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Influence of storage temperature and packaging materials on post-harvest quality and shelf life of moringa (*Moringa oleifera*) pods

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Abstract

Moringa is one of the world's most nutritious food and its pod remain available for the short period. Therefore, this study was undertaken to observe the performance of packaging materials and temperature on post harvest quality and shelf life of moringa pod. The two factor experiment comprised five types of postharvest packaging materials *viz.* P_0: control, P_1: perforated low density polyethylene (LDPE) bag, P_2: non-perforated LDPE bag, P_3: High density polyethylene (HDPE) bag and P_4: brown paper and two levels of storage temperature *viz.* T_1: ambient room temperature (25-28^{0}C) and T_2: refrigerator condition (10-12^{0}C). The experiment was laid out in completely randomized design with three replications. The effect of packaging materials and temperature as well as their combined effects were found significant in all parameters. Results showed that the minimum weight loss, decay loss, maximum marketability and shelf life were observed in moringa stored at refrigerator condition. On the other hand, maximum weight loss, decay loss, minimum marketability and shelf life were recorded in moringa stored in ambient room temperature condition. Shelf life of pods were found 6 and 16.8 days at room and refrigerator temperature condition, respectively. In case of packaging materials, minimum weight loss, decay loss, maximum marketability and shelf life were observed in moringa pods packaging with HDPE bag; and maximum weight loss, decay loss, marketability acceptance and shelf life were recorded in moringa stored without packaging materials. Maximum shelf life (16 days) was recorded from P_3 (HDPE bag) and subsequently 13 and 12 days from P_2 (non-perforated LDPE bag) and P_1 (perforated LDPE bag) and the minimum shelf life was 8 days from both P_0 (control) and P_4 (brown paper) packaging materials. Although, the acceptance of marketability is the major concern. Acceptance of marketability was more than 80% when pods were stored at refrigerated condition whereas stored at ambient condition was poor at 8 days (less than 40%). It is better to store the moringa pods at refrigerator condition with HDPE bag to consume it for long time and ensure the nutritional security.

Introduction

Drumstick or moringa (*Moringa oleifera spp* Lam.) is one of the most nutritious and popular vegetables grown throughout Asia, with predominant crop culture prevalent in semi-arid regions of southern India (Palada and Chang, 2003). The genus *Moringa* consists of 12-14 species under the genus *Moringa*. Nevertheless, the most popular and cultivated moringa is both seasonal and year round available in Bangladesh. It adopts well in different types of soils and adjusts well even in marginal conditions. Incredible ability of *Moringa* to survive in harsh weather and even to drought has made this crop a wider spread in varying situations (Singh and Sagor, 2010). Moringa is now widely cultivated and has become naturalized in many locations in the tropics. It is a perennial softwood tree with timber of low quality, but for centuries has been advocated for traditional medicinal and industrial uses. Various varieties of *Moringa oleifera* have been developed to meet the tastes of local populations (Shahid and Bhanger, 2006). It is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce (Fahey, 2005). The leaves, flowers, roots, and immature pods of the moringa tree are edible and they form a part of traditional diets in many countries of the tropics and sub-tropics (Fuglie, 2001). It has been reported that there is a mammoth nutritional value in moringa such as vitamins, minerals including the rich sources of beta- carotene, vit C, other bio active compounds like flavonoids and phenolic compounds (Anwar and Rashid, 2007; Falowo *et al*., 2018; Pullakhandam and Failla, 2007; Siddhuraju and Becker, 2003; Soetan *et al*., 2010). It is called miracle tree due to its dense nutrient, similarly it is also called mothers best friend because of increase milk of the nursing mothers. (Chukwuebuka, 2015; Oyeyinka and Oyeyinka, 2018).

