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EFFECT OF PACKAGING MATERIALS AND STORAGE CONDITIONS ON FRESH CUT CARROT

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Abstract

In order to meet the rising demand of the consumers, various techniques have been developed to maintain the quality. The study was designed to evaluate the effects of packaging materials and storage conditions on fresh cut carrot (*Daucus carrota* L). Packaging materials were 25, 50, 100 micron and foil paper with respect to storage temperature: ambient temperature, 3 to 7°C & -18°C. Packaging material and their effects in respect of storage condition of fresh cut carrot and quality attributes-such as total weight loss, color, flavor, texture change, moisture content, vita-C content and conductivity were judged by the experiment and skilled panelists respectively. Conductivity decreased with respect to duration of storage. The low temperature treatment (3 to 7°C) and the packaging material (100 micron) followed by carrot treatment reduced weight loss, vitamin C and conductivity and of all the sensory characteristics remain comparatively well than other packaging materials and conditions. Bacterial and fungal growth also remain comparatively low than other packaging materials. The exhibited maximum moisture loss during thawing but color and flavor remain acceptable till the 9th day of experiment. In normal condition of all the product produced off odor and slimy appearance on surface because of which we discarded the package after 5th days of experiment. From the overall observation it was showed that packaging with 100 micron polyethylene and storage in chilling temperature was the best combination to store the fresh-cut carrot.

Key words: Fresh-cut carrot, Packaging, Storage conditions, Shelf-life

Introduction

The recent trend for fresh cut produce industry is showing exponential high in many countries, especially in large metropolitan cities in both fruits (54%) and vegetable (46%). The fresh cut produce focuses on the freshness, convenience and it's spurred by health attributes attached to

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it. Minimal processing (fresh cut) comprises selection, washing, peeling and cutting (Cantwell, 2000) producers that are aimed at producing a product that is fresh and convenient to prepare and consume (Burns, 1995). Among vegetables, carrots (*Daucus carota* L.) are now increasingly consumed, mainly due to their pleasant flavor and perceived health benefits related to their vitamins, minerals and dietary fiber (Alasalvar *et al.*, 2001). Carrots have been ranked tenth in terms of their nutritional value among 38 other fruits and vegetables, and seventh for their contribution to nutrition. Generally, consumer prefers to consume fresh vegetable due to their valuable benefits. The goal of fresh cut products is to maintain the freshness of the product without any reduction on its nutrient content and also to extend the self-life of the product. Fruits and vegetables which is processed by minimally-processing are prepared for easiness for consumption and distribution (King and Bolin, 1989). Carrot is one of the commodities that prone to get damage and it needs to have proper handling after harvesting to ensure its quality till reaching the consumer. Storage temperature can prolong the shelf life of fresh vegetable. Packaging also play an important role in preventing the decaying process. The packaging aims to evade the physical and chemical damage. Packaging not only plays a barrier property to protect the product from environmental obstacles and harmful germs and insects but also it works as a trade mark of their products (Highland, 1981). Several polymer types are currently used for foodstuff packaging to prevent the entrance of pests and contaminations. Based on above discussion, the current study was designed to know the quality of fresh cut carrot during its storage at different temperatures and different packaging materials.

Materials and Methods

Study area

The experiment was conducted in the Laboratories of the Department of Food Technology and Nutritional Science (FTNS) of Mawlana Bhashani Science and Technology University (MBSTU), Department of Food Engineering (FE) of Dhaka University of Engineering and Technology (DUET), Gazipur, Bangladesh.

Sample collection and preparation

Matured and fresh carrot was purchased from a local area of Santosh Bazar, Tangail, Bangladesh. The carrot previously selected for firmness, absence of mechanical damage and fungal infection, and subsequently prewashed in cold water and placed in cold room at 10°C for later processing. Packaging material such as polyethylene of different width such as 25 µm, 50µm, 100µm micron and foil paper were used. After collecting the carrot they were washed and shredded in same size by shredder machine. After this, the carrots were weighed in weighing machine and 50gm for every package was weighed. All the packaging materials were sterilized by ultra violet ray at least for 5 minutes, then packed and sealed by electric sealer. Then it was kept at three different storage condition for their

further test such as weight loss, vitamin C, conductivity, microbial count, sensory (color, flavor, texture) evaluation etc.

Sample analysis

Sample quality was analyzed by visual observation. Three trained panelist were scored the color, flavor and texture of each sample separately by using the hedonic scale recommended by Baker (1961). Weight loss and vitamin-C content were estimated according to the methods by (Ranganna, 2003). Conductivity was measured by conductivity meter (Zubehorbox Cond, Germany). Total plate count for bacteria and fungus were estimated by the method used by Ranganna (2003).

Statistical analysis

Results of three replicates were used for statistical analysis. The values were expressed as the mean. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS-21) for Windows. The Duncan test was performed to evaluate the significant differences among mean values. The confidence limits used in this study were based on 95% ($P < 0.05$).

