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Microbiological quality and sensory evaluation of shallot (*Allium ascalonium*) puree stored in modified atmosphere packaging

[Kualiti mikrob dan penilaian rasa puri bawang merah (*Allium ascalonium*) yang disimpan dalam pembungkusan atmosfera terubah suai]

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Abstract

The optimum conditions of modified atmosphere storage were investigated to provide a basis for the development of modified atmosphere packaging for shallot puree. Microbiological and sensory qualities of shallot puree were evaluated at different atmospheric conditions (by mixing of 5, 10, 15 and 20% CO_2 with nitrogen and normal atmospheric condition as control). Samples were stored at 5 ± 1 °C by using Ony/LLDPE and PET/PE/Al/PE as packaging materials. The results showed that TPC and *Lactobacillus* spp. count increased slowly during storage period in all samples. However, the population of coliform, yeast and mould count and *Pseudomonas* spp. count were undetected in all samples. The sensory quality decreased significantly (p <0.05) throughout the storage period. Shallot puree packed in Ony/LLDPE with 10% CO_2 was found to be the best treatment for extending the storage life up to 12 weeks at 5 ± 1 °C (85–95% RH).

Introduction

Shallot (*Allium ascalonium*), the Liliopsida class (Anon. 2004) is a vegetable very similar to the common onion. Shallot is valued for its therapeutic properties and possesses a strong characteristic aroma and flavour which makes it an important ingredient during food processing (Augusti 1996; Dron et al. 1997). The present trend where the female population is increasingly entering the workplace will undoubtedly mean that they have limited time in preparing food. The food service industry (such as hotels, restaurants, hospital kitchen, catering companies, central kitchens and airports) also need ingredients in convenient form in order to cut down extensive labour, processing, handling and storage. These situations have led to the increase usage of ready-to-use ingredients in food preparation (Hasimah 2003). With this in mind, ready-to-use shallot puree will be able to satisfy the needs of retail and institutional consumers.

Processing environment is critical to the flavour and texture quality as well as minimize microbial contamination in shallot puree. Substandard processing conditions can contribute to heavy microbial loads that lead to quality deterioration as well as possible safety problems (Bett 2002). This is because, as the cuticular layer is broken, cellular fluids and moisture are exposed to microorganism. As a result, microbial

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growth is encouraged (Heard 2002). According to Chen (2002) the wounded tissue releases plant juice or cell contents that serve as nutrients for microorganisms. Thus, cut surfaces, in most cases are ideal for the growth of microorganisms.

Packing foods in modified atmosphere can offer extended shelf life and improve product presentation in a convenient container, making the product more attractive to the retail customer (Michael and Derek 2003). In the 19th century, scientists discovered that increasing carbon dioxide levels and reducing oxygen levels retarded catabolic reactions in respiring foods and slowed the growth of aerobic spoilage organisms (Smith et al. 1990).

Effects of gas composition created in modified atmosphere packaging (MAP) systems on microflora has been reviewed and studied intensively by many researchers (Brackett 1994; Varoquaux and Wiley 1994). Under inappropriate gas composition, spoilage is characterized by undesirable sensory changes in colour, texture, flavour or odour and the potential growth of pathogenic microorganisms. MAP can delay and arrest microbial spoilage but not improving the products' quality (Tareq and Hotchkiss 2002). Therefore, the objective of the present study was to evaluate the effects of modified atmosphere storage on microbial proliferation and sensory quality of shallot puree.

Materials and methods

Preparation of puree

Matured shallots (Indian variety) used in this study were purchased from Pasar Borong Selangor. They were brought to the Processing Laboratory at Food Technology Research Centre, MARDI, Serdang. Upon arrival at the processing laboratory, the tail and top were removed. The shallots were then peeled using abrasive peeling method. In this method, the activities of peeling and washing were done simultaneously. The shallots were then chopped and ground into puree using a bowl chopper (Talleres Model AS-75, Palmerston, New Zealand). Then, the puree was acidified to obtain a pH in the range of 4.0–4.4 by adding 0.3% (w/w) citric acid and heated up to 60 °C (Hasimah 2003; Noor Azizah et al. 2005; Kaymak-Ertekin and Gedik 2005).

Packaging and storage

Approximately 200 g of the freshly processed shallot puree were then packed and sealed immediately in 26 cm x 21 cm each of two types of packaging materials: oriented nylon/linear low density polyethylene (Ony/LLDPE – O_2TR: 18.91 cc/m^2/day; CO_2TR: 1.07E-13 cc.m/m^2.24 h.atm; WVTR: 0.0027 g.mil/day/m^2/mmHg) of 70 µm thickness and polyethylene terephthalate/polyethylene/aluminium/ polyethylene (PET/PE/Al/PE – O_2TR: 0.023 cc/m^2/day; CO_2TR: 2.05E-11 cc.m/ m^2.24 h.atm) of 74 µm thickness which was supplied by TIP Corporation Sdn. Bhd. (Cheras, Wilayah Persekutuan) and Alpha Pack (M) Sdn. Bhd. (Ampang, Selangor) respectively.

