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RESEARCH PAPER

Shelf-Life Enhancement of Fresh Fenugreek (*Trigonella Foenum-graceum*) under Refrigerated Condition

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ABSTRACT

Experiments were conducted to extend the shelf-life of fresh fenugreek in different forms (leaves and bunch), using different packaging material viz. polypropylene, cling film, paper with an unpacked control sample. The packed fresh fenugreek was stored under refrigerated conditions (temperature 6 ± 1°C and RH 95±2%) and were analyzed at regular intervals for their quality attribute i.e. β-carotene, physiological loss in weight (PLW), chlorophyll content, colour change and sensory attributes. It was observed that packaging material had significant effect on of PLW, chlorophyll content, visual appearance and water accumulation. Polypropylene package and bunch form of sample were the best for enhancement of shelf-life of fenugreek up to 7 weeks. Lower PLW was observed to be 2.11 and 2.85% of initial weight in polypropylene material for leaves and bunch, respectively. Chlorophyll content decreased as much as by 91% for leaf and 90% for bunch wrt fresh (220mg/100g) in polypropylene packaging. It was observed that packaging of fenugreek in polypropylene package in bunch form resulted in best maintenance of chlorophyll, colour, weight loss, aroma and visual appearance. Overall it can be concluded that the fresh fenugreek in the form of bunch can be stored safely upto 48 days when packed in polypropylene package and stored under refrigerated conditions.

Overall it can be concluded that the fresh fenugreek in the form of bunch can be stored safely upto 48 days when packed in polypropylene package and stored under refrigerated condition (6±1°C temperature and 95±2% RH).

Keywords: Fenugreek, shelf-life, packaging, quality, aroma, bunch form, leaf form

The fruits and vegetable continue to respire, transpire and ripen even after harvesting; therefore they suffer losses in their quality and quantity between harvest and consumption. However, these losses can be avoided to some extent and the shelf-life can be extended by using appropriate production practices such as pre-cooling, packaging, storage and transportation. The post-harvest practices, refrigerate storage and Packaging of vegetables can contribute in an integrated manner to reduce losses.

India is the second largest producer of vegetables in the world and accounts for about 15 per cent of the world's vegetable production. India's flora comprises of 6000 species of plants used for consumption, one-third of which are green leafy vegetables. These vegetables are good source of minerals, vitamins, antioxidants and bioactive compounds (Nambiar 2007). Leafy vegetables are a diverse group of plants, comprising several different taxonomic plant families, commonly known as greens and potherbs. These may be cool or warm season crops and can be grown as annuals or as perennials. In addition, some leafy vegetable are adapted to the tropics, while others are adapted to the temperate climates. They are raised

either as main crop or as a minor crop depending on the location (Tindal 1983, Bose 1986). The important leafy vegetables are fenugreek, amaranth, spinach, pak choy, broccoli, cabbage, lettuce, celery, kale, mustard greens etc. which are among the most nutritious vegetables on a fresh weight basis and a very good source of minerals, vitamins, antioxidants and bioactive compounds (Ahvenainen, 1996; Cao *et al.*, 1996; Singh *et al.*, 2001; Tarwadi *et al.*, 2003 and Gupta *et al.*, 2005).

Fenugreek (*Trigonella Foenum-graecum*) an annual, herbaceous, leguminous plant, popularly known as "Methi" is an Indian herb, the stems, leaves and the twigs of which are used for cooking, medications and for nutritional value. Leafy vegetables are highly perishable and their shelf-life depends on duration and conditions of storage. Negi and Roy (2004) reported that losses of β–carotene for amaranth ranged from 46.5 to 85.0% and for fenugreek it is 24.0 to 73.0%, depending upon the duration and conditions of storage. It was also observed that the degradation of quality parameters were faster at ambient conditions and packaging of leaves in low density polyethylene bags was beneficial in improving shelf-life and nutritive value. Koraddi and Sumangala (2009) reported that no single type of packaging material viz., brown paper bag, polyethylene bag (20μ), plastic container and LDPE (300 gauge) was found to be suitable for some vegetables viz. fenugreek, coriander, tomato, chilli, french bean, ladies finger, cucumber and carrot. For coriander and cucumber polyethylene was found to be effective in extending the mean shelf-life, for fenugreek, chilli, beans and carrots plastic container, for ladies finger LDPE and for tomato both brown paper bag and plastic container were found suitable.

