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Changes in post-harvest life of French bean through modified atmosphere packaging and storage studies

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Abstract
French beans (*Phaseolus vulgaris* L.) Belongs to Fabaceae family and south America is the probable origin for this crop and the tender pods as well as fully matured grains (beans) are used as vegetable. Since it requires a mild temperature it is sown during February –March in hills. In plains where the winter is not so severe (as in southern India) it is sown during November –December and where the winter and summer are severe as in Northern plains, sowing is done in August and the crop is over in November. The pods have to be harvested when they are tender and before they mature they can be shelled and used. Fully matured seeds (dry beans) can be harvested by removing the entire plant and threshing the pods after drying many of the beneficial results of modified atmosphere storage cannot simply be attributed to a reduction in respiration. In banana under ideal experimental conditions a 12 fold size in the storage life of green banana can be comprising Co2 -5 percent, 02-3 per cent and N2 -92 per cent in the absence of ethylene, but respiration measured in terms of 02 uptake is reduced to only one quarter at the rate in air. The greatly increased storage life is attributed to a reduction in the rate at natural ethylene production by the bananas and also to a reduced sensitivity of the fruits to ethylene. In green vegetables improved retention of green color m low 02 atmosphere is due mainly to a lowering at the rate of chlorophyll destruction Interesting and contrasting effect has been noted in potato The retention of flavor may also be improved under this by increasing CO2 and reduced oxygen, reduced rotting of produce by retarding ripening and senescence, since the natural resistance of the produce host to pathogen decreases as it ripens or ages. Storage

Keywords: French bean, KMS, citric acid, MAP, T1-Treatments

Introduction
Most fresh-cut products will maintain their best quality at temperatures near 0°C (32°F) for temperate and 4-10°C for tropical vegetables. Having achieved excellent temperature control, Modified Atmosphere Packaging (MAP) can be used to further reduce the respiratory rate, loss of moisture, metabolic heat, yellowing, browning, decay and sensitivity to ethylene. The primary guardians of this value added are low temperature and Modified Atmosphere Packaging (MAP). Traditionally only sterile and / or processed foods could be delivered to distant markets during off seasons. With the globalization of food markets and increased consumer desire for fresh foods year around, lucrative markets have been opened to those able to present fresh foods without chemical additives. To this end novel packaging approaches to the preservation to avoid deterioration have emerged under the name of "extended shelf life packaging". The majority of these packages rely on a combination of modified atmosphere and rigorous refrigeration to forestall microbial and chemical deterioration (Thompson, l999) [10].

Modified Atmosphere Packaging (MAP) is the enclosure of food products in high gas barrier materials, in which gaseous environment has been changed once to slow respiration rates; reduce microbial growth and retard enzymatic spoilage with the final effect of increasing shelf life. Modified Atmosphere Packaging (MAP) is a term applied to a range of food packaging technologies that rely on mixtures of the atmosphere gasses like oxygen (02), carbon dioxide (C02), and nitrogen (N2) in different concentrations than these in air, to retard deterioration process in foods (Zagory, 1998) [12]. The technology thus relies on gases that are generally safe, common, cheap and readily available. Different combinations of these gases are appropriate for important foods and package types. Carbon dioxide is important because of its biostatic activity against many spoilage organisms and inhibitory effects and respiration rates oxygen inhibits the growth of anaerobic pathogens. Nitrogen serves as a filler gas to reduce the concentration of other gases.

Many of the beneficial results of modified atmosphere storage cannot simply be attributed to a reduction in respiration. In banana under ideal experimental conditions a 12 fold size in the storage life of green banana can be comprising Co2 -5 percent, 02-3 per cent and N2 -92 per cent in the absence of ethylene, but respiration measured in terms of 02 uptake is reduced to only one quarter at the rate in air. The greatly increased storage life is attributed to a reduction in the rate at natural ethylene production by the bananas and also to a reduced sensitivity of the fruits to ethylene. In green vegetables improved retention of green colour m low 02 atmosphere is due mainly to a lowering at the rate of chlorophyll destruction Interesting and contrasting effect has been noted in potato The retention of flavor may also be improved under this by increasing CO2 and reduced oxygen, reduced rotting of produce by retarding ripening and senescence, since the natural resistance of the produce host to pathogen decreases as it ripens or ages.

