

Short Communication

EFFECT OF HARVESTING STAGES AND PERFORATED PACKAGES ON THE QUALITY AND STORAGE LIFE OF STRAWBERRY FRUIT

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ABSTRACT

A study was done to investigate the effects of harvest stage and perforated packaging on fruit quality and storage in strawberry. Fruit were harvested at three stages of maturity, including the pink, red, and dark red stages, and were stored for 8 days at 5±2°C and 90% RH. The fruit was either unpackaged during storage (control) or stored inside plastic packages that had 12, 18, or 24 circular perforations (0.5cm diameter). Fruit harvested at the dark red stage had the greatest weight loss, total soluble solids (TSS), total sugars, reducing sugars, and sugar/acid ratio, the least number of marketable fruit, the shortest shelf life, and the lowest amount of non-reducing sugars, titratable acidity, moisture content, and ascorbic acid content. In contrast, fruit harvested at the red stage had the greatest number of marketable fruit, the least weight loss, TSS, total sugars, and reducing sugars, and the lowest sugar/acid ratio. Packaging significantly affected fruit storage and quality and was best when fruits were harvested at the red stage and stored in packages with 18 perforations.

Key words: Ascorbic acid, plastic packaging, titratable acidity, total soluble solids, shelf life

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INTRODUCTION

Strawberries are highly perishable at room temperature and have a shelf life of only 1-2 days (Jouki and Khazaei, 2012). The short shelf life is due to high fruit respiration (Cordenunsi *et al.*, 2005), rapid fruit weight loss (Garcia *et al.*, 1998), mechanical injuries (Rosen and Kader, 1989), and high susceptibility to postharvest fungal diseases (Park *et al.*, 2005). Very ripe fruit (dark red stage) are particularly vulnerable to fungal pathogens (Brummel and Harpster, 2001). Many factors are known to affect shelf life of strawberry, including the amount of nitrogen fertilizer applied to the crop (El-Farhan and Pritts, 1997), irrigation frequency (Parikka, 2003), maturity stage at harvest (Klein *et al.*, 2000), and modified atmosphere packaging (Holcroft and Kader, 1999). Nunes *et al.* (2002) found that 'Chandler' strawberry harvested at three-quarter color lasted longer in controlled atmosphere packages than fully ripe fruit during 2 weeks of storage, maintaining better appearance, color, firmness, acidity, TSS and minimum fruit decay. Postharvest life of strawberries can also be extended by changing the storage environment, especially atmospheric oxygen and carbon dioxide concentrations (Church, 1994). The respiration of fruits and vegetables normally declines as the concentration of carbon dioxide increases and oxygen availability decreases (Holcroft and Kader, 1999). Modified atmosphere packages (MAP) prolong the shelf life of strawberries and maintain fruit quality

(Celikel *et al.*, 2005) by increasing carbon dioxide concentrations and reducing oxygen concentrations during cold storage (Gomes *et al.*, 2010).

Soft fruits are highly perishable in nature and almost up to 40% post-harvest losses occur in highly perishable fruits and vegetables including strawberry in developing countries (Jouki and Khazaei, 2012). Post-harvest study of strawberry is need of the time as this nontraditional fruit is flourishing and expanding throughout Pakistan very quickly. Shelf life can be prolonged through different methods including use of proper packages and harvesting of strawberry fruit at proper maturity stage (Aslam and Rasool, 2012).

The objective of the present study was to determine whether perforated packaging increases fruit quality, storage life and strawberry fruit harvested at various stages of development, including an under-ripe pink stage, the red stage, and an over-ripe dark red stage for investigation.

MATERIALS AND METHODS

The research was conducted in 2012-2013 at The University of Agriculture, Peshawar, Pakistan. Strawberries ('Chandler') were harvested at the pink, red, and dark red stages of maturity and stored at 5±2°C and 90% RH for 8 days inside plastic packages (15×20 cm). The TSS contents of pink, red and dark red stages of strawberries were 8.27, 8.42 and 8.65 respectively. The

packages had 12, 18, or 24 circular perforations of 0.5 cm diameter while the control treatment was left unpackaged. Fifty fruit with the calyx attached were selected for each storage treatment and replicated three times

Fruit moisture content and weight loss (%): Fruit moisture content was determined in each treatment after 8 days of storage using the oven drying method (AOAC, 2005). Moisture content was expressed as a percentage and calculated as:

$$\frac{W_1 - W_2}{W_1} \times 100$$

Moisture content (%) =

Where W_1 and W_2 represent the weight of the fruit before and after drying, respectively.

