International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2020; 7(6): 1790-1796

Received: 20-05-2020
Accepted: 21-06-2020

Effect of drying methods on chemical constituents and flour of coriander (*Corianderum sativum)* leaves

Fauzia Shafi, Naeema Jan, Tahiya Qadri, Bazila Naseer, Mushtaq Beigh, Imityaz Zargar and Tashooq Bhat

Fauzia Shafi
Division of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Naeema Jan
Division of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Tahiya Qadri
Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Bazila Naseer
Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Mushtaq Beigh
Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Imityaz Zargar
Division of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, Jammu Kashmir, India

Tashooq Bhat
Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

Corresponding Author:
Tahiya Qadri
Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India

DOI: https://doi.org/10.22271/chemi.2020.v8.i4r.9889

Abstract
The present study was undertaken to study the effects of blanching and drying methods on two different coriander varieties *viz* local variety (V1) and hybrid variety (V2). Sun and cabinet drying were employed post blanching which was carried out at 85^o C for 3.5 min. Blanching decreased the total chlorophyll, chlorophyll b, total phenol, total carotenoid, ascorbic acid, essential oil content and luminosity of dried leaves while increased chlorophyll a content, redness, yellowness and total solids in dried samples. Cabinet drying recorded 36.34% and 32.80% decrease in total chlorophyll content of V1 and V2 respectively against 44.16% decrease in V1 and 38.58% in V2 for total chlorophyll content during sun drying. However, a higher percentage of total phenol content was lost in cabinet dried samples as compared to sun dried samples for both coriander varieties. The study revealed minimum loss of nutrients in cabinet dried leaves and thus cabinet drying at 60^o C is better technique for drying of coriander leaves. Storage studies of the dried leaves revealed that they can be safely stored for 3 months in LDPE pouches under ambient conditions.

Keywords: Blanching, cabinet dryer, coriander, LDPE, sun drying

Introduction
Coriander (*Corianderum sativum*) is an annual herbaceous plant that belongs to the family Umbelliferae. Coriander or "dhanaya" is a culinary and medicinal crop which finds extensive use in food and pharmaceutical industry worldwide for its rich nutritional composition [1]. The leaves of plant are rich in volatile oils, flavonoid glycosides (quercetin, iso-quercetin, and rutin), caffenic acid, minerals (calcium, phosphorus and iron), carotene, fibre, and carbohydrates. It also contains essential vitamins and minerals in profuse amounts [2]. Coriander is also known for its therapeutic effects. Various researchers have reported anti-oxidant, anti-bacterial, anti-fungal, anti-cholinesterase activities as well as memory improving power and cholesterol lowering action of coriander extracts [3]. Fresh leaves are used to garnish various cuisines and mask odour of various foods. Moreover, they act as appetite stimulant and flavouring agent. However, the high perishability and huge post-harvest losses of coriander limits its availability to every corner of world round the year and thus lowers its commercial value. One of the ways to increase the shelf-life of coriander and make it available throughout the year is by drying the leaves as the demand for high quality, minimally processed, shelf-stable dried vegetables are on rise. Drying is the most common and widely practised method for shelf-life extension of coriander leaves. Drying inhibits the growth and proliferation of micro-organisms[4]. In addition, leaves undergo blanching before drying which improves their sensorial characteristics. Several studies have been conducted in past on drying behaviour of coriander leaves. Hihat *et al*. [5]. Studied the effect of oven and microwave drying on phenolic content and anti-oxidant activity of coriander leaves. Khanum *et al*. [6] investigated the anti-oxidant activity and mineral content of dried and fresh coriander leaves. Effect of drying on essential oil content of coriander leaves was studied by Pirbaloutia *et al*. [7]. Yet none of the research work provides a suitable drying method for coriander leaves. Thus, present work was undertaken to study the effect of sun and cabinet drying as well as blanching on physical characteristics and biochemical constituents of fresh coriander leaves. Sun drying and cabinet drying were employed because of low application cost and easy handling.

Materials and Methods

Two coriander varieties were used in this research *viz* local variety (V1) & hybrid variety (SH-DH-1) (V2). Local variety was procured from the markets of Shalimar, Kashmir & the hybrid variety was harvested from the fields of SKUAST -K, Shalimar. The leaves were de-stemmed, washed, and drained. Afterwards, they were blanched at 85° C for 3.5 min, cooled immediately, and dried using sun (3 days) and cabinet dryer (60° C for 6 hours). The dried leaves were then packed in LDPE pouches and stored under ambient conditions (25° C ± 3) for a period of 60 days. *Total chlorophyll, chlorophyll a and chlorophyll b* Estimation of chlorophyll was done by following the procedure of Jones *et al.* [8] using 80% acetone. The absorbance of chlorophyll extracts was measured at 650nm using UV–Vis spectrophotometer (UV 2401 PC, Shimadzu Co., Singapore).