Materials and Methods
- **Raw materials**: French beans (*phaseolus vulgaris* L.)
- **Miscellaneous items**: Refined oil, salt, mustard, black gram

dhal and sugar were purchased from local Departmental store. **Packaging materials**: Gas tight glass bottle of 500 ml capacity with rubber cork was purchased from local market.

- **Chemicals:** The chemicals like citric acid and potassium metabi-sulphite, used were food grade and other chemicals and reagents used in this study were either AR, LR, or GR grade.
- **Equipments:** Designing and erection of Modified Atmosphere Packaging unit (MAP), Gas chromatograph, Klett summer son photoelectric colorimeter, Braun balance, ripple beam balance, Refrigerator, Hand Refrectometer, Ph meter, Hot air oven, centrifuge, Muffle furnace and photo electric colorimeter.
- **Pretreatments:** The minimally processed French beans (*phaseolus vulgaris* L.) Were pretreated by soaking them in the following solution for 30 seconds. Potassium metabisulphite, citric acid and salt were 1.0 percent.
- **Packaging:** The bottles were flushed with gas mixtures for two minutes. Then the pretreated minimally processed French beans (*phaseolus vulgaris* L.) Were filled into bottles and packed under modified atmosphere packaging with standardized gas mixtures. French beans (*phaseolus vulgaris* L.) Oxygen-7.0, corbondioxide-13.0 and nitrogen80.0 were stored at refrigeration temperature maintained at 10+-2.c and 80+-5 per cent relative humidity.
- **Storage studies:** chemical analyses were done in stored vegetables at periodical intervals (once in a 15 days. as per the procedures given below. Moisture content, pH, titrable acidity, fibere, TSS, Reducing sugar, Total sugar, Ascorbic acid, organoleptic evaluation and microbial examination were followed by Ranganna, 1995 [7]. The data on chemical characteristics of the samples were statistically analyzed by factorial completely randomized design as per method described by Gomez and Gomez, 1984 [3].

Result and Discussion

Moisture

The initial moisture content of French beans was 91.4g per cent. From Table 1. It was observed that the moisture content decreased during storage. The whole (Fb1) French beans had moisture content of 85.70 in T_1 (control), 90.70 in T (MAP), 90.80 in T_3 (MAP + citric acid), 90.18 in T (MAP + potassium metabisulphite) and 87.90 g percent in T_5 (MAP + salt) after 15 days of storage. After 30 days there was further reduction in moisture content and ranged between 85.10 and 89.60 g per cent (T_2 to T_5) and the control was spoiled. After 45 days storage a decrease in moisture content was observed in T_2 (87.10), T_3 (86.30) and T_4 (85.75) g per cent whereas T_5 was spoiled.

Table 1: Change in the moisture content (g%) of French beans during MAP storage

Storage days	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP\ Citric\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+\ Salt)}$		
	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}
Initial	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40	91.40
15 (d_1)	85.70	81.45	81.30	90.70	89.20	88.90	90.80	89.36	89.15	90.18	88.66	88.50	87.90	87.35	85.39
20(d_2)	-	-	-	89.60	88.20	88.10	89.30	88.75	87.36	87.76	87.16	86.62	85.35	85.10	85.10
45 (d_3)	-	-	-	87.10	86.30	86.10	86.30	86.45	86.71	85.75	85.96	85.20	-	-	-

After 15 days the moisture content ranged between 81.45 and 89.36 per cent in on the samples in large pieces (Fb_2) French beans. After 30 days of storage controlled was found to be spoiled whereas all the other samples were acceptable. In small pieces (T_3), the moisture content decreased to 81.30, 88.90, 88.50- 85.39 g per cent from the initial value of 91.4 g after 15 days in T1, T_2, T_3, T_4, T_5 samples respectively and further decrease was found in all the samples, after 30 days and the control was spoiled. In small pieces (T_3) the moisture content of T_2, T_3, T_4 samples were 86.l0g, 86.71g and 85.20 g per cent respectively after 45 days and T_5 was spoiled. Statistical analysis of the data revealed that there was a significant difference in moisture content during storage. Vegetable type, days of storage and treatment (T_1) and theft interactions were highly significant. In vegetable type, whole (Fb_1) was the best followed by large pieces (T_2) and small pieces (Fb_3). MAP + citric acid treated (T_3) was the best followed by T_2, T_4, $T_5$and T_1.Packaging played an important role in preventing moisture loss, creating a saturated micro-atmosphere around the fruit or vegetable. According to Aguilar *et al.* (1997) mangoes stored in open air (10°C, 75 per cent RN) suffered a pronounced moisture loss than those packed in the different bags under modified atmosphere packaging. In the present study the results were on par with the above study.

