Environment and Ecology 39 (2) : 432—441, April—June 2021
ISSN 0970-0420

Effect of Pretreatments and Drying Methods on Ascorbic Acid, Chlorophyll Content and β-Carotene Content of Drumstick (*Moringa oleifera* Lam.) Leaves and Shoot

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Received 9 March 2021, Accepted 16 April 2021, Published on 12 May 2021

ABSTRACT

The investigation was carried out during November 2017 to May 2018. The main objective of this experiment was to study the effect of pre-treatments and drying methods on nutritional quality and shelf life stability of leaves and shoots of drumstick powder. The experiment was carried out in a factorial Completely Randomized Block Design with two replications comprising 18 treatment combinations from three factors i.e.plant material with three levels, pre-treatment with three levels and drying method with two levels. Result observed that ascorbic acid, chlorophyll content and β-carotene content showed decreasing trend from initial day to180 days of storage. Un-blanched plant materials (S_3) recorded the highest ascorbic acid and chlorophyll content and water blanched sample recorded the highest beta-carotene content among pre- treatments. Mature leaf without petiole, rachis with rachilla and leaflets (P_3) recorded the highest chlorophyll, β-carotene and ascorbic acid observed maximum in mature leaf with petiole and rachis. Mechanical drier (home scale drier) found that the best for retaining of the all above nutrients. In interaction un-blanched mechanical dried samples (S_3D_2) recorded highest ascorbic acid, chlorophyll content and β-carotene content observed maximum in water blanched mechanical (S_1D_2) dried drumstick leaves and shoot during storage period.

Keywords Ascorbic acid, β-carotene, Chlorophyll, Home scale drier.

INTRODUCTION

Drumstick (*Moringa oleifera* Lam.) is a perennial tree, considered as underutilized plant that comes under the family Moringaceae. It is cultivated in home gardens and field for its leaves, flowers and tender fruits which are used as nutritious vegetables. It is highly valued for the distinct and appealing flavor of its tender pods. They are rich source of proteins, minerals and vitamins (Singh *et al.* 2012). Drumstick leaves contain more vitamin A than carrots, more calcium than milk, more iron than spinach, more vitamin C than oranges and more potassium than bananas (Ali *et al.* 2014).

Generally during drying, changes occur in the product due to the exposure to the temperature. To control these change during drying and pre-treatments

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were given to the fresh products before processing. The main reasons for treating the produce before drying is to stop enzymatic action, to improve flavor, color, to minimize the nutrient loss, to stop decomposition by the microbes and to ensure even drying. To obtain a dried product of excellent quality, the raw produce must be harvested at the right time and handled carefully. Blanching was done in order to inactivate the enzymes and to remove the intercellular air from the tissues and to reduce the drying time. Potassium metabisulphite was used as a stable source of sulfur dioxide which in turn prevents the formation of brown substances.

MATERIALS AND METHODS

Drumstick variety PKM-1 seedlings were raised and planted in the field, located at Post-harvest Technology Research Station, Venkataramannagudem, West Godavari district, Andhra Pradesh. Drumstick leaves were harvested according to the treatments. Tender shoots, mature shoots with petioles and rachis as well as mature leaves without petioles were harvested with the help of secateurs. For each treatment 1 kg of plant materials was taken.

Chemical i.e., 0.5% KMS used for the pre-treatment and it was prepared by dissolving 5 g of KMS in one liter of distilled water. Chemical treatment was given by dipping of drumstick leaf and shoots in pre-treatment solutions. The ratio of pre-treatment solution and sample (4:1.) was 4 L per kg of drumstick leaves and shoots. Pre-treatmented drumstick leaves and shoots were dried in the sun and mechanical drier (home scale drier model EZIDRI Ultra FD1000).

The data collected on the following observations during the course of investigation were statistically analyzed by adopting the standard procedure of Panse and Sukhatme (1985).

Ascorbic acid (mg 100 g^{-1})

Ascorbic acid of fresh and dried powder was estimated as suggested by Ranganna (1986).

$$\text{Ascorbic acid (mg 100 g}^{-1}\text{)} = \frac{\text{Titer value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Volume taken} \times \text{Weight of the sample}} \times 100$$

β-carotene (mg 100 g^{-1})

Beta-carotene content was determined as suggested by Ranganna (1986)

$$\text{Beta-carotene (mg 100 g}^{-1}\text{)} = \frac{\text{O. D} \times 13.9 \times 104 \times 100}{\text{Weight of the sample} \times 560 \times 1000}$$

Chlorophyll content (mg 100 g^{-1})

Chlorophyll content of fresh and dried powder was estimated as suggested by Ranganna (1986) by using acetone as a reagent.

