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Effect of storage conditions on nutritional quality of *Moringa* value added products

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Abstract
Moringa oleifera belongs to the family *Moringa*ceae is an effective treatment for alleviating malnutrition due to its abundance of nutrients, minerals, vitamins and antioxidant *etc*. Almost every part of the *Moringa* plant can be used to provide nourishment and other benefits. The leafy greens are perishable by nature, their shelf life is determined by the conditions in which they are stored. Therefore the study was undertaken to investigate the effect of storage conditions on quality and shelf life of *Moringa* value added products under two different atmospheric storage conditions. *Moringa* powder, tablet, capsule were prepared, each tablet and capsule weighed 500 mg. Prepared products are packed in brown amber bottle then, stored for four months duration and the proximate nutrient analysis was carried out for every 30 days interval. The result revealed that the *Moringa* value added products which was stored in the cold storage condition have retained the best colour and shows significantly (p<0.05) higher levels of nutrient contents compared to the *Moringa* products stored under ambient conditions after 120 days of storage. It was concluded that the *Moringa* samples stored at cold storage condition (4°C) had recorded the less nutrient deterioration and also extended the shelf life during storage.

Keywords: *Moringa* powder, tablet, capsule, nutritional quality and storage

Introduction
Moringa oleifera is an eternal tree indigenous to India but now it is globally popularized and acclimate transversely everywhere to the tropics and subtropics. It is also widely cultivated for a scope of desire in addition to human consumption, also for livestock feed and also used in cosmetics. Due to its great nutritional value, *Moringa* have played an important role in reduction of malnutrition. Drumstick are known to be a miracle tree due to its massed nutrient health value, similarly they also known to mother's best friend because it equivalently helps in the production of milk supply for lactating women. The leaf of miracle tree are eaten up freshly and it can be stored as dried powder for months. The leaves, flowers, roots and immature pods of the *Moringa* tree are edible and they become a biggest part for herbal diets in many countries of the tropics and sub-tropics around the world (Fuglie, 2001) [6]. It has been recounted that there is an immense nutritional value in *Moringa* such as minerals, vitamins, antioxidant, minerals including more sources of beta- carotene, ascorbic acid, other bio active compounds like flavonoids and phenolic compounds (Anwar and Rashid, 2007; Pullakhandam and Failla, 2007) [2, 11]. The *Moringa oleifera* leaves are formulated to value-added products that can be easily consumed. Therefore, packaging and storage conditions are the most important factors to increase the shelf life of the *Moringa* value added products. Because, fresh vegetables are widely used to processed to extend the shelf life and quality. Storage helps in diminishing deterioration of vegetables from physiological, physical depreciation and grasp the produce attractiveness. Soetan *et al.* (2010) [15] described that the temperature is crucial for chemical reaction rates and metabolic rates whereas storage conditions is one of the mainframe factor in extending the shelf life of fresh value added products. The present study aimed to assess the effect of storage conditions on extension of shelf life and maintain the quality.

Materials and Methods
Processing of fresh leaves
Fresh leaves of *Moringa* var. PKM 1 were collected from the organic production field at Horticultural College and Research Institute, Periyakulam, India, during the year 2021. Leaves were harvested and collected freshly, after harvesting the leaflets were removed then, washed in tap water to clean the soil, dirt particles and micro-organism present in the leaves. Second process begins with the draining of excess water present in the leaf sample and spread out for

drying the water content. Then the leaves were subjected to proximate drying using solar tunnel dryer.

Protocol for drying in solar tunnel drier

In solar tunnel drier, the *Moringa* leaves of 1.5 kg spreaded per tray which is made up of aluminium having dimensions of about 25mm x 25mm. Inside the drier the temperature ranges from 40-42°C was maintained and the leaves were dried for four hour duration, the proper indication of dried leaves were identified by the moisture content with 7% and attractive green colour with presence of crispiness in leaves. Once the leaves were dried they are moved for milling process.

Milling of dried leaf sample

The dried leaves were milled by using the pulveriser. The fine textured of 80 mesh *Moringa* powder was packed air tight container immediately after milling process to avoid the absorption of moisture from the atmosphere.

