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Original Research Paper

Effect of dehydration methods on quality parameters of drumstick (*Moringa oleifera* Lam.) leaf powder

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ABSTRACT

A study was undertaken to assess the suitable drying methods for retention of quality parameters of drumstick (*Moringa oleifera* Lam.) leaf powder. The experiment was laid out in Factorial CRD involving three methods of drying (T_1: Sun drying, T_2: Shade drying and T_3: Cabinet tray dryer) with three pre-treatments (B_1: Unblanched, B_2: Blanched with plain water and B_3: Blanched followed by KMS dip) replicated three times. All the pre-treatments had significant effect on biochemical characteristics of drumstick leaves. Among the pre-treatments, unblanched leaves (B_1) retained higher nutrient contents compared to other pre-treatments. The results of the investigation revealed that among the three different drying methods, shade dried sample was found to retain better nutritional properties. Significantly maximum values for moisture (11.18 %), ascorbic acid (156.27 mg/100g), vitamin-A (22.71 mg/100g), iron (16.54 mg/100g), oxalate (378.66 mg/100g), antioxidant activity (77.11%) and phenol (140.04 mg/100g) were recorded in shade dried sample. The interaction effect between pre-treatment and drying methods showed variation in results. However, the treatment combination T_1B_1 (Unblanched sun dried) was found to retain high protein (26.43 g/100g), magnesium (318.70 mg/100g) and potassium (1378.79 mg/100g) whereas T_2B_1 (unblanched shade dried) showed higher ascorbic acid (179.47 mg/100g), saponin (3.66 %), oxalate (541.47 mg/100g) and antioxidant (80.33 %) than rest of the treatment combinations.

Keywords: Cabinet tray, nutritional properties, pre-treatments, shade drying and sun drying

INTRODUCTION

Drumstick (*Moringa oleifera* Lam.) is an underexploited perennial tree species that belongs to the family Moringaceae. It is native to the Sub-Himalayan tracts of India, Bangladesh, Afghanistan and Pakistan (Makkar and Becker, 1997). This fast-growing tree is also known as benzolive tree, horseradish tree, marango, mlonge, moonga, kelor, mulangay, saijhan, sajna or ben oil tree. The crop is grown in homesteads for family use or cultivated commercially in the agriculture field for the market. India stands at first position among the drumstick growing countries with an annual production of 2.20 to 2.40 million tonnes of tender fruits from an area of 38,000 ha with productivity of around 63 tonnes per ha. Among the different states, Andhra Pradesh leads in both area and production (15,665 ha) followed by Tamil Nadu (13,250 ha) and Karnataka (10,280 ha) (Sekhar *et al*., 2018).

Drying is one of the traditional methods of preservations, which converts the leafy vegetables into a light weight, easily transportable and storable product. Drumstick is used as a foodstuff in different dishes in India, but their nutritional value is not considered due to lack of information. Most of the research work on the biochemical characteristics of the drumstick tree are mainly focused on the oil from the seeds due to its antioxidant properties but very little is associated to the nutritional value of other edible products of the plant as a traditional important food commodity to improve economic and health condition of the population. Considering the food value, utilization of dried moringa leaves need to be popularized for consumption by rural as well as urban population. In view of the above, the present study was done with the objective to evaluate the effect of dehydration on nutritive value of drumstick leaves dried under different drying methods along with different pretreatments.

MATERIALS AND METHODS

Preparation of sample

Fresh drumstick leaves were collected from the campus of Bishwanath College of Agriculture, Biswanath Chariali. The twigs containing half matured drumstick leaves were taken to the laboratory. The leaves were separated from twigs, washed thoroughly in clean running water, drained and were spread on clean stainless-steel tray to remove surface moisture. After removal of surface moisture, equal quantity of leaves were weighed to impose different pretreatments such as blanched for 2 min, blanching + KMS(0.5%) and control. Pretreated drumstick leaves were dried by different drying methods, by spreading drumstick leaves on stainless steel trays under the sun, shade and cabinet tray drier (60°C) until they were crisp.

Biochemical nalysis

Biochemical analysis of the drumstick leaf powder was carried out immediately after drying following the standard estimation methods.