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Packaging and storage temperature is one of the most important factors for the storage of pods. Because, fresh fruits and vegetables are generally used to practice to expend the shelf life and quality as well (Rico *et al.*, 2007). Bags, crates, hampers, baskets, cartons, bulk bins, and palletized containers are convenient containers for handling, transporting and marketing of fresh produce. More than 1500 different types of packaging materials are used for produce in the United States and the number continues to increase as the industry introduces new packaging materials and concepts. Packaging helps in minimizing deterioration during handling, transport and marketing of fruits and vegetables from physiological and physical deterioration and retains their attractiveness.

Temperature is a key determinant of chemical reaction rates and therefore, produces metabolic rates. Storage temperature management is one of the most important factor in extending the storage life of fresh produce. Because fresh produce is a living organism this does not always mean that the lower the temperature the longer the storage life. Produce quality can be irreversibly damaged due to not providing suitable temperature of the respected produce. On the other hand, low temperature reduces the physiological activities like respiration and transpiration causing the disease infestation as well during the postharvest stage (Islam and Joyce, 2015; Prusky, 2011).

People of Bangladesh are used to consume mainly pods; and leaves in some regions of our country due to habituate difference. Both, seasonal (one time pods production per year) and year round (three times pods production per year) moringa are growing but people are not getting opportunity to consume pods for a long time due to not long time storage performance. One the other hand, still the research inspiration on this moringa in our country is still scarce. Keeping the above points in view, the present investigation was carried out to observe the postharvest quality and shelf life of moringa pods influenced by storage temperature and packaging materials.

Materials and Methods

Fresh moringa pods were collected from local market of Palika Shobji Bazar, Mymensingh. Collected pods were carried to the Postgraduate laboratory of Horticulture Department, Bangladesh Agricultural University (BAU), Mymensingh during the period April 2017 to observe the postharvest quality and shelf life extension.

Design of the experiment

Two factors experiment was conducted following completely randomized design (CRD) with three replications.

Factor A: Packaging Materials

- P0: Control
- P_1: Perforated low density polyethylene bag (LDPE)
- P_2: Non-perforated LDPE bag
- P_3: High density polyethylene bag (HDPE)
- P_4: Brown paper

Factor B: Temperature

- T1: Ambient room temperature (250C-280C)
- T2: Refrigerator condition (100C-120C)

Packaging materials

All the packaging materials were purchased from the local market, Mymensingh. The low density polyethylene (LDPE) bags thickness were 0.127 mm used as perforated and non-perforated and high density polyethylene (HDPE) bags thickness was 1 mm used as plastic bag to pack the moringa pods. The brown paper thickness was 0.127 mm used in this experiment. Five moringa pods were considered as one replicator and packaged by each packaging materials; sealed tightly by tied up the both end of the pods with thread.

Storage condition

Moringa pods in packaged condition were stored in a refrigerator and ambient room temperature. In the refrigerator 10^0C-12^0C temperature were provided. Because, people are used to consider this temperature at home. In ambient condition temperature was recorded in the laboratory and its average temperature was 25^0C-28^0C.

Data collection

Weights were taken at 4 days interval and it was continued up to perception of marketability of pod. Weight loss (%) of pod was calculated in percentage by following formula:

$$\%\ \text{Weight loss} = \frac{IW - FW}{IW} \times 100$$

Here, IW= Initial Weight and FW= Final Weight.

Percentage of decayed pod was calculated in percentage by following formula:

$$\%\ \text{Decay loss} = \frac{DF}{TF} \times 100$$

Here, DF= Decayed fruits and TF= Total no. of fruits.

Marketability was done from the visual perception. It was calculated in percentage. Samples were kept in the lab till they are supposed to fetch some market prices. Shelf life of the samples was determined by various observations like pathological disorder and marketability. It was calculated in days.

Statistical analysis

Collected data for various characters were statistically analyzed using MSTAT-C computer package program. Mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. The significance of the differences among the treatment mean was evaluated by the least significance the difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984) for the interpretation of results.

Results and Discussion

Moringa pods were treated with different types packaging materials under two different temperatures to observe their shelf life and quality mentioned in this chapter.