Formulation of *Moringa* tablet

The freshly prepared *Moringa* powder were taken for tablet production unit and the tablets were made using with 95% of raw material and 5% of guar gum as a binder which helps in the stabilization of the tablets and tablets were produced using the die. Prepared tablets were packed along with silica gel to avoid moisture absorption.

Preparation of *Moringa* capsule

For capsule preparation, the *Moringa* powder have filled in the empty gelatin capsules using automatic filling machine, then the freshly prepared capsules were packed and stored.

Storage of *Moringa* leaf powder, tablet and capsule

Freshly prepared *Moringa* powder, tablets and capsules were packed and sealed quickly in polylined paper bag, the packed produces have been stored under two different atmospheric condition *i.e.*, ambient storage condition (28 ± 20°C) and cold storage condition (4°C) for a period of four months. The samples of *Moringa* products were drawn at the 30 days intervals for proximate nutrient analysis to assess the quality and shelf life of value added products of *Moringa*.

Proximate analysis of nutritive composition

The protein content of samples was predicted using the Biuret method given by Layne (1957) [8] and the values were manifested as milligram per 100 gram. Fibre content of *Moringa* produces actuate with the method of acid alkali digestion and then the value was expressed in percentage (Maynard, 1970) [10]. Vitamin A content of samples was analysed using UV spectrophotometer method and the values were obtained in milligram/100 gram (Jenson, 1920). Balasubramanian and Sadhasivam, (1987) [12] gave the analytical procedure to calculate the total free amino acid using ninhydrin method and the absorbance was recorded using UV spectrophotometer, then the values were expressed in milligram/100 gram. The iron content of *Moringa* value added products were determined by the triple acid digestion method using Atomic absorption spectrophotometer and the values are expressed as mg/100g (Jackson, 1973) [7].

Statistical Analysis

The experimental design used in this study was FCRD (Factorial Completely Randomized Design). Observations recorded during the experimental study was analysed at 5% level of significance using AGRESS software.

Number of Treatment combinations - 6
Number of Replications - 3
Number of Factors - 2
Factors - 1. *Moringa* produces
2. Storage conditions

Results and discussion

Effect of storage condition on protein content of *Moringa* powder, tablet and capsule

The initial protein content of *Moringa* value added products was found to be 27.44 mg/100g. It is observed that there was a significant differences ($p < 0.01$) among the *Moringa* products and non-significant differences were found between the storage conditions after 120 DAS, hence it shows there is a gradual decrease in protein content during the storage period (Fig.1). The decrease in protein content may be attributed to physiological and metabolic activities of the cells of *Moringa* leaves and at the same time it is also due to proteolysis (Mensah, 2011) [9]. During the present study, Minimum loss of protein content was found in the samples stored under cold condition (4°C) compared to ambient condition after four months of storage. Among the *Moringa* value added products the *Moringa* powder (26.88 mg/100g) which was stored in cold condition was found to have slower decrease in protein content followed by 26.75 mg/100g in *Moringa* powder at ambient storage, 26.69 mg/100g in *Moringa* capsule stored under cold storage condition and the minimum protein content was observed in *Moringa* tablet of 26.47 mg/100g under ambient condition. (Table.1). Suganti *et al*. (2019) [16] have also reported that the *Moringa* leaves stored at refrigerated storage (5+2°C) tend to have higher protein content at the end of the shelf life.

Effect of storage condition on crude fibre content of *Moringa* powder, tablet and capsule

The *Moringa* products are the richest source of fibre content. After 120 days of storage, the *Moringa* value added products showed significant differences ($p<0.05$) in the storage condition whereas no significant differences were found between the *Moringa* products and their interactions. The crude fibre content of 14.9 % was found to be reduced from the initial value of 15.5% in *Moringa* tablet which was stored under cold condition after 120 days of storage period followed by 14.8% of fibre content in *Moringa* powder at ambient storage condition (Fig.2). Then the lowest crude fibre content were observed in *Moringa* capsule with 14.5 % followed by 14.6% in *Moringa* tablet under ambient condition after four months of storage (Table.2). Adejumo *et al.* (2018) [1] also reported that the crude fibre content present in the *Moringa* powder have tend to decrease with increase in storage duration.

