Original Research Article

Performance of Packaging on Shelf life and quality of Fenugreek at Different Storage Conditions in *Kharif* Season

ABSTRACT

Aims: The research work was carried out to study the effect of different packaging materials on quality of fenugreek and to study the shelf life of fenugreek at different storage conditions in *kharif*season.

Study Design: The fresh fenugreek samples were packed with 100 g weight in different polyethylene (100, 200 and 400 gauge) and butter paper bags with 2, 4 and 6 per cent vents and without vents. Sixteen treatment combinations comprisingofpolyethylene and butter paper bags.The experiment was laid in Completely Randomized Design (CRD) with three replications.

Place and duration of study: The present research work was carried out in the Post Harvest Technology Centre, Department of Horticulture, Mahatma PhuleKrishiVidyapeeth, Rahuri during the year 2014-2015.

Methodology: Thefresh fenugreek packed samples were further stored in cold storage(CS), zero energy cool chamber(ZECC) and room temperature(RT). The effect of packaging and storage on moisture content, ascorbic acid, chlorophyll content, iron content, physiological loss in weight and rotting was studied.

Results: The findings of the present study revealed that the composition of fresh fenugreek was found to be 89.08 per cent moisture content, 393 mg/100g ascorbic acid, 62.72 per cent chlorophyll content and 52.38 mg/100g iron content in *kharif* season. All samples of fenugreek packed in different packaging materials showed decreasing trend of moisture content, ascorbic acid content, chlorophyll content and iron content. However, they showed increasing trend of rotting and physiological loss in weight.

Conclusion: It may be concluded that Fenugreek packed in 400 gauge polyethylene bags without vents were found to be the best packaging material for extending the shelf life upto 10 days in CS followed by 4 days in ZECC and upto 2 days at RT in *kharif*season.

Keywords *Fenugreek, packaging, polyethylene bags, storage, shelf life*

1. INTRODUCTION

Fenugreek (*Trigonellafoenum-graecum*L.) is one of the important leafy vegetable. India is the second largest producer of vegetables in the world next to China and accounts for about 15% of the world production of vegetables. In India, the area under vegetable production is 92.05 lakh ha with 162187 MT production and 17.62 MT/ha. productivity. Whereas in Maharashtra, the area under vegetable production is 4,74,000 ha with 8008 MT production and 14.04 MT/ha. Productivity during the year 2014-15 [6].

Leafy vegetables are rich source of vitamins, minerals and dietary fiber. Being an inexpensive source, these leaves can be used by a large population to meet their dietary requirements.

Fenugreek green leaves are one of the most ancient medicinal herbs containing ß- carotene (19mg/100g),ascorbate (220 mg/100g), fibre, iron, calcium and zinc, even more than the regular food items[19].Fenugreek possesses pharmacological properties such as antimicrobial,

anticholesterolemic, carminative, emollient, febrifuge, laxative, restorative, uterine tonic, expectoral, galactogogue, anti-carcinogenic , anti-inflammatory, antiviral, antioxidant, demulcent and hypotensive [17]. In addition, it regulates several enzymatic activities, relieves fever, reduces body pain and fat, alleviates swelling, auguments appetite and promotes lactation and sex hormones, protection against cancer, malaria, allergies, bacteria and viruses [20,25]. Fenugreek in particular is abundant in polyphenolics that inhibit per oxidation and remarkably reduce oxidative hemolysis in human erythrocytes [30]. Moreover their optimal consumption may lower triglyceridesand cholesterol concentrations in the blood [2].However, hypoglycemic effect of fenugreek is likely due to the inhibitory effect of mucilaginous fiber and galactomannan gum. Currently, fenugreek is being used in pharmacology and disease treatments [3].However, leaves are prone to mechanical injury during handling and they lose water because of a high surface area to volume ratio, which makes them highly perishable. Their shelf life is further limited due to loss of chlorophyll, which is accelerated by water loss [8]during harvest season, a huge loss in leafy vegetables is observed mainly due to lack of adequate storage facilities. Extension of shelf life by use of controlled or modified atmosphere storage is well known, but due to high cost, it cannot be afforded. Low cost storage can enhance availability of these vegetables due to reduction in storage cost and extension of shelf life. Fresh vegetables are inherently perishable, during the process of distribution and marketing substantial losses are incurred which range from a slight loss of quality to total spoilage. This can be avoided by giving proper pre-storage treatment such as pre-cooling, packaging, low temperature storage etc.

Therefore, it is necessary to find out the suitable method for storage of fenugreek.Research work was carried out with a view to study the effect of different vents and gauges of polyethylene bags on quality of fenugreek and to study the shelf life of fenugreek at different storage conditions.

