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Modified atmosphere packaging of fresh Bengal gram (*Cicer arietinum* L.) kernels for shelf life enhancement

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Abstract
Bengal gram (*Cicer arietinum* L.) is a member of leguminous family. India is single largest producer of bengal gram. Premature bengal gram green kernels is used for direct consumption as well as for making other preparation for food items. The fresh bengal gram kernel has very short shelf life at room temperature. The modified atmosphere packaging is used to improve the shelf life of fresh Bengal gram kernels. In present study six different gas and temperature combinations were used with (2%O_2 and 8% CO_2; 5% O_2 and 8% CO_2) and HDPE packaging films. The storage was done at ambient, 5±1, 0±1 °C temperature. Treatment combination G1T3 (2% O_2 and 8% CO_2 and 0±1 °C) was found acceptable bases on qualitative and physiological attributes till 15 days for HDPE packaging film.

Keywords: Modified atmosphere packaging, shelf life, fresh Bengal gram kernels, gas composition

1. Introduction
In today's world of population explosion, the importance of food preservation hardly needs any emphasis. Capacity under controlled environment/altered air is known to expand the time span of usability of new vegetables by impeding their physiological metabolism [1]. The shelf-life of perishable foods is limited in the presence of normal air by two principal factors *i.e.* the chemical effect of atmospheric oxygen and the growth of aerobic spoilage microorganisms. MAP is used to reduce the amount of oxygen present in the headspace of the product. The fresh produce has a short shelf life at ambient condition. Premature bengal gram green kernels is used for direct consumption as well as for making their preparation for food items. The scope of present study is to investigate the effect of MAP at different storage condition for enhancement of shelf life of green Bengal gram kernels.

2. Materials and Methods
Fresh Bengal gram (*Cicer arietinum* L.) was purchased from local market. Damaged, under matured and over matured kernels, foreign matter was discarded from lot of shelled kernels and the remaining uniform size kernels were taken for the experimental purpose.

2.1 Pre treatment
In this study washing treatment of fresh Bengal gram kernels was performed by immersion of the fresh kernels in chlorinated water of 200 ppm, followed by rinsing with distilled water to remove traces of chlorine. Then cooled at room temperature, before start of experiment. The chlorine treated kernels then packed in HDPE film packages.

2.2 Packaging and storage conditions
The treated fresh Bengal gram kernels were packed in HDPE package with two different gas composition and three storage temperatures shown in table 1. The dependent parameters were taken as change in gas composition, physiological loss in weight (PLW), decay (%), and quality parameters such as color, firmness, microbial load and sensory evaluation.

Table 1: Gas Compositions For Modified Atmosphere Packaging

Samples	Composition of gases (%)		
	O_2	CO_2	N_2
G1	2	8	90
G2	5	8	87

2.2.1 Modified atmosphere package nomenclature is given as

G1T1: LDPE with G1 gas composition stored at T1 condition.
G1T2: LDPE with G1 gas composition stored at T2 condition.
G1T3: LDPE with G1 gas composition stored at T3 condition.
G2T1: LDPE with G2 gas composition stored at T1 condition.
G2T2: LDPE with G2 gas composition stored at T2 condition.
G2T3: LDPE with G2 gas composition stored at T3 condition.

Where,
G1, G2, - Different gas composition.
T1, T2, T3- Different storage conditions *i.e.*at ambient, 5±1 and 0±1 °C, respectively.

2.3 Quality parameters

70 g of pretreated bengal gram kernels was packed in polymeric film packages and different gas composition during storage studies. These bags were then stored under ambient (T1) and refrigerator at 5 °C (T2) and 0 °C (T3) and observations pertaining to quality were recorded at three days intervals.

2.4 Headspace gas analysis

Package headspace was monitored by a portable headspace Analyzer (Quantek Instrument – Model 902D, Dual Trak).