Effect of storage condition on Vitamin A content of *Moringa* powder, tablet and capsule

Among the *Moringa* value added products, the βeta-carotene content was decreased significantly ($p < 0.01$) with increase in storage condition. On comparing the loss in βeta-carotene after 120 DAS, the minimum loss was observed in the *Moringa* powder with 12.93 mg/100g from the initial value of 13.10 mg/100g followed by 12.75 mg/100g in *Moringa* capsule under cold condition and 12.73 mg/100g in *Moringa* capsule under ambient storage condition, whereas the maximum loss of βeta carotene was found in *Moringa* tablet

(12.37 mg/100g) in ambient condition (Table.3). Mensha, (2011) described that the *Moringa* powder stored in cold atmospheric condition resulted in maximum retention of βeta-carotene. Zareie *et al. (*2019) [18] also reported that the samples stored at 4° C showed the vitamins stability due to absence of light. Similar trend reported in dehydrated green vegetables with the reduction of βeta carotene in storage conditions due to oxidative, non-oxidative and heat sensitive (Seevaratnam *et al.*, 2012) [13].

Effect of storage condition on aminoacid content of *Moringa* powder, tablet and capsule

The composition of amino acids can be a determinant of the characteristics and activities of proteins contained in a substance. There were no significant differences was observed between the interaction effect of *Moringa* value added products for aminoacid content but highly significant ($p < 0.01$) effect on *Moringa* products and storage condition were observed after 120 days of storage. The rate of loss was significantly lower in *Moringa* capsule with 1.63 mg/100g followed by 1.61 mg/100g in *Moringa* powder was observed under cold condition. The higher loss (1.39 mg/100g) of aminoacid content was recorded in *Moringa* powder at cold condition followed by 1.27 mg/100g at ambient condition (Table.4). Udenigwe and Aluko (2011) [17] reported that the amino acids which have higher inhibitory activity against DPPH radicals are types of hydrophobic, aromatic and acidic amino acids. This indicates that the higher the concentration of hydrophobic, aromatic and acidic amino acids in a sample, the potential as an antioxidant will be good (Fig.4).

Effect of storage condition on Iron content of *Moringa* powder, tablet and capsule

The *Moringa* value added products were significant ($p < 0.01$) with the interaction effect and their storage condition was significant at ($p < 0.05$) after 120days of storage. The rate of loss in iron content was found minimum (26.89 mg/100g) in *Moringa* powder stored at cold condition followed by 26.85 mg/100g at ambient condition, 26.64 mg/100g in *Moringa* tablet stored at cold condition and the maximum loss of iron content was recorded in capsule (26.49 mg/100g) at cold condition followed by 26.37 mg/100g under ambient condition after 120 days of storage (Table.5). Shweta priyadarshini and Mukta singh (2015) [14] studied that the fresh spinach stored at 4° C have retained highest iron content of 85.8 % after 6 days of storage compared to the spinach sample stored at cold condition. Cooling of the leafy vegetables for 5 days at 4°C retained iron content of about 50.16 mg/100g from the intial (101.7 mg/100g) during storage. Hence, they concluded that the storage temperature (4°C) could be the best way for maintaining their nutritional characteristics (Florentina *et al.*, 2015) [5].

Table 1: Effect of Protein content on *Moringa* leaf powder, tablet and capsule during storage

		S_1 Ambient Storage						S_2 Cold Storage				
Produces	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**
P_1	27.44	27.42	27.40	27.36	26.75	27.27	27.44	27.42	27.40	27.38	26.88	27.30
P_2	27.22	27.20	27.19	27.11	26.47	27.04	27.22	27.21	27.20	27.17	26.51	27.06
P_3	27.12	27.10	27.08	27.05	26.57	26.98	27.12	27.12	27.10	27.07	26.69	27.02
Mean	27.26	27.24	27.22	27.17	26.60		27.26	27.25	27.23	27.21	26.69	
	30 DAS		**60 DAS**				**90 DAS**			**120 DAS**		
Source	**SEd**	**Cd (0.01)**	**SEd**	**Cd (0.01)**			**SEd**	**CD (0.01)**		**SEd**	**CD (0.01)**	
S	0.00471	0.01440 ^{ns}	0.00471	0.01440 ^{ns}			0.00471	0.01440 ^{NS}		0.00471	0.01440 ^{NS}	
P	0.00577	0.01764**	0.00577	0.01764**			0.00577	0.01764**		0.00577	0.01764**	
S × P	0.00816	0.02494 ^{ns}	0.00816	0.02494 ^{ns}			0.00816	0.02494 ^{NS}		0.00816	0.02494 ^{NS}	