Results and Discussion

Effect of storage condition on sensory properties of fresh cut carrot

Changes of sensory parameters of fresh-cut carrot varied during storage at normal (ambient), chilling (4-5°C) and freezing (-18°C) temperature (Table 1). During ambient condition of storage 25µm polyethylene and foil paper had negative effect on fresh cut carrot. Cell rupture occurred high in carrot stored in foil paper and higher amount of water leached out inside the bag. In fifth day of storage at least one of the three members in sensory panel dislikes slightly the color or flavor of fresh cut carrot. It seemed that packaging material 100µm retained well the physical condition of carrot compared with other packaging material.

It seemed that packaging material such as polyethylene 100µm retains well the physical condition of carrot comparing other packaging materials. According to the hedonic scale, of all the product storage in chilling temperature remained well. Table 1 also displayed that fresh cut carrot storage at freezing temperature (-18˚C) different packaging materials showed different characteristics. In the freezing temperature fresh cut carrot showed abrupt distortion of its texture and become soft during thawing and though a lot of water leaching out from carrot. Fresh cut carrot couldn't retain its body structure and distortion occurred and it lost it's free water. It seemed that packaging material such as polyethylene 100 µm retained well the physical condition of carrot comparing other packaging materials. According to the hedonic scale, of all the product storage in freezing temperature remained well.

Table 1. Sensory evaluation of fresh cut carrot in normal, chilling and freezing condition concerning different packaging material

Packaging materials	Day	Normal condition			Chilling condition			Freezing condition		
		Color	Flavor	Texture	Color	Flavor	Texture	Color	Flavor	Texture
25µ	1	8.3	8	9	-	-	-	-	-	-
	2	7.6	7.3	7.3	8.6	8.3	8.3	8.3	8.3	7
	3	5.6	6	5.6	-	-	-	-	-	-
	4	5	5.3	5.3	8.3	7.3	7.6	7	7.3	6.3
	5	4.6	4.6	5	-	-	-	-	-	-
	6	-	-	-	8	7	7	6.6	6.3	5.6
	8	-	-	-	7.6	6	6	6.3	6	5.3
50µ	1	9	8.6	9	-	-	-	-	-	-
	2	8.6	7.3	7.3	9	8.3	8.6	8.3	8.3	7.6
	3	7.6	6.6	6.6	-	-	-	-	-	-
	4	7	5.3	5.3	8.6	7.6	7.6	7.6	7.6	6.6
	5	6.6	5	5	-	-	-	-	-	-
	6	-	-	-	8.3	7.3	7.3	7	7	6
	8	-	-	-	7.6	6	6.6	6.3	6.3	5.6
100µ	1	9	8	8	-	-	-	-	-	-
	2	8.6	7.6	7.6	9	8.6	9	8.6	8.3	7.6
	3	8.3	7	6.6	-	-	-	-	-	-
	4	7	6.3	5.3	8.6	8	8.3	7.6	7.6	7
	5	6.6	5.6	5	-	-	-	-	-	-
	6	-	-	-	8.3	7.6	7.6	7	7	6.3
	8	-	-	-	7.6	7	7.3	6.3	6.3	5.3
Foil	1	8.6	8.6	7	-	-	-	-	-	-
	2	8.3	7.6	6.6	8	8	8.3	8.3	8	7.3
	3	8	6.6	5.6	-	-	-	-	-	-
	4	7	5.3	5.3	7.3	7.3	7.6	7.3	7.3	6.3
	5	5	4	4.3	-	-	-	-	-	-
	6	-	-	-	6.6	6	7	6.3	6.6	5.6
	8	-	-	-	6	5.3	6	5.6	5.3	5

Moisture loses in different conditions

It was showed (Fig. 1) that during ambient condition of storage 25µm polyethylene and foil paper had negative effect on fresh cut carrot. Cell rupture occurred high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day. About 10% water lost from fresh cut carrot storage in foil paper. Fresh cut in 25µm polyethylene lost also 10% water but it showed that the loss of water does not same during the first day to last day. Water has lost abruptly in forth day and approximately estimated double loss in fifth day. Packaging material 50µm preserved the

moisture as well as weight best among of all the packaging material used in normal condition.

