DEHYDRATION OF DRUMSTICK AND CORIANDER LEAVES

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CERTIFICATE

This is to certify that the thesis entitled **"DEHYDRATION OF DRUMSTICK AND CORIANDER LEAVES"** submitted by **Miss PREMA BIRADAR,** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** to University of Agricultural Sciences, Dharwad is a record of research work done by her during the period of her study in this University under my guidance and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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C O N T E N T S

LIST OF ABBREVIATIONS

%	:	per cent
°C	:	Degree celsius
CD	:	Critical difference
et al.,	:	and others
Fig.	:	Figure
g	:	Gram
i.e.,	:	That is
kg	:	Kilogram
mg	:	Milligram
ml	:	Millilitre
N	:	Normality
A	:	Absorbance
EDTA	:	Ethylene diamaine tetra-acetic acid
nm	:	Nanometer
min	:	Minute
ppm	:	Parts per million
SEm±	:	Standard error of mean
T	:	Treatment
var	:	Variety
viz.,	:	Namely

LIST OF TABLES

Contd…..

Contd…..

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

1. INTRODUCTION

Leafy vegetables which are rich in vitamins, minerals, dietary fibre *etc*. have many benefits in maintaining balanced diet to maintain health. Their availability in fresh form is a major problem in modern life. These vegetables have shelf life of not more than three days. Perishability of leafy vegetables is mainly due to higher rate of respiration and transpiration after harvest, succulent texture of leaves and more surface area to volume and higher moisture available to the microbial growth. Moisture allows microbial growth, which deteriorate the leaf texture, colour and nutritional quality. This makes leafy vegetables not suitable for consumption. To avoid these problems, we have two options, either to remove the moisture or maintain water activity level below the threshold level. We can maintain low water activity only in refrigerated storage which is costlier and is not possible to store in bulk. The second option is to store these leafy vegetables in dehydrated form.

The process of removal of moisture from leaves or any product is called as dehydration. Dehydration is traditional, cheap and important method to remove moisture from any product. It can be done by using hot air, radiation or by vacuum suction. Depending on the availability, we can use sun drying, shade drying, hot air oven drying *etc*. By all these methods, we can store leaves for more days, but we cannot be sure about nutritional and physical quality. Colour of the leaves degrades with drying method and storage. Similarly, vitamins are lost during drying because of oxidation. Hence, one of the concerns related to dehydration is about the loss of nutritional and physical quality of dried leaves. Loss of nutrition depends on temperature, duration of drying and media used for drying. Now-a-days, to retain physical quality, many techniques are followed like sulphitation, sulphonation and blanching. This means additional chemical treatment after harvest and before drying helps in retention of physical quality. This research was carried-out to check the extent of quality retention in dried leaves with respect to pre-treatment and drying method.

In commercial life, whatever we do should be cost effective and more nutritious. Leafy vegetable are seasonal in nature. In season, there will be glut in the market. Farmers lose their income because of low market price. In offseason, it's too costly to buy for the consumers. For dehydration, seasonal and under exploited nutritious vegetables would be the best choice, like drumstick leaves.

Drumstick tree was, and still is, considered a panacea, and is referred to as 'The Wonder Tree', 'The Divine Tree' and 'The Miracle Tree'. Moringa was used extensively in Ayurveda, where virtually all parts were considered useful with a plethora of beneficial attributes. Roots, stems, leaves, seed pods, resin and flowers of drumstick are considered to be healing herbs in Ayurvedic (traditional Indian healing system) and Unani (traditional Middle Eastern healing system) folk medicines. It's energetics, heating and it's effect upon the dosha (Ayurvedic constitutional type) are balancing to Kapha (dosha ruled by earth and water) and Vata (dosha ruled by air and earth) (Anon., 2020). It was employed to support digestion, spleen and eye health, as a cooking additive and also in many other ways. In modern times, the leaves and the seed pods are utilized due to their nutrient content. Modern studies are investigating their vast potential. Fresh drumstick leaves contain four times the vitamin A than that of carrots, seven times more vitamin C than that of oranges, four times the calcium than milk, three times the potassium than bananas, three-fourth times the iron than that of spinach, two times the protein of yogurt. Dried leaves are concentrated capsules, which have 10 times the vitamin A of carrots, ½ time the vitamin C of oranges, 17 times the calcium of milk, 15 times the potassium of bananas, 25 times the iron of spinach and nine times the protein of yogurt (Gopalan *et al*., 1971). South Indian people use drumstick leaves and pods in their regular diet. To make available to the consumers throughout India, even in off-season, dehydration becomes helpful to retain quality. Because of this reason, the research on dehydration of drumstick leaves was initiated.

Indian people like to eat spicy food. They use leaf spice regularly to enhance flavour of the cooked product. Among all leaf spices, coriander leaves are an indispensable part of Indian cooking, be it in soups, salads, rasam, curries or dals, owing to its vibrant green colour and the pleasant aroma of the springs. Coriander is a nutritious herb. Hundred grams of fresh coriander leaves contain 87.9 % of moisture, 3.5 % of protein, 0.6 % of fat, 6.5 % of carbohydrate, 0.14 % of calcium, 0.067 % of phosphorus, 10 mg of iron, 10000 to 12000 IU of vitamin-A and 250 mg of vitamin-C (Anon., 2018). In addition, they confer immense health benefits including regulating blood sugar levels, protecting liver, kidney and provides useful antioxidant properties which improves immunity and boosts memory power, promotes healthy vision, cure liver ailments such as jaundice and bile disorders, fortifies bone density, heals stomach ulcers and indigestion (Anon., 2018). With all these benefits, we should enhance the storage quality. Coriander leaves are too perishable and seasonal in nature. To get health benefits we need to enhance storage life. To enhance storage quality, many research workers are carrying-out research by using different drying methods. I had selected this crop for my second experiment to compare the effect of pre-treatments, different drying methods and packing materials on nutrients retention quality. Keeping these points in mind, the research was carried-out with the following objectives:

1. To study the effect of pre-treatments on physical and chemical quality of dried drumstick and coriander leaves
2. To study the effect of drying methods on physical and chemical quality of dried drumstick and coriander leaves
3. To evaluate the sensory quality of dehydrated drumstick and coriander leaves
4. To study the effect of packaging material on storage quality of dried drumstick and coriander leaves

2. REVIEW OF LITERATURE

Drying is an important process to store food products for longer period. It is necessary for leafy vegetables to store more. Direct drying of vegetables without any treatment will affect the quality. Hence, leaves lose their original colour, texture and nutrition also. The prime aim of pre-treatment and dehydration is to restore physical and nutritional qualities but these may be influenced by many factors. The previous studies that have been conducted to know the influence of pre-treatments and drying methods on dehydration of leafy vegetables has been highlighted in the following subsections.

2.1 Effect of pre-treatment on dehydration in vegetables

2.2 Effect of drying methods on dehydration in vegetables

2.3 Effect of pre-treatment and drying methods on sensory quality of dehydrated vegetables

2.4 Effect of packaging materials on storage of dehydrated vegetables

2.1 Effect of pre-treatment on dehydration in vegetables

In home we can observe browning or blackening of leafy vegetables after two or three days of storage in dry weather. This is the effect of simply drying of leaves without any pre-treatment. Drying without treatment, not only affects colour but also influences nutritional loss. To retain colour, new technique were developed like blanching, sulphitation, sulphonation and other chemical treatments which simultaneously influences the retention of chemical composition in vegetables.

Blanching means hot water treatment to the produce. It softens the cells of leaf tissues, deactivate the enzymatic activity to prevent the browning reaction and minimize the microbial load (Kakade and Neeha, 2014). Blanching has better effect on quality retention of the produce. It helps to retain greenness in vegetables especially green leafy vegetables such as asparagus, amaranthus (Oboh *et al*., 2017 and Rajeswari *et al.*, 2013), fenugreek leaves (Sablani, 2006) and brussel sprouts (Olivera *et al*., 2008). Blanching increased the retention of beta carotene in moringa leaves (Subadra *et al.*, 1997), ascorbic acid in cabbage leaves (Tanongkankit *et al*., 2010), chlorophyll, flavonoid compounds, texture, phenolic compounds and other sensory qualities of vegetables (Negi and Roy, 2000 and Song *et al*., 2003). Blanched leaves have more moisture because of compact structure (Ankita, 2013). But above results were not consistent with Gernah and Sengev (2011). They observed that boiling of drumstick leaves leads to reduction in protein from 8.24 to 6.56 g/100 g, total carotenoids from 6540 to 5138 mg/100 g and vitamin C from 240.36 to 46.78 mg/100 g. Similar results were observed in *Amaranthus gangeticus* and *Spinacia oleracea* by Pavani and Adhuri (2018).

Plain blanched leaves become dark green, lose moisture, temperature liable nutrients and vitamins. To avoid those loss and retain bright green colour, researchers continued with addition of chemicals. Subadra *et al*. (1997) worked on drying of drumstick leaves. Sulphiting (0.2 % potassium meta bisulphate solution) in addition to blanching was more effective in the retention of β-carotene immediately after dehydration and at the end of one month of storage, but not at the end of 90 days of storage and the same results were observed in savoy beet, amaranthus and fenugreek for beta carotene, ascorbic acid and chlorophyll content (Negi and Roy, 2000). Palak and fenugreek leaves blanched for two minutes in water containing 0.1 % $NaHCO_3$, 0.1 % MgO and 0.2 % potassium metabisulphite maintains minimum moisture and dehydration ratio, while maximum in rehydration ratio, chlorophyll and ascorbic acid throughout the storage period as compared to sun drying (Premavalli *et al*., 2001 and Kalaskar *et al*., 2012). In curry leaf dehydration, hot water blanching with 0.1 per cent magnesium oxide and tray drying was best in retention of ascorbic acid, calcium and iron in curry leaf (Sakhale *et al*., 2007). Cauliflower blanched in 0.75 % potassium metabisulphite solution for two minutes and dried in mechanical tray drier had more rehydration ratio and coefficient of rehydration at all temperatures (60, 70, 80 and 90 ºC) over blanching in 5 % brine solution (Mudgal and Pandey, 2007 and Dattatreya *et al*., 2006). The similar result was found by Sharma *et al*. (2014) in cabbage leaves.

Water soluble vitamins and heat sensitive pigments get lost by hot water blanching. To avoid that, some researchers tried chemicals treatment without blanching. Palak leaves treated with six per cent brine and 0.1 per cent potassium metabisulphite for one hour and dried in electric drier at 50 ± 20 °C recorded minimum time for dehydration (6.68 hours), maximum recovery of 11.23 per cent with rehydration ratio of 6.65, reconstitutability ratio of 0.59 and higher retention of chlorophyll (543.89 mg/100 g) (Viresh *et al*., 2009). Similar results were observed with bitter gourd slices treated with 0.2 % potassium metabisulphite for ten minutes and dried by cabinet drying (Dhotre *et al*., 2012). Chemical blanching (MgO, NaCl, $NaHCO_3$, and EDTA) was found better over blanched and unblanched colocasia leaves for minimal loss of green colour, chlorophyll content and nutritional characteristics (Kaushal *et al*., 2013). Green beans treated with 0.1 % magnesium chloride and 0.1 % sodium bicarbonate solution was found to be good in physico-chemical (better chlorophyll retention) and nutritional characteristics (Kuna *et al.,* 2017). Similar results were observed by Singh *et al*. (2014), in dehydration of amaranthus leaves with the pre-treatment of 0.1 % $MgCl_2$ + 0.1 % $NaHCO_3$ + 2 % $K_2S_2O_5$ followed by drying under greenhouse type solar dryer. They were superior in rehydration capacity and sensory quality.

2.2 Effect of drying methods on dehydration of vegetables

Drying is the simple process of dehydrating foods until there is not enough moisture to support microbial activity. Drying removes the water needed by bacteria, yeast and moulds to grow. If adequately dried and properly stored, dehydrated foods are self stable (safe for storage at room temperature) (Anon., 2012).

Drying significantly influences the nutritional value of the products *i.e.*, loss of vitamin C and changes of colour and appearance that might be undesirable. Leafy vegetables are too sensitive and succulent hence, quality of dehydrated leafy vegetables can be influenced by drying rate, drying temperature, drying media and drying method and weather condition during drying. Reviews on effects of different drying methods of previous research reports are noted below.

In home scale, everybody use to dry the foods with shade drying or sun drying. Shade dried drumstick leaves had highest beta-carotene (39600 μg/100 g) and iron (24 mg/100 g) content. Minimum beta-carotene (36000 μg /100 g) and iron (19 mg/100 g) content was found in sun dried and oven dried drumstick leaves respectively (Joshi and Mehta, 2010). In the same way, Vyankatrao (2014), also observed the highest retention of β carotene in shade dried leaves of mint and coriander. In case of curry leaves and bitter gourd, highest β carotene was in oven dried at 60^{o}C and 90^{o}C respectively. However, in all vegetables lowest β-carotene retention was observed in sun dried leaves. In 2016, Kannan and Thaaseen observed similar result in 0.1 % sodium bicarbonate pre-treated and shade dried drumstick leaves *i.e*., the highest carbohydrates (33.86 g), fibre (8.18 g), protein (27.40 g), vitamin-C (13.21 mg) and chlorophyll (3.1 mg) than hot air oven dried and sun dried leaves. In 2015, Olabode and co-workers investigated that increased temperature decreased moisture, protein, fat and crude fibre contents and increased the ash and tannin contents in hot air oven dried drumstick leaves. It would be possible only in dry weather. In humid weather, delayed drying also influences the loss of physical and nutritional quality of sun dried and shade dried product. To retain physical and nutritional quality, drying temperature and drying period plays a major role. High temperature reduces drying period, nutrition loss and increases drying rate. Cabinet dried savoy beet and amaranths leaves were better as compared to solar-dried leaves. Cabinet dried leaves showed better retention of β-carotene, ascorbic acid, chlorophyll (Negi and Roy, 2001), maximum rehydration ratio (Satwase *et al.*, 2013) and total carotenoids (Saini *et al.*, 2014) in dried drumstick leaves. For drumstick leaf powder, chemical blanching (0.5 % potassium metabisulphite + 0.15 % magnesium oxide + 0.15 % sodium bicarbonate) followed by cabinet drying significantly increased the protein, light petroleum extract, ash content, carbohydrate and crude fibre content (Pawase *et al.*, 2019). Balasubramanium *et al.* (2011) observed that betel leaves colour quality was found best in drying at 60°C in tunnel dryer and at 50°C in cabinet dryer whereas, rehydration was found best at 40°C with more acceptability.

Singh and Sagar (2013) studied the effect of drying methods on dehydration of bitter gourd (*Momordica charantia* L.) *cv.* Pusa Hybrid-2. He used three different drying methods *viz.,* solar drying, low temperature drying and cabinet drying. He observed that the cabinet dried slices were superior in ascorbic acid, total chlorophyll, total carotenoids and β-carotene with minimum moisture content, drying ratio and non-enzymatic browning. Similar results were observed in bitter gourd pre-treated with 0.2 % $K_2S_2O_5$ + 2 % salt soaking for 10 min by Dotre *et al*. (2012). In 2006, Kaur *et al*., studied the dehydration of coriander leaves and observed the leaves dipped in 0.1 % $MgCl_2$, 0.1 % $NaHCO_3$ and 2.0 % $K_2S_2O_5$ solution for 15 minutes and mini multi rack solar dryer was found best in quality and rehydration characteristics. Similar results were observed in fenugreek leaves, which were blanched for 2 minutes in water containing 0.1 % MgO + 0.5 % $K_2S_2O_5$ + 0.1 % $NaHCO_3$ solution and dried in cabinet drier (Kalaskar *et al*., 2012). In dehydration of mint leaves, microwave vacuum drying reduced drying time by 85-90 % and maintained higher lightness, greenness and yellowness than hot air drying and also observed more porous and uniform structure in microwave vacuum dried mint leaves than the hot air oven dried by using scanning electron micrographs of mint leaves (Therdthai and Zhou, 2009). In dehydration of amaranthus leaves, Rajeshwari *et al.* (2013), compared the effect of three different pre-treatments (blanching, sulphitation, blanching + sulphitation and untreated as control) in two drying methods (cabinet drier and microwave oven drier) and observed that blanched amaranthus leaves dried in cabinet drier and 3 minutes 31 seconds in microwave oven at 900 power density were found better. Blanched cabinet dried leaves registered higher moisture (3.72 %), protein (18.34 %), ash (18.64 %), iron (56.21 %) and copper content (0.50 %) while, unblanched leaves had higher calcium and zinc contents (296.14 and 11.06 mg/100g respectively). On the other hand, unblanched microwave oven dried leaves recorded higher protein (21.87 %), ash (17.98 %), calcium (293.92 mg/100g), iron (26.23 %), zinc (8.88 %) and copper contents (0.63 %) while, blanched microwave dried leaves had higher moisture content of 3.32 per cent. Chlorophyll content (mg/100g) decreased from 181.5 (fresh) to 92.81 and 52.90 on drying and 48.86 and 48.62 on storage (cabinet and microwave dried leaves respectively). Similarly, cabinet tray drying of drumstick leaves was found as efficient as lyophilisation to retain maximum content of total carotenoids (Saini *et al.*, 2014). Solar cabinet dried bitter gourd slices were falling in between open sun and freeze dried products with respect to quality (Jadhav *et al.*, 2010).

Quality of dehydrated leafy vegetable varies with variety and type of leafy vegetable, drying temperature, drying duration, atmospheric relative humidity, type of drying method *etc.*

2.3 Effect of pre-treatment and drying methods on sensory quality of dehydrated vegetables

Main aim of any developing processed product is to satisfy consumer's need in terms of nutrition, appearance, taste and flavour, which may vary with pre-treatment and drying methods. Some of the reviews over of sensory evaluation are noted below.

Along with the nutrients retention, sensory qualities of dried product are also important to attract consumer. In dill leaves (*Anethum graveolens* L.) increasing the drying air temperature decreased the drying time and increased the drying rate. Compared to the fresh dill leaves, lightness (L*), greenness (-a*) and yellowness ($^{+}$b*) decreased in dried leaves. Considering the product quality, continuous microwave-convective air drying combinations gave better results than intermittent microwave-convective air drying in terms of color and sensory qualities (Esturk and Soysal, 2010). Ankita (2013) observed that the spinach leaves dehydrated at 60 °C for unblanched and 70 °C for blanched could be used for production of enhanced quality green leafy vegetable powder of wider acceptability. Drying of methi was carried out at 40°, 45°, 50° and 60 °C while, coriander was dried at 40°, 45° and 50 °C. Organoleptic quality attributes like colour, appearance and taste of these dried samples were found acceptable to the respondents and solar-dried samples were appreciated for retaining fragrance and utility in off-seasons (Pande *et al*., 2000). In 2015, Olabode *et al*., dehydrated the moringa leaves at temperatures of 60 and 80 °C. They observed non-significant difference ($p > 0.05$) in colour, aroma, flavour, magnesium, sodium and phosphorus content. Fathima *et al*. (2001) studied the microwave drying effect on color, appearance and odour of selected greens (coriander, mint, fenugreek, amaranth and shepu). The relative reconstitution capacity (RRC) for different greens was coriander (10.3), mint (10.3), amaranth (38.3), fenugreek (31.7) and shepu (32.8). The RRC appeared to influence acceptability. Coriander and mint, which exhibited the lowest RRC (10.3 %) had the lowest scores for flavor and color while, amaranthus with the highest RRC (38.3 %) had scores similar to those of fresh amaranthus. Microwave drying was highly suitable for greens such as amaranthus, moderately suitable for shepu and fenugreek and less suitable for coriander and mint. Shaw *et al.* (2006) observed that the drying rate of the microwave dried samples was faster than that of the convective dried samples. The results show that convective thin layer dried coriander samples exhibited a significantly greater color change than microwave dried coriander samples. The color change index values for the microwave dried samples ranged from 2.67 to 3.27 and that of the convective dried samples varied from 4.59 to 6.58. Straumite *et al*. (2012) observed that the dill blanched at 90 °C for 30 seconds followed by microwave vacuum drying was found best for retention of volatile aroma compounds, color and sensory properties. Kumar *et al.* (2016) found that the osmo-dried bitter gourd chips with 90 minutes osmotic diffusion in 10 % NaCl was found better in colour, appearance and overall acceptability. The chips were found microbiologically safe upto three months of storage at ambient condition.

Sensory quality is most important to attract consumers. Kenghe *et al*. (2015) observed that the effect of drying on quality of curry leaves. Time required for tray drying was less (27 %), when compared to sun and shade drying. Tray dried (55 ^{o}C) curry leaves had maintained nutritional constituents up to acceptable limit with superior green color and a more porous and uniform structure than those obtained from sun and shade drying. Dehydrated curry leaves showed good consumer acceptance as well as shelf life. Drying temperature plays major role to retain senory quality. Moringa leaves dried at 50-80 ^{o}C, and that the one dried at 60 ^{o}C was the most preferred (Olabode *et al*., 2015).