The shallot puree was packaged under modified atmosphere condition containing 5, 10, 15 and 20% CO_2 in combination with nitrogen (in all cases made up to 100% with nitrogen). Air from each pouch was first purged out followed by flushing with the desired atmospheric gas using a gas mixer (Gasetechnik, Model WITT KM100-3MEM, Germany). CO_2 and N_2 gases were supplied by Syarikat Gas Pantai Timur, Selangor, Malaysia. Normal atmospheric condition was used as control. These packages were stored at 5 ± 1 °C (85–90 % RH) for 12 weeks. Samples were evaluated every 2 weeks for microbiological analysis and sensory evaluation.

Microbiological analysis

A sample of 10 g was taken from each treatment bag, and transferred aseptically into a stomacher bag (Seward Medical, UK) containing 90 ml Ringer's solution (Oxoid, Hampshire, England) to give 10^{-1} dilution. The mixture was homogenized for 1 min using a stomacher (Seward Lab Blender Model 400, London, UK) at room temperature. Further 10-fold serial dilutions were prepared as required by using the same diluents. A volume of 1 ml sample was poured in duplicate onto four different media as follows: plate count agar (PCA; Difco, Detroit, USA) for total aerobic mesophilic count; *Lactobacillus* spp. were enumerated on the Man Rogosa Sharpe agar (MRS; Difco, Detroit, USA); yeasts and moulds were quantified by potatoes dextrose agar (PDA; Difco, Detroit, USA) and *Pseudomonas* spp. were determined by pouring plating onto *Pseudomonas* Agar Base with selective supplement SR 103 (Oxoid, Hampshire, England).

PCA, MRS, PDA and *Pseudomonas* Agar Base were aerobically incubated at 31 ± 1 °C for 72 h (ICMSF 1978). Total coliform in the homogenate was determined by the MPN method in a three tube series using Mac Conkey Broth (Difco, Detroit, USA) incubated at 35 ± 1 °C for 48 h (ICMSF 1978). Microbiological data were transformed into logarithms of the number of colony forming units (CFU) per g sample and MPN/g sample for total coliform. All plates were examined visually for typical colony types and morphology characteristics associated with each growth medium.

Sensory evaluation

The sensory quality of the shallot puree was regularly evaluated at 0, 2, 4, 6, 8, 10 and 12 weeks of storage by 30 semi-trained panellists, consisting of researchers of the Food Technology Research Centre, MARDI, Serdang. Shallot puree samples (30 g) were packed individually in polypropylene bags (0.04 mm thickness) size 9.0 cm x 6.0 cm, coded with three digits chosen at random and immediately presented to the panellists. Sensory evaluation was conducted in individual booths, in a standard taste panel kitchen. Panellists were asked to score colour, odour and overall acceptability using a 1–5 hedonic scale with 5 corresponding to the acceptable extremely and 1 corresponding to unacceptable extremely. The cut-off score was defined at score 3. Below this score, the sample was unacceptable. During the test sessions, the sample presentation order was randomized.

Statistical analyses

For data analyses, the SAS programme was used (SAS Inst. 1985). The values obtained were subjected to analysis of variance (ANOVA) and tested using the Duncan Multiple Range Test for different treatments and storage periods (Gomez and Gomez 1984).

Results and discussion

Microbiological analysis

Total plate count (TPC) Growth was observed under various gas compositions and different packaging materials. Starting from an initial population density of log 2.87 CFU/g, increases were observed ranging from log 3.17–4.3 CFU/g after 12 weeks storage at 5 ± 1 °C. However, the bacterial number were significantly (p <0.05) lower in the packages undergoing the modified atmospheric treatments compared to control sample.

The results indicated that bacterial population was significantly retarded under modified atmosphere storage. It seems that the gas treatment was effective in controlling microbial growth or quality deterioration. Generally, gas treatment or modified atmosphere packaging reduced the total plate count in shallot puree to less than log 4.0 CFU/g at 12 weeks storage. However, the growth was higher in 5% CO_2 content compared to other gas composition for both packaging materials (log 4.03 CFU/g for Ony/LLDPE and log 3.89 CFU/g for samples packed in PET/PE/Al/PE). According to Farber (1991), as CO_2 is water and lipid soluble, it accumulates in the lipid bilayer of the microbial cell membrane and thus affects the cell permeability leading to intracellular pH changes. It is also known to affect the functionality of enzymes and proteins, thereby blocking the metabolic activities. Gill and Penney (1988) found that the full bacteriostatic effect of CO_2 was achieved when the gas was added to the packs in sufficient quantity to fully saturate the meat and maintain a head space of excess CO_2 at atmospheric pressure. According to Beaudry (1999), control atmospheres with low O_2 and high CO_2, have been successfully used to reduce decay, maintain quality and extend storage life of many fruits. González-Aguilar et al. (2004) found significant improvement in retaining overall quality of fresh-cut peppers treated under modified atmosphere packaging at 5 ± 1 °C.