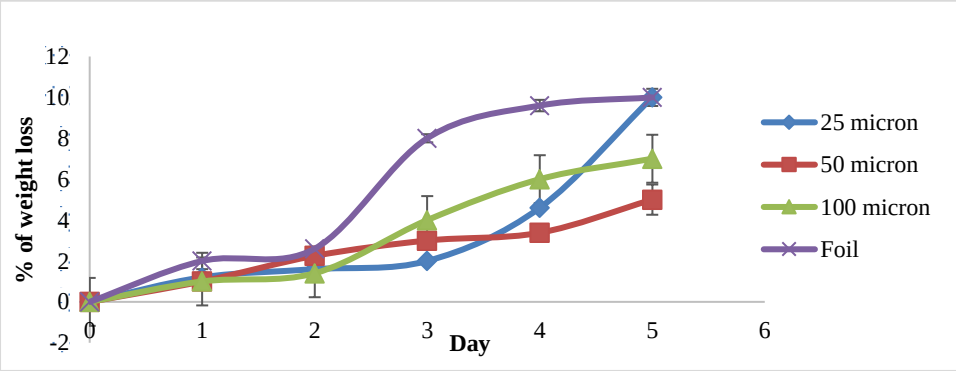

Fig. 1. Comparison of weight loss during normal condition concerning different packaging material

Losing water of fresh cut carrot from packaging material 25µm and 100µm showed a continuous process. Carrot storage in 100µm lost approximately 8% moisture at the end day of study. Packaging material 25µm lost 9% moisture. Foil paper and packaging material 50µm lost highest amount of water in chilling condition. Carrot storage at foil paper and 50µm lost approximately 14% moisture.

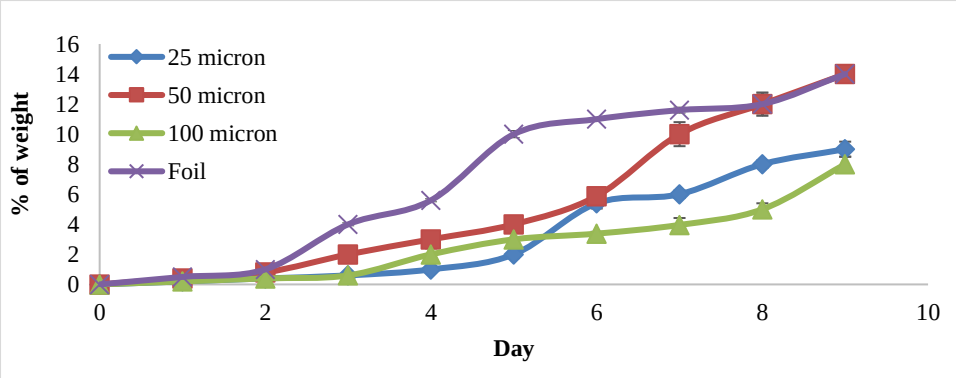

Fig. 2. Comparison of moisture lose from different packaging material at chilling Temperature

It is (Fig. 3) revealed that fresh cut carrot storage at freezing temperature (-18°C) different packaging materials showed different characteristics. In the freezing temperature fresh cut carrot showed abrupt distortion of its texture and become soft during thawing and though a lot of water leaching out from carrot. Fresh cut carrot couldn't retain its body structure and distortion occurred and it lost it's free water. Carrot storage at freezing temperature in 100µm lost about 20% moisture at ninth day. Carrot stored in packaging material of 50µm lost approximately 18.2% moisture at the last day of the study. Product storage in foil paper lost 14% moisture at the last day. Product that was stored at packaging material of 25µm lost approximately 13% moisture.

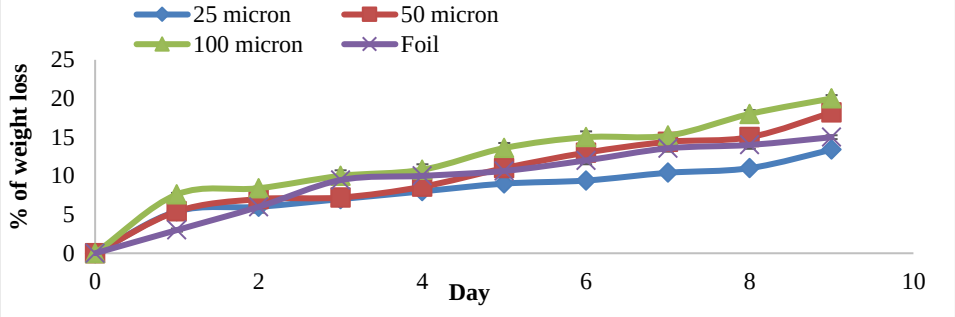

Fig. 3. Comparison of vitamin C loses in sample storage in freezing condition concerning different packaging material

Loss of Vitamin C in different storage conditions

Comparison of vitamin C loss in different packaging material during storage at ambient temperature, chilling temperature and freezing temperature is presented in Figs. 4, 5 and 6 respectively. Fig.4 showed that during ambient condition of storage foil paper and 25µm had negative effect on fresh cut carrot. Cell rupture occurred high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. As vitamin C is a water soluble vitamin and though it was leached out with water. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day. About 10% water lost from fresh cut carrot storage in foil paper simultaneously and it lost higher amount of vitamin C at the initial day the amount of vitamin C in carrot found in about 17.73 mg /100gm of carrot. But at the fifth day the amount decreased at 5.1 mg/100gm of carrot. Packaging material 50µm and 100µm retained approximately same amount of vitamin C.

