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Effect of Different Storage Structures and Duration of Time on Some Postharvest Qualities of Tomato (Lycopersiconesculentum Mill.)

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Abstract: *The rapid quality loss of tomatoes at relatively short period of 4-7 days after harvest requires an efficient means of storing the fruits to reduce postharvest losses. This study therefore evaluated the influence of three different storage structures: Refrigerator (10˚C and 40-45% Relative Humidity), Evaporative coolant structure (ECS) (26 ˚C and 58-62% Relative Humidity) and open shelf (28.8 ˚C and 70-75% Relative Humidity) on the postharvest qualities of mature green tomatoes (San Marzano variety) stored for 34days. Data was collected on firmness, disease incidence and overall freshness of the stored tomatoes fruits at interval of 3 days using a subjective scale. Proximate analysis to determine Titratable Acidity (TA), TotalSoluble Solids (TSS) and Vitamin C content of fruits was also conducted at the green, light red, deep red ripening stages and at deterioration of fruits. Data collected were subjected to analysis of variance and significantly different means were separated using least significant difference at 0.05% level of probability.There was no significant difference in the postharvest physical qualities (firmness, disease incidence and overall freshness) of the stored tomatoes in the three storage structures at the first 9 days of storage. At 27 days after storage the tomatoes fruits stored in the ECS had the least firmness (4.33), freshness (0.67) and the highest disease incidence (3.33) which was significantly lower than the value obtained from the tomatoes stored in the refrigerator and open shelf. Chilling injury was observed on tomatoes stored in the refrigerator at 27 days after storage which led to significantly lower tomatoes fruit quality at 34 days after storage when compared with the open shelf. As ripening progressed it was observed that TSS of the stored tomatoes fruits increased across the three storage conditions while the TA of the fruits declined. The Vitamin C content of tomatoes increased as ripening progressed but decreased at deterioration with ECS giving the highest Vitamin C content (28.37 mg/100g) of stored tomatoes fruits at deteriorationAmong the refrigerator, evaporative coolant structure and open shelf, the ECS gave the best postharvest chemical property of fruits at deterioration. The order of preservation with reference to number of days in storage is open shelf >Refrigerator> ECS.*

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I. Introduction

Tomato (Lycopersiconesculentum Mill.) originated from South America and belongs to the family solanaceae. It is considered as an important food and cash crop in many parts of the world which also serves as raw material for production of value added products by food industry [1, 2]. It is consumed either fresh as salad or after processing into pastes or puree which is used for cooking and in the production of fruit drinks and ketch up [3, 2]. High quality tomatoes have a firm turgid appearance, uniform and shiny color, without sign of mechanical injuries, shriveling or decay [4].

Nigeria has the largest area harvested for fresh tomatoes in Africa with 541.800 Ha and yield of 4.0MT/Ha[5]. However, 45% of the tomatoes produced in the country is estimated as annual loss due to poor processing technology, lack of good storage system and the transport system used for the distribution of fresh tomatoes [6, 7]. It is distressing to know that many resources is devoted to planting the crop, irrigation, fertilizer application and crop protection management only to be wasted in few days after harvest [8]. Postharvest losses in tomatoes cannot beeliminated, but can be reduced within certain limits by applying appropriate postharvesttechnology [9].

Some authors[10] reiterated that the properties, quality and nutritional value of fresh produce is affected by postharvest handling and storage condition. An author [11]submitted that loss of vitamins, especially ascorbic acid (vitamin C), during storage adversely affects nutritional quality of the produce. In Nigeria, tomatoes are harvested at vine-ripe due to lack of cool-chain and ripening facilities to handle mature-green tomatoes to turning stages[12]. However when harvested at the mature green stage, all tomatoes cultivar have the longest shelf-life and shelf-life is the most important aspect in loss reduction biotechnology of fruit and vegetables[13, 14.]

An author[15] reported that an increasing demand for produce with excellent quality and extended shelf-life had made postharvest quality more and more important together with the optimization of storage structures. Thus, sequel to the high postharvest loss of tomatoes, extension of the shelf-life of the fruits by harvesting at the mature green stage necessitates the use of available storage structure for ripening. Erratic power supply and low income of rural farmers makes refrigerator expensive[16] .The evaluation of the influence of low cost cooling system such as the evaporative coolant structure on the physical and chemical properties of stored tomatoes at some ripening stages and deterioration becomes paramount due to the increased interest of consumer in the quality of produce.The objectives of this study are therefore to evaluate the effect of different storage structures on the physical, chemical properties and shelf-life extension of green tomatoes.