Chlorophyll (mg 100 g^{-1}) = 20.2 (A645) +8.02 (A663)*V/1000*W

Where,

A = Absorbance at specific wave length.V = Final volume of chlorophyll extract with 80% acetone.W = Fresh weight of extracted leaf tissue.

RESULTS AND DISCUSSION

Analysis of fresh leaf and shoot

Ascorbic acid (mg 100 g^{-1})

The mean ascorbic acid content over the different treatment combinations decreased from (235.99 mg 100 g^{-1}) on the initial day of storage to (101.30 mg 100 g^{-1}) at 180 days of storage (Table 1). Un-blanched plant materials (S_3) recorded the highest ascorbic acid content 247.11 mg 100 g^{-1} (initial day of storage) to 107.85 mg 100 g^{-1} (180 days of storage) and the lowest ascorbic acid content 230.14 mg 100 g^{-1} (initial day of storage) to 98.07 mg 100 g^{-1} (180 days of storage) recorded in combination of water blanched with 0.5% KMS treatment (S_2). Among the plant material at initial day of storage, the highest ascorbic acid content 298.04 mg 100 g^{-1} (initial day of storage) to149.25 mg 100 g^{-1} (180 days of storage) recorded in mature leaf with petiole and rachis (P_2) as compared to the mature leaf without petiole, rachis with rachilla and leaflets 228.40 mg 100 g^{-1} (initial day of storage) to 95.94 mg 100 g^{-1} (180 days of storage) and terminal young shoot (P_1) 181.54 mg 100 g^{-1} (initial day of

Table 1. Effect of pre-treatments, plant material and drying methods on ascorbic acid (mg 100 g^{-1}) of drumstick leaf and shoot powder. P_1: Terminal young shoot. P_2: Mature leaf with petiole and rachis P_3: Mature leaf without petiole, rachis with rachilla and leaflets S_1: Water blanching S_2: Water blanching+KMS 0.5 % S_3: Without blanching (control) D_1: Sun drying D_2: Mechanical drier (EZIDRI)

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages Initial S_1	S_2	S_3	Mean	30 S_1	S_2	S_3	Mean
	D_1	186.35	164.47	173.30	**174.70**	163.33	146.23	151.81	153.79
P_1	D_2	200.19	174.54	190.40	**188.37**	182.39	153.79	168.53	168.24
	Mean	**193.27**	**169.50**	**181.85**	**181.54**	**172.86**	**150.01**	**160.17**	**161.01**
	D_1	289.46	302.93	310.55	**300.98**	261.15	283.28	283.72	276.71
P_2	D_2	266.44	300.95	317.92	**295.10**	240.40	270.99	287.24	266.21
	Mean	**277.95**	**301.94**	**314.24**	**298.04**	**250.77**	**278.13**	**285.48**	**271.46**
	D_1	219.42	203.13	233.72	**218.76**	197.04	182.02	203.28	194.11
P_3	D_2	222.51	234.84	256.79	**238.04**	202.11	212.52	228.15	214.26
	Mean	**220.96**	**218.99**	**245.25**	**228.40**	**199.57**	**197.27**	**215.71**	**204.18**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	231.74	223.51	239.19	**231.48**	208.17	204.51	212.94	208.54
	D_2	229.71	236.77	255.04	**240.51**	209.30	212.43	227.97	216.56
	Mean	**230.73**	**230.14**	**247.11**	**235.99**	**208.73**	**208.47**	**220.45**	**212.22**

Comparing means	SEm	CD at 5%	SEm	CD at 5%
P	1.393	4.137	1.259	3.742
S	1.393	4.137	1.259	3.742
D	1.137	3.378	1.028	3.055
P x S	2.412	7.166	2.181	6.481
S x D	1.969	5.851	1.781	5.292
P x D	1.969	5.851	1.781	5.292
P × S x D	3.411	10.134	3.085	9.166

Table 1. Continued.

Plants meterial (P)	Drying method (D)	Pretreatment (S) Days of storages 60 S_1	S_2	S_3	Mean	90 S_1	S_2	S_3	Mean
	D_1	142.47	126.84	129.38	**132.90**	121.28	107.24	110.29	112.94
P_1	D_2	160.38	132.49	148.61	**147.16**	140.41	111.62	129.10	127.04
	Mean	**151.42**	**129.66**	**138.99**	**140.03**	**130.84**	**109.43**	**119.69**	**119.99**
	D_1	232.07	252.29	252.56	**245.64**	213.22	228.75	231.72	224.56
P_2	D_2	208.03	239.22	253.21	**233.49**	188.08	215.45	238.73	214.09
	Mean	**220.05**	**245.75**	**252.88**	**239.56**	**200.65**	**222.10**	**235.23**	**219.32**
	D_1	166.74	159.44	180.34	**168.84**	147.66	139.75	162.00	149.80
P_3	D_2	183.68	180.43	203.69	**189.27**	163.41	158.34	183.44	168.40
	Mean	**175.21**	**169.93**	**192.02**	**179.05**	**155.54**	**149.04**	**172.72**	**159.10**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	166.74	159.44	180.34	**168.84**	147.66	139.75	162.00	149.80
	D_2	183.68	180.43	203.69	**189.27**	163.41	158.34	183.44	168.40
	Mean	**175.21**	**169.93**	**192.02**	**179.05**	**155.54**	**149.04**	**172.72**	**159.10**