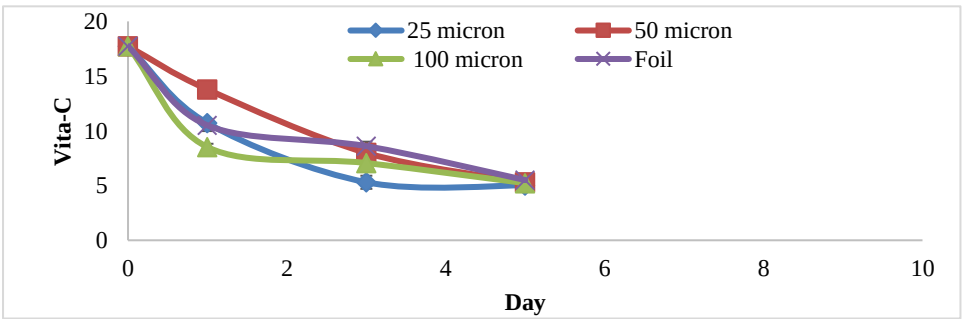

Fig. 4. Comparison of vitamin C lose from different packaging material at normal condition

In this study Fig. 5, demonstrated that during chilling condition of storage foil paper and 25µm had negative effect on fresh cut carrot. Cell rupture occurred in carrot storage in foil paper under chilling condition and though higher amount of water leaching out inside

the bag. As vitamin C is a water soluble vitamin and though it was leached out with water. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day. About 10% water lost from fresh cut carrot storage in foil paper simultaneously it lost higher amount of vitamin C. At the initial day the amount of vitamin C in carrot found in about 17.73mg /100gm of carrot. But at the ninth day the amount was decreased up to 4.10mg. Packaging material 25µm retained approximately 3.98mg vitamin C per 100gm of carrot.

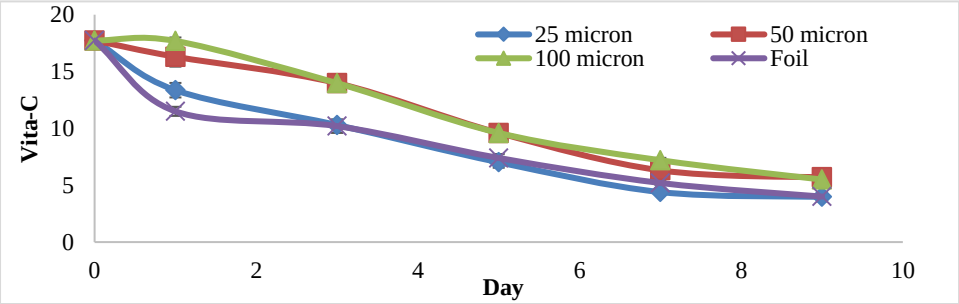

Fig. 5. Comparison of vitamin C lose in sample storage in freezing condition concerning different packaging material

The freezing temperature have negative effect on fresh cut carrot. Cell rupture occurred in carrot storage in freezing condition and though higher amount of water leaching out inside the bag (Fig. 6). As vitamin C is a water soluble vitamin and though it was leached out with water. Carrot storage in foil paper lost approximately about 5.35gm of vitamin C. At the initial day the amount of vitamin C in carrot was found in about 17.73mg /100gm of carrot. But at the ninth day the amount decreased at 5.35mg. Packaging material 25µm retained approximately 2.61mg vitamin C per 100gm of carrot.

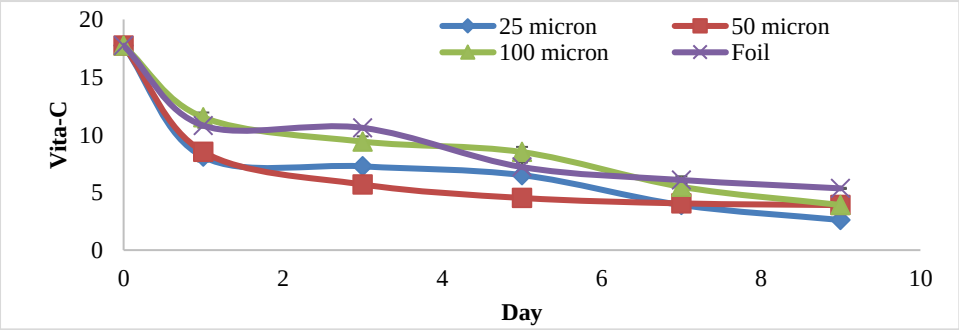

Fig. 6. Comparison of vitamin C lose in sample storage in freezing condition concerning different packaging material

Packaging material 50µm retained 3.9mg vitamin C per 100gm of carrot. Packaging material 100µm contained 3.91mg vitamin C per 100gm of carrot. Packaging material 50µm retained 5.69mg vitamin C per 100gm of carrot. Packaging material 100µm contained 5.5mg vitamin C per 100gm of carrot.

