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Physico chemical and microbial changes of selected Cluserbeans (*Cyamopsis Tetragonoloba* L. Taub) through modified atmosphere packaging and storage

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Abstract
The whole cluster beans had 70.10 g of moisture, pH 5.15, 0.246g of acidity, 2.75 g of fiber, 5.70 degree brix of total soluble solids, 0.90 and 3.00 g per cent of reducing and total sugars at the end of the storage period. There was an increasing trend in bacterial and fungal counts through the storage period. The organoleptic evaluation showed that cluster bean "poriyal" made from (T2) MAP stored vegetables was good as fresh one. Cluster beans belong to Fabaceae family. It is a very hardy crop and withstands very high temperature as well as severe drought conditions. The tender pods are used as vegetables. The probable origins are West Africa and India. The tender pods are harvested as frequently as possible before the pods become fibrous and unit for marketing. The pods would come ready for picking, depending upon the cultivar from 40 days on ward. Day (1991) found that one of the active packaging of modified atmosphere packaging increase the self-life of fruits and vegetables. George (1993) found that freezing was the best method to preserve the nutritional and organoleptic characteristics of fruits and vegetables Shrink wrapping has been adopted (Shantha Krishnamoorthy, 1993) for storage of the fruits and vegetables. Modified Atmosphere Packaging can further extend the shelf life of fresh and minimally processed fruits and vegetables and stated that it served as an additional hurdle factor against microbial growth in the transportation and distribution chain.

Keywords: clusterbeans, itricacid, MAP, KMS, treatment, days, organoleptic, microbial and bacterial

Introduction
Over the past few years, the development and commercialization of MAP for fresh chilled food products has been most rapid in the world. Marketing strategies for industry (MSI) have recently estimated that modified atmosphere packs sold in 1999 was 2.191 billion with growth and predicted to reach 3.249 billion in 1999 as started by Zagory, (1997) [13]. Controlled atmosphere storage refers to a storage atmosphere which is different from normal atmospheric composition wherein the concentrations of component gases (carbon dioxide, oxygen and nitrogen) are precisely controlled and maintained thought the storage period. On the other hand modified atmosphere involves exposure of produce to the atmosphere generated in a package by the interaction of the produces (Shantha Krishnamoorthy and Sudhakar Rao, 1998) [9]. The total wastage in all food sectors is as high as Rs 50,000crore if even half the wastage could be prevented, we will have enough calories to improve the nutritional status of our poor people. With the changing life styles of society, consumers have less time to prepare food for cooking. Therefore convenience and simplicity are important to modem day's busy people. Apart from this for reasons of expense, labor and hygiene consume aims to produce or purchase vegetables that are ready-to-use. Minimally processed (MP) food fit -in well within this trend. The tissues in fresh-cut products are still living: To maintain life, their metabolic process must derive energy primarily through the process of respiration. Respiration involves the consumption, using atmospheric oxygen (O_2), of carbohydrates and organic acids and consequent production of metabolic energy, heat, carbon dioxide, and ethylene and moisture vapor. Different vegetables, and even of a given vegetable will vary in their respiration rates.

Moisture
The initial moisture content was 80.50 g per cent. From the table 1. It was observed that moisture content reduced during storage. After 15 days of storage the reduction in the moisture content was found to be 80.10 in MAP (T_2), 80.20 in MAP + citric acid (T_3), 80.16 in MAP + potassium metabisulphite (T_4) and 80.15 g per cent in MAP + salt (T_5). The control (T_i) had the moisture content of 78.91 g per cent. After 30 days (d_3) the control was deteriorated and in the treated samples, the moisture content ranged between 76.91 and 79.20. After 45 days the reduction was found to be 70.30 in T_2, 70.36 in T3 and 70.30 g per Cent in T samples whereas T_5 was spoiled. In the large pieces (Cb_2) the reduction in the moisture content was higher than whole cluster beans. The percentage reduction in the moisture content was observed as 77.15 in T_1, 79.99 in T_3, 79.90 in T_3, 79.86 in T and 79.88 g per cent in T_5 samples, after 15 days. The reduction was further increased. After 30 days and ranged from 75.99 to 76.79 g per cent in T_2 to T_5 samples. The moisture content was 70.21 g in T_2, 70.22 in T3, 70.10 g per cent in T_4 and T_5 was deteriorated at the end of the storage period (d_3).