Moisture content

Moisture content was determined according to AOAC (1980) method. The moisture content of the fresh and dried samples was measured by using the hot air oven method. At first, the weight of the crucible was measured using a digital balance. Then the sample along with crucible was measured and kept in a hot air oven at 105°C for 24 hours. The crucible was then taken out from the oven and cooled in a desiccator. After attaining the room temperature, the weight of the crucible along with the sample was measured. The moisture content was computed using the following formula:

$$\text{Moisture content (\%)} = 100 \times \frac{A - B}{A}$$

Where, A = Sample weight before oven drying,
B = Final weight of the sample.

Protein

Estimation of protein was done by Lowry's method (Lowry *et al.,*1951). For the estimation of protein, 500 mg of the sample was weighed and ground well with a pestle and mortar in 5-10 ml of the buffer. The above sample was centrifuged and the supernatant was used for estimation of protein. The working standard solutions of 0.2, 0.4, 0.6, 0.8 and 1 ml were taken in a series of test tubes. Again, the sample extracts of 0.1 and 0.2 ml were taken in another 2 test tubes and the volume was made up to 1 ml in all the test tubes. A tube with 1 ml of water served as blank. Five ml of alkaline copper solution as reagent was added to each test tube including blank and allowed to stand for 10 minutes. Then, 0.5 ml of folin-ciocalteu reagent was added to test tubes and allowed to stand for 30 min at room temperature. The reading was taken in a spectrophotometer at 750 nm wavelength.

Ascorbic acid

Ascorbic acid content was determined by the visual titration method using 2,6 dichlorophenol indophenol dye (Freed, 1966). Ten grams of sample was taken in 100 ml volumetric flask and volume was made up with 4 per cent oxalic acid and filtered. Ten ml of filtrate was taken and titrated against the standard dye. Ascorbic acid content was calculated by the following formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value x Dye factor x Volume made up}}{\text{Weight of the sample taken for estimation x Aliquot of sample taken for estimation}} \times 100$$

*Dye factor = 0.5/Titre value

Vitamin A

Vitamin A was determined in terms of beta carotene. Five ml of leaf extract was taken in a separating funnel and 10 ml of acetone and petroleum ether were added and mixed thoroughly. Lower layer was discarded and upper layer was collected and made up the volume to 100 ml with petroleum ether. The reading was taken at 452 nm. using petroleum ether as blank. The amount of Vitamin A was calculated by the following formula and expressed in µg/100g (Srivastava and Kumar, 2007).

$$\beta \text{ carotene (µg/100g)} = \frac{\text{O.D x 13.9 x } 10^4 \text{ x 100}}{\text{wt. of the sample taken x 560 x 1000}}$$

$$\text{Vitamin A (µg/100g)} = \frac{\beta \text{ carotene (µg/100g)}}{6}$$

Mineral compositions of leaves

Calcium (Ca) and Magnesium (Mg)

For the estimation of Ca and Mg, about 1 g of sample was digested by wet ashing method (Saini *et al.,* 2012). Then 5 ml aliquot was taken in a china clay dish and pH of the aliquot was adjusted to 10 by adding 15 ml NH_4Cl + NH_3OH buffer solution. Ten drops of Erichrome black-T indicator was added and

titrated with 0.01 N EDTA solution till the colour changes from red to bright blue. A blank was carried out in the same manner.

Five ml of NaOH solution and 50 mg of murexide indicator were added to 5 ml of aliquot and titrated with 0.01N EDTA solution till the colour changed from pink to purple. Similarly, a blank was also prepared. Both the minerals were calculated by the following formula and expressed as follows,

For Ca + Mg,

Meq. of (Ca+Mg)/100 g of plant material = (0.01 x V_3) x (V/V_1) x (100/1)

Meq. of Ca/100g of plant material = (0.01 x V_2) x (V/V_1) x (100/1)

Where,

V = Volume of the plant digest made

V_1 = Volume of the aliquot taken for analysis

V_2 = Volume of EDTA solution in titration (titre value)

V_3 =Volume of EDTA solution in titration (titre value)

