Effect of Chemical Treatments and Modified Atmosphere Storage on Quality Attributes of Guava (*Psidium guajava L.*)

By

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TO

My Loving Father

Muhammad Aslam Javed (late)

and

My Respected Supervisor

Dr. Muhammad Atif Randhawa

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ABSTRACT

Escalation in the shelf life of guava fruit was investigated in response to post-harvest treatments and modified atmosphere storage conditions. Guava was dipped in chemical solutions of calcium chloride and calcium lactate @ 1, 2 and 3% for 5 minutes at room temperature. The treated fruits from each treatment were divided into three lots. One lot of treated guava fruit was kept in chamber with normal air composition (Phase I), while the second and third lots were kept in modified chamber with 5% and 10% CO_2 level (Phase, II), respectively. The temperature (10±1°C) and humidity (80%) were kept same in all storage conditions. The guava fruit was evaluated for change in quality parameters like TSS (°Brix), pH, Acidity, weight loss%, firmness (Kg force), respiration rate ($mLCO_2Kg^{-1}hr^{-1}$), ethylene gas production ($\mu LKg^{-1}hr^{-1}$), sugars (glucose, fructose, sucrose) g/100g, organic acids (citric acid, ascorbic acid, malic acid, tartaric acid) mg/100g, antioxidant activity (µmolTE/g), total phenolic content (mgGAE/100g) and at last sensory evaluation was carried out. It was obvious from the results that the chemical treatments had significant effect on the quality parameters and with the progression in storage the quality of fruits declined, however the rate of change in quality parameters was higher in control samples than chemically treated fruits. The TSS, glucose, fructose, sucrose, respiration rate and ethylene gas production change rate showed a climacteric pattern, they increased from 9.77 to 10.82, 2.73 to 3.15, 3.31 to 3.5, 1.67 to 1.99, 9.67 to 35 and 2.33 to 15 in control samples that kept at 0% CO_2 level at 12^{th} day of storage which afterwards decreased to 10.49, 3.00, 3.34, 1.84, 46.33 and 10.33 at 18^{th} day of storage, respectively. While the changes in the above parameters kept at 5% CO_2 level were 9.8 to 10.9, 2.71 to 3.28, 3.31 to 3.66, 1.66 to 2.08, 9.67 to 39.67 and 2.33 to 23 at 18^{th} day of storage which further changed to 10.57, 3.22, 3.61, 2.04, 34 and 16.33 at the termination of storage, respectively. Similarly, at 10% CO_2 level the changes in the quality parameters were 9.8 to 10.80, 2.71 to 3.27, 3.31 to 3.64, 1.66 to 2.04, 9.67 to 35.33 and 2.33 to 16.67 from initial to termination of storage, correspondingly. The pH, weight loss, malic acid, tartaric acid increased from 3.86 to 4.39, 1.19 to 2.73, 106 to 166, and 0.786 to 0.898 from 0 to 18^{th} days of storage in sample kept at 0% CO_2 level. Similarly, the change at 5% and 10% CO_2 level from start to 24^{th} days were 3.86 to 4.23, 1.04 to 2.53, 106 to143.67 and 0.787 to 0.875 and 3.86 to 4.12, 0.92 to 2.21,106 to 136.33 and 0.787 and 0.861, respectively. The acidity, firmness, citric acid, ascorbic acid, total phenolic content and antioxidant activity of guava fruit kept at 0% CO_2 decreased to 0.51 to 0.27, 8.424 to 2.977, 374 to 297.33, 176.77 to 91.33, 131.67 to 82.67and 34 to 2.33, respectively. Likewise, the decrease in said parameters at 5% CO_2 level were 0.51 to 0.36, 8.423 to 4.748, 374 to 318.67, 178 to 111.67, 131.67 to 98.67 and 34 to 3.33 and at 10% CO_2 level the changes were 0.51 to 0.40, 8.423 to 5.303, 374 to 328.67, 178 to 120.67, 131.67 to 104.67 and 34 to 7.33, respectively. The calcium dip treatments also affected sensory attributes and retained the firmness of guava fruit and ultimately reduce the weight loss of the fruit. Among the post-harvest dip treatments, 3% calcium chloride was found to be most effective pretreatment in maintaining the post-harvest quality attributes and extending the shelf life of the guava followed by 3% calcium-lactate and the use of 10% carbon dioxide gave better results than 5% carbon dioxide level. The shelf life of the guava fruits treated with calcium salts and stored under different levels of CO_2 was extended up to 24 days but the chemically treated fruits that were stored in normal atmosphere were spoiled after 18 days of storage.

CHAPTER 1

INTRODUCTION

Fruits play an important role in human diet because they are concentrated source of minerals, vitamins and dietary fiber. They are rich sources of iron, phosphorous, calcium, and magnesium and contribute 90% of dietary vitamin C. Yellow and green fruits are rich in vitamin A (β-carotene), folic acid, niacin and thiamine which are vital for normal functioning of the human body (Lima *et al*., 2002).

Guava (*Psidium guajava L*.) is a perennial tree of tropics and subtropics, having great economic value (Usman *et al.,* 2013). Guava is native to tropical America and belongs to family Myrtaceae. Worldwide cultivation areas of guava are Mexico, Brazil, Central America, South America, Peru and Colombia. More than 3800 guava species and 133 genera are found in the world. Guava is cultivated over an area of 62.3 thousand hectares with annual production of 512.3 thousand tons and yield of 8.2 tons per hectare yield in world (FAO, 2011). Guava is main fruit crop of Indian alluvial plains. In Pakistan guava is 4th most produced fruit crop. Guava production in Pakistan increased from 19,000 tons to 552,000 tons from1958 to 2008 with annual growth rate of 6.9% (GOP, 2009).

