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Influence of modified atmosphere packaging on microbiological and sensory quality of artichoke sprouts.

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Abstract

This work was carried out during 2015 and 2016 seasons at Postharvest Department, Horticulture Research Institute, Agriculture Research Center, Egypt, to study the effect of active (15% CO_2 + 10% O_2, 15% CO_2 + 7.5% O_2, 10% CO_2 + 5% O_2) and passive Modified Atmosphere Packaging(MAP) on microbiological and sensory quality of artichoke sprouts during storage at 0°C ± 2°C and 90-95% relative humidity for 18 days. The results showed that active MAP decreased the weight loss and inhibits aerobic mesophilic bacterial count and reduced the incidence of discoloration in comparison to untreated MAP (control). Passive MAP was less effective in reducing aerobic mesophilic bacterial count and maintaining general appearance. In this regards, untreated MAP (control) gave the highest values of weight loss percentage, aerobic mesophilic bacterial count and higher score in discoloration score and off flavor score and gave unsalable appearance after 18 days of storage. The results showed also that the optimum gas composition of MAP tests for artichoke sprouts was 15% CO_2 + 7.5% O_2 which provided the lowest count in aerobic mesophilic bacterial and avoiding the development of off flavor, prevented discoloration in sprouts and gave good appearance after 18 days of storage. This technology is very promising for extend the shelf life of artichoke sprouts.

Key Words: Sprouts, Artichoke, Modified atmosphere, Microbial quality, Sensory quality.

Introduction

Seed sprouts have been gaining much popularity amongst consumers since they are good and inexpensive source of dietary proteins, carbohydrate, minerals and vitamins. Due to their high nutritional value they are considered as healthy food and are consumed often raw or slightly cooked in salads and sandwiches **(Weiss and Hammes, 2003)** or as decorative appetizers.

Seed sprouts are a very perishable product with a short shelf life and high susceptibility to several foodborne pathogens **(Singla *et al*., 2011; Waje *et al*., 2009)**. The main factors of quality degradation of sprouts during prolonged storage are mostly due to decay development **(Jin and Lee, 2007)**, shriveling associated with rapid water loss **(TianYing *et al*., 2008)** poor external appearance **(Singh *et al*., 2012)** and off-flavor **(Ranjitha and Rao, 2014)** as well as reduce of sensory quality **(Amin, 2008)**.Therefore, maintaining freshness of sprouts has been a challenge in keeping its postharvest quality such as reducing water loss, delaying senescence and extending shelf life **(Jin and Lee, 2007)**.Refrigeration (0-1˚C) is the major tool to maintain quality and control decay of sprouts **(Amin, 2008)**. In addition to refrigeration, modified atmosphere packaging (MAP) was used to maintain the quality and improve the shelf life of sprouts (**Eun-Hyun *et al*., 2015**) who found that MAP (100%CO_2 gas and 0% N_2) packaging reduced significantly levels of total mesophilic microorganisms on radish sprouts and their reduction levels were 1.55 and 2.26 log_{10} CFU/g compared with the control after 21 days of storage at 4 ˚C.

Modified atmosphere packaging (MAP) is an atmosphere that is different from that of air, which brings beneficial effect like extension of shelf life of fresh product. MAP can be either passively created by the commodity itself by the respiration process where in O_2 is consumed and CO_2 is evolved or actively by flushing in gases of known composition **(Kader *et al*., 1989)**.

Jin and Lee (2007) found that packaging method such as vacuum, 100% N_2 and 100% CO_2 gas were effective in maintaining low levels of *S. Typhimurium* during 3-7 days storage time and delayed the growth of *S. Typhimurium* in mung bean sprouts.

Saito and Rai (2005) determined the effect of modified atmosphere packaging (MAP) using four different highly permeable microperforated film packages on different qualitative parameters of radish sprouts during storage. Results indicated that a combination of 9-13% $O_2$and 8-11% CO_2generated inside 2 types of film packages used in the study was a suitable gaseous combination to maintain most of the qualitative parameters (weight loss, ascorbic acid, chlorophyll, beta -carotene and smell rating) as well as simultaneously avoiding the development of off-flavors, until 6 days of storage.

