Journal of the Andaman Science Association Vol. 27 (Special issue):88-94 (2022)
ISSN 0970-4183, Printed in India

Sensory Quality of Moringa Leaf Powder as Affected by Different Drying Methods and Packaging Material

V. Sudha Vani*, G. Gnana Deepika, P. Vinayakumar Reddy, C.P. Viji, R.V. Sujatha and T. Tejaswini
College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem-534101, Andhra Pradesh
***Corresponding author's E-mail:** vani.sudha2014@gmail.com*

Abstract

The present experiment was conducted at Post Harvest Technology Laboratory, College of Horticulture, Dr. Y.S.R. Horticultural University, Andhra Pradesh in a Completely Randomized Factorial Design with two factors at unequal levels, replicated thrice. Moringa leaves were dried by using different drying methods *viz.* sun drying, solar drying, tray drying, vacuum drying and freeze drying. These dried powders were packed in three different packaging materials *viz.* PET bottles, aluminium pouches and LDPE (200 gauge) pouches to know their suitability in retention of quality. Using the moringa leaf powder obtained from different drying methods, moringa tea was prepared and evaluated for sensory qualities at 30 days interval up to 90 days of storage period. Sensory scores were obtained for colour, aroma, taste, mouthfeel and overall acceptability. Moringa tea prepared from freeze dried leaf powder (D_5) recorded highest acceptability scores for colour (6.67), aroma (7.12), taste (7.34), mouthfeel (7.18) and overall acceptability (7.47), whereas the lowest score (6.30) for astringency was recorded in moringa tea prepared from sun dried (D_1) leaf powder.

Key words: *Moringa tea, Organoleptic evaluation, overall acceptability, storage*

Introduction

Drumstick (*Moringa oleifera*) is an underexploited perennial vegetable species of Moringaceae family, native to the Sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Makkar and Becker, 1997). This fast growing tree is also known as the moringa, horseradish tree, benzolive tree, or ben oil tree. It is a perennial softwood tree and it has been suggested for medicinal and industrial uses. Moringa is one of the world's most nutritious crops and its leaves have been reported to possess various bioactive compounds such as phenols, flavonoids, tannins, saponins *etc*. (Vergara-Jimenez et al*.,* 2017). Moringa leaf products especially leaf powder is gaining popularity in the recent past due to outstanding nutritive value and traditional preference. Moringa leaves help in protecting the liver, nourishing skin and hair, fighting against bacterial diseases and are reported to have high antioxidant capacity (Siddhuraju and Becker, 2003). With the above background, an investigation on different drying methods and packaging materials on the sensory quality of moringa tea was taken up.

Materials and methods

The present investigation was carried out during November 2020 to April 2021 at Post Harvest Laboratory, College of Horticulture, Dr. Y.S.R Horticultural University, Venkataramannagudem, Andhra Pradesh. The experiment was conducted in Completely Randomized Factorial Design with two factors at unequal levels, each replicated thrice. Moringa variety PKM-1 was used for the experimental studies. Leaves were dried using different methods *viz.* sun drying (D_1), solar drying (D_2), tray drying (D_3), vacuum drying (D_4) and freeze drying (D) (Fig. 1). The produce obtained from these treatments were packed using three packaging materials namely PET bottles (P_1), Aluminium pouches (P_2) and LDPE (200 gauge) polybags (P_3). The packed product was stored up to 90 days at ambient temperature.

Using the moringa leaf powder obtained from different drying methods, moringa tea was prepared using honey and lemon and evaluated for sensory qualities. Sensory scores were obtained for colour, aroma, taste, mouthfeel and overall acceptability. The scores were provided based on hedonic scale 9- like extremely, 8- like very much, 7-

like moderately, 6- like slightly, 5- neither like or dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely (Ranganna, 1995). The data were analysed using the standard statistical procedures for factorial experiments.