2.4 Effect of packaging materials on storage of dehydrated vegetables

Packaging material is equally important as that of drying. If packaging material is more pervious, then the dried hygroscopic product absorbs more moisture easily than less pervious packaging material. Hence, ascorbic acid and chlorophyll reduction can be observed gradually. Curry leaf and drumstick leaves were dried in cabinet drier at 58±2 °C and kept within packaging material (200 and 400 guage LDPE, 150 guage LDPE and 150 guage PP) and stored at room temperature. 200 guage HDPE packaging was found better in maintaining the quality of β-carotene, chlorophyll, ascorbic acid, rehydration ratio along with sensory score and less moisture followed by storage at LT (7±1°C) during three months of storage (Singh and sagar, 2010 and Kumar *et al*., 2013). Suganthi *et al.* (2019) revealed that quality deterioration was found to be lower in aluminum foil followed by HDPE without vent kept in refrigerated conditions respectively. Aluminum foil wrapped treatment was found to be best in retaining the colour, less reduction in vitamin C content, protein content and higher moisture content with the higher shelf life of twelve days. Singh and Singh (2015), dried the mint leaves under four different temperatures at 40 °, 50 °, 60 °C and sun dried, then stored in three different packaging materials (LDPE, HDPE and aluminium foil). The result showed that the mint leaves dried at 40 °C and packed in aluminium foil was found to be best for β-carotene and sundried leaves packed in aluminium foil was found to be best for chlorophyll a, chlorophyll b and total chlorophyll retention. Aluminium foil was found to be best for longer storage life. 40 °C oven dried and sun dried was found to be best to maintain color, flavour and nutritional quality.

Lee *et al.* (2018), packaged Korean red leaf lettuce (*Lactuca sativa* L. *cv*. Tojong-mats) with different films or perforations such as perforated polypropylene with 1320 small-sized holes (PPP-1320-hole), perforated polypropylene with 4 large-sized holes (PPP-4-hole), non-perforated polypropylene (Non-PPP), non-perforated polypropylene with anti-fogging properties (Anti-Fog-PP) or without packaging (control) and stored at 10 °C up to 16 days. It was observed to have minimum water loss in both non-perforated films (< 3 %) as compared to 35 % in control at the end of storage. Significant increase in CO_2 and simultaneous decline in O_2 concentration were recorded in both non-perforated films. A gradual decline in hue angle (h°) and SPAD chlorophyll meter values was found in all samples during storage while the color difference (DE*) values showed opposite trend. However, Anti-Fog-PP treatment exhibited the least DE* values throughout the storage. The contents of chlorophyll a (Chl a), chlorophyll b (Chl b) and total chlorophyll (total Chl), decreased gradually in all cases with a comparatively higher declines in Non-PPP treatment on six days, in PPP-4- hole treatment both on 12 and 16 days. Anti-Fog-PP treatment exhibited the lowest chlorophyll degradation and least changes in anthocyanin content until the end of storage. Result indicated that anti-Fog-PP treatment was found best for about two weeks during storage at market display temperature.

In normal packaging and storage, there might be more loss of nutrients along with physical quality. To avoid loss of nutrition and physical quality, gas packaging was developed. Modified atmospheric packaging means, addition of combination of gasses to avoid oxidation and nutritional loss during storage. 15 % O_2 + 3 % CO_2 + 82 % N_2 was found the best in maintenance of colour, the least bacterial growth and the highest activities of superoxide dismutase and catalase throughout the storage period for coriander leaves (Fang *et al*., 2016).

All results taken into considerations, we can conclude that the pre-treatment, drying methods and packaging materials will directly influence nutrition, sensory and storage quality of dried leaves.

3. MATERIAL AND METHODS

This chapter explains about the planning and execution of pre-treatments and drying methods practiced to accomplish the objectives of the investigation to know their effect on various attributes and qualitative analysis of *Moringa oleifera* and *Coriandrum sativum* leaves. This chapter involves the details of the collection of samples, preparation, pre-treatments, drying methods and experimental procedures used in a sequence to meet the objectives of the present research. This research was conducted in Laboratory, Department of Food Processing and Technology and Department of Horticulture, College of Agriculture, Dharwad.

3.1 Collection of the samples

For dehydration, moringa leaves of the cultivar 'Bhagya' was collected from the plantation unit of the Main Agricultural Research Station, Dharwad. Matured and green coloured drumstick leaves were collected from healthy plants in the morning hours from 8 am to 10 am. Undesired, light green colour (immature), yellow coloured (over matured), dried, diseased and pest infected leaves were sorted-out to get uniformity in the final product.

For coriander, DWD-3 seeds were collected from Department of Horticulture, College of Agriculture, Dharwad and were sown in well ploughed land of Main Agricultural Research Station, Dharwad. Staggered sowing of seed was taken up at one-week intervals. Coriander leaves were harvested thirty days after sowing at the optimum stage for leaf. Harvested leaves were collected; un-healthy leaves were sorted out and cleaned. After that, leaves were weighed and divided into three lots for three pre-treatments *viz.,* untreated, blanched and chemical treated. Each lot was again divided into six equal sub lots of one kilogram fresh leaves for each of drying methods *viz.*, sun drying, shade drying, microwave oven drying, cabinet drying, tray drying and vacuum oven drying.

3.2 Pre-treatments

3.2.1 Untreated (T_1)

Moringa and coriander leaves were cleaned and used for drying simply without any treatment. Leaf samples were washed, weighed, dried in six different ways and then dried leaves were used for analysis.

3.2.2 Blanching (T_2)

Weighed leaf samples were dipped in boiling water in the ratio of 1:5 (leaves: water) containing 0.5 % sodium metabisulphite ($Na_2S_2O_5$) for two minutes.

3.2.3 Chemical treatment (T_3)

Leaf samples were dipped in the combined solution containing 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) for 15 minutes. After that, the leaf sample were drained out, weighed, partitioned into six groups and dried in the respective system.

3.3 Drying methods

3.3.1 Sun drying (D_1)

One kilogram of drumstick and coriander leaves were levelled uniformly as a thin layer in an aluminium tray (100 mm × 40 mm) and kept up on the roof in such a way that the tray experienced more intensity sunshine to maximum hours in a day. Weight loss was recorded at every one hour interval until the weight loss difference reached zero.

3.3.2 Shade drying (D_2)

Leaf samples were weighed and spread within an aluminium tray in a uniform thin layer. Leaves filled tray was kept in a room at ambient temperature of 25 ^oC to 30 ^oC with varied relative humidity of 40 - 60 %. During drying, weight loss was recorded at hourly interval with precision electrical weighing balance and allowed to dry. Observations were recorded until the minimum difference of weight loss was obtained. Then, the drying was stopped and dried samples were collected for further use.

3.3.3 Microwave oven drying (D_3)

A microwave oven with a range of 270 watts was used (Plate 1) (IFB 25SC3). Fresh leaf sample was weighed to 20 g and spread uniformly over the turntable glass plate within the microwave oven. During drying, the loss of weight was recorded per minute. Drying and recording observation continued till no or negligible weight difference was observed. The microwave oven power was applied till sample reached its equilibrium state.

3.3.4 Cabinet drying (D_4)

Pre-treated leaf samples were weighed and spread over the perforated aluminium tray (40 cm × 80 cm) and kept in drier (Plate 1). Drying temperature was 56 °C. Weight of the

Microwave oven drier

Cabinet drier

Tray drier

Vacuum oven drier

Plate 1. Driers used during research

sample was recorded and decreasing weight loss was observed. This process continued till moisture loss reached zero.

3.3.5 Tray drying (D_5)

Pre-treated leaf sample was weighed and then drained sample was loaded uniformly in a perforated tray and kept for dehydration in the drier (Plate 1.) (Varada engineers). During drying, loss of weight was recorded at hourly intervals. The temperature maintained in tray drying was 60 ^oC.

3.3.6 Vacuum oven drying (D_6)

Pre-treated leaf samples were weighed by the use of precision electronic balance. After that, weighed samples were kept in trays inserted inside the vacuum chamber (Plate 1). The temperature of the material and the rate of drying were controlled by regulating the degree of vacuum in the chamber. During drying, vacuum and heat supplied by hot water through shelves make the material to lose moisture. The weight loss readings were recorded at thirty minutes intervals and drying continued till weight reduction rate became zero.

3.4 Experimental details

Drumstick and coriander leaves were analyzed separately and details of technical research program including treatments, replication, design and treatment combinations *etc*., are specified below:

Factor I (Pre-treatments): 03

T_1 (Untreated): Without any treatment

T_2 (Blanching): Hot water + 0.5 % sodium metabisulphite dip for two minutes

T_3 (Chemical treatment): Water + 0.1 % $MgCl_2$ + 0.1 % $NaHCO_3$ + 2 % $K_2S_2O_5$ for 15 minutes dipping

Factor II (Drying methods): 06

D_1: Sun drying

D_2: Shade drying

D_3: Microwave oven drying

D_4: Cabinet drying

D_5: Tray drying

D_6: Vacuum oven drying

Factor III (Packaging materials): 03

P_1: LDPE (Low density polyethylene)

P_2: HDPE (High density polyethylene)

P_3: Aluminium cover

Dehydrated samples were stored and evaluated for quality retention at 30 days after storage.

3.4.1 Design: Factorial- Complete Randomized Design (F-CRD)

3.4.2 Treatment combinations:

Treatment	Combination
T_1D_1	Untreated + sun drying
$T_1 D_2$	Untreated + shade drying
$T_1 D_3$	Untreated + microwave oven drying
$T_1 D_4$	Untreated + cabinet drying
$T_1 D_5$	Untreated + tray drying
$T_1 D_6$	Untreated + vacuum drying
T_2D_1	Blanching + sun drying
T_2D_2	Blanching + shade drying
T_2D_3	Blanching + microwave oven drying
T_2D_4	Blanching + cabinet drying
T_2D_5	Blanching + tray drying
T_2D_6	Blanching + vacuum drying
T_3D_1	Chemical treatment + sun drying
T_3D_2	Chemical treatment + shade drying
T_3D_3	Chemical treatment + microwave oven drying
T_3D_4	Chemical treatment + cabinet drying
T_3D_5	Chemical treatment + tray drying
T_3D_6	Chemical treatment + vacuum drying

Note : T- Pretreatments D- Drying methods

3.5 Observations recorded

Dehydrated leaves of both drumstick and coriander were analyzed with respect to the following parameters.

3.5.1 Drying rate (g/min)

One kilogram of fresh drumstick and coriander leaves were weighed. These leaves were kept for dehydration until a constant weight was achieved. The difference in the weight between fresh and dehydrated leaves was used to compute the drying rate as below;

$$\text{Drying rate} = \frac{\text{Fresh weight of sample} - \text{Dried weight of sample}}{\text{Time taken for drying}} \times 100$$

3.5.2 Dehydration ratio

Dehydration ratio means dried material recovery of known weight of fresh leaves. It is a unitless physical characteristic. Dehydration ratio was analyzed by drying one kilogram of fresh drumstick and coriander leaves until a constant weight achieved. Then dehydration ratio was computed as per the following formula (Viresh *et al.*, 2009).

$$\text{Dehydration ratio} = \frac{\text{Weight of fresh leaves}}{\text{Weight of dried leaves}}$$

3.5.3 Rehydration ratio

Five grams of dehydrated drumstick and coriander leaves was boiled in water in the ratio of 1:5 (dried leaf : water) for 20 minutes. Then, the water was filtered out. The weight of rehydrated leaves was recorded in grams. Then the rehydration ratio was calculated as per the following formula (Ranganna, 1986).

$$\text{Rehydration ratio} = \frac{\text{Final weight of the sample}}{\text{Initial weight of dried material}}$$

3.5.4 Moisture content (%)

Five grams of dried leaves of drumstick and coriander was taken. These weighed leaves were kept in hot air oven for further drying at a temperature of 45 ^{o}C for four hours. Then, the leaf samples were taken-out and recorded in grams. After that, the moisture content was calculated as per the following formula. This method is as per the AOAC (1990) method.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Initial weight (g)}} \times 100$$

3.5.5 Water activity

Water activity of dried drumstick and coriander leaves was determined by digital water activity meter (Model : Novasia AG, Swidzerland). One fourth volume of the container was filled with sample and it was closed with a lid containing sensors and left for three minutes undisturbed. After stabilizing the water activity, the reading displayed by digital water activity meter was recorded. It is a unitless number.

3.5.6 Ash content (%)

Ash content was determined by using AOAC method (Anon., 1984). The ash content was estimated by using a muffle furnace. Initially, silica crucibles and one gram of dried drumstick and coriander leaves were weighed separately. Then the leaves were kept in crucible and completely charred by keeping the sample above the flame. Then charred material was cooled. After that, the charred samples were kept in a muffle furnace along with the crucible at a temperature of 550 ^{o}C for four hours for ashing. At last, ash was kept in desiccators to attain room temperature. Then finally ash and crucible were weighed separately. The ash content was calculated by knowing the difference between the weight of initial dried leaves and final ash weight of the sample.

$$\text{Ash (\%)} = \frac{W_2 - W_1}{W} \times 100$$

W_1- Weight of the empty crucible (g)

W_2 - Final weight of the crucible and ash (g)

W- Weight of the sample (g)

3.5.7 Dry matter (%)

The dehydrated leaves used for determining the moisture content was used to study the dry matter. The dry matter percentage is calculated as follows.

$$DM (\%) = 100 - IMC$$

IMC = Initial moisture content

3.5.8 Protein (%)

Protein per cent was calculated by multiplying the nitrogen content with conversion factor (6.25). Nitrogen was determined by the kjeldhal method. Dried leaves were chopped to fine pieces; 0.5 g of chopped leaf pieces were transferred to 500 ml kjeldhal digestion tube. Further, sulphuric acid at 10 ml was added along with K_2SO_4 and $CuSO_4$ (catalyst mixture) to the digestion tube. Those digestion tubes were kept in the digestion chamber and covered by fume suction panels. Then the unit was switched on and the temperature was maintained upto 420 ^oC. Digestion was over within four to five hours; at end point the digested solution became colourless or light green colour. After that, digested sample was distilled in distillation unit. On one side, digested sample was added with 80 ml of 40 % NaOH and three milligram of methyl red indicator and allowed to distil. On another side, 20 ml of 4 % boric acid was added to 250 ml conical flask which was kept to absorb liberated ammonia. Distillation was completed within eight minutes. At the end, distilled sample turned to green colour. After that the distilled sample was titrated against 0.1 N HCl until light pink colour appeared in the flask (Chang and Nielsen, 2003). Nitrogen in per cent was calculated by using the formula given below;

$$\text{Nitrogen (\%)} = \frac{14.1 \times (\text{Titre} - \text{Blank}) \times \text{Normality of acid} \times 1000}{\text{Sample weight (g)} \times 100}$$

Nitrogen content was multiplied by a conversion factor of 6.25 to calculate protein content.

$$\text{Protein (\%)} = 6.25 \times \text{Nitrogen (\%)}$$

3.5.9 Fat content (%)

The fat content was determined using soxhlet plus solvent extraction unit (SOCSPLUS SCS-03E) (Kirk and Sawyer, 1980). Beakers and two gram of dried leaves were weighed using electrical weighing balance separately and then dried leaves were transferred to thimble. After that, beakers were filled with 80 ml n-hexane and sample containing thimbles were immersed in the beaker. Then, the beaker was kept on the heating plate and allowed to boil at 75 ºC to 150 ºC for two to three hours. Gradually hexane got collected in the condenser during boiling. After completion of hexane in the beaker, the beaker was taken-out and kept in the oven at 60 ºC to evaporate any residual moisture left in the beaker. After that, the beaker was kept in desiccators to maintain equilibrium with room temperature. At last, beakers were again weighed to check the weight difference of beaker. The percentage of fat content was calculated by using the formula;

$$\text{Fat (\%)} = \frac{W_1 - W_2}{W} \times 100$$

Where,

W_1= Weight of the beaker containing fat (g)

W_2 = Weight of the empty beaker (g)

W = Weight of the sample taken (g)

3.5.10 Crude fibre content (%)

Fibre content was estimated by using Weende method (Anon., 2005). Two grams of the dried leaf sample was taken in 250 ml of the conical flask and 200 ml of 1.25 % sulphuric acid was added and the mixture was boiled under reflux for 30 minutes. The solution was filtered with Whatman filter paper, the residue was rinsed thoroughly with hot water until it was no more acidic when tested using pH paper. The residue was transferred into a crucible and placed in an electric oven at 100 ^{o}C for eight hours to dry and weighed (We). It was then removed and placed in desiccators to cool. After that, the sample was reweighed (Wa).

$$\text{Crude fibre (\%)} = \frac{\text{We-Wa}}{\text{Weight of the sample taken}} \times 100$$

3.5.11 Carbohydrate (%)

Carbohydrate per cent was calculated by subtracting the sum of the percentage of moisture, crude fibre, protein, fat and total ash from hundred (Onwuka, 2005).

Carbohydrate content = [100-(Moisture + Crude fibre + Protein + Fat + Ash content)]

3.5.12 Energy value (kilocalories/100g)

Total energy was calculated by the formula given below and expressed in kilocalories per 100 grams (Onwuka, 2005).

Energy (Kcal/100g) = (4 × protein percentage) + (9 × fat percentage) + (4× Carbohydrate percentage)

3.5.13 Total Chlorophyll (mg/g)

Chlorophyll content was calculated by spectral analysis (Arnon, 1949). Leaf sample was weighed to one gram and chopped into small fragments then smashed by using pestle and mortar after adding 20 ml of 80 % acetone. Then, the mixture was centrifuged at 2500 rpm for five minutes and the supernatant was collected and transferred in a 50 ml volumetric flask. Thereafter, 80 % acetone was added to make up volume to 50 ml. Then, the absorbance of extract was recorded at 645 nm and 663 nm in a double beam UV-VIS spectrophotometer. Finally, chlorophyll content was calculated by using the formula as given below,

Total chlorophyll (mg/g tissue) = $20.2\ (A_{645}) + 8.02\ (A_{663}) \times \frac{V}{1000 \times W}$

Where, A= Absorbance at specific wavelength

V= Final value of chlorophyll extract in 80 % acetone

W= weight of tissue extracted

3.5.14 Total carotenoid (mg/100g)

Five grams of dried drumstick and coriander leaves were crushed in 80 % acetone, adding a few crystals of anhydrous sodium sulphate, with the help of pestle and mortar. The supernetant was decanted into a beaker and 10-15 ml petroleum ether was added and mixed thoroughly. The above sample was collected in a 100 ml volumetric flask and made up to 100 ml with petroleum ether and recorded the absorbance at 452 nm using petroleum ether as blank (Ranganna, 1997).

$$\text{Total carotenoid (mg/100g)} = \frac{(7.6\ (A_{480}) - 1.49\ (A_{510}))}{(d \times 1000 \times W)\ \ V}$$

A- Absorbance (nm)

W- Weight of the sample (g)

V- Volume of extractant (ml)

3.5.15 Vitamin C (mg/100g)

Ascorbic acid of the dried moringa and coriander leaves was measured by using the titration method by 2, 6-dichloroindophenol solution (Xiao *et al*., 2012). Dye was prepared by dissolving 50 mg of 2, 6-dichloroindophenol in 150 ml of distilled water containing 42 mg of sodium bicarbonate and then the volume was made up to 200 ml. A known weight of leaves was ground by pestle and mortar, then 10 ml of four per cent oxalic acid was added and made into slurry. The slurry was transferred into a beaker containing 40 ml of oxalic acid. After that, the solution was centrifuged for 10 to 15 minutes and then, the filtrate was collected. Afterwards, a conical flask containing 5 ml of ascorbic acid standard solution and 5 ml of 4 % oxalic acid was titrated against the dye to get dye factor till the appearance of onion pink colour at the endpoint of the titration. It was taken after 15 seconds. Ascorbic acid (mg/100g) was calculated by using the formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made}}{\text{liquid taken} \times \text{weight of sample taken} \times 100} \times 100$$

Dye factor =0.5/titer

3.5.16 Calcium (mg/100g)\

This was determined by the ethylene diamine tetraacetic acid (EDTA) titrimertric method (Page *et al.*, 1982). Ten ml of digested sample was measured into a 250 ml conical flask. A pinch of potassium cyanide, a pinch of hydroxyl amine hydrochloride, 5 ml of 10 % potassium hydroxide were added and shaken gently until the solids dissolved. Then, a pinch of indicator (Pattons and reader's reagent) was added and the mixture was titrated with the 0.01M EDTA solution until the colour changed from wine red to blue which is an endpoint.

$$\text{Ca (mg/100g)} = \frac{\text{TV of EDTA} \times \text{m. eq. Wt. of Ca} \times \text{Vol. Of digest} \times 1000}{\text{Weight of the sample} \times \text{Aliquot of digest}}$$

3.5.17 Color values

The colour of moringa leaves and coriander leaves was measured by a colorimeter CR-10 (Konica Minolta, INC, Japan). The colorimeter was calibrated using the standard white plate; 'L' represented the value colour lightness (0= Black, 100 = white), ^{-}a/ ^{+}a redness or greenness and ^{-}b/ ^{+}b yellowness or blueness. Leaf samples were kept above the scanner and observed readings were recorded in terms of L*, a* and b*. For each treatment, three samples were recorded and averaged. The total changed colour ΔE was calculated by using the equation.

$$\Delta E = \sqrt[2]{(L - L^*))^2 + (a - a^*)^2 + (b - b^*)^2}$$

Where,

ΔE = total difference

L* = Indicates lightness of sample

a* = Red/Green coordinate, and

b* = Yellow/Blue coordinate

L = Lightness of colour standard

a = Greenness or redness of standard

b = Blueness or yellowness of standard

3.5.18 Sensory evaluation:

Sensory evaluation was conducted in food processing Laboratory, Department of Food Processing and Technology, Dharwad. The panel consisted of ten judges.