In Pakistan, total area under guava cultivation is 62.2 thousand hectares, which includes 48.7 in Punjab, 9.5 in Sindh, 3.4 in NWFP and 0.6 thousand hectares in Balochistan. Guava ranks third in area after citrus and mango and occupies 48.7 thousand hectare with annual production of 395.5 thousand tons in Punjab. The Punjab is contributing about 77.2% to the total guava production of Pakistan. The cities like Lahore, Faisalabad, Qasur, Haiderabad, Larkana, Kohat, Haripur, Mardan, Charsadda and Swabi are very eminent for the production of high quality guavas. Approximately 30-40% of fresh guava produce is spoiled annually in Pakistan due to the use of inadequate traditional methods particularly at post-harvest level that leads to a significant loss in country economy (GOP, 2009).

Guava is an imperative fruit grown in tropical and sub-tropical regions of the globe and one of the most important fruit crops of Pakistan grown throughout the country, produced with marginal inputs as compared to other fruits. It is an excellent source of various micronutrients especially vitamin C. Its soft character, limited post-harvest life, and vulnerability to chilling injury, confines it for commercialization. Guava is highly perishable

fruit that ripens quickly in a few days after harvesting at room temperature. Guava cannot be stored for longer period of time due to its delicate nature (Bashir *et al.*, 2003). The surplus quantity of the fruit remains unsold and goes to waste during peak harvest season. Extension in post-harvest shelf life and preservation of guava fruit is the pre-requisite for the economical and efficient utilization of this important fruit commodity in Pakistan.

In Pakistan commercial cultivars of guava include Safeda (Gola and Surahi) and seedless while other varieties like Apple color, Allahabad, Karela and Red fleshed are less frequently cultivated. Two seasons of growth of guava, winter and summer exist in Pakistan. Winter season begins in November and remains up to March. Summer season begins in April and remains up to August. Winter crop is more commercially beneficial. The summer crop is severely attacked by fruit fly infestation which adversely affects the quality and results in a significant loss to most of the guava growers (Khan *et al.*, 2003).

Guava has good potential for marketing because of its good taste, appealing odor, delicious flavor and very fine ratio of pectin, sugar and organic acids. Guava is considered very nutritious, remunerative and delicate crop. It is enriched in phosphorous, pectin, vitamin C, calcium and iron. High grade antioxidants, carotenoids, polyphenols and lycopene present in guava are epitome chemicals that can decrease the chance of many diseases like cancer arteriosclerosis, heart disease, diabetes arthritis and inflammation. It is very useful in diarrhea and gastroenteritis. It is also a good source of dietary fiber. Guava seeds have excellent laxatives properties. Guava fruit are enriched with vitamin C and iron which reduces cold and viral infection chances. Roasted ripe guava is also used as medicine for extreme cases of cough, cold and congestion in some parts of the world. Guava also reduces blood cholesterol and blood thickening problem. The guava fruit contains carotenoids (β-carotene) and flavonoids (anthocyanins) such as lycopene, zeaxanthin and lutein having antioxidant functions in lipidic phases. They block the free radicals that damage the lipoprotein membranes (Shami and Moreira, 2004).

Guava fruit is round and about 3 to 10 cm in diameter. The peel color of guava is yellow or pink at maturity in different species. The weight of guava fruit ranges from 100 to 250 g. Guava fruit contains 83 % moisture, 2.58 % protein, 0.6 % fat, 15 % carbohydrate, 10 % TSS, 0.6 % salt, 0.53 % ash, 280 IU/100g of vitamin A, 266 mg/100g vitamin C, 0.09 mg/100g iron, 42 mg/100g phosphorus and 23 mg/100g calcium (Ayub *et al.*, 2005). Guava

is a rich source of vitamin C and contains 5 times more content of vitamin C than oranges (Conway and Peter, 2001). Manganese in combination with oxalic and malic acids is also present in the guava (Nadkarni and Nadkarni, 1999).

Being a climacteric fruit guava exhibit a rapid rise in rate of respiration and production of ethylene during ripening (Mercado-Silva *et al.*, 1998). Guava fruit shelf life ranges from 2 to 4 days at ambient temperature (Bassetto *et al*., 2005). Numerous postharvest handling methods including controlled/modified atmosphere and cold storage have been recommended to extend the storage life and maintain quality of guava fruit. Its delicate nature, short post-harvest life, and susceptibility to chilling injury and diseases, limits the potential for export of guava fruit.

Marketing of guava in Pakistan is usually done at ambient temperature without cold chain. Guava is a highly perishable fruit so its life is shortened by the rapid softening of fruit that occurs after harvesting of fruits. So it is need of the day to extend the shelf life of guava to expand its commercialization because the distribution of fruits with continual eating quality is currently a major issue that must be subjected to considerable research (Golding *et al*., 2005).

Calcium is considered to play a special role in maintaining cell wall structure in fruits by interacting with pectic acid in the cell wall to form calcium pectate and also facilitating the cross linkage of pectic polymers. Calcium chloride has been widely used as preservative and firming agent in the fruits and vegetables industry for whole and fresh-cut commodities. Akhtar *et al*. (2010) described that the loquat fruits treated with $CaCl_2$ showed greater firmness and shelf life than the untreated fruits. Manganaris *et al*. (2007) suggested 62.5mM $CaCl_2$ immersion treatment for increasing the tissue firmness of whole peaches. Another work done by Manganaris *et al*. (2005) showed that calcium treated fruit showed 34.2-44.7% greater firmness when compared to the non-treated fruits.