2. MATERIALS AND METHODS

The present research work was carried out in the Post Harvest Technology Centre, Department of Horticulture, Mahatma PhuleKrishiVidyapeeth, Rahuri during the year 2014-2015. Freshly harvested fenugreek was procured from the Horticultural Nursery, Department of Horticulture, MPKV.,Rahuri. Procurement of Fenugreek, cleaning and sorting, packaging of Fenugreek in different packaging materials, storage study at room temperature(RT), zero energy cool chamber (ZECC) and cold storage (CS)and chemical and sensory evaluations during storage was studied. The details of materials used, method adopted and the statistical procedures followed during the research work are described below.

The fresh fenugreek samples were packed with 100 g weight in different polyethylene (100, 200 and 400 gauge) and butter paper bags with 2, 4 and 6 per cent vents and without vents in *kharif*season. Sixteen treatment combinations comprising of polyethylene and butter paper bags. The experiment was laid in Completely Randomized Design (CRD) with three replications.

The fresh fenugreek packed samples were further stored in cold storage (5±1 ºC and 90-95 % R.H.), zero energy cool chamber(14.6 to 20.3ºC and 83.59 to 91.90 % R.H.) and room temperature(25.4 to 28.2 ºC and 57.7 to 88.00 % R.H.). The stored samples were analysed for Moisture content [21, 24]; physiological weight loss, iron content [16], chlorophyll content, ascorbic acid [7], rotting and sensory [4]parameterson nine point hedonic scaleat one day interval in case of room temperature (RT), zero energy cool chamber (ZECC) and cold storage

(CS). The data obtained for physical, chemical and sensory parameters was analyzed for the statistical significance according to the procedure given by [28].

The treatment details are given below.

Treatments	Treatment details
T1	100 gauge polythene bag without vents
T2	100 gauge polythene bag with 2 % vent
T3	100 gauge polythene bag with 4 % vent
T4	100 gauge polythene bag with 6 % vent
T5	200 gauge polythene bag without vents
T6	200 gauge polythene bag with 2 % vent
T7	200 gauge polythene bag with 4 % vent
T8	200 gauge polythene bag with 6 % vent
T9	400 gauge polythene bag without vents
T10	400 gauge polythene bag with 2 % vent
T11	400 gauge polythene bag with 4 % vent
T12	400 gauge polythene bag with 6 % vent
T13	Butter paper bag without vent
T14	Butter paper bag with 2% vent
T15	Butter paper bag with 4% vent
T16	Butter paper bag with 6% vent

3. RESULTS AND DISCUSSION

3.1 Chemical composition of fresh fenugreek

The results for chemical composition of fresh fenugreek samples revealed that fresh fenugreek had 89.08 per cent moisture content on dry weight basis, 393 mg/100g ascorbic acid, 62.72 per cent chlorophyll content and 52.38 mg/100g iron content, respectively.Similar results were also reported by [12]in studies on dehydration, packaging and storage of spinach and [11]in the shelf life study of spinach.

The data for changes in physico-chemical composition of fenugreek samples packed in different packaging materials and stored in different storage conditions recorded that the moisture content, ascorbic acid, chlorophyll content, iron content and sensory parameters was found to be decreased whereas physiological loss in weight and rotting was found to be increased during storage period and the rate was faster under room temperature (RT) as compared to zero energy cool chamber (ZECC) and cold storage (CS).The datasubjected to moisture content, physiological loss in weight, rotting, ascorbic acid, chlorophyll content, iron content and sensory parameters are given below.

Moisture content (%)

At the end of storage period at RT i.e. after 2 days of storage, treatment T9 recorded highest moisture content of 84.07 per cent followed by T5 (83.84 %) while the lowest moisture content

was recorded in T16 (80.62%) (Table1).The treatment T9 was at par with T5 (78.55%).At the end of 4 days of storage in ZECC, T9 recorded the highest moisture content of 84.08 per cent followed by T5 (83.85 %) while lowest moisture content was recorded in T16 (80.63%) (Table 3).At the end of 10 days of storage in CS, T9 recorded the highest moisture content 78.90 per cent and it was at par with T5 (78.75 %) followed by T1 (78.60%).While lowest moisture content was recorded in T16 (76.65 %) and it was art par with T15(76.80%), T14 (76.95%) and T13 (77.10 %), respectively(Table 5). Samples stored in polyethylene bags without vents have more moisture retention than ventilated polyethylene bags. Moisture loss increased with increase in ventilation. This occurred because of higher permeability which influences respiration and transpiration rate. These results are comparable to the results reported by previous workers[15, 32].

Physiological loss in weight (PLW) (%)

At the end of storage period at RT i.e. after 2 days of storage, treatment T9 recorded lowest PLW of 10.30 per cent followed by T5 (10.45 %) while the highest PLW recorded in T16 (12.55 %) (Table2). At the end of 4 days of storage in ZECC, T9 recorded the lowest PLW of 10.25 per cent followed by T5 (10.40 %) while highest PLW was recorded in T16 (12.50 %) (Table 4, Fig. 2). At the end of 10 days of storage in CS, T9 recorded the lowest PLW of 10.17 per cent followed by T5 (10.32 %) while highest PLW was recorded in T16 (12.42 %)(Table 6). Samples stored at low temperature were having less PLW as compared to room temperature. Presence of vents also had a marked effect on PLW of vegetables. Samples stored in polyethylene bags without vents have less PLW than ventilated polyethylene bags. PLW increased with increase in ventilation. This occurred because of higher permeability which influences respiration and transpiration rate. These findings are in accordance to the observations of previous workers [15,23, 31, 32].