P_1 – Powder P_2 – Tablet P_3 - Capsule
P* – Produces S*- Storage condition
* - Significant ** - Highly significant
NS - Non significant

Table 2: Effect of Crude fibre content on *Moringa* leaf powder, tablet and capsule during storage

		S_1 Ambient Storage						S_2 Cold Storage				
Produces	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**
P_1	15.5	15.4	15.3	14.7	14.5	15.08	15.5	15.4	15.3	15.1	14.8	15.22
P_2	15.3	15.2	15.1	14.9	14.6	15.02	15.3	15.3	15.2	15.0	14.9	15.14
P_3	15.2	15.1	15.0	14.8	14.5	14.92	15.2	15.2	15.1	14.9	14.7	15.02
Mean	15.33	15.23	15.13	14.8	14.53		15.33	15.3	15.2	15.0	14.8	
	30 DAS		**60 DAS**				**90 DAS**			**120 DAS**		
Source	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**			**SEd**	**CD (0.05)**		**SEd**	**CD (0.05)**	
S	0.04714	0.10271 ^{NS}	0.04714	0.10271 ^{NS}			0.04714	0.10271*		0.04714	0.10271*	
P	0.05774	0.12579 ^{NS}	0.05774	0.12579 ^{NS}			0.05774	0.12579 ^{NS}		0.05774	0.12579 ^{NS}	
S × P	0.08165	0.17790 ^{NS}	0.08165	0.17790 ^{NS}			0.08165	0.17790 ^{NS}		0.08165	0.17790 ^{NS}	

P_1 – Powder P_2 – Tablet P_3 - Capsule
P* – Produces S*- Storage condition
* - Significant ** - Highly significant
NS - Non significant

Table 3: Effect of Vitamin A content on *Moringa* leaf powder, tablet and capsule during storage

		S_1 Ambient Storage						S_2 Cold Storage				
Produces	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**
P_1	13.1	13.09	13.07	12.95	12.72	12.99	13.1	13.1	13.07	13.05	12.93	13.05
P_2	13.08	13.06	12.89	12.65	12.37	12.81	13.08	13.07	12.90	12.68	12.40	12.83
P_3	13.3	13.28	13.27	13.12	12.73	13.14	13.3	13.29	13.27	13.15	12.75	13.15
Mean	13.16	13.14	13.07	12.91	12.61		13.16	13.15	13.08	12.96	12.69	

	30 DAS		**60 DAS**		**90 DAS**		**120 DAS**	
Source	**SEd**	**CD (0.01)**	**SEd**	**CD (0.01)**	**SEd**	**CD (0.01)**	**SEd**	**CD (0.01)**
S	0.00471	0.01440 ^{NS}	0.00471	0.01440 ^{NS}	0.00471	0.01440 ^{NS}	0.00471	0.01440 ^{NS}
P	0.00577	0.01764 **	0.00577	0.01764 **	0.00577	0.01764 **	0.00577	0.01764 **
S × P	0.00816	0.02494^{NS}	0.00816	0.02494^{NS}	0.00816	0.02494^{NS}	0.00816	0.02494^{NS}

P_1 – Powder P_2 – Tablet P_3 - Capsule
P* – Produces S*- Storage condition
* - Significant ** - Highly significant
NS - Non significant

Table 4: Effect of Aminoacid content on *Moringa* leaf powder, tablet and capsule during storage

		S_1 Ambient Storage						S_2 Cold Storage				
Produces	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**
P_1	1.80	1.79	1.68	1.47	1.27	1.60	1.8	1.79	1.69	1.67	1.39	1.67
P_2	1.63	1.62	1.6	1.58	1.47	1.58	1.63	1.63	1.62	1.62	1.61	1.62
P_3	1.83	1.82	1.74	1.63	1.45	1.69	1.83	1.82	1.78	1.73	1.63	1.76
Mean	1.75	1.74	1.67	1.56	1.40		1.75	1.75	1.71	1.68	1.54	