Numerous postharvest handling methods including controlled/modified atmosphere and cold storage have been recommended to extend the storage life and maintain quality of guava fruit. Its delicate nature, short post-harvest life, and susceptibility to chilling injury and diseases, limits the potential for export of guava fruit. Modified atmospheres (MA) storage can extend the storage life of many tropical and subtropical fruits (Yahia, 1998; Kader, 2003). An inappropriate storage atmosphere may result in accumulation of fermentative

metabolites resulting in development of severe off-flavors, thus rendering the fruit unacceptable to the consumer (Ke *et al*., 1991; Beaudry, 1999). The increase in demand of tropical fruit in the world, and changing technological capabilities in developing countries may open new avenues for adoption of MA storage technology. During food preservation and processing, the color, texture, flavor and nutritional qualities of the food undergo changes.

Storage of fruits in controlled atmospheres, where higher CO_2 level is used had proved useful in retarding the rate of softening of nectarines and peaches (Olsen and Schomer, 1975) and many other fruit. However, the tolerance of different fruit to modification of O_2 and CO_2 in the storage atmosphere varies considerably. The storage of guava fruit in high CO_2 levels did not influence the respiration rates, but reduce ethylene production during ripening (Pal and Buescher, 1993).

Consumer demand for more natural, minimally processed and fresh foods is increasing. Modified atmosphere storage is a well-proven technology for preserving natural quality of food products in addition to extending the storage life. Modified atmosphere storage is one of the most successful preservation techniques suitable for wide varieties of agricultural and food products. The storage life of food products is considerably extended by modifying the atmosphere surrounding the food, which reduces the respiration rate of food products and activity of insects or microorganisms in food. Modified atmosphere storage in combination with pretreatments will not only help to minimize the 35-40% post-harvest loss of guava fruit which will ultimately benefits the guava producer by reducing the wastage of guava fruit.

Previously mostly guavas were grown for processed guava products like juices and nectars, jam and jellies, fruit paste, canned whole and halves in syrup. However, international market for fresh guavas is small. But now good international market potential exists for fresh guavas due to more consumer's awareness regarding the health benefits and alluring taste of this fresh fruit.

During the peak season of production large volume of fruits was wasted in absence of processing techniques and proper storage conditions. There is a need for establishment of processing techniques to avoid these losses. Due to delicate nature of guava it cannot be stored for longer period of time. The surplus quantity of the fruit remains unsold and goes to

waste during peak harvest season. The study was carried out with the objective to increase shelf-life of fruit leading to an increase in processing and export.

Objectives of Investigation

- Improve the storability of guava by pretreatments under Modified Atmosphere
- To assess the changes in physico-chemical characteristics during storage

CHAPTER 2

REVIEW OF LITRATURE

The guavas are very delicious fruit and usually picked fresh from the tree when ripe or mature. Guava fruits are used for fresh consumption and processed in the form of drink, nectar, jam and jelly. It is also used in sauce and chutney, or cooked as a vegetable when green. Moreover, guavas are also processed into a variety of products such as toffee, canned fruits, wine, squash, cheese, dried fruits, as well as flavoring for other foods. Guava is becoming more popular over other fruit trees due to its high adaptability, productivity and vitamin C content. Guava has high nutritive value and bear heavy crop every year. On contrary to other major fruits, guava requires little agriculture inputs and give good economic returns. Brief review about chemical composition, post-harvest treatments, storage stabilities, fruit ripening and sensory quality attributes of guava fruit have been reviewed and presented here in.

2.1. Origin and Morphology of Guava Fruit

Guava (*Psidium guajava L.*) is exotic fruit member of Myrtacea family. It is also known as “apple of the tropics” due to its strong aroma and flavor. Its place of origin is quite uncertain, extending in an area from southern Mexico through Central and South America. Currently, its cultivation has been extended to many subtropical and tropical parts of the world, where it also thrives well in the wild environment (Morton, 1987; Yadava, 1996; Mitra, 1997).

Guava tree is very hard with characteristic pale, smooth spotted bark that peels off in skinny flakes and usually grow to about 7-8 meters high. According to their cultivars fruits are different in size, flavor and shape. The sweet varieties are better while others may be astringent. Guava shape ranges from round, ovoid, to pear-shaped and with an average diameter of 4-10cm and weight ranging from 100-400g (Mitra, 1997). Guava fruit is composed of fleshy mesocarp of varying thickness and a softer endocarp with numerous small, hard yellowish-cream seeds (Malo and Campbell, 1994; Marcelin *et al.*, 1993). Exterior skin color ranges from light green to yellow when ripe and its pulp may be white, yellow, pink, or light red. Unripe guava fruit are astringent, hard in texture, acidic in taste and starchy due to its low sugar and high polyphenol content. When it ripens, the fruit

becomes very sweet, soft, its skin becomes thin and edible and non-acidic (Malo and Campbell, 1994; Mitra, 1997). Many guava cultivars exist today, broadly classified as pink or white. Seedless cultivars are grown in many countries, which have a great potential to become popular in the future (Yadava, 1996).

2.2. Nutritional Profile of Guava Fruit

The guava fruit contains 73–87% moisture, 0.8–1.5% protein, 0.4–0.7% fat, 0.5–1% ash, 5% dietary fiber and 12–26% dry matter (Chin and Yong, 1980). It is rich in ascorbic acid (vitamin C) 160-375mg/100g, at higher levels than other fruits. Minerals are present in guava fruit in higher quantities like calcium (14-30 mg/100g), phosphors (23-37 mg/100g), iron (0.5-1.3 mg/100g) and vitamins like B_1, B_2, B_3, B_5 and vitamin A are also present in appreciable amount (Bose *et al.*, 1999). Guava fruit consists of about 20% peel, 50% of fleshy portion and 30% seed core.

