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SHORT COMMUNICATION

Effect of modified atmosphere packaging on quality and shelf life of fresh Bengal gram kernels

Kushal Dhake[1]*, N. K. Jain[2] and S. K. Jain[2]

[1]Department of Agricultural Process Engineering, Dr. Ulhas Patil College of Agricultural Engineering and Technology, Jalgaon, Maharashtra, India

[2]Department of Processing and Food Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

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Bengal gram (*Cicer arietinum* L.) is a member of leguminous family. Premature Bengal gram green kernels were 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 can be used for enhancing the shelf life of fresh Bengal gram kernels. The study consisted of total six treatments comprising of two gases oxygen and carbon dioxide with three combinations (2 % O_2 and 8 % CO_2; 5 % O_2 and 3 % CO_2) and low-density polyethylene (LDPE) packaging films. The storage was done at ambient, 5±1, 0±1 ºC temperature. Treatment combination G_1T_3 (2 % O_2 and 8 % CO_2 and 0±1 ºC) was found acceptable based on qualitative and physiological attributes till 21 days.

Keywords: Carbon dioxide, Fresh Bengal gram kernels, Gas composition, Modified atmosphere packaging, Oxygen, Temperature.

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Introduction

Bengal gram (*Cicer arietinum* L.) also known as ‘chickpea’ or ‘*Chana*’. It is perishable in nature leading to sensory as well as nutrient loss at very high rate. Still, there is almost no appropriate method to preserve Bengal gram kernels in fresh form. The present day consumer prefers the vegetables in fresh form with convenience in use. Fresh Bengal gram kernels are still not available round the year in the market like frozen pea or other minimal processed vegetables as ready to use products.

Storage under controlled atmosphere/ modified atmosphere is known to extend the shelf life of fresh vegetables by retarding their physiological metabolism[1,2]. Modified Atmosphere Packaging (MAP) is used to reduce the amount of oxygen present in the headspace of the product. The oxygen level inside the package limits the shelf life of the product in terms of aerobic microorganisms[3,4]. As the shelf life of the fresh Bengal gram kernel is very short at room temperature, MAP can be explored for enhancing the shelf life. 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.

Material and Methods

Raw material

Fresh Bengal gram plants of variety ‘Pratap Chana 01’ were obtained from the instructional farm of College of Technology and Engineering, MPUAT, Udaipur India. After harvesting, the Bengal gram pods were detached from the plants. These pods were then stripped manually to obtain fresh Bengal gram kernels. From the initial sorting, damaged, poor quality (blemishes or defects), and non uniform fruits were removed. The remaining kernels were sorted according to their size, colour, and weight.

Sample preparation

The washing treatment of fresh Bengal gram kernels was performed by immersing the fresh kernels in treatment solution. Chlorinated water was prepared by adding sodium hypochlorite solution (200 g/L available chlorine) to distilled water to obtain 200 ppm free chlorine, followed by rinsing with distilled water to remove traces of chlorine for 5 min. The kernels were then air cooled for 30-45 min at room temperature, before starting the experiment. The chlorine treated kernels were packed in Low Density Poly Ethelene (LDPE) film packages. The mass of samples was 70 g in each package.

Packaging and storage conditions

The treated fresh Bengal gram kernels were placed in packages with 2 different gas compositions consisted of LDPE film and stored at room temperature[5] (T_1), 5±1 ºC (T_2) and 0 ºC (T_3) (Table 1, 2). Dependent parameters were taken as change in head space gas composition, physiological

*Correspondent author
Email: kpdhake@gmail.com

loss in weight (PLW), decay (%), quality parameters such as sensory evaluation, water activity and microbial parameters.

Modified atmosphere packaging

The packages were sealed at room temperature. Modified atmospheric packaging machine (SEVANA - QS 400 CAP 3G) was used for the experimental work. The machine has a packaging chamber at the top. There are two different techniques to replace the air, by gas flushing and by compensated vacuum.