Conductivity in different conditions

Effect of packaging material on conductivity of fresh cut carrot at ambient, chilling and freezing temperature is presented in Figs. 7, 8 and 9 respectively. After analyzing the result (Fig. 7) it was exhibited that during ambient condition of storage in 25µm and foil paper had negative effect on fresh cut carrot. Cell rupture occurred high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. As water loses from carrot electrolytes also leaching out and though conductivity also decreased day by day. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day and conductivity also decreased. Packaging material 25µm lost conductivity at a minimum level. At the initial day the conductivity measured by conductivity meter approximately 4.10ms/cm and at the fifth day of fresh cut carrot storage at ambient condition in 25µm showed conductivity about 2.93ms/cm same as foil paper about 2.94ms/cm.

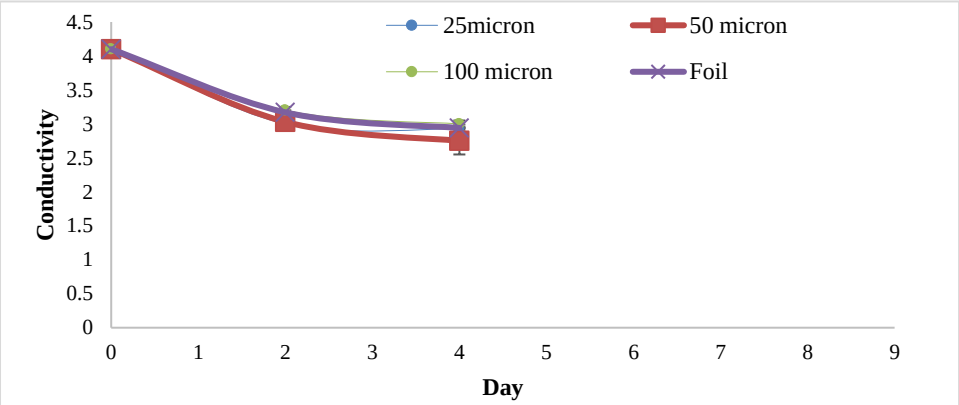

Fig. 7. Change of conductivity during normal condition concerning different packaging material

Fig. 8 showed that during chilling condition of storage carrot became soft after releasing heat. Cell rupture occurred high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. As water loses from carrot electrolytes also leaching out and though conductivity also decreased day by day. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day and conductivity also decreased. Packaging material foil lost conductivity most. At the initial day the conductivity measured by conductivity meter approximately 4.10ms/cm and at the ninth day fresh cut carrot storage at chilling condition in foil paper showed conductivity about 2.10ms/cm. The conductivity of fresh cut carrot in 25µ and 100µ polyethylene package were reduced to 2.35 and 3.25ms/cm respectively at the ninth day of storage. Carrot storage in packaging material 25 µm gave reading in conductivity meter approximately 2.23ms/cm at the ninth day. Carrot in 50µm and 100µm gave reading in conductivity meter about 3.47ms/cm and 3.0µm at the ninth day of the study. During freezing condition of storage carrot become soft after releasing heat. Cell rupture occurred in

carrot storage in foil paper and though higher amount of water leaching out. As water loses from carrot, electrolytes also leaching out and though conductivity of fresh cut carrot with storage time also decreased.

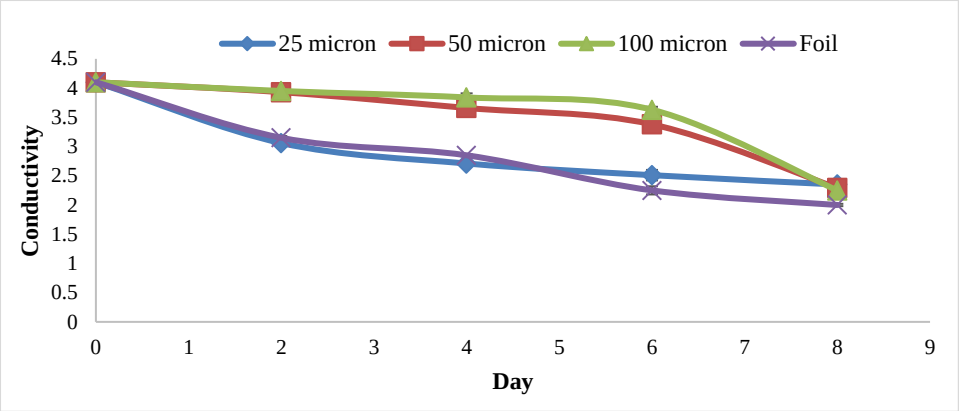

Fig. 8. Comparison of conductivity change in sample day by day concerningvarious packaging material

Fig. 9 exhibited that carrot storage in foil paper lost higher percentage of water from first day and it continued till last day and conductivity also decreased. Carrot storage in packaging material foil paper lost conductivity most. At the initial day the conductivity measured by conductivity meter approximately 4.10ms/cm and at the ninth day fresh cut carrot storage at freezing condition in foil paper showed conductivity 2.10ms/cm.