Weight loss

Temperature had significant effect on percent weight loss of stored moringa pod (Table 1). Data were collected at every four days interval. In case of T_1 (25^0C-28^0C) data were recorded till 8 days, because after 8 days moringa pods were decayed. About 14.07% and 15.57% weight loss occurred at 4 and 8 days, respectively. In case of T_2 (10^0C-12^0C) data were recorded till 24 days. Maximum weight loss 9.14%, 8.14% and 8.19% occurred at 4, 8 and 12 days, respectively. On the other hand, minimum weight loss was 2.28%, 3.11% and 2.38% occurred at 16, 20 and 24 days, respectively. Thompson (2001) reported that weight loss of fruits in polythene bags was far low than from unpackaged fruits in which after 4 weeks of storage the weight loss was found as 1.8 and 2.1%, respectively. Lower weight loss of fruits in the package could be due to slow rate of respiration and prevention of excessive moisture loss (Tilahun and Kebede, 2004). Besides, different researcher reported that fruits wrapped in different packaging films retain better quality for longer duration compared to the unwrapped fruits (Kumar and Nagpal1996; Siddiqul and Gupta 1997).

Packaging materials showed a significant variation in case of % weight loss (Table 2). Data were collected at every four days interval. In case of P_0 (control) 24.84%, 27.72% and 8.81% weight loss occurred at 4, 8 and 12 days, respectively. In case of P_1 (Perforated LDPE) highest weight loss were 4.71% and 4.04% at 8 and 12 days, respectively. In case of P_2 (Non-perforated LDPE bag) the highest weight loss at 4 and 8 days was 2.51% and 2.45%, respectively but lower than P_1 (perforated LDPE bag). After 8 days weight loss was reduced. In case of P_3 (HDPE bag) 2.47%, 1.52% and 1.10% weight loss occurred at 4, 8 and 12 days, respectively and after that the percentage of weight loss was reduced. Lastly in case of P_4 (brown paper) 23.49%, 23.57% and 9.81% weight loss occurred at 4, 8 and 12 days, respectively. Preetha *et al.* (2015) found that high storage temperature leads to accelerate water loss and subsequently to shrivel and softening of the fruit.

The combined effect of temperature and packaging materials showed a significant variation was recorded on all observation. The maximum weight loss (36.55%) occurred in T_1P_0 (25^0C-28^0C with control) at 8 days and minimum weight loss (0.85%) occurred in T_2P_3 (10^0C-12^0C with plastic bag) at 8 days (Table 3).

Decay loss

Temperature had significant effect on decay loss (%) of stored moringa pod (Table 4). Data were collected at every four days interval. In the room temperature (25^0C-28^0C), all the pods were decayed by 16 days but it took 24 days to decay under low temperature (10-12^0C) storage condition. About 20% and 52% decay loss occurred at 4 and 8 days, respectively in case of T_1 (25^0C-28^0C) and moringa pods were almost fully decayed after 8 days. On the other hand, 40% and 55% decay loss occurred at 8 and 12 days, respectively at low temperature storage condition (T_2: 10^0C-12^0C).

Packaging materials showed a significant variation in case of decay loss (Table 5). In case of P_0 (control) 10%, 40%, 80% and 50% loss occurred at 4, 8, 12 and 16 days, respectively. In case of P_1 (perforated LDPE bag) 10%, 20%, 70%, 30%, 40% and 50% loss occurred at 4, 8, 12, 16, 20 and 24 days, respectively. In case of P_2 (Non-perforated LDPE bag) 40%, 70%, 40% and 50% loss occurred at 8, 12, 16 and 20 days, respectively. In case of P_3 (plastic bag) 10%, 40%, 50%, 10% and 20% loss occurred at 8, 12, 16, 20 and 24 days, respectively. Finally, in case of P_4 (brown paper) 10%, 60%, 90% and 50% loss occurred at 4, 8, 12 and 16 days, respectively. Mir and Beaudry (2000) revealed that packaging isolates the product from the external environment and helps to ensure conditions that at least reduce exposure to pathogens and contaminants there extends the shelf life of the produce but it does not reduce the distribution of microorganism inside the packaging materials.