II. Material And Methods

The experiment was conducted at the Department of Agronomy, University of Ibadan, Ibadan, Oyo state between October to November, 2014.

Source of Experimental Materials: Mature green tomatoes (San Marzano variety) obtained from a commercial farm at Ibadan.

Samples Preparation for Storage: The tomatoes were sorted to ensure they were free of spots and bruise, disinfected by dipping in a fungicide solution and subsequently drained and air dried. The tomatoes fruits were weighed and packaged in perforated polyethylene bags.

Experimental Design: Completely randomized design with three replicates.

Storage Experiment: The packaged tomatoes fruits were arranged in the following storage structures;

- The refrigerator (10˚C) and (40% -45% Relative Humidity)
- The evaporative coolant structure (26˚C) and (70% -75% Relative Humidity)
- The open shelf (control) (28.8˚C) and (58% - 62% Relative Humidity)

Construction and Principle of Operation of the Pot-in-Pot Evaporative coolant structure

This was constructed by coating the outside of a burnt clay pot (that is about 65 cm high and has wall thickness of about 8mm) with cement. The pot is placed inside another slightly bigger pot leaving a space of about 7 cm between the two. The space between the two pots is filled with riverbed sand which is kept moist by watering frequently. A perforated plastic sieve was placed at the base of the inner pot and the tomatoes were stored in the inner pot while the clay pot is provided with a suitable cover. The structure was placed on a metallic suitable tripod stand under a constructed shed, where there was free air movement for evaporation of water.

Figure 1: The Pot-in-Pot Evaporative Coolant Structure (26˚C)

An author[16] described the principle underlying evaporative cooling as the conversion of sensible heat to latent heat. The warm and dry outdoor air is forced through porous wall or wetted pads that are replenished with water from the cooler's reservoir. Due to the low humidity of the incoming air, some of the water evaporated. Some of the sensible heat of the air is transferred to the water and becomes latent heat by evaporating some of the water. The latent heat follows the water vapour and diffuses into the air. Evaporation causes a drop in the dry-bulb temperature and a rise in the relative humidity of the air in the inner pot.

Data Collection: Data were taken at three days interval on physical parameters of firmness, disease incidence and overall freshness of the tomatoes fruits during the storage period. While the proximate analysis of tomato fruits to determine the Vitamin C, Titrable acidity and total soluble solids content of the fruits was done at the green, light red and deep red ripening stages as well as at deterioration.
Firmness: This is determined by hand feel and the result was rated on a subjective scale as follows; 5 = Not firm, 4 = Slightly firm, 3 = Moderately firm, 2 = Firm, 1 = Very firm
Disease incidence: This was evaluated through visual observation of tomato fruits at interval of three days for noticeable skin defects, blemishes and mould growth using a subjective scale of 1- 4 where 1 = wholesome, 2 = slightly infected, 3 = moderately infected and 4 = highly infected
Freshness: The overall freshness of the fruits was evaluated by using a scale of 0 - 4 in line with the method of IPGRI/IITA (1998), where 4 = excellent; 3 = good; 2 = acceptable; 1 = unacceptable and 0 = poor.Determination of Titratable Acidity: The sample was transferred into 250 ml conical flask. 4-5 drops of phenolphthalein indicator was added and 25 ml burette was filled with 0.1N Sodium hydroxide. The sample mixture was titrated with the 0.1N Sodium hydroxide until the indicator just turns pink/red. The titre volume of the Sodium Hydroxide that was added was recorded. The calculation of the titratable Acidity was done by dividing the titre value obtained by 10.
Determination of Total soluble solids: 4 gram of sample was weigh and blended with 39 ml water. The tomato suspension was filtered through Whatman No.1 filter paper. The filtrate was put into a weighed petri dish and was evaporated to dryness. The petri dish was weighed to get the weight of dried soluble matter. The weight of dried soluble matter was put over weight of sample taken times 100.
Determination of Ascorbic Acid Content:0.05 g of 2:6 Dichlorophenol was dissolved in water. It was diluted to 100 ml and standardized. 0.05 g pure ascorbic acid was dissolved in 600 ml of 20 % Meta phosphoric acid and diluted with water to exactly 250 ml. 10 ml of this solution was pipette into small flask and titrated with the Indophenol solution until a faint pink colour persists for fifteen seconds. The concentration was expressed as mg. ascorbic acid equivalent to 1.0 ml of the dye solution. Sample was macerated in a mortar and filtered through a nylon cloth. 25.0ml was pipette into a 50 ml flask and 12 ml of 20 % Meta phosphoric acid was added and the mixture was diluted with water to 50 ml. 10 ml of this solution was pipette into a small flask and titrated with the 2:6 Dichlorophenol Indophenol solution. Calculation of the Vitamin C was done as mg. per 100 ml of juice.
Statisticalanalysis:
All data collected were subjected to analysis of variance and significantly different means were separated using least significant difference at 0.05% level of probability.

