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RESEARCH PAPER

Effect of treatment and drying method (Solar and convective) on physico-chemical quality of dried moringa leaves

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Abstract : Moringa is one of the promising crop high nutritional and therapeutic values. While drying of moringa leaves, there is significant loss in physical, chemical and nutritional composition of leaves. So, the present study was conducted to investigate the effect of different treatment and drying method (solar and convective) on physico-chemical quality of moringa leaves. Moringa leaves that were sorted, washed and surface dried were considered non-treated whereas leaves that were blanched at 7.5 min after sorting were considered treated. The following samples were dried in three dryers *viz.,* PAU advanced domestic solar dryer, PAU domestic solar dryer and convective tray dryer. Samples that were treated had better physico-chemical quality than untreated sample. Similarly, samples dried in PAU advanced domestic solar dryer had better quality retention *i.e.* had low moisture content, low colour change, higher protein content, higher ascorbic acid and higher total antioxidant activity.

Key Words : Moringa, Blanching, Solar dryer, Convective tray dryer, Physicochemical quality

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INTRODUCTION

Moringa (*Moringa oleifera* Lam.) also known as horseradish tree, ben oil tree and drumstick tree is the most cultivated species in Moringaceae family. It is an edible tree having medicinal, nutritional and socio-economic virtues attributed to its roots, bark, leaves, flowers, fruits and seeds. India is the prime producer of Moringa with an annual production of 2.2 million tonnes of tender fruits from an area of 43,600 ha leading the productivity of around 51 tonnes per ha. Andhra Pradesh leads in both area and production (15,665 ha), Tamil Nadu (13042 ha) and Karnataka (10,280 ha). In other areas it covers an area of 4,613 ha (Shekhar *et al.,* 2018). Average yields of 6 tons/ha/year in fresh matter can be achieved. The harvest differs strongly between the rainy and dry seasons, with 1120 kg/ha per harvest and 690 kg/ha per harvest, respectively. The leaves can be harvested from the young plants 60 days after seeding and then another seven times in the year.

Moringa is one of the promising crops which could contribute to increased intake of micronutrients and

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antioxidants (Kshirsagar *et al.*, 2017). It has been reported that moringa leaves contains vitamin A more than carrots, vitamin C more than oranges and protein content more than milk and eggs (Kshirsagar *et al.*, 2017). Moringa has been used for centuries due to its medicinal properties and health benefits. It also has antifungal, antiviral, antidepressant, and anti-inflammatory properties.

Moringa leaves are dried and used in various products like moringa leaf powder, moringa blended tea, etc. Drying is a unit operation which removes water by evaporation from a solid, semi-solid or a liquid. Drying helps in decreasing microbial spoilage, slows down the action of enzymes, lowers packaging and transportation cost as well as increases the shelf life (Sidhu *et al.*, 2019; Zalpouri *et al.,* 2021). Among different drying methods, hot air drying is commonly used for preservation of agricultural and horticultural produce. The hot air drying has certain limitation like dried product has lower rehydration ratio and high shrinkage (Kaur *et al.*, 2020). Solar drying mainly aims to provide sufficient amount of heat for drying and reduce the water activity of the produce (Sain *et al.,* 2020). It is more beneficial as compared to open sun drying, and has faster drying rates with better product quality. Solar drying is uniform and retention of nutrient content is better maintaining all sensory qualities (Mohammed *et al.*, 2020). In drying of moringa leaves, there are losses in physical, chemical and nutritional composition of leaves.

Hence, considering the following issue, the present study was planned to compare different treatments and drying methods (solar and convective), which will further help in retention of physicochemical quality of dried moringa leaves.

MATERIAL AND METHODS

Procurement and preparation of sample:

Moringa leaves were procured from the farms of Department of Forestry and Natural Resources, Punjab Agricultural University (PAU), Ludhiana, Punjab, India. The leaves were collected early in the morning just before the conduct of the experiment. To accomplish the desired objective, experiments were performed in the laboratories of the Solar Energy Laboratory and Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana. India. The leaves collected from farm were sorted, steam blanched for 7.5 min and then dried in different dryers. The blanching time was selected after preforming peroxidase test. The samples that were blanched are denoted as treated (T) while the unblanched samples were denoted as non-treated (NT) samples. The non-treated samples were sorted, washed and dried in different dryers.