There were significant ($p < 0.05$) differences between different packaging materials for bacterial numbers. At 5 ± 1 °C, the numbers of total plate count after 12 weeks storage for samples packed in PET/PE/Al/PE were log 3.89, 3.17, 3.2, and 3.66 CFU/g in 5, 10, 15, and 20% CO_2 content respectively (*Table 1*). However, these values increased to log 4.03, 3.24, 3.5 and 3.94 CFU/g for samples packed in Ony/LLDPE with the same condition. Samples treated with CO_2 packed in PET/PE/Al/PE displayed significantly lower total plate count compared to those in Ony/LLDPE. The inhibition of aerobic bacterial growth in PET/PE/Al/PE was probably attributed to the accumulation of CO_2 levels (5, 10, 15 and 20%) inside the package due to low permeability of the material (*Table 1*). Successful storage of beef strip loin steaks in foil-laminate pouches using the bulk packaging technique was also illustrated by Gill and Jones (1994). In the present study, the highest numbers in total plate count were observed in both control samples reaching around log 4.07 and 4.31 CFU/g respectively. Previous report by Watada (1997) indicated that microbial growth was influenced by the physiology of the minimally processed product as well as pre-harvest management, pre- and post-processing treatments and application of an appropriate packaging. The storage study of the shallot puree was terminated after 12 weeks due to colour deterioration and rejection by the sensory panel, even though the microbial counts were still below the acceptable level.

***Lactobacillus* spp. count** Growth trend of *Lactobacillus* spp. in all treatments was contrary to that of aerobic bacteria. Rapid increase in *Lactobacillus* spp. counts occurred in pouches containing 20% CO_2, reaching around log 3.64 CFU/g for samples packed in Ony/LLDPE after 12 weeks. (*Table 2*). There was significant ($p < 0.05$) difference between gas composition and packaging material throughout the storage period. The initial *Lactobacillus* spp. counts of shallot puree were log 2.09 CFU/g sample. By the end of the storage period the *Lactobacillus* spp. counts from both packaging materials had increased to log 3.29 and 3.64 CFU/g sample respectively.

In general, *Lactobacillus* spp. counts were lower under 5% than 20% CO_2 concentration. The results indicated that *Lactobacillus* spp. were the predominant spoilage microflora in shallot puree when stored in 20% CO_2. Lactic acid bacteria are the major bacterial group associated with the spoilage of refrigerated meat products packed under vacuum or modified atmospheres (Borch et al. 1996). According to Jayas and Jeyamkondan (2002), lactic acid bacteria are capable of continuously pumping out CO_2 from the cell to its environment, thereby maintaining its active metabolism for longer period.

Other microorganisms The results showed that packaging of shallot puree in modified atmosphere or under normal atmosphere has no effect on survival or growth of coliform population. Similar results were reported by Abdul Raouf et al. (1993) on shredded lettuce and cucumber. The population of *Pseudomonas* spp., yeasts and moulds on shallot puree were also below the detection level throughout the storage period at 5 ± 1 °C. Kuriyama et al. (1993) reported that the growth

Table 1. Effects of modified atmosphere packaging (MAP) on total plate count (Log CFU/g) of shallot puree stored at 5 ± 1 °C for 12 weeks

