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DEVELOPMENT OF BULK PACKAGING AND STORAGE OF SHALLOT (*Allium ascalonium*) PUREE

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BY

NOOR AZIZAH BINTI AHMAD

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

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Chairman : Professor Russly Abdul Rahman, PhD

Faculty : Food Science and Technology

The present trend where modern housewives have limited time in preparing food and also the food industry and services need ingredients in convenience form in order to cut down extensive labour, has led to the increase of ready to use food ingredient . With this in mind, ready to use shallots (*Allium ascalonium*) is able to satisfy the needs of retail and institutional consumers. Studies on physico-chemical changes, microbiological test and sensory evaluation for development of processing treatments of shallot puree using mild heat and acidification were carried out. The L value (L*) and hue angle (H_{ab}) of shallot puree increased significantly ($p<0.05$) during 8 weeks storage at 5±1 °C (85-95% RH), whilst, the chroma value (C*) decreased significantly ($p<0.05$). Total plate count (TPC) slowly increased during

storage period in all samples. The yeast and mould count increased in both acidified and control samples, whilst, the increment of coliforms was only detected in control sample. However, the mean scores on colour, odour and overall acceptability decreased significantly ($p<0.05$) during storage period for all samples. Total soluble solid (TSS) and pH value slowly decreased during storage period. Sample that was acidified + heated could be kept for 8 weeks at 5±1 °C (85-95% RH) followed by 7 weeks for acidified sample. The shelf life of less than 2 weeks was obtained for both heated and control samples.

The optimal conditions of modified atmosphere storage were investigated, in order to provide a basis for the development of modified atmosphere packs for shallot puree. Qualities of shallot puree were tested at different atmospheric condition (with or without 5, 10, 15 and 20 % CO_2) and temperatures (5, 15 and 25) ±1 °C by using Ony/LLDPE and PET/PE/Al/PE as packaging materials. The carbon dioxide content in shallot puree packed with Ony/LLDPE decreased significantly ($p<0.05$) for all treatments during 12 weeks of storage, whilst the oxygen content increased significantly ($p<0.05$). The L value (L*) and hue angle (H_{ab}) showed significant ($p<0.05$) increased in all samples: However, the chroma value (C*) and organoleptic evaluation decreased significantly ($p<0.05$) throughout the storage period. 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 pH value and TSS decreased significantly

(p<0.05) in shallot puree packed with different carbon dioxide contents and packaging materials during storage period. Shallot puree packed in Ony/LLDPE with 10% carbon dioxide was found to be the best treatment for extending the storage life up to 12 weeks at 5±1 °C (85-95% RH). The quality changes of shallot puree stored at 10 % CO_2 and packed in Ony/LLDPE was studied in bulk form through out storage. There was a significant (p<0.05) increase in the L value (L*) and hue angle (H_{ab}) but not in chroma value (C*) (p<0.05) for both treatments. There is a highly significant decrease (p<0.05) in sugar (fructose, glucose and sucrose) content of shallot puree throughout storage, whilst, total sugar showed no significant (p>0.05) difference between treatments during storage. Volatile oil of shallot puree contained sulphur group as major compounds. TPC and *Lactobacillus* spp. count gradually increased until the end of storage period.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PERKEMBANGAN PEMBUNGKUSAN PUKAL DAN PENYIMPANAN PURI BAWANG MERAH (*Allium ascalonium*)

Oleh

NOOR AZIZAH BINTI AHMAD

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Gaya hidup moden di mana para suri rumah yang kesuntukan masa untuk menyediakan makanan dan juga dalam perkhidmatan dan industri makanan yang memerlukan bahan atau ramuan dalam bentuk yang mudah disediakan bagi mengurangkan pekerja menyebabkan ianya menjadikan faktor penting untuk meningkatkan penghasilan ramuan makanan yang sedia digunakan. Dengan mengambil kira faktor tersebut, bawang merah yang sedia digunakan adalah berupaya untuk memenuhi keperluan pelanggan jualan runcit dan institusi. Kajian ke atas perubahan-perubahan fiziko-kimia, ujian mikrobiologikal dan penilaian ujirasa bagi pembangunan perlakuan pemprosesan puri bawang merah (*Allium ascalonium*) menggunakan pemanasan sederhana dan pengasidan telah dijalankan.

Nilai L (L*) dan hue angle (H_{ab}) puri bawang menunjukkan peningkatan yang sangat bererti ($p<0.05$) selama 8 minggu penyimpanan pada suhu 5±1 °C (85-95% RH), manakala nilai chroma (C*) menurun dengan berkesan ($p<0.05$). Jumlah kiraan plat (TPC) bagi semua sampel telah meningkat secara perlahan-lahan semasa penyimpanan. Kiraan yis dan kulat pula didapati meningkat pada sampel yang diberi perlakuan pengasidan dan juga kawalan, manakala peningkatan bakteria kolifom semasa penyimpanan hanya dapat dilihat pada sampel kawalan sahaja. Walau bagaimanapun, penilaian organoleptik telah menurun dengan sangat bererti ($p<0.05$) semasa tempoh penyimpanan bagi semua sampel. Jumlah pepejal larut (TSS) dan nilai pH pula telah menurun secara perlahan semasa tempoh penyimpanan. Sampel yang diberi perlakuan asid + haba boleh disimpan selama 8 minggu pada suhu 5±1 °C (85-95% RH) dan diikuti selama 7 minggu untuk sampel yang hanya diberi perlakuan asid sahaja. Manakala sampel yang diberi perlakuan haba sahaja dan sampel kawalan mempunyai tempoh penyimpanan kurang dari 2 minggu.

Kondisi penyimpanan atmosfera terubahsuai yang optima telah dikaji untuk dijadikan asas terhadap pembangunan pembungkusan puri bawang merah secara atmosfera terubahsuai. Kualiti puri bawang merah telah diuji dalam keadaan atmosfera (tanpa atau dengan kehadiran kepekatan sebanyak 5, 10, 15 dan 20 peratus kandungan gas karbon dioksida) dan suhu (5, 15 dan 25) ±1 °C yang berbeza dengan menggunakan Ony/LLDPE dan PET/PE/Al/PE sebagai bahan pembungkus. Penurunan nilai kandungan gas karbon dioksida menunjukkan perbezaan bererti