Results and discussion

Colour

Drying methods and packaging material had profound influence on the colour of the tea prepared from moringa leaf powder at 0, 30, 60 and 90 days after storage (Table 1). The freeze dried moringa leaf powder (D_5) had the highest scores for colour (8.11) and significant reduction in colour was observed from initial day of storage to 90 days after storage (6.67). Better retention of colour may be attributed to the low temperatures involved in freeze drying process, when compared with other drying methods studied. This was followed by vacuum dried leaf powder (D_4) in which the initial score was 7.55 and it was reduced to 6.32 after 90 days of storage. In this case also, lower temperature of 40 ºC was employed during drying process and hence better retention of colour was as expected. The least acceptable colour was recorded in sun dried moringa leaf powder (D_1) from initial day of storage (6.44). Score in this case was reduced to 5.35 after 90 days of storage. The results are in accordance with earlier reports by Magdalini et al. (2008) in dehydrated products and Sravankumar et al. (2014) in hibiscus leaves. On the contrary, tea prepared from other drying methods received lower score from the judges due to the fading of colour as a result of high temperatures employed in drying process.

Table 1. Effect of different drying methods and packaging materials on colour of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging material (P) Days of storage															
	Initial(0 day)				30days				60days				90days			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	6.20	7.21	5.93	**6.44**	5.85	7.03	5.76	**6.21**	5.36	6.43	5.33	**5.71**	5.00	6.16	4.90	**5.35**
D_2	7.46	7.92	7.22	**7.53**	7.13	7.36	7.06	**7.18**	6.70	7.06	6.23	**6.66**	6.16	6.40	6.00	**6.18**
D_3	7.35	7.59	6.76	**7.24**	6.40	7.53	6.13	**6.68**	5.93	6.90	5.83	**6.22**	5.73	6.16	5.43	**5.77**
D_4	7.43	7.83	7.40	**7.55**	7.16	7.66	6.86	**7.23**	6.43	7.20	6.33	**6.65**	6.10	6.80	6.06	**6.32**
D_5	8.33	8.33	7.66	**8.11**	7.76	8.33	7.50	**7.86**	7.40	7.60	7.20	**7.40**	6.80	6.92	6.30	**6.67**
Mean	**7.35**	**7.78**	**6.99**	**7.37**	**6.86**	**7.58**	**6.66**	**7.03**	**6.36**	**7.04**	**6.18**	**6.52**	**5.96**	**6.49**	**5.74**	**6.05**
Comparing means	**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**	
(D)	**0.226**		**0.773**		**0.259**		**0.753**		**0.188**		**0.546**		**0.138**		**0.401**	
(P)	**0.206**		**NS**		**0.201**		**0.583**		**0.146**		**0.423**		**0.107**		**0.311**	
Interaction (D×P)	**0.461**		**NS**		**0.449**		**0.301**		**0.326**		**0.223**		**0.240**		**0.121**	

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1:PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Among packaging materials at 30, 60 and 90 days after storage, the highest colour score was recorded in leaf powder packed in aluminium pouches (P_2) from 30 days (7.58), which reduced 6.49 after 90 days of storage. It was followed by leaf powder packed in PET bottles (P_1) from 30 days (6.86), which reduced to 5.96 after 90 days of storage. The lowest colour score was recorded in leaf powder packed in LDPE 200 gauge polybags at 30 days (6.66) and 90 days after storage (5.74). During the storage, the colour scores decreased, irrespective of packaging material due to exposure of the product to light, when stored at ambient condition.

Aroma

Significant differences in scores of aroma were recorded among drying and packaging treatments studied at 0, 30, 60 and 90 days of storage (Table 2). On all the days of storage, the highest aroma score was recorded in

freeze dried moringa leaf powder (D_5). In the freshly dried produce, the score of 8.00 was recorded in this treatment, which reduced with storage duration to 7.12 after 90 days. These values were on par with vacuum dried leaf powder (D_4) in which the aroma score of 7.77 was recorded at 0 days of storage and it was reduced to 6.98 after 90 days. Like the scores observed for colour parameter, least acceptable score for aroma was recorded in sun dried leaf powder (D_1) on the initial day of storage (6.57). The score in sun dried sample dropped to 6.05 after 90 days of storage. No significant difference was observed among packaging materials till the end of storage period. The interaction effect was also found to be non-significant during the storage.