2.5 Physiological loss in weight (PLW)

Different packages kept under different storage conditions were weighed and calculated as:

$$\text{PLW (\%)} = \frac{\text{(Initial Weight} - \text{Final Weight)}}{\text{(Initial Weight)}} \text{ x } 100$$

2.6 Decay (%)

Any form of deterioration in quality was taken as decay. Decay in fresh Bengal gram kernels was observed on weight basis. Here shrinkage was assumed to be zero. Decay for each treatment at each duration was calculated. Here, final weight was noted after removal of decayed material.

$$\text{Decay (\%)} = \frac{\text{(Initial Weight} - \text{Final Weight)}}{\text{(Initial Weight)}} \text{ x } 100$$

2.7 Firmness

Textural Analyzer used for measuring firmness of fresh as well as stored Bengal gram kernels.

2.8 Microbial Analysis

The microbial analysis was done for the bacterial count. After every three days interval the microbial analysis was done. For analysis Nutrient agar (Peptone 10gm, meat extract 5 gm, NaCl 5 gm) was used. The colony forming units per millilitre (CFU/ml) was calculated for plates yielding 30-300 colonies. The count was then round off to two significant digits to avoid fictitious precision and accuracy.

$$\text{CFU/ml} = \frac{\text{(Colonies Counted)}}{\text{(Actual volume of sample in dish (ml))}}$$

2.9 Sensory and visual appearance assessment

The products were served for the evaluation to panel at a time using nine point hedonic scale.

3. Results and Discussion

The present investigation was conducted at Department of Processing and Food Engineering, CTAE, MPUAT, Udaipur.

3.1 Package headspace atmosphere

The headspace got adjusted quickly and the gas piece in the film bundle was to a great extent impacted by the packaging material. The pattern in the levels of O_2 and CO_2 gases in the MA stuffed new bengal gram bits delineated that there was a progressive decline in the O_2 level and a slow increment in the CO_2 level from the earliest starting point of the test which could be ascribed to travel condition of adjustment and harmony of the yield with the environment. Thusly, with the advancement of storage, the decrease in respiration which prompted in-pack collection of CO_2 under all conditions amid later time of storage. Similar pattern of changes in the gaseous atmosphere were reported by numerous researchers [2, 3, 4, 5].

3.2 Head space O_2 (%)

It is clear from data presented in Fig. 1 that O_2 decreased with advancement of storage duration at different storage temperature, but it is significantly affected by the gaseous composition during the storage.

On 6th day of storage minimum O_2 was observed in G1T1 (0.7%) and maximum was in G2T2 (4.2%) treatment combination. On 15th day of storage, minimum O_2 was recorded in G1T2 (0.6%) while maximum was in G2T2 (2.9%). At the end of experiment *i.e.* on 18th day of storage, maximum 1.6% O_2 was recorded in G2T3.

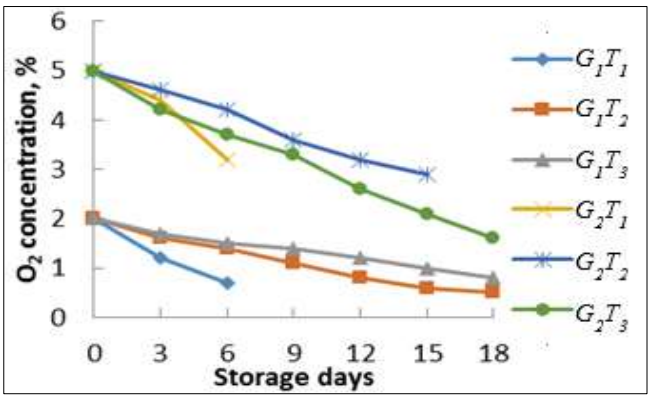

Fig 1: Combined effect of gas composition and storage temperature on O_2 concentration

3.3 Head space CO_2 (%)

Fig. 2 indicated that on 6th day of storage minimum CO_2 was observed in G1T3 (8.8%) and maximum was in G1T1 (11.7%) treatment combination. On the 15th day of storage, minimum CO_2 was recorded in G2T2 (10.1%) while maximum was in both G1T2 (11.00%). At the end of experiment *i.e.* on 18th day of storage, 11.7% CO_2 was recorded in G1T3 treatment combination. The level CO_2 increased continuously because of the respiration of the fresh Bengal gram kernels [6].