Packaging material

LDPE is an extremely versatile material and accounts for the biggest proportion of plastic materials used for packaging. This is an inert film with low permeability for water vapour but high gas permeability. The thickness of the film used for the investigation was having thickness of approximately 40 μ.

Quality parameters

About 70 g of prepared/treated Bengal gram kernels was packed in polymeric film packages and different gas composition during storage studies. These different bags were then stored in ambient condition and in refrigerator at 5 and 0 °C. Observations pertaining to the quality were recorded at regular intervals.

Headspace gas analysis

Package headspace was monitored by means of a portable headspace analyzer (Quantek Instrument – Model 902D, Dual Trak). The instrument evaluated the headspace by means of an electrochemical and an infrared sensor (sensitivity: 0.01 % O_2; 0.01 CO_2, accuracy: 0.01 % O_2; 0.02 % CO_2) for O_2 and CO_2 concentrations, respectively. The instrument was calibrated with the standard O_2 and CO_2 gases before the actual observations.

Table 1 — Gas compositions for Modified atmosphere packaging

Samples	Composition of gases (%)		
	O_2	CO_2	N_2
G_1	2	8	90
G_2	5	8	87

Table 2 — Modified atmosphere package nomenclature

G_1T_1	LDPE with G_1 gas composition stored at T_1 condition
G_1T_2	LDPE with G_1 gas composition stored at T_2 condition
G_1T_3	LDPE with G_1 gas composition stored at T_3 condition
G_2T_1	LDPE with G_2 gas composition stored at T_1 condition
G_2T_2	LDPE with G_2 gas composition stored at T_2 condition
G_2T_3	LDPE with G_2 gas composition stored at T_3 condition

G_1, G_2- different gas composition, T_1, T_2, T_3- different storage conditions i.e. at ambient, 5±1 and 0±1 °C, respectively.

Physiological loss in weight

Different packages kept under different ambient and refrigerated conditions i.e. 0 and 5 °C were weighed at 3 days intervals. The physiological loss in weight (PLW) was calculated as:

$$\text{PLW (\%)} = \frac{(\text{Initial weight} - \text{Fina weight})}{\text{Initial weight}} \text{ x } 100$$

During storage, the weight loss due to transpiration and respiration of the fruit was followed (expressed as a percentage of the original weight of the packaged kernels), by weighing the kernels on each three day interval of the experiment by means of a digital precision balance.

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 was calculated as:

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

Here, final weight was noted after removal of decayed material. The sample weight was determined by means of a digital precision balance (±0.1 g).

Water activity

The concept of water activity has a particular importance as an indicator of product quality, safety, and storability. A reduction of water activity below the optimum delays spores germination and decreases the growth rate. An automated instrument (Novasina–Lab swift-a_w) was used to determine the water activity of stored Bengal gram kernels.

Most bacteria do not grow at water activities below 0.91 and most moulds cease to grow at water activities below 0.80[6]. By measuring the water activity, it is possible to predict which microorganisms will or will not be a potential sources of spoilage. Lower water activity of a dried product implies better potential for storage.

Microbial analysis

The microbial analysis was mainly done for the bacterial count. After every three days interval, the microbial analysis was done. For bacterial analysis, nutrient agar (Peptone 10 g, meat extract 5 g, NaCl 5 g) was used[7]. The colony forming units per millilitre (CFU/mL) was calculated for plates yielding 30-300 colonies. The count was then rounded off to two significant digits to avoid fictitious precision and accuracy.

$$\mathrm{CFU/mL} = \frac{\text{Colonies counted}}{\text{Actual volume of sample in dish (mL)}}$$

Sensory and visual appearance assessment

The products were served for the evaluation to five panellists at a time. All sensory tests were performed on basis of organoleptical properties such as taste, odour, and firmness. The visual properties (colour and general freshness of the kernels, i.e. the first impression the consumer gets about the brightness, the size, and the absence of damage) were judged under daylight. Nine points were awarded as like extremely-9, like very much-8, like moderately-7, like slightly-6, neither like nor dislike-5, dislike slightly-4, dislike moderately-3, dislike very much-2, and dislike extremely-1.