Ranjitha and Rao (2014) revealed that green gram sprouts stored in cryovac PD-901 bags with single microperforation resulted in an equilibrium gas concentration of 13.0 to 15.7% O_2 and 6.8 to 8.5% CO_2during ten days of storage at 8˚C, and this extended the shelf life of green gram sprouts with minimum changes in sprout length, dehulling percentage, antioxidant capacity and good microbiological quality.

KyungGeun *et al*.(2004) found that freshness of soybean sprouts depended on CO_2 release and O_2 depletion and postharvest storage temperature. However, below 10˚C, CO_2 concentration remained lower than 30% for more 60 hrs. When sprouts were stored at 13˚C for more than 25 hrs, abad odor was produced and carbon dioxide concentration was increased over 30%.

Also, **Eun-Hyun *et al*., 2015** found that radish sprouts stored under MAP showed the highest effectiveness in maintaining quality and reduced levels of mesophilic microorganisms and showed high visual quality on sprouts during storage as compared with control.

Therefore, the aim of the present work was to study the effect of modified atmosphere packaging on microbiological and sensory quality of artichoke sprouts.

Materials and Methods

This study was carried out at the Vegetable Post Harvest Research Department laboratory, Horticulture Research Institute during the period from 2015-2016.

Seeds of artichoke (*Cynara scolymus*) were used of 50% seeding density. Seeds were sanitized for 10 minutes in 6% hydrogen peroxide, rinsed and soaked for 12 hrs (over night) with tap water. Seeds were planted using sand medium in transparent polystyrene strawberry pannet 12x7x5cm. All the packages were sprouted inside incubator (15 days) at 21±2 ˚C and sprinkled twice daily with tap water. When the sprouts grew to their optimum size, the sprouts were harvested and washed to remove the seeds which did not germinate and seed coats, the sprouts were hydro cooled for 10 minutes, the water was drained off carefully.

Artichoke sprouts (50g) were packed in market packages (transparent venting polystyrene sandwich pannet) with dimention 25 x 4 cm which represented as one replicate. The pannets divided into five groups, each group contained twenty one pannets for each of the following treatments:

1. The pannets inserted into the polypropylene bags (20 x 30 cm) in size, 30 µM thickness and heat sealed, then flushed with a gas mixture at 15% CO_2 + 10% O_2 (active MAP 1).
2. The pannets inserted into the polypropylene bags (20 x 30 cm) in size, 30 µM thickness and heat sealed, then flushed with a gas mixture at 15% CO_2 + 7.5% O_2 (active MAP 2).
3. The pannets inserted into the polypropylene bags (20 x 30 cm) in size, 30 µM thickness and heat sealed, then flushed with a gas mixture at 10% CO_2 + 5% O_2 (active MAP 3).
4. The pannets inserted into the polypropylene bags (20 x 30 cm) in size, 30 µM thickness and heat sealed (Passive MAP).
5. Pannets that were not placed in polypropylene bags (untreated MAP) were served as control.

The treatments were arranged in a complete randomized design with three replicates and stored at 0°C ± 2°Cand 90-95% RH for 18 days.

The sample for each treatment was tacken at random in three replicates and evaluated after 0, 3, 6, 9, 12, 15 and 18 daysfor the following sprout charactersexcept O_2 and CO_2 concentration inside the packages that were evaluated after 0, 9 and 18 days of storage in packages had never previously opened.

1. Aerobic mesophilic bacterial count evaluation:

Total aerobic plate count (APC) was carried out in artichoke sprouts during storage at 0 ± 2 °C at 0, 3, 6, 9, 12, 15 and 18 days. Appropriate serial dilutions with peptone water were pour-plated with sterile nutrient agar in triplicate using the pour-plate method **(APHA, 1992)**. The plates were incubated for 48 h at 32 °C. After incubation, plates with 30 to 300 Colony Forming Units (CFUs) were enumerated.