(p<0.05) dalam puri bawang merah yang dibungkus dalam Ony/LLDPE bagi semua perlakuan semasa tempoh 12 minggu penyimpanan, manakala nilai kandungan gas oksigen pula didapati meningkat dengan sangat bererti (p<0.05). Nilai L (L*) dan hue angle (H_{ab}) pula menunjukkan peningkatan yang sangat bererti (p<0.05) bagi semua perlakuan. Walau bagaimanapun, nilai chroma (C*) dan penilaian organoleptik menunjukkan penurunan yang sangat bererti (p<0.05) semasa penyimpanan. 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. Kandungan pH dan TSS telah menunjukkan perbezaan penurunan yang sangat bererti (p<0.05) dalam puri bawang merah yang dibungkus dengan kandungan gas karbon dioksida dan bahan pembungkusan yang berbeza semasa tempoh penyimpanan. Puri bawang merah yang dibungkus menggunakan komposisis kandungan gas 10% karbon dioksida 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). Perubahan mutu puri bawang merah yang disimpan dalam kandungan 10% karbon dioksida dan dibungkus dalam Ony/LLDPE telah dikaji dalam bentuk pukal sepanjang penyimpanan. Nilai L (L*) dan hue angle (H_{ab}) menunjukkan peningkatan yang sangat bererti (p<0.05) tetapi nilai chroma (C*) pula menurun dengan sangat bererti (p<0.05) bagi kedua-dua perlakuan semasa penyimpanan. Kandungan gula (fruktosa, glukosa dan sukrosa) dalam puri bawang telah menurun dengan sangat bererti (p<0.05) bagi kedua-dua

perlakuan, manakala jumlah kandungan gula menunjukkan tiada perbezaan bererti (p>0.05) diantara perlakuan semasa penyimpanan. Sebatian minyak meruap di dalam puri bawang merah telah menunjukkan bahawa sebahagian besarnya adalah terdiri dari kumpulan sulfur. Jumlah kiraan plat (TPC) dan kiraan *Lactobacillus* spp. pula meningkat secara perlahan sehingga akhir tempoh penyimpanan.

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LIST OF SYMBOLS AND ABBREVIATIONS

BC	Before Century
%	Percent
<	Less than
>	More than
µL	Micro liter
µm	Micron
^0C	Degree Celcius
BGP	Bulk Gas pack
cc	Centimeter Cubic
CFU	Colony Forming Unit
cm	Centimeter
CO_2	Carbon dioxide
CO_2TR	Carbon dioxide Transmission Rate
EMA	Equilibrium Modified Atmosphere
EVOH	Ethyl Vinyl Alcohol
g	Gram
G/p	Ratio volume of gas and volume of product
GTR	Gas Transmission Rate
h	Hour
HDPE	High Density Polyethylene
Hg	Mercury
IU	International Unit
kg	Kilogram
kGy	Kilo gay
kPa	Kilo Pascal
l	Liter
m	Meter

MAP	Modified Atmosphere Packaging
mg	Milligram
$Mg(NO_3)$	Magnesium Nitrate
min	Minute
ml	Milliliter
mm	Millimeter
MPN	Most Probable Number
N_2	Nitrogen
O_2	Oxygen
O_2TR	Oxygen Transmission Rate
Ony / LLDPE	Oriented Nylon / Linear Low Density Polyethylene
PA	Polyamide
PCA	Plate Count Agar
PDA	Potato Dextrose Agar
PE	Polyethylene
PET	Polyethylene Terephthalate
PET/PE/Al/PE	Polyethylene Terephthalate/Polyethylene/ Aluminium/Polyethylene
pH	- log value of hydrogen ion concentration
PP	Polypropylene
PVC	Poly Vinyl Chloride
PVdc	Poly Vinylidene chloride
RH	Relative Humidity
rpm	Revolutions Per Minute
TPC	Total Plate Count
TSS	Total Soluble Solid
w/w	Weight per weight
WVTR	Water Vapour Transmission Rate

CHAPTER 1

GENERAL INTRODUCTION

Shallot (*Allium ascalonium*), the Liliopsida class (Anon, 2004a) is a vegetables very similar to the common onion. Generally, shallots produce a reddish brown bulb that adds flavour to many dishes. The subtle taste of the shallot makes it indispensable in haute cuisine, as well as other dishes. Many gourmet chefs use shallots for sauce, stews, gravies and roasts. Cooked shallots have a sweeter taste than onions. There are many shallot-based product such as shallot pulp, frozen shallots (or chopped shallots) and peeled shallots. It is widely used in French cuisine such as Beef Bourguignon. Indeed, shallots are an authentic ingredient of many Asian cuisines from Thai soups, red and green curries in Indonesian and fried rice dishes such as "nasi goreng" (http://www.ukshallot.com/).

There are differences in the colour and shape of shallot that may be noticeable, depending on the traditional varieties grown. In Asia, the shallots are mainly small and round with a reddish colour. However, in France shallots that are preferred are those that are more pear-shaped and reddish brown in colour. In the Netherlands and Denmark, round, red-brown and yellow shallots are traditionally used (http://www.shallot.com/gb/1c.htm).

The most important areas of production in the Western world are: France, The Netherlands, The United States of America and Great Britain (http://www.shallot.com/gb/1a.htm). Shallot is grown in large scale in many Asian countries such as Indonesia, Philippines, Thailand, Sri Lanka and India. Presently, Asia produces more than 50% (14.6 million tons) of world onion which also includes shallot (Pathak, 2005).

Shallot is one of the ingredients used in Malaysian dishes especially among the Malay and Indian community. It is added to food not only to impart flavour but also to excite the taste buds to a better appreciation of the dishes presented (Augusti, 1996). Per capita of shallot consumption was 2.45 kg for household and increased when shallot and onion were joined in Allium genus (Lim, 2000). Malaysia imports about 2.5 million tons with RM218 million in 2003 from India, China, Thailand and Indonesia (Department of Statistic Malaysia, 2004).

In Malaysia, shallot crop was introduced in 1980 and was successful in producing the yield. However, cultivation of this crop commercially in a large-scale was not done in this country. Factors such as low price, medium yield and costly production compared to imported shallots make it less economic to plant this crop (Zarinah, 1999).

The present trend where the female population is increasingly entering the workplace which will undoubtedly mean that they have limited time in preparing food and also the food service industry (such as hotels, restaurants, hospital kitchen, catering companies, central kitchens and airports) need ingredients in convenience form in order to cut down extensive labour, processing, handling and storage, has led to the increase of ready to use food ingredient (Hasimah, 2003). With this in mind, ready to use shallots will be able to satisfy the needs of retail and institutional consumers. Based on the widely needs of ready to use shallot in food service industry, a suitable technique of bulk handling, packaging and storage of shallot puree should be studied and introduced to the food producer in order to maintain the product quality.

Therefore, the objectives of this study are:

1. To establish processing treatment in the production of shallot puree.

2. To determine changes in the physico-chemical, microbial and sensory evaluation of shallot puree packed in different packaging materials and gas compositions stored at different temperatures (5 °C, 15 °C and 25 °C).

3. To determine the effect of bulk packaging on storage quality of shallot puree.

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Appendix A

(Sensory evaluation form)

SENSORY EVALUATION FORM
(HEDONIC SCALE TEST)

Name : .....

Sample: **Shallot puree**

Date : .....

Kindly you are given several samples of shallot puree. Please evaluate these samples according to the score below:

A. Colour

5 - acceptable extremely
4 - acceptable
3 - neither acceptable nor unacceptable
2 - unacceptable
1 - unacceptable extremely

Sample code	Colour

B. Odour

5 - acceptable extremely
4 - acceptable
3 - neither acceptable nor unacceptable
2 - unacceptable
1 - unacceptable extremely

Sample code	Odour

C. Overall acceptability

5 - acceptable extremely
4 - acceptable
3 - neither acceptable nor unacceptable
2 - unacceptable
1 - unacceptable extremely

Sample code	Overall acceptability

Comment:

_____

_____

_____

Thank you.