Carbohydrates are the principal and the main component of guava and their composition is dependent on the variety. Sugars contribute about 6-11% of the fresh weight of guava. Of the total carbohydrates content, about 60% are sugars, with a predominance of fructose (about 59%), followed by 35% glucose and 5% sucrose (Yusof, 2003). The dry matter is made of mostly structural and nonstructural carbohydrates. The final sugars contents vary in different varieties of guava, glucose, fructose and sucrose were in the range of 1.9% to 18.1%, 5.6% to 7.7% and 6.2% to 7.8%, respectively (El-Buluk *et al.*, 1996).

Guava fruit is also main source of pectin which range from 0.4% to 1.9% and is affected by several factors such as variety, crop season and stage of maturity. The quality of pectin is determined by its capacity to make a gel and is measured in terms of jelly units. It is reported that in winter season guava fruits contain higher amounts of pectin with more jelly units than the rainy season crop (Dhingra *et al.*, 1983). Unripe guava fruits gave pectin having less jelly units then half-ripe ones. On hydrolysis, guava pectin yields 72% D-galacturonic acid, 12% D-galactose, and 4% L-arabinose (Chang *et al.*, 1971).

Dietary fiber in fruits and vegetables has been associated with a reduction in colon and other cancer risks. Soluble fiber content is generally associated with a reduced risk of cardiovascular disease. A study carried on various tropical fruits showed that guava has highest content of total and soluble dietary fibers with values of 5.60 and 2.70g/100g, respectively (Gorinstein *et al.*, 1999). Soluble and total fiber content of guava are

extraordinarily high in comparison to all fruits and vegetables. It is found that ingestion of high fiber food to decreases sugar level in diabetes patient. It has anti-bacterial property that protects from microbial activity by cleaning the intestine and also improves digestion. Thus it strengthens the digestion system which inhibits constipation and diarrhea. Fiber from guava pulp and peel was tested for antioxidant properties and found to be a potent source of radical-scavenging compounds, presumably from the high content of cell-wall bound polyphenolics (2.62-7.79% w/w basis) present in each fiber isolate. Both guava peel and pulp contained high content of dietary fiber ranging from 48.55 to 49.42% (Jimenez-Escrig *et al.*, 2001). Dietary fiber decreases total cholesterol and bad cholesterol in body and have other helpful effects in diabetic patients (Vinik and Jenkins, 1998).

2.3. Health Benefits of Guava

Guava fruit contains a sufficient amount of benzophenone glycosides in ripe edible fruits and can inhibit accumulation of triglycerides in body (Shu *et al*., 2009). Ascorbic acid, gallic acid, ethyl benzoate and ß-caryophyllene are major components identified in white and red guavas. The guava pulp has antioxidant properties that can be associated with anti-cancer effects. Studies on humans have found that the utilization of guava for a period of 12 weeks reduced total cholesterol levels by 9%, blood pressure by 8%, triacylglycerides by 8%, and with increase in the levels of good cholesterol up to 8% (Singh *et al*., 1992). Farinazzi *et al*. (2012) showed that animals fed on guava pulp juice had lesser body weight, cholesterol, triglycerides and glycemia levels and increased levels of good cholesterol. Lyophilized pulp of guava induced hypoglycemic effects in diabetic rats due to its antioxidant activity.

Guava had been reported to lower the blood glucose level. Guava fruit extract has been shown to significantly restore the loss of body weight and reduces the blood glucose level in the diabetic condition. Fruit extract of guava protects the pancreatic tissues, including islet β-cells, against lipid per oxidation and thus reduces the loss of insulin-positive β-cells and insulin secretion (Huang *et al*., 2011).

Guava is also rich source of lycopene, a major pigment found in guava flesh of pink guavas (Nishino *et al*., 2002). Most important carotenoids which give oxidative defense are α-carotene, β-carotene, lutein, and β-cryptoxanthin. Main function of carotenoids is antioxidant activity. Carotenoids obstruct the free radicals that harm the lipoprotein membranes (Shami and Moreira, 2004). Besides the antioxidant activity carotenoids are

anticarcinogenic, immunogenic and protect the body against cardiovascular diseases and diabetes (Rich *et al*., 2003). Rahmat *et al*. (2006) identified the effect of guava consumptions on antioxidant and lipid state (Low density lipoprotein (LDL) and High density Lipoprotein (HDL) in young men. They found a distinct increase in HDL and antioxidant profile during the treatment phase for four weeks. Increase in HDL was associated with reducing heart diseases.

Ageing is the most common problem in todays modern life. Ageing is generally caused by natural factor like increase in age. In early age due to pollution, smoke and UV radiation ageing process has been stimulated and it is faster than natural. High oxidative stress in our body produces free radicals that are main cause of ageing. However, antioxidants have proven to destroy these free radicals and slow down the ageing process. So guava is considered best food to slow down the ageing process due to its good antioxidant properties.

White guava (*Psidium guajava L*.), as one of traditional Chinese medicines, is widely cultivated and mostly consumed fresh. In folk medicine guava leaves, fruit and stem bark were also used as a hypoglycemic agent. Hypoglycemic activity of guava leaves has been well-documented (Shen *et al*., 2008; Cheng *et al*., 2009), but not for guava fruit. Cheng and Yang (1983) has reported that guava juice exhibited hypoglycemic effects in mice by examining blood glucose level. Rishika and Sharma (2012) reported that guava leaf extract is used for achne vulgrais a chronic inflammatory disease, caused by propinobacterium acne. It is also effective for dental carries and dental plaque. They also demonstrated guava stem, leaf and bark extract was used for the antigiardiasic activity.