Table 2.Effect of different drying methods and packaging materials on aroma of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging material (P)															
	Days of storage															
	Initial (0 day)				Initial (30 day)				Initial (60 day)				Initial (90 day)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	7.35	6.30	6.06	**6.57**	7.21	6.20	5.93	**6.44**	6.80	6.10	5.83	**6.24**	6.63	5.90	5.63	**6.05**
D_2	7.63	8.06	7.30	**7.66**	7.46	7.92	7.22	**7.53**	7.20	7.70	7.02	**7.31**	7.00	7.12	6.71	**6.94**
D_3	7.76	6.96	7.43	**7.38**	7.59	6.76	7.35	**7.24**	7.33	6.53	7.15	**7.00**	7.03	6.26	6.84	**6.71**
D_4	7.66	7.66	8.00	**7.77**	7.43	7.40	7.83	**7.55**	7.06	7.16	7.46	**7.23**	6.93	6.90	7.13	**6.98**
D_5	7.33	8.33	8.33	**8.00**	7.20	8.13	8.13	**7.82**	6.83	7.83	7.83	**7.50**	6.50	7.43	7.43	**7.12**
Mean	**7.55**	**7.46**	**7.42**	**7.47**	**7.38**	**7.28**	**7.29**	**7.31**	**7.04**	**7.06**	**7.06**	**7.05**	**6.82**	**6.72**	**6.75**	**6.76**
Comparing means	**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**	
(D)	**0.268**		**0.779**		**0.267**		**0.775**		**0.259**		**0.752**		**0.240**		**0.697**	
(P)	**0.208**		**NS**		**0.207**		**NS**		**0.201**		**NS**		**0.186**		**NS**	
Interaction (D×P)	**0.465**		**NS**		**0.462**		**NS**		**0.449**		**NS**		**0.416**		**NS**	

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1: PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Taste

The results pertaining to effect of drying methods and packaging material on taste of the moringa tea at initial, 30, 60 and 90 days after storage are presented in Table 3. Irrespective of the drying/ packaging treatment, the scores for taste decreased with storage duration. On all the days of storage, the highest taste score was recorded in freeze dried moringa leaf powder (D_5) on the initial day of storage (7.88) and with passage of time, the scores were reduced to 7.34 after 90 days of storage. This treatment was on par with vacuum dried leaf powder (D_4) in which the scores of 7.72 and 7.01 were recorded after 0 and 90 days of storage, respectively. The least acceptable score was observed in tray dried (D_3) leaf powder in which mean score of 6.70 was recorded on the initial day of storage.

In case of packaging material, the highest taste score was recorded in leaf powder packed in aluminium pouches (P_2) after 30 days (7.47), which reduced to 7.10 after 90 days of storage. This was followed by powder packed in PET bottles (P_1) in which scores of 7.09 and 6.74 were recorded after 30 and 90 days of storage, respectively. The lowest taste scores of 6.61 and 6.27 were recorded in leaf powder packed in LDPE polybags (P_3) after 30 and 90 days, respectively. Interaction effect was found to be non-significant on all the days of storage. The taste was superior in the freeze dried samples which may be due to the superior aroma and better retention of all the nutrients.

Mouthfeel

Mouthfeel of the moringa tea prepared from leaves dried using different drying methods and packaging material was significantly influenced during storage (Table 4). The mean acceptability scores for mouthfeel decreased steadily during the storage period from 7.44 (30 days) to 6.76 (90 days). The highest score for mouthfeel

was recorded in freeze dried moringa leaf powder (D_5) on the initial day of storage (8.07), which dropped to 7.18 at 90 days after storage. This treatment did not differ significantly with vacuum drying (D_4). In vacuum dying, the mean score for mouth feel reduced from 7.77 to 7.23 after 0 and 90 days of storage. The least acceptable score was recorded in sun dried sample (D_1) on initial day of storage (6.77) and 90 days after storage (6.13). Among different packaging materials no significant difference was observed till the end of storage. The interaction effect was also found to be non-significant on all the days of storage.