Potassium

Ten ml of aliquot was taken from the pre-digested sample and 25 ml of neutral NH_4OAc solution was added. The content was then shaken on an electric shaker for 5 minutes and filtered. The filtrate was then fed to the atomizer of the flame photometer. The flame photometer reading was set zero for the blank (NH_4OAc solution) and at 100 for 40 ppm K solution. A standard curve was prepared by making different concentrations of K from 5 – 40 ppm. The concentration of K in the sample was calculated using the standard curve (Ward and Johnson,1962).

$$\text{Potassium (mg/100g)} = \frac{\text{ppm found from Standard curve x Volume made up x Dilution x 100}}{\text{Wt. of sample x 100}}$$

Iron

Three test tubes were taken *viz*. one for blank to which 5 ml water, 0.5ml concentrated sulphuric acid, 2 ml potassium persulphate and 4 ml of potassium thiocyanate were added. In the second test tube for standard, 1 ml standard solution, 4 ml water, 0.5 ml concentrated sulphuric acid, 2 ml potassium persulphate and 4 ml potassium thiocyanate were added and to the third test tube, 5 ml of sample, 0.5 ml concentrated sulphuric acid, 2 ml potassium persulphate and 4 ml potassium thiocyanate were added and the absorbance of each was measured at 480 nm.The amount of iron present was calculated by the following formula given by Saini *et al* (2012).

$$\text{Iron (mg/100g)} = \frac{\text{Absorbance of sample x 0.1 x Total volume of ash solution x100}}{\text{Absorbance of standard x Volume of sample x Wt. of sample taken for ashing}}$$

Anti-nutrient analysis of leaves

Saponin

The saponin content of the samples was determined by the double extraction gravimetric method described by Harborne (1973). A measured amount (5g) of powdered sample was mixed with 50 ml of 20 per cent aqueous ethanol solution in a flask. The mixture was heated with periodic agitation in water bath for 90 minutes at 55ºC; it was then filtered through Whatman filter paper (No. 42). The residue was extracted with 50 ml of 20 per cent ethanol and both extracts were poured together and the combined extract was reduced to about 40 ml at 90ºC and transferred to a separating funnel. About 40 ml of diethyl ether was added to a separating funnel and shaken vigorously. Re-extraction by partitioning was done repeatedly until the aqueous layer becomes clear in colour. The saponins were extracted with 60 ml of butanol. The combined extracts were washed with 5 per cent aqueous sodium chloride solution and evaporated to dryness in a pre-weighed evaporation dish. It was dried at 60ºC in the oven and reweighed after cooling in a desiccator. Saponin content was determined by difference and calculated as below:

$$\text{Saponin (\%)} = \frac{W_2 - W_1}{\text{Weight of the sample}} \times 100$$

Where,

W_1 = Weight of evaporating dish

W_2 = Weight of evaporating dish + sample

Oxalate

Oxalate was determined by AOAC (2005) method. One gram of the sample was weighed into a 100 ml conical ûask. Then, 75 ml of 3M H_2SO_4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1 h and then ûltered using Whatman No.1 ûlter paper. The sample ûltrate (extract, 25 mL) was collected and titrated against hot (80-90°C) 0.1 N $KMnO_4$ solution to the point when a faint pink colour appeared that persisted for at least 30s. The concentration of oxalate in each sample was

obtained from the calculation: 1 ml of 0.1N $KMnO_4$ = 0.006303 g oxalate.

Antioxidant and Phenolic compounds

Antioxidant Activity

DPPH radical scavenging activity of extracts of *M. oleifera* was measured by the modified method of Brand-Williams *et al.* (1995). DPPH in ethanol is a stable radical, dark violet in colour. Its colour is bleached by its reaction with a hydrogen donor. For analyses, 0.1 ml of each extract was added to 2 ml of 100 µM DPPH solution in ethanol. The control was made of 0.1 ml ethanol in 2 ml DPPH. The reaction mixture was incubated for 30 min in the dark at 25°C and the absorbance was read at 517 nm, against a reagent blank. The percentage of free radical scavenging activity was calculated according to equation.

$$\text{Scavenging activity (\%)} = \frac{\text{Abs. control - Abs. test sample}}{\text{Abs control}} \times 100$$

Where Abs. is the Absorbance at 517 nm.