Packaging of vegetables is a dynamic field which is driven largely by consumer demands for fresher, safer, more nutritious and convenient produce. Modified atmosphere packaging (MAP) is a technique for controlling the internal environment and is based on controlling the rate of metabolic process in the packaged product as a result of the changed composition of the atmosphere imposed at the time the product is packaged and the influence over time by the product itself (Burton 1978). Limited research has been reported on the shelf-life enhancement of fresh fenugreek leaves as well as bunch under refrigerated condition, the present investigation has been planned to study the effect of form of fenugreek and packaging material on keeping quality of fenugreek and to select the best form of fenugreek and packaging material for shelf-life enhancement under refrigerated condition.

MATERIALS AND METHODS

Fresh fenugreek harvested from the local farm of Ludhiana were first washed with water to remove foreign matter like mud, sand, dust, etc., after that immersed in water containing 2.5% sodium hypochlorite for 1 min to prevent contamination with micro-organisms, then put under shade drying for 15 minutes. An unsealed package was taken as control sample. 100 g sample of fresh fenugreek leaves and as bunch were packed in different packages (paper, poly propylene, cling film and control). No perforation was made in the poly-propylene film and cling film. Then packets along with control samples were stored at 6±1°C and 95±2% RH in a cold room.

Quality analysis

The moisture content was determined by standard oven method (AOAC 2000). Sample was weighed 50 g and dried at 103 ± 2°C for 16 h in uncovered pre-weighted Petri dishes in forced air oven. The moisture content was calculated on wet basis, using the relationship:

$$M.C.(\%\ wb) = \frac{W_1 - W_2}{W_1} \times 100$$

Where,

W_1 = initial weight of the sample (g)

W_2 = final weight of the sample after drying (g)

The colour of samples was measured by using Miniscan XE plus Hunter lab colorimeter. The Hunter scale L measures lightness (whiteness or darkness).

The chromatic portion of the solid is defined by +a (red); -a (green); +b (yellow) and -b (blue). Three desired functions, total colour difference (ΔE) chroma and hue angle were calculated from the 'L', 'a' and 'b' readings as follows:

$$\Delta E = [(L-L_o)^2 + (a-a_o)^2 + (b-b_o)^2]^{½}$$

$$\text{Chroma} = \sqrt{(a^2 + b^2)}$$

$$\text{Hue angle} = \tan^{-1}(b/a)$$

Where L_o, a_o and b_o represents the respective readings of samples.

Physiological loss in weight was determined using standard method. PLW (%) = (Initial weight – Final weight)/Initial weight*100. The pigments (chlorophyll, β–carotene) were determined by homogenizing 1 g of sample with a mixture of acetone and hexane (4:6), using a pestle and mortar. The homogenized solution was allowed to settle down. The resulting solution was analyzed with the help of UV-Vis spectrophotometer. The optical density was measured in terms of absorbance at different wavelengths (663,645,505 and 453 nm) using acetone and n-hexane (4:6) as a blank. The chlorophyll, β - carotene concentrations (μg ml^{-1}) were quantified using the equation proposed by Nagata and Yamashita (1992) as follows:

$$\text{Chlorophyll a} = 0.999\ A_{663} — 0.989\ A_{645}$$

$$\text{Chlorophyll b} = -0.328\ A_{663} + 1.77\ A_{645}$$

$$\text{Total Chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

$$\beta\text{-carotene} = 0.216\ A_{663} — 1.220\ A_{645} – 0.304\ A_{505} + 0.452\ A_{453}$$

$$\text{Lycopene} = -0.0458\ A_{663} + 0.204\ A_{645} + 0.372\ A_{505} – 0.806\ A_{453}$$

Where A_{663}, A_{645}, A_{505} and A_{453} are the absorbance's at 663,645,505 and 453 nm, respectively.