Table 2: Change in the pH content (g%) of French beans during MAP storage

Storage days	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+\ Citric\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+\ Salt)}$		
	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}	Fb_{1W}	Fb_{2L}	Fb_{3S}
Initial	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.46	5.70	5.70
15 (d_1)	5.40	5.39	5.33	5.38	5.49	5.48	5.47	5.46	5.47	5.47	5.46	5.55	5.54	5.54	5.53
20(d_2)	-	-	-	5.10	5.10	5.12	5.10	5.15	5.10	5.15	5.10	5.15	5.15	5.15	5.15
45 (d_3)	-	-	-	4.48	4.56	4.55	4.68	4.62	4.48	4.65	4.65	4.48	-	-	-

pH

During storage the pH of French beans was decreased Table 2. The initial pH was 5.70.In Whole (Fb_1) French beans the pH decreased and was found to be 5.40, 5.38, 5.47, 5.47 and 5.54 in T_1 T_2,T_3, E and T_5 treatments respectively after 15days. Further reduction was observed in T_2 to T_5 samples (5.10 to 5.15) after 30 days the control sample was spoiled and found unfit for consumption. After 45 days the T_2, T_3 and T_4 samples contained 4.48, 4.68, and 4.65 respectively whereas T_5 was spoiled. During storage in large pieces (Fb_2) on French beaus the pH was found to be 5.39, 5.49, 5.46, 5.46 and 5.54 in T_1, T_2, T_3, T4 and T_5 samples respectively after 15 days. The control T_1 was deteriorated and T_2 to T_5 samples had a pH range between 5.10 and 5.15 after 30 days. At the end of storage period (45 days) the

pH in T_2, T_3 and T_4 were 4.56, 4.62 and 4.65 respectively and T_5 were spoiled. In small pieces (Fb_3) the pH reduced to 5.33 in T_1, 5.48 in T_2, 5.47 in T_3, 5.55 T_4 and 5.53 in T_5 samples after 15 days. After 30 days it decreased further in T_2 to samples and the control was spoiled. After 45 days the pH of T_2, T_3 and T_4 was 4.55, 4.48 and 4.48 and T_5 was spoiled. Similar trends were also recorded in small pieces (Fb_3) of French beans. Statistical analysis the data revealed that highly significant difference was fund in the pH content. Vegetable type (Fb) days of storage and treatment (T) and their interactions were significantly different from each other. Whole (Fb_1) French beans were the best because of minimum reduction and Fb_3 (small pieces) was the poorest one. Treatment T_3 (MAP + citric acid) was the best followed by T_2, T_4, T_5 and T_1.According to Hhowmik and Pan (1992) [4] the pH values of tomatoes stored in the low humidity were consistently lower than those stored in high humidity. This was in agreement with the fact that the tomatoes stored in low humidity had a higher acidity than those in high humidity. Similar observation were found in the study, i.e., when acidity increased, the pH decreased accordingly.

Acidity

The acidity increased during storage as observed from Table 3. The initial acidity was 0.320 g per cent. During storage, the increase in the acidity was found to be 0.341 in control (T_1), 0.342 in MAP (T_2), 0.341 in MAP + citric acid (T_3), 0.344 in MAP + potassium meta bisulphate (T_4) and 0340 g per cent in MAP + salt (T_5) in whole (Fb_1) French beans after tier 15 days at storage. After 30 days of storage it increased 0.360 to 0.363 per cent to T_5 samples whereas the control was spoiled after 45 days T_2, T_3 and T_4 had the acid content of 0.372, 0.372 and 0.371. g per cent and T5 was spoiled.