Fruit weight loss was also calculated in each treatment by weighing the fruit samples immediately before and after storage. Weight loss was expressed as a percentage and calculated as:

$$\frac{\text{Loss of sample weight}}{\text{Weight of sample}} \times 100$$

Weight loss (%) =

Marketable fruit (%): Physically sound fruit, free from any injury or damage, were counted after storage, and the percentage was calculated as:

$$\frac{\text{Number of marketable fruits}}{\text{Total number of fruits}} \times 100$$

Shelf life (days): A second set of 50 fruit (with the calyx attached) were harvested from each treatment and used to determine the shelf life of fruit in the refrigerator. Shelf life was estimated by counting the number of marketable and non-marketable fruit remaining after each day in storage and was identified as the number of days in which 15% of the fruit were no longer marketable.

Total soluble solids, sugars, titratable acidity, sugar acid ratio, and ascorbic acid: Total soluble solids (TSS) in the fruits were measured after 8 days storage using a hand refractometer (Kernco, Instrument Co, Texas). Reducing sugars, non-reducing sugars, titratable acidity, and ascorbic acid were also determined after 8 days following procedures described by the Association of Official Analytical Chemist, using the acid neutralization and titrimetric methods to measure titratable acidity and ascorbic acid, respectively (AOAC, 2005). The sugar acid ratio was calculated by dividing total sugars by titratable acidity.

Statistical analysis: Treatments were arranged in randomized complete block design (RCBD) and were analyzed by two-way analysis of variance (ANOVA). Main effects included fruit maturity and packaging. Means were separated at the 5% levels using the

protected least significant difference (LSD) test (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Fruit moisture content and weight loss (%): Fruit moisture content was significantly affected during storage by the stage of fruit maturity, packaging, and the interaction between the two (Table 1). Moisture content was greatest at the pink and dark red stage in packages with 12 perforations and greatest at the red stage with either no packaging (control) or packages with 18 or 24 perforations. Evapotranspiration is the major process leading to moisture loss in the fruit (Nunes *et al.*, 1995), resulting in loss of freshness and deterioration of fruit quality (Nasrin *et al.*, 2008).

Fruit weight loss was also significantly affected by packaging but, unlike moisture content, was not affected by fruit maturity or the interaction between maturity and package perforations (Table 1). Fruit in packages with 12 perforations had less weight loss than those with no packaging or 18 and 24 perforations per package. Weight loss in stored strawberries is primarily due to water loss produced by fruit respiration (Moing *et al.*, 2001; Zhang, 2001). Modified atmosphere packaging (MAP) often reduces the weight loss and thereby maintains fruit quality (Celikel *et al.*, 2005; Ozkaya *et al.*, 2009). A lower number of perforations in the packing material reduced moisture loss in the present study, but it still likely allowed the release of CO₂ and other respiratory gases from the fruit during storage (Artes *et al.*, 2006).

Marketable fruit (%): The percentage of marketable fruit remaining after 8 days of storage was significantly affected by fruit maturity and packaging (Table 1). On average, the highest percentage was marketable when fruit were harvested at the pink stage and were stored in packages with 18 perforations. Fruit were generally firmer at the pink stage, which reduced fruit damage during storage (Aliasgarian *et al.*, 2013). On the other hand, fruit harvested at the dark red stage were least marketable due to a soft and juicy texture and were quite easily damaged (Cordenunsi *et al.*, 2005). It was also clear that 18 perforations provided the optimum atmosphere among the packaging treatments. Perhaps a higher number of perforations increased fruit exposure to unfavorable external environmental conditions (An *et al.*, 2009) and fewer perforations in the package may create a condition to greater anaerobic respiration (Peano *et al.*, 2014).