$$\text{mg Chlorophyll a/g tissue} = 12.7\,(A_{663}) - 2.69\,(A_{645}) \times \frac{V}{1000 \times W}$$

$$\text{mg Chlorophyll a/b tissue} = 22.9\,(A_{645}) - 4.68\,(A_{663}) \times \frac{V}{1000 \times W}$$

$$\text{mg total chlorophyll} = 20.2\,(A_{645}) - 8.02\,(A_{663}) \times \frac{V}{1000 \times W}$$

Where
A = absorbance at specific wave length
V = Final volume of chlorophyll extract in 80% acetone
W = Fresh weight of tissue extracted

Total Phenols, total carotenoids and ascorbic acid

The total phenols were estimated according to the Folin-Ciocalteu method [9]. For ascorbic acid content determination, 2, 6-dichlorophenol indophenol (DCPIP) titration method described by Rao and Deshpande [10] was followed. Carotenoid content of coriander leaves were quantified by following the spectrophotometric procedure given by Zakaria and Simpson [11] and absorbance was taken at 450nm. Essential Oil estimation Essential oil content of coriander leaves was estimated by steam distillation method outlined by CHEM 333L Organic Chemistry Laboratory (Revision 2.1). Microbial examination Standard serial dilution and pour plate technique was used for microbial analysis of the samples [12]. Instrumental colour Colour measurement of dried coriander leaves was carried out by the following the method of Hunt[13] using a hunter colorimeter model “Lab scan XE” (Hunter associates laboratory, USA) using universal software, based on three colours co-ordinates namely L*, a* and b* value. L* represents the lightness index, a* represents red-green, while b* represents yellow-blue colour components. The instrument was calibrated using a standard white and black reference tile. *Sensory evaluation* A group of 10 semi-trained judges carried out the sensory evaluation of dried coriander leaves using 5-point scale. The dried leaves were dissolved in water and the solution was subjected to organoleptic testing. Before judges could commence the test, they were acquainted with the use of rating method, terminology for each attribute and sensory characteristics. Samples were randomly presented to judges and were asked to rate them on the basis of flavour, colour and taste. Overall acceptability was calculated as average of the other parameters. *Moisture content, water activity and rehydration ratio* Moisture content as determined by laboratory oven method [14]. Water activity of the sample was analyzed using a water activity analyzer (Pre-Aqua Lab, Water Activity Analyser). Rehydration ratio was calculated by the below given formula:

$$\text{Rehydration ratio} = \frac{Wr}{Wd}$$

Where
W_r = weight of rehydrated sample (g)
W_d = weight of dried sample (g)

Total solids

Total solid of dehydrated coriander leaves were determined by drying the samples in oven and following the method given by Ranganna [15]. Total solids percentage was calculated as per the below given equation:

Total solids (%) = 100- moisture content (%).

Statistical Analysis

All the analyses were carried out in triplicate and the results were provided as mean value. Statistical analysis was analysed using SPSS statistics for Windows version 20.0 Armonk, New York. A factorial CRD was employed to test the significance of data at 5% level.

Results and Discussion

Total chlorophyll, chlorophyll a and chlorophyll b Drying method as well as blanching and variety had significant (p<0.05) effects on total chlorophyll content of coriander leaves (Table 1a). Blanching decreased the total chlorophyll content in case of both the varieties irrespective of drying method. Total chlorophyll content in case of V1 before drying was 3.99mg/100g which decreased significantly to 3.55mg/100g after sun drying and 3.97mg/100g after cabinet drying. Similarly, in case of V2, total chlorophyll content before drying was 3.81mg/100g which decreased to 3.45mg/100g after sun drying and 3.76mg/100g after cabinet drying which signifies higher loss of total chlorophyll content in sun dried leaves of both varieties (Table 1a). This may be adduced to the fact that blanching causes conversion of chlorophyll to stable chlorophyll ides due to action of chlorophyllase enzyme. Similar results have been reported by Ahmed *et al*. [4] for drying characteristics of coriander leaves.
In case of unblanched samples, sun as well as cabinet drying caused a significant (p<0.05) decrease in total chlorophyll content of V1 from an initial value of 3.99mg/100g to 2.21mg/100g and 2.54mg/100g respectively. Likewise, a decrease from 3.81mg/100g to 2.34mg/100g and2.56mg/100g was recorded for V2 during sun and cabinet drying respectively. This might be due to exposure of coriander leaves to less drying time and controlled temperatures in cabinet dryer as compared to sun. Higher drying time causes faster conversion of chlorophyll to brown pigment pheophytins [4]. A similar result has been observed by Rocha *et al.* [16] on the drying of basil. Chlorophyll a as well as chlorophyll b content of both varieties were significantly affected by all the three parameters. Blanching significantly (p<0.05) increased chlorophyll a in V1 from 2.34mg/100g to 2.36mg/100g in sun dried samples and 2.63mg/100g in cabinet dried leaves while decreased chlorophyll b content from 1.65mg/100g to 1.34mg/100g and 1.19mg/100g when both the drying techniques were employed. Likewise for V2, blanching enhanced chlorophyll a content from 2.12mg/100g to 2.25mg/100g in case of sun drying and 2.56mg/100g for cabinet dried leaves while reduced chlorophyll b content from 1.69mg/100g to 1.20mg/100g when both drying techniques were employed which signifies higher retention of chlorophyll a in cabinet dried samples as compared to sun dried leaves. This might be due to exposure of coriander