Table 3: Changes In the acidity content (g %) French beans during MAP storage

Storage days	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP\ Citric+\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+\ Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
15	0.341	0.340	0.342	0.342	0.341	0.340	0.341	0.341	0.340	0.344	0.341	0.341	0.340	0.31	
30	-	-	-	0.360	0.371	0.362	0.362	0.374	0.361	0.361	0.378	0.364	0.363	0.372	0.364
45	-	-	-	0.372	0.371	0.371	0.372	0.374	0.372	0.371	0.378	0.374	-	-	-

After 15 days of storage, the large pieces (Fb_2) French beans had an acid content ranging from 0.340 to 0.341 g per cent m T_1 to T_5 samples After 30 days, the control was spoiled T_2 to T_5 samples contained 0371, 0.374, 0.378 and 0.372 g per cent. After 45 days the acidity increased to 0.371, 0.374 and 0.378 g per cent T2, T_3 and T_4 whereas T_5 sample was deteriorated. The small pieces (1%) the acidity increased to 0342, 0340, 0340, 0341 and 0.342 g per cent in T_1, T_2, T_3, it and T_5 samples after 15 days of storage. After 30 days the control sample was deteriorated and T_2 to T_5 samples the acidity was found to be 0361 to 0 3M g per cent. After 45 days, T_2, T_3 and T_4 had 0.371, 0.372 and 0.374 g per cent acidity and T_5 was spoiled similar trends were observed m small pieces (Fb3) of French beans. Statistical analysis of the data revealed that vegetable type (Fb), days of storage and treatment (T_1) and theft interactions were highly and significantly different from each other. The increase was more in Fl, 3 compared to Fb_2, Fb_1. In the treatments (T_1), T_3 was the best followed by T_2, T_4, T and T_1. Among the treatment T_3 and T_4 were on par with each other and significantly different from others. The titrable acidity decreases more in pears when it is stored in air compared to controlled atmosphere storage (Bertolini *et al.* 1997) [1]. In the present study controversially the acidity content increased during storage because of carbon dioxide Concentration. Sometimes carbon dioxide causes the increase in acidity in vegetables during storage.

Fiber

From Table 4. It was observed that there was a reduction in the fiber content during storage. The initial fiber content was 1.80 g per cent.

Table 4: Changes In the fibere content (g%) French beans during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+\ Citric\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Initial	1.71	1.70	1.70	1.79	1.79	1.79	1.71	1.71	1.71	1.70	1.70	1.70	1.71	1.71	1.71
15	-	-	-	1.76	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69
30	-	-	-	1.58	1.59	1.57	1.52	1.53	1.53	1.56	1.52	1.54	-	-	-

During storage it decreased to 1.71 m control (T_1), 1 79 m MAP (T_2), 1.71 MAP + citric acid (T_3), 1.70 in MAP + potassium metabisulphite T_4 and 1.71 g per. 4ent in MAP + salt (T_5) treated French beans after 15 days of storage. After 30 days it decreased and ranged between 1 76 and 1 69 g per cent in T_2 to T_5 samples and the control was spoiled m the case of whole (Fb_1) French beans After 45 days of storage g was decreased further ranged between 1.58 and 1.52 g per cent in T_2 to T_4 samples. In large pieces (Fb2) of French beans, the fibre content decreased to 1.70, 1.79, 171.1 70 and l.71 g percent in T_1 to T_5 samples after 15 days of storage. After 30 days the control sample was spoiled In T_2 to T_5 the fibre content ranged between 1.76 and 1.69. After 45 days it decreased further to 1.59 in T_2, 1.53 in T_3 and 1.52 in T4 and T_5 was spoiled. After 15 days of storage, a reduction in the fibre content of small pieces found and it was 1.69, 1.79, 1.71, 1.70 and 1.71 g per cent in T_1 to T_5 samples. After 30 days further reduction, was observed in treated samples. And the control spoiled. After 45 days the fibre content was 1.57 in T_2, 1.53 in T_3 and 1.54 g per in T4 treated samples and other was spoiled. From the statistical analysis, it was observed that there was a significant difference in the treatments like vegetable type, days of storage and treatments in fibre content. The whole (Fb_1).

French beans retained fibre content in maximum' level compared to large pieces (Fb_2) and small (Fb_3) pieces of French beans. The treatment T_3 (MAP + citric acid) was the best followed by T_4, T_2, T_5 and T_1.