Comparing means	SEm	CD at 5%	SEm	CD at 5%
P	1.238	3.677	1.113	3.308
S	1.238	3.677	1.113	3.308
D	1.011	3.002	0.909	2.701
P × S	2.144	6.369	1.929	5.730
S × D	1.750	5.200	1.575	4.679
P × D	1.750	5.200	1.575	4.679
P × S × D	3.032	9.007	2.727	8.104

Table 1. Continued.

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages 120 S_1	S_2	S_3	Mean	150 S_1	S_2	S_3	Mean	180 S_1	S_2	S_3	Mean
P_1	D_1	101.73	86.72	88.20	**92.22**	82.35	68.45	68.19	**72.99**	62.84	48.16	49.88	**53.63**
	D_2	120.14	92.76	102.46	**105.12**	100.53	72.56	81.20	**84.76**	79.65	50.23	61.52	**63.80**
	Mean	**110.94**	**89.74**	**95.33**	**98.67**	**91.44**	**70.50**	**74.69**	**78.88**	**71.24**	**49.19**	**55.70**	**58.71**
P_2	D_1	188.27	202.00	197.72	**195.99**	169.22	180.61	175.05	**174.96**	147.73	161.00	154.50	**154.41**
	D_2	156.36	193.54	206.87	**185.59**	136.18	172.07	187.12	**165.12**	114.27	152.34	165.67	**144.09**
	Mean	**172.31**	**197.77**	**202.29**	**190.79**	**152.70**	**176.34**	**181.09**	**170.04**	**131.00**	**156.67**	**160.08**	**149.25**
P_3	D_1	123.21	119.97	137.98	**127.05**	103.44	101.02	117.82	**107.42**	84.28	80.04	96.80	**87.04**
	D_2	141.68	135.98	157.44	**145.03**	121.40	115.82	137.73	**124.98**	100.12	96.69	117.75	**104.85**
	Mean	**132.44**	**127.97**	**147.71**	**136.04**	**112.42**	**108.42**	**127.77**	**116.20**	**92.20**	**88.36**	**107.27**	**95.94**
For comparing pre-treatment (S) and drying method (D)													
D_1		137.74	136.23	141.30	138.42	118.33	116.69	120.35	118.46	97.13	96.40	100.39	**94.64**
D_2		139.39	140.76	155.59	145.25	119.37	120.15	135.35	124.95	99.17	99.75	114.98	**107.96**
Mean		**138.56**	**138.49**	**148.44**	**141.83**	**118.85**	**118.42**	**127.85**	**121.71**	**98.15**	**98.07**	**107.68**	**101.30**

Comparing means	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%
P	1.010	3.001	1.095	3.254	1.046	3.108
S	1.010	3.001	1.095	3.254	1.046	3.108
D	1.011	3.002	0.894	2.657	0.854	2.538
P x S	1.750	5.198	1.897	5.635	1.812	5.383
S x D	1.429	4.244	1.549	4.601	1.479	4.395
P x D	1.429	4.244	1.549	4.601	1.479	4.395
P x S x D	2.474	7.351	2.682	7.970	2.562	7.613

storage) to 58.71 mg 100 g^{-1} (180 days of storage). The mechanical drying method (D_2) resulted in higher ascorbic acid content 240.51 mg 100 g^{-1} (initial day of storage) to107.96 mg 100 g^{-1} (180 days of storage) as compared to sun drying method (D_1) 231.48 mg 100 g^{-1} (initial day of storage) to 94.64 mg 100 g^{-1} (180 days of storage).

The interaction between pre-treatment and drying methods, the highest ascorbic acid content 255.04 mg 100 g^{-1} (initial day of storage) to114.98 mg 100 g^{-1} (180 days of storage) recorded in un-blanched mechanical dried samples (S_3D_2) and the lowest ascorbic acid content 223.51 mg 100 g^{-1} (initial day of storage) to 96.40 mg 100 g^{-1} (180 days of storage)recorded in water blanching with 0.5% KMS and sun dried samples (S_2D_1) The effect of interaction between plant material, pre-treatment and drying method, maximum ascorbic acid content 317.92 mg 100 g^{-1} (initial day of storage) to165.67 mg 100 g^{-1} (180 days of storage) recorded in the treatment combination of un-blanched mature leaf with petiole and rachis with mechanical drier ($P_2S_3D_2$), while minimum ascorbic acid content 164.47 mg 100 g^{-1} (initial day of storage) to48.16 mg 100 g^{-1} (180 days of storage) recorded in the treatment combination of water blanching with 0.5% KMS and terminal young shoot dried in sun ($P_1S_2D_1$).