Storage period (week)	Type of packaging material									
	PET/PE/Al/PE					Ony/LLDPE				
	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	2.87Ea ± 0.01	2.87Ba ± 0.01	2.87Fa ± 0.01	2.87Fa ± 0.01	2.87Fa ± 0.01	2.87Fa ± 0.01	2.87Ga ± 0.01	2.87Fa ± 0.01	2.87Fa ± 0.01	2.87Ea ±0.01
2	3.63Db ± 0.06	3.51ABc ± 0.04	2.92Eg ± 0.00	3.06Ef ± 0.01	3.27Ed ± 0.01	3.73Ea ± 0.04	3.62Fb ± 0.03	2.99Efg ± 0.01	3.17Ee ± 0.01	3.56Dbc ±0.06
4	3.76Cb ± 0.01	3.13Be ± 0.01	2.98Dg ± 0.01	3.12De ± 0.01	3.36Dc ± 0.01	3.89Da ± 0.01	3.76Eb ± 0.03	3.04Df ± 0.00	3.19Ed ± 0.00	3.79Cb ±0.02
6	3.82Cc ± 0.02	3.74ABd ± 0.03	3.04Ci ± 0.01	3.18Cg ± 0.01	3.50Ce ± 0.01	3.96Da ± 0.01	3.86Db ± 0.01	3.08Ch ± 0.01	3.23Df ± 0.01	3.84BCbc ±0.00
8	3.89Bb ± 0.02	3.79ABc ± 0.01	3.05Ch ± 0.01	3.19BCf ± 0.00	3.58Bd ± 0.01	4.07Ca ± 0.03	3.91Eb ± 0.01	3.11Cg ± 0.01	3.28Ce ± 0.02	3.88ABb ±0.01
10	3.92Bc ± 0.01	3.87Ac ± 0.01	3.08Bg ± 0.01	3.20Bf ± 0.00	3.64Ad ± 0.01	4.16Ba ± 0.06	3.98Bb ± 0.01	3.17Bf ± 0.02	3.39Be ± 0.01	3.91ABc ±0.02
12	4.07Ab ± 0.01	3.89Ae ± 0.01	3.17Ai ± 0.01	3.23Ah ± 0.01	3.66Af ± 0.01	4.31Aa ± 0.02	4.03Ac ± 0.01	3.25Ah ± 0.02	3.49Ag ± 0.02	3.94Ad ±0.03

Means with the same capital letter within a column and same small letter within a row are not significantly different at 5% level ($p < 0.05$)

Table 2. Effects of modified atmosphere packaging (MAP) on *Lactobacillus* count (Log CFU/g) of shallot puree stored at 5 ± 1 °C for 12 weeks

Storage period (week)	Type of packaging material									
	PET/PE/Al/PE					Ony/LLDPE				
	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	2.09Ea ± 0.13	2.09Ee ±0.13	2.09Ea ± 0.13	2.09Ca ± 0.13	2.09Ea ± 0.13	2.09Ea ±0.13	2.09Fa ±0.13	2.09Da ±0.13	2.09Fa ± 0.13	2.09Ea ±0.13
2	2.56Dbc ± 0.02	2.45Dcd ±0.00	2.42Dd ± 0.02	2.93Ba ± 0.03	2.96Da ± 0.01	2.57Db ±0.11	2.45Ecd ±0.06	2.49Cbcd ±0.05	2.97Ea ± 0.01	3.02Da ±0.00
4	2.72Cd ± 0.04	2.51Df ±0.02	2.50CDf ± 0.01	2.96Bb ± 0.01	3.08CDa ± 0.02	2.84Cc ±0.02	2.59Dee ±0.01	2.60Ce ±0.08	3.09DEa ± 0.03	3.05Da ±0.00
6	2.88Bde ± 0.05	2.57CDg ±0.01	2.62Cfg ± 0.07	2.99Bcd ± 0.01	3.15BCb ± 0.03	3.01Bc ±0.04	2.69CDf ±0.09	2.84Be ±0.08	3.21CDa ± 0.01	3.09Dbc ±0.01
8	2.94Bc ± 0.02	2.67BCe ±0.00	2.78Bd ± 0.07	3.01Bc ± 0.01	3.23ABa ± 0.00	3.18Aa ±0.03	2.84BCd ±0.03	3.09Ab ±0.03	3.27BCa ± 0.05	3.23Ca ±0.01
10	3.02Be ± 0.01	2.80Bg ±0.11	2.92ABf ± 0.02	3.03Be ± 0.03	3.25ABc ± 0.01	3.23Acd ±0.02	2.99Bef ±0.03	3.14Ad ±0.01	3.37ABb ± 0.01	3.49Ba ±0.01
12	3.16Ad ± 0.04	2.97Af ±0.02	3.06Ae ± 0.03	3.18Ad ± 0.03	3.29Ac ± 0.03	3.30Ac ±0.03	3.15Ad ±0.03	3.19Ad ±0.02	3.41Ab ± 0.01	3.64Aa ±0.01

Means with the same capital letter within a column and same small letter within a row are not significantly different at 5% level ($p < 0.05$)

of yeasts is inhibited under high carbon dioxide enriched atmospheres. This result was similar to work reported by Eliot et al. (1998) on mozzarella cheese. Most yeasts and moulds can be inhibited by 5% to 50% (v/v) carbon dioxide (Subramaniam 1993). Zagory and Hurst (1996) noted that *Pseudomonas* spp. normally dominates and may make up to 50–90% of the microbial population on many vegetables. However these microorganisms are not harmful to humans. In previous research conducted by Gill (1988, 1996), he found that further increase of CO_2 concentration produced little additional inhibition of the *Pseudomonas* spp. According to Buys et al. (2000) the inclusion of CO_2 in the modified atmosphere packaging as well as generation and accumulation of carbon dioxide as a result of metabolism of meat enzymes and microbial activity produced an environment which will inhibit *Pseudomonas* spp.