	30 DAS		**60 DAS**		**90 DAS**		**120 DAS**	
Source	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
S	0.00471	0.01027 ^{NS}	0.00471	0.01027*	0.00471	0.01027**	0.00471	0.01027*
P	0.00577	0.01258*	0.00577	0.01258*	0.00577	0.01258*	0.00577	0.01258*
S × P	0.00816	0.01779 ^{NS}	0.00816	0.01779 ^{NS}	0.00816	0.01779**	0.00816	0.01779 ^{NS}

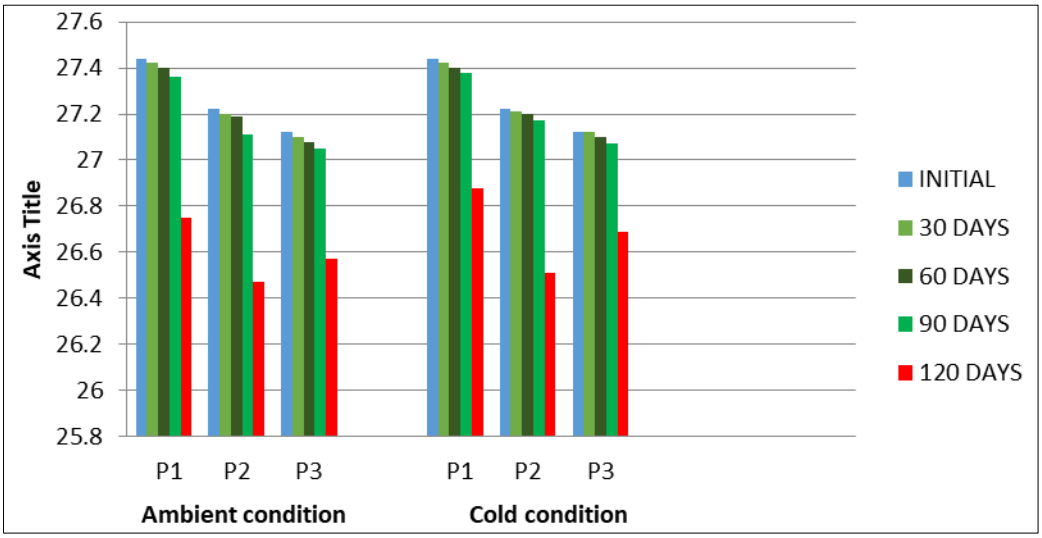
P_1 – Powder P_2 – Tablet P_3 - Capsule
P* – Produces S*- Storage condition
* - Significant ** - Highly significant
NS - Non significant

Table 5: Effect of Iron content on *Moringa* leaf powder, tablet and capsule during storage

		S_1 Ambient Storage						S_2 Cold Storage				
Produces	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**	**Initial**	**30 Days**	**60 Days**	**90 Days**	**120 Days**	**Mean**
P_1	27.42	27.38	27.25	27.12	26.85	27.20	27.42	27.4	27.39	27.14	26.89	27.25
P_2	27.7	27.69	27.68	27.4	26.54	27.40	27.7	27.7	27.69	27.4	26.64	27.43
P_3	27.24	27.22	27.19	26.53	26.37	26.91	27.24	27.24	27.20	26.64	26.49	26.93
Mean	27.45	27.43	27.37	27.02	26.59		27.45	27.50	27.43	27.06	26.67	

