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RESEARCH PAPER

Studies on Fresh Processing of *Moringa oleifera* Leaves

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Abstract

Minimal processing adds to convenience of consumption and marketing of fruits and vegetables suitable for retail markets. In the present study, an attempt has been made to freshly process and pack *Moringa oleifera* leaves in different packaging materials and storage conditions as a convenience product. Freshly harvested *Moringa* leaves were stripped in a mechanical stripper to remove the leaflets from the branches, washed in chlorinated water, surface dried and packed in different packaging materials viz., LDPE (40 micron), LDPE (80 micron), Polypropylene (40 micron), Polypropylene (60 micron), at different levels of ventilation (0, 1% & 2%) and kept for storage under ambient (29±33 °C, 50-70% RH) and refrigerated (5±2 °C, 90-95% RH) conditions. The physiological changes based on Weight Loss, % wilting and the changes in the nutrient content (chlorophyll, vitamin C, vitamin A & Iron) were periodically analysed during storage. The study revealed that packaging treatment with Polypropylene 40 micron at 1% vent was found to be the best for freshly processed *Moringa* leaves under ambient conditions and LDPE 80 micron with 1% vent was found to be best for refrigerated storage. Quality analysis revealed that there was not much difference in the nutrient content of *Moringa* leaves except for ascorbic acid content during storage.

Keywords: *Moringa* leaves, fresh processing, packaging, storage, colour, quality

Green leafy vegetables are rich sources of vitamins, viz., vitamin A, vitamin B, vitamin C, minerals viz., iron, calcium, folic acid and appreciable amounts of other minerals. These leafy vegetables are relatively less expensive, easy to cook and rich in several nutrients especially β-carotene and iron which are essential for human health. *Moringa oleifera* leaves commonly known as drumstick leaves is one of the widely consumed green leafy vegetables in India, Sri Lanka and the African countries. It belongs to the family, Moringaceae and is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. India is the largest producer of *Moringa* in an area of 38,000 ha. (Rajangam *et al.* 2001). Of all the parts, the leaves are extensively used. The alternate, twice or thrice pinnate leaves grow mostly at the branch tips. They are 20-70 cm long, grayish-downy when young, having long petiole with 8-10 pairs of pinnae each bearing two pairs of opposite, elliptic or obovate leaflets and one at the apex, all 1-2 cm long; with glands at the bases of the petioles and pinnae (Morton, 1991). The leaves are consumed either green, as a vegetable or dried, as a potherb.

Consumption of green leafy vegetables has found to decline over the past years due to the time intense process viz., sorting, stripping (as in the case of *Moringa* leaves) and washing. This has directly been related to the less consumption of micronutrients which is found in abundance in greens. In such a situation, it is essential to encourage the consumption of green leafy vegetables to alleviate the deficiency in micronutrient and to attain security. This could be achieved by making them available in ready to cook or use form, by minimal processing or light

processing or partial processing which are gaining importance to satiate the demand of high quality and convenience foods to the consumer. Minimal or lightly processed operations have been defined as those procedures such as washing, sorting, trimming, peeling, slicing or chopping that doesn't affect the freshness of vegetables (Kaur and Kapoor, 2000). Pre-Packaging helps in easy handling of food products in the retail market. Appropriate packaging conditions viz., type of material, vent area aids in maintaining the product's quality, thus extending the shelf life of the packed produce.

Fresh *Moringa* leaves when kept in the open atmosphere lose their freshness due to wilting by evaporation of moisture. Processing of *Moringa* leaves in its fresh form and pre-packaging in appropriate package would extend the shelf life, making it available in a ready to use form. The present study was taken up to freshly process and pre-pack the *Moringa* leaves as a ready to cook product which eliminates the time and drudgery involved in cleaning the leaves, thereby increasing the consumption of greens in human diet.

MATERIALS AND METHODS

Sample preparation

Fresh *Moringa* leaves, PKM-1 variety harvested from farmer's field were first stripped in a mechanical stripper to remove the leaflets. They were then washed in water containing Sodium hypochlorite at 100 ppm concentration for 1 minute (Luo *et al.* 2004). The washed leaves were spread on a clean surface to remove the excess moisture. This step plays a substantial role in removal of dust, pathogens as well as microbes present on the leave's surface.

Pre Packaging of fresh *Moringa* leaves

The stripped and washed leaves were then packed in LDPE (40 micron), LDPE (80 micron), Polypropylene (40 micron), Polypropylene (60 micron) bags of size 22.5 × 15 cm, with levels of ventilation as 0 % (no holes), 1% (2 holes) , 2% (3 holes). The packed samples were kept for storage under ambient (29±33 °C, 50-70% RH) and refrigerated (5±2 °C, 90-95% RH) conditions.