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

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP\ Citric+\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+\ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50	80.50
15 (d_1)	78.91	77.15	77.10	80.10	79.99	79.98	80.20	79.90	79.89	80.16	79.86	79.87	80.15	79.88	79.79
30 (d_2)	-	-	-	79.20	76.33	75.91	78.80	75.99	75.91	78.90	76.79	76.20	76.91	76.30	76.30
45 (d_3)	-	-	-	70.30	70.21	70.22	70.36	70.22	70.21	70.30	70.10	70.00	-	-	-

In the small size cluster beans (Cb_3) the percentage reduction in moisture content was found to be 77.10, 79.98, 79.89, 79.87 and 79.79 in T_1, T_2, T_3, T_4 and T_5 samples respectively after 15 days. After 30 days further reduction was observed. The T_2, T_3, T_4 and T5 samples had the moisture contents of 75.91, 75.91, 76.20 and 76.30 g per cent respectively and T5 sample was deteriorated after 45 days. Similar trend was also observed in small pieces of cluster beans (Cb_3) during storage. Statistical analysis of the data revealed that a significant difference was found in the reduction of moisture content in vegetable type (Cb), storage days (d) and treatments (T). In vegetable type, the minimum decrease was found in whole (Cb_1) followed by large pieces (Cb_2) and (Cb_3). Among the treatments MAP + citric acid (T_3) was the best followed by T_2, T_4, T_5 and T_1. Statistical analysis revealed that there was highly significant difference between the treatments and their interactions. A marked difference in weight loss was found between non wrapped cucumber samples and other treatments after five days at storage of 5°C. The difference became even more pronounced as storage progressed. After 18 days of storage the non-wrapped samples lost 9.2 per cent while fruit from sealed bags lost only 0.2 per cent. Shrivel in fresh cucumbers became obvious when losses occurred in large amounts (Wang and Qi, 1997) [12]. These changes were observed in cucumbers stored under modified atmosphere packaging. In the present study similar observations were observed. Modified atmosphere packaging prevents moisture loss compared to control samples.

pH

The initial pH of the cluster beans was 4.75 but it increased during storage Table 2.

Table 2: Changes in the pH of cluster beans during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP\ Citric+\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+\ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75
15 (d_1)	4.87	4.86	4.86	4.87	4.84	4.84	4.87	4.83	4.83	4.86	4.81	4.82	4.87	4.85	4.86
30 (d_2)				4.92	4.98	4.98	4.98	4.95	4.98	4.98	4.93	4.99	4.98		
45 (d_3)				5.18	5.17	5.15	5.17	5.16	5.16	5.15	5.15	5.14			

After 15 days of storage the pH increased to 4.87 in T_1 (control), 4.87 in T_2 (MAP), 4.87 in T_3 (MAP + citric acid), 4.86 in T4 (MAP + potassium Meta bisulphate) and 4.87 in T_5 (MAP + salt) in whole cluster beans (Cb_1). After 30 days it increased to 4.92 to 4.98 in T_2 to T_5 samples whereas the control was spoiled. At the end of the storage period (d_3, 45 days) the pH content was 5.18 in T_2, 5.17 in (T3) and 5.15 in T4 and T_5 sample was deteriorated.

In the large pieces (Cb_2) of cluster beans also, the pH content increased after 15 days storage (d1) as 4.86, 4.84, 4.83, 4.81 and 4.85 in T_1 to T, samples respectively. After 30 days it ranged between 4.93 and 4.98 and the control was spoiled. At the end of the storage period (d3) pH was observed as 5.17, 5.16 and 5.15 in T_2 T_3, T_4 samples respectively and T_5 was spoiled.

During the storage period the pH increased in small pieces of (Cb_3) cluster beans also. After 15 days an increase in pH was found to be 4.86 in T_1, 4.84 in T_2, 4.83 in T_3 4.82 in T4 and 4.86 in T_5 samples. After 30 days there was a increase in pH 4.83 pH. At the end of the 45 days (d_3) the pH ranged as 5.15, 5.16 and 5.14 in T_2, T_3 and T_4 whereas T_5 was spoiled.

Statistical analysis of the data revealed that there was a highly significant difference in pH. The vegetable type (Cb), storage days and treatment (T) and their interactions were highly significant. In the vegetable type, whole (Cb^1) was the best followed by large pieces (Cb_2) and small pieces (Cb_3) in cluster beans. In the treatments MAP (T_2) was the best followed by T_3, T_4, and T_1 and significantly differed horn T_5 and was on par with each other.

The pH of tomatoes, increased after harvest during ripening in air. The tomatoes stored in CA exhibited a consistent change, a reduction was observed during Storage (Santeree, 1989) [8]. In the present study contrary values were observed. Initially the pH content increased whereas it decreased (due to the reduction in the respiratory rates as carban dioxide content increased in the atmosphere) at the end of the storage.

Acidity

The initial acidity was 0.313 g per cent during storage the acidity increased Table 3.