Appendix B

(Tables)

Table 28
Effects of modified atmosphere packaging (MAP) with different packaging materials on CO_2 concentrations (%) of shallot puree stored at 15±1 °C for 4 weeks

Storage period (week)	Type of packaging material							
	PET/PE/Al/PE				Ony/LLDPE			
	5% CO_2	10% CO_2	15% CO_2	20% CO_2	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	5.11 ± 0.03^{B}	10.84 ± 0.14^{A}	15.03 ± 0.04^{A}	20.87 ± 0.01^{A}	5.11 ± 0.03^{A}	10.84 ± 0.14^{A}	15.03 ± 0.04^{A}	20.87 ± 0.01^{A}
1	5.29 ± 0.01^{A}	10.62 ± 0.10^{B}	14.76 ± 0.01^{B}	20.64 ± 0.02^{B}	3.81 ± 0.08^{B}	7.10 ± 0.14^{B}	11.21 ± 0.01^{B}	14.45 ± 0.04^{B}
2	5.04 ± 0.01^{C}	10.25 ± 0.07^{C}	14.73 ± 0.01^{B}	20.53 ± 0.02^{C}	3.16 ± 0.15^{C}	5.70 ± 0.05^{C}	9.08 ± 0.11^{C}	12.05 ± 0.09^{C}
3	4.88 ± 0.01^{D}	10.08 ± 0.06^{C}	14.67 ± 0.03^{C}	20.44 ± 0.04^{D}	2.77 ± 0.08^{D}	4.73 ± 0.04^{D}	7.43 ± 0.38^{D}	8.71 ± 0.01^{D}
4	4.75 ± 0.04^{E}	9.90 ± 0.08^{D}	14.62 ± 0.01^{D}	20.63 ± 0.01^{E}	1.45 ± 0.01^{E}	3.09 ± 0.04^{E}	4.49 ± 0.04^{E}	5.67 ± 0.02^{E}

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

Table 29
Effects of modified atmosphere packaging (MAP) with different packaging materials on O_2 concentrations (%) of shallot puree stored at 15±1 °C for 4 weeks

Storage period (week)	Type of packaging material							
	PET/PE/Al/PE				Ony/LLDPE			
	5% CO_2	10% CO_2	15% CO_2	20% CO_2	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	2.19 ± 0.19^{BCa}	2.19 ± 0.19^{Ba}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Da}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Da}	2.19 ± 0.19^{Da}
1	2.42 ± 0.04^{Bc}	2.78 ± 0.01^{Ab}	2.48 ± 0.00^{ABc}	2.06 ± 0.02^{Cd}	3.28 ± 0.08^{Ca}	3.35 ± 0.01^{Ba}	3.30 ± 0.04^{Ca}	3.37 ± 0.12^{Ca}
2	2.84 ± 0.01^{Ac}	2.41 ± 0.00^{Bd}	2.17 ± 0.13^{Ce}	2.49 ± 0.02^{ABd}	3.48 ± 0.11^{BCb}	3.61 ± 0.06^{Bab}	3.63 ± 0.02^{Bab}	3.74 ± 0.06^{Ba}
3	2.25 ± 0.07^{BCc}	2.16 ± 0.18^{Bc}	2.69 ± 0.02^{Ab}	2.74 ± 0.08^{Ab}	3.83 ± 0.15^{ABa}	3.90 ± 0.06^{Aa}	3.86 ± 0.07^{Ba}	3.95 ± 0.03^{ABa}
4	2.07 ± 0.04^{Cc}	2.27 ± 0.03^{Bb}	2.31 ± 0.04^{Bcb}	2.31 ± 0.08^{BCb}	4.11 ± 0.13^{Aa}	4.15 ± 0.11^{Aa}	4.23 ± 0.05^{Aa}	4.22 ± 0.09^{Aa}

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 30
Effects of modified atmosphere packaging (MAP) with different packaging materials on CO_2 concentrations (%) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	Type of packaging material							
	PET/PE/Al/PE				Ony/LLDPE			
	5% CO_2	10% CO_2	15% CO_2	20% CO_2	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	5.11 ± 0.03^{B}	10.84 ± 0.14^{A}	15.03 ± 0.04^{A}	20.87 ± 0.01^{A}	5.11 ± 0.03^{A}	10.84 ± 0.14^{A}	15.03 ± 0.04^{A}	20.87 ± 0.01^{A}
2	5.11 ± 0.01^{B}	10.67 ± 0.02^{B}	14.81 ± 0.02^{B}	20.56 ± 0.06^{B}	4.88 ± 0.06^{B}	9.46 ± 0.03^{B}	13.79 ± 0.13^{B}	18.30 ± 0.07^{B}
4	5.08 ± 0.01^{B}	10.59 ± 0.01^{B}	14.69 ± 0.01^{C}	20.41 ± 0.02^{C}	4.10 ± 0.11^{C}	8.56 ± 0.02^{C}	12.63 ± 0.02^{C}	16.55 ± 0.14^{C}
6	5.25 ± 0.03^{A}	10.53 ± 0.02^{B}	14.55 ± 0.03^{D}	20.36 ± 0.02^{C}	3.74 ± 0.04^{D}	7.11 ± 0.05^{D}	11.6 ± 0.03^{D}	14.37 ± 0.04^{D}

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

Table 31
Effects of modified atmosphere packaging (MAP) with different packaging materials on O_2 concentrations (%) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	Type of packaging material							
	PET/PE/Al/PE				Ony/LLDPE			
	5% CO_2	10% CO_2	15% CO_2	20% CO_2	5% CO_2	10% CO_2	15% CO_2	20% CO_2
0	2.19 ± 0.19^{Aa}	2.19 ± 0.19^{Aa}	2.19 ± 0.19^{Aa}	2.19 ± 0.19^{Aa}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Ca}	2.19 ± 0.19^{Ca}
2	2.21 ± 0.05^{Ac}	2.12 ± 0.01^{Ac}	2.19 ± 0.05^{Ac}	2.26 ± 0.07^{Ac}	2.48 ± 0.04^{Cab}	2.50 ± 0.17^{Ca}	2.54 ± 0.11^{Ca}	2.29 ± 0.06^{Cbc}
4	2.12 ± 0.09^{Ab}	2.22 ± 0.03^{Ab}	2.09 ± 0.06^{Ab}	2.24 ± 0.01^{Ab}	3.10 ± 0.08^{Ba}	3.06 ± 0.19^{Ba}	3.09 ± 0.08^{Ba}	3.04 ± 0.09^{Ba}
6	2.31 ± 0.06^{Ab}	2.21 ± 0.00^{Ab}	2.28 ± 0.02^{Ab}	2.17 ± 0.03^{Ab}	3.51 ± 0.06^{Aa}	3.54 ± 0.03^{Aa}	3.53 ± 0.16^{Aa}	3.42 ± 0.03^{Aa}