2. Weight loss percentage:

Sprout weight loss was calculated as percentage of intial weight using the following formula:

$$\text{Weight loss\%} = \frac{\text{Sprout intial weight} - \text{sprout weight at each sampling date}}{\text{Sprout intial weight}} \times 100$$

Sensory(general appearance, discoloration and off flavor) and gases analysis.

This was obtained by submitting samples to a member panel experienced in judging sensory analysis of sprouts. Samples were identified with random numbers and arranged on individual plates. Samples were rated using score system as described by **Kader *et al*. (1973)** as follows:

3. General appearancescore system (GA):

Visual appearace was evaluated using a scale from (1-9) wheres,

9=excellent, **7**=good, **5**=fair, **3**=poor, **1**=unsalable. This scale depends on the morphological defects, such as wilted sprouts, color change of sprouts and change of brightness and freshness.

4. Discolorationscore system:

1=non, **2**=slight, **3**=moderate
4=moderately severe, **5**=severe.

The score was based on russed and browned spoting.

5. Off flavor score system:

1=non, **2**=slight, **3**=moderate, **4**=moderately severe, **5**=severe.

It was determined after opening packages.

6. CO_2 and O_2gas composition inside the packages:

The concentration of CO_2 and O_2 inside the packages were monitored using Dual Trak model 902 D gas analyzer. By inserting the test probe through a rubber seal attached to the outside of the packaging.

Statistical analysis:

Statistical analysisof obtained data was done according to **(Snedecor and Cochran, 1980)**. Data were subjected to analysis of variance (ANOVA) using the statistical analysis system **(SAS, 1996)** with Duncan's Multiple Range test to determine significant differences between treatments at the 5% level of significance.

Results and Discussion

Aerobic mesophilic bacterial count:

Data in **Table 1** show that aerobic mesophilic bacterial count in artichoke sprouts was increased with increasing the storage period particularly in untreated MAP (control). Similar results were reported by **Saito and Raj (2005)**. Concerning the effect of MAP treatments on aerobic mesophilic bacterial count, data reveal that all active or passive MAP had lower of aerobic mesophilic bacterial count load in comparison to untreated MAP (control). Artichoke sprouts stored in active MAP at 15% CO_2 + 7.5% O_2 provided the lowest count in aerobic mesophilic bacterial followed by 15% CO_2 + 10% O_2 with significant differences between them, while the other treatments showed less effect in reducing this character during storage. These results are in agreement with **Jin and Lee (2007)** theyfound that successful inhibition of *S. Trphimurium* and *L. monocytogenes* in mung bean sprouts during storage occurred when the combination of 100 ppm chlorine dioxide (ClO_2) with MAP (air, vacuum, 100%CO_2 gas and 100%N_2 gas) was applied.

Eun-Hyun *et al*. (2015) revealed that 100% $CO_2$and 0 N_2 gases packaging resulted in the highest effectiveness in reduced the levels of total mesophilic microorganisms on radish sprouts compared to the control.

The reduction in aerobic mesophilic bacterial count may be due to that active MAP apparently delayed fruits senescence and inhibited microbial growth **(Nielsen and Leufven, 2008)** and controlled the exponential growth of microorganisms **(Allende *et al*., 2007)**. Furthermore, **Farber (1991)** found that CO_2 inhibits microbial activity in two ways; it dissolves in water in the product and it has negative effect on enzymes and biochemical activities in cells of both product and microorganisms.

The interaction between MAP treatment and storage period was significant, however, artichoke sprouts stored in active MAP at 15% CO_2 + 7.5% O_2 had the lower level of aerobic mesophilic bacterial count in comparison to the other treatments or untreated MAP (control) during all storage period.

Singh *et al*. (2014) revealed that chickpea sprouts stored under **passive** MAP at 10˚C for 7 days may restrict spoilage problem caused by mold and yeast and extend the shelf life of chickpea sprouts.

Table 1. Effect of modified atmosphere packaging on total aerobic mesophilic counts (log_{10} CFU/g) of artichoke sprouts (15 days old) during cold storage (0 ˚C) (combined of two experiments).