Sensory evaluation

The sensory evaluation scale for rating the sensory quality of fresh fenugreek were developed on the basis of three main parameters i.e. visual appearance, odour and water accumulation. The sensory and visual assessment for stored fresh fenugreek leaves was carried out through a panel of judges in order to access the acceptability of stored vegetables, score card was selected. Aroma was evaluated by suitably modifying the procedure of Carvalho and Clement (1998) as per the scale: 5=no off odour, 4 =very light off odour, 3=light off odour, 2=medium off-odour and 1=strong off-odour. Visual appearance was scored as: 5=very good, 4=good, 3=normal, 2= limited quality, 1=not accepted. Water accumulation severity inside the packages was evaluated by another nine point scale; 0 = vegetable completely wet and water accumulation, 1=vegetable and film moderately wet, 3 = vegetable moderately wet, 5 = vegetable and film slightly wet, 7= vegetable slightly wet, 9=no water accumulation was used to represent the water vapour accumulation inside the film packages. Visually colour was scored on five point scale as green=5, slightly light green=4, light green=3, yellowish green=2, yellow=1. During scoring, the intermediate scores were also given to the samples depending upon the perceived conditions of samples.

Statistical analysis

The statistical analysis of data obtained was carried out to establish the difference among treatments. All the experiment were performed in triplicate. One way analysis of variance (ANOVA) and Duncan's multiple range tests (DMRT) (α = 0.05) were used to determine statistically significant differences between treatments, concerning the chlorophyll content, β-carotene, colour change and sensory attributes. Evaluations were based on a p = 0.05 significance level.

RESULTS AND DISCUSSION

Physiological loss in weight

The physiological loss in weight ranges from 0.25 to 50 per cent seen collectively. PLW shows minimum variation in polypropylene package 2.38% and cling film 2.85% at the end of storage period. It is evident

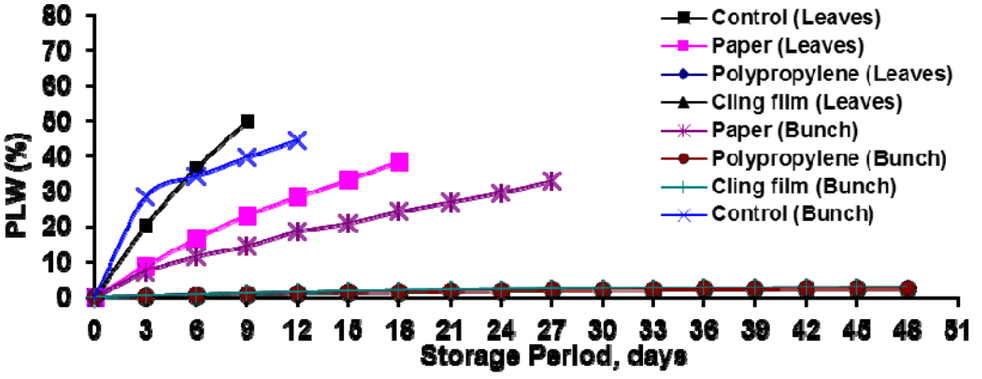

Fig. 1: Change in the amount of physiological loss in weight (%) in different packaging material in different forms