Results and Discussion

Package headspace atmosphere

The headspace got modified rapidly and the gas composition in the film package was largely influenced by the packaging materials. The pattern in the level of O_2 and CO_2 gases in the modified atmosphere packed fresh Bengal gram kernels depicted that there was a gradual decrease in the O_2 level and a gradual increase in the CO_2 level from the beginning of the experiment that could be attributed to the transit state of stabilization and equilibrium of the crop with the surroundings. Similar pattern of changes in the gaseous atmosphere have been reported by numerous researchers[8-11].

Head Space (O_2)

The combined effect of package gas composition and storage temperature on O_2 concentration is shown in Fig. 1. On the 6th day of storage, minimum O_2 (0.9 %) was observed in G_1T_1 and maximum O_2 (4.1 %) was observed in G_2T_3 treatment combination. On the 24th day of storage, minimum O_2 (0.6 %) was recorded in G_1T_3 and maximum O_2 (0.9 %) was recorded in G_2T_3. At the end of the experiment (30th day of storage), 0.2 % O_2 was recorded in G_1T_3.

Head space CO_2 (%)

The combined effect of package gas composition and storage temperature on CO_2 concentration is shown in Fig. 2. On the 6th day of storage, minimum CO_2 (4.3 %) was observed in G_2T_2 and the maximum CO_2 (11.2 %) in G_1T_1 treatment combination. On the 24th day of storage, minimum CO_2 (11.00 %) was recorded in G_1T_3 and maximum CO_2 (11.7 %) was recorded in G_2T_3. At the end of experiment (30th day of storage), 11.60 % CO_2 was recorded in G_1T_3 treatment combination.

Physiological loss in weight

It was observed that PLW increased at a steady rate with the duration of storage. Fig. 3 shows the average values of PLW for Bengal gram kernels with the different gas composition and storage conditions. On the 6th day of storage, minimum PLW (0.54 %) was observed in G_1T_3 and maximum PLW (6.94 %) was observed in G_2T_1 treatment combination. On the 24th day of storage, minimum PLW (9.23 %) was recorded in G_1T_3 and maximum PLW (13.20 %) was

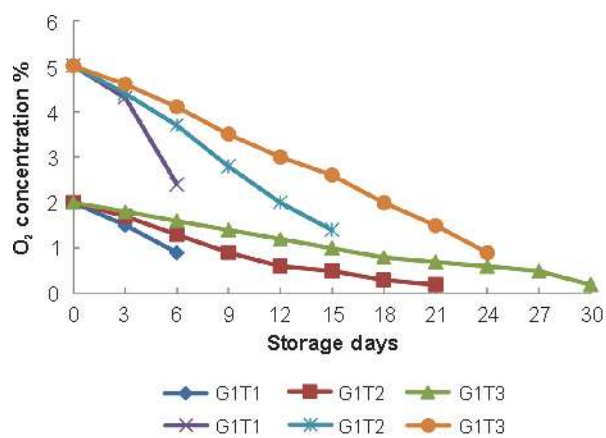

Fig. 1 — Combined effect of gas composition and storage temperature on O_2 concentration

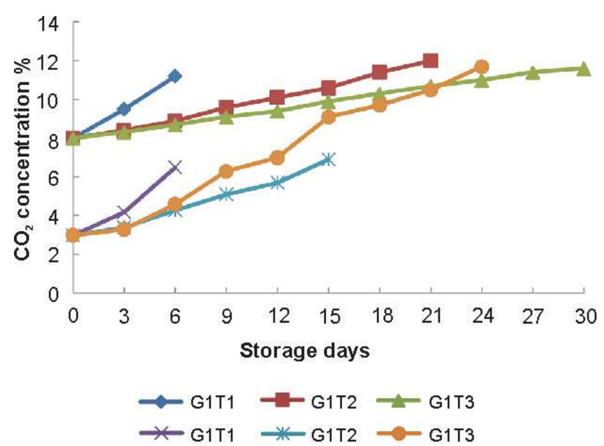

Fig. 2 — Combined effect of gas composition and temperature on CO_2 concentration

recorded in G_2T_3. Similarly, at the end of experiment (30th day of storage), 18.56 % PLW was recorded in G_1T_3 treatment combination.