III. Result

Effect of storage conditions on firmness

The result on Figure 2 shows that no significant ($P<0.05$) difference was observed in firmness of the tomatoes in the three storage conditions during the first 12 days of storage. However, from 15 to 27 days length of storage, the evaporative coolant structure recorded the least firmness of tomatoes fruits (with average scores that ranged from 2.7 to 4.3 i.e. moderately firm to slightly firm) which were significantly ($P<0.05$) lower than the refrigerator (with mean scores from 1.3 to 3.0 i.e. very firm to moderately firm) and open shelf (2.0 i.e. firm) with the exception of the 15 days length of storage when it had firmness score 2.7 i.e. moderately firm that was not significantly ($P<0.05$)different from the open shelf (2.0 i.e. firm). At 34 days length of storage the best firmness was observed in the open shelf (2.3 i.e. firm) which was significantly ($P<0.05$) better than the refrigerator (3.3 i.e. moderately firm).

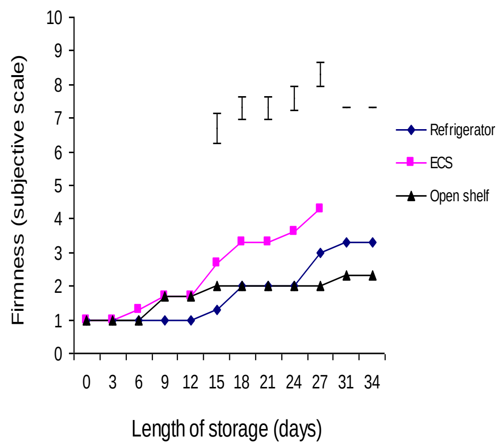

Figure 2: Effect of storage conditions on firmness

Effect of storage conditions on disease incidence

The results on Figure 3 shows that during the first 12 days of storage, there was no significant (P<0.05) difference among the three storage conditions with respect to disease incidence. The evaporative coolant structure however had

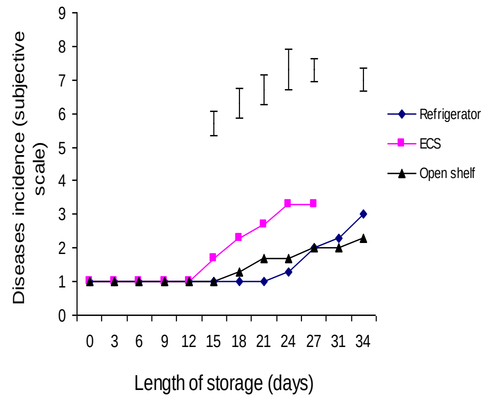

Figure 3: Effect of storage conditions on disease incidence

the highest incidence of disease (with average scores of 1.7 to 3.3) from 15 to 27 days length of storage which was significantly (P<0.05) higher than that observed in the open shelf (with mean scores of 1.0 to 2.0) and refrigerator (with mean scores of 1.0 to 2.0) during this storage period. At 34 days length of storage the least disease incidence was observed in the open shelf (2.0) which was significantly (P<0.05) lower than that observed in the refrigerator (3.0).

Effect of storage conditions on freshness of tomatoes

The result on Figure 4 shows that there was no significant (P<0.05) difference in freshness among the three storage conditions for the first 6 days after storage. From 12 to 27 days length of storage the refrigerator had the best fruit freshness with average score of 4.0 to 3.0 (i.e. excellent to good) which was significantly (P<0.05) better than the evaporative coolant structure (with average scores of 3.0 to 0.7) and open shelf (with average scores of 3.3 to 3.0) with the exception of 24 and 27 days length of storage when it had average freshness score of 3.3 (good) and 3.0(good) respectively which were not significantly (P<0.05) different from the open shelf with mean score of 3.0 (i.e. good appearance). The open shelf however had a better fruit freshness mean score of 3.0 at 31 and 34 days length of storage, which was significantly (P< 0.05) better than the refrigerators with freshness mean score of 2.0.