Sensory evaluation

The sensory mean scores on the characteristics of the shallot puree stored under MAP and different packaging materials were depicted in *Tables 3–5*. The sensory characteristics determined include colour, odour and overall acceptability in each treatment. There were significant differences (p <0.05) between carbon dioxide concentration and packaging material for colour, odour and overall acceptability. There were significant differences between treatments for the first 2 weeks at 5 ± 1°C for colour attribute (*Table 3*). Significant differences (p <0.05) on the overall acceptability were also detected among the treated samples at week 2 of storage (*Table 5*). However, the mean scores for both attributes were still at the acceptable level (more than 3.0).

At week 10, mean scores of overall acceptability for all treated samples were more than 3 (neither accepted nor unaccepted), indicating substantial acceptance of the product. At the end of week 12, the general appearance of

Table 3. Effects of modified atmosphere packaging (MAP) on colour acceptability scores of shallot puree stored at 5 ± 1 °C for 12 weeks

Storage Period (week)	Type of packaging material									
	PET/PE/Al/PE					Ony/LLDPE				
	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	3.88Aa ± 0.88	3.88Aa ± 0.88	3.88Aa ± 0.88	3.88Aa ± 0.88	3.88Aa ± 0.88	3.88ABCa ± 0.88	3.88ABa ± 0.88	3.88Aa ± 0.88	3.88Aa ± 0.88	3.88Aa ± 0.88
2	3.64ABbc ± 0.81	3.80Aab ± 0.82	3.76Abc ± 0.94	3.32ABcd ± 0.90	3.64ABbc ± 0.76	4.32Aa ± 0.90	3.32Ccd ± 0.69	3.96Aab ± 1.02	3.04BCd ± 0.98	3.72ABbc ± 0.89
4	3.52Bcd ± 0.82	3.88Aab ± 0.83	3.38ABcd ± 0.86	3.72Abc ± 0.98	3.40Bcd ± 0.82	4.28ABa ± 0.94	3.44Aa ± 0.71	3.52Acd ± 0.96	3.00BCd ± 1.00	3.40ABcd ± 0.87
6	3.32BCd ± 0.90	3.48ABcd ± 0.82	3.78Ab ± 0.87	3.72Ab ± 1.02	3.52Bcd ± 0.82	3.72BCb ± 0.82	4.08ABCab ± 1.08	3.92Aab ± 0.76	3.60Abc ± 1.00	3.24Bd ± 0.93
8	2.92CDd ± 0.86	3.24Bcd ± 0.88	3.72Aab ± 0.79	3.48ABbc ± 1.04	3.68ABab ± 0.75	3.44CDbc ± 0.88	3.64ABCab ± 1.04	3.52Abc ± 1.00	3.40ABcd ± 0.87	3.74ABa ± 0.75
10	2.96Ccd ± 0.86	3.24Bbc ± 0.93	3.36ABbc ± 0.90	3.12Bcd ± 1.01	3.32Bbc ± 0.94	2.92DEd ± 0.86	3.72ABCab ± 0.79	3.74Aa ± 0.83	3.40ABcd ± 0.88	3.30Bbc ± 1.06
12	2.72Dbc ± 0.88	3.12Bab ± 1.05	3.18Bab ± 0.71	2.96Bbc ± 0.88	3.04Bbc ± 0.89	2.72Ebc ± 0.88	3.32Cab ± 0.85	3.48Aa ± 0.92	2.60Cc ± 0.82	3.28Bab ± 0.98

Means with the same capital letter within a column and same small letter within a row are not significantly different at 5% level (p <0.05)

Note: 5 = acceptable extremely; 4 = acceptable; 3 = neither acceptable nor unacceptable; 2 = unacceptable; 1 = unacceptable extremely

Table 4. Effects of modified atmosphere packaging (MAP) on odour acceptability scores of shallot puree stored at 5±1 °C for 12 weeks