Physiological properties of *Moringa* leaves

The Physiological Weight Loss (PWL) of the freshly processed *Moringa* leaves in different packaging treatments and storage condition was observed daily by weighing the packaged leaves in an electronic balance (BL 220H) of 0.01 accuracy. The initial and final weight of the leaves was recorded and the percentage loss in weight was calculated. Decay percentage was measured in terms of rotten leaves present in the sample. The extent of wilting was determined by weighing the amount of leaves that wilted from the stored sample. Colour value, "L", "a" and "b" of freshly processed and dry processed *Moringa* leaves was found using Colour Flex meter (Make: Hunter Lab, Model: 45°/0°)

Nutrient Analysis of *Moringa* leaves

Ascorbic acid in the sample was estimated by titration method described by Srivastava (1998). Beta Carotene in the leaves sample was estimated by acetone extraction and measuring the OD at 452 nm (Srivastava, 1998). The chlorophyll content in *Moringa* leaves was estimated according to the standard procedure (Srivastava, 1998). Iron present in the sample was estimated by ashing and measuring the absorbance at 510 nm as per the procedure in FSSAI Manual, 2012.

Statistical Analysis

The experiment was designed in a Completely Randomised Design with three replications. The effect of packaging on the quality of freshly processed *Moringa* leaves was statistically analysed, using ANOVA at $p \leq 0.05$ and the significant effects further evaluated using AGRES software.

RESULTS AND DISCUSSION

Effect of packaging on Physiological Weight Loss of freshly processed *Moringa* leaves during storage

Freshly harvested fruits and vegetables carry out respiration and transpiration that leads to Physiological Weight Loss (PWL). The effect of

packaging on PWL of fresh *Moringa* leaves stored under ambient conditions is presented in Table 1.

Generally physiological weight loss increased with increase in storage time both under ambient and refrigerated storage conditions.

From Table 1, it could be seen that the packaging treatments significantly influenced the PWL throughout the storage period. Despite the packaging films, there was significant increase in Physiological Weight Loss of samples with the increase in vent % ($P<0.05$) compared to the samples with no ventilation. Increase in PWL % and shrinkage in control sample were observed by Deepak Patel, (2011) on packaging studies with guava. The reduction in weight loss by non ventilated polyethylene could be attributed to the reason that polyethylene bags act as a barrier for moisture loss by creating high humidity in the vicinity of the samples and thereby retarding the moisture loss through transpiration. As in the case of decay, the leaves packed in packaging materials with no vents and 1% vent for LDPE films showed negligible percentage of decay on the second day of storage. This may be due to the reason of built up of heat inside the packages due to respiration by the samples which could also be influenced by the permeability of the films. Similarly, wilting was observed on the second day of storage in all the packaging materials with 2% vent. Similar results with polypropylene 40 micron were obtained by (Jyothi, 2010) for Shepu leaves stored at ambient conditions. Low density polyethylene (PE) film is generally used for packing fresh vegetables and fruit owing to its high permeability and softness compared with high density polyethylene film (Somjate, 2006).

The effect of storage at refrigerated condition on fresh *Moringa* leaves in different packaging materials is presented in Table 2.

The Physiological Weight Loss increased in a slow phase due to less respiration under controlled condition. The PWL of all the samples were measured every alternate day under refrigerated storage. There was significant increase ($p<0.05$) in PWL of ventilated samples compared to non ventilated samples at the end of storage. *Moringa* leaves stored under refrigerated condition showed decreased PWL due to slowing of enzymatic and respiratory activity and thereby reduced water loss (Ladaniya, 1999). In comparison with Polypropylene, LDPE showed decreased PWL

Table 1: Effect of packaging on PWL of freshly processed *Moringa* leaves under ambient condition