Rotting (%)

At the end of storage period at RT i.e. after 2 days of storage, treatment T9 recorded lowest rotting of 6.56 per cent followed by T5 (7.23 %) while the highest rotting was recorded in T16 (16.61 %) (Table 2). At the end of 4 days of storage in ZECC, T9 recorded the lowest rotting of 6.10 per cent followed by T5 (6.76 %) while highest rotting was recorded in T16 (16.00 %) (Table 4). At the end of 10 days of storage in CS, T9 recorded the lowest rotting of 5.17 per cent followed by T5 (5.89 %) while highest rotting was recorded in T16 (15.97 %) (Table 6). Rotting may be caused by the condensation in the bag which creates aqueous focuses for the development of microorganisms. Also, low levels of oxygen favours fermentation process which might cause the formation of the acetaldehyde and off flavour compounds which may cause rotting [14]. The results obtained are similar to the observations of previous workers[13, 22,27].

Ascorbic acid content (mg/100 g)

At the end of storage period at RT i.e. after 2 days of storage, treatment T9 recorded highest ascorbic acid content 229 mg/100g followed by T5 (224 mg/100g) while the lowest ascorbic acid content was recorded in T16 (154 mg/100g) (Table 1). At the end of 4 days of storage in ZECC, T9 recorded the highest ascorbic acid content of 232 mg/100g followed by T5 (227 mg/100g)

while lowest ascorbic acid content was recorded in T16 (157 mg/100g) (Table 3). At the end of 10 days of storage in CS, T9 recorded the highest ascorbic acid content of 235 mg/100g followed by T5 (230 mg/100g) while lowest ascorbic acid content was recorded in T16 (160 mg/100g) (Table 5). The chief reason for losses in ascorbic acid is the solubility in water, thermic destruction and enzymatic oxidation during storage. These findings are in agreement with those of previous workers[5, 11, 23, 29, 33,35].

Chlorophyll content (%)

At the end of storage period at RT i.e. after 2 days of storage, treatment T9 recorded highest chlorophyll content of 57.45 per cent and it was at par with T5 (57.07 %) and T1 (56.69%) while the lowest chlorophyll content was recorded in T16 (51.75 %) and it was at par with T15 (52.13%) (Table 1, Fig.1). At the end of 4 days of storage in ZECC, T9 recorded the highest chlorophyll content 57.87 per cent and it was at par with T5 (57.47 %) and T1 (57.07 %)while lowest chlorophyll content was recorded in T16 (51.87 %) (Table 3).At the end of 10 days of storage in CS, T9 recorded the highest chlorophyll content of 57.31 per cent and it was at par with T5 (56.99 %) while lowest chlorophyll content was recorded in T16 (52.51 %) (Table 5).Low oxygen and high carbon dioxide concentration can prevent chlorophyll degradation. Presence of vents has failed to increase carbon dioxide concentration, thus leading to higher amount of yellowing. The principal causes of the breakdown of chlorophyll are pH changes mainly due to leakage of organic acids from the vacuole, oxidative system and chlorophyllases[34].These results of decreasing trend of chlorophyll content with storage are similar with those reported by the previous workers[1, 9, 18,29].Similarly, [10] suggested that packaging of fenugreek with polypropylene (PP) film in two perforation packets with mustard seeds resulted in best maintenance of chlorophyll, ascorbic acid, phenols and aroma. Water accumulation was also consoled due to mustard seeds after 6 days of storage (15°C&75%RH).

Iron content (mg/100g)

At the end of storage period at RT i.e. after 2 days of storage, T9 recorded highest iron content of 50.91 mg/100g and it was at par with T5 (50.77 mg/100g) and T1(50.63 mg/100g) while the lowest iron content was recorded in T16 (48.81 mg/100g) and it was at par with T15 (48.95 mg/100g) (Table 1).At the end of 4 days of storage in ZECC, T9 recorded the highest iron content 50.98 mg/100g and it was at par with T5 (50.84 mg/100g) and T1(50.70 mg/100g)while lowest iron content was recorded in T16 (48.88 mg/100g)and it was at par with T15 (49.02 mg/100g) and T14(49.16 mg/100g)(Table 3). At the end of 10 days of storage in CS, T9 recorded the highest iron content 51.01 mg/100g followed by T5 (50.87 mg/100g) while lowest iron content was recorded in T16 (48.91 mg/100g) and it was at par with T15 (49.05 mg/100g) and T14 (49.19 mg/100g)(Table 5). Loss of iron may be attributed to leaching of these nutrients into the water and the moisture had decreased during storage period as reported by previous workers[15, 31].