leaves to less drying time and controlled temperatures in cabinet dryer as compared to sun. Higher drying time causes faster conversion of chlorophyll to brown pigment pheophytin [4]. A similar result has been observed by Rocha *et al*. [16] on the drying of basil.

For unblanched samples, sun drying resulted in 41% decrease in V1 and 46% loss in V2 while cabinet drying caused only 34% and 36% loss in V2 which implies higher retention of chlorophyll a in cabinet dried samples. A similar reduction of 63.03% and 39.39% and 28.40% and 27.81% in chlorophyll b content of unbleached sun and cabinet dried samples of V1 and V2 respectively was recorded. A rapid degradation in chlorophyll a content of sun-dried coriander leaves was observed as compared to chlorophyll b content of sun-dried coriander leaves (Table 1). This is due to higher sensitivity of Chlorophyll a to pheophytinization [17].

Total phenols

Total phenolic content of coriander leaves was significantly (p<0.05) influenced by drying method and blanching treatment. The phenolic content of fresh coriander leaves of V1 was recorded as 62.41mg/100g which decreased to 43.39mg/100g and 16.42mg/100g after sun and cabinet drying of blanched samples respectively. Similar decrease from 60.07mg/100g to 45.02 and16.12mg/100g after sun and cabinet drying treatments was recorded in case of blanched hybrid (V2) coriander leaves (Table 1a). Some phenolic compounds are bound to cells of the plant which limit their solubility in water. Blanching promotes leaching of phenolics in water [18] by disrupting the cell wall material of plant cells, thereby releasing the phenolic compounds into water [19]. The other possible reason for decrease in phenolic content upon blanching may be due to the formation of phenolic complexes with other leaf constituents (carbohydrates, proteins, anti-nutritional factors) which limit their extractability [20]. Similar decrease in phenolic compounds have been also reported by Ironic *et al*. [21] in blanched *Adansonia digestate.* In case of unbranched samples, sun drying lead to 30.12% and 24.55% reduction whereas cabinet drying showed 73.14% and 72.78% loss in total phenol content of V1 and V2 respectively. Thus, a predominant decrease in total phenolic content was recorded in case of cabinet drying as compared to sun dying for both the varieties (Table 1a). This decline in phenolics is adduced to intense and prolonged heating during cabinet drying which leads to thermal degradation of phenolic compounds during [22] as phenolics decompose readily at elevated temperatures [23]. In addition, during drying, phenolic compounds undergo oxidation in presence of polyphenol oxidase (PPO), which results in intermolecular condensation reactions thus, reducing their content [24]. Katsube *et al*. [25] and Chan *et al*. [26] have reported a similar decline in poly phenolic content of mulberry leaves and ginger leaves after drying respectively. Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching (high temperature 90° C and time (10-15 min),

disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching (high temperature 90° C and time (10-15 min), disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching (high temperature 90° C and time (10-15 min), disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching(high temperature 90° C and time (10-15 min), disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching (high temperature 90° C and time (10-15 min), disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Francisco *et al*. (2010) [19] reported that some phenolic compounds are known to be insoluble form in combination with plant cell wall components. During blanching (high temperature 90° C and time (10-15 min), disruption of the cell wall of the plant may occur leading to leaching out of the soluble phenolic Total carotenoids Drying method as well as blanching had a significant (p<0.05) effect on total carotenoid content of coriander leaves (Table 1a). Blanching decreased the carotenoid content of V1 from 31.89mg/100g to 12.24mg/100g and 22.87mg/100g in case of sun and cabinet drying respectively. A similar reduction in carotenoid content of blanched V2 leaves was recorded from 32.20mg/100g in fresh coriander leaves to 12.26mg/100g in sun dried leaves and 22.18mg/100g in cabinet dried samples. Decrease in carotenoids due to blanching treatment may be ascribed to leaching of pigments through cell membrane as high temperature increases the permeability of cells by breakdown of pectin material in cell wall [27]. Negi and Roy [28] have also reported the sensitivity of β-carotene towards heat and oxidation during blanching and drying. For unbranched samples, 60.67% and 27.21% decrease while 59% and 28.81% reduction were observed during sun and cabinet drying of local & hybrid variety respectively which implies a higher carotenoids loss in sun dried leaves of both the varieties due to greater instability of this pigments to sun light [29]. Sun drying involves exposure of leaves to heat, light and oxygen and all these factors accelerate the rate of oxidation of carotenoids [30]. Various studies in past have also reported that traditional drying methods resulted in excessive losses of β-carotene in vegetables due to photo-oxidation [31]. Ascorbic acid content the ascorbic acid content of coriander leaves was significantly (p<0.05) affected by drying method as well as blanching treatment (Table 1a). A decrease in ascorbic acid content of local coriander leaves (V1) was recorded from 113.30mg/100g to 23.42mg/100g and 46.40mg/100g in blanched leaves during sun and cabinet drying respectively. Similarly, ascorbic acid content of blanched hybrid varieties (V2) decreased from initial value of 107mg/100g to 22.71mg/100g in case of sun drying and 46.76 in case of cabinet drying. Blanching decreases the ascorbic acid content via thermal degradation and leaching due to its water-soluble nature [32]. Negi and Roy [28] have reported that ascorbic acid is susceptible to oxidation during blanching and drying. For unbranched samples, a reduction in ascorbic acid content of V1 and V2 was 60.67% and 59% in case of sun drying and 27.21% and 28%.81% in case of cabinet drying which implies pronounced ascorbic acid loss during sun drying. This may be adduced to oxidation of ascorbic acid to dehydroascorbate in presence of sufficient amount of oxygen. Chauhan *et al*. [32] also observed a higher ascorbic acid loss while drying of mint leaves in sun drying as compared to cabinet drying. Essential oil All the three factors *viz* variety, drying method and blanching had a significant ($p<0.05$) effect on essential oil content of coriander leaves. The essential oil content of fresh coriander leaves of V1 was found to be 0.16% and 0.12% for V2. Blanching decreased the essential oil content in V1 from 0.16% to 0.021% and 0.026% in sun and cabinet drying respectively. A similar decrease in essential oil content of V2 coriander leaves was observed from 0.12% to 0.018% in sun dried samples and 0.020% in cabinet dried leaves (Table 1a). This decrease in essential oil content of coriander leaves during blanching may be attributed to high temperatures[33] as high temperature causes breakage of oil cells, subsequently leading to loss of volatile oil [34]. In unblanched leaves of V1, a reduction of 85% and 82.5% and for V2, a loss of 81.66% and 75.83% of essential oil was recorded during sun and cabinet drying respectively. During drying process, essential oil along with water is dragged to leaf surface mainly by diffusion which explains the loss of essential oil content during drying [35]. Saied *et al*. [36] also reported higher loss of essential oil content when Mentha long folia leaves were dried under sun. Colour the colour parameters for fresh leaves of both the coriander varieties varied significantly ($p<0.05$) (Table 1b). Blanching had a significant ($p<0.05$) decreasing effect on L* value of coriander leaves from 37.35 for fresh V1 coriander leaves to 25.36 and 34.20 in case of sun and cabinet dried coriander leaves respectively. Similarly, L* value of V2 coriander leaves also decreased with blanching from 39.36 to 25.92 and 34.36 during sun and cabinet drying respectively. Excessive loss of natural colour pigments due to leaching during blanching increased lightness of the leaves [27]. The other possible reason for decrease in luminosity of dried coriander leaves might be formation of chlorophyll ides which increase the colour saturation of coriander leaves [37]. In unbleached leaves of V1 and V2, sun drying reduced L* value by 29.26% and 31.60% while cabinet drying caused 1.7% and 7.26% reduction in luminosity of coriander leaves. At elevated drying temperatures coriander leaves undergo non-enzymatic browning which decreased the lightness in leaves [38]. Drying as well as blanching significantly effected a* value of coriander leaves. Blanching enhanced the redness of V1 coriander leaves from -6.34 to -4.26 and -5.77 in case of sun and cabinet dried leaves respectively. For V2, redness of sun and cabinet dried leaves increased from -7.67 to -5.24 and -6.74 respectively. High temperature promotes non-enzymatic browning reaction, and turn the samples less greenish[38]. In unblanched samples, a 73.34% and 12.46% increase in redness and 13.21% and 2.04% decrease in b* value of V1 while 68.05% and 27.11% increase in redness and 7.18% and 2.86% decrease in greenness of V2 variety was recorded during sun and cabinet drying respectively. Blanching causes degradation of chlorophyll to pheophytin which increases the yellowness of dried leaves [17]. Dwivedy *et al*. [39] found that after microwave drying of Indian Borage leaves all the three chromatic coordinates values decreased, but the reduction in L* values was not significant.

