The carbohydrate content in dried powder was increased as compared to fresh leaves. The carbohydrate content of dried powder was found in the range of 55.87 per cent to 59.48 per cent. It was observed the TC3 drying was significant with TC1 and at par with TC2. The increase in these nutrients could be attributed to the application of heat.

The crude fibre of dried powder was found in the range of 6.30 to 12.95 per cent. It was observed the TC2 was significant with TC3 and at par with TC1. The ash content of curry leaves powder increased significantly as compare with fresh curry leaves i.e. TC0 (4.65). The ash content of curry leaves powder by TC1, TC2 and TC3 was found to be 11.10, 10.85 and 11.90 per cent, respectively. In case of ash content, TC3 was statistically significant with TC1 and TC2 drying. The TC3 had high ash content which might be due to less moisture as compared to TC1 and TC2 drying.

The increase in ash content observed in this study could be due to the removal of moisture, which tends to increase the concentration of nutrients (Morris *et al.,* 2004) [12]. The protein, carbohydrate, fat, fibre and ash content of curry leaves powder were increased when subjected to sun, shade, cabinet oven drying (Satwase *et al.,* 2013) [13]. The similar trend of protein, fat, ash and carbohydrate was reported by Abioye *et al.,* (2014) [14].

Mineral composition of curry leaves powder

The result of minerals composition of the three different drying techniques (i.e. sun, shade and cabinet) drying on curry leaves powder with respect to calcium, potassium, iron, magnesium, zinc and phosphorous are presented in Table 4.

Table 4: Effect of drying methods on mineral composition of curry leaves powder

Treatments	Minerals content (mg/100g)					
	Calcium (Ca)	Potassium (K)	Iron (Fe)	Magnesium (Mg)	Zinc (Zn)	Phosphorus (P)
TC1	449.30	416.13	19.55	129.72	2.09	64.30
TC2	455.55	428.35	19.40	144.18	2.43	68.50
TC3	475.05	432.60	18.30	156.57	2.10	63.25
SE+	0.4714	0.3943	0.01218	0.3586	0.1896	0.2811
CD at 5%	0.0295	0.03895	0.00074	0.00354	1.1963	0.00046

TC1 Sun dried curry leaves powder
TC2 Shade dried curry leaves powder
TC3 Cabinet oven dried curry leaves powder

It was found in table 16 that the TC3 was found significantly superior over TC1 and TC2 drying. The mineral contents were found to be increased upon drying. The calcium content was found in increased trends measured. The calcium content in TC1, TC2 and TC3 was 449.30, 455.55 and 475.05 mg/100g, respectively. According to Perez-Lopez *et al.*, (2002), the calcium content was affected by temperature, calcium chloride concentration and treatment time. The

potassium content in TC1, TC2 and TC3 was 416.13, 428.35 and 432.60 mg/100g respectively. This observation may be due to potassium being cationic element that does not polarizes easily in heating but forms oxides when exposed to light and air (Liman *et al.*, 2014).

The iron content in TC1, TC2 and TC3 was 19.55, 19.40 and 18.30 mg/100g respectively. The magnesium content of TC1, TC2 and TC3 powder was 129.72, 144.18 and 156.57 mg/100g respectively. The increase in magnesium content is probably be due to the heating effect of the drying minerals which do not escape/vaporize and as such higher values in magnesium were seen (Liman *et al.*, 2014).

The TC2 curry leaves powder (2.43 mg/100g) recorded higher zinc content over TC3 (2.10 mg/100g) and TC1 powder (2.09 mg/100g). The TC2 curry leaves powder (68.50 mg/100g) recorded higher phosphorus content over TC1 (64.30 mg/100g) and TC3 powder (63.25 mg/100g).