Dehydrated leaf tea was used for sensory evaluation (taste and acceptability). Score card was given to the panel members in which each quality had a separate score. The panel members gave scores according to the hedonic scale (Amerine *et al*., 1965).

Organoleptic Score	Rating
9	Like Extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

3.6 Packaging and storage for one month

Good quality dehydrated leaves of both drumstick and coriander were packed and stored for further storage and evaluation. Packaging materials used were given below;

P_1: LDPE (150 gauge)

P_2: HDPE (200 gauge)

P_3: Aluminium foil

Total moisture per cent and ascorbic acid contents were analysed for one month stored leaves in different packaging materials.

3.7 Statistical analysis

Effect of pre-treatments and drying methods on physical, nutritional, colour and sensory quality of dried drumstick and coriander leaves were analyzed by two factorial CRD (3×6) design and effects of pre-treatments, drying methods, packaging material and there interaction on one month stored quality of dried drumstick and coriander leaves were analyzed by three factor CRD (3×3×6) design with two way ANOVA at one per cent critical difference (Panse and Sukhatme, 1967).

4. EXPERIMENTAL RESULTS

Drumstick and coriander leaves were pre-treated variously and dried under different drying methods. Results were analysed by using two factorial complete randomized (F-CRD) design for physical, nutritional, colour and sensory quality analysis of dried leaves and three factor CRD was used to analyze one month storage quality in three different packaging materials.

The results obtained under the investigation on the topic 'Dehydration of drumstick and coriander leaves' conducted in the laboratories of Department of Food Processing and Technology and Department of Horticulture, College of Agriculture, Dharwad are penned in this chapter under sub-headings of:

4.1 Effect of pre-treatment and drying methods on dehydrated drumstick and coriander leaves

4.2 Effect of pre-treatment and drying methods on sensory quality of dehydrated drumstick and coriander leaves

4.3 Effect of different packaging materials on quality of dried drumstick and coriander leaves after one month storage

4.1 Effect of pre-treatment and drying methods on dehydrated drumstick and coriander leaves

4.1.1 Drying rate (g/min)

Drying rate of drumstick leaves was significantly affected by pre-treatments, drying methods and their interaction. Quick drying rate was observed in untreated leaves (4.58 g/min) followed by chemical treated leaves (4.07 g/min) and slow drying rate was observed in blanched leaves (3.25 g/min). Among drying methods, the quickest drying rate was found in microwave oven drying (9.88 g/min) followed by vacuum drying (6.95 g/min) and slow drying rate observed in shade drying (0.07 g/min). With respect to interaction, quick drying rate was found in untreated and microwave oven dried (12.81 g/min) followed by chemical treated and microwave oven dried leaves (8.66 g/min) and slow drying rate was found in blanched and shade dried leaves (0.06 g/min) and which was at par with T_1D_2 and T_3D_2 (0.07 g/min) (Table 1a).

Table 1a. Effect of different pre-treatments and drying methods on drying rate of drumstick leaves

Parameters	Drying rate (g/min)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	0.35	0.25	0.32	0.31
D_2	0.07	0.06	0.07	0.07
D_3	12.81	8.16	8.66	9.88
D_4	2.72	2.19	2.53	2.48
D_5	3.92	2.91	5.52	4.12
D_6	7.60	5.95	7.31	6.95
Mean	4.58	3.25	4.07	3.97

Factors	T	D	T × D
S. Em ±	0.026	0.036	0.063
CD @ 1 %	0.070	0.099	0.171

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

In dehydration of coriander leaves, drying rate was significantly affected by pre-treatments, drying methods and their interaction (Table 1b). Quick mean drying rate was observed in untreated leaves (5.89 g/min) followed by chemical treated leaves (4.72 g/min) and slow drying rate was observed in blanched leaves (4.13 g/min). Among drying methods, the quickest drying rate was found in microwave oven drying (11.26 g/min) followed by vacuum drying method (8.24 g/min) and slow drying was observed in shade drying (0.14 g/min). With respect to interaction, quickest drying rate found in untreated and microwave oven dried samples (14.57 g/min) followed by chemical treated and microwave oven dried leaves (9.73 g/min) and slow drying rate was observed in blanched and shade dried leaves (0.13 g/min) which was at par with T_1D_2 (0.15 g/min) and T_3D_2 (0.14 g/min).

4.1.2 Dehydration ratio

Dehydration ratio of drumstick leaves was significantly affected by pre-treatments and drying methods and their interaction (Table 2a). Maximum dehydration ratio was found in untreated leaves (4.47) followed by chemical treated leaves (4.10) and minimum dehydration ratio was observed in blanched leaves (4.09). Among drying methods, the maximum dehydration ratio was found in microwave oven drying (5.12) followed by tray drying (4.77) and minimum was observed in shade dry (3.43). With respect to interaction, the maximum dehydration ratio was found in untreated and microwave oven dried leaves (5.92) and lowest dehydration ratio was observed in blanched and shade dried drumstick leaves (3.30) which was at par with T_3D_2 (3.42).

Dehydration ratio of coriander leaves was significantly affected by pre-treatments and drying methods (Table 2b). Maximum dehydration ratio was found in untreated leaves (4.49) followed by chemical treated leaves (4.20) and lowest dehydration ratio was observed in blanched leaves (3.88). Among drying methods, the maximum dehydration ratio was found in microwave oven drying (5.12) followed by vacuum drying (4.68) and minimum was observed in shade dried leaves (3.14). With respect to interaction, maximum dehydration ratio was found in untreated and microwave oven dried leaves (5.92) and minimum dehydration ratio was found in blanched and shade dried (2.99) which was at par with T_3D_2 (3.07).

4.1.3 Rehydration ratio

Pre-treatments significantly influenced rehydration ratio of dried drumstick leaves. Maximum rehydration ratio was found in chemical treated leaves (5.19) followed by blanched

Table 1b. Effect of different pre-treatments and drying methods on drying rate of coriander leaves

Parameters	Drying rate			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	0.69	0.53	0.65	0.62
D_2	0.15	0.13	0.14	0.14
D_3	14.57	9.48	9.73	11.26
D_4	4.09	3.43	3.82	3.78
D_5	6.93	4.17	5.22	5.44
D_6	8.90	7.06	8.76	8.24
Mean	5.89	4.13	4.72	4.91

Factors	T	D	T × D
S. Em ±	0.026	0.037	0.065
CD @ 1 %	0.072	0.102	0.176

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 2a. Effect of different pre-treatments and drying methods on dehydration ratio of drumstick leaves

Parameters	Dehydration ratio			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	3.84	3.74	3.60	3.73
D_2	3.57	3.30	3.42	3.43
D_3	5.92	4.77	4.67	5.12
D_4	3.74	3.49	3.66	3.63
D_5	4.84	4.66	4.81	4.77
D_6	4.91	4.58	4.42	4.64
Mean	4.47	4.09	4.10	4.22

Factors	T	D	T × D
S. Em ±	0.045	0.063	0.109
CD @ 1 %	0.12	0.17	0.29

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 2b. Effect of different pre-treatments and drying methods on dehydration ratio of coriander leaves

Parameters	Dehydration ratio			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	4.20	3.60	3.61	3.80
D_2	3.37	2.99	3.07	3.14
D_3	5.92	4.67	4.77	5.12
D_4	3.72	3.74	4.5	3.99
D_5	4.84	4.42	4.58	4.61
D_6	4.91	4.48	4.66	4.68
Mean	4.49	3.88	4.20	4.19

Factors	T	D	T × D
S. Em ±	0.012	0.017	0.029
CD @ 1 %	0.033	0.046	0.080

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

leaves (5.13) and lowest rehydration ratio was observed in untreated leaves (5.04). Drying methods influenced rehydration ratio of dried leaves. Maximum rehydration ratio was found in microwave oven dried leaves (5.23) which was at par with cabinet dried leaves (5.17), tray and vacuum dried leaves (5.14) and lowest rehydration ratio was found in shade and sun dried method (5.02). with respect to interaction, maximum rehydration ratio was observed in chemical treated and microwave oven dried leaves (5.28) which was at par with T_3D_5 (5.27) and T_2D_3 (5.26), T_3D_6 (5.19), T_1D_3 (5.16), T_2D_6 (5.15) and T_2D_5 (5.15). Minimum rehydration ratio was found in untreated and shade dried leaves (4.92) which was at par with T_1D_1 (4.97), T_2D_1 (4.99), T_2D_2 and T_1D_5 (5.04) and T_1D_6 (5.08). It has been tabulated in Table 3a.

Pre-treatments, drying methods and their interaction were significantly influenced by rehydration ratio of dried coriander leaves (Table 3b). Maximum rehydration ratio was found in chemical treated leaves (4.86) followed by blanched leaves (4.60) and lowest rehydration ratio was observed in untreated leaves (3.89). Drying methods influenced rehydration ratio of dried leaves. Maximum rehydration ratio was found in microwave oven dried leaves (4.54) which was at par with tray dried leaves (4.53), D_4 (4.52), D_6 (4.50) and D_1 (4.48). Lowest rehydration ratio found in shade dried method (4.14). With respect to interaction, maximum rehydration ratio was observed in chemical treated and microwave oven dried leaves (4.90) and which was at par with T_3D_4 and T_3D_5 (4.89), T_3D_1 (4.87), T_3D_6 (4.82), T_2D_5 (4.77), T_3D_2 (4.80), T_2D_3 (4.78) and minimum rehydration ratio was found in untreated and shade dried leaves (3.79) which was at par with T_1D_1 (3.82), T_2D_2 (3.83), T_1D_4, T_1D_5, T_1D_6 (3.92) and T_1D_3 (3.94).

4.1.4 Moisture content (%)

Moisture content present in dried drumstick leaves varied with pre-treatment and drying method used (Table 4a). Blanched leaves showed maximum moisture content (3.88 %) followed by chemical treated (3.62 %) leaves and minimum moisture content was present in untreated leaves (2.68 %). Maximum moisture content was retained in shade and sun (3.48 %) dried leaves which were at par with cabinet dried (3.38 %) leaves and minimum moisture content was retained in microwave oven dried leaves (3.25 %). Interaction between pre-treatment and drying methods also influenced the moisture per cent. Blanched and shade dried (T_2D_2) leaves had maximum moisture per cent (3.99 %) and which was at par with T_2D_1 (3.94 %), T_2D_6 (3.85 %), T_2D_4 (3.84 %), T_2D_5 (3.83 %). Untreated and microwave oven (T_1D_3)

Table 3a. Effect of different pre-treatments and drying methods on rehydration ratio of dried drumstick leaves

Parameters	Rehydration ratio			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	4.97	4.99	5.09	5.02
D_2	4.92	5.04	5.09	5.02
D_3	5.16	5.26	5.28	5.23
D_4	5.09	5.21	5.21	5.17
D_5	5.04	5.12	5.27	5.14
D_6	5.08	5.15	5.19	5.14
Mean	5.04	5.13	5.19	5.12

Factors	T	D	T × D
S. Em ±	0.025	0.036	0.062
CD @ 1 %	0.068	0.097	0.167

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 3b. Effect of different pre-treatments and drying methods on rehydration ratio of dried coriander leaves

Parameters	Rehydration ratio			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	3.82	4.74	4.87	4.48
D_2	3.79	3.83	4.80	4.14
D_3	3.94	4.78	4.90	4.54
D_4	3.92	4.74	4.89	4.52
D_5	3.92	4.77	4.89	4.53
D_6	3.92	4.76	4.82	4.50
Mean	3.89	4.60	4.86	4.45

Factors	T	D	T × D
S. Em ±	0.026	0.037	0.065
CD @ 1 %	0.072	0.102	0.177

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 4a. Effect of different pre-treatments and drying methods on retention of moisture in dried drumstick leaves

Parameters	Moisture (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	2.76	3.94	3.73	3.48
D_2	2.78	3.99	3.66	3.48
D_3	2.55	3.80	3.40	3.25
D_4	2.64	3.84	3.65	3.38
D_5	2.61	3.83	3.63	3.36
D_6	2.73	3.85	3.64	3.41
Mean	2.68	3.88	3.62	3.39

Factors	T	D	T × D
S. Em ±	0.028	0.039	0.068
CD @ 1 %	0.075	0.106	0.184

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

dried leaves had minimum moisture per cent (2.55 %) which was at par with T_1D_5 (2.61 %), T_1D_4 (2.64 %), T_1D_6 (2.73 %) and T_1D_1 (2.76 %).

Moisture content present in dried coriander leaves varied with pre-treatment, drying method and their interaction (Table 4b). Blanched leaves had maximum moisture content (2.83 %) followed by chemical treated leaves (2.35 %) and minimum moisture was observed in untreated leaves (1.66 %). Among drying methods, maximum moisture content was retained in shade dried leaves (2.40 %) which was at par with sun dried leaves (2.35 %). Minimum moisture content was present in microwave oven dried leaves (2.17 %). Blanched and shade dried leaves showed maximum moisture per cent retention (2.97 %) and untreated and microwave oven dried leaves exhibited minimum moisture retention (1.53 %).

4.1.5 Water activity

Pre-treatment, drying methods and interaction significantly influenced water activity in dried drumstick leaves. Maximum mean water activity was found in blanched (0.63) followed by chemical treated leaves (0.62) and minimum mean water activity was found in untreated leaves (0.56). Shade dried leaves showed maximum average water activity (0.67) followed by cabinet dried leaves (0.61) and minimum water activity was found in microwave oven dried leaves (0.57). Maximum water activity was found in blanched and shade dried (T_2D_2) leaves (0.74) and minimum water activity was in untreated microwave oven dried (0.52) drumstick leaves (Table 5a).

Pre-treatments, drying methods and their interaction significantly influenced water activity in dried coriander leaves. Blanched leaves had comparatively more water activity (0.65) followed by chemical treated leaves (0.62) and minimum water activity was found in untreated leaves (0.58). Shade dried leaves showed more mean water activity (0.68) followed by sun dried leaves (0.64) and minimum water activity was found in microwave oven dried leaves (0.58). Maximum water activity was found in blanched and shade dried leaves (0.74) followed by T_2D_1 (0.68) and minimum water activity was found in untreated microwave oven dried (0.57) coriander leaves (Table 5b).

4.1.6 Ash (%)

Ash per cent indicates the total minerals found in the dried leaf material. Ash per cent of drumstick leaves varied significantly with pre-treatment, drying methods and their

Table 4b. Effect of different pre-treatments and drying methods on retention of moisture in dried coriander leaves

Parameters	Moisture (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	1.72	2.88	2.44	2.35
D_2	1.78	2.97	2.46	2.40
D_3	1.53	2.75	2.24	2.17
D_4	1.75	2.84	2.37	2.32
D_5	1.59	2.75	2.30	2.21
D_6	1.58	2.76	2.27	2.20
Mean	1.66	2.83	2.35	2.28

Factors	T	D	T × D
S. Em ±	0.007	0.009	0.016
CD @ 1 %	0.018	0.026	0.045

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 5a. Effect of different pre-treatments and drying methods on water activity in dried drumstick leaves

Parameters	Water activity (a_w)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	0.53	0.62	0.60	0.58
D_2	0.62	0.74	0.66	0.67
D_3	0.52	0.60	0.59	0.57
D_4	0.56	0.63	0.63	0.61
D_5	0.59	0.59	0.62	0.60
D_6	0.53	0.62	0.60	0.58
Mean	0.56	0.63	0.62	0.60

Factors	T	D	T × D
S. Em ±	0.000422	0.001	0.001
CD @ 1 %	0.001	0.002	0.003

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 5b. Effect of different pre-treatments and drying methods on water activity in dried coriander leaves

Parameters	Water activity (a_w)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	0.61	0.68	0.63	0.64
D_2	0.63	0.74	0.66	0.68
D_3	0.57	0.59	0.58	0.58
D_4	0.55	0.64	0.63	0.61
D_5	0.53	0.63	0.62	0.59
D_6	0.58	0.62	0.61	0.60
Mean	0.58	0.65	0.62	0.62

Factors	T	D	T × D
S. Em ±	0.003	0.004	0.007
CD @ 1 %	0.007	0.010	0.018

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

interaction and tabulated in table 6a. In drumstick leaves, chemical treatment significantly increased ash per cent (11.83 %) followed by hot water blanching with sodium bicarbonate (11.50 %) but in untreated leaves, ash per cent was found minimum (10.64 %). Among drying methods, maximum ash per cent was observed in microwave oven dried leaves (11.48 %) which was at par with D_6 (11.45 %), D_2 and D_4 (11.3 %) and minimum ash per cent was observed in sun dried leaves (11.16 %). Among different interactions**,** maximum ash per cent was observed in chemical treated and microwave oven dried leaves (11.87 %) which was at par with T_3D_2 (11.80 %), T_3D_4 (11.81 %), T_3D_5 (11.85 %) and T_3D_6 (11.78 %). Minimum ash per cent was reported in untreated and sundried drumstick leaves (10.21 %) which is at par with T_1D_5 (10.32 %).

In the same way, ash per cent in dried coriander leaves also varied significantly with pre-treatment, drying methods and their interactions as noted in Table 6b. Maximum ash per cent was found in chemical treated leaves (5.57 %) followed by blanched leaves (5.32 %) and minimum ash per cent was found in untreated leaves (4.62 %). Among drying methods, microwave oven dried leaves tabulated maximum ash per cent (5.45 %) and sun drying reported minimum ash per cent (4.95 %). Among different combination of pre-treatment and drying methods**,** maximum ash per cent was observed in chemical treated and microwave oven dried leaves (5.81 %) which is at par with T_3D_6 (5.64 %). Untreated and sundried coriander leaves reported minimum ash per cent (4.36 %).

4.1.7 Dry matter (%)

Dry matter per cent in dried drumstick leaves was significantly influenced by pre-treatments, drying methods and their interaction (Table 7a). Maximum dry matter per cent was observed in untreated leaves (97.36 %) followed by chemical treated leaves (96.38 %) and minimum dry matter was observed in blanched leaves (96.13 %). Among drying methods, microwave oven drying was found more efficient in having more dry matter per cent (96.75 %) succeeded by tray dried leaves (96.66 %) and minimum dry matter per cent was found in shade dried leaves (96.54 %). With respect to interaction of pre-treatment and drying methods, untreated and microwave oven dried leaves (97.47 %) were found to have maximum dry mater content followed by untreated and tray dried (97.45 %) and minimum dry mater was exhibited in blanched and shade dried leaves (96.01 %).

Table 6a. Effect of different pre-treatments and drying methods on ash content in dried drumstick leaves

Parameters	Ash (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	10.21	11.40	11.86	11.16
D_2	10.60	11.51	11.80	11.30
D_3	11.03	11.55	11.87	11.48
D_4	10.62	11.46	11.81	11.30
D_5	10.32	11.53	11.85	11.23
D_6	11.03	11.54	11.78	11.45
Mean	10.64	11.50	11.83	11.32

Factors	T	D	T × D
S. Em ±	0.055	0.077	0.134
CD @ 1 %	0.149	0.210	0.364

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 6b. Effect of different pre-treatments and drying methods on ash content in dried coriander leaves

Parameters	Ash (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	4.36	5.14	5.36	4.95
D_2	4.80	5.36	5.60	5.25
D_3	5.00	5.54	5.81	5.45
D_4	4.47	5.17	5.46	5.03
D_5	4.48	5.30	5.56	5.11
D_6	4.59	5.38	5.64	5.20
Mean	4.62	5.32	5.57	5.17

Factors	T	D	T × D
S. Em ±	0.031	0.043	0.075
CD @ 1 %	0.083	0.118	0.204

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 7a. Effect of different pre-treatments and drying methods on dry matter content in dried drumstick leaves

Parameters	Drying matter (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	97.39	96.06	96.38	96.61
D_2	97.27	96.01	96.34	96.54
D_3	97.47	96.20	96.59	96.75
D_4	97.24	96.16	96.35	96.58
D_5	97.45	96.17	96.37	96.66
D_6	97.36	96.15	96.23	96.58
Mean	97.36	96.13	96.38	96.62

Factors	T	D	T × D
S. Em ±	0.043	0.061	0.106
CD @ 1 %	0.118	0.167	0.289

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Dry matter per cent in dried coriander leaves were significantly influenced by pre-treatments, drying methods and their interaction (Table 7b). Maximum dry matter per cent was observed in untreated leaves (98.34 %) followed by chemical treated leaves (97.60 %) and minimum dry matter was observed in blanched leaves (97.18 %). Among drying methods, microwave oven dried leaves were found to have maximum dry matter per cent (97.86 %) followed by tray dried leaves (97.83 %) and minimum dry matter per cent was found in shade dried leaves (97.64 %). With respect to interaction of pre-treatment and drying methods, untreated and microwave oven dried leaves (98.47 %) were found to have maximum dry mater content followed by untreated and tray dried (98.41 %) and minimum dry mater was in blanched and shade dried leaves (97.03 %).