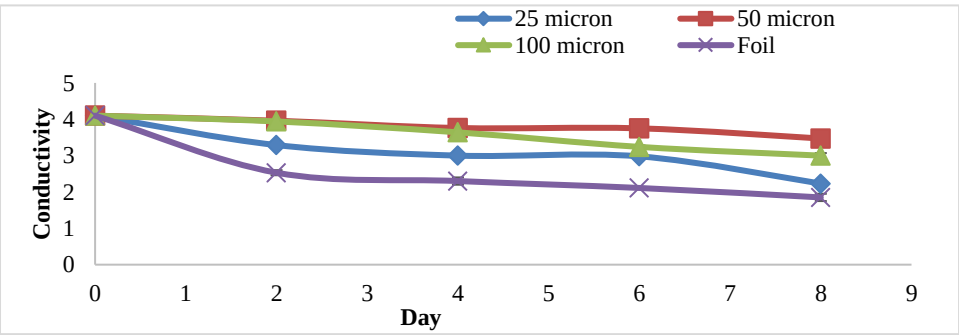

Fig. 9. Comparison of conductivity change in sample day by day storage infreezing condition concerning various packaging material

Bacterial growth in different conditions

Bacterial growth of fresh cut carrot storage at ambient, chilling and freezing temperature in different packaging material are presented in Fig. 10, 11 and 12 respectively. During ambient condition of storage in 25µm and foil paper had negative effect on fresh cut carrot. Cell rupture occurred high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day and therefore bacteria got enough moisture to grow.

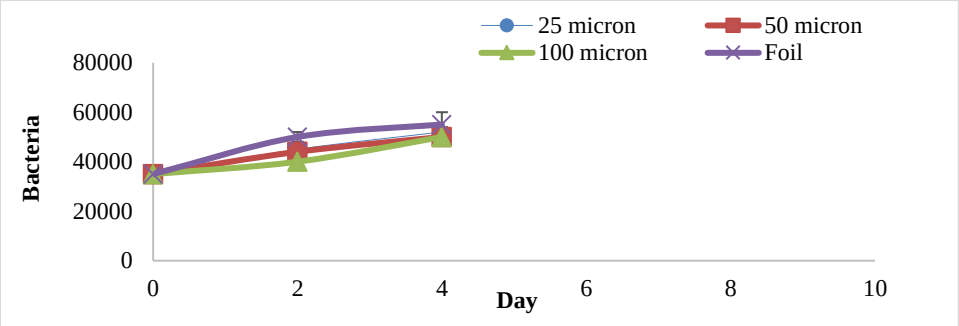

Fig. 10. Bacterial growth count during normal condition concerning different packaging material

Microbial count showed that the foil paper provides most favorable condition for bacterial growth. In the initial day the number of bacteria found about 35000 and the fifth day it was about 55000 in foil paper. In the chilling temperature fresh cut carrot showed abrupt distortion of its texture and become soft during releasing temperature and though water leaching out from carrot. Losing water of fresh cut carrot from packaging material 2 µm and 100µm showed a continuous process. Carrot in foil paper and packaging material, 50µm polyethylene lost highest amount of water in chilling condition. Carrot storage at foil paper and 50µm lost14% moisture and though it provided better opportunity for bacterial growth. In the chilling temperature mesophillic bacteria could survive and after that getting favorable condition bacterial growth occurred more. Microbial count showed that foil paper provided most favorable condition for bacterial growth. In the normal sense the different in the number of bacteria found in different sample storage in chilling temperature within different packaging material did not cut a grate fact in this case. In the initial day the number of bacteria found about 35000 and the ninth day it was about 55000 in foil paper. At the same time carrot storage polyethylene 25µm, 50µm and 100µm had the number of bacteria about 53000, 55000 and 51000 in this condition.

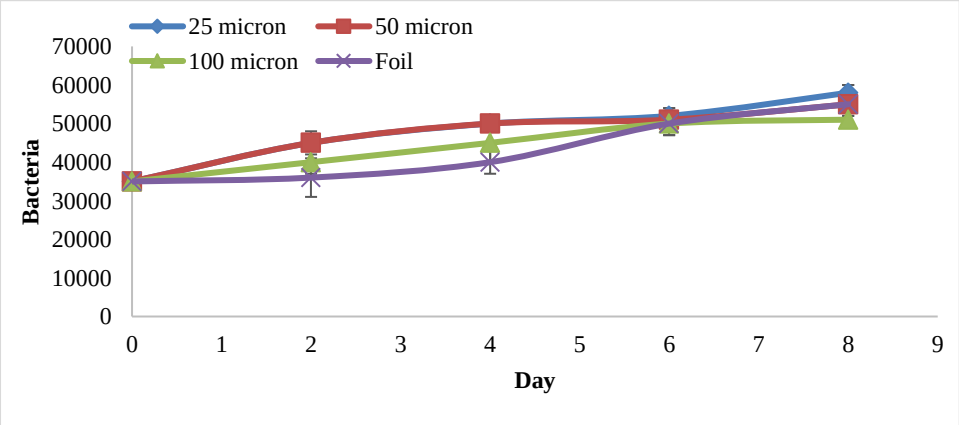

Fig. 11. Comparison of bacterial growth in chilling condition concerning differentpackaging material