Phenolic compounds

Phenolic compounds were determined by using the method given by Malik and Singh (1980). Sample of 1.0 g was taken and ground it with a pestle and mortar in 10 times volume of 80 per cent ethanol. The homogenate was then centrifuged at 10,000 rpm for 20 minutes and the supernatant was collected. The residue was re-extracted and the collected supernatants were pooled. Supernatants were evaporated to dryness and the residue was dissolved in distilled water (5 ml). Different aliquots of 0.2 to 2 ml were taken in a series of test tubes and volume was made up to 3 ml with water in each tube. Folin-ciocalteu reagent of 0.5 ml was added and after 3 minutes, 2 ml of 20 per cent Sodium carbonate solution was added in each tube. The tubes were placed in boiling water for exactly 1 minute, cooled and the absorbance was measured at 650 nm against a reagent blank. The standard curve was prepared using different concentrations of catechol.

RESULTS AND DISCUSSION

Moisture content

The initial moisture content of fresh drumstick leaves was 74.50 per cent which decreased significantly from 74.50 to 7.84 per cent irrespective of the drying method. Blanching significantly reduced the level of moisture as compared to unblanched sample (9.04 to 10.67%). This might be due to loss of cell wall integrity in blanched sample where bound water loss was at faster rate compared to unblanched sample as reported by Waldron *et al.* (2003). The lowest moisture level was found in the treatment combination T_3B_3 (7.60%) (Table1).

Protein content

The protein content of drumstick leaves increased on drying from 6.09 g per 100g to maximum level in sun dried sample (25.12 g/100g) and minimum amount in shade dried sample (24.27 g/100g). Removal of moisture leads to an increase in the concentration of nutrients. In the present study, the increase in protein content of dried drumstick leaves compared to fresh leaves as a result of moisture loss might have influenced dry matter content (Oulai *et al.*, 2016). The result was in agreement with the work of Osum *et al.* (2013) who reported that the drying process increased the protein content due to moisture loss. The unblanched leaf sample retained higher protein (25.67g/100g) than that of the blanched sample. The reduced protein content in blanched sample might be due to leaching loss. The treatment combination of T_1B_1 (unblanched sun-dried leaves) showed highest protein (26.43g/100g) from rest of the combinations (Table 1).

Vitamins

Ascorbic Acid content

Ascorbic acid being highly water soluble and heat labile vitamin, was found to decrease significantly on dehydration. However, shade dried sample retained maximum ascorbic acid (156.27 mg/100g). The unblanched sample showed higher ascorbic acid as compared to blanched sample. The reduced level of ascorbic acid might be due to oxidation of ascorbic acid. These results were well supported by Gupta *et al*. (2008) in green leafy vegetables. Among the treatment combinations, unblanched shade dried leaves (T_2B_1) recorded highest amount (179.47 mg/100g) of ascorbic acid (Table 2).

Vitamin-A content

Vitamin-A is a fat soluble and heat stable vitamin but sensitive to light. The β-carotene content increased on drying from 6.76 mg /100g (fresh leaves) to 19.81 mg /100g in cabinet tray drying, 19.85 mg/100g in sun drying and 22.71 mg /100g in shade drying. The variation in β-carotene content due to different drying

Table 1. Effect of pre-treatment and drying methods on moisture and protein content of drumstick leaves

	Moisture (%)				Protein (g/100g)			
Fresh leaves:	**74.50 %**				**6.09 g/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	10.00	9.73	9.73	9.82	26.43	25.07	23.86	25.12
Shade dried (T_2)	13.80	9.93	9.80	11.18	24.97	24.25	23.61	24.27
Cabinet tray (T_3)	8.20	7.73	7.60	7.84	25.61	24.56	24.45	24.87
Mean	10.67	9.13	9.04		25.67	24.62	23.97	
CD (P= 0.05)	T: 0.31, B: 0.31, T x B: 0.53				T: 0.19, B: 0.19, Tx B: 0.32			

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS

Table 2. Effect of pre-treatment and drying methods on ascorbic acid and vitamin-Acontent of drumstick leaves

	Ascorbic acid (mg/100g)				Vitamin A (mg/100g)			
Fresh leaves:	**206.67 mg/100g**				**6.79 mg/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	154.53	132.93	131.47	139.64	18.73	21.19	19.62	19.85
Shade dried (T_2)	179.47	145.60	143.73	156.27	22.02	23.63	22.50	22.71
Cabinet tray (T_3)	134.67	122.67	123.20	126.84	17.78	20.83	20.81	19.81
Mean	156.22	133.73	132.80		19.51	21.88	20.98	
CD (P= 0.05)	T: 2.24, B: 2.24, TxB: 3.87				T: 0.49, B: 0.49, TxB: 0.85			