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. The combined effect of gas composition and storage temperature and polythene film is shown in Fig. 4. A sample of Bengal gram kernels was considered unacceptable when 10 % of the kernels were visibly decayed as per an earlier study conducted on fruits (strawberry and raspberry)[12].

On the 6th day of storage, minimum decay (11.04 %) was observed in G_2T_3 and maximum decay (100 %) was observed in G_1T_1, G_2T_1 treatment combination. On the 15th day of storage, minimum

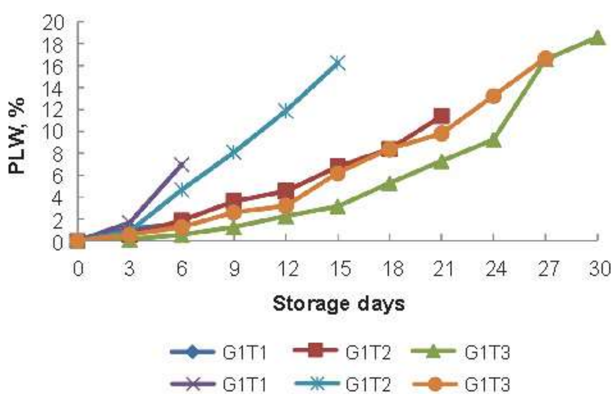

Fig. 3 — Combined effect of gas composition and temperature on PLW

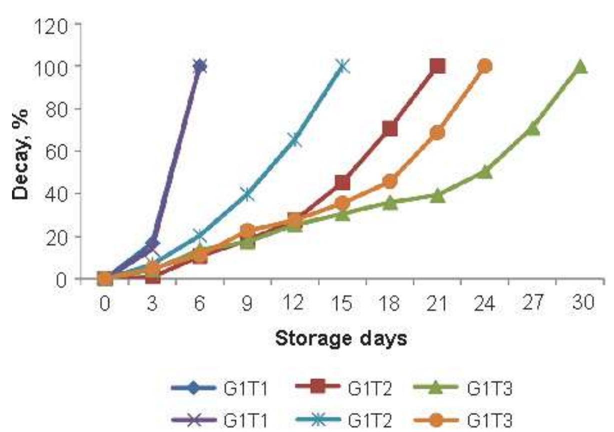

Fig. 4 — Combined effect of gas composition and temperature on decay

decay (4.36 %) was recorded in G_1T_3 while the maximum decay (50 %) was observed in G_2T_2. Similarly, on the 24th day of storage, minimum decay (24.68 %) was recorded in G_1T_3 and maximum decay (100 %) was recorded in G_2T_3. Similarly, at the end of experiment (30th day of storage), 100 % decay was recorded in G_1T_3 treatment combination.

From Fig. 4, 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 G_1T_3 product survived.

It can be inferred from the data that gas composition G_1 with storage condition T_3 results in decay of less than or equal to 10 % value till 21 days. The decay level of 10 % was considered acceptable[13]. Therefore the product can be acceptable up to 21 days.

Water activity

During storage, the most controllable parameters are the temperature and the relative humidity for water activity. The deterioration reaction of the nutrient do not necessarily depend solely on the total moisture content of the food materials, it is the state of water, measured by water activity, that determines the reactions in foods[14]. Hence, it is more appropriate to relate nutrient loss in food material to water activity rather than to its actual water content. The water activity of fresh Bengal gram kernel sample was 0.962.