Shelf life (days): Shelf life of the fruit was significantly affected by fruit maturity and packaging (Table 1). Fruit had the longest shelf life when harvested at the pink stage and stored in packages with 18 perforations. In both cases, the fruit remained marketable for up to 8 days. In

comparison, fruit lasted 7 days, on average, when harvested at the red stage and were stored in packages with 12 or 24 perforations, and lasted only 6 days when harvested at the dark red stage and were stored without any packaging material. It has been reported that shelf life of strawberry fruit may vary and depends on maturity stage at which harvested (Ali *et al.*, 2011) as well as storage environments (Almenar *et al.*, 2006). The maximum storage life of pink fruit as compared to dark red fruit can be attributed to greater firmness at this stage (Ali asgarian *et al.*, 2013). Similarly, packages having 18 holes increased the storage life to the maximum because it may have retained a balance high CO₂ and low oxygen concentrations in the packages, which has been shown to retain firmness (Smith, 1992), by slowing the action of ethylene and delay ripening (Aday and Caner., 2011)

Total soluble solids, sugars, titratable acidity, sugar acid ratio and ascorbic acid: Total soluble solids, non-reducing sugars, total sugars, titratable acidity, sugar acid ratio, and ascorbic acid content were all significantly affected by fruit maturity, packaging, and the interaction between fruit maturity and packaging, while reducing sugars were only affected by fruit maturity and packaging (Table 2).

Total soluble solids ranged from 8.27-8.73% and were similar among the packaging treatments at the pink stage, greater with no packaging than with packaging at the red stage, and greater with no packaging or in packages with 12 perforations than in packages with 18 or 24 perforations at the dark red stage (Table 2). In general, TSS increase with fruit ripening and are greatest at full maturity i.e., the dark red stage (Pineli *et al.*, 2010). They also often increase during storage because of moisture loss, which may explain why concentrations were greater in unpackaged ripe berries than in packaged berries (Kirad *et al.*, 2003; Nunes, *et al.*, 2002). However, it does not explain why TSS were also high in dark red berries stored in packages with 12 perforations.

Dark red fruit had a higher percentage of reducing sugars than pink or red fruit but a lower percentage of non-reducing sugars. Unpackaged fruit likewise had a higher percentage of reducing sugars than packaged fruit, as well as higher percentage of non-reducing sugars than packaged dark red fruit. However, fruit had a higher percentage of non-reducing sugars with packaging than with no packaging at the pink stage and packages with 12 or 18 perforations at the red stage. Sucrose is the primary non-reducing sugar in strawberry, which then converts to reducing sugars, including glucose and fructose, as the fruit matures (Basson *et al.*, 2010; Sturm *et al.*, 2003). These sugars apparently concentrated more so during storage when the fruit, particularly the ripe fruit, were unpackaged. This was probably due to

greater moisture loss. However, it is also possible that perforated packages provided more suitable O₂ and CO₂ concentrations, and thus, creating modified atmosphere that resulted in lower rates of respiration (Almenar *et al.*, 2006) and ethylene production (Bower *et al.*, 2003). Among the three packaging treatments, fruit packed in packages with 12 perforations had the highest percentage of non-reducing sugars.

Total sugars ranged from 8–11%, and the percentage was highest when fruit were harvested dark red and were stored in packaging and lowest when fruit were harvested red and were stored in packages with 18 perforations. The percentage of total sugars in the fruit is directly related to TSS (Chang and Chang, 2010) and therefore increased with fruit maturity and was likely more concentrated when the fruit were unpackaged due to greater water loss (Kirad *et al.*, 2003).

Titratable acidity decreased from 1.8% at the pink stage to 1.5–1.7% at red and dark red stages and was greatest in fruit stored in packages with 12 perforations and lowest in red and dark red fruit stored with no packaging or in packages with 24 perforations (Table 2). Acidity is one of the most important factors affecting fruit taste and flavor (Wozniak *et al.*, 1997). Acidity of fruits normally decreases during storage (Nicole *et al.*, 2015), which over time may reduce quality of acidic fruits such as strawberries (Usenik *et al.*, 2008). The perforated packages helped maintain fruit acidity during storage in the present study, regardless of the maturity stage.

A proper sugar acid ratio is also essential for characteristic fruit flavor in strawberries (Kafkas *et al.*, 2007). The ratio averaged 4.7 in pink fruit and increased to 5.0 in red fruit and 6.9 in dark red fruit and was highest in dark red fruit stored without packaging or in packages with 24 perforations and lowest in pink fruit stored in any packaging and red fruit stored in packages with 12 or 18 perforations.