Un-blanched plant materials recorded the highest ascorbic acid and it might be due to water-soluble nature of vitamin C, which was causes, it to leach into cooking water, which was generally discarded after cooking. Mechanical drying method resulted in higher ascorbic acid content as compared to sun drying method which was might be due to instability of ascorbic acid at high temperatures and exposure of samples for longer period in the solar drier. Similar results recorded by Udhal *et al.* (2006).

Ascorbic acid a highly soluble substance and thermal processing leads to degradation of ascorbic acid. Similar results recorded by the Patel *et al.* (2016).

Table 2. Effect of pre-treatments, plant material and drying methods on chlorophyll (mg 100 g^{-1}) of drumstick leaf and shoot powder. P_1: Terminal young shoot. P_2: Mature leaf with petiole and rachis P_3: Mature leaf without petiole, rachis with rachilla and leaflets S_1: Water blanching S_2: Water blanching + KMS 0.5 % S_3: Without blanching (control) D_1: Sun drying D_2: Mechanical drier (EZIDRI)

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages: Initial S_1	Initial S_2	Initial S_3	Initial Mean	30 S_1	30 S_2	30 S_3	30 Mean
	D_1	131.46	134.11	135.85	**133.81**	126.40	126.14	129.61	**127.38**
P_1	D_2	141.52	143.78	149.42	**144.91**	138.56	140.48	147.13	**142.06**
	Mean	**136.49**	**138.95**	**142.64**	**139.36**	**132.48**	**133.31**	**138.37**	**134.72**
	D_1	112.64	116.04	147.05	**125.24**	106.40	110.71	141.78	**119.63**
P_2	D_2	138.39	141.81	144.67	**141.62**	132.90	136.29	142.50	**137.23**
	Mean	**125.52**	**128.93**	**145.86**	**133.43**	**119.65**	**123.50**	**142.14**	**128.43**
	D_1	133.41	137.32	139.11	**136.61**	127.49	130.84	135.01	**131.11**
P_3	D_2	143.47	142.80	159.91	**148.73**	137.39	137.35	154.78	**143.17**
	Mean	**138.44**	**140.06**	**149.51**	**142.67**	**132.44**	**134.09**	**144.89**	**137.14**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	125.83	129.15	140.67	**131.88**	120.09	122.56	135.46	**126.03**
	D_2	141.12	142.79	151.33	**145.08**	136.28	138.04	148.13	**140.81**
	Mean	**133.48**	**135.97**	**146.00**	**138.48**	**128.18**	**130.30**	**141.79**	**133.42**

Comparing means	SEm	CD at 5%	SEm	CD at 5%
P	0.370	1.099	0.327	0.970
S	0.370	1.099	0.327	0.970
D	0.302	0.897	0.267	0.792
P x S	0.641	1.903	0.566	1.681
S x D	0.523	1.554	0.462	1.372
P x D	0.523	1.554	0.462	1.372
P x S x D	0.906	2.691	0.800	2.377

Table 2. Continued.

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages: 60 S_1	60 S_2	60 S_3	60 Mean	90 S_1	90 S_2	90 S_3	90 Mean
	D_1	119.91	120.23	124.42	**121.52**	114.13	114.10	118.22	**115.48**
P_1	D_2	135.05	134.90	140.81	**136.92**	129.12	128.34	135.15	**130.87**
	Mean	**127.48**	**127.56**	**132.61**	**129.22**	**121.62**	**121.22**	**126.68**	**123.18**
	D_1	100.00	106.34	135.19	**113.84**	94.58	100.93	129.56	**108.36**
P_2	D_2	125.32	129.29	138.55	**131.05**	119.75	123.74	132.55	**125.35**
	Mean	**112.66**	**117.82**	**136.87**	**122.45**	**107.17**	**112.34**	**131.06**	**116.85**
	D_1	121.98	125.31	128.01	**125.10**	116.06	118.30	121.91	**118.75**
P_3	D_2	131.86	131.94	149.26	**137.69**	125.04	125.53	143.33	**131.30**
	Mean	**126.92**	**128.63**	**138.64**	**131.39**	**120.55**	**121.91**	**132.62**	**125.03**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	113.95	117.29	129.20	**120.15**	108.25	111.10	123.22	**114.19**
	D_2	130.74	132.04	142.87	**135.21**	124.63	125.87	137.01	**129.17**
	Mean	**122.34**	**124.66**	**136.03**	**127.68**	**116.44**	**118.48**	**130.11**	**121.68**

Comparing mean	SEm	CD at 5%	SEm	CD at 5%
P	0.385	1.145	0.347	1.030
S	0.385	1.145	0.347	1.030
D	0.315	0.935	0.283	0.841
P × S	0.667	1.983	0.600	1.784
S × D	0.545	1.619	0.490	1.457
P × D	0.545	1.619	0.490	1.457
P × S × D	0.944	2.804	0.849	2.523

Table 2 Continued.