The combined effect of gaseous composition and storage temperature on Bengal gram kernels were found to be significant during the entire period of storage as presented in Fig 5. On the 6th day of storage, minimum water activity (0.965) was observed in G_1T_3 and maximum water activity (0.985)

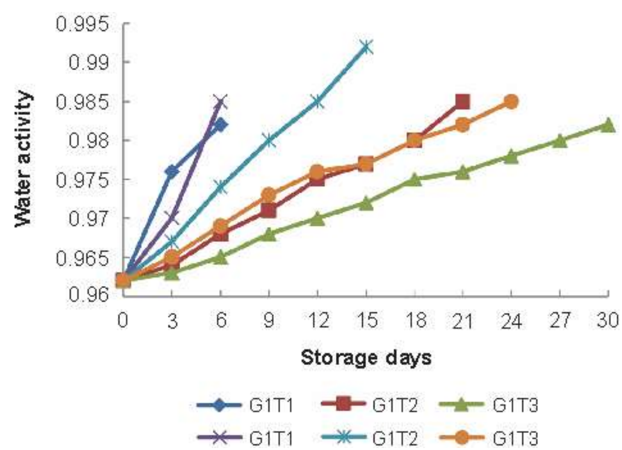

Fig. 5 — Combined effect of gaseous composition and temperature on water activity

was observed in G_2T_1 treatment combination. On the 15th day of storage, minimum water activity (0.972) was recorded in G_1T_3 while maximum water activity (0.992) was recorded in G_2T_2. Similarly, on 24th day of storage, minimum water activity (0.978) was recorded in G_1T_3 and maximum water activity (0.985) was recorded in G_2T_3. Similarly, at the end of experiment (30th day of storage), 0.987 water activity was recorded in G_1T_3 treatment combination.

From the data, it can be inferred that, the water activity of the kernels increased from 0.965 to 0.990. Water activity is related with the microbial load. As water activity increases, the microbial load also increases. The gas composition G_1 with storage condition T_3 resulted into the water activity of less than 0.980. Further, the water activity suddenly increased. On the 27th day sample showed this limit of water activity.

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 as well as during post-harvest handling and therefore, the numbers of microorganisms found on vegetables are highly variable. Initial mesophilic counts reported for all the samples in previous studies were in the range 10^1–10^2 CFU/mL[13,15,16].

Large differences in microbial counts have been reported between batches of vegetable samples. This has been attributed to numerous factors such as ambient conditions during harvest, the presence of soil accompanying the sample, or postharvest handling[17]. The washing process helped to reduce the total microbial load, resulting in maintained quality of the fresh Bengal gram kernel.

Bacterial load

Bacterial count was checked on the sample at 3 days interval. The count was converted into log CFU/mL and is shown in Table 3. The combined effect of gaseous composition and storage temperature on Bengal gram kernels were found to be significant during entire period of storage as presented in Fig. 6. On the 6th day of storage, minimum bacterial count was observed in G_2T_3 (3.37) and the maximum bacterial count was observed in G_1T_1 (7.15) treatment combination. On the 15th day of storage, minimum bacterial count was recorded in G_1T_3 (4.46) while maximum bacterial count was recorded in G_2T_2 (6.66). Similarly, on the 24th day of storage, minimum bacterial count was recorded in G_1T_3 (6.17) and maximum bacterial count was recorded in G_2T_3

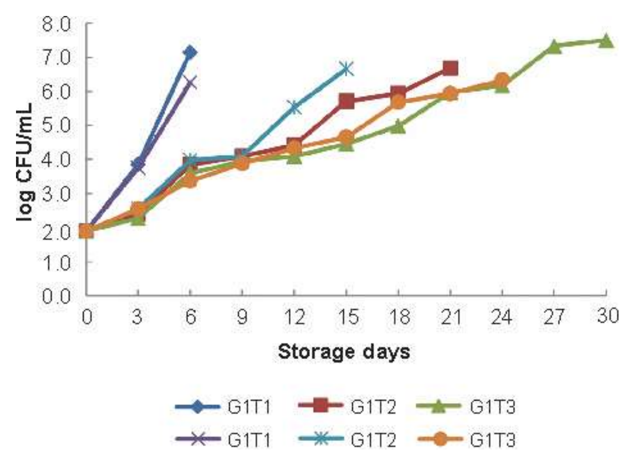

Fig. 6 — Combined effect of gaseous composition and temperature on bacterial count