The increase in acidity was found to be 0.210 m control (T_1), 0.212 MAP (T_2). and in MAP + citric acid (T_3), 0.214 in MAP + potassium metabisulphite (T_4) and 0210 g per cent m MAP +salt (T_5) m whole cluster beans ($Cb,_1$) after 15 days of the Further increase in acidity was observed after 30 days of storage and ranged between 0.233 and 0.336 g per cent m T_2 to T_5 treatments The control was spoiled after 45 days the acidity was found to be 0.244 m T_2, 0.246 inT_3 and 0.245 g per cent inT_4 and T_5 sample was spoiled.

In large pieces of cluster beans (Cl,2) the percentage of acidity increased to 0.211, 0.214, 0.212, 0.215 and 0.212 g per cent in T_1 to T_5 after 15 days of storage. After 30 days the control was spoiled and others ranged between 0.230 and 0.236 g per cent of acidity. At the end of storage period the acid content increased to 0.245, 0.246 and 0.246 g per cent in $_{T2,}$ T_3 and T_4 respectively and the T_5 was deteriorated. Similar trends were also observed in small pieces of cluster beans (Cb_3). The increase in acidity was higher than those mentioned earlier.

Statistical analysis of the data revealed that there was a highly significant difference in acid content. The vegetable type (Cb), days of storage and treatments (T) and their interactions were highly significant from one another. In the vegetable type, the whole beans (Cb_1) was the best followed by large pieces (Cb_2) and small pieces (Cb_3) of cluster beans. In the treatments MAP + potassium metabisulphite (T_4) was the best followed by T_2, T_3, T_5 and T_1. Among the treatments, T_4 and T_5 were on par with each other and was significantly different from others.

The acidity levels in fruits and vegetables could affect their flavor and acceptability. Controlled atmosphere (CA) storage decreased the respiration rate and utilization of organic acids most effectively, thus CA stored samples had significantly higher titrable acidity than air stored samples Girard and Lau (1995) [3] studied that acidity of tomatoes in CAS generally increased during first 20 days of storage at both 13 and 15°C then tend to maintain or decrease until 70 days of storage which were in line with the study.

The reduction in fiber content was observed from Table 4. Fiber

The initial fiber content of cluster beans was found to be 3.20 g per cent. During storage it decreased to 3.11, 3.07, 3.02, 3.14, 3.10 g per cent in control (T_i), MAP (T_2), MAP + citric acid (T_3), MAP + potassium metabisuiphite (T_4) and MAP + gait (T_5) samples respectively in whole cluster beans (Cb1) at the end of the 15 days of storage. Further reduction in the fiber content was found to be in T_2 to T_5 and ranged between 2.89 and 2.97 g per cent and the control was spoiled after 30 days. After 45 days it decreased in T_2, T_3 and T_4 (2.72, 2.74 and 2.79 g per cent) whereas T_5 sample was spoiled.

Table 3: Changes in the acidity content (g%) of cluster bean during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
15	0.210	0.211	0.210	0.212	0.214	0.212	0.210	0.212	0.212	0.214	0.215	0.212	0.216	0.212	0.212
30				0.233	0.232	0.232	0.234	0.236	0.232	0.336	0.234	0.232	0.332	0.230	0.232
45				0.244	0.245	0.246	0.246	0.246	0.246	0.245	0.246	0.246			

In large pieces of cluster beans ($Cb_{2)}$ further reduction was found in the fiber content. After 15 days of storage the values of the fiber content were 3.10, 3.07, 3.04, 3.06 and 3.07 g per cent T_1 to T_5 samples. After 30 days the control was spoiled and in T_2 to T_5 samples the fiber content ranged between 2.97 and 2.98 g per cent. At the end of the storage period (45 days, d_3) the fiber content decreased to 2.71 in T_2, 2.72 in T_3 and 2.70 in T_4 and T_5 sample was deteriorated.

In large pieces of cluster beans (Cb_2) further reduction was found in the fiber content. After 15 days of storage the values of the fiber content were 3.10, 3.07, 3.04, 3.06 and 3.07 g per cent T_1 to T_5 samples. After 30 days the control was spoiled and in T_2 to T_5 samples the fiber content ranged between 2.97 and 2.98 g per cent. At the end of the storage period (45 days, d_3) the fiber content decreased to 2.71 in T_2, 2.72 in T_3 and 2.70 in T_4 and T_5 sample was deteriorated.

After 15 days of storage the fiber content reduced in small pieces of cluster beans (Cb_2). The range of fiber content decreased from 3.10 to 3.12 in T_1 to T_5 samples. After 30 days of storage further reduction was observed in T_2 to T_5 except in Control (T_1) which was spoiled. T_2, T_3 and EU4 contained 2.75, 2.76 and 2.74 g per cent Of the end of the storage (45 days, d_3).