2.4. Post-harvest Changes in Guava

The ripening of the fruits corresponds to a series of physiological, biochemical and structural factors and variations such as changes in color, firmness, production of volatile compounds, accumulation of sugars, organic acid oxidation and decrease of alkaloids (Rhodes, 1980). Firmness is the most important attribute defining the quality of the fruit for consumption and processing, it also contributes to postharvest life of the fruit by offering protection during transportation and resistance to microorganism attack. The decrease in firmness during ripening has been attributed to modifications and degradation of the

components of the cell wall (Carvalho, 2001) as well as to the decrease of the fruit integrity (Chitarra and Chitarra, 2005).

Mowlah and Itoo (1982) determined that distinctive changes occurred in reducing sugars in pink and white guava at different stages of ripening. They found that reducing sugars increase during ripening up to the fully ripe stage. During ripening TSS increases and titratable acidity reduces with ripening as reported by Yamdagni *et al*. (1987). During different stages of guava fruit ripening, changes in chemical properties occur. Sweetness of flesh, softness, and skin color differs between different stages among different varieties. Variation in the rate of softening process in guava fruit depended upon the loss of pectin content in different varieties (Chin *et al*., 1994). During maturation process structure of cellulose and hemicelluloses also change. Actions of the softening enzymes like galactosidase, pectinesterase (PE) and cellulase enhances with ripening process (El-Buluk *et al*., 1995).

Two forms of cell-wall tissues make guava pulp, stone cells and parenchyma cells. Stone cells are more tough woody material responsible for a sandy sense in the mouth and these cells were not broken by enzymes due to their nature. Stone cells are responsible for 73% of the mesocarp tissue, while the endocarp is rich in parenchyma cells, which give it a softer feel (Marcelin *et al*., 1993). The texture firmness of guava fruit tends to decline progressively during ripening (Bashir *et al*., 2003). The firmness of fruit was dropped by eight-times from the hard mature green stage to the final soft ripe stage. The decrease in the flesh firmness took place during the first 10 days. When fruit ripens, outer color of skin changes from light green to yellow and its pulp may be white, pink, yellow, or light red. Unripe fruit is firm in touch, starchy, sour in taste and dry due to its low sugar and high polyphenol contents. Once the fruit ripens, it becomes soft, sweet, non-acidic and its skin becomes thin and edible (Malo and Campbell, 1994).

Guava fruit had 3-7 days of shelf life due to fast rate of ripening. The variety, harvesting time, and environmental conditions also effect on the rate of ripening of fruit (Reyes and Paull, 1995). In guava respiration and ethylene production rate increases after the first day of harvest. Climacteric peak of guava reaches between 4 to 5 days after harvest and then declines (Bashir and Abu-Goukh, 2002). Moisture losses in guava in hot climates results in weight loss up to 35% that effected on the postharvest quality and consumer acceptability

(Mitra, 1997). In guava highest amount of vitamin C is present at the un-ripe green phase and it reduces as the fruit ripens. During ripening in guava total fiber contents decreases due to the actions of certain enzymes (El-Zoghbi, 1994).

Rodriguez *et al.* (1971) observed a gradual increase in total sugars and TSS during guava fruit ripening. Total sugars and TSS increase within the duration of fruit ripening to hydrolysis of starch to sugars. More increase in total sugars in pulp and peel was observed after fruit firmness reached to 1.21 kg/cm^2, which coincided with the climacteric peak of respiration. The significant increase in total sugars observed after the climacteric peak may be attributed to the increase in activity of enzymes responsible for decline in the rate of sugar breakdown by respiration and for starch hydrolysis. The pulp of guava, have less total sugars than the peels because the peel has less moisture content as compared to pulp.

Medlicott and Jeger (1987) did research on two different varieties of guava and it was found that in both guava varieties, pH steadily enhanced during different maturity phases while acidity higher in the green and intermediary stage of maturation which reduced with the attainment of maturity. During maturation increase in both parameters indicate formation of organic acids. Increases in both pH and acidity are interrelated with greater amounts of un-dissociated organic acids, that is stored in the vacuole and fruits utilize these acids as respiratory substrate due to which titratable acidity decrease during ripening of guava. Results showed that rate of changes in titratable acidity vary in different cultivars of guava. Proportion of titratable acidity decreased with maturation process of guava and reached minimum at the last stage. Yamdagni *et al*. (1987) observed that titratable acidity decreased with ripening of guava in cultivars of Allabad safeda, Baranasi Sukhra and Sardar. Agarwal *et al.* (2002) have stated that the acidity decreased from 0.72% - 0.55% during ripening. Chang *et al*. (1971) found that malic, citric, tartaric and glycolic acids contribute toward the total acidity of guava. The titratable acidity increases up to the climacteric peak and then declines. The ascorbic acid content are in maximum concentration when the fruit is mature green and then its concentration tends to drop rapidly as the fruit ripens (Bashir *et al*., 2003). Bashir *et al.* (2003) described that in white and pink guava pulp acidity increased from 0.15% to 0.20% up to the ripening process and started to decrease after ripening.

The CO_2 production rate, during ripening of guava (both types, white flesh and pink flesh) showed a climacteric array of respiration, which is maximum during ripening at 1.21

Kg/cm^2 flesh firmness. The rate of respiration were high in pink flesh guavas than the white ones (Bashir *et al*., 2003).The maximum production of ethylene took place when the fruit is half ripped usually at the fourth day of harvest (Broughton and Leong, 1979).