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 32
Effects of modified atmosphere packaging (MAP) with different packaging materials on colour acceptability of shallot puree stored at 15±1 °C for 3 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	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{ABCa} ±0.88	3.88^{ABa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88
1	3.44^{Aa} ±0.82	3.68^{Aa} ±0.85	3.76^{ABa} ±0.83	3.72^{Aa} ±0.98	3.36^{Ba} ±0.86	3.68^{Aa} ±1.03	3.40^{Ba} ±0.71	3.52^{Aa} ±1.08	3.40^{ABa} ±0.87	3.28^{Ba} ±1.10
2	2.80^{Bbc} ±0.76	3.08^{Babc} ±0.74	3.44^{BCa} ±0.71	3.40^{Aa} ±0.65	3.24^{Bab} ±0.72	2.64^{Bc} ±0.95	3.20^{Bab} ±0.82	3.36^{ABa} ±0.62	3.12^{BCab} ±0.83	3.14^{Bab} ±0.83
3	2.52^{Bbc} ±0.87	2.72^{Babc} ±0.89	3.12^{Ca} ±0.73	2.54^{Bbc} ±0.84	2.48^{Cbc} ±1.04	2.20^{Bc} ±0.76	2.72^{Cabc} ±0.84	2.96^{Bab} ±0.89	2.68^{Cabc} ±0.94	2.60^{Cabc} ±0.82

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 33
Effects of modified atmosphere packaging (MAP) with different packaging materials on odour acceptability of shallot puree stored at 15±1 °C for 3 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	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81
1	3.80^{Ab} ±0.87	3.44^{Ba} ±0.77	3.72^{ABa} ±0.74	3.52^{ABa} ±1.00	3.68^{Aa} ±0.85	3.76^{Aa} ±0.92	3.60^{ABa} ±0.64	3.74^{ABa} ±0.92	3.48^{ABa} ±0.77	3.52^{Aa} ±0.87
2	2.84^{Bde} ±0.89	3.40^{Bab} ±0.64	3.52^{ABa} ±0.59	3.00^{Bbcde} ±0.87	2.88^{Bcde} ±0.83	2.80^{Bde} ±0.91	3.26^{Babcd} ±0.83	3.36^{Babc} ±0.70	3.24^{Babcd} ±0.72	2.64^{Be} ±0.99
3	2.44^{Bdef} ±0.77	3.04^{Babc} ±0.84	3.32^{Ba} ±0.80	2.76^{Cbcd} ±0.76	2.68^{Bcd} ±0.90	2.00^{Cf} ±0.71	2.60^{Ccde} ±0.76	3.20^{Bab} ±0.83	2.16^{Cef} ±0.85	2.36^{Bdef} ±0.76

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 34
Effects of modified atmosphere packaging (MAP) with different packaging materials on overall acceptability of shallot puree stored at 15±1 °C for 3 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	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71
1	3.72^{Ba} ±0.54	3.78^{Ba} ±0.82	3.28^{Ba} ±0.79	3.76^{Ba} ±0.78	3.56^{Ba} ±0.65	3.52^{Ba} ±0.71	3.48^{Ba} ±0.77	3.58^{Ba} ±0.76	3.52^{Ba} ±0.87	3.44^{Ba} ±1.00
2	3.00^{Cab} ±0.82	3.28^{Ca} ±0.61	3.44^{Ba} ±0.77	3.32^{Ca} ±0.63	3.20^{Ba} ±0.87	2.68^{Cb} ±0.94	3.36^{Ba} ±0.64	3.40^{Ba} ±0.87	3.00^{Cab} ±0.71	3.36^{Ba} ±0.70
3	1.68^{De} ±0.69	2.20^{Dbcd} ±0.76	2.60^{Cab} ±0.76	2.08^{Dcde} ±0.85	2.48^{Cbc} ±0.69	1.96^{Dde} ±0.72	2.56^{Cabc} ±0.77	2.96^{Ca} ±0.79	2.32^{Dbcd} ±0.84	2.40^{Cbcd} ±0.91

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 35
Effects of modified atmosphere packaging (MAP) with different packaging materials on colour acceptability of shallot puree stored at 25±1 °C for 4 days

Storage period (day)	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	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{ABCa} ±0.88	3.88^{ABa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88	3.88^{Aa} ±0.88
2	2.96^{Ba} ±0.89	3.20^{Ba} ±0.96	3.28^{Ba} ±0.97	3.32^{Ba} ±0.94	2.96^{Ba} ±0.89	3.12^{Ba} ±0.88	3.28^{Ba} ±0.79	3.40^{Ba} ±0.81	3.16^{Ba} ±0.94	3.12^{Ba} ±0.93
4	1.44^{Ce} ±0.56	1.96^{Ccd} ±0.59	2.60^{Ca} ±0.58	2.12^{Cbc} ±0.82	2.20^{Cabc} ±0.76	1.54^{Cde} ±0.58	2.36^{Cab} ±0.79	2.36^{Cab} ±0.77	1.96^{Cbcd} ±0.69	2.16^{Cabc} ±0.91

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 36
Effects of modified atmosphere packaging (MAP) with different packaging materials on odour acceptability of shallot puree stored at 25±1 °C for 4 days

Storage period (day)	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	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81	3.92^{Aa} ±0.81
2	2.76^{Bbc} ±0.88	3.08^{Bab} ±0.99	3.36^{Ba} ±0.76	3.08^{Bab} ±0.86	2.70^{Bbc} ±0.98	2.40^{Bc} ±0.90	2.84^{Babc} ±0.89	3.16^{Bab} ±0.85	2.84^{Babc} ±0.89	2.88^{Babc} ±0.71
4	1.56^{Cc} ±0.56	1.82^{Cbc} ±0.72	1.96^{Cabc} ±0.84	1.94^{Cabc} ±0.81	1.72^{Cbc} ±0.72	1.50^{Cc} ±0.58	2.08^{Cab} ±0.86	2.32^{Ca} ±0.96	2.12^{Cab} ±0.88	1.88^{Cabc} ±0.74

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 37

Effects of modified atmosphere packaging (MAP) with different packaging materials on overall acceptability of shallot puree stored at 25±1 °C for 4 days

Storage period (day)	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	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71	4.20^{Aa} ±0.71
2	3.00^{Ba} ±0.87	3.40^{Ba} ±1.07	3.56^{Ba} ±0.89	3.28^{Ba} ±0.87	3.16^{Ba} ±1.04	2.98^{Ba} ±0.74	3.48^{Ba} ±0.80	3.56^{Ba} ±0.90	3.32^{Ba} ±0.67	3.40^{Ba} ±0.96
4	1.58^{Cc} ±0.62	1.96^{Cabc} ±0.73	2.18^{Ca} ±0.76	1.72^{Cbc} ±0.74	2.00^{Cabc} ±0.71	1.58^{Cc} ±0.61	2.02^{Cabc} ±0.71	2.14^{Cab} ±0.64	1.78^{Cabc} ±0.63	1.78^{Cabc} ±0.72