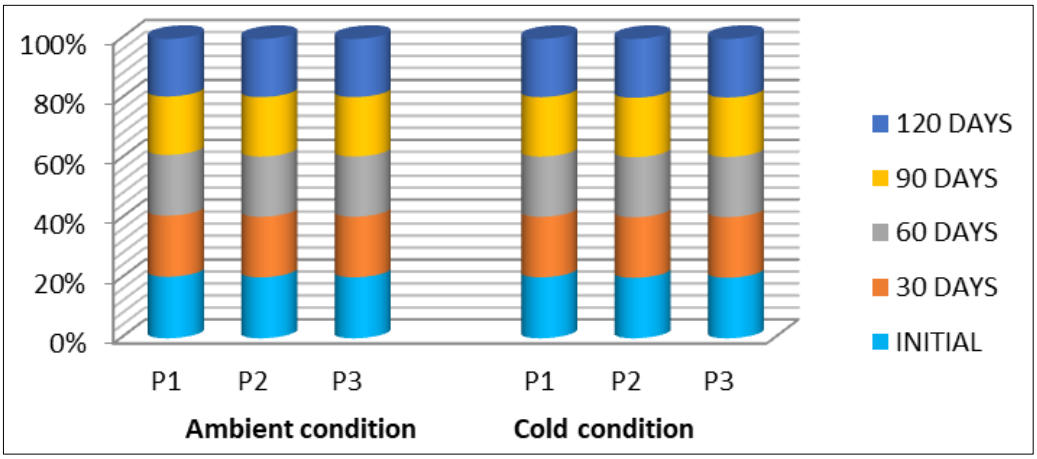
	30 DAS		**60 DAS**		**90 DAS**		**120 DAS**	
Source	**SEd**	**CD (0.01)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
S	0.00471	0.01440**	0.00471	0.01440**	0.00471	0.01440**	0.00471	0.01440**
P	0.00577	0.01764**	0.00577	0.01764**	0.00577	0.01764**	0.00577	0.01764**
S × P	0.00816	0.02494**	0.00816	0.02494**	0.00816	0.01799*	0.00816	0.01799*

P_1 – Powder P_2 – Tablet P_3 - Capsule
P* – Produces S*- Storage condition
* - Significant ** - Highly significant
NS - Non significant



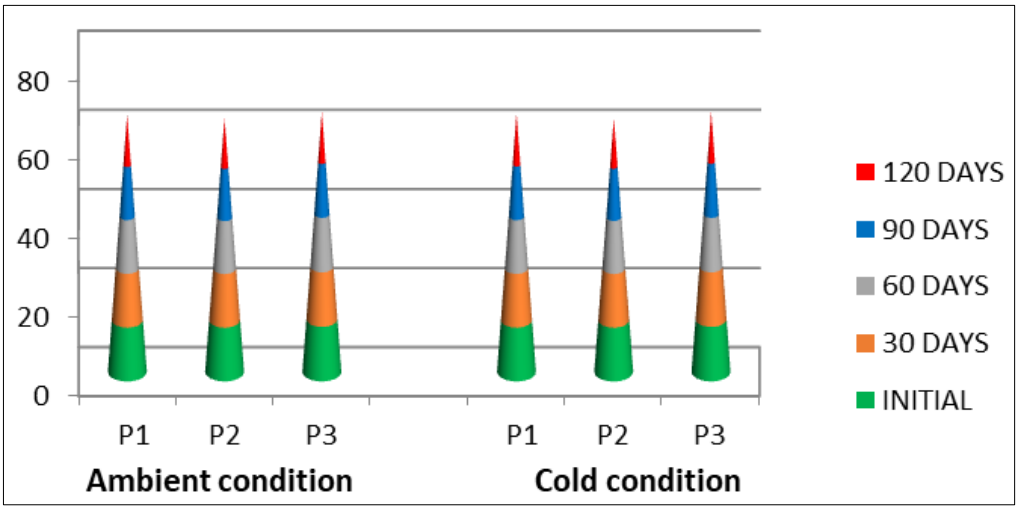
P1* - *Moringa* powder P2* - *Moringa* tablet P3* - *Moringa* capsule

Fig 1: Effect of protein content in *Moringa* value added products during storage