Drying of moringa leaves:

Drying was carried out using three dryers *i.e.* PAU advanced domestic solar dryer (ADSD), PAU domestic solar dryer (DSD) and convective tray dryer (TD). PAU advanced domestic solar dryer fabricated in Department of Renewable Energy Engineering, PAU, Ludhiana, Punjab is a small sized natural circulation solar dryer capable of drying about 1-3 kg of fresh produce in about 2-4 sunny days (Fig.1a). Its aperture area is 0.40 m^2 and needs shadow free space of 80 cm x 66 cm. PAU domestic solar dryer (DSD) fabricated in Department of Renewable Energy Engineering, PAU, Ludhiana, Punjab consisted of a hot box, three trays and base frame (Fig.1b). The frame of size 19 mm x 19 mm x 1.6 mm had the hot box made up of angle iron. A glazing transparent window glass (4 mm) was fixed to the hot box with an aluminium angle, in order to provide air circulation in the drier. Convective tray drying was carried out in a Kilburn tray dryer (Macheill and Magor Ltd., Kolkata, India) at selected temperature of 60ºC. It consisted of an insulated cabinet having internal dimensions of 45.72 cm x 45.72 cm x 60.96 cm. The sample was loaded in perforated stainless steel trays and placed inside the dryers. The sample were dried until weight became constant. The initial and final weights of the products were measured.

Quality analysis of dried sample:

The quality parameters of dried moringa leaves *viz.,* physical and biochemical parameters were assessed using procedures described as follows:

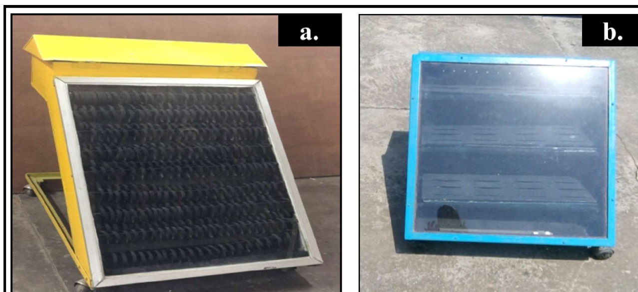


Fig. A : **(a) PAU advanced domestic solar dryer (ADSD) and (b) PAU domestic solar dryer (DSD)**

Physical parameter:

Moisture content:

The moisture content of sample was determined using hot air oven method. The know weight of sample were kept in the hot air oven at 100ºC for 24 h. After 24 h, the sample was weighed again (AOAC, 2000). Moisture content was calculated using the formula:

$$\text{MC (db \%)} = \left(\frac{\text{Initial weight} - \text{Final weight}}{\text{Final weight}}\right) \text{x } 100$$

Colour change:

The colour measurements were made using the colorimeter (Konica Minolta Sensing Inc., Japan). The colour is measured in terms of L, a, b. Colour change (ΔE) was calculated using the formula:

$$\Delta E = \sqrt{[(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2]}$$

Biochemical parameter:

Protein content (mg/g dry weight (dw)):

Protein content was determined by Kjeldahl method (Sáez-Plaza *et al.,* 2013). 1g sample was digested in 20 ml of sulphuric acid at 420ºC using copper sulphate and potassium sulphate in 1:9 ratio as catalyst mixture. Digested sample was cooled and 250 ml distilled water was added about 50 ml of this mixture was distilled using 40% sodium hydroxide. Ammonia was absorbed in excess of 4% boric acid mix with 5 to 7 drops of indicator solution and then titrated with standard acid (0.1N hydrochloric acid) to estimate the protein content. The absorbance of mixture was measured by the spectrophotometer (Spectroscan 80DV, Biotech Engineering Management Company, United Kingdom). The protein content was estimated using following eq.:

$$\text{Protein content} = \left(\frac{\text{(Sample titre – blank tire) x (Normality of HCl x 14)}}{\text{Weight of sample traken x 1000}}\right) \text{x } 100$$

Ascorbic acid (mg/100g dw):

Ascorbic acid was determined using AOAC method (AOAC, 2000). One g sample was mixed with 25 ml of 25% acetic acid and vortexed. The supernatant was filtered and titrated using 2, 6-dichlorophenolindophenol.