Effect of storage conditions on Vitamin C (mg/100g) content of tomatoes at some ripening stages and deterioration

he result on Table no1 shows that at the light red stage, the vitamin C content of tomatoes increased from the initial 28.77 mg/100g obtained at the green stage across all the three storage conditions with the evaporative coolant structure giving the highest vitamin C content of 33.57 mg/100g which was significantly (P<0.05) higher than the refrigerator (32.40 mg/100g) and open shelf (29.77mg/100g) at this ripening stage. However at the deep red stage, the vitamin C content of the refrigerator and open shelf further increased with refrigerator giving the highest vitamin C value of 35.37 mg/100g which was significantly (P<0.05) higher than the open shelf 32.84 mg/100 and the evaporative coolant structure which decreased to 25.77 mg/100g at this stage of ripening. At deterioration the vitamin C content of the open shelf and refrigerator however decreased with the open shelf giving the lowest vitamin C content of 23.83 mg/100g which was significantly (P<0.05) lower than the evaporative coolant structure (28.37 mg/100g) and refrigerator (24.53 mg/100g) .

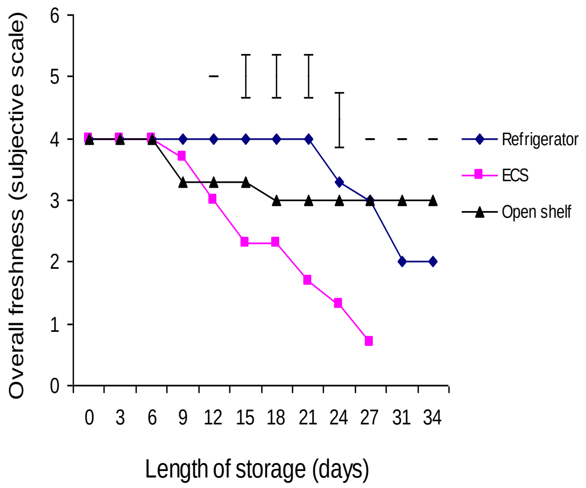

Figure 4: Effect of storage conditions on overall freshness

Table no1: Effect of storage conditions on Vitamin C (mg/100g) content of tomatoes at some ripening stages and deterioration.

Storage Structures	Ripening Stages (Vitamin C (mg/100g)			
	Green Stage	Light Red Stage	Deep Red Stage	Deterioration
Refrigerator	28.77	32.40	35.37	24.53
ECS	28.77	33.57	25.77	28.37
Open Shelf	28.77	29.77	32.84	23.83
Lsd (P<0.05)	Ns	0.48	0.42	0.35

Effect of storage conditions on Total Soluble Solids (%) of tomatoes at some ripening stages and deterioration

The total soluble solids increased across the ripening stages towards deterioration in all the three storage conditions with the exception of evaporative coolant structure which gave a decreased total soluble solids of 42.97 % at deterioration which was significantly (P<0.05) lower than the refrigerator (45.57 %) and open shelf (43.83 %) whencompared with the value of 43.33 % obtained in the ECS at the deep red stage of ripening (Table no2). The three storage conditions were however significantly (P<0.05) different from each other across all the ripening stages with the exception of the light red stage when the refrigeration had total soluble solids of 38.63 % that was not significantly (P<0.05) different from the open shelf (38.37 %).

Effect of storage conditions on Titrable Acidity (T/10) of tomatoes at some ripening stages and deterioration

The titrable acidity decreased from the green stage to the deep red ripening stage in all the three storage conditions with the exception of the evaporative coolant structure which gave a titrable acidity value of 0.51 at the deep red

Table no2: Effect of storage conditions on the Total Soluble Solids content (%) of tomatoes at some ripening stages and deterioration

Storage Conditions	Ripening Stages (Total Soluble Solids content (%))			
	Green Stage	Light Red Stage	Deep Red Stage	Deterioration
Refrigerator	28.77	38.63	40.17	45.57
ECS	28.77	39.53	43.33	42.97
Open shelf	28.77	38.37	39.13	43.83
LSD (P<0.05)	Ns	0.28	0.46	0.64

stage which was higher than the 0.44 titrable acidity value observed at the light red stage of ripening (Table no3). However the titrable acidity of the tomatoes under the three storage conditions increased at deterioration with the refrigerator having the highest titrable acidity of (0.57) which was significantly (P<0.05) higher than the open shelf (0.52) and evaporative coolant structure (0.54).