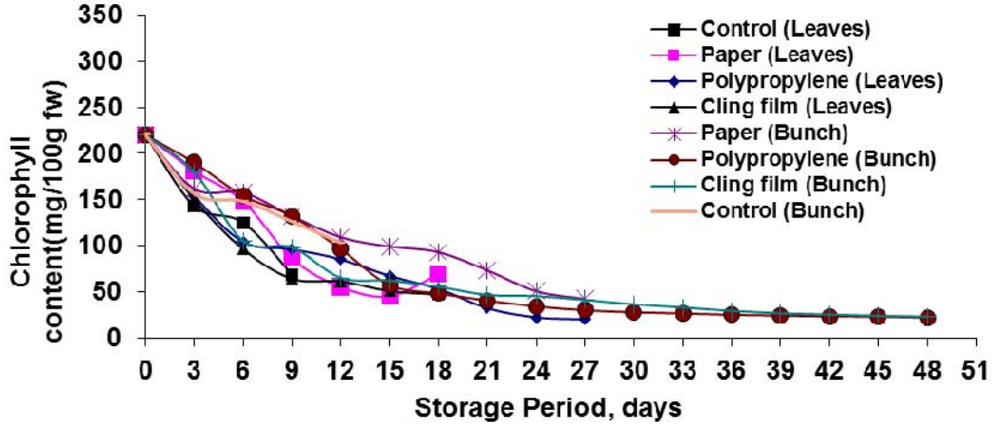

Fig. 2: Change in the amount of total chlorophyll ontent (mg/100g fw) in different packaging material and in different forms

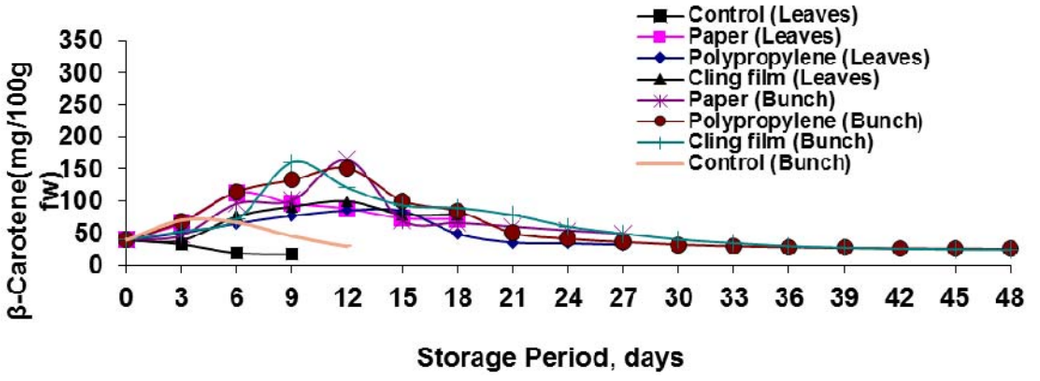

Fig. 3: Change in amount of β –carotene content mg/100g fw) in different packaging material and in different forms

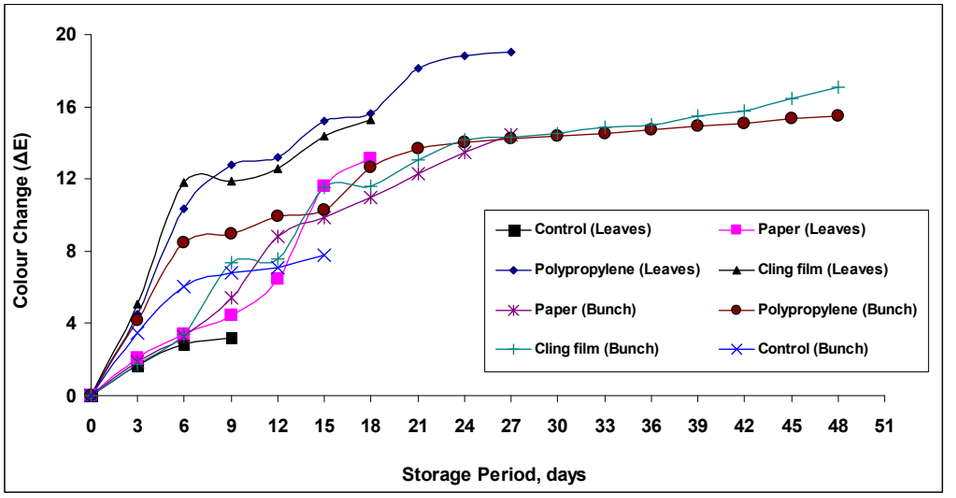

Fig. 4: Changes in colour (ΔE) parameter of fenugreek in different packaging material and in different forms