Storage period (week)	Type of packaging material									
	PET/PE/Al/PE					Ony/LLDPE				
	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81	3.92Aa ± 0.81
2	4.00Aa ± 0.76	3.72ABab ± 0.79	3.84Aab ± 0.69	3.44ABb ± 0.87	4.00Aa ± 0.82	4.04Aa ± 0.93	3.72ABab ± 0.61	3.88Aab ± 0.73	3.54ABab ± 0.91	3.76Aab ± 0.78
4	3.80Aa ± 0.81	3.52ABa ± 0.77	3.52Aa ± 0.82	3.28Ba ± 0.89	3.60ABa ± 0.82	3.76ABa ± 0.93	3.56ABa ± 0.65	3.48Aa ± 0.77	3.42ABa ± 0.91	3.52Aa ± 0.82
6	3.16BCab ± 0.89	3.28Bab ± 0.96	3.68Aa ± 0.90	3.40ABab ± 1.19	3.16Bab ± 0.89	3.44BCab ± 0.95	3.40Bab ± 1.19	3.44Aab ± 0.95	3.44ABab ± 0.97	3.52Aab ± 1.02
8	3.32ABa ± 1.04	3.46ABa ± 0.92	3.64Aa ± 0.91	3.42ABa ± 0.96	3.32Ba ± 1.08	3.42BCa ± 0.91	3.52ABa ± 0.96	3.52Aa ± 0.98	3.38ABa ± 0.83	3.62Aa ± 0.81
10	3.16BCbc ± 0.94	3.24Babc ± 0.91	3.84Aa ± 0.89	3.48ABabc ± 0.92	3.68ABab ± 0.63	2.96CDc ± 0.94	3.32Babc ± 0.88	3.64Aab ± 0.70	3.40ABabc ± 0.94	3.68Aab ± 0.89
12	3.08Cab ± 0.91	3.40ABa ± 0.82	3.60Aa ± 0.94	3.36ABa ± 0.93	3.48ABa ± 0.97	2.76Db ± 0.95	3.36Ba ± 0.89	3.58Aa ± 0.91	3.04Bab ± 0.93	3.38Aa ± 0.85

Means with the same capital letter within a column and same small letter within a row are not significantly different at 5% level (p <0.05)
Note: 5 = acceptable extremely; 4 = acceptable; 3 = neither acceptable nor unacceptable; 2 = unacceptable; 1 = unacceptable extremely

Table 5. Effects of modified atmosphere packaging (MAP) on overall acceptability scores of shallot puree stored at 5 ± 1 °C for 12 weeks

Storage period (week)	Type of packaging material									
	PET/PE/Al/PE					Ony/LLDPE				
	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2	Control	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71	4.20Aa ± 0.71
2	3.92ABab ± 0.58	3.82ABab ± 0.48	3.92ABab ± 0.70	3.72Bbc ± 0.71	4.00ABa ± 0.58	4.16Aa ± 0.80	3.52BCbc ± 0.82	4.16Aa ± 0.85	3.88ABab ± 0.73	3.30CDc ± 0.84
4	3.72Ba ± 0.46	3.70BCa ± 0.71	3.84ABa ± 0.46	3.36BCb ± 0.70	3.56BCDab ± 0.65	3.76ABa ± 0.81	3.40Cb ± 0.71	3.78ABa ± 0.79	3.48BCb ± 0.92	3.34CDb ± 0.75
6	3.48BCb ± 0.87	3.64BCDab ± 0.84	3.56Bab ± 1.08	3.40BCb ± 0.82	3.72BCa ± 0.89	3.76ABa ± 0.72	3.68Bab ± 0.95	3.76ABa ± 0.72	3.38BCb ± 0.71	3.40BCb ± 0.81
8	2.92Cc ± 1.22	3.40BCDab ± 0.71	3.52Bab ± 0.71	3.32BCbc ± 0.69	3.44CDEab ± 0.87	3.48BCab ± 0.71	3.52BCab ± 0.77	3.70BCa ± 0.84	3.46BCab ± 0.79	3.72Ba ± 0.71
10	2.90Cb ± 1.19	3.24Db ± 0.71	3.48Bab ± 0.71	3.12Cb ± 0.71	3.24Deb ± 0.71	2.90Cb ± 0.71	3.48BCab ± 0.71	3.64BCa ± 0.64	3.62BCa ± 0.71	3.56BCab ± 0.87
12	2.80Cc ± 1.07	3.32CDab ± 0.80	3.44Ba ± 0.87	3.02Cbc ± 0.83	3.06Ebc ± 0.78	2.82Cc ± 1.07	3.32Cab ± 0.80	3.48Ca ± 0.71	3.24Cab ± 0.88	2.84Dc ± 0.85

Means with the same capital letter within a column and same small letter within a row are not significantly different at 5% level (p <0.05)
Note: 5 = acceptable extremely; 4 = acceptable; 3 = neither acceptable nor unacceptable; 2 = unacceptable; 1 = unacceptable extremely

shallot puree treated with 10% CO_2 was significantly better than that treated with other concentrations (5, 15 and 20% CO_2). Scores of overall acceptability decreased continuously in higher carbon dioxide concentrations (15 and 20%) during storage at 5 ± 1 °C. The overall acceptability of shallot puree packed in both packaging materials decreased significantly at the end of 12 weeks storage at 5 ± 1 °C and the colour was unacceptable by panellists.