Statistical analysis of the data revealed that highly significant difference was observed in the fiber content Vegetable type (Cb), days of storage and treatments (T) their interactions were significantly different from one another. In the vegetable type (T), whole bean (Cb_1) was the best followed by others. In the treatments (T), MAP + citric acid (T_3) was the best followed by T_2, T_4, T_5 and T_1

Table 4: Changes in the fiber content (g%) of cluster bean during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP +Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
15	3.11	3.10	3.12	3.07	3.07	3.10	3.02	3.04	3.10	3.14	3.06	3.11	3.10	3.07	3.10
30				2.94	2.98	2.97	2.89	2.97	2.97	2.97	2.97	2.97	2.97		
45				2.72	2.71	2.75	2.74	2.72	2.76	2.79	2.70	2.74			

Generally there was no change in the fiber content during processing whereas in the present study only slight reduction was observed. This may be due to some enzymatic changes on cutting and other minimal processing actions.

Total soluble solids (TSS)

The initial TSS content of cluster beans was 5.6° Brix from Table 5. An increase in the TSS was found during storage.

After 15 days of storage also the TSS was found to be 5.6°Brix, in control and all the other samples. After 30 days it was 5.6° Brix in T_2 and T_5 where as in T_3 and T_4 was 5.7°Brix samples and the control was spoiled After 45 days TSS was found to be 5_7 in T_2, T_3 and T_4 samples and T_5 sample was spoiled. The large pieces of cluster beans (Cb_2) had the TSS contents of 5.6 for the treatments T_1, T_2, T_3, T_4 and T_5 samples after 15 days of storage. Alter 30 days it ranged between 5.6 and 5.7°Brix in T_2 to T_5 samples and the control was spoiled. After 45 days the TSS was found to be 5.6 in T_2, T_3 and T_4 samples and the other sample was spoiled. Similar trend was also observed in small pieces (Gb_3) of cluster.

The large pieces of cluster beans (Cb2) had the TSS contents of 5.6 for the treatments T_1, T_2, T_3, T_4 and T_5 samples after 15 days of storage. Alter 30 days it ranged between 5.6 and 5.7°Brix in T_2 to T_5 samples and the control was spoiled. After 45 days the TSS was found to be 5.6 in T_2, T_3 and T_4 samples and the other sample was spoiled. Similar trend was also

observed in small pieces (Gb_3) of cluster beans Statistical analysis of the data revealed that there was highly significant difference in TSS of cluster beans during storage. In vegetable type (Gb), minimum increase in TSS was found to be in whole (Gb_1) followed by Gb_2 and Cb_3. The treatment T_2 (MAP) was the best followed by T_3, T_4, T_5 and T_i. Among them T_4 and were on par with each other and significantly different from T_3 and T_1.

Haruenkit and Thompson (1996) [5] showed that storage of pineapples in oxygen levels below 5.4 per cent has little effect on total soluble solids (°Brix). The results were in line with the present study. The changes in the TSS did not depend upon treatments and storage time hi modified atmosphere storage, particularly respiration rates determined the TSS If oxygen concentration reduced below 5 per cent the changes occurred.

Reducing sugar

The initial value of reducing sugar was 0.47 g per cent in the cluster beans during storage it increased as given in Table 6 From the Table it was observed that in whole (Cb1) cluster beans, the reducing sugar content increased to 0.68, 0.62, 0.62, 0.68 and 0.69 g per cent in control (T_1), MAP (T_2), MAP + citric acid (T_3), MAP + potassium metabisuiphite (T_4) and MAP + salt (T_5) after 15ys. The control sample was spoiled and the reducing sugar content further increased to 0.80 to 0.89 g per cent in T_2 to T_5. After 30 days. After 45 days the days the reducing sugar content was found to be 0.96 in T_2, 0.99 in T_3 and 0.94 in T_4 samples and T_5 samples was spoiled.

In the large pieces (Cb2) cluster beans, the reducing sugar increased to 0.69, 0.63, 0.64, 0.62 and 0.66 g per cent in T1 to T5 after 15 days. Further increase in reducing sugar content was observed in T2 to T5 samples (0.81 to 0.84 g per cent) after 30 days. The control sample was spoiled. T2, T3and T4 had 0.95, 0.98 and 0.99 g per cent of reducing sugar and other sample was spoiled after 45 days of storage.