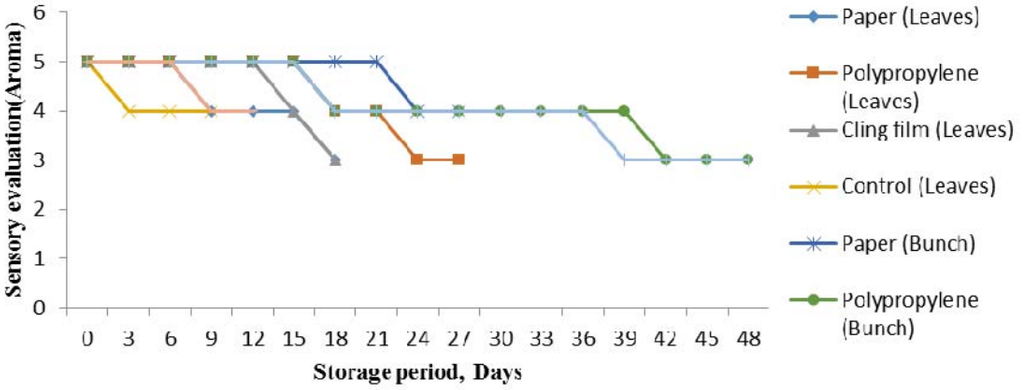

Fig. 5: Changes in aroma rating of fenugreek in different packaging material and in different forms

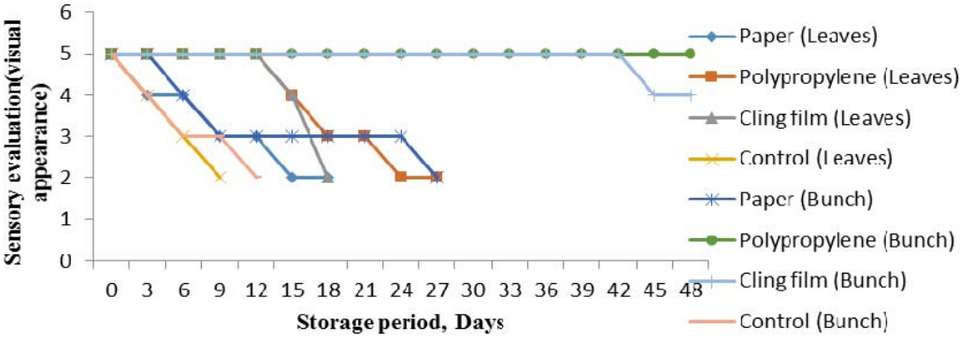

Fig. 6: Changes in visual appearance in different packaging material and in different form

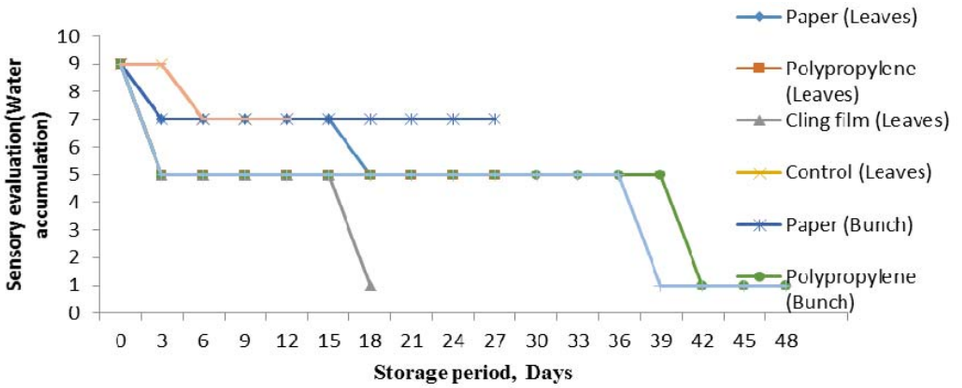

Fig. 7: Changes in water accumulation inn different packaging material and in different forms