Table 3. Effect of different drying methods and packaging materials on taste of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging materials (P)															
	Days of storage															
	Initial (0 day)				30 days				60 days				90 days			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	7.50	6.46	7.06	**7.01**	6.83	7.23	6.20	**6.75**	6.63	7.10	6.06	**6.60**	6.50	6.93	5.90	**6.44**
D_2	7.00	6.96	7.66	**7.21**	6.80	7.46	6.80	**7.02**	6.60	7.20	6.56	**6.78**	6.43	7.00	6.36	**6.60**
D_3	6.80	7.10	6.20	**6.70**	6.50	6.86	5.96	**6.44**	6.31	6.70	5.80	**6.27**	6.24	6.56	5.63	**6.14**
D_4	6.83	8.33	8.00	**7.72**	7.60	8.00	6.63	**7.41**	7.36	7.73	6.43	**7.17**	7.23	7.53	6.26	**7.01**
D_5	8.00	8.00	7.66	**7.88**	7.73	7.81	7.49	**7.67**	7.53	7.64	7.38	**7.52**	7.33	7.47	7.21	**7.34**
Mean	**7.22**	**7.37**	**7.32**	**7.30**	**7.09**	**7.47**	**6.61**	**7.05**	**6.89**	**7.27**	**6.44**	**6.86**	**6.74**	**7.10**	**6.27**	**6.70**

Comparing means	SEm±	CD@5%	SEm±	CD@5%	SEm±	CD@5%	SEm±	CD@5%
(D)	**0.265**	**0.770**	**0.262**	**0.761**	**0.261**	**0.757**	**0.262**	**0.760**
(P)	**0.205**	**NS**	**0.203**	**0.590**	**0.202**	**0.587**	**0.203**	**0.589**
Interaction (D×P)	**0.450**	**NS**	**0.454**	**NS**	**0.452**	**NS**	**0.454**	**NS**

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1: PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Table 4. Effect of different drying methods and packaging materials on astringency of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging materials (P)															
	Days of storage															
	Initial (0 day)				Initial (30 day)				Initial (60 day)				Initial (90 day)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	7.21	6.36	6.40	**6.66**	7.11	6.26	6.26	**6.54**	6.96	6.16	6.10	**6.41**	6.86	6.03	6.00	**6.30**
D_2	7.63	6.83	7.49	**7.31**	7.52	6.73	7.30	**7.18**	7.30	6.60	7.13	**7.01**	7.16	6.46	7.00	**6.87**
D_3	7.46	7.53	7.96	**7.65**	7.30	7.53	7.80	**7.54**	7.16	7.33	7.63	**7.37**	7.06	7.23	7.53	**7.27**
D_4	7.43	8.15	8.15	**7.91**	7.26	8.01	8.04	**7.77**	7.06	7.78	7.80	**7.55**	6.96	7.40	7.66	**7.34**
D_5	7.50	8.09	7.22	**7.60**	7.40	7.93	7.03	**7.45**	7.13	7.73	6.83	**7.23**	7.03	7.63	6.73	**7.13**
Mean	**7.44**	**7.39**	**7.44**	**7.42**	**7.32**	**7.29**	**7.28**	**7.30**	**7.12**	**7.12**	**7.10**	**7.11**	**7.02**	**6.95**	**6.98**	**6.98**

Comparing means	SEm±	CD@5%	SEm±	CD@5%	SEm±	CD@5%	SEm±	CD@5%
(D)	**0.237**	**0.687**	**0.234**	**0.678**	**0.234**	**0.680**	**0.240**	**0.695**
(P)	**0.183**	**NS**	**0.181**	**NS**	**0.181**	**NS**	**0.186**	**NS**
Interaction (D×P)	**0.410**	**NS**	**0.405**	**NS**	**0.406**	**NS**	**0.415**	**NS**