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages 120				150				180			
		S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
	D_1	106.68	107.64	112.71	**109.01**	99.22	99.90	105.62	**101.58**	91.23	91.25	96.50	**92.99**
P_1	D_2	122.78	122.61	127.71	**124.36**	113.84	114.75	119.53	**116.04**	105.44	106.81	111.08	**107.44**
	Mean	**114.73**	**115.13**	**120.21**	**116.69**	**106.53**	**107.32**	**112.58**	**108.81**	**98.33**	**99.03**	**103.29**	**100.22**
	D_1	89.30	94.99	122.55	**102.28**	81.58	87.16	114.80	**94.51**	74.32	78.59	107.35	**86.75**
P_2	D_2	113.37	116.39	125.80	**118.52**	106.47	108.95	118.53	**111.31**	95.38	101.64	110.62	**102.54**
	Mean	**101.34**	**105.69**	**124.17**	**110.40**	**94.02**	**98.05**	**116.66**	**102.91**	**84.85**	**90.11**	**108.99**	**94.65**
	D_1	109.91	110.80	115.99	**112.23**	102.48	103.31	108.55	**104.78**	93.92	95.83	99.72	**96.49**
F_3	D_2	119.79	118.50	136.03	**124.77**	111.90	110.33	128.21	**116.81**	101.53	101.52	120.33	**107.79**
	Mean	**114.85**	**114.65**	**126.01**	**118.50**	**107.19**	**106.82**	**118.38**	**110.79**	**97.72**	**98.67**	**110.02**	**102.14**
		For comparing pre-treatment (S) and drying method (D)											
	D_1	101.96	104.47	117.08	**107.84**	94.42	96.78	109.65	100.28	86.48	88.55	101.18	**92.07**
	D_2	118.65	119.16	129.84	**122.55**	110.73	111.34	122.08	114.72	100.77	103.32	113.67	**105.92**
	Mean	**110.30**	**111.82**	**123.46**	**115.19**	**102.57**	**104.06**	**115.87**	**107.50**	**93.63**	**95.93**	**107.43**	**99.001**

Comparing means	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%
P	0.446	1.326	0.510	1.515	0.601	1.787
S	0.446	1.326	0.510	1.515	0.601	1.787
D	0.364	1.083	0.416	1.237	0.491	1.459
P x S	0.773	2.297	0.883	2.624	1.042	3.095
S x D	0.631	1.875	0.721	2.142	0.851	2.527
P x D	0.631	1.875	0.721	2.142	0.851	2.527
P x S x D	1.093	3.248	1.249	3.710	1.473	4.377

Kaushal *et al.* (2013) reported similar result in colocasia leaves ; they reported that blanching leads to the loss of 20-25% ascorbic acid content in colocasia.

Chlorophyll content (mg 100 g^{-1})

The mean chlorophyll content value steadily decreased from 138.48 mg 100 g^{-1} on the initial day of storage to 99.00 mg 100 g^{-1} at 180 days of storage (Table 2). Un-blanched drumstick leaf and shoot (S_3) recorded the highest chlorophyll content 146.00 mg 100 g^{-1} (initial day of storage) to 107.43 mg 100 g^{-1} (180 days of storage) and the lowest chlorophyll content 133.48 mg 100 g^{-1} (initial day of storage) to 93.63 mg 100 g^{-1} (180 days of storage)recorded in combination of water blanched drumstick leaf and shoot (S_1).Among the plant material at initial day of storage the highest chlorophyll content 142.67 mg 100 g^{-1} (initial day of storage) to102.14 mg 100 g^{-1} (180 days of storage) recorded in the mature leaf without petiole, rachis with rachilla and leaflets (P_3) as compared to terminal young shoot (P_1) 139.36 mg 100 g^{-1} (initial day of storage) to 100.22 mg 100 g^{-1} (180 days of storage) and mature leaf with petiole and rachis 133.43 mg 100 g^{-1} (initial day of storage) to 94.65mg 100 g^{-1} (180 days of storage).The mechanical drying method (D_2) resulted in the highest chlorophyll content 145.08 mg 100 g^{-1} (initial day of storage) to 105.92 mg 100 g^{-1} as compared to sun drying method (D_1) 131.88 mg 100 g^{-1} (initial day of storage) to 92.07 mg 100 g^{-1} (180 days of storage).