The combined effect of temperature and packaging materials showed a significant variation was recorded on all observation. Mostly, major decay loss was observed by 12 to 16 days (Table 6). The maximum weight loss (36.55%) occurred in T_1P_0 (25^0C-28^0C and control) at 8 days and minimum weight loss (0.85%) occurred in T_2P_3 (10^0C-12^0C and plastic bag) at 8 days (Table 6). Similar findings were reported by Ozkaya *et al.* (2009) and found that the modified atmospherically packed strawberry fruits resulted in a lower decay loss than the control fruits (without packaging).

Table 1. Effect of temperature on weight loss (%) of moringa pods

Temperature	Weight loss (%) at different days of storage of moringa					
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}
T_1	14.07	15.57	0.00	0.00	0.00	0.00
T_2	9.14	8.14	8.19	2.28	3.11	2.38
$LSD_{0.05}$	0.65	0.96	0.00	0.00	0.00	0.00
Level of significance	*	*	*	*		*

* = Significant at 5% level of probability, T_1= Ambient room temperature (25^0C-28^0C), T_2= Refrigerator condition (10^0C-12^0C)

Table 2. Effect of packaging materials on weight loss (%) of moringa pods

Packaging materials	Weight loss (%) at different days of storage of moringa					
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}
P_0	24.84	27.72	8.81	0.00	0.00	0.00
P_1	4.71	4.04	0.60	1.36	2.19	1.24
P_2	2.51	2.45	0.67	1.33	1.07	0.00
P_3	2.47	1.52	1.10	0.74	1.42	1.14
P_4	23.49	23.57	9.31	0.00	0.00	0.00
$LSD_{0.05}$	1.03	1.52	0.86	0.09	0.11	0.07
Level of significance	*	*	*	*	*	*

* = Significant at 5% level of probability, P_0= Control, P_1= Perforated LDPE bag, P_2= Non-perforated LDPE bag, P_3= HDPE bag, P_4= Brown paper

Table 3. Combined effect of temperature and packaging materials on weight loss (%) of moringa pods

Treatment combination	Weight loss (%) at different days of storage of moringa					
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}
T_1P_0	31.75	36.55	0.00	0.00	0.00	0.00
T_1P_1	6.50	6.12	0.00	0.00	0.00	0.00
T_1P_2	3.15	3.91	0.00	0.00	0.00	0.00
T_1P_3	3.02	2.18	0.00	0.00	0.00	0.00
T_1P_4	25.92	29.11	0.00	0.00	0.00	0.00
T_2P_0	17.93	18.89	17.61	0.00	0.00	0.00
T_2P_1	2.92	1.95	1.20	2.72	4.37	2.47
T_2P_2	1.86	0.98	1.34	2.65	2.14	0.00
T_2P_3	1.91	0.85	2.20	1.47	2.83	2.28
T_2P_4	21.06	18.02	18.61	0.00	0.00	0.00
$LSD_{0.05}$	1.45	2.15	1.21	0.13	0.15	0.09
Level of significance	*	*	*	*	*	*

*= Significant at 5% level of probability, T_1= Ambient room temperature (25^0C-28^0C), T_2= Refrigerator condition (10^0C-12^0C), P_0= Control, P_1= Perforated LDPE bag, P_2= Non-perforated LDPE bag, P_3= HDPE bag, P_4= Brown paper

Table 4. Effect of temperature on decay loss and shelf life of moringa pods

Temperature	Decay loss (%) at different days of storage of moringa						Shelf life
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}	(days)
T_1	20.00	52.00	96.00	100.00	-	-	6.00
T_2	0.00	40.00	55.00	85.00	66.67	70.00	16.80
$LSD_{0.05}$	0.00	5.22	4.34	5.52	0.00	0.00	0.79
Level of significance	*	*	*	*	*	*	*