4.1.8 Protein content (%)

Protein retention per cent varied significantly by pre-treatment, drying methods and interaction of pre treatment and drying methods in dried drumstick leaves (Table 8a). Maximum protein per cent was retained in chemical treated leaves (23.21 %) followed by untreated leaves (22.87 %) and minimum protein was found in blanched leaves (16.69 %). Maximum protein was retained in microwave oven dried leaves (21.54 %) succeeded by vacuum dried leaves (21.20 %) and minimum protein content was found in sun drying (20.11 %) method. Chemical treated and microwave oven dried leaves contained more protein per cent (23.65 %) which was at par with T_1D_3 (23.63 %), T_3D_4 and T_3D_6 (23.56 %) and minimum protein per cent retained in blanched and sun dried drumstick leaves (16.23 %).

In coriander leaves, protein retention per cent varied significantly by pre-treatment, drying methods and interaction of both pre-treatment and drying methods (Table 8b). Maximum protein per cent was retained in chemical treated leaves (23.38 %) followed by untreated leaves (23.11 %) and minimum protein per cent was found in blanched leaves (16.76 %). Maximum protein per cent was retained in microwave oven dried leaves (21.52 %) followed by cabinet dried leaves (21.22 %) and minimum protein per cent was retained in sun dried (20.41 %) leaves. Chemical treated and microwave oven dried leaves retained more protein per cent (23.69 %) which was at par with T_3D_6 (23.59 %), T_3D_5 (23.15 %), T_3D_4 (23.52 %), T_3D_2 (23.46 %), T_1D_2 (22.96 %), T_1D_3 (23.52 %), T_1D_4 (23.40 %), T_1D_5 (23.08 %) and T_1D_6 (23.46 %). Blanching followed by sun drying decreased the protein per cent (16.25 %) in coriander leaves which was at par with T_2D_6 (16.37 %).

Table 7b. Effect of different pre-treatments and drying methods on drying matter content in dried coriander leaves

Parameters	Drying matter (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	98.42	97.12	97.56	97.77
D_2	98.25	97.03	97.54	97.64
D_3	98.47	97.25	97.76	97.86
D_4	98.28	97.16	97.63	97.72
D_5	98.41	97.25	97.70	97.83
D_6	98.22	97.24	97.43	97.73
Mean	98.34	97.18	97.60	97.76

Factors	T	D	T × D
S. Em ±	0.007	0.009	0.016
CD @ 1 %	0.018	0.026	0.045

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 8a. Effect of different pre-treatments and drying methods on protein content in dried drumstick leaves

Parameters	Protein (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	22.00	16.23	22.11	20.11
D_2	22.88	16.73	23.36	20.99
D_3	23.63	17.34	23.65	21.54
D_4	22.71	16.71	23.56	20.99
D_5	23.00	16.13	23.00	20.71
D_6	23.02	17.02	23.56	21.20
Mean	22.87	16.69	23.21	20.92

Factors	T	D	T × D
S. Em ±	0.023	0.032	0.055
CD @ 1 %	0.061	0.087	0.150

Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with 0.5 % sodium meta bisulphite, T_3-chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2-Shade drying, D_3- Microwave oven drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum drying

Table 8b. Effect of different pre-treatments and drying methods on protein content in dried coriander leaves

Parameters	Protein (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	22.21	16.25	22.77	20.41
D_2	22.96	16.75	23.46	21.06
D_3	23.52	17.35	23.69	21.52
D_4	23.40	16.75	23.52	21.22
D_5	23.08	17.06	23.15	21.10
D_6	23.46	16.37	23.59	21.17
Mean	23.11	16.76	23.38	21.08

Factors	T	D	T × D
S. Em ±	0.123	0.175	0.302
CD @ 1 %	0.336	0.475	0.822

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

4.1.9 Fat content (%)

Fat content was significantly influenced by pre treatments (Table 9). Chemical treated leaves had significantly higher fat content (2.68 %) which was almost similar to untreated leaves (2.59 %) and blanching significantly decreased the fat content in drumstick leaves (1.33 %) but drying methods were did not significantly influence the fat per cent retention in drumstick leaves.

4.1.10 Crude fibre content (%)

Retention of crude fibre content in dried drumstick leaves were significantly influenced by pre-treatments and non-significantly influenced by drying methods and their interaction (Table 10a). Maximum crude fibre was found in chemical treated leaves (9.62 %) followed by untreated leaves (9.37 %) and minimum crude fibre content was found in blanched leaves (9.33 %).

In dehydration of coriander leaves, crude fibre content was influenced significantly by pre-treatments and drying methods (Table 10b). Maximum crude fibre content was found in chemical treated leaves (5.86 %) followed by untreated (5.72 %) and minimum crude fibre content was found in blanched leaves (5.71 %). Among drying methods, microwave oven dried leaves (5.81 %) had maximum fibre per cent in coriander leaves which is at par with cabinet dried and tray dried leaves (5.80 %) and minimum fibre content was exhibited in sun dried leaves (5.68 %). Maximum crude fibre content was found in chemical treatment followed by microwave oven drying. Shade drying was found superior in crude fibre content retention in dried coriander leaves (5.87 %) which is at par with T_3D_5 and T_3D_6 (5.86 %), cabinet dry (5.85 %). Hot water blanching with 0.5 % sodium bicarbonate followed by sun drying significantly reduced crude fibre content in coriander leaves (5.49 %).

4.1.11 Carbohydrates content (%)

Pre-treatment, drying methods and their interaction significantly influenced the carbohydrates retention in dried drumstick leaves (Table 11a). Maximum per cent of carbohydrates were retained in blanched leaves (57.29 %) followed by untreated leaves (51.57 %). Minimum carbohydrate content was found in chemical treated leaves (49.39 %). Maximum carbohydrates were found in sun dried leaves (53.73 %) followed by D_5 (52.89 %) and minimum carbohydrates were found in D_3 (52.12 %). Blanching and vacuum drying

Table 9. Effect of different pre-treatments and drying methods on fat content in dried drumstick leaves

Parameters	Fat (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	2.67	1.46	2.76	2.30
D_2	2.68	1.50	2.78	2.32
D_3	2.53	1.29	2.62	2.15
D_4	2.55	1.24	2.64	2.14
D_5	2.54	1.23	2.63	2.13
D_6	2.54	1.23	2.62	2.13
Mean	2.59	1.33	2.68	2.20

Factors	T	D	T × D
S. Em ±	0.075	0.106	0.184
CD @ 1 %	0.205	NS	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 10a. Effect of different pre-treatments and drying methods on crude fibre content in dried drumstick leaves

Parameters	Crude fibre (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	9.27	9.21	9.46	9.31
D_2	9.39	9.34	9.42	9.38
D_3	9.36	9.42	9.76	9.51
D_4	9.33	9.33	9.64	9.43
D_5	9.33	9.31	9.72	9.45
D_6	9.52	9.34	9.73	9.53
Mean	9.37	9.33	9.62	9.44

Factors	T	D	T × D
S. Em ±	0.059	0.083	0.144
CD @ 1 %	0.160	NS	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 10b. Effect of different pre-treatments and drying methods on crude fibre content in dried coriander leaves

Parameters	Crude fibre (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	5.71	5.49	5.83	5.68
D_2	5.78	5.60	5.87	5.75
D_3	5.78	5.79	5.87	5.81
D_4	5.78	5.77	5.85	5.80
D_5	5.76	5.78	5.86	5.80
D_6	5.50	5.81	5.86	5.72
Mean	5.72	5.71	5.86	5.76

Factors	T	D	T × D
S. Em ±	0.028	0.039	0.068
CD @ 1 %	0.076	0.107	0.185

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 11a. Effect of different pre-treatments and drying methods on carbohydrate content in dried drumstick leaves

Parameters	Carbohydrates (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	53.05	57.75	50.39	53.73
D_2	51.63	56.94	49.08	52.55
D_3	51.23	56.57	48.56	52.12
D_4	50.68	57.43	49.65	52.59
D_5	52.08	57.11	49.48	52.89
D_6	50.75	57.92	49.16	52.61
Mean	51.57	57.29	49.39	52.75

Factors	T	D	T × D
S. Em ±	0.124	0.176	0.304
CD @ 1 %	0.338	0.478	0.827

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

significantly maximised the carbohydrates (57.92 %) in drumstick leaves which was at par with T_2D_1 (57.75 %) and minimum carbohydrates were found in T_3D_3 treatment of drumstick leaves (48.56 %).

In coriander leaves, carbohydrates were significantly influenced by pre-treatments and non-significantly influenced by drying methods and their interactions (Table 11b). Maximum carbohydrates were found in blanched leaves (69.40 %) followed by untreated leaves (64.90 %) and minimum carbohydrates were observed in chemical treated leaves (62.80 %).

4.1.12 Energy (K cal/100 g)

Pre-treatment, drying methods and their interactions significantly influenced the energy per cent retention in dried drumstick leaves. Maximum per cent of energy was retained in chemical treated leaves (322.82 K calories/100 g) followed by untreated leaves (312.64 K calories/100 g). Minimum energy was found in blanched leaves (307.85 K calories/100 g). Microwave oven dried leaves (316.04 K calories/100 g) had maximum energy, which is at par with D_2 (315.02 Kcal/100 g) and D_5 (314.78 K cal/100 g). D_6 exhibited minimum energy (313.20 K calories/100 g). Among combination, untreated and sun dried leaves had more energy value (325.42 K calories/100 g) which is at par with T_1D_5 (323.97 K calories/100 g). T_2D_6 exhibited minimum energy in drumstick leaves (307.24 K calories/100 g) (Table 12a).

In the same way, coriander leaves were also significantly influenced by pre treatment and drying methods. Chemical treated leaves had maximum energy (352.02 K calories/100 g) followed by T_3 (344.71 K calories/100 g). T_2 had minimum energy (344.63 K calories/100 g). Among drying methods, microwave oven drying was found significantly superior for energy value (348.30 K calories/100 g) followed by D_5 (347.48 K calories/100 g). Minimum energy value was found in sun dried leaves (345.68 K calories/100 g). Interaction of pre-treatments and drying methods did not influence the energy value significantly (Table 12b).

4.1.13 Total chlorophyll (mg/100 g)

Chlorophyll content of drumstick leaves was significantly influenced by pre-treatment and drying methods (Table 13a). Maximum chlorophyll retention was observed in chemical treated (T_3) leaves (25.19 mg/100 g) followed by untreated (T_1) leaves (24.48 mg/100 g). Blanched leaves (T_2) were found inferior in chlorophyll content retention (23.17 mg/100 g). In drying methods, microwave oven dried (D_3) leaves were found superior for chlorophyll

Table 11b. Effect of different pre-treatments and drying methods on carbohydrate content in dried coriander leaves

Parameters	Carbohydrates (%)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	65.69	70.02	63.36	66.36
D_2	64.82	68.97	62.87	65.55
D_3	64.55	69.14	62.40	65.36
D_4	64.59	69.47	62.78	65.61
D_5	65.08	69.11	63.13	65.77
D_6	64.68	69.68	62.24	65.53
Mean	64.90	69.40	62.80	65.70

Factors	T	D	T × D
S. Em ±	0.144	0.203	0.352
CD @ 1 %	0.390	NS	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 12a. Effect of different pre-treatments and drying methods on energy in dried drumstick leaves

Parameters	Energy (k calories/ 100g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	311.61	307.27	322.99	313.96
D_2	313.88	308.14	323.03	315.02
D_3	313.59	309.12	325.42	316.04
D_4	312.38	307.71	320.70	313.60
D_5	312.78	307.60	323.97	314.78
D_6	311.57	307.24	320.78	313.20
Mean	312.64	307.85	322.82	314.43

Factors	T	D	T × D
S. Em ±	0.428	0.605	1.048
CD @ 1 %	1.163	1.645	2.849

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 12b. Effect of different pre-treatments and drying methods on energy in dried coriander leaves

Parameters	Energy (k calories/ 100g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	343.44	343.56	350.03	345.68
D_2	344.52	345.09	351.60	347.07
D_3	346.23	345.31	353.36	348.30
D_4	345.23	344.91	351.95	347.36
D_5	345.12	344.68	352.65	347.48
D_6	343.71	344.23	352.55	346.83
Mean	344.71	344.63	352.02	347.12

Factors	T	D	T × D
S. Em ±	0.131	0.185	0.320
CD @ 1 %	0.355	0.502	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 13a. Effect of different pre-treatments and drying methods on total chlorophyll content in dried drumstick leaves

Parameters	Total chlorophyll (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	22.00	22.23	23.63	22.62
D_2	23.93	22.46	25.01	23.80
D_3	25.55	23.75	25.94	25.08
D_4	24.98	23.29	25.26	24.51
D_5	25.17	23.61	25.49	24.76
D_6	25.24	23.69	25.79	24.91
Mean	24.48	23.17	25.19	24.28

Factors	T	D	T × D
S. Em ±	0.0451	0.064	0.111
CD @ 1 %	0.123	0.174	0.301

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

retention (25.08 mg/100 g) which was at par with D_6 (24.91 mg/100 g) and minimum chlorophyll was observed in D_1 leaves (22.62 mg/100 g). Among interaction, chemical treated and microwave oven dried (T_3D_3) leaves had more chlorophyll (25.94 mg/100 g) which was at par with chemical treated and vacuum dried (T_3D_6) leaves (25.79 mg/100 g). Minimum chlorophyll content was found in untreated and sun dried (T_1D_1) leaves (22.00 mg/100 g) and which was at par with T_2D_1 (22.23 mg/100 g).

Chlorophyll content of dried coriander leaves was influenced by pre-treatments, drying methods and their interaction (Table 13b). Maximum retention of chlorophyll was observed in chemical treated (T_3) leaves (7.20 mg/100 g) followed by untreated (T_1) leaves (6.99 mg/100 g). Minimum chlorophyll was observed in blanched (T_2) leaves (6.62 mg/100 g). Among drying methods, microwave oven dried (D_3) leaves had more retention of chlorophyll, (7.16 mg/100 g) which is at par with vacuum dried leaves (7.12 mg/100 g) and D_5 (7.07 mg/100 g). Minimum chlorophyll was found in sun dried (D_1) leaves (6.46 mg/100 g). Among different combinations, chemical treated and microwave oven dried (T_3D_3) leaves were found superior in chlorophyll retention (7.41 mg/100 g) which was at par with T_3D_6 (7.37 mg/100 g), T_1D_3 (7.30 mg/100 g), T_1D_6 (7.21 mg/100 g) and T_1D_5 (7.19 mg/100 g). Minimum chlorophyll content was observed in untreated and sun dried (T_1D_1) leaves (6.28 mg/100 g) which is at par with T_2D_1 (6.35 mg/100 g).

4.1.14 Total carotenoids (mg/100 g)

Total carotenoids of dried drumstick leaves were significantly influenced by pre-treatments, drying methods (Table 14a) and interaction was non-significant. Higher carotenoids were found in chemical treated (T_3) leaves (27.19 mg/100 g) followed by untreated (T_1) leaves (25.52 mg/100 g). Minimum carotenoid was found in blanched (T_2) leaves (25.15 mg/100 g). Maximum carotenoid per cent was observed in microwave oven dried leaves (D_3) (26.57 mg/100 g) which is at par with vacuum dried leaves (26.50 mg/100 g). Sun drying reduced the carotenoids in drumstick leaves (24.87 mg/100 g).

Pre-treatments, drying methods and their interaction significantly influenced the total carotenoid retention in coriander leaves as observed in Table 14b. Maximum carotenoids retention was observed in chemical treated (T_3) leaves (13.51 mg/100 g) followed by untreated (T_1) leaves (12.59 mg/100 g). Minimum carotenoids were observed in blanched (T_2) leaves (12.28 mg/100 g). In drying methods, microwave oven dried (D_3) leaves retained maximum

Table 13b. Effect of different pre-treatments and drying methods on total chlorophyll content in dried coriander leaves

Parameters	Total chlorophyll (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	6.28	6.35	6.75	6.46
D_2	6.84	6.42	7.14	6.80
D_3	7.30	6.78	7.41	7.16
D_4	7.14	6.65	7.22	7.00
D_5	7.19	6.74	7.28	7.07
D_6	7.21	6.77	7.37	7.12
Mean	6.99	6.62	7.20	6.94

Factors	T	D	T × D
S. Em ±	0.0331	0.047	0.081
CD @ 1 %	0.090	0.127	0.220

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 14a. Effect of different pre-treatments and drying methods on total carotenoid content in dried drumstick leaves

Parameters	Total carotenoid (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	24.60	23.80	26.20	24.87
D_2	25.60	24.80	27.30	25.90
D_3	25.90	25.90	27.90	26.57
D_4	25.50	24.90	27.21	25.87
D_5	25.60	25.60	26.80	26.00
D_6	25.90	25.90	27.71	26.50
Mean	25.52	25.15	27.19	25.95

Factors	T	D	T × D
S. Em ±	0.1239	0.175	0.303
CD @ 1 %	0.337	0.476	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 14b. Effect of different pre-treatments and drying methods on total carotenoid content in dried coriander leaves

Parameters	Total carotenoid (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	12.13	11.74	12.93	12.27
D_2	12.63	12.23	13.47	12.78
D_3	12.78	12.78	13.76	13.11
D_4	12.58	12.28	13.44	12.77
D_5	12.65	12.31	13.71	12.89
D_6	12.78	12.32	13.75	12.95
Mean	12.59	12.28	13.51	12.8

Factors	T	D	T × D
S. Em ±	0.0354	0.050	0.087
CD @ 1 %	0.096	0.136	0.236

Note: **Note:** T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying carotenoids content (13.11 mg/100g) which is at par with vacuum dried (D_6) leaves (12.95 mg/100g). Sun drying (D_1) reduced the carotenoids content (12.27 mg/g) followed by D_4 (12.77 mg/100g). Among different combinations, chemical treated and microwave oven dried (T_3D_3) leaves had maximum carotenoids (13.76 mg/100g) which is at par with T_3D_6 (13.75 mg/100g) and T_3D_5 (13.71 mg/100g). Blanching and sun drying (T_2D_1) significantly reduced chlorophyll (11.74 mg/100g).

4.1.15 Ascorbic acid (mg/100g)

In dehydration of drumstick leaves, pre-treatments, drying methods and their interaction significantly influenced the ascorbic acid content which is tabulated in table 15a. Chemical treated (T_3) found significantly superior for ascorbic acid retention (97.14 mg/100g) followed by untreated (T_1) leaves (85.57 mg/100g). Minimum ascorbic acid was retained in blanched (T_2) leaves (70.09 mg/100g). Maximum ascorbic acid content was observed in microwave oven dried (D_3) leaves (96.23 mg/100g) which is at par with vacuum dried (D_6) leaves (94.18 mg/100g) and cabinet dried (D_4) leaves (94.11 mg/100g). Minimum ascorbic acid was found in sun dried (D_2) leaves (63.77 mg/100g). In combinations, chemical treatment followed by microwave oven drying (T_3D_3) had retained maximum ascorbic acid content (111.23 mg/100g). Chemical treated and cabinet dried (T_3D_4) leaves (110.69 mg/100g) were almost similar to T_3D_3. Minimum ascorbic acid was found in blanched and sun dried (T_2D_1) leaves (59.24 mg/100g).

Ascorbic acid content significantly varied with pre-treatments, drying method and their interaction during dehydration of coriander leaves which was noted in Table 15b. Maximum ascorbic acid was content found in chemical treated (T_3) leaves (70.82 mg/100g) followed by untreated (T_1) leaves (59.11 mg/100g). Minimum was found in blanched (T_2) leaves (53.28 mg/100g). Among drying methods, microwave oven dried (62.53 mg/100g) leaves were found to have more ascorbic acid content which is at par with vacuum dried leaves (61.54 mg/100g) and D_5 (61.52 mg/100g). Among interactions, chemical treated and microwave oven dried leaves retained maximum ascorbic acid (71.23 mg/100g) content which is at par with T_3D_6 (71.15 mg/100g), T_3D_5 (71.13 mg/100g), T_3D_4 (71.12 mg/100g), T_3D_1 (70.15) and T_3D_2 (70.14).

Table 15a. Effect of different pre-treatments and drying methods on ascorbic acid content in dried drumstick leaves

Parameters	Ascorbic acid (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	61.51	59.24	70.56	63.77
D_2	64.26	60.25	79.84	68.12
D_3	99.81	77.64	111.23	96.23
D_4	96.32	75.32	110.69	94.11
D_5	95.24	72.48	99.89	89.20
D_6	96.28	75.63	110.64	94.18
Mean	85.57	70.09	97.14	84.27

Factors	T	D	T × D
S. Em ±	0.0573	0.081	0.140
CD @ 1 %	0.156	0.220	0.382

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 15b. Effect of different pre-treatments and drying methods on ascorbic acid content in dried coriander leaves

Parameters	Ascorbic acid (mg/100 g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	57.25	52.50	70.15	59.97
D_2	56.43	52.49	70.14	59.69
D_3	62.63	53.73	71.23	62.53
D_4	58.77	53.64	71.12	61.18
D_5	59.77	53.66	71.13	61.52
D_6	59.80	53.67	71.15	61.54
Mean	59.11	53.28	70.82	61.07

Factors	T	D	T × D
S. Em ±	0.3638	0.515	0.891
CD @ 1 %	0.989	1.399	2.424

Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with 0.5 % sodium meta bisulphite, T_3-chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2-Shade drying, D_3- Microwave oven drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum drying

4.1.16 Calcium (mg/100g)

Calcium content of dried drumstick leaves varied significantly with pre-treatments, drying methods and their interaction. Chemical treated (T_3) leaves had maximum calcium content (187.39 mg/100g) followed by blanched (T_2) leaves (186.62 mg/100g). Minimum calcium content was found in untreated (T_1) leaves (185.07 mg/100g). Among drying methods, shade dried (D_2) leaves had maximum calcium (186.85 mg/100g) content which is at par with D_3 (186.7 mg/100g) and D_1 (186.64 mg/100g). Minimum calcium content was found in tray dried (D_5) leaves (185.71 mg/100g). In combination, maximum calcium was found in chemical treated and shade dried (T_3D_2) leaves (187.83 mg/100g) which is at par with T_3D_6 (187.80 mg/100g), T_3D_1 (187.50 mg/100g) and T_3D_4 (186.86 mg/100g). Minimum calcium content was found in untreated and tray dried (T_1D_5) leaves (183.49 mg/100g) and which was at par with T_1D_4 (183.83 mg/100g) (Table 16a).