The interaction between pre-treatment and drying methods, the highest chlorophyll content 151.33 mg 100 g^{-1}(initial day of storage) to 113.67 mg 100 g^{-1} (180 days of storage) recorded in un-blanched mechanical dried samples (S_3D_2) and the lowest chlorophyll content 25.83 mg 100 g^{-1} (initial day of storage) to 86.48 mg 100 g^{-1}(180 days of storage) recorded in water blanching and sun dried samples (S_1D_1). The effect of interaction between plant ma-

Table 3. Effect of pre-treatments, plant material and drying methods on Beta-carotene (mg 100 g^{-1}) of drumstick leaf and shoot powder. P_1: Terminal young shoot, P_2: Mature leaf with petiole and rachis, P_3: Mature leaf without petiole, rachis with rachilla and leaflets S_1: Water blanching, S_2: Water blanching + KMS 0.5 %, S_3: Without blanching (control), D_1: Sun drying, D_2: Mechanical drier (EZIDRI) .

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages: Initial				30			
		S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
	D_1	10.39	9.84	10.23	**10.15**	9.47	9.03	9.28	**9.26**
P_1	D_2	19.40	18.00	17.02	**18.14**	18.25	16.98	16.13	**17.12**
	Mean	**14.89**	**13.92**	**13.63**	**14.15**	**13.86**	**13.00**	**12.70**	**13.19**
	D_1	12.26	11.32	10.51	**11.36**	11.25	10.76	9.79	**10.60**
P_2	D_2	17.79	16.02	17.10	**16.97**	16.97	15.23	16.12	**16.11**
	Mean	**15.02**	**13.67**	**13.81**	**14.17**	**14.11**	**13.00**	**12.95**	**13.35**
	D_1	14.05	13.83	12.24	**13.37**	12.97	12.99	11.14	**12.37**
P_3	D_2	21.21	18.43	17.52	**19.05**	20.14	17.65	16.91	**18.23**
	Mean	**17.63**	**16.13**	**14.88**	**16.21**	**16.55**	**15.32**	**14.03**	**15.30**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	12.23	11.66	10.99	**11.63**	11.23	10.93	10.07	**10.74**
	D_2	19.46	17.48	17.21	**18.05**	18.45	16.62	16.39	**17.15**
	Mean	**15.85**	**14.57**	**14.10**	**14.84**	**14.84**	**13.77**	**13.23**	**13.95**
Comparing means		SEm		CD at 5%		SEm		CD at 5%	
P		0.112		0.333		0.099		0.295	
S		0.112		0.333		0.099		0.295	
D		0.092		0.272		0.081		0.241	
P x S		0.194		0.577		0.172		0.511	
S x D		0.159		0.471		0.140		0.417	
P x D		0.159		0.471		0.140		0.417	
P x S x D		0.275		0.816		0.243		0.722	

Table 3. Continued.

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages: 60				90			
		S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
	D_1	8.55	8.19	8.38	**8.37**	7.65	7.38	7.44	**7.49**
P_1	D_2	17.35	15.90	15.22	**16.16**	16.26	15.03	14.18	**15.15**
	Mean	**12.95**	**12.05**	**11.80**	**12.27**	**11.95**	**11.21**	**10.81**	**11.32**
	D_1	10.37	9.88	8.87	**9.70**	9.41	8.99	8.09	**8.83**
P_2	D_2	15.86	14.28	15.09	**15.08**	14.79	13.32	14.01	**14.04**
	Mean	**13.11**	**12.08**	**11.98**	**12.39**	**12.10**	**11.15**	**11.05**	**11.43**
	D_1	12.03	12.17	10.22	**11.47**	11.01	11.18	9.30	**10.50**
P_3	D_2	19.17	16.48	16.09	**17.24**	18.26	15.32	15.11	**16.23**
	Mean	**15.60**	**14.32**	**13.15**	**14.36**	**14.63**	**13.25**	**12.20**	**13.36**
		For comparing pre-treatment (S) and drying method (D)							
	D_1	10.32	10.08	9.16	**9.85**	9.36	9.18	8.27	**8.94**
	D_2	17.46	15.55	15.47	**16.16**	16.43	14.56	14.43	**15.14**
	Mean	**13.89**	**12.81**	**12.31**	**13.00**	**12.89**	**11.87**	**11.35**	**12.04**
Comparing means		SEm		CD at 5%		SEm		CD at 5%	
P		0.088		0.262		0.068		0.201	
S		0.088		0.262		0.068		0.201	
D		0.072		0.214		0.055		0.164	
P x S		0.153		0.455		0.117		0.349	
S x D		0.125		0.371		0.096		0.285	
P x D		0.125		0.371		0.096		0.285	
P x S x D		0.216		0.643		0.166		0.493	

Table 3. Continued.