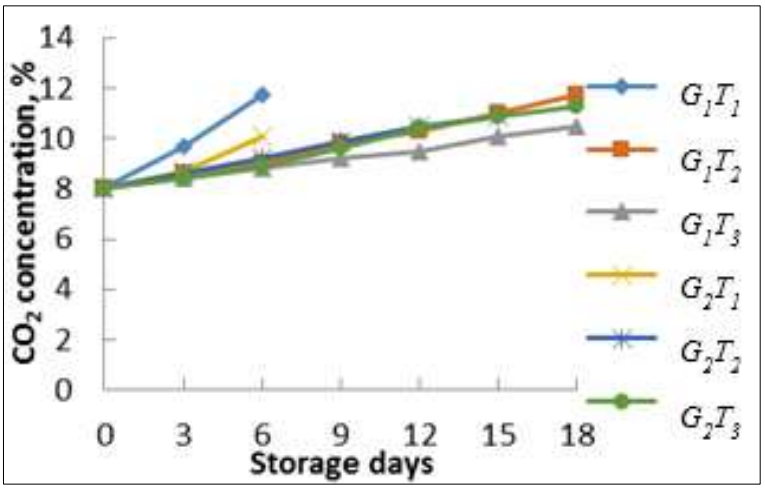

Fig 2: Combined effect of gas composition and storage temperature on CO_2 concentration

3.4 Physiological loss in weight (PLW)

Fig. 3 shows that on 6th day of storage minimum PLW was observed in G1T3 (1.28%) and maximum was in G2T1 (2.84%) treatment combination. On 15th day of storage, minimum PLW was recorded in G1T3 (5.98%) while maximum was in G1T2 (8.40%). At the end of experiment *i.e.* on 18th day of storage, minimum PLW in G1T3 (7.71%) while maximum in G2T2 (10.79%) was recorded. It was observed that PLW increased at a steady rate with the duration of storage. The data depicted that the use of lower storage temperature contributed to the significant reduction of weight loss bengal gram kernels through the storage time.

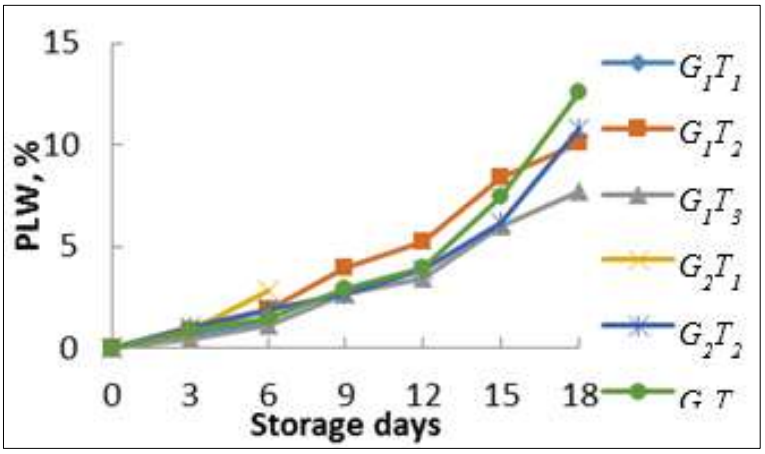

Fig 3: Combined effect of gas composition and storage temperature on PLW

3.5 Decay

After noting the sample weight for PLW, the visible decay was determined by separating the kernels having dark blemishes almost more than 1/3rd on its surface as well as having loose texture. The kernels weight was taken after discarding of decayed material.