In coriander dehydration, significant variation was observed by pre-treatments, drying methods and their interaction (Table 16b). Chemical pre-treatment was found efficient for calcium content retention (T_3) (2.18 mg/100g) followed by blanching (2.15 mg/100g). Minimum calcium content was found in untreated (T_1) leaves (2.11 mg/100g). Among drying methods, microwave oven was found superior (2.17 mg/100g) which is at par with D_6 leaves (2.16 mg/100g), D_5 (2.15 mg/100g), D_2 and D_4 (2.14 mg/100g). Sun drying (D_1) significantly decreased calcium content during dehydration of coriander leaves (2.11 mg/100g). In combination, maximum calcium content was found in chemical treated and microwave oven dried (T_3D_3) leaves (2.20 mg/100g) which is at par with chemical treated and vacuum dried (T_3D_6) leaves (2.19 mg/100g), T_3D_2 and T_3D_5 (2.18 mg/100g), T_3D_1 (2.17 mg/100g), T_2D_2, T_2D_3, T_2D_6, T_3D_4 (2.16 mg/100g), T_2D_5 (2.15 mg/100g), T_1D_3, T_1D_6 (2.14 mg/100g), T_2D_1, T_1D_4 (2.13 mg/100g) and T_1D_5 (2.12 mg/100g). Minimum mean calcium content was found in untreated and sun dried leaves T_1D_1 (2.03 mg/100g) and it is at par with T_1D_2 (2.09 mg/100g).

4.1.17 Colour values

4.1.17.1 L* (Lightness / Darkness)

L* values says lightness or darkness of dried drumstick leaves. Table 17a showed that the sodium bicarbonate and potassium metabisulphite treated leaves showed more lightness

Table 16a. Effect of different pre-treatments and drying methods on calcium content in dried drumstick leaves

Parameters	Calcium content (mg/100g)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	185.86	186.57	187.50	186.64
D_2	186.67	186.06	187.83	186.85
D_3	185.99	186.85	187.47	186.77
D_4	183.83	186.73	186.86	185.81
D_5	183.49	186.80	186.85	185.71
D_6	184.60	186.72	187.80	186.37
Mean	185.07	186.62	187.39	186.36

Factors	T	D	T × D
S. Em ±	0.0818	0.116	0.200
CD @ 1 %	0.223	0.315	0.545

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 16b. Effect of different pre-treatments and drying methods on calcium content in dried coriander leaves

Parameters	Calcium content			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	2.03	2.13	2.17	2.11
D_2	2.09	2.16	2.18	2.14
D_3	2.14	2.16	2.20	2.17
D_4	2.13	2.14	2.16	2.14
D_5	2.12	2.15	2.18	2.15
D_6	2.14	2.16	2.19	2.16
Mean	2.11	2.15	2.18	2.15

Factors	T	D	T × D
S. Em ±	0.012	0.02	0.03
CD @ 1 %	0.03	0.05	0.08

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 17a. Effect of different pre-treatments and drying methods on lightness/darkness (L*) of dried drumstick leaves

Parameters	Lightness/darkness (L*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	50.87	45.35	51.38	49.20
D_2	49.30	45.13	51.17	48.53
D_3	51.78	45.56	52.94	50.09
D_4	51.35	45.55	52.18	49.69
D_5	51.4	45.52	52.16	49.69
D_6	51.43	45.56	52.75	49.91
Mean	51.02	45.45	52.10	49.52

Factors	T	D	T × D
S. Em ±	0.03	0.04	0.07
CD @ 1 %	0.08	0.11	0.20

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

followed by untreated leaves. Lightness significantly varied with pre-treatment and drying methods and their interaction. Chemical treated (T_3) leaves were more light (52.10) followed by T_1 (51.02) and T_2 found dull light / darker (45.45). With respect to drying methods, D_3 was found more light (50.09) which was at par with D_6 (49.91). Minimum lightness was observed in D_2 (48.53). In combinations, T_3D_3 had more lightness (52.94) and which was at par with T_3D_6 (52.75). Minimum lightness was found in T_2D_2 (45.13) followed by T_2D_1 (45.35).

Table 17b showed L* values which indicated lightness or darkness of dried coriander leaves. Sodium bicarbonate and potassium metabisulphite treated leaves showed more lightness followed by untreated leaves. Lightness significantly varied with pre-treatment and drying methods and their interaction. More lightness was observed in T_3 (53.20) followed by T_1 (51.57). Minimum lightness was observed in T_2 (46.06). With respect to drying methods, D_3 was found more light (51.17) followed by D_6 (50.70). Minimum lightness was observed in D_2 (49.29). In combinations, T_3D_3 had more lightness (53.91) followed by T_3D_6 (53.55) and minimum lightness was found in T_2D_2 (44.33).

4.1.17.2 a* (Redness / Greenness)

a* shows redness or greenness of dried drumstick leaves. Table 18a showed significantly maximum greenness in T_3 (-3.17) followed by T_1 (-0.46). Minimum greenness was observed in T_2 (-0.41). Among drying methods, microwave oven drying retained more greenness in D_3 (-1.56) followed by D_4 (-1.42). Minimum greenness was observed in D_1 (-1.17). Among different combinations of pre-treatment and drying methods, T_3D_3 and T_3D_4 had more greenness (-3.26) and which was at par with T_3D_6 (-3.25). Minimum greenness was observed in T_1D_1 (-0.17).

In coriander also T_3 was more green (-1.26) followed by T_1 (-0.36). Minimum greenness was observed in T_2 (-0.27) as tabulated in Table 18b. In drying methods, significantly higher greenness was observed in D_3 (-1.26) followed by D_5 (-0.84). Minimum greenness was observed in D_1 (-0.27). In combination, T_3D_3 had more greenness (-3.08), which is at par with T_3D_5 (-1.08). Minimum greenness was observed in T_1D_1 and T_1D_2 (-0.04).

4.1.17.3 b* (Yellowness/ Blueness)

b* values represents the blue–yellow opponents, with negative numbers toward blue and positive toward yellow color of dried drumstick leaves which are tabulated in Table 19a.

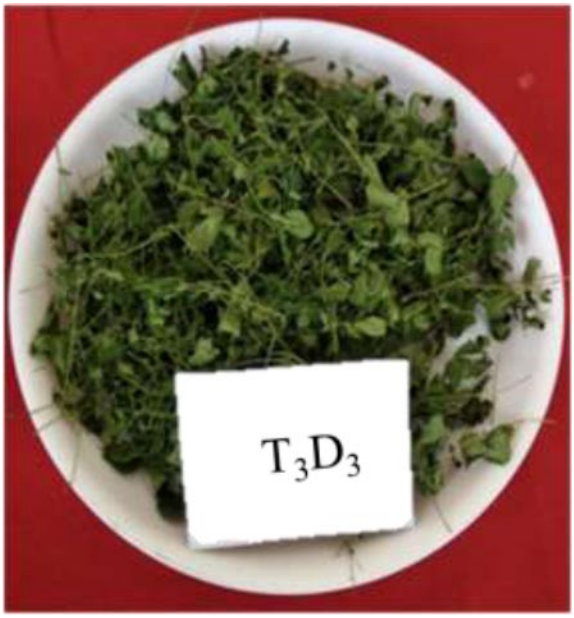


Plate 2. Effect of pre-treatments on microwave oven dried drumstick leaves

a. T_1D_3 : Untreated microwave oven dried leaves

b. T_2D_3 : Blanched with 0.5 % sodium metabisulphite and microwave oven dried leaves

c. T_3D_3: Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) and microwave oven dried leaves

Plate 3: Effects of pre-treatments on microwave oven dried coriander leaves

d. T_1D_3 : Untreated microwave oven dried leaves

e. T_2D_3 : Blanched with 0.5 % sodium metabisulphite and microwave oven dried leaves

f. T_3D_3: Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) and microwave oven dried leaves

Table 17b. Effects of pre-treatments and drying methods on lightness/darkness (L*) of dried coriander leaves

Parameters	Lightness/darkness (L*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	51.38	45.13	52.65	49.72
D_2	51.18	44.33	52.35	49.29
D_3	52.59	47.02	53.91	51.17
D_4	51.42	46.51	53.49	50.47
D_5	51.25	46.40	53.23	50.29
D_6	51.61	46.94	53.55	50.70
Mean	51.57	46.06	53.20	50.27

Factors	T	D	T × D
S. Em ±	0.03	0.05	0.08
CD @ 1 %	0.09	0.13	0.22

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 18a. Effect of different pre-treatments and drying methods on redness/greeness (a*) of dried drumstick leaves

Parameters	Redness/greeness (a*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	-0.17	-0.26	-3.07	-1.17
D_2	-0.43	-0.20	-3.02	-1.22
D_3	-0.58	-0.84	-3.26	-1.56
D_4	-0.52	-0.57	-3.18	-1.42
D_5	-0.53	-0.26	-3.26	-1.35
D_6	-0.52	-0.34	-3.25	-1.37
Mean	-0.46	-0.41	-3.17	-1.35

Factors	T	D	T × D
S. Em ±	0.01	0.01	0.02
CD @ 1 %	0.02	0.03	0.06

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 18b. Effects of different pre-treatments and drying methods on redness/greeness (a*) of dried coriander leaves

Parameters	Redness/greeness (a*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	-0.04	-0.05	-0.72	-0.27
D_2	-0.04	-0.32	-1.04	-0.47
D_3	-0.47	-0.22	-3.08	-1.26
D_4	-0.43	-0.08	-0.58	-0.36
D_5	-0.68	-0.75	-1.08	-0.84
D_6	-0.48	-0.22	-1.03	-0.58
Mean	-0.36	-0.27	-1.26	-0.63

Factors	T	D	T × D
S. Em ±	0.003	0.004	0.01
CD @ 1 %	0.01	0.01	0.02

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 19a. Effect of different pre-treatments and drying methods on yellowness/blueness (b*) of dried drumstick leaves

Parameters	Yellowness/blueness (b*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	3.15	3.24	4.19	3.53
D_2	3.17	3.26	4.04	3.49
D_3	3.12	3.13	4.11	3.45
D_4	3.17	3.15	4.12	3.48
D_5	3.19	3.14	4.42	3.58
D_6	3.16	3.11	4.11	3.46
Mean	3.16	3.17	4.19	3.50

Factors	T	D	T × D
S. Em ±	0.02	0.02	0.04
CD @ 1 %	0.05	0.06	0.11

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

In chemical treated leaves (T_3), blueness were significantly higher (4.19) followed by T_2 (3.17). Minimum blueness was observed in T_1 (3.16). Among drying methods, more blueness was found in tray dried D_5 (3.58), which is at par with sun dried (3.53). Minimum was in D_3 (3.45). In combination, T_3D_5 leaves had more yellow (4.42) and minimum yellowness was found in T_2D_6 (3.11) and which was at par with T_2D_3 (3.13), T_1D_3 (3.12), T_2D_5 (3.14), T_1D_1 and T_2D_4 (3.15), T_1D_2 and T_1D_4 (3.17), T_1D_6 (3.16) and T_1D_5 (3.19) (Table 19a).

b* values indicates yellowness or blueness of dried coriander leaves as shown in the Table 19b. T_3 (5.83) had significantly more blue followed by T_2 (4.36) and T_1 (3.64). Among drying methods, D_3 had significantly more blue (5.26) followed by D_4 (4.80). Minimum blueness was found in D_1 (4.14). In combinations, T_3D_3 had significantly maximum blue (6.72) followed by T_3D_4 and T_3D_5 (5.98) and T_1D_1 had significantly reduced blueness (3.14) (Table 19b).

4.2 Effect of pre-treatment and drying methods on sensory quality of dehydrated drumstick and coriander leaves

Sensory evaluation was done by jury team containing ten members. Score given according to hedonic scale, depend on their feel and perception. Table 20a and 20b showed sensory evaluation of dried drumstick and coriander leaves respectively.

4.2.1 Appearance

Sensory qualities of dried drumstick leaves were significantly influenced by pre-treatments, drying methods and their interaction of pre-treatment and drying methods (Table 20a). T_3 was better (8.17) in appearance followed by $T_{1,}$ (6.67). T_2 (4.78) was disliked slightly. Among drying methods, D_3 was liked moderately (7.67) which is at par with D_6 (7.45). D_2 scored minimum (5.45) which means neither liked nor disliked. Among interactions, T_3D_3 scored maximum (9.00) which means it was liked extremely and which is at par with T_1D_6 (8.67). Minimum rating was scored by T_2D_1 (3.67) and T_2D_2 (2.67) which means disliked moderately.

Sensory qualities were significantly influenced by pre-treatments, drying methods and their interaction between pre-treatment and drying methods (Table 20b). T_3 was liked very much (7.89) in appearance followed by T_1 liked moderately (7.22). T_2 scored less (3.50). Among drying methods, D_3 was liked moderately (7.00) followed by D_6 (6.89). D_1 and D_2 scored minimum (5.66) means neither liked nor disliked. Among interactions, T_3D_3 scored

Table 19b. Effects of different pre-treatments and drying methods on yellowness/ blueness (b*) of dried coriander leaves

Parameters	Yellowness/blueness (b*)			
Pre-treatments / Drying methods	T_1	T_2	T_3	Mean
D_1	3.14	4.10	5.17	4.14
D_2	3.28	4.05	5.20	4.18
D_3	4.25	4.82	6.72	5.26
D_4	4.19	4.28	5.92	4.80
D_5	3.42	4.42	5.98	4.61
D_6	3.58	4.46	5.98	4.67
Mean	3.64	4.36	5.83	4.61

Factors	T	D	T × D
S. Em ±	0.012	0.018	0.03
CD @ 1 %	0.03	0.05	0.08

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 20a. Effect of different pre-treatment and drying methods on sensory quality of dried drumstick leaves

Parameter	Appearance				Taste				Flavour				Acceptability			
Pre-treatment / Drying method	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
D_1	5.67	3.67	8.00	5.78	6.33	4.67	8.33	6.44	6.67	4.33	8.00	6.33	5.67	5.33	8.33	6. 44
D_2	5.67	2.67	8.00	5.45	6.33	3.33	8.33	6.00	6.00	4.00	7.67	5.89	5.00	5.33	8.33	6.22
D_3	6.67	7.33	9.00	7.67	7.33	7.67	9.00	8.00	7.00	6.67	9.00	7.56	7.00	7.00	9.00	7. 67
D_4	6.67	4.67	8.00	6.45	7.33	5.33	8.00	6.89	7.33	4.67	8.00	6.67	6.67	6.00	8.33	7.00
D_5	6.67	4.67	8.00	6.45	7.33	5.33	8.00	6.89	6.33	5.00	8.00	6.44	6.67	6.00	8.33	7.00
D_6	8.67	5.67	8.00	7.45	8.67	6.33	8.00	7.67	7.00	5.67	9.00	7.22	7.00	6.67	9.00	7.56
Mean	6.67	4.78	8.17	6.54	7.22	5.44	8.28	6.98	7.00	5.00	8.00	6.67	6.34	6.06	8.55	6.98
Factors		T	D	T×D	T	D	T×D		T	D	T×D		T	D	T×D	
S. Em ±		0.11	0.16	0.27	0.14	0.20	0.35		0.09	0.13	0.22		0.10	0.14	0.25	
CD @ 1%		0.30	0.43	0.74	0.39	0.55	0.96		0.25	0.35	0.60		0.28	0.39	0.68	

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

Table 20b. Effect of different pre-treatment and drying methods on sensory quality of dried coriander leaves

Parameter	Appearance				Taste				Flavour				Acceptability			
Pre-treatment / Drying method	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
D_1	6.33	3.33	7.33	5.66	5.67	4.00	8.33	6.00	6.00	3.67	8.00	5. 89	5.40	4.67	8.33	6.13
D_2	6.33	3.33	7.33	5.66	6.00	3.00	8.33	5.78	6.00	3.67	7.33	5.67	4.53	4.23	8.00	5.59
D_3	7.33	4.67	9.00	7.00	8.33	7.33	9.00	8.22	7.27	5.33	9.00	7.20	7.00	7.00	9.00	7.67
D_4	7.33	3.00	7.67	6.00	6.67	4.67	8.33	6.56	7.00	4.67	7.67	6.45	6.00	5.67	8.33	6.67
D_5	7.33	2.67	8.00	6.00	6.67	4.67	8.33	6.56	6.33	4.67	7.67	6.22	6.00	6.00	8.53	6.84
D_6	8.67	4.00	8.00	6.89	6.67	6.00	8.67	7.11	7.00	5.00	9.00	7.00	6.83	6.67	8.77	7.42
Mean	7.22	3.50	7.89	6.20	7.00	5.00	8.00	6.67	7.00	5.00	8.00	6.67	5.96	5.71	8.49	6.72
Factors		T	D	T×D	T	D	T×D		T	D	T×D		T	D	T×D	
S. Em ±		0.12	0.16	0.28	0.12	0.16	0.28		0.10	0.14	0.24		0.09	0.13	0.23	
CD @ 1%		0.31	0.44	0.77	0.31	0.44	0.77		0.27	0.38	0.66		0.26	0.37	0.63	

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying

maximum (9.00) which means it was liked extremely which is at par with T_1D_6 (8.67). Minimum rating was scored by T_2D_1 and T_2D_2 (3.33) which are disliked moderately.

4.2.2 Taste

Taste was significantly influenced by pre-treatment, drying methods and their interaction. T_3 was liked very much (8.28), and had taste similar to fresh drumstick leaves followed by T_1 (7.22) which was liked moderately. T_2 leaves were neither liked nor disliked by judges (5.44). Among drying methods, D_3 was liked very much (8.00) which is at par with vacuum drying (7.67). Minimum score was given to D_2 which means liked slightly (6.00). Among interaction, more score was given to T_3D_3 (9.00) which means T_3D_3 was liked extremely followed by T_3D_4, T_3D_5, T_3D_6 (8.00). Minimum score was obtained by T_2D_2 (3.33) (Table 20a).

Taste of dehydrated coriander leaves were significantly influenced by pre-treatment, drying methods and their interaction (Table 20b). T_3 was like very much (8.00) which was just like fresh leaves followed by T_1 (7.00) which was liked moderately. T_2 leaves were neither liked nor disliked by judges (5.00). Among drying methods, D_3 was liked very much (8.22) followed by D_6 (7.11). Minimum score was given to D_2 (5.78) which means leaves were liked slightly. Among interaction, more score was given to T_3D_3 (9.00) which means T_3D_3 was liked extremely (9.00) and which is at par with T_3D_6 (8.67). T_2D_2 was disliked moderately (3.00).

4.2.3 Flavour

Flavour of dried drumstick leaves were significantly influenced by pre-treatments, drying methods and interaction between pre-treatment and drying methods. T_3 scored high which means T_3 was liked extremely (8.00) followed by T_1 liked very much (7.00). T_2 was liked slightly (5.00). Among drying methods, D_3 had scored more (7.56) followed by D_6 (7.22). Minimum was scored by D_2 (7.67). Among interactions, T_3D_3 and T_3D_6 had maximum score (9.00) followed by T_3D_1, T_3D_4 and T_3D_5 (8.00). T_2D_2 had scored minimum (4.00) (Table 20a).

Flavour of dried coriander leaves was significantly influenced by pre-treatments, drying methods and interaction between pre-treatment and drying methods. T_3 was liked extremely (8.00) followed by T_1 which was liked very much (7.00). T_2 scored less (5.00). Among drying methods, D_3 had scored more (7.20) followed by D_6 (7.00). Minimum score was by D_2 (5.67). Among interactions, T_3D_3 and T_3D_6 had found maximum score (9.00) followed by T_3D_1 (8.00). T_2D_1 and T_2D_2 had minimum score (3.67) (Table 20b).

4.2.4 Acceptability

Acceptability of dried drumstick leaves was significantly influenced by pre-treatments, drying methods and interaction between pre-treatment and drying methods. T_3 was liked extremely in acceptability (8.55) followed by T_1 (6.34). T_2 (6.06) were liked slightly. Among drying methods, D_3 had scored more (7. 67), which is at par with D_6 (7.56). Minimum score was by D_2 (6.22). Among interactions, T_3D_3 and T_3D_6 had found maximum score (9.00). T_2D_1 and T_2D_2 had minimum score (5.33) (Table 20a).