A general deterioration trend in colour and overall acceptability was observed for control sample during storage. The sample was not acceptable starting from week 8 onwards for sample packed in PET/PE/Al/PE and week 10 for sample packed in Ony/LLDPE (*Table 5*). At week 10, the general appearance of the control sample was significantly worse than that of the treated shallot puree. It seems that modified atmosphere treatment was more effective in controlling colour deterioration. From the results obtained, it may be concluded that panellists could detect the differences among control and CO_2 treated puree right from the initial stage to the end of storage study.

Puree packed in Ony/LLDPE showed higher scores for colour, odour and overall acceptability throughout the storage period. This was probably due to the permeability properties of this packaging material which allowed the oxygen gas to pass through, thus reducing anaerobic deterioration (caused undesirable colour and odour) and delaying the colour degradation.

Conclusion

The yield and quality of shallot puree obtained are important economic criteria in the culinary product business. In general, shallot puree kept in modified atmosphere maintained their appearance and microbial load better than the control (normal atmospheric condition). A modified atmosphere packaging containing 10% CO_2 packed in Ony/LLDPE and stored at 5 ± 1 °C provided the best storage conditions for preserving the quality of shallot puree for up to 12 weeks, with organoleptic acceptability and slow rate of microbial growth. However, beyond 10% CO_2, the multiplication of certain microorganisms may be stimulated.

References

Abdul-Raouf, U.M., Beuchat, L.R. and Ammar, M.S. (1993). Survival and growth of *E.coli 0157:H7* on salad vegetables. *Appl. Environ. Microbiology* 59: 1999–2006

Anon. (2004). Columbia Encyclopedia, 6th Edition. Retrieved on 6 May 2004 from http//: www.encyclopedia.com/html/01/onion.asp.

Augusti, K.T. (1996). Therapeutic values of onion and garlic. *Indian Journal Experimental Biology* 64: 334–336

Beaudry, R.M. (1999). Effect of O_2 and CO_2 partial pressure on selected phenomena affecting fruit and vegetable quality. *Postharvest Biology and Technology* 15: 293–303

Bett, K.L. (2002). Evaluating sensory quality of fresh-cut fruits and vegetables. In: *Fresh-cut fruits and vegetables: Science, technology and market* (Lamikanra, O., ed.), p. 427–437. Boca Raton, London, New York, Washington: CRC Press LLC

Borch, E., Kant-Muermans, M.L. and Blixt, Y. (1996). Bacterial spoilage of meat and cured meat products. *International Journal of Food Microbiology* 33: 103–120

Brackett, R.E. (1994). Microbiological spoilage and pathogens in minimally processed refrigerated fruits and vegetables. In: *Minimally processed refrigerated fruits and vegetables,* (Wiley, R., ed.), p. 269–312. New York: Chapman & Hall

Buys, E.M., Nortjé, G.L., Jooste, P.J. and Von Holy, A. (2000). Microbiological shelf life of bulk-packaged *musculus gluteus medius* supplemented with dietary vitamin E. *Meat Science* 55: 433–441

Chen, J. (2002). Microbial enzymes associated with fresh-cut produce. In: *Fresh-cut fruits and vegetables: Science, technology and market* (Lamikanra, O., ed.), p. 249–262. Boca Raton, London, New York, Washington: CRC Press LLC

Dron, A., Guyer, D.E., Gage, D.A. and Lira, C.T. (1997). Yield and quality of onion flavour oil obtained by super critical fluid extraction and other methods. *Journal of Food Science* 20: 107–124

Eliot, S.C., Vuillemard, J.C. and Emond, J.P. (1998). Stability of shredded mozzarella cheese under modified atmospheres. *Journal of Food Science* 63: 1075–1080

Farber, J.M. (1991). Microbiological aspects on modified atmosphere packaging technology-a review. *Journal of Food Protection* 54(1): 58–70

Gill, C.O. (1988). The solubility of carbon dioxide in meat. *Meat Science* 22: 65–71

—— (1996). Extending the storage life of raw chilled meats. *Meat Science* 43: 99–109

Gill, C.O. and Jones, T. (1994). The display life of retail-packaged beefsteaks after their storage in master packs under various atmospheres. *Meat Science* 38: 385–396

Gill, C.O. and Penney, N. (1988). The effect of the initial gas volume to meat weight ratio on the storage life of chilled beef packaged under carbon dioxide. *Meat Science* 22: 53–63

Gomez, K.A. and Gomez, A.A. (1984). *Statistical procedures for agricultural research,* 2nd Edition, p. 680. New York: Wiley

González-Aguilar, G.A., Ayala-Zavala, J.F., Acedo-Félix, E. and Díaz-Cinco, M.E. (2004). Effect of temperature and modified atmosphere packaging on overall quality of fresh-cut bell peppers. *Lebensm.-Wissiu Technoogy* 37: 817–826