Table no3: Effect of storage conditions on the Titrable Acidity (T/10) of tomatoes at some ripening stages and Deterioration

Storage Conditions	Ripening Stages (Titrable Acidity (T/10))			
	Green Stage	Light Red Stage	Deep Red Stage	Deterioration
Refrigerator	0.72	0.54	0.45	0.57
ECS	0.72	0.44	0.51	0.54
Open shelf	0.72	0.49	0.46	0.52
LSD (P<0.05)	Ns	0.03	0.02	0.02

The observation of reduction in tomatoes fruit firmness with the passage of time in storage is in line with the submission of some authors[17] who reported that the fruit firmness of some tomatoes varieties decreased with time in different storage conditions except in the deep freezer. This decrease in fruits firmness is caused by the softening of fruits which results from the remodeling and degradation of the cell wall that occurred during ripening[18, 19, 20]. The highest softening of fruits and subsequent loss of firmness in the ECS can be attributed to the cooking of fruit by the heat of respiration and water droplet trapped in the polyethylene bags that was used for packaging. However, the occurrence of chilling injury at 27 days of storage of tomatoes in the refrigerator led to softening of fruits and subsequent reduction in firmness. This confirms the observation of some authors[21, 22] that tomatoes cannot be stored in the domestic refrigerator for a long period as they are susceptible to chilling injury. The maintenance of firmness in the open shelf was due to the removal of heat of respiration by the Free air which flows around produce[23].

Disease incidence is observed on fruits when spots, blemishes, mould growth and other abnormities are observed on fruits. The result (Figure 3) showed that the three storage structures can prevent disease incidence on tomatoes fruits to the same extents up to 12 days of storage. The high disease incidence observed in the evaporative coolant structure from 15 to 27 days of storage might be attributed to high relative humidity, poor ventilation (which led to carbon dioxide accumulation around the produce), and increasing moisture loss from fruit which is accumulated within the polyethylene bag during this storage period. Some authors[24] reported that bacteria which is one of the major disease causing organism can rapidly multiply and spread, particularly in water even on thin coating of water, such as on a wet fruit. The onset of chilling injury in the refrigerator which was observed on 27th day of storage made the fruit susceptible to attacks by psychrophilic microorganism which resulted to disease incidence[25]. Accumulation of water on fruit when electric power supply fails combined with the increase in temperature during such period of storage provides a conducive environment for the proliferation of disease causing organism. The same author[25] also stated that refrigerated tomatoes can be ruined by the growth of psychrophilic microorganism. An author[26] also explained that the presence of bacteria, yeast, and mold can have an adverse impact upon refrigerated products. Lower disease incidence of 2.3 (slightly infected) was however observed in the open shelf at 34 days after storage which was significantly (P<0.05) lower than the refrigerator (3.0 i.e. moderately infected). In Nigeria the higher disease incidence that is always observed in the open shelf during the postharvest chain is due to exposure of tomatoes to direct sunshine, poor postharvest handling and reuse of traditional weaved wicker baskets for packaging tomatoes until the baskets becomes infected with primary fungal spores from previously infected fruits. These pathogenic inocula occurring on wooden boxes and baskets can initiate disease upon contact with healthy fruits, which eventually result to losses[27].

The overall freshness of a produce depends on the extent of changes that occurs in it quality parameter during the process of storage. The major problem during storage is the change in the quality parameters of the produce especially the physical characteristics such as; the color, texture, and freshness .Generally, the loss of freshness of perishable commodities depends on the rate of respiration[28]. The reduction in tomatoes freshness from the 9th day of storage which increased with increasing length of storage towards deterioration and storage conditions validated the assertion of some authors[29] that deterioration of fresh commodities can result from physiological break down due to natural processes, water loss, temperature injury, physiological damage or invasion by microorganisms and that all these can interact and are influenced by temperature. The highest freshness of tomatoes fruits of 4.0 (excellent appearance) observed in the refrigerator from 12 days after storage to 21 days after storage which was significantly ($P<0.05$) higher than the open shelf and evaporative coolant structure can be attributed to the low temperature in the refrigerator which slowed down all processes that can lead to rapid physiological break down of fruit and hence minimized deterioration of fruits with the passage of time. This result also agrees with the submission of some authors that the refrigerator creates a high humid environment for the stored produce that slows the rate of moisture loss, metabolic activities and the activities of micro-organisms (pathogens) which are the most destructive activity during storage of fruits and vegetables[30, 31, 9]. In another development, an author[32] also reported that fruits storage at extremely low temperature preserves quality better at increased storage period. At 34 days of storage, the open shelf was however observed to have freshness of 3 (good appearance) that was significantly ($P< 0.05$) better than the refrigerator which had a freshness score of 2 (acceptable freshness).