2.5. Antioxidant Activity

Fruits are an important part of our daily diet as they not only provide nutrition but also have beneficial health effects because they are rich sources of phenols and antioxidants. Antioxidants are the chemicals that provide immunity against certain degenerative disease like cancer, inflammation, brain dysfunction, heart disease, arthritis, arteriosclerosis and accelerate the ageing process (Feskanich *et al*., 2000; Gordon, 1996; Halliwell, 1996). In the human body by normal metabolic action free radicals and active oxygen, such as superoxide anion (O_2-), hydroxyl radical (OH) and hydrogen peroxide (H_2O_2) are constantly formed. Their action is opposed by antioxidant defense system in the body, including antioxidant compounds and enzymes but if the system is disturbed, it causes oxidative stress which can lead to cell injury and death (Halliwell and Gutteridge, 1999). Therefore, much attention has been given on the utilization of antioxidants, especially natural antioxidants, to defend against the damage of free radicals or to prevent lipid peroxidation (Vendemiale *et al*., 1999). DPPH scavenging activity of guava extract was found at different maturity stages. It was found that at un-ripe stage guava showed maximum DPPH scavenging capacity (40–45%), while the minimum value (38%) was observed at the fully-matured phase. Lim *et al*. (2006) found that more DPPH activity at the green phase of development of fruit may be associated to its greater levels of total phenolic contents. Free radicals play main functions in different types of permanent diseases such as heart diseases and cancer (Valko *et al*., 2004; Nakabeppu *et al*., 2006). A compound which has radical reducing power acts as antioxidant and it decreases the chances of dangerous diseases by finishing free radicals (Khan *et al*., 2006). The quantities of DPPH activity of guava fruit extract increases when amount of guava extract increases. When concentration of antioxidants increase then this increase in concentration is associated with increasing the activity of DPPH and this indicates more antioxidants capacity (Gordon, 1996).

Declining of scavenging activity during development of fruit may be due to lowest amount of phenolic components, anthocyanins, physical and chemical changes during fruit ripening. Connor *et al*. (2002) reported that in blueberry fruit antioxidant concentration were

different that were harvested from various regions in different years. These differences attributed to the agro climatic conditions and differences in cultural practices, temperature, type of soils, and type of area. All these parameters affected on nutritional profile and antioxidant activities of the fruit.

2.6. Guava Polyphenols

Polyphenols are the most abundant phytochemicals and fruits are main source of these biochemicals (Jimenez-Escrig *et al.*, 2001). Currently, limited studies exist on the identification and quantification of guava polyphenolics. Guava are somewhat unusual in their flavonoid polyphenolic content as well, with significant levels of myricetin (55 mg/100g) and apigenin (58 mg/100g) present in edible tissues, but do not contain the more commonly found flavonoids quercetin and kaempferol (Miean and Mohamed, 2001) that are abundant in other fruits and vegetables. Procyanidins (condensed tannins) in both white and pink cultivars, concentrated in the skin and seeds, but very little in the pulp. Also, free ellagic acid was isolated in both varieties (0.2 mg/100g in pink, 0.05 mg/100g in white). In the whole guava, total phenolics are concentrated on the peel, followed by the pulp (Bashir and Abu-Goukh, 2002).

Polyphenolic compounds gradually decrease in pulp and skin of guava when firmness of flesh was decreased. Mowlah and Itoo (1982) described the stability of polyphenol components in white and pink guava. They identified that there were more polyphenol components during unripe stage of guava. When guavas attained maturity their polyphenol contents were decreased. Decreasing levels of polyphenolic compounds were also determined in mango (Abu-Goukh and Abu-Sarra, 1993) and banana (Ibrahim *et al*., 1994).

Gorinstein *et al.* (1999) found that guava is naturally enriched with gallic acid, total phenolics and soluble dietary fiber of the fruits. Bashir and Abu-Goukh, (2002) found condensed tannins like procyanidins in white and pink varieties. They found that condensed tannins concentrated in the skin and seeds but very little in the pulp. Itoo *et al.* (1987) found that unripe guava contains about 66% condensed tannins of its total polyphenols which decrease as the fruit grows and develops. Peel shows prominent levels of phenolics components than pulp. This may play an important role in protecting plants from diseases and give defense to the fruit against different ailments and insect pests. During guava ripening a decrease in astringency occurs due to increase in condensed tannins to form an

insoluble polymer and hydrolysis of a soluble arabinose ester of hexahydroxydiphenic acid, a precursor of ellagic acid. Quantity of polyphenols in fruit also effected by the degree of maturity as reported by Kondakova *et al.* (2009).

Phenolic compounds in peel and pulp of both guava types gradually decreased with decrease in flesh firmness. In the white and pink types total phenolics decreased to 7 and 3 fold in the pulp respectively. Hydrolysis of the astringent arabinose ester of hexahydrodiphenic acid and the increased polymerization of leucoanthocyanidins are related with decrease in astringency in guava ripening.

Rop *et al.* (2011) reported during ripening process from un-ripe to ripening stage, reduction in phenolic contents of guava was observed. According to their observations this process may be due to increased polyphenol oxidase actions in guava and due to the loss in astringency. Reduction in astringency is related with increased polymerization of leucoanthocyanidins and breakdown of astringent compounds. During ripening period in high bush blueberries phenomena of reducing of phenolic compounds has already reported by Kalt *et al*. (2003).

Flavonoids and Anthocyanins are compounds that belong to the group of compounds responsible for the coloration that ranges from dark red to violet and from white to light yellow. Flavonoids are diverse group of polyphenolics which can polymerize to form strong tannins. Major flavonoids classes include flavones, anthocyanidins, flavanones, and flavonols. Significant amounts of the flavonoids apigenin and myricetin have been found in guava (Arima and Danno, 2002).