Treatments	Storage period in days							Mean
	0	3	6	9	12	15	18	
A	4.15 W	4.70 UV	5.05 Q	5.69 LM	6.12 I	6.73 F	7.01 C	**5.63 D**
B	4.15 W	4.67 V	4.97 R	5.65 M	6.04 J	6.64 G	6.91 D	**5.57 E**
C	4.15 W	4.75 TU	5.16 P	5.72 KL	6.15 I	6.75 F	7.03 C	**5.67 C**
D	4.15 W	4.77 T	5.30 O	5.75 K	6.52 H	6.85 E	7.15 B	**5.79 B**
E	4.15 W	4.90 S	5.52 N	6.00 J	6.65 G	7.02 C	7.48 A	**5.96 A**
Mean	**4.15 G**	**4.76 F**	**5.20 E**	**5.76 D**	**6.29 C**	**6.80 B**	**7.11 A**	

A=15% Co_2 + 10% O (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP) E=Control (Untreated MAP)

Weight loss percentage:

Data in Table 2 demonstrated that weight loss percentage of artichoke sprouts increased considerably and consistently with the prolongation of storage period up to 18 days of storage. Similar results were in agreement with **TianYing *et al*. (2008)**.

Concerning the effect of MAP on weight loss percentage, data reveal that there were significant differences among MAP treatments, however, active and passive MAP retained their weight during storage as compared with untreated MAP (control). Moreover, artichoke sprouts held in active MAP at 15% CO_2 + 7.5% O_2 resulted in prominent reduction in weight loss percentage during storage. On the other hand, the highest values of weight loss percentage was recorded with untreated MAP (control).

These results are in agreement with **Singh *et al*. (2014)** who revealed that chickpea sprouts stored under passive MAP at 10˚C for 7 days had effectively reduced the weight loss percentage of sprouts (lower than 1.5%) during storage and extending the shelf life of chickpea sprouts.

The lowest weight loss percentage from active MAP treatment is due to the confinementof moisture around the produce by polypropylene bags. This increases the relative humidity and reduces vapor pressure deficit and transpiration. In addition, packaging creates a modified atmosphere with higher concentration of CO_2 and reduced O_2 around the produce which slow down the metabolic processes and transpiration **(Thompson, 1996)** which diminished the weight loss during storage **(Wang and Qi, 1997).**

The highest weight loss observed in untreated MAP (control) throughout the storage period can be attributed to air movement, which tend to sweep away the unstirred layer of air adjacent to the surface of the produce, thus increasing the vapor pressure deficit **(Wills *et al*., 1998).**

The interaction between MAP and storage period was significant and it has been noticed that treatments had significant effect on weight loss percentage. All active and passive MAP reduced the loss in weight as compared with control during storage, however artichoke sprouts stored in active MAP at 10% CO_2 + 5% O_2 was the most effective treatment in reducing the weight loss.

Table 2. Effect of modified atmosphere packaging on weight loss percentage of artichoke sprouts (15 days old) during cold storage (0 ˚C) (combined of two experiments).

Treatments	Storage period in days							Mean
	0	3	6	9	12	15	18	
A	0.00 N	0.39 MN	0.77LMN	1.95 DEFGHIJK	2.25 DEFGHI	2.47DEFG	3.03CD	**1.55 BC**
B	0.00 N	0.35 MN	1.44GHIJKLM	2.10 DEFGHIJ	2.37 DEFGH	2.72CDE	2.96CD	**1.70 B**
C	0.00 N	0.38 MN	1.11 JKLMN	1.57 FGHIJKL	1.79 EFGHIJKL	1.96 DEFGHIJK	2.44DEFG	**1.32 BC**
D	0.00 N	0.39 MN	0.93KLMN	1.14 IJKLM	1.29 HIJKLM	2.44DEFG	2.71CDEF	**1.27 C**
E	0.00 N	0.43 MN	2.53DEFG	3.81BC	4.47AB	5.09A	5.53A	**3.12 A**
Mean	**0.00 E**	**0.39 E**	**1.35 D**	**2.12 C**	**2.43BC**	**2.93AB**	**3.33A**	