Ascorbic acid content averaged 45.3 mg/100 g fresh weight in red fruit and 40–42 mg/100 g in pink and dark red fruit and increased when fruit were stored in packages with 12 or 18 perforations at each stage of maturity. Ascorbic acid of strawberry declines during storage and may decrease by as much as 50% during extended storage (Cordenunsi *et al.*, 2003). High temperature and low relative humidity during storage increases the loss of ascorbic acid due to ascorbate oxidase activation and this enzyme is mainly responsible for loss of ascorbic acid (Morales *et al.*, 2014). Perforated packaging with 12 or 18 perforations reduced the loss of ascorbic acid in the present study and therefore improved nutritional quality of the fruit i.e., vitamin C during refrigerated storage.

Table 1. Physical properties of strawberries harvested at three different stages of fruit maturity and stored for 8 days at 5°C and 90% RH with either no packaging (control) or in plastic packages with 12, 18, or 24 perforations.

Treatment	Fruit moisture content (%)	Fruit weight loss (%)	Marketable fruit (%)	Storage life (days)
Fruit maturity				
Pink	88.9 b	14.0	95.9 a	8.0 a
Red	90.0 a	11.9	92.2 b	7.0 b
Dark Red	88.0 c	17.0	86.3 c	6.0 c
LSD (0.05)	0.6	NS	1.2	0.4
Package perforations				
Control	87.9 b	18.6 a	88.9 d	6.0 c
12	90.0 a	7.9 b	92.2 b	7.0 b
18	89.5 a	15.3 a	94.1 a	8.0 a
24	88.4 b	15.3 a	90.8 c	7.0 b
LSD (0.05)	0.7	6.6	1.3	0.4
Fruit maturity × packaging				
LSD (0.05)	1.3*	NS	NS	NS

* $P \leq 0.05$; ^{NS} Non-significant.**Table 2. Chemical properties of strawberries harvested at three different stages of fruit maturity and stored for 8 days at 5°C and 90% RH with either no packaging (control) or in plastic packages with 12, 18, or 24 perforations.**

Treatment	Total soluble solids (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Titrateable acidity (%)	Sugar: acid ratio	Ascorbic acid (mg/100 g)
Fruit maturity							
Pink	8.27 c	5.83 b	2.69 a	8.53 b	1.83a	4.71 c	40.0 b
Red	8.42 b	5.84 b	2.41 b	8.24 c	1.66 b	5.02 b	45.3 a
Dark Red	8.65 a	8.03 a	2.09 c	10.11 a	1.48 c	6.94 a	41.7 b
LSD (0.05)	0.12	0.19	0.09	0.14	0.04	0.12	2.5
Package perforations							
Control	8.73 a	6.91 a	2.32 b	9.24 a	1.54 c	5.99 a	39.8 b
12	8.44 b	6.36 c	2.47 a	8.83 b	1.82 a	4.91 c	46.1 a
18	8.27 c	6.39 bc	2.46 a	8.85 b	1.68 b	5.26 b	44.2 a
24	8.32 bc	6.60 b	2.34 b	8.94 b	1.58 c	6.05 a	39.2 b
LSD (0.05)	0.14	0.21	0.11	0.17	0.04	0.14	2.8
Fruit maturity × packaging							
LSD (0.05)	0.24*	NS	0.19*	0.29*	*0.07	*0.24	*4.9

* $P \leq 0.05$; ^{NS} Non-significant

Conclusion: The results indicated that strawberries could be harvested at the dark red stage when used quickly for consumption or processing but should be harvested at the pink or red stage for longer storage life. Plastic packaging enhanced cold storage and was best when the packages had 18 perforations.

REFERENCES

- Aday, M.S. and C. Caner (2011). The applications of active packaging and chlorine dioxide for extended shelf life of fresh strawberries. *Packaging Technology Science* 24: 123-136.
- Aliasgarian, S., H.R. Ghassemzadeh, M. Moghaddam and H. Ghaffari (2013). Mechanical damage of strawberry during harvest and postharvest operations. *World Appl. Sci. J.* 22: 969-974.
- Ali, A., M. Abrar, T. Sultan, A. Din, and B. Niaz (2011). Postharvest physicochemical changes in full ripe strawberries during cold storage. *J. Animal & Plant Science* 21(1): 38-41.
- Almenar, E., M.P. Hernandez, J.M.L. Agaron, R. Catala and R. Gavara (2006). Controlled atmosphere storage of wild strawberry fruit. *J. Agric. Food Chem.* 54: 86-91.