Table 3 — Bacterial count (log CFU/mL)

	Gas Composition					
Days	G_1T_1	G_1T_2	G_1T_3	G_2T_1	G_2T_2	G_2T_3
0	1.9	1.9	1.9	1.9	1.9	1.9
3	3.86	2.38	2.28	3.76	2.55	2.55
6	7.15	3.85	3.60	6.26	3.98	3.37
9		4.10	3.96		4.10	3.88
12		4.42	4.10		5.54	4.34
15		5.71	4.46		6.66	4.66
18		5.94	4.99			5.69
21		6.69	5.98			5.94
24			6.17			6.33
27			7.33			
30			7.50			

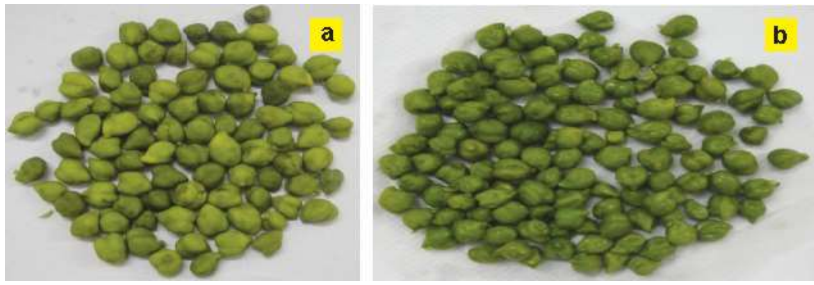

Plate 1 — a) Final sample stored of G_1T_3 treatment, b) Final sample stored of G_1T_1 room temperature

(6.33). Similarly, at the end of experiment (30^{th} day of storage), 7.50 bacterial load was recorded in G_1T_3 treatment combination. The total bacterial load (10^6 CFU/mL) for the samples was within the permissible range of 10^7 CFU/mL at 21 day, which depicts that these products are safe for the human consumption.

Sensory evaluation

The sensory evaluation was done on the basis of colour, texture, taste, visual appearance, odour, and overall acceptability. It was observed that temperature and gas composition also significantly affect the scores. Further, it was observed that all the three gas composition combinations with storage at ambient conditions were not accepted by the judges of consumer panel after three days of storage. While, samples stored at 0 ºC i.e. G_1T_3, G_2T_3 were most accepted by the panel of judges. The different headspace environment under different packaging treatments affected the equilibrated in-pack aroma differently.

Overall acceptability of the Bengal gram kernels decreases as the increase in storage days and storage temperature. Bengal gram kernels packed with G_1 gas composition shows acceptable score up to 21 days, while T_3 condition shows acceptable score up to 21 days. With respect to the visual appearance (decay), judges have accepted Bengal gram kernels from all the treatments up to an acceptable limit. The combination of G_1 gas composition and T_3 condition depicts the maximum acceptable 21 storage days of acceptable storage life. Plate 1a shows the final products obtained from G_1T_3 treatment at the end of the 21^{st} day of storage and plate 1b shows the final obtained from G_1T_1 treatment at the end of the 3^{rd} day of storage.

Conclusion

The fresh Bengal gram kernels packed in LDPE film package with G_1 gas composition (2 % O_2 and 8 % CO_2) and stored in T_3 temperature condition retained most of the desirable quality parameters such as sensory score, colour, and texture with least bacterial load. The physiological loss in weight was found within the acceptable limit for 24 days. The decay was 10.00 % for 21^{st} day. The microbial load was within permisible limit for the sample stored at T_3 condition and with G_1 composition. Bengal gram kernels packed with G_1 gas composition depicted acceptable score up to 21 days, while T_3 composition showed acceptable score up to 21 days, respectively. The combination of G_1 gas composition and T_3 condition with LDPE depicted the maximum acceptability till 21^{st} storage days. It was further inferred that the product obtained with G_1 gas composition (2 % O_2 and 8 % CO_2) was better than the product obtained at G_2 gas composition. The storage at lower temperature resulted into maximum shelf life and minimum quality loss.

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