A=15% Co_2 + 10% O (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP) E=Control (Untreated MAP)

General appearance score (GA):

Data in Table 3 show that the score of general appearance (GA) of artichoke sprouts was decreased with prolonging of storage period. Such decrease in GA of sprouts, mostly may be due to shrivilling, wilting, changes of color and decay **(Jin and Lee 2007).**

There were significant differences between MAP treatments and untreated control in GA during storag. In addition, active MAP was better than passive MAP or untreated MAP (control). However the results proved that active MAP at 15% CO_2 + 7.5%O_2 or 15% CO_2 + 10% O_2 were the most effective treatments for maintaining GA during storage of artichoke sprouts with no significant differences between them. These results are in agreement with **TianYing *et al*. (2008)** who found that lyceum sprouts stored at 1 ˚C under 1% oxygen concentration significantly reduced decay incidence and weight and vitamin C losses, and delayed the increase in cellulose content during storage and inhibited tissue senescence and prolonged the storage life.

Previous studies showed that MAP delay senescence of mung bean sprouts **(Jin and Lee 2007).** Water saturated atmosphere within the packages controlled water loss and delayed senescence thereby extended postharvest longevity of sprouts**Singh *et al*., (2012)** found that chickpea sprouts stored under MAP had better appearance and maintained quality attribute (lightness of hypocotyl) and increase shelf life of chickpea sprouts during storage. Besides, MAP caninhibit effectively the cell permeability. Therefore, the shelf life of sprouts was increased accordingto **Singh *et al*., (2014).**

Table 3. Effect of modified atmosphere packaging on general appearance score of artichoke sprouts (15 days old) during cold storage (0 ˚C) (combined of two experiments).

Treatments	Storage period in days							Mean
	0	3	6	9	12	15	18	
A	9.00 A	9.00 A	9.00 A	8.33 AB	7.66 BC	6.33 DE	5.66 EF	**7.66 A**
B	9.00 A	9.00 A	9.00 A	8.33 AB	7.66 BC	7.00 CD	7.00 CD	**8.00 A**
C	9.00 A	9.00 A	8.33 AB	7.66 BC	6.33 DE	5.66 EF	5.00 F	**7.00 B**
D	9.00 A	9.00 A	7.66 BC	6.33 DE	5.00 F	3.66 G	3.00 G	**5.77 C**
E	9.00 A	9.00 A	7.00 CD	5.00 F	3.66 G	3.00 G	1.66 H	**4.88 D**
Mean	**9.00 A**	**9.00 A**	**8.20 B**	**7.13 C**	**6.06 D**	**5.13 E**	**4.46 F**	

A=15% Co_2 + 10% O (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP) E=Control (Untreated MAP)

The interaction betwee MAP treatments and storage period was significant, however, artichoke sprouts stored at active MAP at 15% CO_2 + 7.5% O_2 show the best appearance and did not exhibit any changes in their appearance till 9 days of storage and gave good appearance after 18 days of storage. However MAP at 15% CO_2 + 10% O_2 had good appearance until 12 days of storage, then dropped to fair levelat the end of storage (18 days). On the other hand, untreated MAP (control) resulted in poor appearance after 18 days of storage.

Jin and Lee (2007) found that the combination of chlorine dioxide and MAP under CO_2 gas packaging could be used by industry to maintain quality and extend the shelf life of mung bean sprouts.

Discoloration score:

Data in Table4 show the effect of active and passive modified atmosphere packaging (MAP) on discoloration scores of artichoke sprouts during cold storage. Results indicate that there were increments in discoloration of artichoke sprouts as the storage period was prolonged. These results are in agreement with **Dash *et al*. (2013).** The color change is related primarily to the oxidation of phenolic compounds to a quinines a reaction catalyzed by polyphenol oxidase. Quinines then polymerized to dark brown, black or red polymers **(Sapers and Hicks, 1989).**