Total soluble solids (TSS)

The initial TSS value of French beans was found to be 5.75° Brix. During Storage it was observed that there was a slight increase in TSS Table 5.After 15 days of storage, the TSS was found to be 5.75° Brix in control (T_1), MAP (T_2), MAP + citric acid (F3), MAP + potassium metabisulphite (T_4) and MAP + Salt(T_5) samples respectively for the whole, (Fb1) French beans. After 30 days it was 5.75^0 Brix in T_2 to T_5 samples and the control was spoiled After 45 days TSS was found to be 5.75 in T_2 and 5.78 in T_3 and T_4 samples and other was spoiled. During storage the large pieces (Fb_2) French beans had the TSS content of 5.75 mall the samples after 15 days of storage. After 30 days there was no change except the control which was spoiled After 45 days the TSS was found to be 5.78 and 5.78 Brix in T, T_3 and T_4 samples and the other sample was spoiled. Similar trend was also observed in large pieces (Fb_2) at French beans.

Table 5: Changes in the total soluble solids (°brix) of French beans during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP +Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
15	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
30	-	-	-	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
45	-	-	-	5.75	5.76	5.76	5.78	5.78	5.78	5.78	5.78	5.76	-	-	-

In small pieces (Fb3) of French beans the TSS content was 5.75° Brix m T_1 to T_5 samples, after T_5 days of storage Alter 30 days the control was spoiled After 45 days the TSS of T_2, T_3 and T_4 were found to be 5.76,5.78 and 5.76° Brix and other samples was spoiled. Statistical analysis of the data revealed that there was highly significant difference in TSS of French beans during storage In vegetable type (F_6), minimum increase in TSS was found to be in whole (Fb_1) followed by Fb_2 and Fb_3. The treatment T_2 (MAP) was the best followed by T_3, T_4, T_5 and T_1. Among them T_4 and T_5 were on par with each other and significantly different from T_3 and T_1.During storage TSS content was slightly increased in pears. The increase was higher in control samples compared to modified atmosphere packaging at pears. Bertolini *et al.*, (1997) [1].

Reducing sugar

The reducing sugar content increased from its initial value dining storage as observed from Table 6. The initial reducing sugar content was 0.65 g per cent. After 15 days of storage it increased to 0.74 g in control (T_1) 0.76 g in MAP ($T2_)$, 0.75 gin MAP + citric acid (T_3), 0.76 gin MAP ÷ potassium metabisulphite (T_4) and 0.75 g in MAP + salt (T_5) treated samples in whole (Fb_1) French beans. After 30 days the control (T_1) sample was spoiled and T_2 to T_5 samples had the reducing sugar content in the range of 0.88 to 0.89 g per cent. After 45 days, T_2, T_3 and T_4 had 0.97, 0.96 and 0.97 g per cent and the other was spoiled. Similar trend was observed in large pieces (Fb_2) French beans during storage. After 15 days of storage the small pieces (Fb_3) of French beans had the reducing sugar contents of 0.74, 0.75, 0.73, 0.73 and 0.74 g per cent

Table 6: Changes in the reducing sugar content (g) of French beans during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
15	0.74	0.73	0.74	0.76	0.74	0.75	0.75	0.73	0.73	0.76	0.74	0.73	0.75	0.73	0.74
30				0.88	0.89	0.89	0.89	0.88	0.89	0.89	0.88	0.88	0.88	0.89	0.89
45				0.97	0.97	0.96	0.96	0.96	0.97	0.97	0.96	0.97			

In T1, T2, T3, T4 to T5 samples respectively after 30days it increased to 0.89, 0.89, 0.88 and 0.89 g percent T2 to T5 samples and the control (T1) was spoiled. After 45 days of storage 0.96 in T2, 0.97 m T3 and T4 samples were found and the other was spoiled similar trends were observed in small pieces (Fb3) of French beans. Statistical analysis of the data revealed that highly significant difference was observed in reducing sugar content In vegetable type (Fb), whole French beans (Fb1) was the best followed Fb2 and Fb3. The treatments and their interactions were highly significant. Fructose and glucose are the major sugars in vegetables with trace amounts of sucrose. According to Wang and Qi (1997) cucumber kept in CA conditions maintained higher fructose concentrations than those in air storage. Fructose increased during storage at 5°C for six days. In the present study similar results were observed during storage.

Total sugar

The initial total sugar content was 3.95 g per cent. During storage it was decreased from its initial value as observed as shown in Table 7.