Sensory evaluation

At the end of storage period at RT i.e. after 2 days of storage, T9 recorded highest value for overall acceptability (7.50) followed by T5 (7.40) while the lowest value for overall acceptability was recorded in T16 (6.00) (Table 2). At the end of 4 days of storage in ZECC, T9 recorded the highest value for overall acceptability 7.75 followed by T5 (7.65) while lowest value for overall acceptability was recorded in T16 (6.20) (Table 4). At the end of 10 days of storage in CS, T9 recorded the highest value for overall acceptability 8.20 followed by T5 (8.10) while lowest value for overall acceptability was recorded in T16 (6.70) (Table 6). Similar findings were reported by previous workers[11, 12, 26].

4. CONCLUSION

The present study made it clear that fenugreek samples packed in 400 gauge polyethylene bags without vents were found superior followed by 200 and 100 gauge polyethylene bags without vents. Also, samples packed in 400 gauge polyethylene bags without vents showed more retention of all physico-chemical characteristics than ventilated polyethylene bags in *kharif*season and were more acceptable from sensory point of view. The shelf life of fenugreek was found to be two days at room temperature, four days in zero energy cool chamber and ten days in cold storage in *kharif*season.

From the findings of present study it may be concluded that fenugreek packed in 400 gauge polyethylene bags without vents were found to be the best packaging material for extending the shelf life upto 10 days in Cold storage (CS) followed by Zero energy cool chamber (ZECC)upto 4 days and Room temperature (RT)upto 2 days.

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COMPETING INTERESTS

Authors have declared that no competing interests exists.

REFERENCES

1. Abe K, Watada AE. Ethylene absorbent to maintain quality of lightly processed fruits and vegetables. Journal of Food Science.1991; 56: 1589-1592.
2. Afef KE, Jan F, Alexander R, Siv T,. Effects of dietary phenolic compounds on tocopherol, cholesterol and fatty acids in rats. Lipids. 2000; 35: 427- 435.
3. Ahmad A, Alghamdi SS, Mahmood K, Afzal M. Fenugreek a multipurpose crop: Potentialities and improvements. Saudi J Biol Sci. 2016; 23:300-310.
4. Amerine MS, Pangborn RM,RoesslerEA. Principles of sensory evaluation of food. 1965. Academic press, New York.
5. Anguilla JSD, Sasaki FF, Heiffig LS, Ortega EMM, Jacomino AP, Kluge RA. Fresh-cut radish using different cut types and storage temperatures.PostharvestBiological Technology. 2006; 40: 149-154.
6. Anonymous. Indian Horticulture Database 2014. National Horticulture Board. 2014.
7. AOAC. Official methods of analysis of the association of official analytical chemist.1975; 829-830.
8. Ben Yehoshua S. Transpiration, water stress and gas exchange. In Weichmann J (ed), Post Harvest Physiology of Vegetables. New York: Marcel Dekker. 1987; pp 113–170.
9. Bolin HR, Huxsoll CC. Effect of preparation procedures and storage parameters on quality retention or salad-cut lettuce. Journal of Food Science. 1991; 56(1): 62-67.
10. Brar JK, Rai DR, Singh A, Kaur N. Biochemical and physiological changes in Fenugreek (*Trigonellafoenum-graecum*L.*)* leaves during storage under modified atmosphere packaging. J Food Sci Technol. 2013; doi:10.1007/s13197-011-0390-4.
11. Jagtap B. Effect of foliar spray of growth substance on the growth, yield and shelf life of leafy vegetables viz., Fenugreek and Spinach. 1986; M. Sc. (Agri.) thesis submitted to Mahatma PhuleKrishiVidyapeeth, Rahuri (M.S.).
12. Jorwar MM. Studies on dehydration, packaging and storage of fenugreek. 2001; M. Tech thesis submitted to Mahatma PhuleKrishiVidyapeeth, Rahuri (M.S.).
13. Kablan T, Navery RK, Koussemon M, Oule MK. The effects of different storage temperatures on the quality of fresh bell peppers (*Capsicum annuum*L.). Agricultral Journal.2008; 3(2): 157-162.
14. Kays, C. and Kapoor, H. C. Minimal processing of fruits and vegetables, Indian Food Packer.2000; pp.156-164.
15. Koraddi V. Methods of storage of vegetables in the refrigerator at household level. 2005; M.Sc. thesis submitted to University of Agricultural Sciences, Dharwad (Karnataka).
16. Linder RC, Harley CP. A rapid method for the determination of nitrogen in plant tissue. Science.1942;96 : 565-566.