Regarding the effect of postharvest treatments, data revealed that active and passive MAP treatments reduced the incidence of discoloration compared to untreated MAP (control). Artichoke sprouts stored in active MAP at 15% CO_2 + 7.5% O_2 or 15% CO_2 + 10% O_2 prevented discoloration in sprouts, which showed the lower score of discoloration with no significant differences between them, while passive MAP or active MAP at 10% CO_2 + 5% O_2 were less effective in reducing the incidence of discoloration. In addition case of the control the higher score in discoloration during storage was recorded in. These results are in agreement with **Heimdal *et al*. (1995)** reported that shredded iceberg lettuce stored under MAP at 10˚C for 10 days inhibited enzymatic browning during storage. Also, **Dash *et al*. (2013)** found that no browning was observed in lettuce stored under MAP at 2-3% O_2 and 12-14% CO_2 and this may be due to the decrease in the amount of phenyl propanol, therefore prevented discoloration of the product. Regarding the interaction among MAP treatments and storage period on discoloration, data in Table 4 reveal that artichoke sprouts stored in active MAP at 15%CO_2 + 7.5% O_2 did not show any changes in their colortill 9 days of storage, then had slight score at the end of storage period (18 days), while those stored in a passive MAP or untreated MAP (control) resulted in moderate to severe discoloration with the highest score after 18 days of storage.In this regard, **Dash *et al*.(2013)** found that fresh-cut cantaloupe stored under modified atmosphere packaging (packed in polypropylene bags) prevented discoloration in the cut surface.

Table 4. Effect of modified atmosphere packaging on discoloration score of artichoke sprouts (15 days old) during cold storage (0 ˚C) (combined of two experiments).

Treatments	Storage period in days							
	0	3	6	9	12	15	18	**Mean**
A	1.00 H	1.00 H	1.00 H	1.00 H	1.33 GH	1.66 FG	2.33 DE	**1.33 CD**
B	1.00 H	1.00 H	1.00 H	1.00 H	1.33 GH	1.33 GH	1.66 FG	**1.19 D**
C	1.00 H	1.00 H	1.00 H	1.00 H	1.66 FG	2.33 DE	2.66 CD	**1.52 BC**
D	1.00 H	1.00 H	1.00 H	1.33 GH	2.00 EF	2.33 DE	3.33 AB	**1.71 B**
E	1.00 H	1.00 H	1.00 H	2.33 DE	3.00 BC	3.33 AB	3.66 A	**2.19 A**
Mean	**1.00 E**	**1.00 E**	**1.00 E**	**1.33 D**	**1.86 C**	**2.20 B**	**2.73 A**	

A=15% Co_2 + 10% O (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP) E=Control (Untreated MAP)

Off flavor score:

Data in Table 5 show the effect of active and passive modified atmosphere packaging (MAP) on off flavor scores of artichoke sprouts during cold storage. Results indicate that there were significant differences in off flavor of artichoke sprouts during storage. All used treatments and the control did not present clear changes in their flavor till 12 days of storage and then increased in off flavor as the storage period was prolonged. These results were in agreement with **Ranjitha and Rao (2014).**

Concerning the effect of MAP treatments, data show that active MAP treatments gave significantly lower score in off flavor as compared with passive MAP and untreated MAP (control). Artichoke sprouts stored in active MAP at the different concentration of gases (15% CO_2 + 7.5% O_2 or 15% CO_2 + 10% O_2 or 10% CO_2 + 5% O_2) were the most effective in reducing the off flavor score (maintaining the flavor) during storage period with no significant differences between them. The higher score in off flavor was obtained from passive MAP or untreated MAP (control). These results are in agreement with **KyoungShim *et al*. (2006)** who found that freshness of soybean sprout depended on CO_2 release and O_2 depletion and postharvest storage temperature. So, at below 10˚C, CO_2 concentration remained lower than 30% for more than 25 h, while when sprouts were stored at 13˚C for more than 25 h, a bad odor was produced and CO_2 increased over

30%. Also, **Troszynska *et al*., (2008)** found that negative correlation was observed between the overall quality color, green pea odor, off odor, sweet taste, bitter taste of pea sprouts and contents of total phenols.