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 38
Effects of modified atmosphere packaging (MAP) with different packaging materials on L* value of shallot puree stored at 15±1 °C for 4 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	34.21^{Ca} ±0.81	34.21^{Ca} ±0.81	34.21^{Ca} ±0.81	34.21^{Da} ±0.81	34.21^{Da} ±0.81	34.21^{Da} ±0.81	34.21^{Da} ±0.81	34.21^{Ca} ±0.81	34.21^{Ca} ±0.81	34.21^{Ba} ±0.81
1	34.16^{Ce} ±1.06	36.22^{Bab} ±0.69	34.99^{Cde} ±0.99	35.31^{Ccd} ±0.85	35.29^{Ccd} ±1.18	36.84^{Ca} ±0.77	35.89^{Cbc} ±0.59	34.92^{Cde} ±0.86	34.71^{Cde} ±0.89	34.79^{Bde} ±0.64
2	41.59^{Bab} ±0.62	40.96^{Abc} ±0.93	40.62^{Bbc} ±1.06	40.45^{Bc} ±0.64	42.38^{Aa} ±0.89	42.29^{Ba} ±1.29	41.64^{Bab} ±1.13	41.59^{Aab} ±1.36	41.72^{ABab} ±1.25	41.58^{Aab} ±1.72
3	43.27^{Aa} ±1.09	41.09^{Acde} ±1.71	40.83^{Bcde} ±1.28	39.82^{Be} ±1.87	41.37^{Bcd} ±1.34	42.85^{Bab} ±1.30	41.68^{Bbc} ±1.19	40.04^{Bde} ±0.99	42.27^{Aabc} ±1.06	41.42^{Acd} ±2.09
4	42.31^{Bbcd} ±1.09	41.97^{Acde} ±1.15	42.44^{Abc} ±0.94	43.27^{Ab} ±1.11	40.99^{Be} ±0.57	44.59^{Aa} ±0.96	43.20^{Ab} ±1.17	41.39^{Ade} ±0.99	41.08^{Be} ±1.29	42.68^{Abc} ±1.44

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 39
Effects of modified atmosphere packaging (MAP) with different packaging materials on Hue angle of shallot puree stored at 15±1 °C for 4 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	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Da} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14	28.35^{Ea} ±1.14
1	35.58^{Dd} ±0.93	35.78^{Dcd} ±1.06	37.47^{Dab} ±0.91	36.51^{Dbcd} ±1.21	35.55^{Dd} ±0.55	33.37^{De} ±1.34	36.77^{Cabc} ±1.07	37.74^{Da} ±1.35	36.75^{Dabc} ±0.99	37.04^{Dab} ±1.55
2	47.15^{Cdef} ±0.68	46.40^{Cef} ±0.81	46.06^{Cf} ±1.10	48.79^{Cab} ±0.86	48.69^{Cabc} ±1.79	49.09^{Ca} ±2.19	47.59^{Bcde} ±1.09	46.74^{Cdef} ±0.86	47.25^{Cdef} ±1.03	47.84^{Cbcd} ±0.83
3	52.55^{Bd} ±1.04	55.05^{Bb} ±0.43	54.36^{Bbc} ±0.59	57.00^{Ba} ±0.93	52.59^{Bd} ±1.09	50.89^{Be} ±0.61	54.79^{Ab} ±2.89	51.02^{Be} ±0.93	50.64^{Be} ±1.18	53.52^{Bcd} ±0.69
4	59.02^{Ab} ±0.46	59.19^{Ab} ±0.86	58.22^{Ab} ±0.87	60.35^{Aa} ±0.68	58.70^{Ab} ±1.44	55.55^{Acd} ±0.49	55.46^{Acd} ±1.19	56.42^{Ac} ±1.29	54.63^{Ad} ±1.75	55.15^{Ad} ±0.87

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 40
Effects of modified atmosphere packaging (MAP) with different packaging materials on chroma value of shallot puree stored at 15±1 °C for 4 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	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62
1	16.01^{Bde} ±0.43	16.39^{Bcd} ±0.75	16.85^{Babc} ±0.25	16.06^{Bde} ±0.46	16.71^{Bbc} ±0.29	15.78^{Be} ±0.32	17.25^{Aa} ±0.35	17.08^{Bab} ±0.40	17.11^{Bab} ±0.52	16.77^{Babc} ±0.54
2	16.02^{Bcd} ±0.36	15.61^{CDd} ±0.49	15.77^{Cd} ±0.32	15.69^{Bd} ±0.50	15.98^{Ccd} ±0.43	15.74^{Bd} ±0.37	17.54^{Aa} ±0.47	16.89^{Bb} ±0.46	16.49^{Cbc} ±0.49	16.47^{Bbc} ±0.26
3	15.14^{Cd} ±0.34	15.85^{Cab} ±0.30	15.57^{Cbc} ±0.37	15.81^{Bab} ±0.59	15.90^{Cab} ±0.59	15.19^{Ccd} ±0.51	15.55^{Bbc} ±1.57	16.08^{Ca} ±0.48	16.05^{CDa} ±0.59	15.86^{Cab} ±0.48
4	14.58^{Db} ±0.46	15.28^{Da} ±0.66	14.78^{Db} ±0.66	14.81^{Cb} ±0.38	15.22^{Da} ±0.23	15.37^{BCa} ±0.38	15.47^{Ba} ±0.63	15.55^{Da} ±0.43	15.61^{Da} ±0.61	15.63^{Ca} ±0.42

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 41
Effects of modified atmosphere packaging (MAP) with different packaging materials on L* value of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	34.21^{Da} ±0.81	34.21^{Ca} ±0.81	34.21^{Da} ±0.81	34.21^{Ca} ±0.81	34.21^{Da} ±0.81	34.21^{Ca} ±0.81	34.21^{Da} ±0.81	34.21^{Da} ±0.81	34.21^{Ca} ±0.81	34.21^{Ca} ±0.81
2	37.16^{Cbcd} ±0.86	37.98^{Bab} ±1.17	35.49^{Ce} ±0.66	36.59^{Bcd} ±0.85	37.44^{Cbc} ±1.37	37.24^{BCbc} ±1.96	38.61^{Ca} ±0.96	36.09^{Cde} ±0.99	38.15^{Bab} ±1.43	35.09^{Be} ±0.88
4	45.57^{Bcd} ±0.99	46.34^{Abc} ±1.07	45.45^{Bd} ±0.76	47.25^{Aab} ±0.79	46.75^{Ab} ±0.81	47.87^{Aa} ±0.74	46.73^{Bb} ±1.48	47.68^{Aa} ±1.11	47.11^{Aab} ±0.46	46.45^{Ab} ±0.76
6	47.07^{Aa} ±1.19	46.65^{Aab} ±1.14	46.55^{Aab} ±0.79	47.41^{Aa} ±1.09	45.72^{Bab} ±1.18	42.79^{ABa} ±1.02	48.26^{Aa} ±0.74	45.51^{Bab} ±1.34	47.52^{Aa} ±0.81	46.68^{Aab} ±0.56

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 42
Effects of modified atmosphere packaging (MAP) with different packaging materials on Hue angle of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14	28.35^{Aa} ±1.14
2	49.46^{Ca} ±0.92	42.44^{Ce} ±1.06	46.33^{Cbc} ±0.76	46.77^{Cbc} ±0.84	47.46^{Cb} ±1.11	46.82^{Cbc} ±2.63	40.38^{Cf} ±1.05	41.59^{Cef} ±1.78	43.96^{Cd} ±1.11	45.99^{Cc} ±1.35
4	50.66^{Bbc} ±1.52	49.30^{Bcd} ±1.54	53.25^{Ba} ±0.88	50.33^{Bc} ±1.33	52.35^{Bab} ±1.39	53.47^{Ba} ±1.63	48.27^{Bd} ±1.49	53.68^{Ba} ±4.38	50.01^{Bcd} ±0.92	52.26^{Bab} ±0.72
6	59.64^{Abcd} ±0.81	60.97^{Aa} ±1.35	61.09^{Aa} ±0.97	59.97^{Aabc} ±1.11	58.57^{Ad} ±0.73	59.67^{Abcd} ±1.13	61.08^{Aa} ±0.89	60.88^{Aa} ±1.30	60.62^{Aab} ±1.78	59.43^{Acd} ±1.04