17. MoradiKor N, Moradi K. Physiological and pharmaceutical effects of fenugreek (Trigonellafoenum-graecum L.) as a multipurpose and valuable medicinal plant. Global J. Med. Plant Res. 2013;1:199–206.
18. Moretti CL, Washington LV, Silva, Aravjo AL. Quality attributes and carbon dioxide evaluation of bell peppers as affected by minimal processing and storage temperature. Proceedings of Fla. State Horticultural Society. 2000;113: 295-296.
19. Muralidhara, Narasimhamurthy K, Viswanatha S, Ramesh BS. Acute and subchronic toxicity assessment of debitterized fenugreek powder in the mouse and rat. Food Chem. Toxicol. 1999; 37: 831–838.
20. Naidu MM, Shyamala B, Naik JP, Sulochanamma G, SrinivasP. Chemical composition and antioxidant activity of the husk and endosperm of fenugreek seeds. LWT – Food Sci. Technol. 2011; 2 :451–456.
21. Nambiar VS, Sheshadri S. A study on β-carotene and moisture content of some green leafy vegetables of western India by high performance liquid chromatography. J. Food Sci. Tech. 1998; 35 (4): 365-367.
22. Nath A, Bidyut CD, Paul D, Misra LK. Ambient storage of capsicum (*Capsicum annuum* L.) under different packaging materials. Bioinfolet. 2010;7(3): 266-270.
23. Negi PS and Roy SK. Changes in β-carotene and ascorbic acid content of fresh amaranth and fenugreek leaves during storage by low cost technique. Plant Foods for Human Nutrition.2004; 58: 225-230.
24. NIN. Manual of laboratory techniques. National Institute of Nutrition, ICMR, Hyderabad. 1993.
25. Priya V, Jananie R, Vijayalakshmi K. GC/MS determination of bioactive components of *Trigonellafoenumgraecum*. J. Chem. Pharm. Res. 2011; 5:35–40.
26. Nunes MCN, Delgado A, Emond JP. Quality curves for green bell pepper (*Capsicum annum* L.) stored at low and recommended relative humidity levels. ActaHorticulturae. 2012; 945 : 71-78.
27. Nyanjage MO, Nyalala SPO, Illa AO, Mugo BW, LimbeAE,Vulimu EM. Extending post-harvest life of sweet pepper (*Capsicum annum* L.) 'California Wonder' with modified atmosphere packaging and storage temperature. Agricultural TropicaETSubtropica. 2005; 38,2.
28. Panse VG, Sukhatme PV. Stastical methods of agricultural workers 1985; ICAR, New Delhi. pp.143-147.
29. Rai DR, Narsaiah K, Bharati DK, Reddy PMK, Brar SS. Modified atmosphere packaging of minimally processed cabbage. Journal of Food Science and Technology. 2009; 46(5): 436-439.
30. Rayyan S, Fossen T, Andersen OM. Flavone C-glycosides from seeds of fenugreek, *Trigonellafoenum-graecum* L. J. Agric. Food Chem. 2010; 12, 7211–7217.
31. Reddy JB, Bharati P, Naik KR, Chimmad BV, Itagi SK, Hasalkar S. Effect of packaging materials on shelflife of minimally processed rajagira leaves *(Amaranthuspaniculatus)*. Karnataka Journal of Agricultural Science. 2013; 26 (2): 285-287.
32. Roy JK, Khurdiya BL. Studies on evaporatively cooled zero energy input cool chamber for the storage of horticultural produce. Indian Food Packer. 1986; 40(6): 26-31.
33. Selman ID. Vitamin retension during blanching of vegetables. Food chemistry. 1994; 49:137-147.

34. Wills RBH, Mcglasson WB, Graham D, Lee TH, Hall EG. Postharvest: An introduction to the physiology and handling of fruits and vegetables. South China Printing Company Limited, 3rd edn.1989; pp.170-190.
35. Yadav SK, Sehgal S. Effect of home processing and storage on ascorbic acid and β-carotene content of Bathua*(Chenopodium album)* and fenugreek *(Trigonellafoenumgraecum)* leaves. Plant Foods for Human Nutrition.1997; 50: 239-247.

Table 1. Effect of various combinations of packaging on chemical composition of fenugreek (whole) at room temperature storage

Particulars	Storage period (days)	Treatments																		
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Moisture content (%)																					
	1	83.61	82.92	82.23	81.54	83.84	83.15	82.46	81.77	84.07	83.38	82.69	82.00	81.31	81.08	80.85	80.62	82.345	0.127	0.366	0.267
	2	78.32	77.63	76.94	76.25	78.55	77.86	77.17	76.48	78.78	78.09	77.40	76.71	76.02	75.79	75.56	75.33	77.055	0.014	0.400	0.031
Ascorbic acid(mg/100g)																					
	1	305	296	287	278	308	299	290	281	311	302	293	284	275	272	269	266	288.5	0.115	0.333	0.069
	2	219	204	189	174	224	209	194	179	229	214	199	184	169	164	159	154	191.5	0.156	0.449	0.141
Chlorophyll content (%)																					
	1	58.93	58.12	57.31	56.5	59.2	58.39	57.58	56.77	59.47	58.66	57.85	57.04	56.23	55.96	55.69	55.41	57.44	0.092	0.266	0.278
	2	56.69	55.55	54.41	53.27	57.07	55.93	54.79	53.65	57.45	56.31	55.17	54.03	52.89	52.51	52.13	51.75	54.60	0.162	0.466	0.513
Iron (mg/100g)																					
	1	51.65	51.26	50.87	50.48	51.78	51.39	51.00	50.61	51.91	51.52	51.13	50.74	50.35	50.22	50.09	49.96	50.94	0.081	0.233	0.275
	2	50.63	50.21	49.79	49.37	50.77	50.35	49.93	49.51	50.91	50.49	50.07	49.65	49.23	49.09	48.95	48.81	49.86	0.092	0.266	0.321