Ranjitha and Rao (2014) revealed that green gram sprouts stored in cryovac PD-901 bags with single microperforation resulted in an equilibrium gas concentration of 13.0 to 15.7% O_2 and 6.8 to 8.5% CO_2 during ten days of storage at 8 ˚C, and this suppressed respiration rates of green gram sprouts, inhibited certain metabolic processes with maintaining thequality of sprouts and good microbiological quality, so extended the storage life.

Regarding the effect of the interaction between postharvest treatment and storage period on discoloration, data revealed that artichoke sprouts stored in active MAP at 15% CO_2 + 7.5% O_2 did not appear changes in their flavor till the end of storage (18 days) which gave typical flavorartichoke sprouts (non off flavor), while active MAP at15% CO_2 +10% O_2 or 10% CO_2 + 5% O_2 gave non to slight score of off flavor after 18 days of storage. While, passive MAP or untreated MAP (control) independently showed a slight to moderate score of off flavor at the same period.

Saito and Raj (2005) studied the effect of MAP (4 different highly permeable microperforated film package) on gas concentrations and qualitative parameters of radish sprouts during storage at 15 ˚C for 6 days, found that a combination of 9-13% O_2 and 8-11% CO_2 generated inside the film packages was suitable gaseous combination to maintain the qualitative parameters of radish sprouts as well as simultaneously avoiding the development of off-flavors, until 6 days of storage at 10 ˚C.

KyoungShim *et al*., (2006) found that soybean sprouts stored in film packed at lower temperature resulted in lower consumption of O_2, lower production of ethanol and less off-flavor. No off-flavor could be detected when the atmospheric oxygen concentration was maintained over 4%, while the alcoholic-flavored off flavor characteristics were initiated when O_2 was decreased to 2 and 1% respectively. Under low oxygen condition, the alcoholic-flavor following ethanol production preceded prior to sensory off flavor detection.

Table 5. Effect of modified atmosphere packaging on off-flavor score of artichoke sprouts (15 days old) during cold storage (0 ˚C) (combined of two experiments).

Treatments	Storage period in days							Mean
	0	3	6	9	12	15	18	
A	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.33 BC	1.33 BC	**1.09 BC**
B	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	**1.00 C**
C	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.33 BC	1.66 B	**1.14 BC**
D	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.33 BC	2.33 A	**1.23 AB**
E	1.00 C	1.00 C	1.00 C	1.00 C	1.00 C	1.66 B	2.66 A	**1.33 A**
Mean	**1.00 C**	**1.00 C**	**1.00 C**	**1.00 C**	**1.00 C**	**1.33 B**	**1.80 A**	

A=15% Co_2 + 10% O (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP) E=Control (Untreated MAP)

Gases composition inside the packages:

Artichoke sprouts are still alive after harvest, it is also respites. It is necessary toachieve proper gas composition in the packages, so it is very important to study the gas changes inside the package of MAP. Moreover, the atmosphere analysis showed that, in active and passive MAP the atmosphere had been modified.

Results in Table 6 indicate that there was a significant decrease in O_2 and increase in CO_2 during storage. These result are in agreement with **KyungGeun*et al*. (2004)** and may be due to O_2 consumption and CO_2 production of sprouts during respiration process **Saito and Raj (2005).**

Table 6. Effect of modified atmosphere on Co_2 and O_2 percentage of artichoke sprouts (15 days old) during cold storage (0˚C)(combined of two experiments).

Treatment	Storage period in days						Mean	
	0		9		18			
	Co_2	O_2	Co_2	O_2	Co_2	O_2	Co_2	O_2
A	15.000 D	10.000 D	18.533 C	5.867 F	21.733 B	3.367 H	18.422 A	6.411 B
B	15.000 D	7.500 E	18.767 C	3.500 H	22.767 A	1.633 I	18.844 A	4.211 C
C	10.000 E	5.000 G	14.200 D	3.100 H	18.200 C	1.300 I	14.133 B	3.133 D
D	0.040 H	20.567 A	1.533 G	16.800 B	4.867 F	12.833 C	2.147 C	16.733 A
Mean	10.010 C	10.767 A	13.258 B	7.317 B	16.892 A	4.783 C		