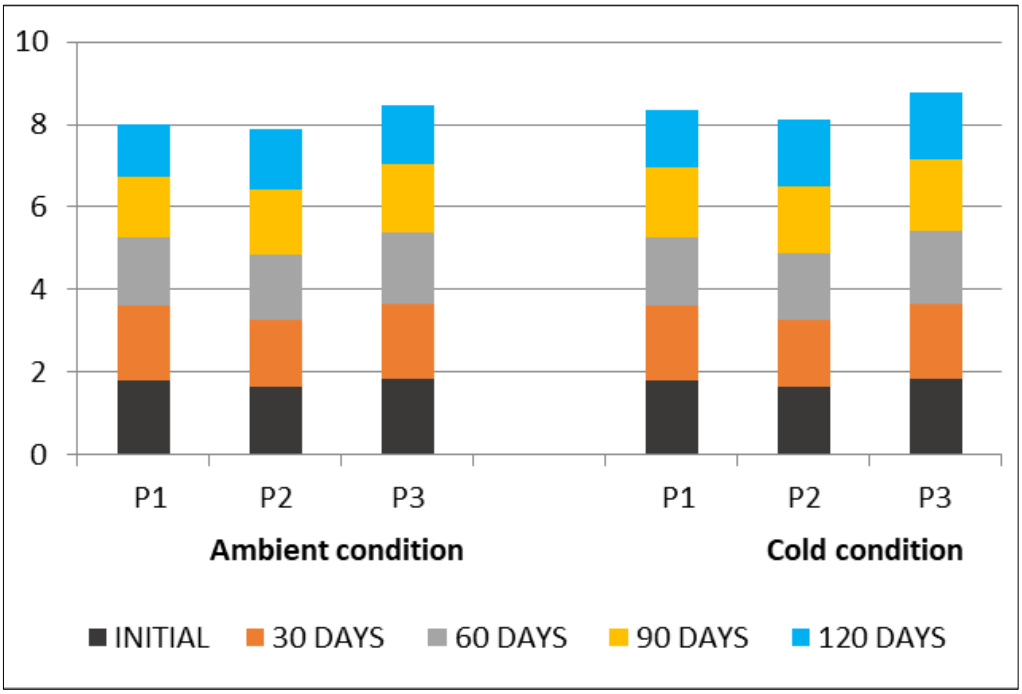
P1* - *Moringa* powder P2* - *Moringa* tablet P3* - *Moringa* capsule

Fig 2: Effect of crude fibre content in *Moringa* value added products during storage



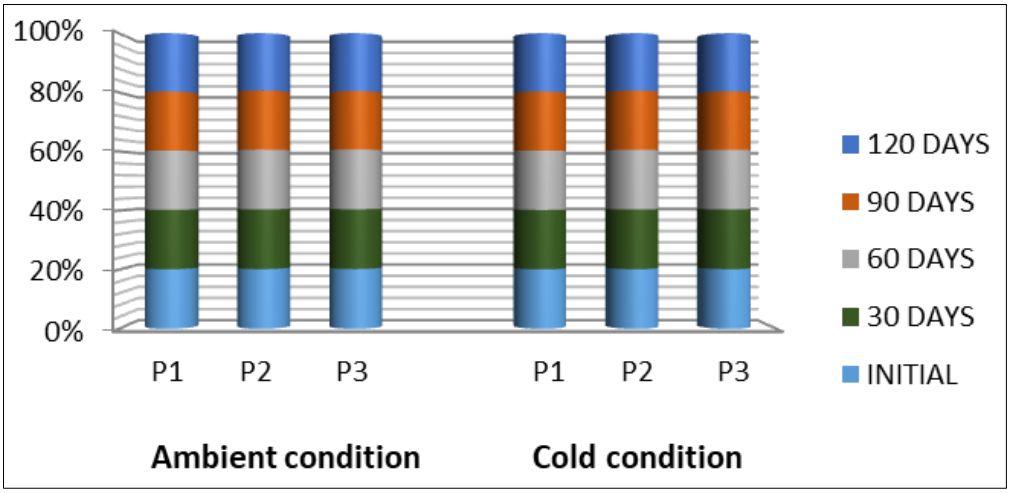
P1* - *Moringa* powder P2* - *Moringa* tablet P3* - *Moringa* capsule

Fig 3: Effect of vitamin A content in *Moringa* value added products during storage



P1* - *Moringa* powder P2* - *Moringa* tablet P3* - *Moringa* capsule

Fig 4: Effect of aminoacid content in *Moringa* value added products during storage



P1* - *Moringa* powder P2* - *Moringa* tablet P3* - *Moringa* capsule

Fig 5: Effect of iron content in *Moringa* value added products during storage

Conclusions

Refrigerated conditions of *Moringa* value added products retains maximum nutrient contents when compared to the products stored under the ambient conditions at 120 days of storage, hence the nutrient loss was less in the cold storage and among the produces the *Moringa* leaf powder have retains maximum nutrients followed by *Moringa* capsule and tablet, then the minimum nutrient contents were recorded in the ambient storage produces. The Cold storage condition have retains best colour, increases the shelf life and minimize the quality loss of the *Moringa* value added products after 120 days of storage conditions.

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