The flavonoids contents in guava pulp are higher in green immature stage than semi ripe or fully matured stage. Flavonoids contents were lower in semi-ripe or fully matured fruit. Maximum concentration of flavonoids in green stage guava fruit was explained by scientists that at the mature stage of fruit different acids of phenols aggregate to form more complex compounds of phenol like tannins and lignin (Ben-Ahmed *et al.,* 2009). Therefore, due to variations in quantity of phenolic compounds in fruit with maturation, fully matured fruit has lesser quantities of flavonoids compounds than that in un-ripe and semi-ripe fruits. Variations in quantities of flavonoids contents in guava fruit at various phases of ripening can be due to the presence of flavonoids which is affected by genetic makeup of variety, growing

conditions, cultivar, conditions of soils, presence of different nutrients at harvesting stage (Jaffery *et al*., 2003).

2.7. Ascorbic Acid

Guavas are considered an outstanding source of ascorbic acid (AA), 3 to 6 times higher than the content of an orange and after acerola cherries it has the second highest concentration among all fruits. Guava fruits ripened during winter season (November-December) contained more ascorbic acid (325mg/100g) than those ripened during rainy season (July±August) (140mg/100g). Enhancement of ascorbic acid in guava was determined by Mercado-Silva *et al.* (1998) that ascorbic acid increased with the maturation of guava and fruit that were obtained during the winter-season had more amount of ascorbic acid than those that were obtained during the summer season. The ascorbic acid content is higher in the skin and declines towards the middle portion. Mitra (1997) mentioned that AA content is more influenced by the fruit's variety than by its ripening stage and storage conditions. Within the fruit, AA is concentrated in the skin, followed by the mesocarp and the endocarp (Malo and Campbell, 1994).

At the mature green stage the ascorbic acid content in guava is at maximum level and starts to decrease rapidly as the fruit ripens. At the final stage (flesh firmness 0.3kg/cm 2) the quantity of ascorbic acid was 85.6% in the peel and 86.3% in the pulp of the white-fleshed guava fruits compared to 78.1% and 76.6% of the peel and pulp of the pink fleshed guavas, respectively. It was observed that peel of guava fruit has more ascorbic acid then pulp (Bashir *et al*., 2003).

Maximum level of vitamin C is present in guava at green un-ripe stage and when fruit ripens its level starts to decline. Different research reports are present about the concentration of vitamin C in white and pink guavas. El-Faki and Saeed (1975) identified greater level in white pulp guava, while other researcher reports indicate reverse conditions. Maximum vitamin C is present in peel of guava fruit as compared to pulp of fruit (Wilson, 1980). Maximum level of vitamin C in the skin of guava due to intervening of phenolic components with the dye 2, 6 dichlorophenol indophenols used to analyze it. Minimum levels of vitamin C were determined in skin of mango than flesh of fruit in three varieties of mango cultivar by (Abu-Goukh and Abu-Sarra, 1993).

The white guava fruits had 19.2% and 22.3% more ascorbic acid than the pink ones, in pulp and peel, respectively. Different reports are available regarding the quantity of ascorbic acid in the pink and white guava types. El-Faki and Saeed (1975) reported that white guava have higher values of AA, while other scientists reported the reverse. Rodrigues *et al*., (1971) also reported that concentration of ascorbic acid was enhanced during ripening period of fruit. Mitra (1997) determined that ascorbic acid contents are more influenced by the fruit's variety than by its ripening stage and store room conditions.Within the fruit, ascorbic acid is more in the skin, then in the mesocarp and the endocarp (Malo and Campbell, 1994). As a water-soluble vitamin, ascorbic acid is extremely vulnerable to oxidation due to its unstable nature and is considered as a standard for stability of other nutrients during processing.

Lim *et al*. (2006) found that seeded guava has more ascorbic acid contents as compared to that of seedless guava. Variations in ascorbic acid concentration occur due to presence of multiple factors like type of variety, cultivar, practices during cultivation and situations during harvesting. The other changes like heat, photosynthesis, humidity and presence of pollutants are major factors that cause changes in concentration of ascorbic acid. Vitamin C concentration varies in different fruit with different manners during ripening stages. During ripening of fruit ascorbic acid concentration may increase, decrease or can remain constant (Cordenunsi *et al*., 2002).

Soares *et al.* (2007) conducted study on increasing style in amount of ascorbic acid during maturation. It was seen in their research that concentration of ascorbic acid in green stage fruit was75mg per 100 g of sample. After that quantity of ascorbic acid increased from 126 to 170 mg/100g at mature and fully ripe stage of sample. This increase in ascorbic acid quantity in fruit may be due to degradation of starch or carbohydrate to glucose that enhances the synthesis of vitamin C. Lim *et al*. (2006) reported increased quantity of ascorbic acid from 30mg to 145mg/100g in mature fruit. Gomez and Lajolo (2008) found 55% increase in vitamin C concentration in guava at maturity stage, but in mango fruit 35% concentration of ascorbic acid reduced during ripening period.

2.8. Storage Environment

The escalation in plea of tropical fruit in non-producing countries and changing technological skills in developing countries open new horizons for adoption of controlled

atmosphere technology. Even though much research has been done on finding the optimal conditions for controlled atmosphere storage for most of horticultural freights, guava is one of those commodities which have received less attention, in spite of its commercial significance.