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1: PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Table 5. Effects of different drying methods and packaging materials on mouth feel of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging materials (P)															
	Days of storage															
	Initial (0 day)				Initial (30 day)				Initial (60 day)				Initial (90 day)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	7.66	6.66	6.00	**6.77**	7.40	6.43	5.85	**6.56**	7.30	6.26	5.71	**6.42**	6.86	5.96	5.57	**6.13**
D_2	7.50	8.16	7.66	**7.77**	7.33	7.96	7.46	**7.58**	7.16	7.81	7.32	**7.43**	6.96	7.62	7.10	**7.23**
D_3	7.83	6.40	6.66	**6.96**	7.60	6.13	6.40	**6.71**	7.13	5.96	6.68	**6.59**	6.76	5.76	6.28	**6.27**
D_4	7.33	8.00	7.66	**7.66**	6.80	7.73	7.36	**7.30**	6.60	7.63	7.16	**7.13**	6.30	7.43	7.26	**7.00**
D_5	7.50	8.40	8.33	**8.07**	7.20	8.10	8.10	**7.80**	7.00	7.93	7.90	**7.61**	6.46	7.66	7.43	**7.18**
Mean	**7.56**	**7.52**	**7.26**	**7.44**	**7.26**	**7.27**	**7.03**	**7.19**	**7.04**	**7.12**	**6.95**	**7.03**	**6.67**	**6.89**	**6.73**	**6.76**
Comparing means	**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**	
(D)	**0.323**		**0.937**		**0.300**		**0.872**		**0.284**		**0.825**		**0.286**		**0.831**	
(P)	**0.250**		**NS**		**0.233**		**NS**		**0.220**		**NS**		**0.222**		**NS**	
Interaction (D×P)	**0.259**		**NS**		**0.520**		**NS**		**0.492**		**NS**		**0.496**		**NS**	

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1: PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Table 6. Effect of different drying methods and packaging materials on overall acceptability of moringa tea over the storage period of 90 days

Drying methods (D)	Packaging materials (P)															
	Days of storage															
	Initial (0 day)				Initial (30 day)				Initial (60 day)				Initial (90 day)			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
D_1	7.35	6.96	6.40	**6.90**	7.18	6.79	6.16	**6.71**	7.00	6.50	6.01	**6.50**	6.93	6.40	5.83	**6.38**
D_2	7.63	8.06	7.36	**7.68**	7.40	7.89	7.27	**7.52**	7.18	7.63	7.13	**7.31**	6.96	7.49	7.01	**7.15**
D_3	7.76	6.96	7.43	**7.38**	7.59	6.76	7.29	**7.21**	7.43	6.50	6.86	**6.93**	7.30	6.40	6.73	**6.81**
D_4	7.66	8.00	8.26	**7.97**	7.53	7.76	8.02	**7.77**	7.16	7.50	7.74	**7.47**	7.03	7.33	7.63	**7.33**
D_5	7.66	8.66	8.33	**8.22**	7.26	8.46	8.10	**7.94**	6.83	8.10	7.80	**7.57**	6.73	8.00	7.70	**7.47**
Mean	**7.61**	**7.73**	**7.56**	**7.63**	**7.39**	**7.53**	**7.37**	**7.43**	**7.12**	**7.24**	**7.11**	**7.15**	**6.99**	**7.12**	**6.98**	**7.03**
Comparing means	**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**		**SEm±**		**CD@5%**	
(D)	**0.235**		**0.681**		**0.227**		**0.658**		**0.222**		**0.644**		**0.220**		**0.642**	
(P)	**0.182**		**NS**		**0.176**		**NS**		**0.172**		**NS**		**0.171**		**NS**	
Interaction (D×P)	**0.407**		**NS**		**0.393**		**NS**		**0.384**		**NS**		**0.383**		**NS**	

Drying methods: D_1: Sun drying, D_2: Solar drying, D_3: Tray drying, D_4: Vacuum drying, D_5: Freeze drying Packaging materials: P_1: PET bottle, P_2: Aluminium pouch, P_3: LDPE (200 gauge)

Astringency

The data pertaining to effect of drying methods and packaging material on astringency scores of moringa tea at initial, 30, 60 and 90 days after storage are presented in Table 5. The least score for astringency was recorded in sun dried moringa leaf powder (D_1) from initial day of storage (6.66) to 90 days after storage (6.30). The highest score was recorded in vacuum dried moringa leaf powder (D_4) from initial day of storage (7.91) to 90 days after storage (7.34). This was on par with tray dried sample (D_3) with mean scores of 7.65 and 7.27 scores at 0 and 90 days, respectively followed by freeze dried leaf powder (D_5). No significant difference in astringency scores among packaging materials and the interaction effect was recorded during 90 days of storage.