Packaging material	Packaging vent, %	% PWL		%Decay		%Wilt	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
LDPE-40 micron	0	1.197±0.002	2.260±0.05	—	0.2	—	—
	1	1.685±0.002	2.383±0.01	—	0.15	—	—
	2	3.131±0.03	4.130±0.02	—	—	—	0.15
LDPE-80 micron	0	0.255±0.02	0.783±0.02	—	0.21	—	—
	1	0.84±0.01	1.986±0.005	—	0.20	—	—
	2	2.387±0.003	4.136±0.04	—	—	—	0.12
PP- 40 micron	0	0.958±0.05	1.452±0.02	—	0.12	—	—
	1	1.139±0.02	2.661±0.05	—	—	—	—
	2	3.553±0.02	5.118±0.02	—	—	—	0.05
PP- 60 micron	0	0.946±0.003	2.570±0.001	—	0.2	—	—
	1	1.083±0.004	1.754±0.007	—	—	—	—
	2	1.742±0.01	2.207±0.002	—	—	—	0.09
SED			0.02				
CD (0.01)%			0.065				
CD (0.05)%			0.049				

Table 2: Effect of packaging on PWL of freshly processed *Moringa* leaves under refrigerated condition

Packaging material	Packaging Vent	% PLW							%Decay							% wilt						
		2	4	6	8	10	12	14	2	4	6	8	10	12	14	2	4	6	8	10	12	14
LDPE 40 micron	0	0.195	0.3874	0.682	1.834	1.949	2.240	2.370	—	—	—	—	—	—	0.12	—	—	—	—	—	—	—
	1	0.672	1.050	1.225	1.540	2.123	2.391	2.670	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	0.284	0.854	1.125	1.591	2.045	2.546	3.008	—	—	—	—	—	—	—	—	—	—	—	—	—	—
LDPE 80 micron	0	0.283	0.359	0.451	0.676	0.677	0.863	0.885	—	—	—	—	—	—	0.12	—	—	—	—	—	—	—
	1	0.199	0.298	0.398	0.597	0.796	0.895	1.091	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	0.289	0.678	0.993	1.270	1.569	1.570	2.24	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polypropylene 40 micron	0	0.131	0.401	0.295	0.395	0.695	0.864	1.084	—	—	—	—	—	—	0.16	—	—	—	—	—	—	—
	1	0.311	0.529	0.845	1.028	1.360	1.572	1.978	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	0.379	0.665	0.956	1.534	1.705	2.091	2.371	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polypropylene 60 micron	0	0.097	0.099	0.192	0.295	0.391	0.456	0.555	—	—	—	—	—	—	0.15	—	—	—	—	—	—	—
	1	0.202	0.288	0.371	0.556	0.736	0.834	1.017	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	0.096	0.274	0.498	0.692	0.893	1.092	1.285	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SED				0.2121																		
CD (0.01)%				0.5528																		
CD (0.05)%				0.4188																		

of *Moringa* leaves. Similar results were observed in the case of packaging studies on okra by Babarinde and Fabunmi (2009). *Moringa* leaves packaged under non ventilated packages exhibited decaying after 13th day. Often produce in non-ventilated film packages maintains a good appearance. This may be due to an effect of modified atmosphere of low O_2 and increased CO_2. But off odours and off flavors may develop in sealed packages even though the produce looks attractive (Robert, 1971).

Effect of packaging treatment on colour value of freshly processed *Moringa* leaves during storage

Chlorophyll degradation and the resultant loss of green colour during storage is a major quality defect for most leafy green vegetables (Jiang *et al.* 2002). Table 3, shows the effect of packaging treatment on the Hunter scores ('L', 'a' and 'b') of freshly processed *Moringa* leaves stored under ambient condition.

There was a decrease in 'a' value with storage for all the samples. Similar trend was noted for 'L' value. Decrease in 'b' was insignificant during storage. Since greenness is indicated by –a, the retention of the same was considered to be a good quality attribute of *Moringa* leaves under different packaging treatments. 'a' value was found to be more for all the ventilated samples (1% vent) compared to control and ventilation with 2% vent.

The colour value of samples under refrigerated storage is presented in Table 4. From the results, there was a gradual decrease in the 'a' values for all the packaging treatments. This may be due to the slow metabolic activity of the samples at low temperatures. LDPE films maintained higher 'a' value compared to PP films.