- An, D.S., E. Park and D.S. Lee (2009). Effect of hypobaric packaging on respiration and quality of strawberry and curled lettuce. *Postharvest Biol. Tec.* 52: 78-83.
- AOAC (2005). Association of official analytical chemist. Official methods of analysis, 18th edition, Washington DC USA.
- Artes, F., J.A. Tudela, J.G. Marin, R. Villaescusa, F.H. Artes (2006). Modified atmosphere packaging of strawberry under self-adhesive films. 5th international symposium on protected cultivation in mild winter climates. International society of horticultural science (ISHS). *Acta Hort.* 559.
- Aslam, M. and S. Rasool. 2012. Potential of strawberry's export from Pakistan. Published on 8th June 2012. Available at <http://pkeconomists.com/potential> of strawberry's export from Pakistan.
- Basson, C.E, J.H. Groenewald, J. Kossmann, C. Cronje, R. Bauer (2010). Sugar and acid related quality attributes and enzyme activities in strawberry fruits. *Food Chem.* 121: 1156-1162.
- Bower, J.H., W. V. Biasi and E. J. Mitcham (2003). Effects of ethylene and 1-MCP on the quality and storage life of strawberries. *Postharvest Bio. and Tech.* 28(2): 417-423.
- Brummel, D.A. and M.H. Harpster (2001). Cell wall metabolism in fruit softening and quality and its manipulation in transgenic plants. *Plant Molecular Biol.* 47: 311-340.
- Celikel, F.G, K. Kaynas and B. Erenoglu (2005). A study on modified atmosphere storage of strawberry. 24th International horticultural congress, issues and advances in postharvest horticulture. *Acta Hort.* (ISHS) 628.
- Church, N. (1994) Developments in modified atmosphere packaging and related technologies. *J. Food Sci.* 5: 345-352.
- Chang, J.C. and M.W. Chang (2010). Elongated fruit No. 1, mulberry, an elite cultivar for fresh consumption. *J. Am. Pomol. Soc.* 64: 101-105.
- Cordenunsi, B.R, J.R.O. Nascimento and F.M. Lajolo (2003). Physicochemical changes related to quality of five strawberry fruit cultivars during cool storage. *J. Food Chem.* 83: 167-173.
- Cordenunsi, B R., M.I. Genovese, J.R.O. Nascimento, N.M.A. Hassimotto, R.J. Santos and F.M. Lajolo (2005). Effects of temperature on the chemical composition and antioxidant activity of three strawberry cultivars. *Food Chem.* 91: 113-121.
- El-Farhan, A.H and M.P. Pritts. (1997). Water requirements and water stress in strawberry. *Advancement in Strawberry Research* 16: 5-12.
- Garcia, M.A, M.N. Martino and N.E. Zaritzky (1998). Plasticized starch based coatings to improve strawberry quality and stability. *J. Agric Food Chem.* 46: 3758-3767.
- Gomes, M.H., R.M. Beaudry, D.P.F Almeida, and F.X. Malcata (2010) Modelling respiration of packaged fresh cut pear as affected by oxygen concentration and temperature. *J. Food Engineering* 96:74-79.
- Holcroft, D.M and A.A. Kader (1999). Controlled atmosphere induced changes in pH and organic acid metabolism may affect color of stored strawberry fruit. *Postharvest Biol. Tec.* 17: 19-32.
- Jouki, M. and N. Khazaei (2012). The effect of modified atmosphere packaging and calcium chloride dipping on the quality and shelf life of Kurdistan strawberries. *J. Food Process Tec.* 3: 1-7.
- Kafkas, E.M. Kosar, S.Paydas, S. Kafkas and K.H.C. Baser (2007). Quality characteristics of strawberry genotypes at different maturation stages. *Food Chem.* 100: 1229-1236.
- Kirad, K.S., S. Barche, A. Dash and R.K. Sharma (2003). Response of different packaging materials and chemicals on the shelf life of strawberry and correlation between different traits. International conference on quality management of fresh cut produce. *Acta Hort.* 746.
- Klein, I., M. Strime, L., Fanberstein and Y. Mani (2000) Irrigation and fertigation effects on phosphorus and potassium nutrition of wine grapes. *39(2):55-62.*
- Moing, A. C., M. Renaud, P. Gaudillere, P. Raymond, P. Roudeillac and B.D. Rothan (2001). Biochemical changes during fruit development of four strawberry cultivars. *J. Amer. Soc. Horti. Sci.* 124: 394-403.
- Morales, M. L., R.M. Callejon, C. Ubeda, A. Guerreiro, C. Gago, M.G. Miguel and M.D. Antunes (2014). Effect of storage time at low temperature on the volatile compound composition of Sevellana and Maravilla raspberries. *Postharvest Biology & Technology*, 96: 128-134.
- Nasrin, T.A.A., M.M. Molla, M.H. Alamgir, M.S. Alam and L. Yasmin. (2008). Effect of postharvest treatments on shelf life and quality of different fruits. *Bang. J. Agric. Res.* 33: 579-585.
- Nicole R.G., R. Briano, C. Baudino and Cristiana. (2015). Effects of packaging and storage conditions on quality and volatile compounds of raspberry fruits. *Cyta J. of Food* 13:4, 512-521.
- Nunes, M.C.N., J.K. Brecht, A.M.M.B. Morais and S.A. Sargent (1995). Physical and Chemical quality characteristics of strawberries after storage are reduced by a short delay to cooling. *Postharvest Biol. Tec.* 6: 17-28.
- Nunes, M.C.N, A.M.M.B. Morais, J.K. Brecht and S.A. Sargent (2002). Fruit maturity and storage