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS

processes could be attributed to the length of exposure to light, oxygen and heat and also, it has been described as being labile to different drying techniques (convection, sun, vacuum or freeze drying) as reported by Soria *et al.* (2009). Thus, more loss in vitamin A was observed in sun drying than other drying methods. The drumstick leaves retained highest vitamin A content in shade dried leaves and lowest in cabinet drying. Similar results were also reported by Joshi and Mehta (2010) that shade drying retained highest vitamin A content followed by oven drying at 60°C. Blanching resulted in significant loss of β carotene content of drumstick leaves. The β carotene content of blanched leaves (21.88 mg/100g) was higher than those of their corresponding unblanched leaves (19.51 mg/100g). The carotene content on the plant is bounded with protein, the heat treatment such as steaming, cooking and blanching can release the carotene that bounded (Howard *et al*., 1999). The treatment combination T_2B_2 (Blanched and shade dried leaves) showed highest (23.63 mg/100g) vitamin-A content from rest of the combinations (Table 2).

Minerals content

Calcium

The calcium content of fresh drumstick leaves was 438 mg /100g and it was much lower than the dried leaves. Among the drying methods, highest (2078.73 mg/100g) calcium content was noticed in cabinet tray dried leaves than the other two methods. Liman *et al.* (2014) also observed enhanced mineral nutrients in *Moringa oleifera* leaves dried under moisture analyzer drying method as compared to sun and oven drying. The general increase in mineral content with increase in drying temperature is attributable to concentration factor due to moisture removal, which resulted in higher

level of total soluble solid (Alakali *et al*., 2014). The result revealed that drumstick leaves blanched along with KMS dip had the highest calcium content (2062.91 mg/100g) followed by only blanched (2051.56 mg/100g) while unblanched leaves showed the lowest calcium concentration (2031.79 mg/100g) (Table 3).

Magnesium

Magnesium occurs abundantly in chloroplast as a constituent of chlorophyll molecule. The fresh drumstick leaves contain 48.36 mg /100g, which increased significantly upon drying to 289.32 mg 100g in cabinet drying, 294.78 mg /100g in shade drying and 315.41 mg per 100g in sun drying. Buchaillot *et al*.(2009) reported that magnesium could transform into pyropheophytin and pheophytin because of high temperature. Hence, magnesium might have bound in which it inhibited the mineral from leaching when structure of the leaf breaks. The amount of magnesium in drumstick leaves without blanching was found to be much higher (304 mg/100g) than the blanched leaves (Table 3).

Potassium

The result revealed that out of three drying methods, sun dried drumstick leaves had the highest potassium content (1210.06 mg/100g) followed by shade drying and the lowest potassium was observed in cabinet tray dried leaves (1099.87 mg/ 100g). Probably the reason might be due to potassium being cationic in nature that do not polarize on heating but forms oxides when exposed to light and air. Blanching significantly reduced the level of potassium content in leaves. The blanched leaves showed lowest value for potassium while highest potassium content (1242.43 mg/100g) was noticed in unblanched leaves. The reduced potassium content of blanched green leafy vegetable indicated the solubility and the leaching of the minerals into the water because of their highly reactive nature of the metal that readily reacts with water (Michael, 2006) (Table 4).

Iron

The iron concentration of dried drumstick leaves was higher as compared to fresh leaves. Present study revealed that there was an increment of iron content during drying of leaves irrespective of drying procedure. The shade dried leaves showed 16.54 mg / 100g of iron content while cabinet tray dried and sun dried sample exhibited 13.62 and 13.52 mg/100g respectively. However, shade dried leaves significantly retained higher iron content in comparison to sun drying and cabinet tray drying. This might be due to the fact that concentration of solid increases with the removal of moisture from the leaves. A similar trend of iron content in shade dried moringa leaves was reported by Emelike and Ebere (2016). Blanching increased the availability of iron content in leaves. The result revealed that drumstick leaves blanched and dipped in KMS solution retained highest (16.09 mg/100g) iron content while unblanched leaves recorded the lowest amount (13.04 mg/100g) (Table 4).