Total solids

Drying, blanching as well as variety had a significant ($p<0.05$) effect on total solid content of dried coriander leaves (Table 1b). The total solid content of fresh coriander leaves of V1 was 14.91% which increased to 86.63% and 86.90% in case of sun and cabinet dried blanched leaves respectively. In V2 blanched leaves, total solid content increased from 14.67% to 86.71% in case of sun drying and 86.87% in case of cabinet dried leaves. Moreover, for unblanched leaves, an increase in 82.81% and 82.83% total solid content of V1 samples was observed while V2 leaves recorded 83.06% and 83.07% increase in total solid content during sun and cabinet drying which implied a predominant increase in total solid content of dried leaves during cabinet drying. The pronounced increase in total solids of coriander leaves during cabinet drying may be due to greater loss of moisture. An efficient and accelerated heat transfer and mass transfer rates are encountered during cabinet drying, which removes moisture even from the centre of material [40]. Storage Studies Biochemical evaluation of different coriander varieties after sun and cabinet drying revealed that blanched cabinet dried samples proved superior in terms of quality. In order to check the shelf stability of dried coriander leaves, the sample was packed in LDPE and stored under ambient conditions (25^o C ± 3) for a period of 90 days. The stored samples were analysed for moisture gain, water activity, microbial analysis (bacterial count and fungi count), rehydration ratio and sensory evaluation (on 5-point scale) at an interval of 30 days. The change in selected quality attributes during storage are depicted in Table 2. Storage period had a significant ($p<.05$) effect on all the quality parameters. Moisture content of the dried coriander leaves increased from 13.10% at the beginning to 16.51% at the end of storage. This gain in moisture content of samples over storage period is because of the hygroscopic nature of the dried leaves [41]. In addition, ingress of water vapour through micro cracks which develops in packaging material also contributes to moisture gain [42]. Similar result has been observed by Razak *et al*. [43] during storage of Orthosiphon stamineus dried leaf. A significant ($p<0.05$) increase in water activity of dried coriander leaves was reported over storage time of 90 days. At the beginning of storage, water activity was 0.44 which increased up to 0.61 with the advancement of storage. This increase in water activity is due to increase in moisture content of dried leaves [44]. The bacterial and fungi count of dried samples were recorded as 3 cfu/g and 0.31cfu/g respectively at 0th day of storage which. Increased to 250cfu/g and 3.10cfu/g respectively at the completion of storage period of 90 days. This increase in microbial flora of dried leaves is due to increase in water activity and moisture content of samples with storage45. Rehydration ratio of the dried leaves was significantly ($p<0.05$) affected by storage time. At the beginning of storage, rehydration ratio of 1.60 was recorded which increased to 2.21 at the end of 90th day of storage. A gradual increase in rehydration ratio over time can be adduced to increased porosity of the cellular structure of dried leaves46. Similar results have been reported by Khedkar and Roy47 in mango slices. Storage period had a significant effect on overall acceptability of dried coriander leaves. Overall acceptability of dried samples decreased over storage period of 90 days from 3.76 to 2.32 which may be ascribed to loss of crisp texture due to ingress of moisture content by dried leaves. In addition, the stored leaves lost colour and flavour upon reconstitution with the storage time which further decreased the acceptability of dried coriander leaves.

Table 1a: Effect of drying method and blanching on various biochemical constituents of coriander leaves.

Drying Method (D)	Total Chlorophyll (mg/100g)				Chlorophyll a (mg/100g)				Chlorophyll b (mg/100g)				Total phenol (mg/100g)				Total carotenoids (mg/100g)				Ascorbic acid (mg/100g)				Essential oil (%)			
	1		V2		V1		2		1		2		1		V2		V1		V2		V1		V2		V1		V2	
Fresh coriander leaves	3.99		3.81		2.34		2.12		1.65		1.69		62.41		60.07		31.89		32.20		113.30		107.0		0.16		0.12	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Sun (D1)	3.55	2.21	3.45	2.34	2.36	1.60	2.25	1.13	1.34	0.61	1.20	1.21	43.39	43.60	45.02	45.32	12.24	12.54	12.26	13.20	23.42	24.01	22.71	23.07	0.021	0.024	0.018	0.022
% increase or decrease	11.02	44.61	9.44	38.58	0.85	31.62	6.13	46.69	18.78	63.03	29	28.40	30.47	30.13	25.05	24.55	61.61	60.67	61.92	59	79.32	78.80	78.77	78.43	86.87	85	85	81.66
Cabinet (D2)	3.97	2.54	3.76	2.56	2.63	1.54	2.56	1.34	1.19	1.00	1.20	1.22	16.42	16.76	16.12	16.35	22.87	23.21	22.18	22.92	46.40	51.39	46.76	51.98	0.026	0.028	0.020	0.029
% increase or decrease	0.50	36.34	1.31	32.80	12.39	57.26	20	36.80	27.87	39.39	29	27.81	73.69	73.14	73.16	72.78	28.28	27.21	31.11	28.81	59.04	54.64	56.30	51.42	83.75	82.5	83.33	75.83
C.D. (p<0.05)	D: 0.032; T: 0.032; D × T: 0.045; V: 0.032; D × V: 0.045; T × V: 0.045; D × T × V: 0.063				D: 0.034; T: N.S; D × T: 0.048; V: 0.034; D × V: 0.048; T × V: 0.048; D × T × V: 0.068				D: 0.032; T: 0.032; D × T: 0.045; V: 0.032; D × V: 0.045; T × V: 0.045; D × T × V: 0.063				D: 0.065; T: 0.065; D × T: 0.092; V: 0.065; D × V: N.S; T × V: N.S; D × T × V: N.S				D: 0.025; T: 0.025; D × T: 0.035; V: 0.025; D × V: 0.035; T × V: 0.035; D × T × V: 0.050				D: 0.025; T: 0.025; D × T: 0.035; V: 0.025; D × V: 0.035; T × V: 0.035; D × T × V: 0.050				D: 0.002; T: 0.002; D × T: N.S; V: 0.002; D × V: N.S; T × V: N.S; D × T × V: N.S			