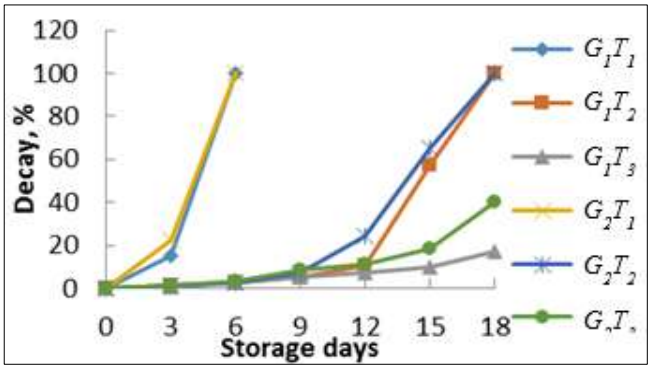

Fig 4: Combined effect of gas composition and storage temperature on Decay

A sample of bengal gram kernels was considered unacceptable when 10% of the kernels were visibly decayed as suggested by [5] for fresh Bengal gram kernels. From fig. 4 it is clear that on 6th day of storage minimum decay was observed in G2T2 (2.35%) and maximum was in G1T1, G2T1 (100%) treatment comination. On 15th day of storage, minimum decay was recorded in G1T3 (10.00%) while maximum was in G2T2 (65.47%). At the end of experiment *i.e.* on 18th day of storage, minimum decay was recorded in G1T3 (17.25%). It is clear that product stored at ambient temperature decayed at faster rate as compared to all other combinations. At the end of experiment only G1T3 product survived within the permissible limit of 10%.

3.6 Firmness

Fig. 5 shows that on 6th day of storage maximum firmness was observed in G1T3 (4.61 N) and minimum was in G2T1 (2.20 N) treatment combination. On 15th day of storage, maximum firmness was recorded in G1T3 (3.41 N) while minimum was in G2T2 (1.42 N). At the end of experiment *i.e.* on 18th day of storage, maximum firmness was recorded in

G1T3 (2.90 N).

It is clear that sample stored at ambient temperature loose texture at faster rate as compared to all other combinations. At the end of experiment only G1T3 sample was survived.

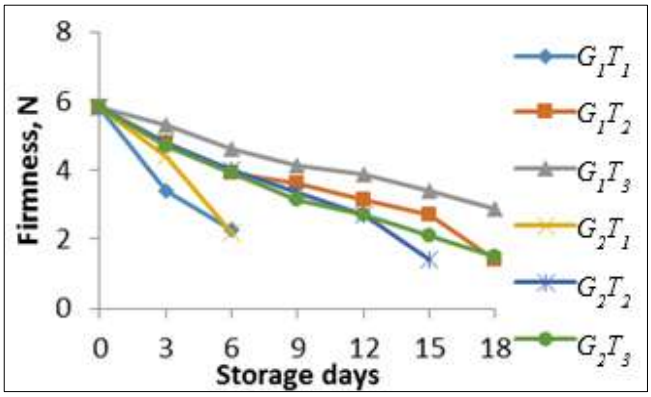

Fig 5: Combined effect of gas composition and storage temperature on Firmness

3.7 Microbial Load

Microorganisms are ubiquitous in fruits and vegetables; therefore sanitation is essential in keeping the microbial population to a minimum. Fresh vegetables normally have an elaborate spoilage microflora, due to intense contact with various types of microorganisms during growth and post-harvest handling, and therefore the numbers of microorganisms found on vegetables are highly variable. Initial mesophilic counts of all of the samples fell within the range 101–102 cfu g-1 which agrees with those found by [7, 8]. The washing process helped to reduce the total microbial load, resulting in maintained quality of the fresh bengal gram kernel. In treatment of chlorine, the concentration was 200 ppm free Cl_2. However, the results showed that using chlorine for washing treatment reduces initial microbial count on the fresh bengal gram kernel. This confirms the washing fresh bengal gram kernel with chlorinated water (100–200 mg/L free Cl_2) delayed the deterioration on microbiological front.