Acceptability of dried coriander leaves was significantly influenced by pre-treatments, drying methods and interaction between pre-treatment and drying methods. T_3 was liked extremely in acceptability (8.49) followed by T_1 (5.96). T_2 (5.71) were liked slightly. Among drying methods, D_3 had scored more (7.67), which is at par with D_6 (7.42). Minimum score was by D_2 (5.59). Among interactions T_3D_3 score maximum (9.00), which is at par with T_3D_6 (8.77). T_2D_2 had minimum score (4.23) (Table 20b).

4.3 Effect of different packaging materials on quality of dried drumstick and coriander leaves after one month of storage

4.3.1 Moisture content (%)

After one month storage, moisture content in dried drumstick leaves increased significantly. This was influenced by pre-treatments, drying methods and packaging material used for storage and their interactions (Table 21a). Maximum moisture content was observed in blanched leaves (3.17 %) followed by chemical treated leaves (2.92 %). Minimum moisture content was found in untreated leaves (2.24 %). In drying methods, shade dried leaves (2.88 %) had more moisture content followed by sun dried leaves (2.86 %). Minimum moisture content was found in microwave oven dried leaves (2.63 %). In three different packaging materials, leaves packed in LDPE (P_1) cover had more moisture content (3.87 %) followed by packed leaves in HDPE (P_2) (3.72 %). Minimum moisture content was observed in leaves packed in aluminium cover (3.50 %) which was impervious for moisture re-absorption. In interactions, interaction of pre-treatments and drying methods, drying methods and packaging material also influenced significantly. In T×D, maximum moisture content was found in T_2D_2

Table 21a. Effect of different packaging materials on moisture content in dried drumstick leaves after one month of storage

Packaging material	Drying method / Pre-treatment	D_1	D_2	D_3	D_4	D_5	D_6	Mean
P_1	T_1	3.27	3.34	2.86	3.10	3.09	3.09	3.13
	T_2	4.56	4.68	4.27	4.41	4.42	4.36	4.45
	T_3	4.20	4.15	3.71	4.09	4.06	4.07	4.05
	Mean	4.01	4.06	3.61	3.87	3.86	3.84	3.87
P_2	T_1	3.12	3.18	2.86	2.99	2.95	3.07	3.03
	T_2	4.33	4.39	4.13	4.21	4.19	4.21	4.24
	T_3	4.08	4.04	3.61	3.88	3.85	3.86	3.89
	Mean	3.85	3.87	3.54	3.69	3.66	3.71	3.72
P_3	T_1	2.87	2.89	2.66	2.75	2.72	2.84	2.79
	T_2	4.05	4.10	3.91	3.95	3.94	3.96	3.99
	T_3	3.84	3.77	3.51	3.76	3.74	3.75	3.73
	Mean	3.59	3.59	3.36	3.49	3.47	3.52	3.50
		To compare T and D						
	T_1	2.32	2.35	2.10	2.21	2.19	2.25	2.24
	T_2	3.24	3.29	3.08	3.14	3.14	3.13	3.17
	T_3	3.03	2.99	2.71	2.94	2.92	2.92	2.92
	Mean	2.86	2.88	2.63	2.76	2.75	2.77	2.77
		T	D	P	T×D	T×P	D×P	T×D×P
S. Em±		0.02	0.02	0.02	0.04	0.03	0.04	0.07
C. D 1%		0.04	0.06	0.04	0.11	0.08	0.11	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying, P (Packaging materials): P_1- LDPE (150 guage), P_2- HDPE (200 guage) and P_3-Aluminium foil

(3.29 %) followed by T_2D_1 (3.24 %) and minimum moisture content was found in T_1D_3 (2.10 %). Among T×P combinations, T_2P_1 had more moisture content (4.45 %) followed by T_2P_2 (4.24 %). Minimum moisture content was found in T_1P_3 (2.79 %). In D×P, D_2P_1 (4.06 %) had maximum moisture content followed by P_1D_1 (4.01 %). Minimum moisture content was found in P_3D_3 (3.36 %). Interaction of all three factors was found non-significant.

After one month of storage, moisture content in dried coriander leaves was increased significantly by the influence of pre-treatments, drying methods, and packaging material used for storage and their interactions (Table 21b). Maximum moisture content was observed in blanched leaves (2.38 %) followed by chemical treated leaves (1.96 %). Minimum moisture content was found in untreated leaves (1.47 %). In drying methods, shade dried leaves (2.06 %) had more moisture content followed by sun dried leaves (2.02 %). Minimum moisture content was found in microwave oven dried leaves (1.82 %). In three different packaging materials, leaves covered in LDPE (P_1) had more moisture content (2.75 %) followed by leaves packed in HDPE (P_2) (2.60 %). Minimum moisture content was observed in aluminium laminated cover (2.38 %) which had negligible moisture re-absorption. In interactions, interaction of pre-treatments and drying methods were also influenced significantly. In T×D, maximum moisture content was found in T_2D_2 (2.53 %) followed by T_2D_1 (2.44 %). Minimum moisture content was found in T_1D_3 (1.33 %). Among T×P, T_2P_1 had more moisture content (3.40 %) followed by T_2P_2 (3.19 %). Minimum moisture content was found in T_1P_3 (1.76 %). In D×P, D_2P_1 (2.96 %) had maximum moisture content followed by P_1D_1 (2.87 %) and minimum moisture content was found in P_3D_3 (2.28 %).and T×D×P were found non significant.

4.3.2 Ascorbic acid (mg/100g)

After one month storage, ascorbic acid content in dried drumstick leaves decreased significantly by the influence of pre-treatments, drying methods, and packaging material used for storage and their interactions (Table 22a). Maximum ascorbic acid was observed in chemical treated leaves (37.92 mg/100g) followed by untreated leaves (35.76 mg/100g). Minimum ascorbic acid was found in blanched leaves (23.39 mg/100g). In drying methods, microwave oven dried leaves (33.24 mg/100g) had more ascorbic acid followed by vacuum dried leaves (32.93 mg/100g). Minimum ascorbic acid was found in shade dried leaves (30.67 mg/100g). In three different packaging materials, leaves covered in aluminium laminated cover had more ascorbic acid (33.37 mg/100g) followed by leaves packed in HDPE (P_2)

Table 21b. Effect of different packaging materials on moisture content in dried coriander leaves after one month of storage

Packaging materials	Drying method / Pre-treatment	D_1	D_2	D_3	D_4	D_5	D_6	Mean
P_1	T_1	2.23	2.28	1.83	2.21	2.07	1.94	2.09
	T_2	3.49	3.65	3.21	3.41	3.34	3.27	3.40
	T_3	2.90	2.95	2.55	2.81	2.73	2.70	2.77
	Mean	2.87	2.96	2.53	2.81	2.71	2.64	2.75
P_2	T_1	2.14	2.12	1.83	2.10	1.93	1.92	2.00
	T_2	3.27	3.37	3.08	3.20	3.10	3.11	3.19
	T_3	2.79	2.84	2.45	2.60	2.52	2.49	2.61
	Mean	2.73	2.77	2.45	2.63	2.52	2.50	2.60
P_3	T_1	1.89	1.82	1.64	1.86	1.70	1.69	1.76
	T_2	2.99	3.08	2.86	2.95	2.86	2.87	2.94
	T_3	2.55	2.57	2.35	2.48	2.41	2.38	2.45
	Mean	2.48	2.49	2.28	2.43	2.32	2.31	2.38
		To compare T and D						
	T_1	1.56	1.55	1.33	1.54	1.42	1.39	1.47
	T_2	2.44	2.53	2.29	2.39	2.33	2.31	2.38
	T_3	2.06	2.09	1.84	1.97	1.91	1.89	1.96
	Mean	2.02	2.06	1.82	1.97	1.89	1.86	1.94
		T	**D**	**P**	**T×D**	**T×P**	**D×P**	**T×D×P**
S. Em±		0.01	0.02	0.01	0.03	0.02	0.03	0.05
C. D 1%		0.03	0.04	0.03	0.08	0.05	NS	NS

Note: T (Pre-treatment): T_1- Untreated leaves, T_2- Blanched with 0.5 % sodium meta bisulphite, T_3- Chemical treated with 0.1% magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying, P (Packaging materials): P_1- LDPE (150 guage), P_2- HDPE (200 guage) and P_3-Aluminium foil

Table 22a. Effect of different packaging materials on ascorbic content in dried drumstick leaves after one month of storage

Packaging materials	Drying method / Pre-treatment	D_1	D_2	D_3	D_4	D_5	D_6	Mean
P_1	T_1	35.15	30.67	36.99	35.99	35.75	36.42	35.16
	T_2	22.64	21.98	22.92	22.43	22.49	22.71	22.53
	T_3	37.11	36.77	37.26	37.16	37.17	37.11	37.1
	Mean	31.63	29.81	32.39	31.86	31.81	32.08	31.6
P_2	T_1	36.14	31.46	37.74	36.74	36.5	37.17	35.96
	T_2	23.48	22.83	23.76	23.28	23.34	23.55	23.37
	T_3	37.86	37.52	38.01	37.91	37.92	37.86	37.84
	Mean	32.49	30.6	33.17	32.64	32.58	32.86	32.39
P_3	T_1	36.9	32.45	38.73	37.74	37.5	38.16	36.91
	T_2	24.47	23.83	24.75	24.27	24.33	24.54	24.37
	T_3	38.85	38.51	39	38.9	38.91	38.85	38.84
	Mean	33.41	31.6	34.16	33.64	33.58	33.85	33.37
		To compare T and D						
	T_1	36.06	31.53	37.82	36.82	36.58	37.25	35.76
	T_2	23.53	22.88	23.81	23.33	23.39	23.60	23.39
	T_3	37.94	37.60	38.09	37.99	38.00	37.94	37.92
	Mean	32.51	30.67	33.24	32.71	32.66	32.93	32.36
		T	**D**	**P**	**T×D**	**T×P**	**D×P**	**T×D×P**
S. Em±		8.66	12.25	8.66	21.22	15	21.22	36.75
C. D 1%		22.66	32.05	22.66	NS	NS	NS	NS

Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with 0.5 % sodium meta bisulphite, T_3- Chemical treated with 1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$), D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4- Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying, P (Packaging materials): P_1- LDPE (150 guage), P_2- HDPE (200 guage) and P_3- Aluminium foil

Table 22b. Effect of different packaging materials on ascorbic acid content in dried coriander leaves after one month of storage

Packaging materials	Drying method / Pre-treatment	D_1	D_2	D_3	D_4	D_5	D_6	Mean
P_1	T_1	21.95	21.8	33.00	32.7	31.38	32.53	28.89
	T_2	20.32	18.86	21.08	20.75	20.74	20.11	20.31
	T_3	36.14	35.94	36.59	36.42	36.15	36.13	36.23
	Mean	26.14	25.53	30.22	29.96	29.42	29.59	28.48
P_2	T_1	22.95	22.65	33.77	33.47	32.17	33.3	29.72
	T_2	21.17	19.73	21.93	21.6	21.59	20.97	21.17
	T_3	36.89	36.69	37.34	37.17	36.9	36.88	36.98
	Mean	27.01	26.36	31.01	30.75	30.22	30.38	29.29
P_3	T_1	23.8	23.65	34.77	34.47	33.16	34.3	30.69
	T_2	22.17	20.73	22.93	22.6	22.59	21.96	22.16
	T_3	37.89	37.69	38.33	38.16	37.9	37.88	37.97
	Mean	27.95	27.35	32.01	31.74	31.22	31.38	30.28
		To compare T and D						
	T_1	22.9	22.7	33.85	33.55	32.24	33.38	29.05
	T_2	21.22	19.77	21.98	21.65	21.64	21.01	21.25
	T_3	36.97	36.77	37.42	37.25	36.98	36.96	37.08
	Mean	27.03	26.41	31.08	30.82	30.29	30.45	29.13
		T	**D**	**P**	**T×D**	**T×P**	**D×P**	**T×D×P**
S. Em±		7.81	11.04	7.81	19.12	13.52	19.12	33.12
C. D 1%		20.43	28.89	20.43	NS	NS	NS	NS

Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with 0.5 % sodium meta bisulphite, T_3- Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$). D (drying methods): D_1- Sun drying, D_2- Shade drying, D_3- Microwave oven drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum oven drying. P (Packaging materials): P_1- LDPE (150 guage), P_2- HDPE (200 guage) and P_3-Aluminium foil

(32.39 mg/100g). Minimum ascorbic acid was observed in leaves packed in LDPE (P_1) (31.60). In interactions, interaction between pre-treatments and drying methods also influenced significantly. T×D, T×P and D×P and T×D×P were found non significant.

One month after storage, ascorbic acid content in dried coriander leaves increased significantly by the influence of pre-treatments, drying methods, and packaging material used for storage and their interactions (Table 22b). Maximum ascorbic acid was observed in chemical treated leaves (37.08 mg/100g) followed by untreated leaves (29.05 mg/100g). Minimum ascorbic acid content was found in blanched leaves (21.25 mg/100g). In drying methods, microwave oven dried leaves (31.08 mg/100g) had more ascorbic acid followed by vacuum dried leaves (30.45 mg/100g). Minimum ascorbic acid content was found in shade dried leaves (26.41 mg/100g). In three different packaging materials, leaves covered in aluminium laminated cover had more ascorbic acid (30.28 mg/100g) followed by leaves packed in HDPE (P_2) (29.29 mg/100g). Minimum ascorbic acid was observed in leaves packed in LDPE (P_1) (28.48 mg/100g). Interaction of pre-treatments and drying methods were also influenced significantly. T×D, T×P and D×P and T×D×P were found non significant.

5. DISCUSSION

Physical, chemical and sensory characteristics of dehydrated leaves vary with pre-treatments, drying methods and weather conditions. Every proximate gets reduced by different reactions, denaturation, oxidation, leaching *etc*. Pre-treatments before drying influence the final product quality. The present study analysed the effects of pre-treatments, drying methods and packaging material on retention of physical, chemical and storage qualities of dried drumstick and coriander leaves. This research was conducted in B-tech Laboratory, Department of Food Processing and Technology and Department of Horticulture, College of Agriculture, Dharwad, and the results obtained are discussed under following headings:

5.1 Effect of pre-treatments on physical and chemical qualities of dried drumstick and coriander leaves

5.2 Effect of drying methods on physical and chemical qualities of dried drumstick and coriander leaves

5.3 Effect of pre-treatment and drying methods on sensory quality of dehydrated drumstick and coriander leaves

5.4 Effect of packaging material on storage quality of dried drumstick and coriander leaves after one month

5.1 Effect of pre-treatments on physical and chemical qualities of dehydrated drumstick and coriander leaves

5.1.1 Effect of pre-treatments on physical quality of dehydrated drumstick and coriander leaves

5.1.1.1 Drying rate (g/min)

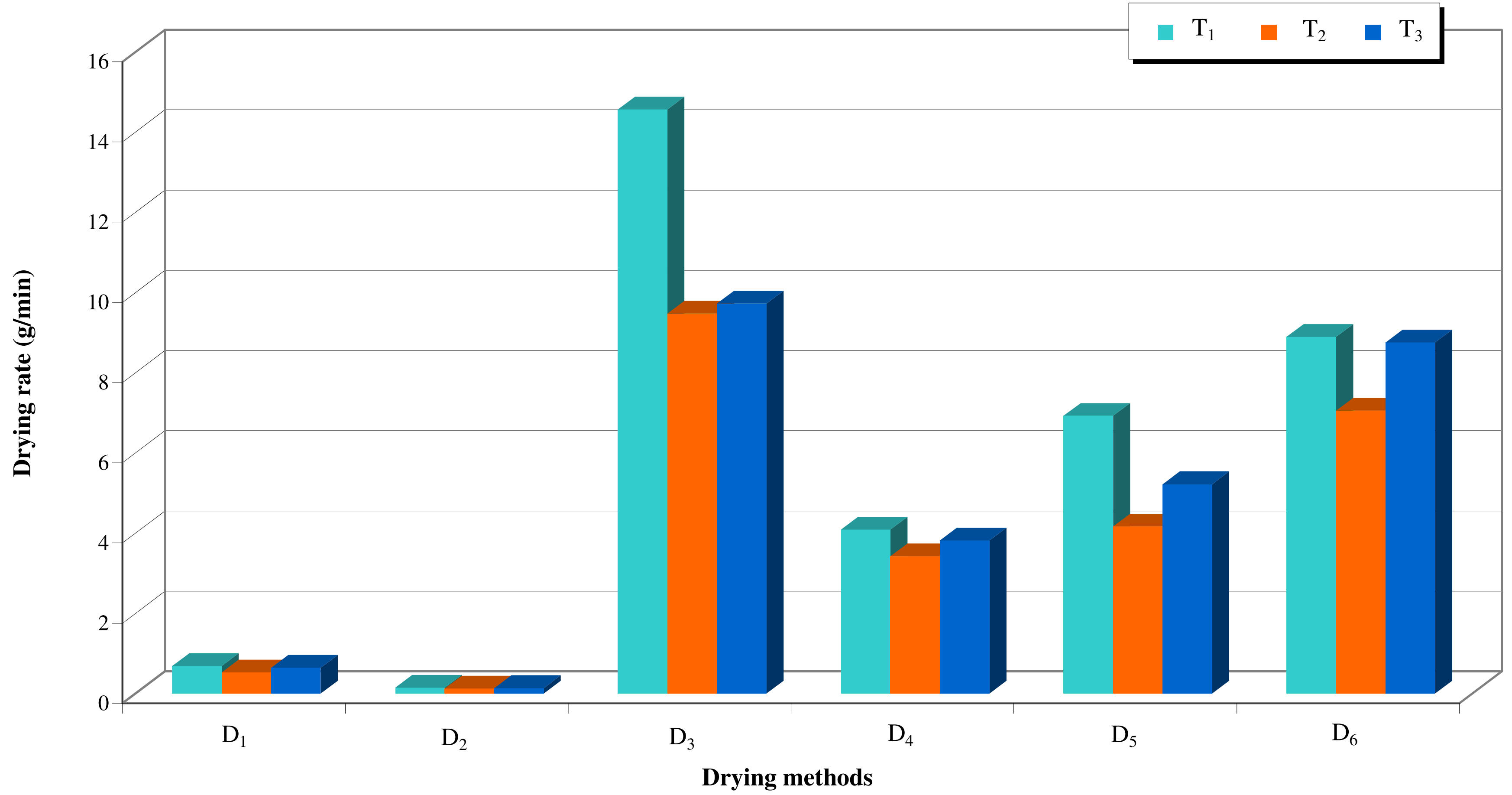
Drying rate is the rate at which internal moisture evaporates to the surroundings. Significantly higher dehydration rate was found in untreated leaves (T_1) followed by chemical treated leaves (0.1 % $MgCl_2$ + 0.1 % $NaHCO_3$ + 2 % $K_2S_2O_5$ dip) (Fig.1). Untreated leaves were just dipped and washed in normal water, so there is no much absorption of water by leaf tissues and therefore, there was quick drying. In T_3, washed leaves were dipped in chemical solution (Magnesium chloride, sodium bicarbonate and potassium metabisulphite) for 15 minutes, during this time there was time for absorption of solution and water. Hence, slow drying was observed. Very slow drying rate was observed in both drumstick and coriander blanched (T_2) leaves. Hence, blanched leaves were not attractive and acceptable to the judges. Slow drying rate may be due to imbibed soft leaf tissues. Drying rate indirectly influences the other parameters like colour of dried leaves (chlorophyll), ascorbic acid content *etc*. Moderate to quick drying influences retention of chemical composition, chlorophyll and ascorbic acid while, slow drying reduces physical, chemical and sensory quality characteristics. High drying rate in untreated and chemical treated leaves recorded high chlorophyll (Table 13a and 13b) and ascorbic acid content (Table 15a and 15b). Slow drying rate in blanched leaves resulted in decreased ascorbic acid and carotenoid contents, denatures protein (Table 8a and Table 8b) and fat (Table 9a) and degrades chlorophyll (Table 13a and Table 13b). This result are in agreement with the earlier results of Subadra *et al.* (1997) in drumstick leaves and Shaw *et al.* (2007) in coriander leaves. Contradictory results were observed by Rocha *et al*. (1993) and Ramesh *et al.* (2001). They mentioned steam blanching significantly increased the drying rate of basil and spice paprika due to higher cell wall destruction, resulting in less resistance to moisture movement during drying. Drying rate depends on the pressure gradient developed due to the difference between sample and media of drying, air temperature, leaf thickness and surface area of leaf exposed to heat.

5.1.1.2 Dehydration ratio

Dehydration ratio is the ratio of fresh leaf weight to dried leaf weight. Highest dehydration ratio was found in untreated leaves because of minimum weight at the end of drying. This was followed by chemical treated leaves where moderately high weight was observed at the end of drying. This might be due to higher dried leaf weight because of chemical imbibitions but not due to moisture retention. Hence, chemical treated leaves were found to be best for dehydration ratio. Least dehydration ratio was observed in blanched leaves indicating higher weight at the end of drying. This could be due to moisture retention even after getting constant dried weight. Similar results were observed by Ankita (2013) in spinach leaf powder and Singh *et al*. (2020) in dehydrated coriander leaves.