371 **Table 2. Effect of various combinations of packaging on sensory and physical properties of fenugreek (whole) at room temperature storage**

Particulars	Storage period (days)	Treatments																		
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Sensory evaluation																					
	2	7.30	7.00	6.70	6.40	7.40	7.10	6.80	6.50	7.50	7.20	6.90	6.60	6.30	6.20	6.10	6.00	6.75	0.075	0.216	1.926
PLW (%)																					
	1	5.16	5.61	6.06	6.51	5.01	5.46	5.91	6.36	4.86	5.31	5.76	6.21	6.66	6.81	6.96	7.11	5.985	0.110	0.316	3.175
	2	10.6	11.05	11.50	11.95	10.45	10.9	11.35	11.8	10.3	10.75	11.20	11.65	12.1	12.25	12.4	12.55	11.425	0.121	0.349	1.838
Rotting (%)																					
	1	6.91	8.62	10.33	12.04	6.34	8.05	9.76	11.47	5.77	7.48	9.19	10.90	12.61	13.18	13.75	14.32	10.045	0.115	0.333	1.991
	2	7.90	9.91	11.92	13.93	7.23	9.24	11.25	13.26	6.56	8.57	10.58	12.59	14.6	15.27	15.94	16.61	11.585	0.087	0.249	1.295

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Table 3. Effect of various combinations of packaging on chemical composition of fenugreek (whole) at zero energy cool chamber storage

Particulars	Storage period (days)	Treatments																		
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Moisture content (%)																					
	2	83.62	82.93	82.24	81.55	83.85	83.16	82.47	81.78	84.08	83.39	82.70	82.01	81.32	81.09	80.86	80.63	82.355	0.115	0.333	0.243
	4	78.37	77.68	76.99	76.30	78.60	77.91	77.22	76.53	78.83	78.14	77.45	76.76	76.07	75.84	75.61	75.38	77.105	0.012	0.035	0.027
Ascorbic Acid (mg/100gm)																					
	2	309	303	297	291	311	305	299	293	313	307	301	295	289	287	285	283	298.0	0.064	0.183	0.037
	4	222	207	192	177	227	212	197	182	232	217	202	187	172	167	162	157	194.5	0.075056	0.216	0.067
Chlorophyll content (%)																					
	2	59.13	58.02	56.91	55.80	59.50	58.39	57.28	56.17	59.87	58.76	57.65	56.54	55.43	55.06	54.69	54.32	57.095	0.104	0.299	0.315
	4	57.07	55.87	54.67	53.47	57.47	56.27	55.07	53.87	57.87	56.67	55.47	54.27	53.07	52.67	52.27	51.87	54.870	0.110	0.316	0.346
Iron content (mg/100g)																					
	2	51.71	51.32	50.93	50.54	51.84	51.45	51.06	50.67	51.97	51.58	51.19	50.8	50.41	50.28	50.15	50.02	50.995	0.144	0.416	0.490
	4	50.70	50.28	49.86	49.44	50.84	50.42	50.00	49.58	50.98	50.56	50.14	49.72	49.30	49.16	49.02	48.88	49.93	0.156	0.4505	0.541

Table 4 . Effect of various combinations of packaging on sensory and physical properties of fenugreek (whole) at zero energy cool chamber storage

Particulars	Storage period (days)	Treatments																		
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Sensory evaluation																					
	4	7.55	7.25	6.95	6.65	7.65	7.35	7.05	6.75	7.75	7.45	7.15	6.80	6.50	6.40	6.30	6.20	6.984	0.098	0.283	2.434
PLW (%)																					
	2	5.30	5.75	6.20	6.65	5.15	5.60	6.05	6.50	5.00	5.45	5.90	6.35	6.80	6.95	7.10	7.25	6.125	0.098	0.283	2.776
	4	10.55	11.00	11.45	11.90	10.40	10.85	11.30	11.75	10.25	10.70	11.15	11.60	12.05	12.20	12.35	12.50	11.375	0.127	0.366	1.934
Rotting (%)																					
	2	5.35	7.21	9.07	10.93	4.73	6.59	8.45	10.31	4.11	5.97	7.83	9.69	11.55	12.17	12.79	13.41	8.76	0.098	0.283	1.941
	4	7.42	9.40	11.38	13.36	6.76	8.74	10.72	12.70	6.10	8.08	10.06	12.04	14.02	14.68	15.34	16.00	11.05	0.115	0.333	1.810