Optimisation of packaging treatment based on shelf-life

Shelf life is estimated from the time when a commodity is packed. Shelf-life of fresh commodity under packaging is influenced by the packaging material, temperature of storage, method of storage

Table 3: Colour value of freshly processed Moringa leaves under different packaging treatment at ambient condition

Packaging material	Packaging treatment	Colour value					
		L		a		b	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
LDPE-40 micron	0	36.83	34.77	-8.03	-7.466	19.05	18.3
	1	42.03	37.55	-8.82	-7.56	21.55	18.23
	2	42.58	41.2	-8.10	-7.19	22.10	22.03
LDPE-80 micron	0	39.78	38.89	-6.88	-6.43	20.21	20.19
	1	39.99	36.36	-7.01	-6.1	19.32	18.41
	2	42	36.77	-6.96	-6.61	21.12	18.48
PP-40 micron	0	36.91	32.07	-5.84	-5.72	17.99	17.97
	1	40.59	33.17	-6.15	-6.01	19.87	16.36
	2	39.84	37.73	-5.21	-5.19	19.91	18.95
PP-60 micron	0	34.23	32.06	-5.37	-5.39	15.84	16.7
	1	41.12	36.34	-6.77	-6.18	19.48	19.35
	2	39.06	38.92	-6.41	-5.94	20.62	20.58
SED		0.1778		0.0925		0.1535	
CD (0.01)%		0.4755		0.2481		0.4119	
CD (0.05)%		0.3564		0.1860		0.3087	

etc. Based on the symptoms of visible decay to the produce, the shelf life was predicted. Though LDPE films resulted in higher 'a' value, based on % decay during storage, polypropylene 40 micron at 1 % vent was considered to be the best treatment under ambient storage, wherein the shelf-life of the sample was found to be two days. Due to good barrier property, the LDPE films were more effective during refrigerated storage arresting decay for a period of 14 days. Under refrigerated storage, statistical analysis of the results revealed that LDPE of 80 micron thickness having 1% vent was found to be good compared to other packaging treatments.

Quality changes in freshly processed *Moringa* leaves stored at ambient and refrigerated condition

The nutrient content present in the fresh *Moringa* leaves and freshly processed *Moringa* leaves packed in the best packaging treatments under ambient and refrigerated storage is presented in Table 5.

Ascorbic acid content in fresh leaves was found to be 266.15mg/100g. There was a decrease in ascorbic acid content of the sample packaged in polypropylene 40 micron with 1% vent after 2 days of storage. Ascorbic acid content of stored produce generally decreases more rapidly at higher storage temperature since it is thermo labile. The reason for the decrease of ascorbic acid under ambient conditions is due to the oxidation of ascorbic acid to dehydroascorbic acid by enzyme ascorbic-nase (Rokolhuu *et al.* 2003). Samples packaged in LDPE 80 micron with 1% under refrigerated condition showed a further decrease in ascorbic acid content after 14 days of storage. Vitamin C is influenced by temperature and storage period (Seung & Kader, 2000). The decrease in ascorbic acid content in refrigerated condition could be due to long term storage. Similar results were observed for fresh-cut kiwifruit and grapes (Oyetade *et al.* 2012). Beta carotene which is a precursor of vitamin A, was found to be 1658.95µg/100g for fresh *Moringa* leaves and for sample stored at ambient condition it was found to be 1543.2µg/100g. In the case of refrigerated storage, Beta carotene was found to be 925.9µg/100g. Beta carotene decreased during storage under ambient and refrigerated condition. Similar results

Table 4: Colour value of freshly processed *Moringa* leaves under different packaging treatment at refrigerated condition