* = Significant at 5% level of probability, T_1= Ambient room temperature (25^0C-28^0C), T_2= Refrigerator condition (10^0C-12^0C)

Table 5. Effect of Packaging materials on decay loss and shelf life of moringa pods

Packaging materials	Decay loss (%) at different days of storage of moringa						Shelf life (days)
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}	
P_0	10.00	40.00	80.00	50.00	0.00	0.00	8.00
P_1	10.00	20.00	70.00	30.00	40.00	50.00	12.00
P_2	0.00	40.00	70.00	40.00	50.00	0.00	13.00
P_3	0.00	10.00	40.00	50.00	10.00	20.00	16.00
P_4	10.00	60.00	90.00	50.00	0.00	0.00	8.00
$LSD_{0.05}$	0.00	8.25	6.87	8.73	4.66	5.39	1.25
Level of significance	*	*	*	*	*	*	*

* = Significant at 5% level of probability, P_0= Control, P_1= Perforated LDPE bag, P_2= Non-perforated LDPE bag, P_3= HDPE bag, P_4= Brown paper

Table 6. Combined effect of temperature and packaging materials on decay loss and shelf life of moringa pods

Treatment combination	Decay loss (%) at different days of storage of moringa						Shelf life (days)
	4^{th}	8^{th}	12^{th}	16^{th}	20^{th}	24^{th}	
T_1P_0	20.00	60.00	100.00	-	-	-	4.00
T_1P_1	20.00	40.00	100.00	-	-	-	6.00
T_1P_2	0.00	80.00	100.00	-	-	-	6.00
T_1P_3	0.00	20.00	80.00	100.00	-	-	8.00
T_1P_4	20.00	60.00	100.00	-	-	-	6.00
T_2P_0	0.00	20.00	60.00	100.00	-	-	12.00
T_2P_1	0.00	0.00	40.00	60.00	80.00	100.00	18.00
T_2P_2	0.00	0.00	40.00	80.00	100.00	-	20.00
T_2P_3	0.00	0.00	0.00	0.00	20.00	40.00	24.00
T_2P_4	0.00	60.00	80.00	100.00	-	-	10.00
$LSD_{0.05}$	0.00	11.66	9.71	12.34	6.60	7.62	1.77
Level of significant	*	*	*	*	*	*	*

* = Significant at 5% level of probability, T_1= Ambient room temperature (25^0C-28^0C), T_2= Refrigerator condition (10^0C-12^0C), P_0= Control, P_1= Perforated LDPE bag, P_2= Non-perforated LDPE bag, P_3= HDPE bag, P_4= Brown paper

Marketability

Temperature had significant effect on marketability acceptance of stored moringa pod (Fig. 1). In both cases of T_1 (25^0C-28^0C) and T_2 (10^0C-12^0C) marketability quality decreases eventually. In case of T_1 (25^0C-28^0C) marketability quality reduced as 88%, 48% and 20% at 4, 8 and 12 days, respectively. In case of T_2 (10^0C-12^0C), marketability acceptance reduced as 84%, 56%, 53.33% and 50% at 8, 12, 16 and 20 days, respectively. It indicates that the product quality was consumable up to 12 and 20 days stored at refrigerated and ambient temperature condition. Longer storage condition is possible at low temperature due to slow process of physiological condition (Gonzalez *et al.,* 2003). Packaging materials showed a significant variation in case of marketability acceptance (Fig. 2). In case of P_0 (control) marketability acceptance reduced as 90%, 60% and 20% at 4, 8 and 12 days, respectively. In case of P_1 (perforated LDPE) marketability reduced as 90%, 80%,30%, 20% and 10% at 4, 8, 12, 16 and 20 days, respectively. In case of P_2 (non-perforated LDPE) marketability acceptance reduced as 60%, 30% and 10% at 8, 12 and 16 days, respectively. In case of P_3 (plastic bag) marketability (%) reduced as 90%, 60%, 50%and 40% at 8, 12, 16 and 20 days respectively. Finally, in case of P_4 (brown paper) marketability acceptance reduced as 90%, 40% and 10% at 4, 8 and 12days, respectively. This result is in line with the study of Vitti *et al.,* (2005) who reported that, packaging of climacteric fruits in low density polythene bags delay ripening and softening, and hence improves marketability. Here, it indicates that acceptance of marketability loss more than 50% by 8 days. Rest days' acceptability diminishing depends on the storage temperature and packaging condition. Although, only one variety was used to observe the acceptability. Marketable acceptance or cooking quality depends on some genetic factors it can vary cultivars to cultivars. In Bangladesh, both seasonal and year round cultivars are available including other germplasms of Moringa. Similarly, Khan *et al*., (2005) found the acceptability of cooking quality which varied in the different accession of vegetable like pumpkin.