A=15% Co_2 + 10% O_2 (Active MAP) B=15% Co_2 + 7.5% O_2 (Active MAP) C=10% Co_2 + 5% O_2 (Active MAP) D=Passive (Passive MAP)

Concerning the effect of MAP, data indicate that O_2 levels in active MAP were significantly lower than those of passive MAP or untreated MAP (control). While the values of CO_2 in packages atmosphere were higher in active MAP than passive MAP during storage. Similar pattern in the reduction of O_2 and the increase in CO_2 levels were observed in all packages at cold storage conditions. These results are in agreement with **Ranjitha and Rao (2014)** who revealed that green gram sprouts stored in cryovac PD-901 bags with single microperforation resulted in an equilibrium gas concentration of 13.0 to 15.7% O_2 and 6.8 to 8.5% CO_2 during ten days of storage at 8 ˚C, and this suppressed respiration rates of green gram sprouts, inhibited certain metabolic processes with maintaining thequality of sproutsandgood microbiological quality, so extended the storage life.
The interaction between MAP and storage period on gas concentration was significant. The O_2 and CO_2 levels in active MAP at 15% CO_2 + 7.5% O_2 were 1.633 O_2 + 22.767% CO_2 after 18 days of storage, while the gas composition inside the package with passive MAP reached 12.833% O_2 + 4.867% CO_2 in the same period.

Conclusion

From the previous results, it could be concluded that the optimum gas composition of MAP tests for artichoke sprouts was 15% CO_2 + 7.5% O_2 which provided the lowest count in aerobic mesophilic bacteria and avoiding the development of off flavor, prevented discoloration in sprouts and gave good appearance after 18 days of storage. This technology is very promising for extending the shelf life of artichoke sprouts.

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تأثير التخزين فى جو هوائى معدل على الجودة الميكروبية والحسية لنبت الخرشوف

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**** قسم البساتين– كلية زراعة – جامعة بنها**

اجريت هذه الدراسة في معامل قسم بحوث تداول الخضربمعهد بحوث البساتين بمركز البحوث الزراعية خلال موسمى2015 و 2016 لدراسة تأثير تخزين نبت الخرشوف فى جو هوائى معدل بالحقن الغازى داخلالعبوة (موجب) بنسب غازية:
($15\%\ CO_2 + 10\%\ O_2$), ($15\%\ CO_2 + 7.5\%\ O_2$), ($10\%\ CO_2 + 5\%\ O_2$) أو الذى تحدثه الثمار بنفسها داخل العبوة (سالب) بالإضافة إلى الغير معاملة (الكنترول)وتاثير ذلك على الجودة الميكروبية والحسية لنبت الخرشوف أثناء التخزين المبرد لمدة 18 يوم على درجة الصفر المئوى ورطوبة نسبية 90–95%.

أوضحت النتائج أن تخزين نبت الخرشوف فى جو هوائى معدل موجب قد أدى إلى تقليل الفقد فى الوزن والعدد الكلى للبكتيريا المحبة للحرارة المتوسطة وكذلك التغير فى اللون مقارنة بمعاملة الكنترول (بدون جو هوائى معدل) والتى أعطت عكس تلك النتائج. وكان تخزين نبت الخرشوف فى جو هوائى معدل سالب أقل تأثير فى هذا الخصوص.

كما أوضحت النتائج أن أنسب تركيز للغازات المختبرة كان 15% ثانى اكسيد الكربون + 7.5% أكسيجين حيث أعطت هذه المعاملة أقل عدد من البكتريا المحبة للحرارة المتوسطة كما قللت من الطعم الغير مقبول (الأحتفاظ بالطعم) والتغير فى اللون وأعطت مظهر جيد للنبت الذى تم تخزينه لمدة 18 يوم على درجة الصفر المئوى ورطوبة نسبية 90–95%. وهى تعتبر طريقة واعدة لإطالة فترة حياة نبت الخرشوف.