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 43
Effects of modified atmosphere packaging (MAP) with different packaging materials on chroma value of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62	17.99^{Aa} ±0.62
2	15.74^{Bcd} ±0.39	16.22^{Bab} ±0.51	15.67^{Bd} ±0.45	15.70^{Bd} ±0.49	15.49^{Bd} ±0.41	15.91^{Bbcd} ±1.09	16.22^{Bab} ±0.69	16.12^{Bbc} ±0.91	16.57^{Ba} ±0.59	16.20^{Bab} ±0.29
4	14.49^{Bbcde} ±0.54	15.31^{Cde} ±0.24	15.71^{Babcd} ±0.22	15.78^{Babc} ±0.42	15.17^{Be} ±0.55	15.99^{Ba} ±0.54	15.41^{Ccde} ±0.53	15.79^{Cabc} ±0.29	15.89^{Cab} ±0.41	16.00^{Ba} ±0.38
6	14.52^{Cd} ±0.39	15.27^{Cab} ±0.40	15.31^{Bab} ±0.45	15.24^{Cab} ±0.48	15.03^{Bbcd} ±0.67	15.18^{Bbc} ±0.29	15.84^{BCa} ±0.41	15.54^{Cab} ±0.26	15.23^{Dab} ±0.38	14.61^{Ccd} ±0.35

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 44
Effects of modified atmosphere packaging (MAP) with different packaging materials on total plate count (Log CFU g^{-1}) of shallot puree stored at 15±1 °C for 4 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	2.87^{Da} ±0.01	2.87^{Ea} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Ca} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01
1	4.16^{Cbc} ±0.02	4.11^{Dcd} ±0.01	3.96^{Ce} ±0.03	3.99^{Ce} ±0.03	4.09^{Bd} ±0.02	4.26^{Ca} ±0.01	4.20^{Cb} ±0.00	3.99^{Ce} ±0.05	4.07^{Cd} ±0.03	4.17^{Cbc} ±0.01
2	4.18^{Cbcd} ±0.01	4.16^{Ccd} ±0.00	4.15^{Bef} ±0.01	4.11^{Bef} ±0.01	4.15^{Bde} ±0.02	4.30^{Ca} ±0.01	4.21^{Cb} ±0.01	4.12^{Bef} ±0.00	4.11^{Cf} ±0.01	4.19^{Cbc} ±0.03
3	4.23^{Bc} ±0.02	4.20^{Bcd} ±0.01	4.17^{Ac} ±0.01	4.23^{Ac} ±0.01	4.22^{Ac} ±0.00	4.42^{Ba} ±0.02	4.32^{Bb} ±0.02	4.24^{Ac} ±0.02	4.21^{Bc} ±0.00	4.29^{Bb} ±0.01
4	4.31^{Acd} ±0.01	4.28^{Acde} ±0.02	4.23^{Ade} ±0.02	4.25^{Ade} ±0.01	4.24^{Ade} ±0.03	4.94^{Aa} ±0.08	4.57^{Ab} ±0.01	4.31^{Acd} ±0.03	4.33^{Ac} ±0.00	4.54^{Ab} ±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 ($p<0.05$).

Table 45
Effects of modified atmosphere packaging (MAP) with different packaging materials on total plate count (Log CFU g^{-1}) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Ca} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01	2.87^{Da} ±0.01
2	3.92^{Cabc} ±0.08	3.85^{Ccde} ±0.01	3.79^{Cef} ±0.01	3.73^{Bf} ±0.04	3.81^{Cdef} ±0.01	4.00^{Ca} ±0.04	3.96^{Cab} ±0.02	3.82^{Cdef} ±0.05	3.81^{Cdef} ±0.01	3.89^{Cbcd} ±0.03
4	4.21^{Bbc} ±0.00	4.21^{Bbc} ±0.01	4.13^{Bf} ±0.01	4.17^{Ade} ±0.01	4.19^{Bcd} ±0.01	4.62^{Ba} ±0.03	4.24^{Bb} ±0.01	4.15^{Bef} ±0.01	4.21^{Bbc} ±0.01	4.19^{Bcd} ±0.01
6	4.54^{Ab} ±0.03	4.28^{Ade} ±0.01	4.18^{Ag} ±0.00	4.23^{Af} ±0.01	4.25^{Adef} ±0.01	5.22^{Aa} ±0.02	4.58^{Ab} ±0.01	4.24^{Aef} ±0.03	4.29^{Ad} ±0.01	4.49^{Ac} ±0.02

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 46
Effects of modified atmosphere packaging (MAP) with different packaging materials on *Lactobacillus* count (Log CFU g^{-1}) of shallot puree stored at 15±1 °C for 4 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	2.09^{Da} ±0.13	2.09^{Da} ±0.13	2.09^{Da} ±0.13	2.09^{Da} ±0.13	2.09^{Da} ±0.13	2.09^{Ca} ±0.13	2.09^{Ea} ±0.13	2.09^{Da} ±0.13	2.09^{Ca} ±0.13	2.09^{Da} ±0.13
1	3.21^{Ce} ±0.01	3.01^{Ch} ±0.02	3.15^{Cf} ±0.02	3.39^{Cc} ±0.01	3.43^{Cbc} ±0.01	3.27^{Bd} ±0.01	3.09^{Dg} ±0.03	3.23^{Ce} ±0.02	3.44^{Bb} ±0.01	3.51^{Ca} ±0.01
2	3.77^{Be} ±0.01	3.71^{Bf} ±0.00	3.73^{Bf} ±0.01	3.82^{Bcd} ±0.01	3.85^{Bc} ±0.01	3.89^{Ab} ±0.02	3.77^{Ce} ±0.01	3.79^{Bde} ±0.03	3.92^{Ab} ±0.01	3.96^{Ba} ±0.01
3	3.93^{Ade} ±0.00	3.90^{Ae} ±0.00	3.94^{Acde} ±0.01	3.96^{ABbcd} ±0.00	3.99^{ABabc} ±0.02	3.97^{Abcd} ±0.03	3.95^{Bcd} ±0.01	3.97^{Abcd} ±0.03	4.01^{Aab} ±0.03	4.03^{ABa} ±0.01
4	3.97^{Ad} ±0.02	3.95^{Ad} ±0.01	4.01^{Acd} ±0.01	4.05^{Ac} ±0.03	4.07^{Abc} ±0.01	3.97^{Ad} ±0.00	4.16^{Aa} ±0.02	4.05^{Ac} ±0.06	4.07^{Abc} ±0.04	4.13^{Aab} ±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 ($p<0.05$).