V1: Local variety; V2: T1: blanched; T2: unblanched; C.D: Critical Difference

Table 1b: Effect of drying method and blanching on physical properties of coriander leaves

Drying Method (D)	L*				a*				b*				Total Solids			
	V1		V2		V1		V2		V1		V2		V1		V2	
Fresh coriander leaves	37.35		39.36		-6.34		-7.67		28.38		30.75		14.91		14.67	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Sun (D1)	25.36	26.42	25.92	26.92	-4.26	-1.69	-5.24	-2.45	28.45	24.62	32.41	28.54	86.63	86.77	86.71	86.60
% increase or decrease	32.10	29.26	34.19	31.60	32.80	73.34	31.68	68.05	2.4	13.21	5.39	7.18	82.78	82.81	83.08	83.06
Cabinet (D2)	34.20	36.70	34.36	36.50	-5.77	-5.55	-6.74	-5.59	30.33	27.80	32.72	29.87	86.90	86.85	86.87	86.67
% increase or decrease	8.43	1.7	12.70	7.26	9	12.46	12.12	27.11	6.87	2.04	6.40	2.86	82.84	82.83	83.11	83.07
C.D. (p<0.05)	D: 0.034; T: 0.034; D × T: 0.048; V: 0.034; D × V: 0.048; T × V: 0.048; D × T × V: 0.068				D: 0.030; T: 0.030; D × T: 0.043; V: 0.030; D × V: 0.043; T × V: 0.043; D × T × V: 0.061				D: 0.032; T: 0.032; D × T: 0.045; V: 0.032; D × V: 0.045; T × V: 0.045; D × T × V: 0.063				D: 0.015; T: 0.015; D × T: 0.022; V: 0.015; D × V: 0.022; T × V: 0.022; D × T × V: 0.031			

V1: Local variety; V2: T1: blanched; T2: unblanched; C.D: Critical Difference

Conclusion

The results of the study revealed that blanching treatment retained various nutrients in the leaves and enhanced the colour of dried leaves. Moreover, cabinet drying was found superior to sun drying in maintaining biochemical and physical properties of leaves. Storage studies of the dried leaves revealed that they can be safely stored for 3 months in LDPE pouches under ambient conditions. The study can help in drying of various other leaves of underutilized plants with several medicinal benefits.

Table 2: Effect of storage time on quality parameters of dried coriander leaves

Storage Time	Moisture content (%)	a_w	Bacterial count(cfu/g × 10^2)	Fungal count(cfu/g)	Rehydration ratio	Overall acceptability
0^{th} day	13.10	0.44	0.03	0.31	1.60	3.76
30 DAS	14.22	0.49	0.06	1.54	1.80	3.40
60 DAS	15.30	0.54	1.45	2.28	2.05	2.70
90 DAS	16.51	0.61	2.50	3.10	2.21	2.32
C. D ($p<0.05$)	0.601	0.066	0.081	0.085	0.096	0.086