3.7.1 Bacterial load

Bacterial count on the sample at 3 days interval the count was converted into log CFU/ml. The initial bacterial count was 1.9 in all samples. From Fig. 6 it is clear that on 6th day of storage minimum bacterial count was observed in G2T3 (3.41) and maximum was in G2T1 (6.42) treatment combination. On 15th day of storage, minimum bacterial count was recorded in G1T3 (4.91) while maximum was in G2T2 (6.33). At the end of experiment *i.e.* on 18th day of storage, minimum bacterial count was recorded in G1T3 (5.72) treatment combination.

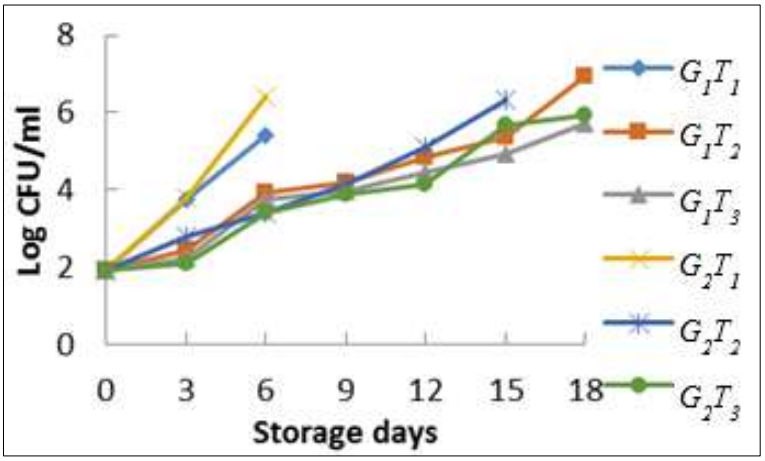

Fig 6: Combined effect of gas composition and storage temperature on bacterial load

3.8 Sensory evaluation

The sensory evaluation was done on the basis of colour, texture, taste, visual appearance, odor and overall acceptability. It was observed that the combination G1T1, G2T1, *i.e.* storage at ambient conditions was not accepted by the judges of consumer panel after 3 days of storage. While G1T3, G2T3 were most accepted by the panel of judges. In this study the different headspace environment under different packaging treatments affected the equilibrated in-pack aroma differently.

The overall acceptability of the Bengal gram kernels decreases as the increase in storage days and storage temperature. Bengal gram kernels packed with G1 gas composition shows acceptable score up to 15 while G3 composition shows acceptable score up to 12. With respect to the visual appearance (decay), judges have accepted Bengal gram kernels from all the treatments up to acceptable limits. The combination of G1 gas composition and T3 condition depicts the maximum acceptable 15 storage day's life.

4. Conclusion

The fresh Bengal gram kernels packed in an HDPE film package with G1 gas composition *i.e.* (2% O_2 and 8% CO_2) and stored in T3 temperature conditions helped to retain most of the desirable quality parameters such as sensory score, colour, texture, and bacterial load. The PLW was found within the limit for maximum days for samples stored at T3 conditions. Decay was found to be within the limit of maximum of 10% for sample G1T3, which was 9.028% for the 15th day. The combination G1T3 results in firmness of more than or equal to 60% of the initial value till 15 days for HDPE packaging film. The microbial load is within the limit for the combination. The overall acceptability of the Bengal gram kernels decreases with an increase in storage days and storage temperature. Bengal gram kernels packed with G1T3 combination show acceptable scores up to 15 days. It was concluded that the results obtained for G1 gas composition (2% O_2 and 8% CO_2) were better. The storage at lower temperatures resulted in maximum shelf life and minimum

quality loss.

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