Table 47
Effects of modified atmosphere packaging (MAP) with different packaging materials on *Lactobacillus* count (Log CFU g^{-1}) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13	2.09^{Da} ±0.13	2.09^{Da} ±0.13	2.09^{Ca} ±0.13	2.09^{Ca} ±0.13
2	3.09^{Bf} ±0.01	2.84^{Bf} ±0.01	3.02^{Bg} ±0.04	3.17^{Be} ±0.00	3.34^{Bc} ±0.01	3.37^{Bbc} ±0.01	2.97^{Ch} ±0.03	3.26^{Cd} ±0.00	3.39^{Bb} ±0.01	3.43^{Ba} ±0.01
4	3.58^{Ad} ±0.03	3.44^{Ag} ±0.01	3.51^{Aef} ±0.00	3.62^{Acd} ±0.02	3.71^{Aa} ±0.04	3.65^{Abc} ±0.02	3.47^{Bfg} ±0.01	3.56^{Bde} ±0.06	3.69^{Aab} ±0.01	3.74^{Aa} ±0.01
6	3.70^{Ac} ±0.01	3.56^{Ad} ±0.03	3.69^{Ac} ±0.00	3.77^{Ab} ±0.02	3.83^{Aa} ±0.00	3.77^{Ab} ±0.01	3.68^{Ac} ±0.02	3.78^{Ab} ±0.03	3.81^{Aab} ±0.01	3.85^{Aa} ±0.02

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 48
Effects of modified atmosphere packaging (MAP) with different packaging materials on coliforms (MPN g^{-1}) 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	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
4	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
8	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
10	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
12	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table 49
Effects of modified atmosphere packaging (MAP) with different packaging materials on coliforms (MPN g^{-1}) of shallot puree stored at 15±1 °C for 4 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	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
3	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
4	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table 50
Effects of modified atmosphere packaging (MAP) with different packaging materials on coliforms (MPN g^{-1}) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
4	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table 51
Effects of modified atmosphere packaging (MAP) with different packaging materials on *Pseudomonas* spp. count (CFU g^{-1}) 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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
6	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
8	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
12	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 52
Effects of modified atmosphere packaging (MAP) with different packaging materials on *Pseudomonas* spp. count (CFU g^{-1}) of shallot puree stored at 15±1 °C for 4 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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
1	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
3	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 53
Effects of modified atmosphere packaging (MAP) with different packaging materials on *Pseudomonas* spp. count (CFU g^{-1}) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
6	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 54
Effects of modified atmosphere packaging (MAP) with different packaging materials on yeast and moulds count (CFU g^{-1}) 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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
6	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
8	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
12	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 55
Effects of modified atmosphere packaging (MAP) with different packaging materials on yeast and moulds count (CFU g^{-1}) of shallot puree stored at 15±1 °C for 4 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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
1	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
3	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 56
Effects of modified atmosphere packaging (MAP) with different packaging materials on yeast and moulds count (CFU g^{-1}) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10
6	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Table 57
Effects of modified atmosphere packaging (MAP) with different packaging materials on pH value of shallot puree stored at 15±1 °C for 4 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	4.35^{Aa} ±0.01	4.35^{Aa} ±0.01	4.35^{Aa} ±0.01	4.35^{Aa} ±0.01	4.35^{ABa} ±0.01	4.35^{ABa} ±0.01	4.35^{ABa} ±0.01	4.35^{ABa} ±0.01	4.35^{ABa} ±0.01	4.35^{Aa} ±0.01
1	4.36^{Aa} ±0.01	4.36^{Aa} ±0.00	4.36^{Aa} ±0.01	4.36^{Aa} ±0.00	4.36^{Aa} ±0.01	4.35^{ABa} ±0.00	4.35^{ABa} ±0.01	4.37^{Aa} ±0.01	4.37^{Aa} ±0.00	4.37^{Aa} ±0.01
2	4.36^{Aa} ±0.00	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.37^{Aa} ±0.01	4.36^{Aa} ±0.00	4.37^{Aa} ±0.00	4.37^{Aa} ±0.01	4.37^{Aa} ±0.01	4.37^{Aa} ±0.00	4.37^{Aa} ±0.00
3	4.33^{Bc} ±0.01	4.35^{Aab} ±0.01	4.35^{Aabc} ±0.01	4.36^{Aa} ±0.01	4.33^{BCbc} ±0.01	4.35^{Babc} ±0.01	4.34^{Babc} ±0.01	4.35^{ABab} ±0.00	4.35^{BCabc} ±0.01	4.35^{Aab} ±0.01
4	4.29^{Ccd} ±0.01	4.29^{Bcde} ±0.01	4.19^{Bcde} ±0.00	4.29^{Bde} ±0.01	4.31^{Cbcd} ±0.01	4.27^{Ce} ±0.01	4.31^{Cabc} ±0.00	4.33^{Ba} ±0.01	4.33^{Ca} ±0.01	4.33^{Bab} ±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 ($p<0.05$).

Table 58
Effects of modified atmosphere packaging (MAP) with different packaging materials on pH value of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01	4.36^{Aa} ±0.01
2	4.35^{Ba} ±0.00	4.35^{ABa} ±0.00	4.36^{Aa} ±0.00	4.34^{ABab} ±0.01	4.35^{ABa} ±0.00	4.33^{Bb} ±0.00	4.36^{Aa} ±0.01	4.35^{Aa} ±0.01	4.34^{ABab} ±0.01	4.35^{ABa} ±0.00
4	4.33^{BCc} ±0.02	4.35^{Babc} ±0.01	4.35^{Aabc} ±0.01	4.35^{ABabc} ±0.01	4.33^{Bbc} ±0.01	4.33^{Bc} ±0.01	4.36^{Aab} ±0.01	4.36^{Aa} ±0.01	4.34^{ABabc} ±0.01	4.34^{Babc} ±0.01
6	4.32^{Cb} ±0.01	4.33^{Cb} ±0.00	4.35^{Aa} ±0.00	4.33^{Bb} ±0.01	4.32^{Cb} ±0.01	4.33^{Bb} ±0.01	4.36^{Aa} ±0.00	4.36^{Aa} ±0.00	4.33^{Bb} ±0.00	4.33^{Cb} ±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 ($p<0.05$).

Table 59
Effects of modified atmosphere packaging (MAP) with different packaging materials on total soluble solids content (°Brix) of shallot puree stored at 15±1 °C for 4 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	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{ABa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00
1	19.55^{Aa} ±0.07	19.65^{Aa} ±0.07	19.65^{Aa} ±0.07	19.55^{Aa} ±0.07	19.55^{Aa} ±0.07	19.55^{ABa} ±0.07	19.55^{Aa} ±0.07	19.55^{Aa} ±0.07	19.60^{Aa} ±0.00	19.55^{Aa} ±0.07
2	19.65^{Aa} ±0.07	19.60^{Aa} ±0.00	19.65^{Aa} ±0.07	19.65^{Aa} ±0.07	19.65^{Aa} ±0.07	19.60^{Aa} ±0.00	19.55^{Aa} ±0.07	19.65^{Aa} ±0.07	19.55^{Aa} ±0.07	19.55^{Aa} ±0.07
3	19.60^{Aa} ±0.07	19.55^{Aa} ±0.07	19.55^{ABa} ±0.07	19.65^{Aa} ±0.07	19.60^{Aa} ±0.00	19.65^{Aa} ±0.07	19.65^{Aa} ±0.07	19.60^{Aa} ±0.00	19.65^{Aa} ±0.07	19.65^{Aa} ±0.07
4	19.55^{Aa} ±0.00	19.55^{Aa} ±0.07	19.45^{Aab} ±0.07	19.55^{Aa} ±0.07	19.55^{Aa} ±0.07	19.45^{Bab} ±0.07	19.35^{Bb} ±0.07	19.35^{Bb} ±0.07	19.35^{Bb} ±0.07	19.60^{Aa} ±0.00