DAS: Days after storage; cfu: colony forming unit; C.D: Critical Difference

References

1. Mani V, Parle M, Ramasamy K, Majeed A, Bakar A. Reversal of memory deficits by Coriandrum sativum leaves in mice. J Sci. Food Agri. 2011; 91:186-192.
2. Purseglove JW, Brown EG, Green CL, Robbins SRJ. Coriander. Tropical Agriculture Series: Spices, Longman Inc., New York. 1981; 2:736-788.
3. Shahwar MK, El-Ghorab AH, Anjum FM, Butt MS, Hussain S, Nadeem M. Characterization of coriander (Coriandrum sativum L.) seeds and leaves: volatile and non-volatile extracts. Int. J Food Prop. 2012; 15:736-747.
4. Ahmed J, Shivhare US, Singh G. Drying characteristics and product quality of coriander leaves. Food Bioprod. Process. 2001; 79(C):103-106.
5. Hihat S, Remini H, Madani K. Effect of oven and microwave drying on phenolic compounds and antioxidant capacity of coriander leaves. Int. Food R. J. 2017; 24(2):503-509.
6. Khanum H, Sulochanamma G, Borse BB. Impact of drying coriander herb on antioxidant activity and mineral content. J Biol. Sci. Opi. 2013, 1(2).
7. Pirbaloutia AG, Salehia S, Craker L. Effect of drying methods on qualitative and quantitative properties of essential oil from the aerial parts of coriander. J Appl. Res. Medici. Aroma. Plants, 2016.
8. Jones ID, White RC, Gibbs E, Butler LS. Estimation of zinc pheophytins, chlorophylls, and pheophytins in mixtures in diethyl ether or 80% acetone by spectrophotometry and fluorometry. J Agri. Food Chem. 1977; 25(1):146-149.
9. Stanciu G, Chirila E, Dobrinas, S, Negreanu-Pirjol T. Evaluation of Antioxidant Activity and Total Phenols Content in Selected Spices Rev. Chem. 2017; 68(7): 1429-1434.
10. Rao B, Deshpande V. Experimental biochemistry. Tunbridge Wells, Kent: Anshan, 2006.
11. Zakaria M. Simpson KL. Use of reversed phase HPLC analysis for the determination of pro Vitamin A carotenes in tomatoes. J Chromato. 1976; 176:109-117.
12. Anonymous. Manual of Microbiological Methods. McGraw Hill Book Co., New York, 1957, 125-279.
13. Hunt RWG. Measuring colour. 2nded. New York: Ellis Horwood; 1991, 75-76.
14. AOAC. Official method of Analysis of the Association of Official Analytical chemists. 10th Ed., Washington DC. USA. 2005.
15. Ranganna S. Handbook of Analysis and quality control for fruit and vegetables. III Edition. Tata McGraw Hill Publisher Co. Ltd. New Delhi, 1999.
16. Rocha T, Lebert A, Marty-Audouin C. Effect of Pre-treatments and Drying Conditions on Drying Rate and Colour Retention of Basil (Ocimum basilicum). LWT. 1993; 26(5):456-463.
17. Nartnampong A, Kittiwongsunthon W, Porasuphatana S. Blanching process increases health promoting phytochemicals in green leafy Thai vegetables. Int Food Res. J. 2016; 23(6):2426-2435.
18. Bamidele OP, Fasogbon MB, Adebowale OJ, Adeyanju AA. Effect of Blanching Time on Total Phenolic, Antioxidant Activities and Mineral Content of Selected Green Leafy Vegetables. Curr. J Appl. Sci. Tech. 2017; 24(4):1-8.
19. Francisco M, Velasco P, Moreno DA, Garcia-Viguera C, Cartea ME. Cooking methods of Brassica rapa affect the preservation of glucosinolate, phenolics and vitamin C. Food Res. Int. 2010; 43:1455-1463.
20. Awika JM, Dykes L, Gu L, Rooney LW, Prior RL. Processing of sorghum (sorghum bicolor) and sorghum products alters procyanidin oligomer and polymer distribution and content. J. Agri. Food Chem 2003; 51:5516-5521.
21. Irondi EA, Akintunde JK, Agboola SO, Boligon AA, Athayde ML. Blanching influences the phenolics composition, antioxidant activity, and inhibitory effect of Adansonia digitata leaves extract on α-amylase, α-glucosidase, and aldose reductase. Food Sci. Nutri 2016; 25(2):233-242.
22. Suvarnakuta P, Chaweerungrat C, Devahastin S. Effects of drying methods on assay and antioxidant activity of xanthones in mangos teen rind. Food Chem. 2011; 125:240-247.
23. Cheng Y, Xu Q, Liu J, Zhao C, Xue F, Zhao Y. Decomposition of Five Phenolic Compounds in High Temperature Water. J. Brazi. Chem. Soci. 2014; 25(11):2102-2107.
24. Bennett LE, Jegasothy H, Konczak I, Frank D, Sudharmarajan S, Clingeleffer PR. Total polyphenolics and anti-oxidant properties of selected dried fruits and relationships to drying conditions. J Funct. Foods 2011; 3:115-124.
25. Katsube T, Tsurunaga Y, Sugiyama M, Furuno T, Yamasaki Y. Effect of air-drying temperature on antioxidant capacity and stability of polyphenolic compounds inmulberry (Morus alba L.) leaves. Food Chem 2009; 113:964-969.
26. Chan EWC, Lim YY, Wong SK, Lim KK, Tan SP, Lianto FS, Yong MY. Effects of different drying methods