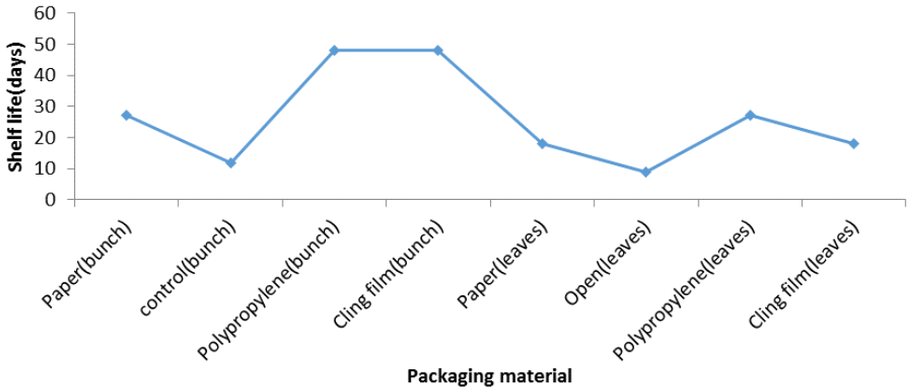

Fig. 8: Shelf-life of fenugreek in different packaging material and in different forms

from the Fig. 1 that the PLW in control samples was remarkably higher whereas the weight of the sample was best retained by polypropylene package in bunch form.

Chlorophyll content

Greenness, an indicator of freshness and wholesomeness of leafy vegetable product quality, is the result of the chlorophyll. As chlorophyll degrades during senescence, the green leaves become yellow and brown in colour. The chlorophyll content of fresh sample was 220mg/100g fw and during storage period it changed from 220mg/100g fw to 20mg/100g fw seen collectively. The percentage reduction in chlorophyll content at the end of 9th day of storage was 60.9, 56.36, 70.90, 68.87 % for leaves and 40, 40, 55.45, 42.72 % for bunch in paper, polypropylene, cling film and control respectively, as can be seen from the Fig 2. The chlorophyll was best retained in polypropylene and cling film packages in the bunch form.

β –carotene content

The β –carotene content ranges from 39.19 mg/100g fw to 25.3 mg/100g fw in polypropylene package. The β –carotene content of polypropylene (bunch) and paper (leaves) first increased and then decreased a bit during the progress of storage period. The β –

carotene content was best retained in polypropylene and cling film in the form of bunch as is evident from the results in Fig. 3.

Colour

The variation in colour of fresh fenugreek measured with Miniscan XE plus Hunter lab colorimeter in terms of L, a, and b. ΔE shows minimum variation in polypropylene and cling film packages in bunch form during storage period. ΔE shows "15.34" and "16.48" for polypropylene and cling film in bunch form at the end of 7 weeks of storage (Fig. 4).

Sensory evaluation: The shelf-life of the stored produce is influenced largely by the sensory quality parameters such as odour, water accumulation and visual appearance which suggest its suitability for human consumption; irrespectively of objectively or instrumentally determined parameters. In this study aroma rating after regular interval is shown in Fig. 5. Polypropylene and cling film packages having "light off odour" in bunch form after 7 weeks. The visual appearance shows "very good" for polypropylene in bunch form and "good" for cling film in bunch form at the end of 7 weeks of storage. It is seen from the Fig. 6 that polypropylene shows visually best appearance up to 7 weeks of storage in the form of bunch followed by cling film package in bunch form.

Water accumulation ranges from 1 to 9 seen collectively shown in Fig. 7. The water accumulation of fresh sample was of no water accumulation=9. The water accumulation shows "vegetable and film moderately wet" for polypropylene and cling film in the bunch form at the end of 7 weeks. The results obtained were compared with the control samples. Keeping all the parameters into the consideration, it was observed that polypropylene and cling film packs have more shelf-life as compared with paper and control samples. The shelf-life of samples irrespective of form ranges from 9 days to 48 days seen collectively in the Fig. 8. The shelf-life of polypropylene and cling film in the form of bunch was 7 weeks.

CONCLUSION

The pre-treatment with sodium hypochlorite (2.5%) having a beneficial effect on the shelf-life and other biochemical and sensory attributes otherwise highly perishable fenugreek have low shelf-life. Among all the treatments, it was observed packaging of fenugreek in polypropylene package in bunch form resulted in best maintenance of chlorophyll, colour, weight loss, aroma and visual appearance.

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