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 60
Effects of modified atmosphere packaging (MAP) with different packaging materials on total soluble solids content (°Brix) of shallot puree stored at 25±1 °C for 6 days

Storage period (day)	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	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00
2	19.55^{Aa} ±0.07	19.45^{Ba} ±0.07	19.60^{Aa} ±0.07	19.55^{Aa} ±0.07	19.60^{Aa} ±0.00	19.50^{ABa} ±0.07	19.55^{Aa} ±0.07	19.60^{Aa} ±0.00	19.55^{Aa} ±0.07	19.45^{Ba} ±0.07
4	19.35^{Bc} ±0.07	19.45^{Bbc} ±0.07	19.45^{Bbc} ±0.07	19.60^{Aa} ±0.00	19.55^{Aab} ±0.07	19.45^{BCbc} ±0.07	19.55^{Aab} ±0.07	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.55^{ABab} ±0.07
6	19.25^{Cbc} ±0.07	19.55^{ABa} ±0.07	19.35^{Cb} ±0.00	19.60^{Aa} ±0.00	19.60^{Aa} ±0.00	19.15^{Cc} ±0.14	19.60^{Aa} ±0.00	19.45^{Bab} ±0.07	19.55^{Aa} ±0.07	19.45^{Bab} ±0.07

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 61
Coliforms, *Pseudomonas* spp., and yeast and moulds counts of control and 10% CO_2 Ony/LLDPE packaging of shallot puree during storage at 5±1 °C for 12 weeks

Storage period (week)	Coliforms (MPN g^{-1})		*Pseudomonas* spp. count (CFU g^{-1})		Yeast and Moulds count (CFU g^{-1})	
	Control	10% CO_2 Ony/LLDPE	Control	10% CO_2 Ony/LLDPE	Control	10% CO_2 Ony/LLDPE
0	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
2	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
4	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
6	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
8	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
10	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10
12	<3.0	<3.0	<1.0X10	<1.0X10	<1.0X10	<1.0X10

Appendix C

(Plates)

Plate 1. Control shallot puree (no treatment).

Plate 2. Heated shallot puree.

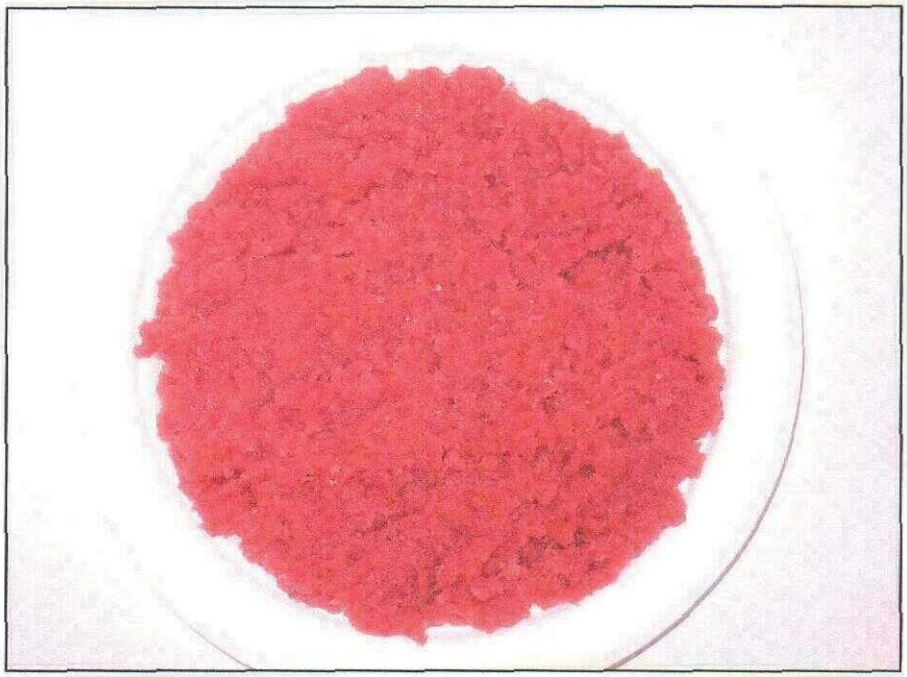

Plate 3. Acidified shallot puree.

Plate 4. Acidified + heated shallot puree.

Plate 5. **Shallot puree packed in Ony/LLDPE after 12 weeks storage at 5 °C (Control).**

Plate 6. **Shallot puree packed with 10% CO_2 in Ony/LLDPE after 12 weeks storage at 5 °C.**

Appendix D

(List of Publications)

1. **Noor Azizah, A.,** Russly, A.R., Azizah, O., Salmah, Y. and Hasimah, H.A. (2005). Effects of different temperatures on quality changes of shallot puree. *Proc. 9th ASEAN Food Conference 05 Jakarta Indonesia*, 8 -10 August 2005. PFPC14.

2. **Noor Azizah, A.,** Russly, A.R., Azizah, O., Salmah, Y., Razali, M. and Hasimah, H.A. (2006). Production of shallot (Allium ascalonium) puree using different processing methods. *Paper presented at 5th Food Science and Technology Seminar 2006, KUSTEM Kuala Terengganu*, 2-3 September 2006. (Poster)

3. **Ahmad, N.A.,** Abdul Rahman, R., Osman, A., Yusof, S., Mustaffa, R. and Karim, N. (2007). Effect of different packaging materials on quality of shallot puree during storage. Proc. 10th ASEAN Food Conference 07 Kuala Lumpur, Malaysia, 21-23 August 2007. PE(2)-23

4. **Noor Azizah Ahmad,** Russly Abdul Rahman, Azizah Osman, Salmah Yusof, Razali Mustaffa and Hasimah Hafiz Ahmad. (2008). Establishment of processing parameters for production of shallot (Allium ascalonium) puree during storage. (Submitted to LWT-Food Science and Technology, LWT-D-08-00855)

5. **Noor Azizah, A.,** Russly, A.R., Azizah, O., Razali, M. and Ngadiman, K. (2008). Effect of modified atmosphere packaging storage on physico-chemical characteristic of shallot (Allium ascalonium) puree. (Submitted to J. Trop. Agric. and Fd. Sc.)

Biodata of Student

Noor Azizah Ahmad was born on March 10, 1972 in Pengkalan Chepa, Kelantan Darul Naim. She started her primary education at Sekolah Kebangsaan Parang Puting and secondary lower education at Sekolah Menengah Pengkalan Chepa, Kelantan Darul Naim. Then she continues her form four at MARA Junior Science Collage, Kuala Terengganu, Terengganu Darul Iman. She enrolled at MARA Institute of Technology in 1990 for a Diploma in Food Technology. Upon completion of the 4 years course, she enrolled for a Bachelor's Programme and successfully graduated with a Bachelor Science and Food Technology in 1997 at University Putra Malaysia. She then worked as a Research Officer in the Food Technology Research Centre at Malaysian Agricultural Research and Development Institute (MARDI). After 5 years in service, she did her Master's Programme.