5.1.1.3 Rehydration ratio

Rehydration ratio is gaining original weight as that of fresh upon rehydration. It is due to hygroscopicity and water holding capacity of dried leaves. It depends on difference in



Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with sodium metabisulphite, T_3-Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), **D (drying methods):** D_1- Sun drying, D_2- Shade drying, D_3- Microwave drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum drying

Fig. 1. Effect of pre-treatments and drying methods on drying rate of coriander leaves

weight of dried leaves between before and after rehydration. Untreated leaves were more hygroscopic but were also more porous. Therefore, they didn't hold more moisture. Chemical treated leaves had least moisture and compact cells (It might be due to modification of chemical imbibed cells) which increased the water holding capacity of dried leaves. Therefore chemical treated leaves were found good for rehydration which influenced good cooking quality. Lowest rehydration ratio was observed in blanched leaves. This is nothing but reflection of high initial moisture content in dried leaves. Upon rehydration there is no much water absorption. Hence difference in initial and final weight of dried leaves was less. Similar results were observed by Bishnoi *et al.* (2020), Singh *et al*. (2020) and Porntewabancha and Siriwongwilaichat (2010) in fenugreek, coriander and lettuce leaves respectively.

5.1.1.4 Moisture (%)

Even dried leaves have moisture content. This was calculated by the ratio of weight difference in initial weight of dried material to final weight of the oven dried leaves. Blanched (T_2) leaves had higher moisture content because, blanched leaf cells are more compact and there would be hidden moisture. Untreated leaves (T_1) were found to be more porous. So while drying, complete moisture loss will be there. Hence, least moisture content was observed in untreated dried leaves. Reduction in moisture per cent simultaneously increased the storage period which prohibited the microbial growth. Similar observations were found by Ankita (2013) in spinach leaves powder. This result is in contradictory to the result reported by Pande *et al.* (2000) in coriander and methi leaves, and he stated that it was due to conspicuous anatomy and symplast movement of water.

5.1.1.5 Water activity

Water activity indicates the bound moisture available for the microbial growth and which is significantly influenced by pre-treatments of dehydrated drumstick and coriander leaves. Minimum water activity indicates the reduced microbial growth, thus, increase in the storage life of dehydrated leaves. Among different pre-treatments, minimum moisture was observed in T_1 and maximum moisture was observed in T_2. So, water activity was found to be minimum in T_1 and more in T_2. With respect to water activity, untreated leaves were found good followed by chemical treated leaves. As the moringa leaves water activity values were lower than 0.70, they are considered safe and shelf-stable to microbial growth (Rajkumar *et al.*, 2007).

5.1.1.6 Ash (%)

Ash per cent indicates the overall mineral retained in dried leaves. It is obtained by burning of organic components leaving behind the inorganic components of leaves. Pre treatments improved the mineral retention or added the extra minerals. Chemical treated (T_3), 0.1 % $MgCl_2$ + 0.1 % $NaHCO_3$ + 2 % $K_2S_2O_5$ dipped leaves had maximum ash per cent due to increased Ca, Fe and Mn content, in addition to the extra addition of $MgCl_2$ through pre-treatment. Blanched leaves with 0.5 % sodium metabisulphite treated leaves (T_2) had lesser minerals which led to loss of trace minerals as observed by Pawase *et al.* (2019) in drumstick leaves. This was proved in dehydrated coriander leaves also.

5.1.1.7 Dry matter (%)

Dry matter is the total matter content of dried drumstick and coriander leaves excluding moisture. It is indirectly related to moisture content of dried leaves. Minimum moisture indicates more dry matter per cent and more moisture content indicates less dry matter per cent. Hence, untreated leaves had less moisture indicating high dry matter content. Blanched leaves had more moisture as they had less dry matter per cent. This result confirmed the result of Pawase *et al.* 2019 in dried moringa leaf powder with the same reason.

5.1.2 Effect of pre-treatments on chemical quality of dried drumstick and coriander leaves

5.1.2.1 Protein (%)

Protein is a class of nitrogenous organic compound which has large molecules composed of one or more long chains of amino acids, which is directly proportional to nitrogen per cent in dried drumstick and coriander leaves. In blanched leaves, because of high temperature treatment, breaking of many of the weak linkages or bonds (e.*g.,* hydrogen bonds) within a protein molecule takes place which is responsible for the highly ordered structure of the protein in its natural (native) state (Anon., 2022). Maximum protein per cent was found in T_3, because, there was no heating during pre-treatment and additional treatment with $K_2S_2O_5$ and $NaHCO_3$ might be the reason for retention of protein. Blanched leaves had least protein due to protein denaturation as there was exposure of fresh leaves to heat. Hence,

T_3 was found to be the best for protein retention. Similar results were recorded by Pawase *et al.* (2019) in moringa, where increase in dry matter content led to increased protein content in leaf powder.

5.1.2.2 Fat content (%)

Fat is a major source of energy which is stable at room temperature and unstable during heating due to denaturation. So, T_2 has less fat content in comparison to T_1 and T_3, in dried drumstick leaves. Hence, T_1 and T_3 were found to be the best for fat retention. This result was consistent with the result of Kshirsagar *et al*. (2017) in dehydration of moringa leaves.

5.1.2.3 Carbohydrates (%)

Carbohydrates may be monosaccharides and oligosaccharides. In dried drumstick and coriander leaves, carbohydrates were significantly influenced by pre-treatments. Carbohydrate content has negative correlation with moisture, protein, fat and fibre content in dried leaves. Increased moisture content (Table 4a and Table 4b), protein (Table 8a and Table 8b), fat (Table 9a) and fibre content (Table 10a and Table 10b) indicate reduced carbohydrates content in per cent. Hence, blanched leaves had more carbohydrates per cent due to least fat and protein (while blanching, denaturation of protein and fat took place) and least carbohydrates per cent observed in chemical treated leaves which had maximum protein and fat. Similar results were found by Pawase *et al*. (2019) in dehydrated drumstick leaves. Carbohydrates are source of energy to day-to-day life.

5.1.2.4 Energy (kcal/100g)

Energy value is directly proportional to the summation of multiples of protein, fat and carbohydrates with their respective cofactors. Maximum energy value was observed in chemical treated leaves (T_3) because it has more protein, fat and fibre content followed by untreated leaves (T_1). Minimum energy value was in blanched leaves (T_2) because denaturation took place due to exposure to heat. Hence, protein and fat content got reduced, hereby energy value was reduced both in drumstick and coriander leaves.

5.1.2.5 Total Chlorophyll content (mg/100g)

Chlorophyll is the member of the most important class of pigments involved in photosynthesis, by which light energy is converted to chemical energy through the synthesis of organic compounds. Chlorophyll content is sensitive to heat, and degradation increases with increasing duration of drying. In chemical treated (T_3) leaves, faster drying rate along with chemical imbibitions with $NaHCO_3$ and $K_2S_2O_5$ increased the total chlorophyll retention. The treatment T_2 had minimum total chlorophyll content due to slow drying rate and high temperature, water blanching increased the degradation of total chlorophyll. In untreated leaves, faster drying rate decreased the degradation of total chlorophyll content (Fig. 2) and degradation continued along the storage. This result was similar with the result of Dhotre *et al*. (2012), in bitter gourd slices and Bishnoi *et al*. (2020), in fenugreek leaves.

5.1.2.6 Total carotenoids (mg/100g)

The treatment T_3 had more carotenoids retention and in T_2, total carotene content got reduced. During blanching, carotenoid content was oxidised. Hence, there was loss of carotenoid content. Similar loss in β-carotene content was observed by Negi and Roy (2000) and Bishnoi *et al.* (2020), in fenugreek leaves.

5.1.2.7 Ascorbic acid (mg/100g)

Ascorbic acid is water soluble and heat liable. The treatment T_3 had more ascorbic acid content followed by untreated leaves (Fig. 3). In chemical treated leaves, there was faster drying. Leaves treated with $NaHCO_3$ and $K_2S_2O_5$ retained more ascorbic acid (Table 15a and Table 15b). While blanching, due to hot water dip, ascorbic acid got leached out. Similar results were found by Gupta *et al*. (2008), Dhotre *et al*. (2012) in bitter gourd slices and Bishnoi *et al*. (2020). This result was in contradiction to Pande *et al.* (2000) and it might be due to inherent nutrient content because of better protection by sodium metabisulphite during blanching and less moisture content in the surface.

5.1.3 Colour value

5.1.3.1 L* a* b*

In dehydrated drumstick and coriander leaves, T_3 had maximum lightness (L*), blueness (b*) and greenness (a*), because of pre-treatment with $NaHCO_3$, $K_2S_2O_5$ solution and quick drying. Result of chemical pre-treatment on dried drumstick and coriander leaves can be observed in Plate 2 and Plate 3, respectively. Similar results were observed by Viresh *et al*. (2010), in dried palak. Untreated leaves (T_1) had less brightness, because direct exposure of leaf surface to heat reduces greenness gradually. Blanched leaves (T_2) had

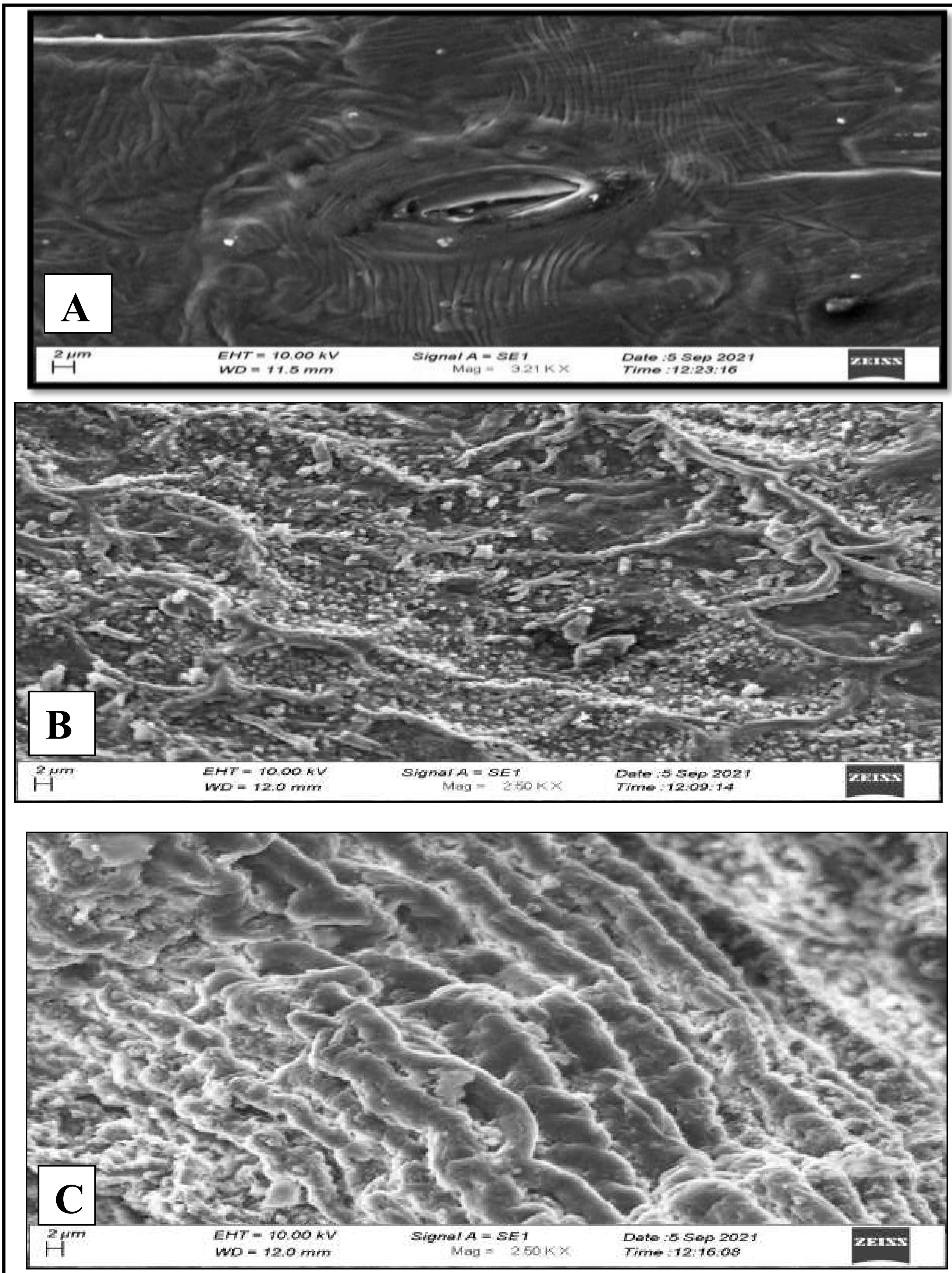


Plate 4. SEM images of microwave oven dried drumstick leaves

A. Untreated and microwave oven dried drumstick leaves
B. Blanched and microwave oven dried drumstick leaves
C. Chemical treated and microwave oven dried drumstick leaves

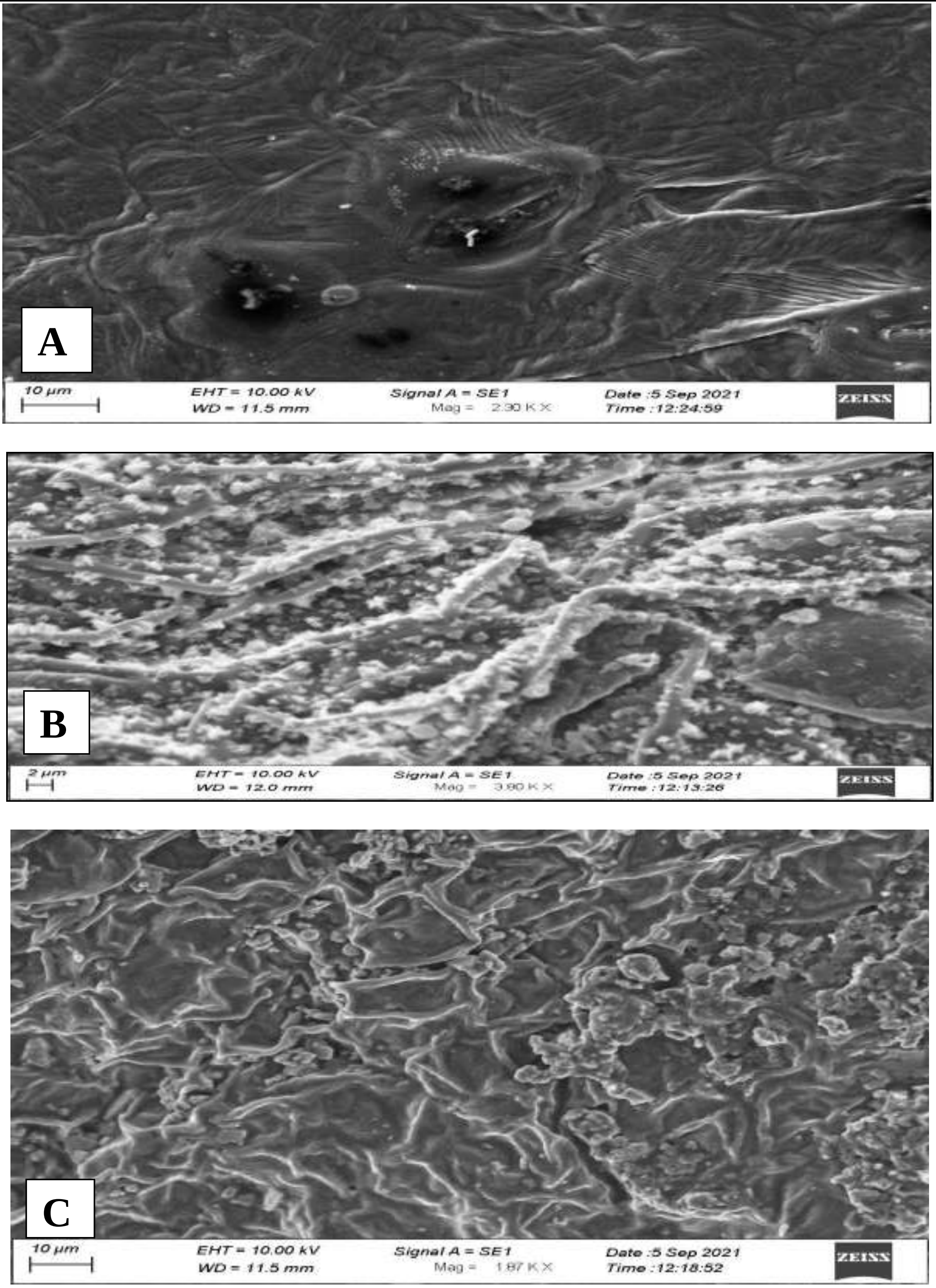


Plate 5. SEM images of microwave oven dried coriander leaves

A. Untreated and microwave oven dried coriander leaves
B. Blanched and microwave oven dried leaves
C. Chemical treated and microwave dried coriander leaves

minimum brightness and blueness, because, blanched leaves lose their texture and brightness. This kind of similar result was observed by Kidmose *et al*. (2005), in spinach leaves.

5.1.4 Colour retention of drumstick and coriander leaves on pre-treatment before dehydration

Plate 4 and 5 showed difference in the effect of pre-treatments on dried leaf tissue of drumstick and coriander leaves, respectively. Scanning electron microscope was used to observe the changes in pre-treated and microwave oven dried leaves. Pre-treated and microwave oven dried leaves were observed under 11000X magnification of scanning electron microscope. Under the same magnification, microwave oven dried leaves observed to examine the cell changes due to pre-treatments. From the above plates, picture A showed untreated leaves in which leaf cells can be observed easily, indicating that there was no imbibition of any chemical and direct exposure of the leaves to the drying media. This might be the reason for reduction of greenness or browning of untreated leaves. Picture B showed blanched leaves, because of blanching, there might be damage to cell structure and crystals might be sodium metabisulphite, hence leaves became dark. Picture C showed chemical treated leaves. It might be the uniform imbibition of 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) without damage to cells. Under 11000X magnification, cell structure was not visible, means there was no direct exposure of leaves cell to the drying media. It might be the reason for colour retention and other heat liable nutrient retention. Similar results were observed by Gorb *et al*. (2017) while analysing modification of oil drops on the leaf surface.

5.2 Effect of drying methods on physical and chemical qualities of drumstick and coriander leaves

5.2.1 Effect of drying methods on physical qualities of drumstick and coriander leaves

5.2.1.1 Drying rate (g/min)

Drying rate is nothing but amount of moisture lost from leaf per unit time. It depends on drying media, pre-treatment of drying leaves, drying temperature and moisture difference between sample and weather, time exposed for drying. Open sun drying and shade drying took days to attain equilibrium moisture where as cabinet, tray drying and vacuum drying took hours and microwave drying took minutes to attain constant minimum weight (Fig. 1).

Maximum drying rate was observed in microwave drying and minimum drying rate was observed in shade drying. In shade drying, because of low temperature, moisture content got evaporated slowly. In palak, same results were found by Viresh *et al.* (2010).

5.2.1.2 Dehydration ratio

It depends on the final weight of dried leaves. Moisture retention in dried leaves depends on moisture removal capacity of drying methods. Maximum dehydration ratio indicates less weight of dried leaves *i.e.*, more moisture and more final weight leads to less dehydration ratio. Maximum dehydration ratio was observed in microwave dried leaves (D_3). Minimum dehydration ratio was found in shade and sun dried leaves (D_2). Microwave oven drying was most preferable as it retained minimum moisture at the end of drying (Punathil and Basak, 2017).

5.2.1.3 Rehydration ratio

Rehydration ratio is the measure of ability of dried product to regain their original mass and a higher rehydration ratio is the indication of quality product. Rehydration ratio depends on the moisture retained. The leaves under D_3 had minimum moisture content, hence more rehydration ratio was recorded. The leaves dried under D_2 had maximum moisture content, hence they had less rehydration ratio. This result is similar to that of Bishnoi *et al.* (2020), in fenugreek leaves.

5.2.1.4 Moisture (%)

Moisture per cent was significantly influenced by drying methods. Maximum moisture was retained in shade dried leaves and there might be hidden moisture in the leaves. Microwave oven dried leaves (D_3) had least moisture content because radiation absorbs OH^- molecules from in and around the cell**.** Similar results were found by Yashaswini *et. al.* (2021) in moringa leaves. The leaves dried under D_3 were found to be the best for minimum moisture retention.

5.2.1.5 Water activity

Drying methods significantly influence water activity level in dried drumstick and coriander leaves. Shade dried leaves showed more bound water which inturn lead to more water activity. Similar result was found by Mathad *et al*. (2019), in asthma plant and the least water activity was found in microwave oven dried leaves (D_3). Similar result was observed by

Mujaffar and Bynoe (2019) in dried bay leaves. The method D_3 was found good for longer storage with minimum moisture and minimum microbial growth.

5.2.1.6 Ash (%)

Microwave oven dried leaves (D_3) had maximum ash per cent, while minimum ash per cent was observed in sun dried (D_1) and shade dried (D_2) leaves. It might be due to shorter drying duration which helps in retention of mineral content in D_3. Similar results were recorded in different vegetables (Iheanacho and Udebuani, 2009).