Total antioxidant activity (mg/100g dw):

Total antioxidant activity was measured using method described by Sharma *et al.* (2018a). One g sample mixed with 10 ml of distilled water was boiled for 1h and kept overnight. Two ml of above extract, one ml of TAA (0.6 M H_2SO_4, 28 mM sodium phosphate and 4 mM ammonium molybdate, mixed in equal amounts before use) reagent was added and mixture was incubated at 95°C for 90 min. After cooling, absorbance of developed colour was analyzed at 695 nm using the UV-vis spectrophotometer (Spectroscan 80DV, Biotech Engineering Management Company, United Kingdom).

Statistical analysis:

The two-way factorial ANOVA was used to study the effect of factors *viz.,* treatments and drying method and their interactions using SAS 9.2 software package. The experiment was performed in triplicate. The results of the analysis were used to estimate the significant difference among the various parameters at $p < 0.05$.

RESULTS AND DISCUSSION

The effect of treatment and drying method on physicochemical quality was studied on dried moringa leaves.

Physical parameters:

Moisture content:

Moisture content represents the amount of water present in the sample. The initial moisture of fresh moringa leaves were 257.53 ± 2% dry basis (db). The moisture content of fresh leaves were in accordance with Rajput *et al.* (2017). It was observed that among three different drying methods the maximum moisture content of treated moringa leaves was recorded in DSD (6.68% db) and minimum was recorded in ADSD (6.43% db) (shown in Fig 2a). Similarly, it was observed that non treated samples dried in DSD had maximum moisture content (6.32%db) and samples dried in ADSD had minimum moisture content (6.28%db). The sample dried in TD had slightly lower moisture content than DSD samples. It can be observed from Table 1 that treatment, drying method and their interaction had significant effect (p<0.05) on moisture content. The samples that were treated had higher moisture content than non-treated sample. Similar trend was observed by Nobosse *et al.* (2017) for dried moringa leaves and Zalpouri *et al.* (2020a) for potato flakes.

Table 1: *p* values of different physical characteristics of dried moringa leaves

Source	Moisture content (%db)	Colour change	Protein content (mg/g dw)	Ascorbic acid (mg/100g dw)	Total Antioxidant activity (mg/100g dw)
Treatment (A)	0.001*	0.001*	0.001*	0.001*	0.021*
Drying method (B)	0.002*	0.012*	0.001*	0.011*	0.001*
A x B	0.001*	0.032*	0.038*	0.039*	0.029*

Note: * indicates there is a significant effect ($p<0.05$) of specific factors or their combinations on the quality parameter

Colour change:

Colour is an important parameter and influences the organoleptic properties of dried sample (Sharma *et al*., 2017). Colour also determines the heat treatment severity which in turn results in degradation of quality (Zalpouri *et al.*, 2020b). In case of non-treated samples, colour change value was low for ADSD samples (4.57) and high for DSD samples (5.39) whereas in case of treated samples, colour change value was low in case of ADSD samples (4.02) and high for DSD samples (4.73) (shown in Fig 2b). In treated sample, it was observed that ADSD sample and TD sample had almost similar value of colour change but there was significant difference in non-treated sample. From Table 1, it can be concluded that treatment, drying method and their interaction had significant effect on colour change of dried moringa leaves. The increase in colour change also symbolize reduction of L value, hence, decrease in luminous intensity due to Maillard reaction (Zalpouri *et al*., 2021).

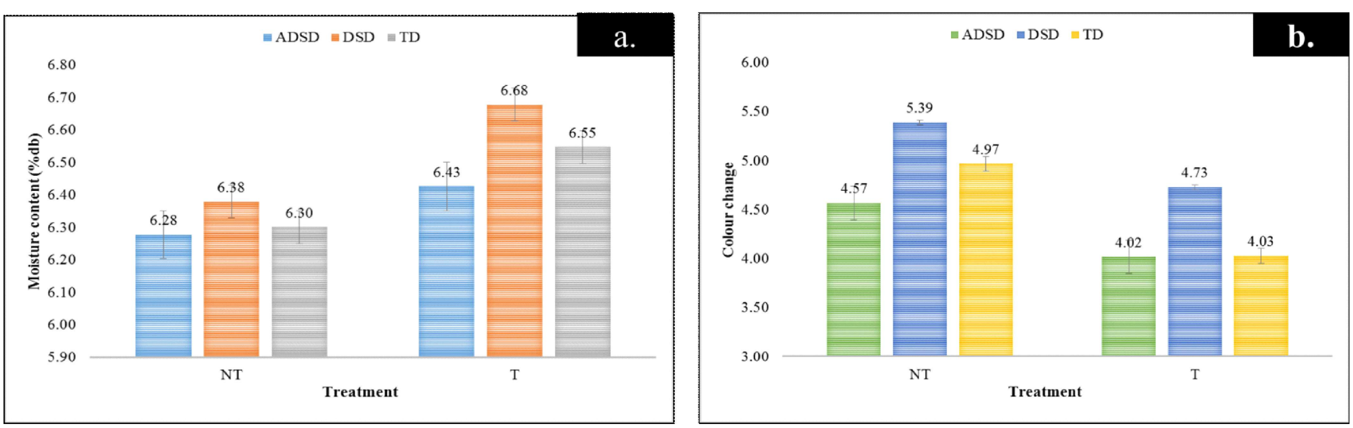
Biochemical parameters:

Protein content:

Protein content of fresh leaves was found to be 628.60 ± 0.35 mg/g fresh weight (fw). The protein content in fresh leaves was found to higher than 200mg/g fw reported by Nobosse *et al.* (2017). Among the non-treated samples, samples dried using ADSD contains higher protein content of 861.16 mg/g dw as compared to 639.92 mg/g dw in samples dried using DSD. Similarly, treated samples dried using ADSD had higher protein content of 649.11mg/g dw while DSD had a lower protein content of 442.28 mg/g dw (shown in Fig. 3a). Table 1 illustrated that treatment, drying method and their interaction had significant effect on protein content. It is observed that protein content in leaves reduced significantly on drying, owing to the denaturation of protein content at high temperatures (Zalpouri *et al*., 2021). Similar trend was observed for beetroot leaves powder by Kakade and Hathan (2014).

Ascorbic acid :

Ascorbic acid of fresh leaves was found to be 149.78 ± 0.53 mg/100 g dw. Among the non-treated samples, samples dried using ADSD contains higher ascorbic acid of 124.57 mg/g dw and samples dried using DSD had lower ascorbic acid of 110.59 mg/100 g dw. Similarly, treated samples dried using ADSD had higher protein content of 129.57 mg/g dw while DSD had a lower protein content of 115.88 mg/100 g dw (shown in Fig 3b). Sample dried in TD had lower value of ascorbic acid than sample dried in ADSD but had higher value



Note: NT- non-treated sample, T-treated sample, ADSD- PAU advanced domestic solar dryer, DSD- PAU domestic solar dryer and TD- convective tray dryer

Fig. 1 : Effect of treatment and drying method on physical parameters *viz.*, a) Moisture content and b) Colour change