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

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
15	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
30				5.6	5.6	5.6	5.7	5.6	5.6	5.7	5.6	5.6	5.6	5.7	5.6
45				5.7	5.6	5.6	5.7	5.6	5.6	5.7	5.6	5.6		5.7	

In small pieces (Cb_3) cluster beans the reducing sugar content increased to 0.67 in T_1, 0.68 in T, 0.69 in T_3, 0.64 in T and 0.63 in T samples after 15 days. The Control sample was spoiled and in others it ranged between 0.82 to 0.85 g per cent After 30 days. After 45 days T_2, T_3 and T_4 had reducing sugar content of 0.94, 0.97 and 0.90 g per cent while T_5 sample was spoiled. From the statistical analysis of the data, it was clearly known that the education of reducing sugar content was significantly different. Vegetable type (Cb), days of storage and treatment (T) were highly significantly different from one another. In vegetable type whole bean (Cb_1) was the best followed by large pieces (Cb_2) and small pieces (Cb_3) In the treatments T_3 (MAP + citric acid) was the best followed by T_2, T_4, T5 and T_1 Among the treatments T_4 and T_5 were on par with each other and significantly different from T_3 and T_1.

Sugars, acids and their interactions are important to sweetness, sourness and overall flavor intensity Changes in reducing sugars, total sugars and sucrose were parallel and the general trend was a decrease with time at each storage conditions Reduction m the loss of sugars was probably the result of decreased respiration rate (Hagenmaeir and Shaw, 1992) [4].

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

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP +Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
15 (d_1)	0.68	0.69	0.67	0.62	0.63	0.68	0.62	0.64	0.69	0.68	0.62	0.64	0.69	0.66	0.63
30 (d_2)				0.80	0.81	0.82	0.86	0.84	0.84	0.88	0.82	0.82	0.89	0.83	0.85
45 (d_3)				0.96	0.95	0.94	0.99	0.98	0.97	0.94	0.99	0.90			

Total sugar

The initial total sugar content was 3.41 g per cent- During storage a decreasing trend in total sugar was noticed Table 7

In the treated samples MAP (T_2), MAP + citric acid (T_3), MAP ± potassium metabisulphite (T_4) and MAP+ salt (T_5) the total sugar content decreased in the range of 3.22 to 332 g per cent in the whole cluster beans.(Cb_1) after 15 days of storage. After 30 days the reduction ranged between 3.10 and 3.19 g per cent in T_2 toT_5 samples. After 45 days the reduction was 3.00, 3.02 and 3.03 g per cent in T_2, T_3 and T_4 whereas T_5 sample was spoiled.

In the large pieces (Cb_2) the total sugar ranged between 3.20 and 3.24 g per cent in T_2 to T_5 after 1_5 days of storage. The reduction in the total sugar content was found to be 3.11 to 3.19 per cent in T_2 to T_5 after 30 days. After 45 days the total sugar was found to be 3.02 in T_2 and T_3, 3.03 g percent in T_4 whereas T_5 sample was spoiled.

In the small pieces (Cb_3) the total sugar content was found in T2 to T5 which ranged between 3.20 and 3.24 g per cent after 15 days. Further decrease was noticed as 3.12 to 3.17 g per cent in T_2 toT_5 After 30 days. 3.00, 3.01 and 3.03 g per cent was found in T_2, T_3 and T_4, T_5 sample was spoiled after 45 days.

From the analyzed statistical data it was observed that the days of storage and treatment (T) were highly significant whereas vegetable type (Cb) had no significant difference. In the treatments (T) T_2, T_3 and T_4 were on par with each other and significant different from T_5 and T_1.

Table 7: Changes in the total sugar content of (g%) cluster bean during MAP storage

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+Citric\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41
15 (d_1)	3.24	3.20	3.21	3.22	3.20	3.24	3.32	3.20	3.24	3.31	3.21	3.20	3.30	3.24	3.23
30 (d_2)				3.10	3.11	3.12	3.18	3.17	3.15	3.17	3.13	3.10	3.19	3.19	3.17
45 (d_3)				3.00	3.02	3.00	3.02	3.02	3.01	3.03	3.03	3.03			

In case of modified atmosphere (MA) at 5 +1°C, total sugar decreased with increase in carbon dioxide levels till 20 days except in 5 percent level in kin now mandarins. (Singh and Singh, 1996) [11]. The results were in line with the present study. The decrease in sugar content is due to their subsequent utilization via glycol sis for maintenance of respiration over longer period of storage.

Ascorbic acid

The initial ascorbic acid content was 23.40 mg per cent. During storage it decreased in samples which are shown in Table 8.

The whole cluster beans (Cb_2) had the ascorbic acid content of 19.79 g per cent (T_1) after 15 days of storage. In treated samples the ascorbic acid content was 20.99,20.60,20.51 and 20.50 mg per cent in MAP (T_2), MAP + citric acid (T_3), MAP + potassium metabisulphite (T_4) and MAP + salt (T_5) respectively. After 30 days the control sample was soi1ed and the ascorbic acid content varied from 19.10 to 19.21 mg per cent in treated samples (T_2 to T_5). The ascorbic acid content was found to be 1880, 18.86 and 18.81 mg per cent in.T_2, T_3 and T_4 and T_5 sample was spoiled after 45 days.