- temperature influence response of strawberries to controlled atmospheres. *J. Amer. Soc. Hort. Sci.* 127: 836-842.
- Ozkaya O., O. Dundar, G.C. Scovazzo and G. Volpe (2009). Evaluation of quality parameters of strawberry fruits in modified atmosphere packaging during storage. *African J. Biotech.* 8: 789-793.
- Parikka, P. (2003). The effect of irrigation method on the quality and shelf-life of strawberry fruit in organic production. Published in plant protection in sustainable strawberry production, page 22. Nordic Association of Agricultural Scientists.
- Park, I. S., D.S. Stan, A.M. Daeschel and Y. Zhao. (2005). Antifungal coatings on fresh strawberries (*Fragaria* × *ananassa*) to control mold growth during cold storage. *J. Food Sci.* 70(4): 202-207.
- Peano, C., N.R. Giuggioli and V. Girgenti (2014). Effect of different packaging materials on postharvest quality of cv, Envie 2 strawberry. *International Food Res. J.* 21(3):1165-1170.
- Pineli, L.L.O, C.L. Moretti, M.S. Santos, A.B Campos, A.V. Brasileiro, A.C. Cordova and M.D. Chiarello. (2010). Antioxidants and other chemical and physical characteristics of two strawberry cultivars at different ripeness stages. *J. Food Composition and Analysis.* 14: 27-35.
- Rosen, J.C. and A.A. Kader (1989). Postharvest physiology and quality maintenance of sliced pear and strawberry fruits. *J. Food Sci.* 54: 656-659.
- Smith, R.B. (1992). Controlled atmosphere storage of 'Redcoat' Strawberry fruit. *J. Amer. Soc. Hort. Sci.* 117: 260-264.
- Steel, R.G.D., J.H. Torrie and D.A. Dickey (1997). Principles and procedures of statistics. A biometrical approach. 3rd ed. McGraw Hill Book Co Inc. New York: 400-428.
- Sturm, K., D. Koron and F. Stampar (2003). The composition of fruit of different strawberry varieties depending on maturity stage. *Food Chem.* 83: 417-422.
- Usenik, V., J. Fabčić and F. Stampar (2008). Sugars, organic acids, phenolic composition and antioxidant activity of sweet cherry. *Food Chem.* 107: 185-192.
- Wozniak, W., B. Radajewska, A. Reszelska-Sieciechowicz and I. Dejewor (1997). Sugars and acid content influence organoleptic evaluation of fruits of six strawberry cultivars from controlled cultivation. *Acta Hort.* 439: 333-336.
- Zhang, M., C.L. Li, Y.J. Huan, Q. Tao, H.O. Wang (2001). Preservation of fresh grapes at ice temperature and high humidity, *Int. Agro Physics* 15: 139-143.