5.2.1.7 Dry matter (%)

The dry matter of food includes carbohydrates, fats, proteins, vitamins, minerals, and antioxidants (e.g., thiocyanate, anthocyanin and quercetin). Carbohydrates, fats and proteins, which provide the energy in foods (measured in kilocalories or kilojoules) make up ninety per cent of the dry weight of a diet (Anon., 2020). It is calculated by subtracting the initial moisture content from hundred. As the moisture content increases, dry matter per cent decreases. So, D_2 had minimum dry matter content because of more moisture content and D_3 had maximum dry matter content because of minimum initial moisture content.

5.2.2 Effect of drying methods on chemical composition of drumstick and coriander leaves

5.2.2.1 Protein (%)

Protein denaturation depends on drying temperature and drying duration. Increase in duration of drying would increase the denaturation, thereby reduce the protein per cent. In microwave oven drying, duration was less than other drying methods in both drumstick and coriander leaves. Hence, retention of protein per cent was more in microwave oven dried leaves. Similar results were found in dried amaranthus and moringa leaves by Rajeshwari *et al.* (2013) and Samad *et al*. (2021), respectively.

5.2.2.2 Carbohydrates (%)

Carbohydrates per cent was calculated by subtracting the sum of protein, fat, crude fibre, ash and moisture content from hundred. Microwave oven dried leaves (D_3) had less carbohydrate content. It might be due to high protein and fat content. Sun and shade dried leaves had more carbohydrates due to less protein and fat content, which might be due to long duration of drying.

5.2.2.3 Energy value (k calories/100 g)

Energy value is directly proportional to protein, fat and carbohydrates in dried leaves. *i.e.*, energy value was calculated by the summation of multiples of protein, fat and carbohydrates with their respective co-factors. Microwave oven dried leaves (D_3) had more energy due to higher protein and fat in dried drumstick and coriander leaves.

5.2.2.4 Total chlorophyll (mg/100 g)

The chlorophyll retention may be due to effect of temperature, duration of temperature exposed and oxidation during drying. Thermal dehydration of chlorophyll content had greater degradation effect than non-thermal drying (Kumar *et al.,* 2015). Air dried leaves might have more degradation because of auto oxidation than microwave radiation dried leaves. Shade dried, sun dried, cabinet dried and tray dried leaves had less chlorophyll content as compared to microwave oven dried (D_3) leaves (Fig. 2).

5.2.2.5 Total carotenoids (mg/100 g)

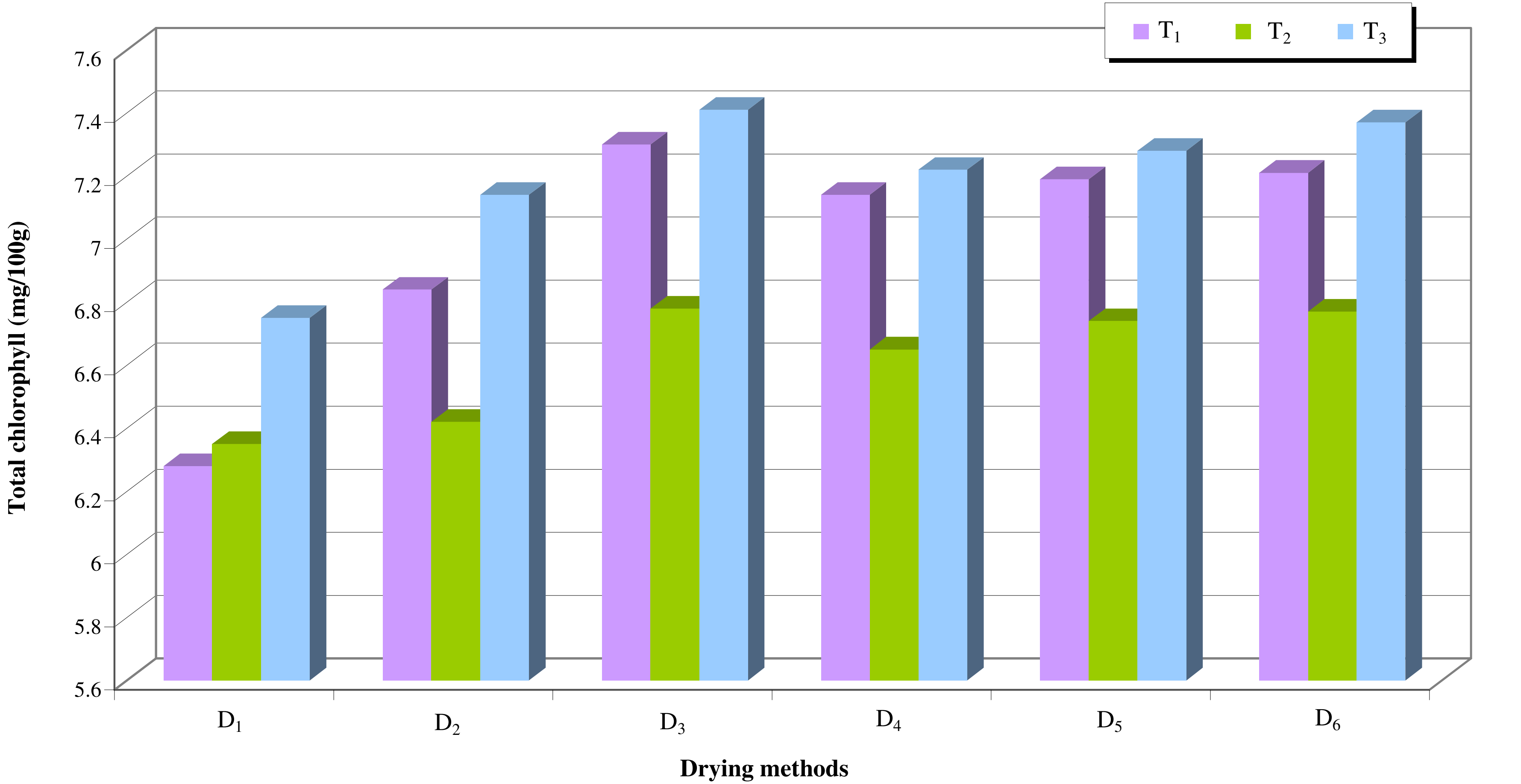
There is possibility of oxidation of carotenoid, due to longer processing time and exposure to high temperature. Microwave oven dried (D_3) samples had more carotenoids and this may be due to faster drying rate as well as lesser oxidation. Sun dried (D_1) leaves had less carotenoids due to more oxidation. Similar results were experienced by Shivanna and Subban (2013) in curry leaves.

5.2.2.6 Ascorbic acid (mg/100 g)

Ascorbic acid is heat sensitive. High temperature along with duration influenced vitamin C retention in dried leaves. Maximum ascorbic acid was found in D_3 due to maximum drying rate which was on par with D_6 and minimum mean ascorbic acid was found in D_2 (Fig. 3). Similar results were experienced by Gladys (2011) in spinach and pumpkin leaves.

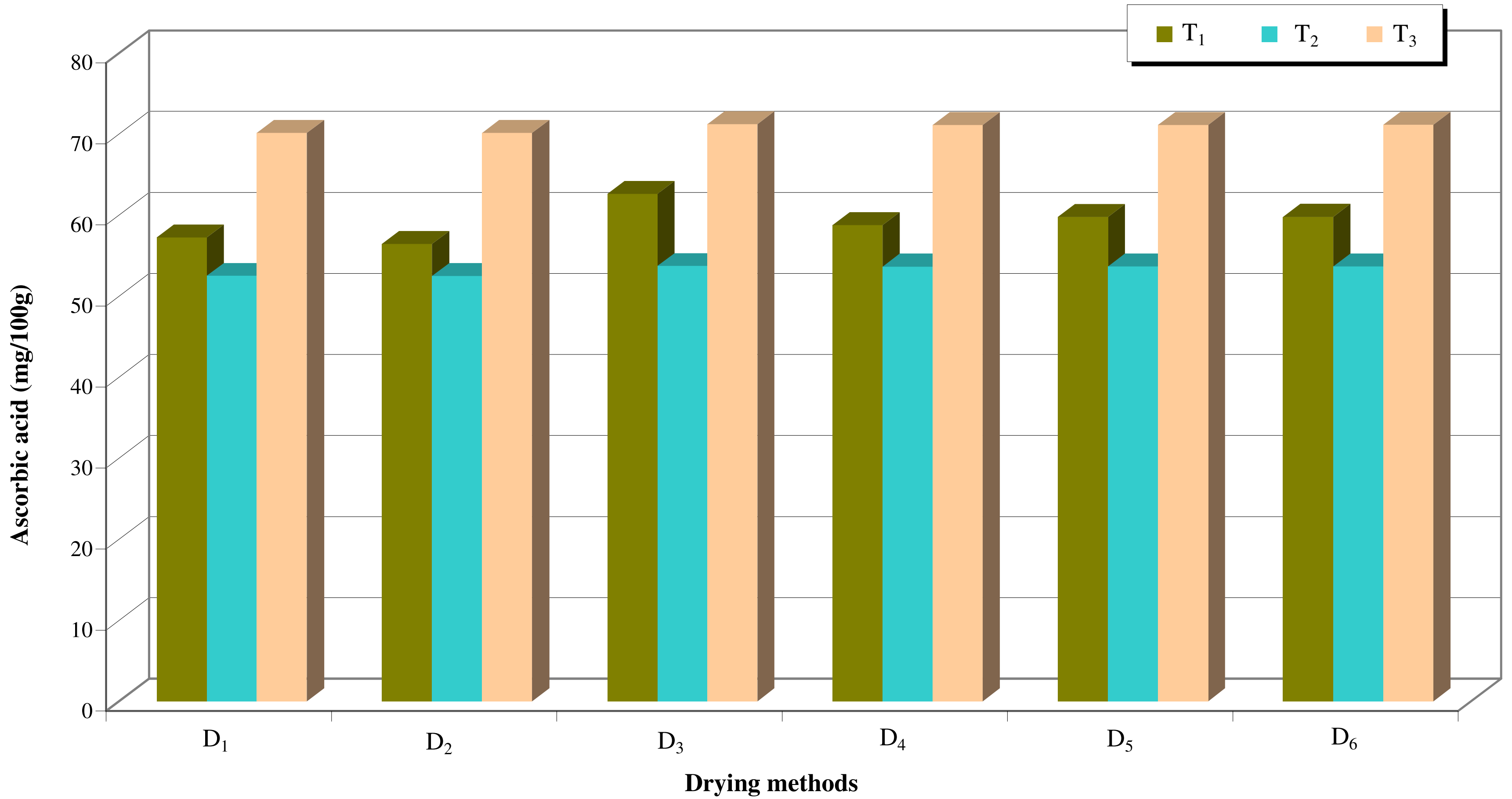
5.2.2.7 Color values

Microwave oven dried leaves (D_3) had more lightness followed by cabinet dried leaves (D_4) and minimum lightness was observed in sun dried leaves (D_1). Colour and texture



Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with sodium metabisulphite, T_3-Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), **D (drying methods):** D_1- Sun drying, D_2- Shade drying, D_3- Microwave drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum drying

Fig. 2. Effect of different pre-treatments and drying methods on total chlorophyll content in dried coriander leaves



Note: T (Pre-treatment): T_1-Untreated leaves, T_2-Blanched with sodium metabisulphite, T_3-Chemical treated with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$), **D (drying methods):** D_1- Sun drying, D_2- Shade drying, D_3- Microwave drying, D_4-Cabinet drying, D_5- Tray drying, D_6- Vacuum drying

Fig. 3. Effect of different pre-treatments and drying methods on ascorbic acid content in dried coriander leaves

mostly depend on high temperature and duration of heat exposed. Slow drying reduces colour lightness, greenness and increases yellowness gradually. Lower drying period influence maximum greenness retention, increase brightness and less yellowness (Esturk and Soysal, 2010).

5.3 Effect of pre-treatment and drying methods on sensory quality of dehydrated drumstick and coriander leaves

5.3.1 Effect of pre-treatments

Sensory quality was significantly influenced by pre-treatments and drying methods. Chemical treated leaves (T_3) were extremely liked by judges, because $NaHCO_3$ + $K_2S_2O_5$ increased green colour intensity and brightness which was more attractive. Blanched leaves (T_2) were less attractive because of dull dark green colour in both dried drumstick and coriander leaves. This result confirmed the result of Singh *et. al*. (2020).

Dried leaves were little bit bitter in nature. The treatment T_3 was mild bitter and at par with T_1 but T_2 was comparatively more bitter. Hence, T_3 had scored more than T_1 and T_2.

The treatment T_3 had scored more because of its aroma as that of fresh leaves and it was at par with T_1 which had mild original aroma. The treatment T_2 had scored low because of unpleasant mild aroma. Flavour includes taste and aroma. Considering both into account, T_3 was liked extremely and T_2 was liked moderately.

Acceptability is dependent on appearance, taste and flavour. Considering all, T_3 was found to be more acceptable. Similar results were observed by Viresh *et al*. (2009) in palak when treated with six per cent brine + 0.1 per cent $K_2S_2O_5$.

5.3.2 Effect of drying methods

Drying methods significantly influence appearance and flavour of dried leaves. Drying method and drying duration influence appearance and flavour. Quick dried leaves had less colour degradation and less destruction of aroma. So, D_3 leaves were liked extremely by judges. As drying duration exceeds, chlorophyll degradation extends, leaf colour become dull and flavour becomes not acceptable. Hence, D_1 and D_2 were not much acceptable. This result was similar to one obtained by Esturk and Soysal (2010), in dehydration of dill leaves.

5.4 Effect of packaging material on storage quality of dehydrated drumstick and coriander leaves after one month

5.4.1 Moisture (%)

One month after storage, moisture content in dried drumstick and coriander leaves increased significantly. This was by the influence of pre-treatments, drying methods, packaging material used for storage. Dried leaves were more hygroscopic in nature. In humid weather storage, they absorb moisture easily. Moisture re-absorption depends on nature of packaging material. Maximum moisture content was observed in blanched leaves, shade drying and LDPE packaged leaves. Blanched leaf cells were more compact. They retained more moisture and LDPE packaging material is more pervious than other packaging materials. Hence, if absorbed more moisture. Minimum moisture content was found in untreated, microwave oven dried leaves and aluminum laminated cover packed dried samples. Untreated and microwave oven dried leaf cells are more porous and aluminum laminated cover are non pervious. Hence, moisture reabsorbed was negligible. Similar results were obtained by Singh and Sagar (2010) in dehydrated drumstick leaves.

5.4.2 Ascorbic acid (mg/100 g)

One month after storage, ascorbic acid content in dried drumstick leaves decreased. This was by the influence of pre-treatments, drying methods and packaging material used for storage and their interactions. Maximum ascorbic acid was observed in leaves treated with chemical, microwave oven dried and stored in aluminium laminated pouch. Ascorbic acid might decrease with increase in the moisture content in dried leaves during storage. It might be due to rapid increase in ascorbic acid oxidation and other relevant oxidizing enzymes in dried leaves. Similar result was observed by Kumar and Sreenarayanan (2000), in dried onion flakes.

6. SUMMARY AND CONCLUSION

The research was conducted to examine the effect of pre-treatments, drying methods and packaging materials during storage on retention of colour (chlorophyll), physical and chemical characteristics in dried drumstick and coriander leaves. Important findings are summarised here under.

Drumstick leaves

For physical parameters, untreated (T_1) showed maximum drying rate (4.58 g/min), dehydration ratio (4.47) and minimum water activity (0.56) and moisture content (2.68 %).

For chemical properties, chemical treatment (T_3) with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$) for 15 minutes found to have maximum rehydration ratio (5.19), ash content (11.83 %), protein (23.21 %), fat (2.68 %), crude fibre (9.62 %), carbohydrates (12.44 %), energy (322.82 K cal./100 g), total chlorophyll (25.19 mg/100 g), total carotenoids (27.19 mg/100 g), ascorbic acid content (97.14 mg/100 g), calcium content (187.39 mg/100 g), more lightness L* (52.10), greenness a* (-3.17) and b* blueness (4.19).

For sensory quality, chemical treated (T_3) with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) for 15 minutes had extremely liking appearance (8.17), taste (8.28), flavour (8.00) and acceptability (8.55).

Among drying methods, microwave oven drying had minimum moisture content (3.25 %), water activity (0.57), maximum drying rate (9.88 g/min), dehydration ratio (5.12), rehydration ratio (5.23), ash (11.48 %), protein (21.54 %), carbohydrates (12.40 %), energy (316.04 k calories/100 g), total chlorophyll (25.08 %), total carotenoids (26.57 %), ascorbic acid (96.23 %), calcium content (186.70), L* (50.09), a* (-1.56) and least yellowness b* (3.45).

For sensory quality, D_3 was liked extremely in appearance (7.67), taste (8.00), flavour (7.56) and acceptability (7.67).

Coriander leaves

For physical parameters, untreated (T_1) showed maximum drying rate (5.89 g/min), dehydration ratio (4.47), minimum moisture content (1.66 %), water activity (0.58). Chemical treated (T_3) with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium meta bisulphite ($K_2S_2O_5$) for 15 minutes found to have highest in ash per cent (5.57 %), protein content (23.38 %), crude fibre (5.81 %), energy (348.30 %), total chlorophyll (25.08 mg/100 g), total carotenoids (13.11 mg/100 g), ascorbic acid (62.53 mg/100 g), calcium content (2.17 mg/100 g) with more lightness L* (51.17) and greenness a* (-1.56).

For sensory quality, chemical treated (T_3) had extremely liking appearance (8.72), taste (8.22), flavour (7.20) and acceptability (8.49).

Among drying methods, microwave oven drying had minimum moisture per cent (2.17 %), water activity (0.58) and maximum drying rate (11.26 g/min), dehydration ratio (5.12), rehydration ratio (4.54), ash (5.45 %), protein (21.52 %), carbohydrates (12.40 %), energy (94.99 %), chlorophyll (2.15 mg/100 g), carotenoids (16.89 mg/100 g), ascorbic acid (62.53 mg/100 g), calcium content (2.17 mg/100 g), lightness L* (51.17), greenness a* (-1.26) and blueness b* (5.26).

Sensory quality, D_3 was liked extremely in appearance (7.89), taste (8.22), flavour (7.00) and acceptability (7.67).

For storage of dried drumstick and coriander leaves, aluminium foil packaging material found to be the best for less moisture (3.50 and 2.38 %) and more ascorbic acid (33.37 and 30.28 %).

This research concluded that pre-treatments and drying methods significantly influence the quality characteristics. Chemical treated (T_3) with 0.1 % magnesium chloride ($MgCl_2$) + 0.1 % sodium bicarbonate ($NaHCO_3$) + 2 % potassium metabisulphite ($K_2S_2O_5$) for 15 minutes along with microwave oven dried leaves found to be good for many physical, chemical properties and sensory quality in both drumstick and coriander leaves. After one month storage of dried leaves, significant gain in moisture and loss of ascorbic acid were observed. However, aluminium foil packaging material found to be the best for storage.

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Appendix I. Monthly meteorological data during the period of investigation from July 2021 to August 2021

Months	Maximum Temperature (ºC)	Minimum Temperature (ºC)	Maximum RH (%)	Minimum RH (%)	Rainfall (mm)	Rainy days
July	27.2	20.7	90.6	83.1	187.4	14
August	28.0	20.5	89.6	84.5	72.9	10

DEHYDRATION OF DRUMSTICK AND CORIANDER LEAVES

PREMA BIRADAR **2022** **Dr. R. V. PATIL**
MAJOR ADVISOR

ABSTRACT

The research entitled "Dehydration of drumstick and coriander leaves" was conducted in B-tech Laboratory, Department of Food Processing and Technology and Department of Horticulture, UAS, Dharwad during 2021.

The study included three factors: a) Pre-treatments like, untreated, blanched with 0.5 % sodium metabisulphate for 2 minutes and chemical treatment of fresh leaves with 0.1 % magnesium chloride + 0.1 % sodium bicarbonate + 2 % potassium metabisulphite dip for 15 minutes. b) Drying methods *viz.,* sun drying, shade drying, microwave oven drying, cabinet drying, tray drying and vacuum drying. c) Packaging material: LDPE, HDPE and aluminium foil.

In dehydration of drumstick and coriander leaves, untreated leaves had maximum drying rate, dehydration ratio, minimum moisture content and water activity. Chemical treated leaves had highest per cent of protein, fat, crude fibre, carbohydrates, energy, chlorophyll, carotenoids, ascorbic acid and calcium content. This was brighter (L*) with more greenness (a*) and less yellowness (b*) with extremely liked appearance, taste, flavour and acceptability.

Among drying methods, microwave oven drying had reduced moisture and water activity with quicker drying rate, maximum dehydration ratio, rehydration ratio, ash, protein, carbohydrates, energy, chlorophyll, carotenoids, ascorbic acid and calcium content. These leaves were brighter (L*) with more greenness (a*) and less yellowness (b*) with extremely liked appearance, taste, flavour and acceptability over other drying methods. Aluminium packaging material retained maximum ascorbic acid content and minimum moisture content over LDPE and HDPE after one month of storage.

Drumstick and coriander leaves treated with 0.1 % magnesium chloride + 0.1 % sodium bicarbonate + 2 % potassium meta bisulphite solution for 15 minutes and microwave oven dried leaves found to be the best for physical, chemical properties and sensory quality. Aluminium foil found to be the best to retain quality during storage.