Plant material (P)	Drying method (D)	Pretreatment (S) Days of storages 120 S_1	S_2	S_3	Mean	150 S_1	S_2	S_3	Mean	180 S_1	S_2	S_3	Mean
	D_1	6.92	6.64	6.93	**6.83**	5.95	5.88	6.20	**6.01**	5.20	5.19	5.23	**5.17**
P_1	D_2	15.34	14.01	13.28	**14.21**	14.53	13.02	12.40	**13.32**	13.66	12.03	11.21	**12.40**
	Mean	**11.13**	**10.33**	**10.10**	**10.52**	**9.89**	**9.45**	**9.30**	**9.66**	**9.88**	**8.61**	**8.22**	**8.75**
	D_1	8.55	8.14	7.34	**8.01**	7.82	7.63	6.69	**7.38**	6.93	6.85	5.76	**6.51**
P_2	D_2	13.72	12.36	13.06	**13.14**	12.66	11.40	11.94	**12.00**	11.85	10.40	10.88	**11.14**
	Mean	**11.13**	**10.25**	**10.20**	**10.54**	**10.24**	**9.51**	**9.37**	**9.69**	**9.19**	**8.47**	**8.32**	**8.78**
	D_1	10.13	10.35	8.47	**9.65**	9.34	9.45	7.70	**8.83**	8.36	8.57	6.76	**7.89**
P_3	D_2	17.41	14.18	14.21	**15.27**	16.45	13.38	13.35	**14.39**	15.44	13.24	12.51	**13.73**
	Mean	**13.77**	**12.27**	**11.34**	**12.46**	**12.89**	**11.42**	**10.52**	**11.61**	**11.90**	**10.90**	**9.63**	**10.81**
		For comparing pre-treatment (S) and drying method (D)											
	D_1	8.53	8.38	7.58	**8.16**	8.04	7.58	6.83	**7.48**	7.09	6.77	5.88	**6.58**
	D_2	15.49	13.52	13.52	**14.17**	14.54	12.60	12.56	**13.24**	13.55	11.89	11.63	**12.36**
	Mean	**12.01**	**10.95**	**10.55**	**11.17**	**11.29**	**10.09**	**9.70**	**10.36**	**10.32**	**9.33**	**8.76**	**9.47**

Comparing means	SEm	CD at 5%	SEm	CD at 5%	SEm	CD at 5%
P	0.068	0.203	0.083	0.245	0.107	0.318
S	0.068	0.203	0.083	0.245	0.107	0.318
D	0.056	0.165	0.067	0.200	0.088	0.260
P x S	0.118	0.351	0.143	0.425	0.186	0.552
S x D	0.096	0.287	0.117	0.347	0.152	0.450
P x D	0.096	0.287	0.117	0.347	0.152	0.450
P x S x D	0.167	0.496	0.202	0.600	0.263	0.780

terial, pre-treatment and drying method, the highest chlorophyll content 159.91 mg 100 g^{-1}(initial day of storage) to 120.33 mg 100 g^{-1} (180 days of storage) recorded in the treatment combination of un-blanched mature leaf without petiole, rachis with rachilla and leaflets with mechanical drier ($P_3S_3D_2$), whereas the lowest chlorophyll content 112.64 mg 100 g^{-1} (initial day of storage) to 74.32 mg 100 g^{-1} (180 days of storage) recorded in the treatment combination of water blanched sun dried mature leaf with petiole

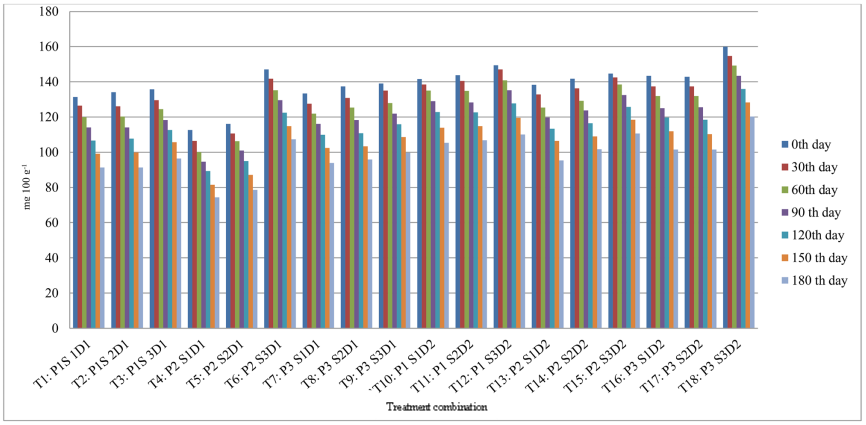

Fig. 1. Effect of pre-treatments, plant material and drying methods onchlorophyll content (mg 100 g-1) of drumstick leaves and shoot.

and rachis ($P_2S_1D_1$).