In the large pieces (Cb_2) the control (T_1) had ascorbic acid content of 19.10 mg per cent. In treated samples it ranged between 19.10 and 20.98 mg per cent after 15 days. The control sample was spoiled and the treated samples (T_2 to T_5) had an ascorbic acid content of 19.00 to 19.21 mg per cent After 30 days. The ascorbic acid content was found to be 18.91, 18.88 and 18.80 in T_2, T and T_4 where asT_5 sample Was spoiled After 45 days.

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

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+Citric\ acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40	23.40
15	19.79	19.10	19.10	20.99	20.98	20.98	20.60	20.61	20.61	20.51	20.51	20.51	20.50	20.50	20.50
30				19.10	19.11	19.10	19.00	19.00	19.00	19.20	19.21	19.20	19.21	19.21	19.21
45				18.90	18.91	18.91	1.86	18.88	18.89	18.81	18.80	18.80			

In the small pieces of (Cb_3) cluster beans the loss of ascorbic acid was um control sample had the ascorbic acid content of 19.00 mg per cent whereas treated samples (F_2 to T_5) were m the range of 20.50 to 20.98mg per cent after 15 days After 30 days it reduced m the range of 19.00 to 1921 mg per cent m treated samples (T_2 to T_5), whereas the control was spoiled. After 45 days the ascorbic acid content was found to be 1891 (T_2), 18.89 (T_3) and 1880 (T_4) mg per cent respectively

From statistical analysis of the data it was observed that vegetable type (Cb), storage days (d) and treatments (F) and their interactions were highly significant In the vegetable type (Cb), whole bean (Cb_1) was the best followed by large pieces (Cb_2) and small pieces (Cb_3) In the treatments (T), T_3 (MAP + citric acid) was the best followed by T_2, T_4, T_5 and T_1.

Low temperature was found to have pronounced effect m reducing respiration rate because of which the ascorbic acid was retained to a greater extent The ascorbic acid decreased to 2622, 2697, 2802 and 2772 mg / 100 ml of know juice m two, three, four and five per cent Co2 levels at 5± 1°C after 40 days of storage (Singh and Singh, 1996) [11]. The results observed were on par in the present study. The decrease in ascorbic acid was minimum in MAP stored samples because it has been shown to hasten the loss of ascorbic acid compared to air storage.

Organoleptic evaluation — cluster beans 'porlyal'

Fresh cluster beans were used as a control for comparing stored samples. The appearance color, flavor, texture, taste and overall acceptability of samples were as good as control Table 9. The MAP + citric acid, MAP + potassium metabisulphite treated samples were good in appearance, color, texture whereas there was a reduction in flavor.

Table 9: Organoleptic evaluation of Cluster bean "Porlyal"

Quality Attributes	$T_{1(control)}$	$T_{2(MAP)}$	$T_{3(MAP+Citric\ acid)}$	$T_{4(MAP+KMS)}$	$T_{5(MAP+Salt)}$
Appearance	4.00	3.41	3.30	3.31	3.32
Color	3.98	3.56	3.41	3.40	3.31
Flavor	4.00	3.56	3.31	3.21	3.10
Texture	3.97	3.41	3.30	3.19	3.10
Taste	3.98	3.46	3.35	3.34	3.11
Overall acceptability	3.98	3.29	3.10	3.11	3.10

taste and overall acceptability and hence scored low values at the end of the storage period (30 days).

Statistical analysis of the data revealed that quality attributes and treatments (T) and their interactions were highly significant In the quality attributes color scored higher values followed by appearance, flavor, texture, taste and overall acceptability In the treatments, control (T_1) scored higher values followed by T_2 (MAP), T_3 (MAP + citric acid), T_4 (MAP + potassium metabisulphite and T_5 (MAP + salt)

Higher sensory scores for orange color intensity, slipperiness and preference were appearances were noticed. These results were similar to those previously reported for samples evaluated under fluorescent light (Howard and Dewi, 1995) [6] Similar results was observed in the present study.

Microbial load - bacteria x 10^{-6} cfu/g

The initial microbial counts were 6.00, 5.00, 6.00, 5.00 and 6.00 x 10^{-6} cfu/g for control (T_1), MAP (T_2), MAP + citric acid (T_3), MAP + potassium metabisuiphite (T_4) and MAP + salt (T_1) respectively During storage the microbial counts increased Table 10.

In the whole cluster beans (Cb_1) the bacterial count was found to be 12.10 (T_1), 7.15 (T_2), 7.14 (T_3), 8.13 (T_4) and 8.19 (T_5) x 10 cfu/g samples during 15 days of storage. After 30 days the control sample was spoiled and it increased to 8.77,8.98, 9.16 and 8.76 x 10^{-6} cfu/g in T_2, T_3, T_4 and T_5 respectively. After 45 days 9.15 in El'$_2$, 9.17 in T_3 and 9.25 x 10 cfu/g in T_4 counts were found whereas T_5 sample was completely spoiled.

