

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 comprising of polyethylene 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 Phule Krishi Vidyapeeth, Rahuri during the year 2014-2015.

Methodology: The fresh 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 (*Trigonella foenum-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 β -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, galactagogue, 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, augments 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 triglycerides and 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 Phule Krishi Vidyaapeeth, 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 °C and 90-95 % R.H.), zero energy cool chamber (14.6 to 20.3 °C and 83.59 to 91.90 % R.H.) and room temperature (25.4 to 28.2 °C 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] parameter on nine point hedonic scale at 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 | 95 |
| T2 | 100 gauge polythene bag with 2 % vent | 96 |
| T3 | 100 gauge polythene bag with 4 % vent | 97 |
| T4 | 100 gauge polythene bag with 6 % vent | 98 |
| T5 | 200 gauge polythene bag without vents | 99 |
| T6 | 200 gauge polythene bag with 2 % vent | 100 |
| T7 | 200 gauge polythene bag with 4 % vent | 101 |
| T8 | 200 gauge polythene bag with 6 % vent | 102 |
| T9 | 400 gauge polythene bag without vents | 103 |
| T10 | 400 gauge polythene bag with 2 % vent | 104 |
| T11 | 400 gauge polythene bag with 4 % vent | 105 |
| T12 | 400 gauge polythene bag with 6 % vent | 106 |
| T13 | Butter paper bag without vent | 107 |
| T14 | Butter paper bag with 2% vent | 108 |
| T15 | Butter paper bag with 4% vent | 109 |
| T16 | Butter paper bag with 6% vent | 110 |
| | | 111 |
| | | 112 |

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 data subjected 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 at 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 with respect to the decrease in moisture content are comparable to the results reported by previous workers at different storage conditions [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 of increase in physiological loss in weight are in accordance to the observations of previous workers worked on different packaging and storage conditions [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 above mentioned results obtained on increased rotting are similar to the observations of earlier research workers worked on different packaging and storage conditions [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 on decrease in Ascorbic acid content (mg/100 g) are in agreement with those of earlier workers on different packaging and storage conditions [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 conserved 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 worked on different packaging methods and storage conditions [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 of decreasing trend in sensory evaluation were reported by earlier workers on different packaging and storage conditions [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.

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COMPETING INTERESTS

Authors have declared that no competing interests exists.

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354 (*Trigonellafoenumgraecum*) leaves. Plant Foods for Human Nutrition.1997; 50: 239-247.

360 **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 | |

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376 **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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378 **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 |

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

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417 **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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420 **Table 6. Effect of various combinations of packaging on sensory and physical properties of fenugreek (whole) in cold storage**

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| Particular s | Storag e 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 |

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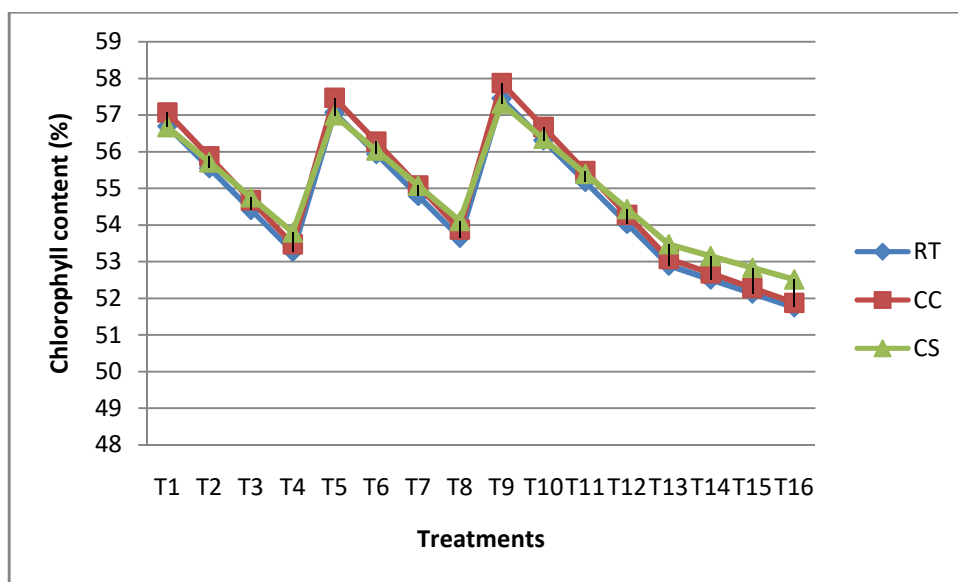


Fig.1 : Effect of various combinations of packaging on chlorophyll content of fenugreek (whole) at different storage conditions

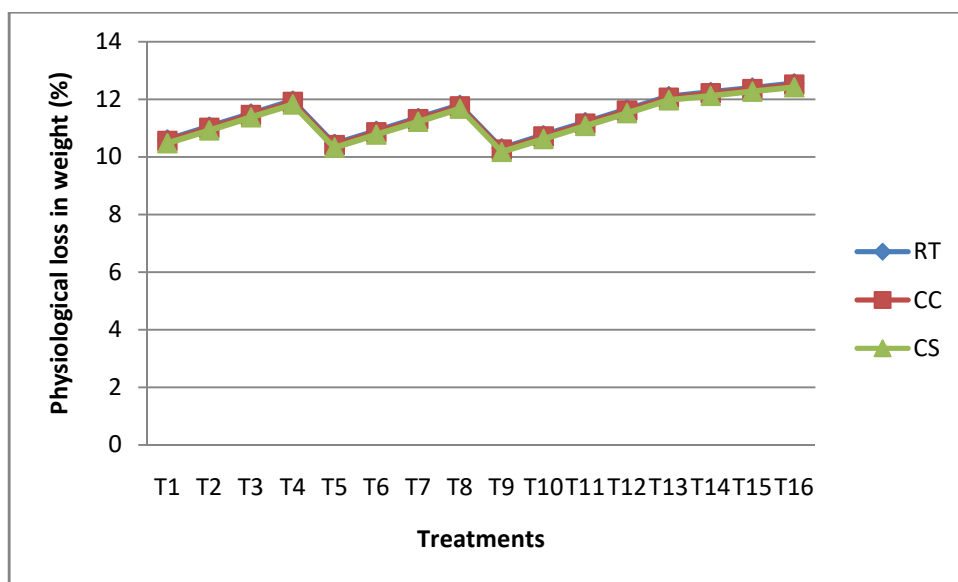


Fig.2 : Effect of various combinations of packaging on physiological loss in weight of fenugreek (whole) at different storage conditions