Pac Packaging Material	Packaging treatment	Colour value																				
		L							a							b						
		2	4	6	8	10	12	14	2	4	6	8	10	12	14	2	4	6	8	10	12	14
LDPE 40 M micron	0	39.52	38.23	39.36	39.17	33.21	33.25	33.12	-7.49	-7.39	-7.21	-7.10	-6.93	-6.14	-6.07	19.36	18.63	18.73	18.28	15.65	15.42	14.32
	1	42.07	39.86	39.26	38.57	36.76	36.43	36.56	-7.37	-7.21	-7.27	-7.13	-6.29	-6.22	-5.91	19. 85	19.81	18.95	18.72	18.60	18.20	17.62
	2	39.75	38.90	38.45	38.37	38.37	38.18	38.08	-6.80	-6.24	-5.83	-5..82	-5.66	-5.52	-5.36	18.77	20.58	14.83	17.69	17.85	19.71	19.51
LDPE 80 micron	0	40.32	36.15	37.83	38.55	37.81	36.24	35.75	-8.10	-7.43	-7.10	-6.20	-6.53	-6.09	-7.09	18.75	18.62	18.57	17.02	16.84	16.58	16.2
	1	40.23	40.23	39.33	38.44	38.00	37.78	35.29	-7.72	-7..62	-7.38	-7.17	-6.92	-6.92	-6.69	20.08	18.00	17.99	17.44	17.43	17.09	16.45
	2	42.02	41.412	39.43	39.83	38.98	38.41	36.09	-7.64	-7.21	-7.14	-6.48	-6..23	-5.99	-5.91	20.16	19.03	18.25	17.72	17.61	17.59	17.15
PP 40 micron	0	38.98	38.47	37.48	37.18	36.44	36..05	33.41	-6.21	-6.11	-5.89	-5.7	-5.37	-5.11	-5..01	18.17	18.04	17.71	17.62	17.18	16.93	16.03
	1	39.93	39.27	38.75	38.25	36.45	34.49	34.18	-7.73	-7.71	-7.53	-7.19	-6..25	-6.02	-5.03	18.67	17.46	15.25	18.45	20.64	17.61	16.36
	2	39.97	39.92	38.74	38.16	37.97	35.40	34.32	-7.73	-7.37	-6.9	-6.7	-5.97	-5.59	-5.23	19.69	19.54	18.91	18.42	17.05	16.81	16.78
Poly PP 60 Mi micron	0	38.31	37.39	37.19	37.6	35.44	34.38	32.94	-7.66	-7.62	-5.92	-5.77	-5.50	-5.86	-5.58	20.17	19.91	19.47	17.94	17.22	16.64	16.06
	1	40.34	39.62	38.20	37.91	37.09	36.48	35.17	-7.91	-7.62	-7.59	-6.86	-6.85	-6.48	-6.42	20.94	20.83	19.41	18.83	17.18	17.61	17.09
	2	41.70	39.81	39.76	37.01	37.57	36.70	35.33	-7.83	-7.68	-7.54	-7.23	-6.79	-6.78	-6.04	19.91	18.93	18.76	17.74	17.52	16.61	16.39

Table 5: Nutrient content of fresh and freshly processed *Moringa* leaves under different packaging treatments

Sample type	Packaging treatment	Ascorbic acid (mg/100g)	Beta Carotene (µg/100g)	Vitamin A (IU)	Chlorophyll (mg/100g)	Iron (mg/100g)
Fresh	—	266.15	1658.95	2764.91	97.28	0.171
Ambient	Polypropylene 40 micron, 1% vent	45.696	1543.2	2572.22	53.20	0.169
Refrigerated	Polyethylene 80 micron, 1% vent	38.94	925.9	1543	67.94	0.169
SED		0.5670	2.8101	0.8686	0.3535	0.0008
CD (0.01)%		2.1030	10.418	2.1256	1.3093	0.029
CD (0.05)%		1.3876	6.8765	3.2205	0.8642	0.0019

were reported by Ruhsar *et al.* (1999) and Rahman *et al.* (2012) for carrots and chillies respectively. The decline in Beta carotene may be both due to oxidative and non-oxidative changes. Vitamin A found in fresh sample was 2764 IU in fresh *Moringa* leaves. Vitamin A in freshly processed *Moringa* leaves stored for two days under ambient condition was 2572.22 IU. Similarly vitamin A of the freshly processed and refrigerated stored sample was 1543 IU at the end of 14 days storage. Degradation of chlorophyll is one of the symptoms of maturity in harvested greens. There was reduction in the chlorophyll content of *Moringa* leaves during storage. The chlorophyll content of fresh leaves was found to be 97.28mg/100g. The chlorophyll content of the freshly processed *Moringa* leaves stored under ambient condition was 53.20mg/100g. Leaves packed in LDPE 80 micron stored under refrigerated condition had chlorophyll content of 67.94mg/100g. The decrease in chlorophyll is due to the fact that the chlorophyll appears to be degraded by the peroxidase pathway as reported by Naoki Yamauchi, (1991) for spinach leaves. Similar results were observed by Shengmin Lu, (2007) on minimally processed Bok Choy and Prabhu, Snehal (2009) on African leafy vegetables. There was no significant change in iron content during storage. The iron content of fresh leaves was 0.171mg/100g. There was a slight decrease in the iron content (0.169 mg/100g) of samples during storage; it was on par for the samples stored under ambient and refrigerated condition.

CONCLUSION

Green leafy vegetables are rich in micronutrients and vitamins and consumption of the same addresses to the malnutrition problems in adults and children. These greens could be processed in their fresh form as a minimally processed product which adds convenience to the users. In this study, attempt has been made to freshly process the *Moringa* leaves as a ready cook product by pre-packaging in different plastic films and ventilation levels. The study revealed that the keeping quality of freshly processed *Moringa* leaves was found to be two days in polypropylene bags of 40 micron thickness at 1% vent and 14 days under refrigerated condition when packed in LDPE bag of 80 micron thickness with 1% vent.

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