During drying and pre-treatment, the chlorophyll content molecules were degraded to pyropheophytin and pheophytin. Therefore, at higher temperatures greenness reduced. Thus, visually, dark green color of the leaf turned into dull green yellow. Similar observations were reported by Ali *et al.* (2014).

Kaushal *et al*. (2013) reported that blanching leads to the loss of chlorophyll content from colocasia, but the use of EDTA, magnesium oxide will help in retention of chlorophyll during the blanching.

β -carotene content (mg 100 g^{-1})

The mean β-carotene content (mg 100 g^{-1}) steadily decreased from 14.84 mg 100 g^{-1} on the initial day of storage to 9.47 mg 100 g^{-1} at 180 days of storage (Tables 2 and 3) (Fig. 1).The water blanched drumstick leaf and shoot (S_1) recorded the highest β-carotene content 15.85 mg 100 g^{-1}(initial day of storage) to10.32 mg 100 g^{-1} (180 days of storage) and the lowest β-carotene content 4.10 mg 100 g^{-1} (initial day of storage) to 8.76 mg 100 g^{-1} (180 days of storage) recorded in combination of un-blanched drumstick leaf and shoot (S_3). Among the plant material, the highest β-carotene content 16.21 mg 100 g^{-1} (initial day of storage) to 10.81 mg 100 g^{-1} (180 days of storage) recorded in the mature leaf without petiole, rachis with rachilla and leaflets (P_3) as compared to mature leaf with petiole and rachis (P_2) 14.17 mg 100 g^{-1} (initial day of storage) to 8.78 mg 100 g^{-1} (180 days of storage) and terminal young shoot (P_1) 14.15 mg 100 g^{-1} (initial day of storage) to 8.75 mg 100 g^{-1} (180 days of storage). The mechanical drying method (D_2) resulted in the highest β-carotene content (18.05 mg 100 g^{-1} (initial day of storage) to 12.36 mg 100 g^{-1} (180 days of storage) as compared to sun drying method (D_1) (11.63 mg 100 g^{-1} (initial day of storage) to 6.58 mg 100 g^{-1} (180 days of storage).

The interaction between pre-treatment and drying methods, the highest β-carotene content 19.46 mg 100 g^{-1}(initial day of storage) to13.55 mg 100 g^{-1} (180 days of storage) recorded in water blanched mechanical dried samples (S_1D_2) and the lowest β-carotene content 10.99 mg 100 g^{-1} (initial day of storage) to 5.88 mg 100 g^{-1} (180 days of storage) recorded in un-blanched and sun dried samples (S_3D_1).The effect of interaction between plant material, pre-treatment and drying method, maximum β-carotene content 21.21 mg 100 g^{-1} (initial day of storage) to 15.44 mg 100 g^{-1}(180 days of storage) recorded in the treatment combination of water blanched mature leaf without petiole, rachis with rachilla and leaflets in mechanical drier ($P_3S_1D_2$), whereas minimum β-carotene content 9.84 mg 100 g^{-1} (initial day of storage) to 5.19 mg 100 g^{-1}(180 days of storage) recorded in the treatment combination of water blanching with 0.5% KMS and sun dried terminal young shoot ($P_1S_2D_1$).

Beta-carotene content in blanched leaf significantly higher it might be because β-carotene content heat stable and therefore not destroyed by most of blanching methods with short time period. Similar results were also reported by Titi *et al.* (2013). Olabode *et al.* (2015) reported that as the temperature increased, there significant reduction in the β-carotene scomposition of moringa leaves. Similar results were also reported by Derossi *et al.* (2011).

CONCLUSION

Water blanched sample recorded the highest beta-carotene content and un-blanched plant materials (S_3) recorded the highest ascorbic acid and chlorophyll content. Mature leaf without petiole, rachis with rachilla and leaflets (P_3) recorded the best among the plant material for retention of chlorophyll, β-carotene and ascorbic acid observed maximum in mature leaf with petiole and rachis. Mechanical drier was the best for retaining of the all above nutrients. In interaction un-blanched mechanical dried samples (S_3D_2) recorded the best in retaining ascorbic acid, chlorophyll content and β-carotene content observed maximum in water blanched mechanical (S_1D_2) dried drumstick leaves and shoot during storage period.

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