In the large pieces (Cb_2) the bacterial count was increased and the values were 12.11, 7.14, 7.16, 8.14 and 7.19 x 10 cfu /g in T_1, T_2, T_3, T_4 and T samples after 15 days. The bacterial count was found to be 8.76, 8.97, 9.15 and 8.75 x 10^{-6} cfu /g in T_2, T_3, T_4 and T samples Alter 30 days and the control was spoiled. After 45 days the bacterial count was found to be 9.16, 9.18 and 9.26x 10^{-6} cfu /g in T_3 and T_4 whereas T_5 was spoiled. In the small pieces (Cb_3) the microbial count increased during storage as indicated above.

Statistical analysis of the data revealed that vegetable type (Cb), days of storage and treatments (T) and their interactions were highly significant. In the vegetable type (Cb), minimum bacterial load was found in whole cluster beans (Cb_1) followed by large pieces (Cb_2) and small pieces (Cb_3) In the case of treatments (1) T_2 T_3 were on par with each other and were significantly different from T_4 and T_5.

Kakiomeneu *et al*., (1996) [7] studied that microbial changes m total viable count, lactic acid bacteria, yeast, and pseudomonas during storage of refrigerated (4°C) and temperature abused (10° C) shredded carrots m 93 per cent N_2 The lactic acid bacteria were found to be highest among counts on clii, and yeast although initially present were only 140 per cent of the total viable counts. According to Carlin *et al*., (1990) [1] the lactic acid bacteria dominant in shredded carrot. Similar trends were also observed in the present study.

Table 10: Enumeration of bacteria (x 10^{-6} dfu/ g) in stored cluster bean

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP+ Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	6.00	6.00	6.00	5.00	5.00	5.00	6.00	6.00	6.00	5.00	5.00	5.00	6.00	6.00	6.00
15	12.10	12.11	12.12	7.15	7.14	7.16	7.14	7.16	7.16	8.13	8.14	8.14	8.19	7.19	7.16
30				8.77	8.76	8.76	8.98	8.97	8.98	9.16	9.15	9.15	8.76	8.75	8.76
45				9.15	9.16	9.15	9.17	9.18	9.17	9.25	9.26	9.26			

Fungi x 10^{-3} cfu/g

The initial fungal counts were 5.00, 5.00, 6.00, 5.00 and 6.00 x 10^{-3} cfu/g in T_1 toT_5 samples. From Table 11 was observed that fungi count increased during storage.

After 15 days of storage the counts were 14.00, 8.00, 9.10, 8.00 and 9.00 x 10^{-3} cfu /g in control (T_1), MAP T_2), MAP + citric acid (T_3), MAP +potassium metabisulphite (T_4) and MAP + salt (T_5) samples of whole cluster beans (Cb_1) respectively. After 30 days it ranged between 9.00 and 10.33 x 10^{-3} cfu/g in T_2 to 'F_5 and the control was spoiled. After 45 days the counts were 11.00, 10.00 and 10.00 x io-3 cfu/g in T_2, T_3 and T_4 respectively whereas T_5 sample was completely spoiled.

In the large pieces (Cb2) it increased further than earlier and ranged as 14.20, 9.67, 10.00, 9.56 and 10.00 x 10^3 cfu/g in T_1 to T_5 samples after 15 days. After 30 days counts were found to 10.00, 11.00, 10.00 and 10.00 x10^{-3} cfu /g in T_2 to T_5 Samples. After 45 days 12.22 (T_2), 12.15 (T_3) and 11.33 (F_4) x 10^{-3} cfu/g counts were observed and T_5 sample was spoiled. Similar trends were also observed in small Pieces (Cb_3) counts increased to 14.00, 8.00, 9.10, 9.10 and 10.00 x 10^{-3} cfu/ g in T_1 to T_5 samples after 15 days At the end of the storage period the counts were 1200, 11.33 and 12.00 x 10^{-3} cfu/g in T_2, T_3 and T_4 respectively whereas T_5 was spoiled.