on the antioxidant properties of leaves and tea of ginger species. Food Chem. 2009; 113(1):166-172.
27. Sistrunk WA, Gonzalez AR, Moore KJ. Green beans. In: Quality and Preservation of Vegetables. Eskin NAM (ed). CRC Press, Inc., Boca Raton, FL, USA Chapter. 1989; 6: 185-216.
28. Negi P, Roy S. Effect of Blanching and Drying Methods on β -Carotene, Ascorbic acid and Chlorophyll Retention of Leafy Vegetables. LWT. 2000; 33(4): 295-298.
29. Butnariu M. Methods of Analysis (Extraction, Separation, Identification and Quantification) of Carotenoids from Natural Products. J Ecosys. Ecograp, 2016, 6(2).
30. Ndawula J, Kabasa JD, Byaruhanga, YB. Alterations in fruit and vegetable beta-carotene and vitamin C content caused by open-sun drying, visqueen-covered and polyethylene-covered solar-dryers. Afri. Health Sci. 2004; 4(2):125-130.
31. Gomez MI. Food drying. In: Proceedings of a workshop held at Edmonton, Alberta, IDRC, Ottawa, Canada 1981;
32. Chauhan N, Singh BR, Singh SGR, Singh J, Sengar RS, Chandra S. Effect of drying conditions on ascorbic acid of dried mint leaves. Annals Horti. 2016; 9(1):73-76.
33. Jerkovic I, Mastelic J, Milos M. The impact of both the season of collection and drying on the volatile constituents of Origanum vulgare L. ssp. hirtum grown wild in Croatia. Int. J. Food Sci. Technol. 2001; 36:649-654.
34. Parmar MR, Rajput RL, Kumpavat, Bhalodiya VB. Retention of active ingredients in hot air tray drying. Int. J Engg. Res. Develop 2018; 14(3):28-36
35. Khangholi S, Rezaeinodehi A. Effect of drying temperature on essential oil content and composition of sweet wormwood (Artemisia annua) growing wild in Iran. Pak. J. Biol. Sci. 2008; 11:934-937.
36. Saeidi K, Ghafari Z, Rostami S. Effect of Drying Methods on Essential Oil Content and Composition of Mentha long folia (L.) Hudson. J Essen. Oil-Bearing Plants. 2016; 19(2):391-396.
37. Jones ID, White RC, Gibbs E. Influence of blanching or brining treatments on the formation of chlorophyllides, pheophytins, and pheophorbides in green plant tissue. J Food Sci. 1963; 28(4):437-439.
38. Mrad ND, Boudhrioua N, Kechaou N, Courtois F, Bonazzi C. Influence of air-drying temperature on kinetics, physicochemical properties, total phenolic content and ascorbic acid of pears. Food Bioprod. Proc. 2012; 90:433-441.
39. Dwivedy S, Rayaguru K, Sahoo GR. Mathematical modelling and quality characteristics of microwave dried medicinal borage leaves. Int. Food Res. J. 2013; 20:769-774.
40. Islam MK, Karim MS, Begum NN, Zahir-ud-din K. Fabrication and Performance Study of a Direct Type Solar Dryer Int. J Sci Eng. Res, 2018, 9(2).
41. Puranik V, Chauhan DK, Mishra V, Rai GK. Effect of drying techniques on the physicochemical and bioactive components of selected medicinal herbs Annals Phytomed. 2012; 1(2):23-29.
42. Pecht MG, Ardebili H, Shukla AA, Hagge JK, Jennings D. Moisture ingress into organic laminates. IEEE Transactions on Components and Packaging Technologies. 1999; 22(1):104-110.
43. Razak NA, Shaari AR, Nat AFA. Effect of Initial Leaf Moisture Content on the Herbal Quality Parameter of Orthosiphon stamineus Dried Leaf during Storage Int. J Agri. Innova. Res. 2014; 2(6):2319-1473.
44. Dalgıç AC, Pekmez H, Belibaglı KB. Effect of drying methods on the moisture sorption isotherms and thermodynamic properties of mint leaves. JFST 2011; 49(4):439-449.
45. Kulshrestha R, Gupta CP, Shukla G, Kundu MG, Bhatnagar SP, Katiyar, CK. The effect of water activity and storage temperature on the growth of Aspergillus flavus in medicinal herbs. Planta Medical 2008; 74:1308-1315.
46. Attkan AK, Kumar N. Effect of drying on physico-chemical and nutritional properties of fenugreek leaves. Agri. Eng. 2016; 3:27-36
47. Khedkar DN, Roy SK. Storage studies in dried and dehydrated raw mango slices. Acta Horti. 1988; 231:721-730.