The whole (Fb1) French beans had 3.76 g in control (T1), 3.75 g in MAP (T2), 3.76 gin MAP + citric acid (1), 3.75g each in MAP + potassium metabisulphite (T4) and in MAP + salt (T5) after IS days of storage. Alter 30 days the control (T1) was spoiled and in T2 to T5 the total sugar content ranged between 3.45 to 3.50 g per cent. After 45 days (T3) T2, T3 and T4 had the total sugar content of 3.24, 3.22 and 3.21 g per cent and other was spoiled. After 15 days of storage, the large pieces (F12) French beans had the total sugar content of 3.75, 3.78, 3.79, 3.79 and 3.78 g per cent in T1, T2, T3, T and T5 samples respectively. After 30 days T2 toT5

Table 7: Changes in the total sugar content (g%) French beans during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
	3.76	3.75	3.75	3.75	3.78	3.7	3.76	3.79	3.74	3.75	3.79	3.74	3.75	3.78	3.74
				3.45	3.47	3.46	3.48	3.51	3.47	3.50	3.50	3.47	3.49	3.48	3.47
				3.24	3.21	3.22	3.20	3.22	3.21	3.21	3.22				

Samples had the total sugar content in the between 3.47 and 3.51 g per cent and the control sample was spoiled. After 45.20 and 3.21 gpercentwasfoundmT_2, T_3 and T_4 and other were spoiled. In the small pieces (Fb3) of French beans the total sugar had undergone these changes similar to the above mentioned types whereas the reduction was maximum pared to Fb_1 and Fb_2.Statistical analysis of the data revealed that there was a significant difference between the treatments (T) vegetable type (F_b) and days of storage and their interactions in total sugar content In vegetable type Fb1 was the best followed by Fb_2 and Fb_3 In the treatments MAP + citric acid (T_3) prevented the loss compared to others T_2, T_4, T_5 and T_1).Total sugars changed significantly with storage period and temperature under modified atmosphere. There was no change in total sugars but slightly decreased with an increase in carbon dioxide levels. This may be due to the decreased rate of respiration levels (Singh and Singh, 1996) [9]. The results were in line with the present study.

Ascorbic acid

The initial ascorbic acid content was 24.10 mg per cent During storage it was reduced and observed from Table 8..During storage it reduced to 22.91, 22.88, 22.90, 22.86 and 22.90 mg per cent in control (T_1), MAP (T_2), MAP + citric acid (T_3), MAP + potassium metabisulphite (T_4) and MAP + salt (T_5) samples, after 15 days of storage in whole (Fb_1) French beans. After 30 days it was decreased to 20.72 to 20.78 mg per cent in T_2 to T_5 samples whereas the control (T_1) sample was spoiled. After 45 days T_2 T_3 and; had the ascorbic acid contents of 19.98, 19.90 and 19.95mg per cent and Er5 was spoiled;

Table 8: Changes in the ascorbic acid content (mg) of French bean during storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1
	22.91	22.92	22.91	22.88	22.94	20.88	22.90	22.96	22.96	22.86	22.96	22.94	22.90	22.98	22.92
	-	-	-	20.72	20.90	20.71	20.76	20.74	20.73	20.70	20.76	20.76	20.78	20.70	20.72
	-	-	-	19.98	19.88	19.91	19.90	19.90	19.92	19.95	19.92	19.92	-	-	-

After 15 days, the ascorbic acid content was 22.92 in T_1, 22.94 in T2, 22.96 in T_3, 22.96 in T_4 and 22.98 mg per cent in T_5 samples in large pieces (Fb_2) of French beans. After 30 days it further reduced to 20.70 to 20.90 mg per cent in T_2 to T_5 samples whereas the control (T1) sample was spoiled. After 45 days the ascorbic acid content was found to be 19.88 in T_2, 19.90 in T3 and 19.92 mg per cent in T_4 and T_5 was spoiled.

In small pieces (Fb_3) after 15 days of storage the ascorbic content was 22.91 in T1, 20.88 in T_2, 22.96 in T_3, 22.94 in T and 22.92 mg per cent in T_5 samples. After 30 days it ranged between 20.71 and 20.76 mg per cent in T_2 to T_5 samples and the control was spoiled. At the end of the storage period (45 days, d_3) the reduction was further increased. Statistical analysis of the data revealed that days of storage and treatments m and their interactions were highly significant whereas vegetable type (I) was not significantly different. During storage 15 days and 30 days (d_2) were on par with each other and significantly different from 45 days of storage. In the treatments T_2, T_3,T_4 and T_5 were on par with each other and significantly differed from the control (T_1).Ogata *et al.*, (1975) stored okra at 1°C in air or three per cent oxygen combined with 3,l0 to 20 percent carbon dioxide and at with three per cent carbon dioxide and three per cent oxygen. At 1°C there were no effects of any of the CAS treatments on ascorbic acid retention but at 12°C this treatment resulted in lower ascorbic acid retention. In the present study the okras were stored at 12°C.