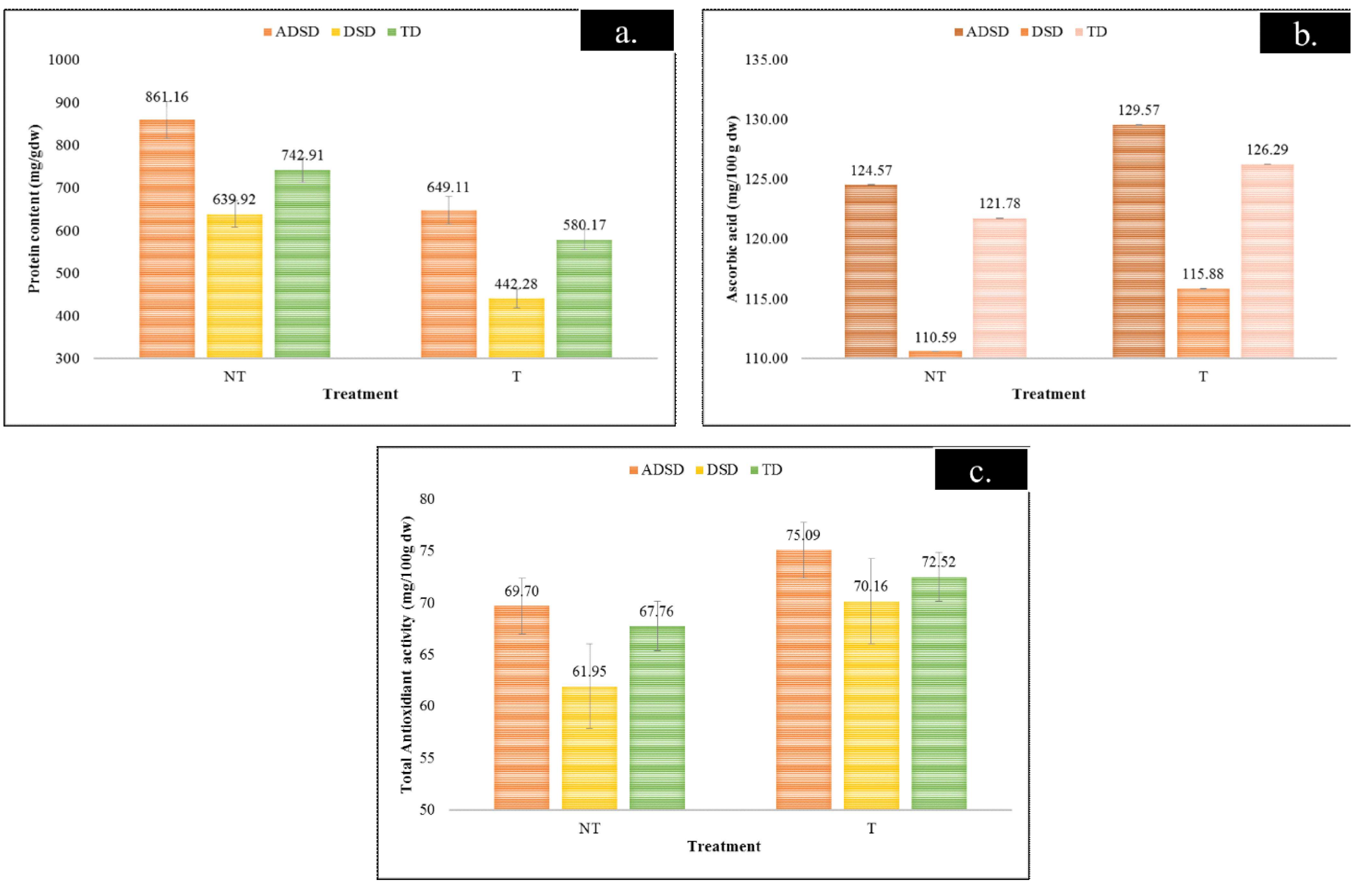
than DSD dried sample. It is observed that ascorbic acid in dried moringa leaves was significantly affected by treatment and drying method (Table 1). This is because blanching before drying has a defensive effect to degradation of ascorbic acid. Similar trend was observed by Nobossehttp://pubs.sciepub.com/ajfst/5/2/4/ - Aff1 *et al.* (2017)

Total antioxidant activity:

Total antioxidant activity consists of lipophilic and hydrophilic antioxidant activity (Sharma *et al.*, 2018b). The total antioxidant activity of fresh leaves was found to be 229.28 ± 0.43 mg/100g dw. Among the non-treated samples, samples dried using ADSD contains higher total antioxidant activity of 69.70 mg/100g dw followed by TD (67.76 mg/100g dw) and least in DSD (61.95 mg/100g dw). Similarly, treated samples dried using ADSD contains higher total antioxidant activity of 75.09 mg/100g dw followed by TD *i.e.* 72.52 mg/100g dw and lower in DSD *i.e.* 70.16 mg/100g dw (shown in Fig. 3c). The total antioxidant activity decreased significantly by drying method. The decrement of total antioxidant activity can be attributed to thermal degradation of phenolic compound and loss of antioxidant enzyme activities (Sharma *et al.*, 2018b). Similar trend was observed by Nobossehttp://pubs.sciepub.com/ajfst/5/2/4/ - Aff1 *et al.* (2017) for moringa leaves.

Conclusion:

In this study, variation in physicochemical properties of dried moringa leaves was influenced by treatment and drying method. Treated samples were considered to have better quality retention in terms of lower colour change, higher ascorbic acid and higher total antioxidant activity. Among three drying methods, PAU advanced domestic solar dryer had better quality retention followed by



Note: NT- non-treated sample, T-treated sample, ADSD- PAU advanced domestic solar dryer, DSD- PAU domestic solar dryer and TD- convective tray dryer

Fig. 2 : Effect of treatment and drying method on biochemical parameters viz. a.) Protein content, b.) Ascorbic acid and c.) Total antioxidant activity

convective tray dryer and PAU domestic solar dryer. It can be concluded that moringa leaves when hot water blanched for 7.5 min and dried in PAU advanced domestic solar dryer will have maximum retention of physical and biochemical quality.

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