Shelf life

Temperature had significant effect on shelf life of stored moringa pod (Table 4). In case of T_1 (25^0C-28^0C) and T_2 (10^0C-12^0C) effect, the longest shelf life was found 6 and 16.8 days, respectively. Refrigerated storage found to be effective in maintaining the color and appearance, texture, quality throughout the storage period and maximum overall acceptability might be due to low temperature during storage which led to reduce minimum moisture and physiological loss in weight. Similarly, Parveen *et al*., (2004) conducted experiments with different different vegetables where low temperature gave the better extension of shelf of those respected vegetables. Because, low temperature influence to intensity of diseases attack resulting the increase of shelf of flowers like poinsettia (Islam and Joyce (2015). Packaging materials showed a significant variation in case of % decay loss (Table 5). Data were collected at every four days interval. The shelf lives of P_0 (Control), P_1 (Perforated LDPE), P_2 (Non-perforated LDPE bag), P_3 (Plastic bag) and P_4 (Brown paper) were 8, 12, 13, 16 and 8 days, respectively. The present findings are in agreement with the results reported in salad savoy and okra (Kim *et al.,* 2004; Koraddi and Devendrappa, 2011). Similar result of present study is in close conformity with the results of banana and pear with different packaging materials (Hailu *et al.*, 2014; Nath *et al.,* 2011). Even, different solutions like Aloevera and chitosan solutions were used to extend the shelf life of Mango where the highest shelf life was 7 days (Monira *et al*., 2016). The combined effect of temperature and packaging materials showed a significant variation was recorded on all observation. The longest (24 days) shelf life was observed in T_2P_3 (10^0C-12^0C and plastic bag) and shortest (4 days) was recorded in T_1P_0 (25^0C-28^0C and control) (Table 6). Lower respiration and ethylene production rates, reduced ethylene action, delayed ripening and senescence, retarding the growth of decay causing pathogens and insects due to modification of the gas atmosphere inside the package could be possible reason to extend the storage life of fruits (Kader and Rolle, 2004).