Overall acceptability

Data related to the effect of different drying methods and packaging material on overall acceptability scores of moringa tea during storage period has been presented in Table 5. Throughout the storage period, the highest score of overall acceptability was recorded in moringa tea prepared from freeze dried sample (D_5). On the initial day of storage the score in freeze dried sample was 8.22, which reduce to 7.47 after 90 days of storage. No significant difference in overall acceptability scores among the packaging materials and the interaction effect was recorded during the storage period. Overall acceptability score had decreased during storage due to change in chemical composition of the product and loss of colour and flavour. These kind of observations were recorded by Singh et al. (2006).

The highest overall acceptability recorded for moringa tea prepared from freeze dried leaf powder might be due to the retention of more nutrient content, balance of the taste, aroma and colour, mouth feel and astringency. The main advantage of freeze drying is that it results in products that appear almost like the fresh. Physically, retention of original texture, structure and highly volatile components (responsible for aroma) has been reported in freeze dried food products (Chen et al. 2000). The least acceptable score (6.90) was recorded in sun dried leaf powder (D_1) on the initial day of storage, which dropped to 6.38 after 90 days of storage. Lower acceptability score was recorded in moringa tea prepared from sun dried leaf powder which might be due to its less acceptable taste and aroma.

Conclusion

Organoleptic evaluation of moringa tea prepared from leaves dried using different drying methods and stored in different packaging material was carried out. Moringa tea prepared from freeze dried leaf powder (D_5) recorded the highest acceptability scores for colour (6.67), aroma (7.12), taste (7.34), mouthfeel (7.18) and overall acceptability (7.47) whereas the lowest score (6.30) for astringency was recorded in moringa tea prepared from sun dried (D_1) leaf powder. The most effective method for drying moringa leaves was freeze drying. An overall recommendation of drying of moringa leaves by the freeze drying method based on the results is not possible due to requirement of high cost and skill. The initial cost of equipment, electrical energy consumption and equipment maintenance are relatively higher than those for other drying methods. Alternatively, cost effective method of drying moringa leaves in vacuum drier and packing in LDPE 200 gauge polybags is recommended.

References

Chen, W., Karen, L.B.G. & Smithey, S. (2000). The effects of different freeze-drying processes on the moisture content, colour, and physical strength of roses and carnations. Sci. Hortic. 84:321-332.

Magdalini, K.K., Zacharias, B.M.& George, D.S. (2008). Effect of the method of drying on the colour of dehydrated products. J. Food Sci. Technol. 56(1):53-59.

Makkar, H.P.S. & Becker, K. (1997). Nutrients and anti-quality factors in different morphological parts of the *Moringa oleifera* tree. J. Agric. Sci. 128(3):311-322.

Rangana, S. (1995). Handbook of analysis and quality control for fruit and vegetable products. New Delhi, India: Tata McGraw Hill Publishing Company Limited.

Siddhuraju, P. and Becker, K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera*) leaves. J. Agric. Food Chem. 51(8):2144-2155.

Singh, U., Sagar, V.R. & Behera, T.K. (2006). Effect of drying conditions on the quality of dehydrated selected leafy vegetables. J. Food Sci. Technol. 43(6):579-582.

Sravankumar, S., Manoj, P., Nandini, P. and Giridhar, P. (2014). Effect of drying methods on chlorophyll, ascorbic acid, and antioxidant activity compounds retention of leaves of Hibiscus. J. Sci. Food Agri. 95(9):1812-1820.

Vergara-Jimenez, M., Almatrafi, M.M. & Fernandez, M.L. (2017). Bioactive components in *Moringa oleifera* leaves protect against chronic diseases. Antioxidants 6(91):1-13. DOI:10.3390/antiox6040091.

Received: 28th July, 2022 **Accepted: 20th December, 2022**