In the freezing temperature fresh cut carrot showed abrupt distortion of its texture and became soft and lost highest amount of water. In the freezing temperature cyst of mesophillic bacteria could survive and after that getting favorable condition bacterial growth occurred more. In the initial day the number of bacteria found about 35000 and the ninth day it was about 58000 in fresh cut storage in polyethylene 50µm. At the same time carrot storage in polyethylene 25µm, 100µm and foil paper had the number of bacteria about 52000, 50000 and approximately 50000 in the freezing temperature.

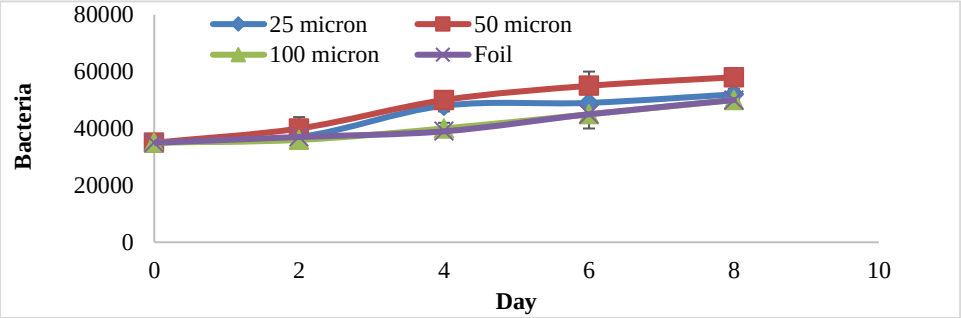

Fig. 12. Comparison of bacterial growth storage in freezing condition concerning different packaging material

Fungal growth in different condition

Fig. 13, 14 and 15 are represented the effect of packaging material on fungal growth in fresh cut carrot stored in ambient, chilling and freezing temperature respectively.

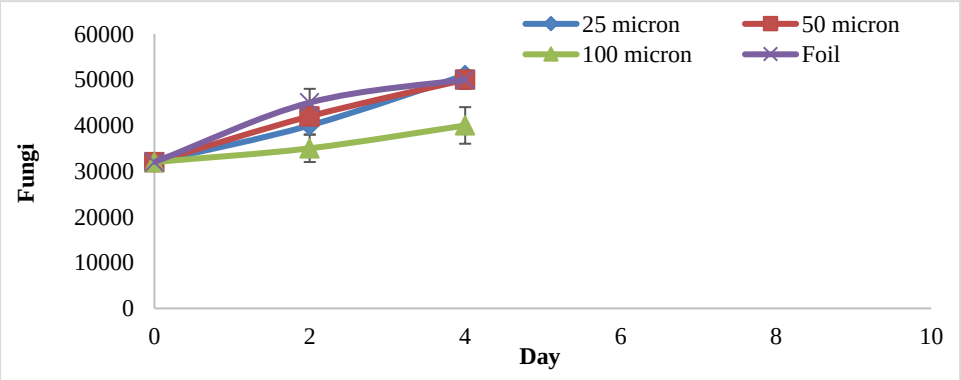

Fig. 13. Comparison of fungal growth during normal condition concerning different packaging materials

During ambient condition of storage in 25µm and foil paper had negative effect on fresh cut carrot. Cell rupture occurred was high in carrot storage in foil paper and though higher amount of water leaching out inside the bag. Carrot storage in foil paper lost higher percentage of water from first day and it continued till last day and though fungi got enough moisture to grow. In normal appearance slimy layer found at the last days of

storage. Microbial count showed that 25µm polyethylene provided most favorable condition for fungal growth. In the normal sense the different in the number of fungi found in different sample storage in ambient condition in different packaging material had not so much difference except 100µm. In the initial day the number of fungi found about 32000 and the fifth day the fungal no increased to 100µm polyethylene. In this storage condition 25µm polyethylene provide most favorable condition for fungal growth.