The result (Table no1) showing the increase in vitamin C content of open shelf and refrigerator from the green stage to the deep red stage is in line with the observation some authors[33] who reiterated that during storage, it is noticed that ascorbic acid increased first with the ripening stage from light pink stage to red stage of ripening after this it decreased with the increase in red color and storage time. Preservation of ascorbic acid content during storage is however a difficult task since it undergoes oxidation[34]. Thus the observed reduction of the vitamin C content of the refrigerator and open shelf at deterioration. The lowest vitamin C content observed in the open shelf (23.83 mg/100g) at deterioration was due to the presence of higher oxygen concentrations in the storage atmosphere which hastens this process[35]. Since vitamin C is easily oxidized, storage and the cooking in air leads to the eventual oxidation of vitamin C by oxygen in the atmosphere[36]. Also according to two authors[37], increased temperatures normally results in high percentage loss of ascorbic acid. The highest mean temperature recorded in the open shelf might also be responsible for this reduction.

The total soluble solids acts as a rough index of the amount of sugars present in fruits. It is the amount of sugar and soluble minerals present in fruits and vegetables[35]. It was observed that the total soluble solids content of the tomatoes changed as ripening progressed towards deterioration (Table no2). This agreed with the findings of some authors[33] who reported that during ripening, the total soluble solute content of tomato fruit changes. This change in TSS content was due to the natural phenomenon that occurred during ripening and are correlated with hydrolytic changes in starch concentration during postharvest period. In tomatoes, conversion of starch to sugar is an important index of ripening[38]. Thus the significant increase in the total soluble solids during ripening in tomatoes stored in all the storage structures might be due to conversion of polysaccharides to simple sugars[39]. Present observation agrees with the findings of some author[40, 41] who reported that total soluble solids of tomatoes increased at different ripening stages, temperatures and packaging materials. Chilling injury observed in refrigerator however accelerated the rate of polysaccharide degradation to sugar and this led to increased total soluble solids of tomatoes of refrigerator at deterioration when compared with the open shelf.

Titratable acidity is a measure of all aggregate acids and sum of all volatile and fixed acids[39]. According to an author[42], acidity is often used as an indication of maturity, as acid decreases on ripening of fruit. A decreased titrable acidity was observed in the three storage conditions at the light and deep red stage of ripening when compared with the green stage (Table no3). The general gradual decrease in titrable acidity of tomatoes with time during ripening and storage had been confirmed by different authors[43.41]. This can be attributed to the disappearance of malic acid first, followed by citric acid which results in reduction of the amount of titrable acidity, suggesting the catabolism of citrate via malate[44, 45].

IV. Conclusion

Present observations in this study revealed that the three storage structures influence the deviation from the initial quality of tomatoes to different extent. Although the ECS preserved the nutritional composition of tomatoes better at deterioration, its higher rate of deterioration, poor postharvest physical quality preservation and low shelf life extension makes it an economic and efficient storage structure for only short term storage of tomatoes The open shelf may therefore be a good storage method for long term storage of tomatoes provided the tomatoes are properly handled and kept away from direction of sunlight. The use of perforated plastic crates or basket is preferable to the use of woven bamboo basket which react with tomatoes to hasten spoilage especially when they are reused for a long time without disinfecting them. Further studies to validate the efficiency of the open shelf to extend the shelf-life of tomatoes and preserve it postharvest quality for long storage period should be conducted. Further research should also be conducted to improve the efficiency of the ECS by providing controlled ventilation for fruits.