412 **Table 5.Effect of various combinations of packaging on chemical composition of fenugreek (whole) in cold storage**

Particulars	Storage period (days)	Treatments																		
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Moisture																					
	2	86.52	85.83	85.14	84.45	86.75	86.06	85.37	84.68	86.98	86.29	85.6	84.91	84.22	83.99	83.76	83.53	85.255	0.133	0.383	0.270
	4	84.97	84.28	83.59	82.90	85.20	84.51	83.82	83.13	85.43	84.74	84.05	83.36	82.67	82.44	82.21	81.98	83.705	0.013	0.037	0.026
	6	83.07	82.38	81.69	81.00	83.30	82.61	81.92	81.23	83.53	82.84	82.15	81.46	80.77	80.54	80.31	80.08	81.805	0.156	0.450	0.330
	8	80.83	80.38	79.93	79.48	80.98	80.53	80.08	79.63	81.13	80.68	80.23	79.78	79.33	79.18	79.03	78.88	80.005	0.162	0.466	0.350
	10	78.60	78.15	77.70	77.25	78.75	78.30	77.85	77.40	78.90	78.45	78.00	77.55	77.10	76.95	76.80	76.65	77.775	0.167	0.482	0.373
Ascorbic Acid mg/100gm																					
	2	343	337	331	325	345	339	333	327	347	341	335	329	323	321	319	317	332	0.121	0.350	0.063
	4	305	297	290	282	307	300	292	285	310	302	295	287	280	277	275	272	291	0.173	0.499	0.103
	6	247	238	229	220	250	241	232	223	253	244	235	226	217	214	211	208	230.5	0.202	0.582	0.152
	8	239	227	215	203	243	231	219	207	247	235	223	211	199	195	191	187	217	0.208	0.599	0.166
	10	225	210	195	180	230	215	200	185	235	220	205	190	175	170	165	160	197.5	0.214	0.615	0.187
Chlorophyll content																					
	2	61.01	60.47	59.93	59.39	61.19	60.65	60.11	59.57	61.37	60.83	60.29	59.75	59.21	59.03	58.85	58.67	60.02	0.115	0.333	0.333
	4	59.66	58.97	58.28	57.59	59.89	59.20	58.51	57.82	60.12	59.43	58.74	58.05	57.36	57.13	56.9	56.67	58.395	0.144	0.416	0.428
	6	58.75	57.91	57.07	56.23	59.03	58.19	57.35	56.51	59.31	58.47	57.63	56.79	55.95	55.67	55.39	55.11	57.21	0.150	0.432	0.454
	8	57.54	56.70	55.86	55.02	57.82	56.98	56.14	55.30	58.10	57.26	56.42	55.58	54.74	54.46	54.18	53.90	56.00	0.156	0.449	0.482
	10	56.67	55.71	54.75	53.79	56.99	56.03	55.07	54.11	57.31	56.35	55.39	54.43	53.47	53.15	52.83	52.51	54.91	0.162	0.466	0.510
Iron (mg/100g)																					
	2	51.78	51.39	51.00	50.61	51.91	51.52	51.13	50.74	52.04	51.65	51.26	50.87	50.48	50.35	50.22	50.09	51.065	0.115	0.333	0.392
	4	51.61	51.22	50.83	50.44	51.74	51.35	50.96	50.57	51.87	51.48	51.09	50.70	50.31	50.18	50.05	49.92	50.895	0.139	0.399	0.472
	6	51.40	51.01	50.62	50.23	51.53	51.14	50.75	50.36	51.66	51.27	50.88	50.49	50.10	49.97	49.84	49.71	50.685	0.144	0.416	0.493
	8	51.07	50.68	50.29	49.90	51.20	50.81	50.42	50.03	51.33	50.94	50.55	50.16	49.77	49.64	49.51	49.38	50.355	0.150	0.432	0.516
	10	50.73	50.31	49.89	49.47	50.87	50.45	50.03	49.61	51.01	50.59	50.17	49.75	49.33	49.19	49.05	48.91	49.96	0.156	0.449	0.540

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Table 6. Effect of various combinations of packaging on sensory and physical properties of fenugreek (whole) in cold storage