Organoleptic evaluation - French beans 'poriyal'

Organoleptic characteristics such as appearance, colour, flavor, texture, taste and overall acceptability scored high in all treatments after 30 days of storage Table 9. The scores obtained for the appearance was ranged between 3.30 and 3.46 in all the samples. In the case of colour the score varied from 3.30 from to 3.46. In the case of flavor the samples score ranged between 3.29 and 3A5. Taste was as good as control in all other treatments. Overall acceptability also ranged between 3.10 and 3.35.Statistical analysis of the data revealed the quality attributes and treatments (T) and their interactions were highly and significantly different in organoleptic evaluation. The quality attributes appearance, colour, texture, taste and overall acceptability on par with each other and significantly different from flavor. In treatments T_1 and T_2, T_3 and T_4 were on par with each other and significantly different from T_5.Minimally processed bread fruit slices was highly scored in colour, texture and taste (John and Narasimbam, 1998) [5]. Similar results were also observed in this study except in MAP + salt treated samples.

Microbial count — bacteria x10^{-6} cfu/g

The initial microbial count was 10.00 in control (T_1), 5.00 in MAP (T_2), 5.00 in MAP 4 citric acid (T_3), 6.00 in MAP + potassium metabisuiphite (T_4) and 7.00 x HP cfu/g in MAP + salt (T_5) treated samples. From the Table 10. It was observed that there was an increase in bacterial count.

Table 9: OrganoleptiC evaluation of French bean "Porlyal"

Quality Attributes	Fresh French bean	T_1 (control)	T_2 (MAP)	T_3 (MAP+Citric acid)	T_4 (MAP+KMS)	T_5 (MAP+ salt)
Appearance	4.00	3.46	3.41	3.31	3.30	3.32
Colour	3.97	3.46	3.40	3.30	3.31	3.31
Flavour	4.00	3.45	3.41	3.29	3.28	3.10
Textre	3.98	3.40	3.41	3.29	3.27	3.10
Taste	3.97	3.45	3.40	3.30	3.27	3.11
Overall acceptability	3.98	3.20	3.35	3.19	3.10	3.10

After 15 days of storage it increased to 14.0, 8.47, 8.67, 9.00 and 8.71 x 10 cfu/g in T_1, T_2, T_3, T_4 and T_5 samples in whole (Fb_1) French beans. After 30 days the increase was found to be 9.00 to 9.10^{-6} x cfu/g in T_2 toT_5 samples and the control (T_1) sample was spoiled and unfit for consumption. Alter 45 days the bacterial count was found to be 10.10 inT_2, 10.11 in T_3 and 11.21 x 10^{-6} cfu/ginT_4 samples and T_5 sample was spoiled. In large pieces (Fb_2) French beans the bacterial count was found to be 8.46 to 14.00 x 10 cfu/g T_1 toT_5 samples after 15 days of storage. After 30 days the control was spoiled and in T_2 to T5 it ranged from 9.00 to l0.00 x 10^{-6} cfu/g. After 45 daysT_2, T_3 and T_4 contained 10.10, 10.12 and 11.22x l0 cfu/g bacterial count and T_5 was unfit for consumption.

In small pieces (Fb_3) after 15 days of storage the bacterial count was 14.00 to 8.46 x 10^{-4} cfu/g in T_1 to T_5 samples. After 30 days the count (d_2) increased further d the control (T1) sample was spoiled. After 45 days the bacterial count was found to be 10.11, 10.12 and 11.12 x 10.12 and 11.12 x 10^{-6} cfu/g T_2, T_3 and T_4 and samples and T_5 sample unfit for consumption. Statistical analysis of the data revealed that there was a significant difference between the treatments during storage. In the vegetable type (Fb), maximum count was found in small pieces (Fb_3) because of exposure of the large surface area. During 15 (d_1) and 30 days (d_2) were on par with each other and significantly different from 45 days of storage. In the treatments T_2, T_3 and T_4, T_5 were on par with each other and was significantly different from the control (T_1).