References

[1]. Soe, U. M.. Value-Added Food Production Based on Farm Produce in Myanmar Ministry of Agriculture and Irrigation, Myanmar ,2003.
[2]. Babalola DA, Makinde YO, Omonona BT, Oyekanmi MO. Determinants of postharvest losses in tomato production: a case study of imeko – Afon local government area Ogun State. Acta SATECH. 2010;3:14-18.
[3]. Martinez-Valvercle, I, Periage MJ, Provan G, ChessonA..Phenolic compounds, Lycopene and antioxidant activities in commercial varieties of tomato (lycopersiconesculentum).Journal of the Science of Food and Agriculture. 2002;82:323–330.
[4]. Steven A.S. and Celso L.M. Tomatoes, http: // usna.usda.gov/ h666/138tomatoes 2005.
[5]. FAOSTAT. Food and Agriculture Organization of the United Nations. Available: http://faostat.fao.org/ . 2014.
[6]. FAO. Food and Agriculture Organization of the United Nations. FAOSTAT. Available: http://faostat.fao.org/. 2010.
[7]. UgonnaC U, Jolaoso MO, Onwualu AP. Tomato value chain in Nigeria: Issues, challenges and strategies. Journal of Scientific Research and Reports. 2015; 7(7): 501-515.
[8]. Ajagbe BO, Oyediran, W O, Omoare AM, and Sofowora OO. Assessment of post-harvest practices among tomato (solanum lycopersicum) farmers/processors in Abeokuta north local government area of Ogun state, Nigeria. International Journal of Education and Research.(2014); 2(3)
[9]. Ullah J. Storage of fresh tomatoes to determine the level of ($cacl_2$) coating and optimum temperature for extended shelf – life .Post Doctoral Fellowship Report. 2009
[10]. Sablani SS, Opara LU, Al – Balushi K. Influence of bruising and storage Temperature on vitamin C content of Tomato. Journal of Food, Agriculture and Environment. 2006; 4(1):54 – 56.
[11]. Irtwange SV. Application of Modified Atmosphere Packagingand Related Technology in Postharvest Handling of Fresh Fruitsand Vegetables. Agricultural Engineering International: TheCIGR E journal. 2006 ;8(4)
[12]. Achoja FO and Okoh RN. Post-harvest properties of tomato and effect on its marketing efficiency.Turkish Journal of Agricultural and Natural Sciences. 2014;1(1): 52–58,
[13]. Anju-kumari, Bhardwaj ML, Guleria SPS, Kumari A. Influence of stage of harvest on shelf life and quality of tomato. Horticultural Journal. 1993; 6(2):89-92.
[14]. Moneruzzaman KM, Hossain ABMS, Sani W, Saifuddin M, and Alenazi M. Effect of harvesting and storage conditions on thepost harvest quality of tomato (LycopersiconesculentumMill) cv. Roma VF . Australian Journal of Crop Science. 2009;113-121
[15]. Bayoumi VA. Improvement of postharvest keeping quality of white pepper fruits (Capsicum anuum L by hydrogen perioxide treatment storage conditions. Biologicaszegediensis. 2008;52(1):7-15
[16]. Ndukwu MC. Development of a Low Cost Mud Evaporative Cooler for Preservation of Fruits and Vegetables. Agricultural Engineering International: CIGR Journal. 2011; 13(1): 1-8
[17]. Babatola LA, Ojo DO, and Lawal OI. Effect of storage condition on tomato (Lycopersiconesculentum Mill.) quality and shelf life. Journal of Biological Sciences. 2008; 8(2): 490-493
[18]. Crookes PR, Grierson D. Ultrastructure of tomato fruit ripening and the role of polygalacturonaseisoenzymes in cell wall degradation. Plant Physiology. 1983;72: 1088–1093
[19]. Seymour GB, Colquhoun IJ, Dupont MS, Parsley KR, Selvendran RR. Composition and structural features of cell-wall polysaccharides from tomato fruits. Phytochemistry 1990;29: 725–731
[20]. Matas AJ, Gapper NE, Chung MY, Giovannoni JJ, Rose JKC. Biology and genetic engineering of fruit maturation for enhanced quality and shelf-life. CurrOpinBiotechnol. 2009;20: 197–203
[21]. Shewfelt RL, Prussia, SE, and Dooley JH. Quality of fruits and vegetables in home handling systems: Integrated view of fruits and vegetables quality. Technomic publ. co., Lancaster, PA. 2000: 273.283
[22]. Adebisi OW, Igbeka JC, Olurin T.O. Performance Evaluation of absorbent materials in Evaporative Cooling System for the Storage of Fruits and Vegetables. International Journal of Food Engineering . 2009; 5:3.
[23]. Elazar R. Postharvest physiology, pathology and handling of fresh commodities. Lecture Notes. Department of Market Research. Ministry of Agriculture and Rural Development, Israel. 2004
[24]. Ebimieowei E, Nwauzoma AB, and Bawo DDS. Postharvest Spoilage of Tomato (LycopersiconesculentumMill.) and Control Strategies in Nigeria. Journal of Biology, Agriculture and Healthcare 2013;3:10
[25]. Okanlawon E. Preservation of tomato using plant extract (calotropisproceraand hibiscus sabdariffaleaf extract). A research project submitted to the department of microbiology college of natural sciences, (COLNAS) University of Agriculture Abeokuta, Ogun state.2010
[26]. Singh RP. Scientific principles of shelf-life evaluation, In D. Man and A. Jones (Edition) Shelf-life evaluation of foods 2nd Edition, Aspen publishers, line. 2000;3-22.
[27]. Kora C, McDonald MR, Boland GJ. Occurrence of fungal pathogens of carrots on wooden boxed used for storage. Plant pathol.2005;54:665-670
[28]. Liberty JT, Okonkwo WI, and Echiegu EA, Evaporative Cooling: A Postharvest Technology for Fruits and Vegetables Preservation. International Journal of Scientific & Engineering Research. 2013; 4(8):2257- 2266.
[29]. Wilson LG, Boyette MD, and Estes EA. Postharvest Handling and Cooling of Fresh Fruits, Vegetables and Flowers for Small Farms. Leaflets North Carolina Cooperative Extension Service. Accessed on- line at: http://www.foodsafety.org/nc/1995; 800– 804.
[30]. Thompson JF. Ethylene control in storage facilities. Perishables Handling Newswletter Issue No. 80. University of California, Davis, CA, USA. 1994;7.
[31]. Katsoulas N, Baille A and Kittas C. Effect of misting on transpiration and Conductance of a greenhouse rose canopy. Agricultural and Forest Meteorology, 2001;106:233–247
[32]. Bachmann J. and Earles R. Postharvest handling of fruits and vegetables.ATTRR. Horticultural technical note. 2000;200:19.
[33]. Nadeem AA, Lubna Z, Hammad AK and Abdul ahad Q. Effects of naphthalene acetic acid and calcium chloride application on nutrient uptake, growth, yield andpostharvest performance of tomato fruit. Pak. J. Bot. 2013; 45(5): 1581-1587.
[34]. Okolie NP. andSanni TE. Effect of postharvest treatments on quality of whole tomatoes. Afr. J, Food Sci. 2012;6:70-76
[35]. Shahnawaz M, SaghirAhS, Aijaz HS, Aasia AP, and Shahzo GK. Quality characteristics of tomatoes (lycopersiconesculentum) stored in various wrapping materials. African Journal of Food Science and Technology.2012; 3(5): 123-128
[36]. Haruna, U, Sani MH, Danwanka HA, and Adejo E.Economic analysis of fresh tomato marketers in Bauchi metropolis of Bauchi state, Nig. NJAFE. 2012; 8(3):1-8.