Table 11: Enumeration of fungi (x10^{-3} cfu/g) in stored cluster bean

Storage period	$T_{1(control)}$			$T_{2(MAP)}$			$T_{3(MAP Citric acid)}$			$T_{4(MAP+KMS)}$			$T_{5(MAP+ Salt)}$		
	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}	Cb_{1w}	Cb_{2L}	Cb_{3S}
Initial	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
15 (d_1)	14.00	14.20	14.00	8.00	9.67	8.00	9.10	10.00	9.10	8.00	9.56	9.10	9.00	10.00	10.00
30 (d_2)	-	-	-	9.00	10.00	10.00	10.33	11.00	12.00	9.33	10.00	10.00	10.00	10.00	10.00
45 (d_3)	-	-	-	11.00	12.22	12.00	10.00	12.15	11.33	10.00	11.33	12.00	-	-	-

Conclusions

Moisture

The whole cluster beans (Cb_1) exhibited higher moisture content throughout the study period compared to others like large pieces (Cb_2) and small pieces (Cb_3) cluster beans. The final moisture content of whole (Cb_i) cluster beans was 70.30 for (MAP) T_2, 70.36 in MAP+ citric acid (T3) and 70.30 for MAP + potassium metabisulphite (T_4) after 45 days of storage.

pH

(A gradual increase in pH was observed after 15 days of storage. After that a decreasing trend was noticed throughout the study period. The percentage reduction was maximum in small pieces (Cb_3) compared to others. The final pH of small pieces cluster beans was 5.15 in T_2, 5.16 in T_3, 5.14 in T_4 respectively.

Acidity

An increasing trend in the acid content of cluster beans was noted throughout the storage period in whole (Cb_1), large pieces (Cb_2) and small pieces (Cb_3) types. The initial acidity was 0.3 13 per cent which increased to 0.244, 0.246 and 0.245 and 0.245, 0.246 and 0.246 and 0.245, 0.246 and 0.246 in MAP (T_2), MAP+ citric acid (T_3) and MAP + potassium metabisulphite (T_4) respectively in Cb_1, Cb_2 and Cb_3 Cluster beans at the end of the storage period.

Fiber
Variations in the fiber content of cluster beans was noted during the study period. The fiber content reduction was maximum in small pieces cluster beans ($Cb_{3)}$ and minimum in whole cluster beans (Cb_1) the values were 2.75, 2.76 and 2.74, in 2.74 and 2.74 in T_2, T_3 and T_4 of Cb_1 and Cb_3 respectively.

Total soluble solids (TSS)
A slight change in the TSS content was observed during the study period The initial TSS content of the cluster beans was 5.6 °brix which had increased to 5.7 (T_2), 5.7(13) and 5.7(14) m whole cluster beans (Cb_1) which was minimum The minimum s noted in small pieces (Cb_3) at the end of the storage period.

Reducing sugar
The control had slightly higher reducing sugar content than the pretreated samples The actual increase of reducing sugar content were 0.96, 0.99 and 0.94 g per cent in MAP (T_2), MAP+ citric acid (T_3) and MAP + potassium metabisuiphite (T_4) in whole (Cb_1) cluster beans The large pieces (Cb_2) and small pieces (Cb_3) had 0.95, 0.98 and 0.99, 0.94, 0.97 and 0.90 g per cent in T_2, T_3 and T_4 respectively.

Total sugar
A decreasing trend in the total sugar content was observed during the storage period. The initial sugar content was 3.41 g per cent. The reduction percentage was minimum in whole (Cb_1) cluster beans, followed by large pieces (Cb_2) and small Pieces (Cb_3) types. After 45 days of storage the total sugar content reduced to 3.00, 302 and 3.03 in T_2, T_3 and T_4 respectively in Cb_1 cluster beans.

Ascorbic acid
A reduction in the ascorbic acid content was observed irrespective of the Storage period. The reduction was maximum in control compared to other pretreat cluster beans. The initial ascorbic acid content was 23.40 mg per cent. The percentage reduction was maximum in whole (Cb_1) which had the T_2, T_3 and T_5 values of 1890, 18.86 and 18.81 mg per cent respectively.

Organoleptic evaluation
The quality attributes like appearance, color, flavor, texture, taste and overall acceptability exhibited higher values (3.98) for fresh cluster beans 'ponyal' whereas decreasing trend was observed m MAP (T_2), MAP+ citric acid MAP and MAP + potassium metabisulphite (T_4) where T_5 showed a slight bitter taste and scored lower values.

Bacterial load
A gradual increase in the bacterial flora was noted in cluster beans after 45 days of storage the increase was maximum in small pieces (Cb_3) type and had 9.15, 9.17 and 9.26 x 10 cfu /g for T_2, T_3 and T_4 which bad the initial counts of 5.00, 6.00 and 5 00 x 10 cfy/g respectively.

Fungi
Similar to bacterial flora an increase in the fungal population was observed stored cluster beans as storage period increased the whole cluster beans (Cb_1) exhibited a slightly lower fungal population than others. Fungal populations of whole cluster beans (Cb_1) at the 45th day of storage in T_2, T_3, T_4 and T_5 were noted as 11.00, 10.00 and 10.00 x 10^{-3} respectively.

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