Table 3. Effect of pre-treatment and drying methods on calcium and magnesium content of drumstick leaves

	Calcium (mg/100g)				Magnesium (mg/100g)			
Fresh leaves:	**438 mg/100g**				**48.36 mg/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	2044.00	2064.67	2082.07	2063.07	318.70	314.43	313.11	315.41
Shade dried (T_2)	1984.03	2004.57	2023.23	2003.94	298.72	294.16	291.57	294.78
Cabinet tray (T_3)	2067.33	2085.43	2083.43	2078.73	294.70	277.60	295.67	289.32
Mean	2031.79	2051.56	2062.91		304.00	295.40	300.11	
CD (P= 0.05)	T: 1.87, B: 1.87, Tx B: 3.25				T: 1.68, B: 1.68, Tx B: 2.92			

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS

Table 4. Effect of pre-treatment and drying methods on magnesium and iron content of drumstick leaves

	Potassium (mg/100g)				Iron (mg/100g)			
Fresh leaves:	**254.71 mg/100g**				**1.07 mg/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	1378.79	1124.69	1126.71	1210.06	12.80	13.38	14.37	12.80
Shade dried (T_2)	1219.79	1121.18	1194.64	1178.54	13.38	16.67	19.61	13.38
Cabinet tray (T_3)	1128.72	1099.03	1071.86	1099.87	12.96	13.61	14.29	12.96
Mean	1242.43	1114.97	1131.07		13.04	14.56	16.09	
CD (P= 0.05)	T: 0.39, B: 0.39, Tx B: 0.68				T: 0.96, B: 0.96, Tx B: 1.67			

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS

Antinutritional Factors

Saponin

Saponin, a naturally occurring glycoside that is widely distributed in the plants. It acts as antinutrient and also as antioxidant in human. Fresh drumstick leaves contain 5.71 % of saponin, which gets reduced to 0.76 -1.76 % upon dehydration by different methods. All three drying method could reduce saponin content drastically. Reduction in saponin content may be attributed to heat induced degeneration involved in drying processs (Ademiluyi *et al*., 2018). Saponin content was also influenced by pretreatments. The decrease in the saponin content upon blanching of drumstick leaves was 89.49% in only blanched and 87.74 % in blanched and dip in KMS solution. Whereas unblanched leaves showed 62.87 % reduction. The treatment combination T_2B_1 (unblanched shade dried leaves) recorded highest (3.66 %) amount of saponin and lowest (0.50 %) in blanched sun-dried leaves (T_1B_2) (Table 5).

Oxalate

The antinutritional constituent oxalate can reduce the bioavailability of some minerals, especially calcium. Oxalate occurs naturally in plants. It occurs as soluble salts of potassium and sodium and as insoluble salts of calcium, magnesium and iron. The total oxalate content of drumstick leaves was found to increase on drying. The oxalate present in fresh leaves was 121.56 mg/100g and in dried sample it ranged from 299.84 to 378.66 mg /100g. The result of the present study was in accordance with Aditi *et al*. (2017) who reported increase in oxalate content of moringa leaves. It has been observed that after drying, the oxalate content increased, which may be due to considerable

Table 5. Effect of pre-treatment and drying methods on saponin and oxalate content of drumstick leaves

	Saponin (%)				Oxalate (mg/100g)			
Fresh leaves:	**5.71%**				**121.56 mg/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	1.54	0.50	0.62	0.89	380.14	265.21	254.16	299.84
Shade dried (T_2)	3.66	0.74	0.88	1.76	541.47	298.36	296.15	378.66
Cabinet tray (T_3)	1.15	0.55	0.59	0.76	413.29	265.21	269.63	316.04
Mean	2.12	0.60	0.70		444.97	276.26	273.32	
CD (P= 0.05)	T: 0.10, B: 0.10, Tx B: 0.18				T: 3.12, B: 3.12, Tx B: 5.40			

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS

loss of moisture content, hence other compounds such as oxalate content of dehydrated sample became concentrated and their value was much greater than those of fresh sample (Paul *et al.*, 2012).