[37]. Smith, J.S., Hull, Y.H.. Food Processing Principles and Applications, Blackwell Publishing. 2004
[38]. Kays SJ. Post harvest Physiology of Perishable Plant Products. Van Nostrand Rein Hold Book. AVI Publishing Co. New York. 1997: 149-316.
[39]. Naik DM, Mulekar VG, Chandel CG, Kapse BM. Effect of prepackaging on physico-chemical changes in tomato (Lycopersicon esculentum Mill.) during storage. Indian Food Packer. 1993:9-13.
[40]. Shehla S and Masud T. Effect of different packaging systems on the quality of tomato (Lycopersiconesculentum var. Rio Grande) fruits during storage. Int. J. Food Sci. Technol. 2007;10 (11): 1365-2621
[41]. Abdullah A, Alsadon I, Abdullah M, Mahmoud A, Obied A. Effect of Plastic Packaging on Tomato Fruits Stored at Different Temperatures and High Relative Humidity: Quality Attributes, Shelf-life, and Chemical Properties. Food Science and Agricultural Resources Center, King Saud Univ. 2004: 5-28.
[42]. Bhattacharya G. Served Fresh. Spotlight. Times Food Processing Journal http://www.timesb2b.com/food. 2004.
[43]. Aneesh M, Kudachikar VB, Ravi R. Effect of ionizing radiation and modified atmosphere packaging on shelf-life and and quality of tomato stored at low temperature. J. Food Sci. Technol. 2007; 44(6): 633-635.
[44]. Mattoo AK, Murata TH, Pantastica EB, Chachin K, Ogata K, and Phan CT. Chemical changes during ripening and senescence. Post harvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. Pantastico, Er. B. (Edn.). AVI Publication, Westport, Conn. 1975:103.
[45]. Salunkhe, D. K. and B. B. Desai. PostHarvest Biotechnology of Vegetables. CRC Press, Inc. Boca Raton, Florida, US. 1984;1: 55-82

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