Particulars	Storage period (days)	Treatments																			
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	GM	SE±	CD at 5%	CV (%)
Sensory evaluation																					
	10	8.00	7.70	7.40	7.10	8.10	7.80	7.50	7.20	8.20	7.90	7.60	7.30	7.00	6.90	6.80	6.70	7.45	0.156	0.45	3.624
PLW (%)																					
	2	2.39	2.84	3.29	3.74	2.24	2.69	3.14	3.59	2.09	2.54	2.99	3.44	3.89	4.04	4.19	4.34	3.215	0.069	0.199	3.732
	4	3.94	4.39	4.84	5.29	3.79	4.24	4.69	5.14	3.64	4.09	4.54	4.99	5.44	5.59	5.74	5.89	4.765	0.139	0.399	5.037
	6	5.84	6.29	6.74	7.19	5.69	6.14	6.59	7.04	5.54	5.99	6.44	6.89	7.34	7.49	7.69	7.79	6.668	0.150	0.432	3.90
	8	8.24	8.69	9.14	9.59	8.09	8.54	8.99	9.44	7.94	8.39	8.84	9.29	9.74	9.89	10.04	10.19	9.065	0.156	0.449	2.978
	10	10.47	10.92	11.37	11.82	10.32	10.77	11.22	11.67	10.17	10.62	11.07	11.52	11.97	12.12	12.27	12.42	11.295	0.162	0.466	2.479
Rotting (%)																					
	8	3.77	5.42	7.07	8.72	3.22	4.87	6.52	8.17	2.67	4.32	5.97	7.62	9.27	9.82	10.37	10.92	6.795	0.104	0.299	2.649
	10	6.61	8.77	10.93	13.09	5.89	8.05	10.21	12.37	5.17	7.33	9.49	11.65	13.81	14.53	15.25	15.97	10.57	0.069	0.199	1.135

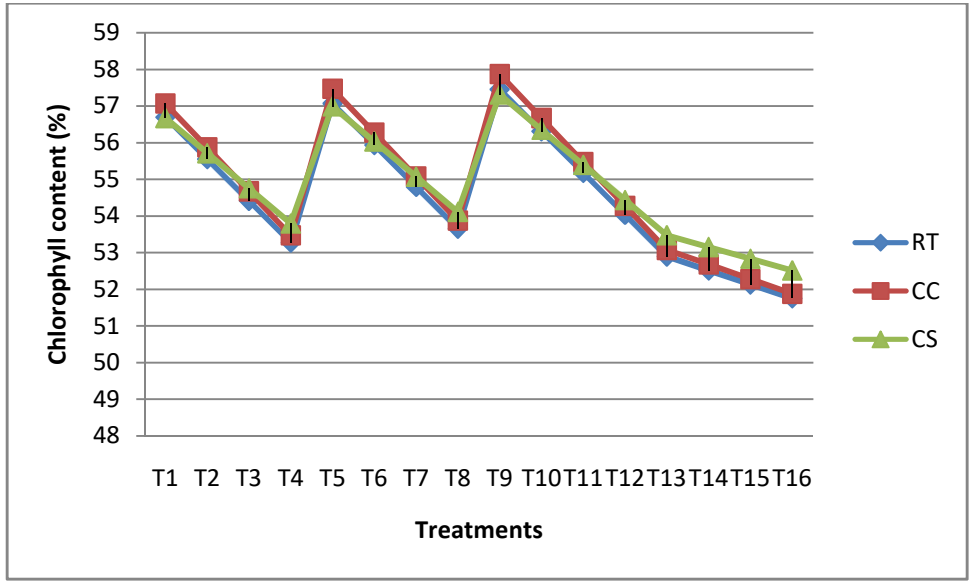

Fig.1 :Effect of various combinations of packaging on chlorophyll content of fenugreek (whole) at different storage conditions

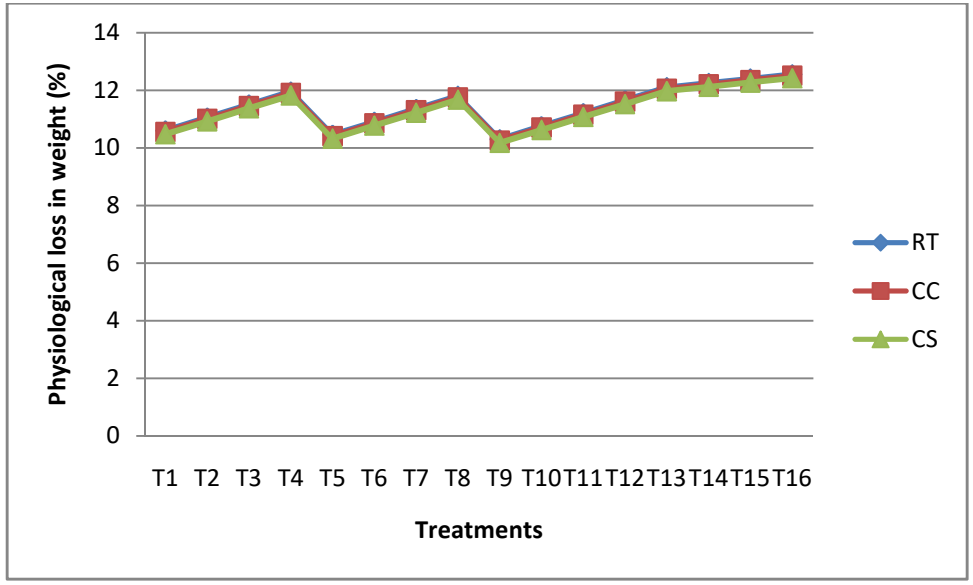

Fig.2 :Effect of various combinations of packaging on physiological loss in weight of fenugreek (whole) at different storage conditions

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