Table 10: Enumeration of bacterial (x 10^{-6} cfu/g) in stored French bean

Storage period	T_1(control)			T_2(MAP)			T_3(MAP+ Citric acid)			T_4(MAP+KMS)			T_5(MAP +Salt)		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	10.00	10.00	10.00	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00	6.00	7.00	7.00	7.00
	14.00	14.00	14.00	8.47	8.46	8.46	8.67	8.66	8.66	9.00	9.00	9.00	8.77	8.76	8.76
				9.00	9.00	9.00	9.10	9.12	9.11	10.00	10.00	10.00	9.10	9.11	9.11
				10.10	10.10	10.11	10.11	10.12	10.12	11.21	11.22	11.12			

Fungi 10^{-6} cfu/g

The initial fungal count found in control T_1, MAP (T_1), MAP + citric acid (T_3) MAP + potassium metabisulphite (T_4) and MAP + salt (T_5) samples were 5.00, 4.00, 5.00,4.00 and 5.00 x 10^{-6} chug respectively Table 11.During storage it increased to 7.00,5.00,5.11,5.11 and 5.10 x l0 cfu/g in T_1, T_3, T_4 and T_5 samples after 15 days in whole French beans (Fb_1). After 30 days, it further increased in T_2 to T_5 samples in the range of 6.00 x 10^{-3} cfu/g to6.12 x 10^{-3} and the control sample was spoiled. After 45 days the fungal count was found to be 7.00 x 10^{-3} cfu/g in T_2, T_3 where as in T_4 it was 7.13. T_5 sample was led and unfit for consumption. Similar trends were observed in large pieces (1%) and small pieces (Fb_3) of French beans during storage. Statistical analysis of the data revealed that there was a highly significant difference in vegetable type (Fb), days of storage and the treatments (1) and their interactions during storage. In the vegetable type (Fb) maximum count was found in T_4 whereas T_2 and T_3 were on par with each other and significantly different from T_1. Treatments MAP (T_2) had the minimum fungal count among treatments T_3, T_4, were on par with each other and significantly different from T_1.The low microbial count of the samples observed in the experiment would be due to the effects of pre storage washing and cleaning, low storage temperature and the modified atmosphere storage. The values for custard apple were low when compared with the values reported for grapes (3.8 x 10^{-4} to 6.8 x10^{-4}). Brecht, 1998 [2]. Similar trend was observed in the present study.

Table 11: Enumeration of fungi (x 10^{-3} cfu/g) in stored French bean

Storage period	T_1(control)			T_2(MAP)			T_3(MAP+ Citric acid)			T_4(MAP+KMS)			T_5(MAP+ Salt)		
	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}	Fb_{1w}	Fb_{2L}	Fb_{3S}
Initial	5.00	5.00	5.00	4.00	4.00	4.00	5.00	5.00	5.00	4.00	4.00	4.00	5.00	5.00	5.007.00
15	7.00	7.00	7.00	5.00	5.00	5.00	5.11	5.10	5.11	5.11	5.10	5.11	5.10	5.10	5.11
30	-	-	-	6.00	6.00	6.00	6.10	6.11	6.1	6.10	6.11	6.12	6.12	6.12	6.11
45	-	-	-	7.00	7.00	7.00	7.00	7.16	7.00	7.13	7.12	7.00	7.00	-	-

In minimally processed potatoes, a microbial load of 10^{-5} cfu/cm^2 products has been observed in the products and it has been associated with microbial spoilage and an unacceptable aroma Santeree *et al.* 1991. Similar result was observed in the present study. Unacceptable aroma was observed in control, MAP + citric acid (T_3) MAP+ potassium metabisulphite (T_4) and MAP + salt (T_5) treated samples.

Conclusions

The results obtained from the experiments carried out to increase the post-harvest life of selected French beans through Modified Atmosphere packaging and storage. Gradual reduction in the

moisture content of French beans was observed irrespective of the storage temperature through the storage period. The final moisture contents were 87.10, 86.30 and 85.75 g per cent in (MAP) T2, MAP +citric acid T3 and MAP + potassium meta bisulphate T4 which had the initial moisture content of 91.4g per cent in whole French beans

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