Blanching reduced the oxalate content because the concentration of antinutrients was highest on the superficial layer of vegetable and blanching ruptures this layer (Albinhna and Savage, 2001). In the present findings, oxalate content was at its minimum level in blanched sample (273.32- 276.26 mg/100g) compared to unblanched sample (444.97 mg/100g). Among the treatment combinations, lowest oxalate was found in T_1B_3 (254.16 mg/100g) (Table 5).

Antioxidant and Phenolic compounds

Antioxidant activity

The drumstick leaves were endowed with the added benefits of antioxidants such as vitamin A, C and phenolic compounds. The result of the present findings showed that antioxidant activities of the drumstick leaves were reduced due to dehydration and blanching. Antioxidant activities (DPPH) of the leaves ranged from 63.76 to 77.47 % among the drying methods. The leaves dried under shade had the highest radical scavenging power (77.47%) than the other drying methods. Cabinet tray dried sample showed lowest activity. The drying process lead to deterioration of antioxidants in leaves. It appears that mainly vitamin C involved in free radical scavenging activity while carotenoid and total phenol are mostly implicated but to a lesser extent in the ion reducing power. During drying, exposure to heat, light and oxygen accelerate the rate of oxidation of vitamin A and C present in vegetables (Oulai *et al.*, 2015)

Blanching had significant influence on antioxidant properties. The scavenging power of drumstick leaves reduced on blanching while unblanched leaves recorded highest activity. This may be due to leaching out and thermal degradation of heat sensitive compounds, vitamin C and A. Bamidele *et al.* (2017) also observed similar trend in bitter leaves (*Vernonia amygdalina*) and found a significant decrease in reducing power and the DPPH scavenging activity of blanched sample. The highest activity was observed in T_2B_1 (unblanched shade dried) (80.33 %) (Table 6).

Phenolic compounds

Phenolics are one of the most effective antioxidant constituents of drumstick leaves. The total phenol content of drumstick leaves varies with the drying procedure and pre-treatments. Phenol content was found to decrease from 163.42 mg /100g (fresh leaves) to 140.04 mg /100g in shade dried, 136.05 mg / 100g in sun dried and 130.81 mg /100g in cabinet tray dried leaves. The decrease in the phenolic contents of the moringa leaves exposed to drying processes such as sun and cabinet tray drying could be due to heat-induced degradation of phenolic compounds (Oboh *et al.,* 2010). The maximum (137.32 mg/100g) total phenol content was observed in unblanched sample and the minimum (134.20 mg/100g) was in only blanched sample.

Table 6. Effect of pre-treatment and drying methods on antioxidant activity and phenol content of drumstick leaves

	Antioxidant activity (%)				Total Phenol (mg/100g)			
Fresh leaves:	**85.25 %**				**163.42 mg/100g**			
Drying methods	**Pre-treatments**			**Mean**	**Pre-treatments**			**Mean**
	B_1	**B_2**	**B_3**		**B_1**	**B_2**	**B_3**	
Sun dried (T_1)	73.80	69.48	71.54	71.61	137.67	134.62	135.86	136.05
Shade dried (T_2)	80.33	73.52	77.47	77.11	141.89	138.18	140.05	140.04
Cabinet tray (T_3)	66.07	61.86	63.35	63.76	132.40	129.79	130.23	130.81
Mean	73.40	68.29	70.79		137.32	134.20	135.38	
CD (P= 0.05) T: 0.24, B: 0.24, Tx B: 0.41T: 0.46, B: 0.46, Tx B: NS								

B_1: Unblanched B_2: Blanched B_3: Blanched + KMS NS: Non-Significant

CONCLUSION

The result obtained from the present study indicated that out of three drying methods, shade drying was found to have better retention of nutrients. The pre-treatments had significant effect on physiochemical characteristics of drumstick leaves. The nutrients such as vitamin A, C, iron, anti-nutrients, antioxidant and phenol retention ability of drumstick leaves was better in shade dried samples while protein, calcium, magnesium and potassium retention was more in sun dried samples. The combination of unblanched leaves dried under shade was found superior in terms of retention of nutrients from rest of the treatment combination. Considering the above fact, both shade and sun drying may be considered best for preserving nutrient and also from the point of view of cost involvement.

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