Fungi growth count of fresh cut carrot storage in chilling condition within different packaging material showed in Fig. 14. In the chilling temperature fresh cut carrot showed abrupt distortion of its texture and become soft during releasing temperature and though water leaching out from carrot. Losing water of fresh cut carrot from packaging material 25 µm and 100 µm showed a continuous process. Foil paper and packaging material polyethylene 50 µm lost highest amount of water in chilling condition. Carrot storage at foil paper and 50 µm lost approximately 14% moisture and though it provided better opportunity for fungal growth. In the chilling temperature fungi could survive and after that getting favorable condition fungi growth more. Microbial count showed that 25 µm polyethylene provided most favorable condition for fungal growth. In the normal sense the different in the number of fungi found in different sample storage in chilling temperature within different packaging material did not cut a grate fact in this case. In the initial day the number of fungi found about 35000 and the ninth day it was about 53000 in polyethylene 25µm. At the same time carrot storage polyethylene 50µm and 100µm having the number of fungi about 50000, 48000 and in foil paper had 42000 in the chilling condition.

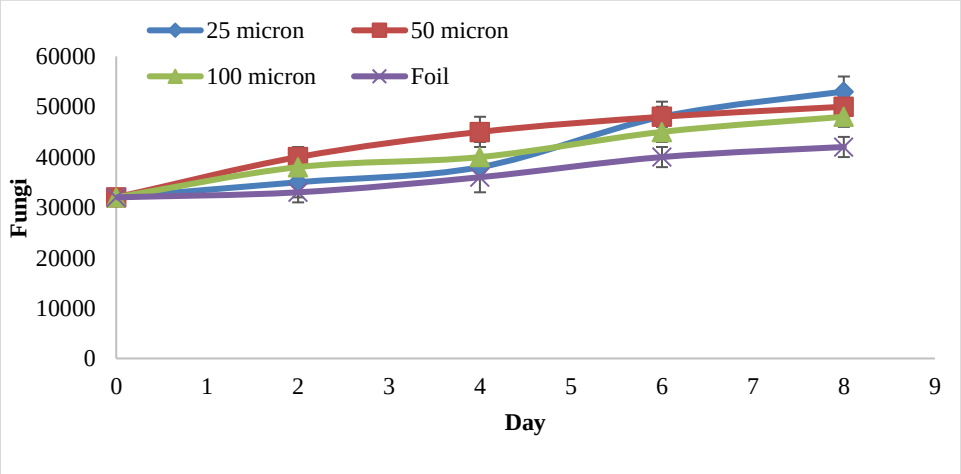

Fig. 14. Comparison of fungal growth in chilling condition concerning different packaging material

In the study of fungal growth count of fresh cut carrot storage in freezing condition within different packaging material showed in the Fig. 15. In the freezing temperature

fresh cut carrot showed abrupt distortion of its texture and become soft and lose highest amount of water. In the freezing temperature fungi could survive and after thawing getting favorable condition fungal growth occurred more. In the initial day the number of fungi found about 32000 and the ninth day it was about 54000 in fresh cut storage in polyethylene 50µm. At the same time carrot storage polyethylene 25µm, 100µm and foil paper had the number of fungi about 50000, 42000 and 43000 in the freezing temperature.

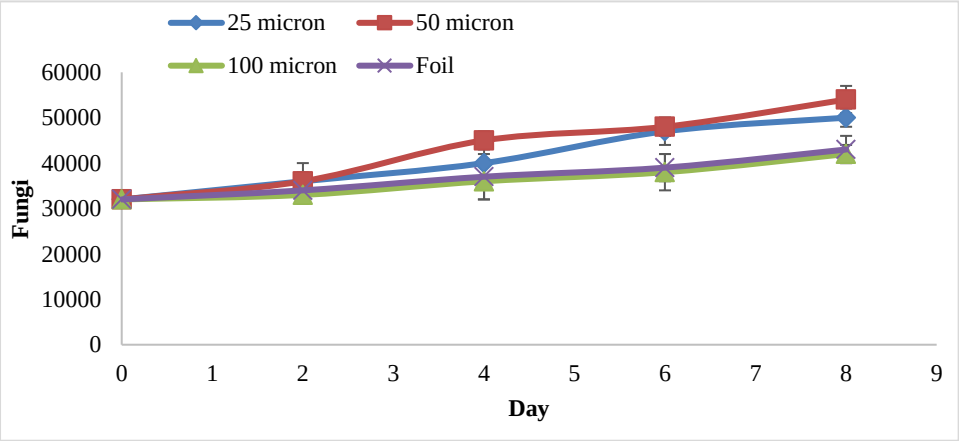

Fig. 15. Comparison of fungal growth in freezing condition concerning different packaging material

Conclusion

This experiment showed that the total weight loss decreased and at the same time loss of vitamin C, conductivity, also decreased. Physical changes of fresh cut carrot such as color, flavor and texture also decreased. Packaging materials such as polyethylene 100µm and 50µm protected all the physical appearance of carrot during chilling condition. Bacterial and fungal growth remained minimum at freezing condition. Chilling temperature retained all the quality parameters better than other condition. Carrot stored at foil paper produced off odor during storage. Packaging material such as polyethylene 25µm, 50µm and 100µm stored at normal temperature produced gas and became slimy.

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