Hasimah, H.A. (2003). Development of ready to use saute ingredients. End of project report 01-03-03-0488 (TM-01-05-06). Submitted to Ministry of Science, Technology and the Environment, Malaysia 30.11.2003

Heard, G.M. (2002). Microbiology of fresh-cut produce. In: *Fresh-cut fruits and vegetables: Science, technology and market,* (Lamikanra, O., ed.), p. 187–235. Boca Raton, London, New York, Washington: CRC Press LLC

ICMSF (1978). Microorganisms in food. 1n: *International commission on microbiological specifications for food,* 2nd Edition, p. 115–8, 158–9. Toronto: University of Toronto Press

Jayas, D.S. and Jeyamkondan, S. (2002). Modified atmosphere storage of grains, meats, fruits and vegetables – review paper. *Biosystems Engineering* 82(3): 235–251

Kaymak-Ertekin, F. and Gedik, A. (2005). Kinetic modeling of quality deterioration in onions during drying and storage. *Journal of Food Engineering* 68: 443–453

Kuriyama, H., Mahakarnchanakul, W., Matsui, S. and Kobayashi, H. (1993). The effects of CO_2 on yeast growth and metabolism under continuous fermentation. *Biotechnol. Lett.* 15: 189–194

Michael, M. and Derek, Mc.D. (2003). *Modified atmosphere packaging*. Boca Raton, Florida: CRC Press LLC

Noor Azizah, A., Russly, A.B., Azizah, O., Salmah, Y. and Hasimah, H.A. (2005). Effect of different temperatures on quality changes of shallot puree. In: *Guide Book. 9th ASEAN Food Conference 2005*, Jakarta, p. 301

SAS Inst. (1985). *SAS User's Guide: Statistics,* Version 5 Edition. Cary, North Carolina: SAS Institute Inc.

Smith, J.P., Ramaswamy, H.S. and Simpson, B.K. (1990). Developments in food packaging. Part II: Storage aspects. *Trend in Food Science and Technology* 11: 111–118

Subramaniam, P.J. (1993). Miscellaneous applications. In: *Principles and applications of modified atmosphere packaging of food*, (Parry, R.T., ed.), p. 170–187. London, Glasgow, New York, Tokyo, Melbourne, Madras: Blackie Academic and Professional

Tareq, A. and Hotchkiss, J.H. (2002). Application of packaging and modified atmosphere to fresh-cut fruits and vegetables. In: *Fresh-cut fruits and vegetables: Science, technology and market,* (Lamikanra, O., ed.), p. 305–334. Boca Raton, London, New York, Washington: CRC Press LLC

Varoquaux, P. and Wiley, R. (1994). Biological and biochemical changes in minimally processed refrigerated fruits and vegetables. In: *Minimally processed refrigerated fruits and vegetables*, (Wiley, R., ed.), p. 226–268. New York: Chapman & Hall

Watada, A.E. (1997). Quality maintenance of fresh-cut fruits and vegetables. *Food Biotechnology* 44: 116–122

Zagory, D. and Hurst, W.C. (1996). *Food safety guidelines for the fresh-cut produce industry*, 3rd Edition. Washington: International Fresh-Cut Produce Association.

Abstrak

Keadaan penyimpanan atmosfera terubah suai yang optimum telah dikaji untuk dijadikan asas terhadap pembangunan pembungkusan atmosfera terubah suai bagi puri bawang merah. Kualiti mikrobiologi dan penilaian deria ke atas puri bawang merah telah diuji dalam keadaan atmosfera yang berbeza (campuran kepekatan sebanyak 5, 10, 15 dan 20% CO_2 dengan nitrogen dan normal atmosfera sebagai kawalan). Sampel disimpan pada suhu 5 ± 1 °C dengan menggunakan Ony/LLDPE dan PET/PE/Al/PE sebagai bahan pembungkus. Keputusan menunjukkan jumlah kiraan plat (TPC) dan kiraan *Lactobacillus* spp. meningkat secara perlahan semasa penyimpanan bagi semua perlakuan. Walau bagaimanapun, bakteria kolifom, kiraan yis dan kulat serta kiraan *Pseudomonas* spp. tidak dapat dikesan pada semua sampel. Kualiti penilaian rasa menunjukkan penurunan yang sangat bererti (p <0.05) semasa penyimpanan. Puri bawang merah yang dibungkus menggunakan komposisi kandungan gas 10% CO_2 dalam Ony/LLDPE didapati telah memberi kesan perlakuan yang paling baik untuk memanjangkan hayat simpanan selama 12 minggu pada suhu 5 ± 1 °C (85–95% RH).

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