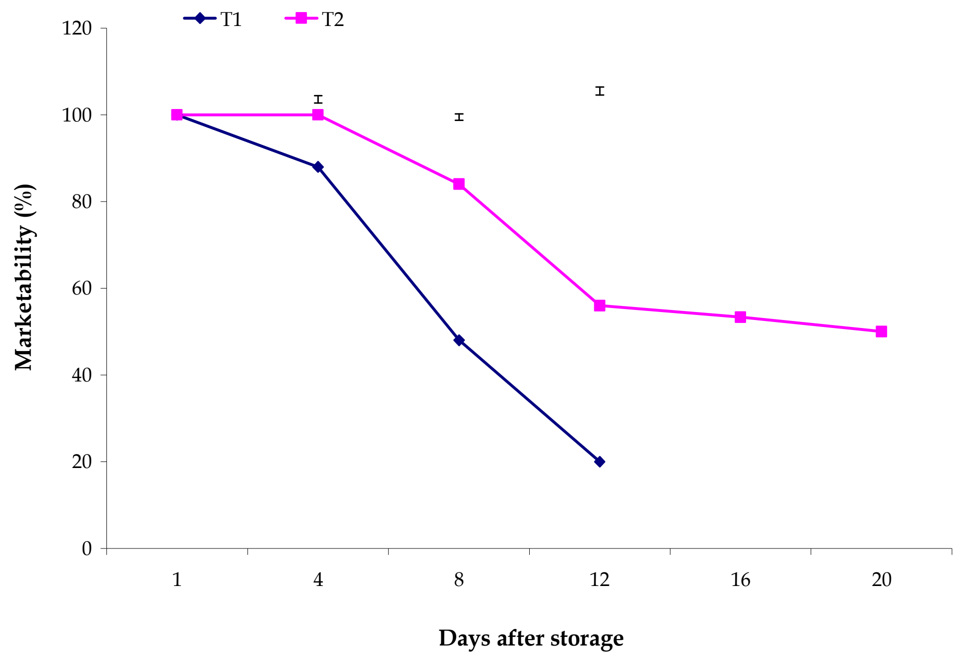

Fig. 1. Effect of temperature on marketability acceptance (%) of moringa pods. T_1= Ambient room temperature (25^0C-28^0C), T_2= Refrigerator condition (10^0C-12^0C)

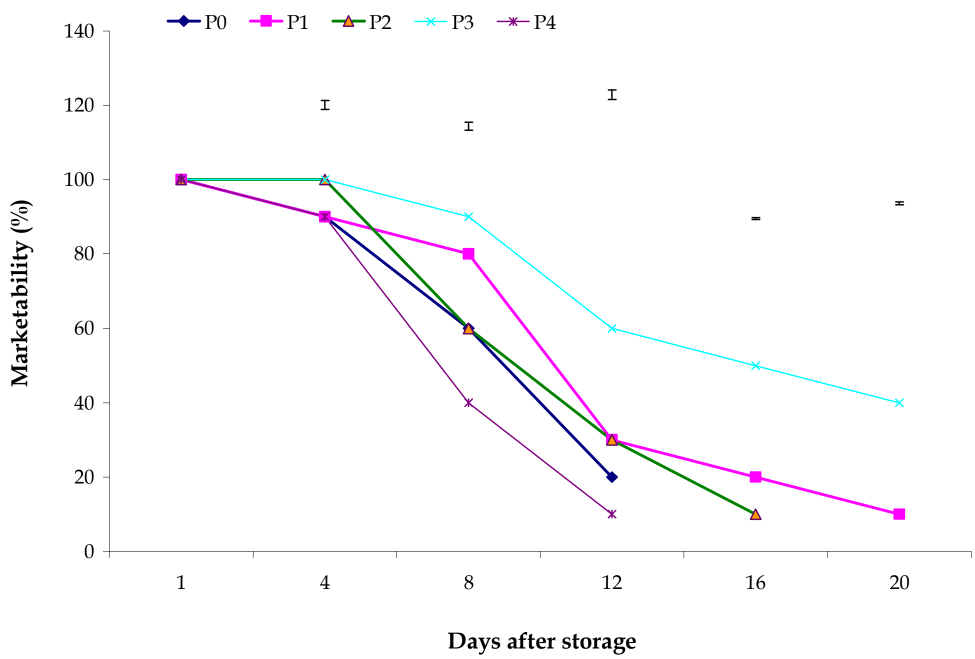

Fig. 2. Effect of packaging materials on marketability acceptance (%) of Moringa pods. P_0= Control, P_1= Perforated LDPE bag, P_2= Non-perforated LDPE bag, P_3= HDPE bag, P_4= Brown paper

Conclusion

Shelf life extension of moringa pods and consistence of the marketable acceptance, moringa pods can be stored at refrigerator condition (10-12^{0}C), also HDPE bag can be used for packaging. This can help to store at least 8 days to some extent of 16 days. This combination could give the opportunity to consume the highly dense nutrient moringa pods for long time for the nutritional security.

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