However, the value of mineral contents increases in relation to the drying method. The increase or decrease of micronutrient of dried sample may be attributed to the removal of water molecule by drying. The similar findings were also reported by Joshi and Mehta (2010) [16], who studied the effect of dehydration on nutritive value of drumstick leaves and concluded that shade dried samples, had highest minerals retention followed by shade dried samples. Mbah *et al.*, (2012) [17] studied the effect of drying method on nutrients and non-nutrients composition of *Moringa oleifera* leaves and observed that treatments (sun drying, shade drying and oven drying) improved calcium and zinc content of the leaves.

Phytochemical content of curry leaves powder

Data pertaining with respect to alkaloids, flavonoids, total phenol and β-Carotene presented and result tabulated in Table 5.

Table 5: Effect of drying methods on phytochemical content of curry leaves powder

Treatments	Phytochemical content (g/100gm)			
	Total Alkaloid	Total Flavonoid	Total Phenol (µg/g)	β-Carotene
TC0	8.49	7.79	0.83	2.09
TC1	8.25	6.50	0.70	1.20
TC2	9.74	8.12	0.99	1.50
TC3	7.60	5.35	0.65	0.90

TC0 Fresh curry leaves
TC1 Sun dried curry leaves powder
TC2 Shade dried curry leaves powder
TC3 Cabinet oven dried curry leaves powder

With reference to Table 19, the alkaloids, flavonoid, total phenol and β-Carotene recorded their highest value in the samples were TC2 i.e. 9.74, 8.12, 0.99 and 1.50 g/100g respectively compared to fresh curry leaves sample TC0 i.e. 8.49, 7.79, 0.83 and 2.09 g/100g respectively. There is not much critical difference observed in the phytochemical content in the treatments.

The maximum value of alkaloids content was found in TC2 (9.74 g/100g) than TC0, TC1 and TC3 i.e. 8.49, 8.25 and 7.60 g/100g respectively. Maximum reduction in flavonoid content found in TC2 (8.12 g/100g) aqueous extract to other samples i.e. TC0, TC1 and TC3 have 7.79, 6.50 and 5.35 g/100g respectively. The loss in alkaloids and flavonoids in sample TC1 and TC3 may due to breakdown or leakage by chemical reactions includes oxygen, enzymes and light (Davey *et al.*, 2000) [18]. Increasing preheating temperature decreased the enzyme activity to degrading enzyme such as polyphenol oxidase, which resulted in an increase in flavonoid content (Sukrasno *et al.*, 2011) [19].

The reduction in total phenol and β-Carotene content were also found by Mansour, (2016), who found that drying process significantly decreased the phenolic and β-Carotene contents i.e total phenol reduced from 0.99 to 0.65 g/100g and β-Carotene reduced from 2.09 to 0.90 g/100g. These could be explained by the fact that the drying time was extended at higher temperatures, such that the samples had a longer duration of oxygen exposure resulting in increased redox activity and degradation of phenolic compounds (Hung and Duy 2012) [20]. Drying process led to loss of 30% of polyphenols in total phenol content and 25% loss of β-Carotene which reported in Felipe *et al.*, (2010) [21].

The thermal processing can affect the phytochemicals by thermal breakdown that affect the integrity of the cell structure which then results in the migration of components, leading to losses by leakage or breakdown by various chemical reactions involving enzymes, light and oxygen (Schieber *et al.*, 2001) [22]. The shade dried powder contained more alkaloids, flavonoid, total phenol and β-Carotene than sun drying and cabinet oven drying.

Conclusion

Energy consumption and time taken for drying found to be more in shade drying method and produce quality of end-dried product is superior in all respect like colour, flavour taste as compared to other dried products. This increment of proximate composition was seen in all dried powder prepared from different drying methods in all dried. The value of mineral contents increases in relation to the drying method. The increase or decrease of micronutrient of dried sample may be attributed to the removal of water molecule by drying. A variation in the concentration of such compounds as alkaloids, flavonoids, total phenol and β-Carotene and found more concentration in shade dried curry powder TC2 had values 9.74, 8.12, 0.99 and 1.50 respectively.

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