Guava is a highly perishable fruit which ripens rapidly and has a shelf life of 2 to 3 days at room temperature (Basseto *et al*., 2005). Guava was stored at low temperatures to extend the shelf life by inhibiting enzymatic activity. T_0 increase the shelf life of guava usage of low temperatures is one of the most common practices. Guava fruit transpiration and its weight loss is reduced commonly by using of high relative humidity and low temperatures, which are closely associated to fruit deterioration and senescence (Sigrist, 1988). Reduction in weight not only leads to quantitative losses but also to deteriorate the texture (softening, loss of juiciness, and freshness) and the appearance (wrinkling and shrinkage) of fruit (Kader, 2002). Guava being highly chill sensitive cannot be stored at low temperatures such as 0 °C.

Modified atmospheres storage can prolong the shelf life of subtropical and tropical fruit (Kader, 2003). If storage atmosphere is not suitable, fermentative metabolites may be produced in fruits that resulting in development of severe off-flavors, thus the fruit become unacceptable to the consumer (Beaudry, 1999). In non-producing countries, increase in demand of tropical fruit and changing technological skills in developing countries may open new horizons for adoption of modified atmospheres storage technology. Kader (2003) recommended controlled atmosphere storage of guava at 5-15°C, 0-1% CO_2 and 2-5% O_2. Storage of fruits in modified atmosphere or coating with waxes was found to prolong the shelf life of guava (Kader *et al*., 1989).

Modified atmosphere prolong the shelf life of guava fruits (Kader *et al*., 1989) .The fruits stored under modified atmosphere had less weight loss, more percentage of pulp and ascorbic acid high organoleptic score and there were no adverse changes. However, like most tropical fruits, it must be considered that guava, is highly chill sensitive. Numerous researchers have observed that guava can be preserved for 2-5 weeks by storing them at 85%-95% of relative humidity at 5 to 10°C temperature (Gonzaga-Neto *et al*., 1999; Barkai-Golan, 2001). However, the ripening degree and variety of guava influenced the precise temperature range for storage (Gonzaga-Neto *et al*., 1999; Sidhu, 2006; Kader, 2009). Fully

ripe fruit are less chill sensitive as compared to mature-green guavas. Mature green guava should be stored at 8 to 10℃, while fully ripe may be kept at 5°C up to a week without showing signs of chilling injury (Kader, 2009).

The controlled atmospheres, mainly high in CO_2, has proved useful in delaying the rate of softening of peaches , pipfruit, nectarines (Olsen and Schomer, 1975), and many other fruit. Gonzalez-Aguilar *et al*., (2004) defined that storage of guava below10℃ may result in severe chilling injury signs in the form of skin and flesh browning and surface pitting, therefore controlled/modified atmospheres (CA/MA) storage can prolong the life of several subtropical and tropical fruits (Yahia, 1998; Kader, 2003). The effects of controlled atmospheres (CA) on respiration, firmness, ethylene production, weight loss, chilling injury, quality, and decay incidence of three varieties of guava fruit were studied by the Singh and Pal (2007) during storage in atmospheres containing 2.5, 5, 8 and 10 kPa O_2 with 2.5, 5 and 10 kPa CO_2 at 8℃, at temperature normally inducing chilling injury. Mature light green fruit of cultivars, 'Lucknow-49', Apple Colour' and 'Allahabad Safeda' were stored for 30 days either in CA or transferred to ambient conditions (60-70% R.H and 25-28°C) and normal air, for ripening. Respiratory and ethylene peaks of guava fruits during ripening were suppressed and retarded by usage of CA storage. It was observed that fruit stored in low O_2 (≤5 kPa) atmospheres has greater retardation of ethylene production and respiration than those stored in CA containing 8 or 10 kPa O_2 levels. The amount of ascorbic acid decrease in guava if concentration of CO_2 was high (>5 kPa). Modified atmosphere storage was effective in retaining fruit firmness and reducing the weight loss. The changes in titratable acidity (TA), soluble solids content (SSC), total phenols and ascorbic acid, were suppressed by CA, the extent of which was dependent upon atmosphere composition and cultivar. When fruits stored in atmospheres containing 2.5 kPa O_2 higher levels of ethanol, fermentative metabolites and acetaldehyde were produced. Decay incidence and chilling injury were greater during ripening of fruit stored in air as compared in stored at optimal atmospheres. In conclusion, guava varieties ,'Allahabad Safeda', 'Lucknow-49' and 'Apple Colour' may be stored at low temperature (8℃) for 30 days supplemented with 5 kPa O_2 + 2.5 kPa CO_2, 5kPaO_2 +5kPaCO_2 , and 8 kPa O_2 + 5kPa CO_2, respectively.

Similarly Kader (2003) recommended 2-5% O_2 and 0–1% CO_2 for CA storage of guava at 5-15°C. The short term exposure of guava fruit to high CO_2 levels (10, 20 and 30%)

reduced ethylene production during ripening but did not affect the respiration rates (Pal and Buescher, 1993). Treating guavas with 10% O_2 +5% CO_2 for 24 h before storage in air for 2 weeks at 4°C decrease chilling injury and delayed color change, compared to fruit held in air (Bautista and Silva,1997). Modified atmosphere conditions for long term storage of guava have not yet been defined. The available data on the tolerance limits of guava fruit to low O_2 and high CO_2 atmospheres is erratic and indecisive.

2.9. Effect of Calcium Salts Pretreatments

Firmness in fruits is an important quality criterion that is used to determine storability. Firmness is determined by cell wall composition and structure. Loss of firmness quality in guava is a growing concern for the industry since daminozide use has stopped. The texture of guava fruit tends to decline progressively during ripening (Bashir *et al*., 2003). The hard mature green guavas drop their firmness about eight-folds at the final soft ripe stage. The decrease in the flesh firmness took place during the first 10 days.

Calcium is said to play a distinct role in maintaining cell wall structure in fruits and storage organs by interacting with pectic acid in the cell wall to make calcium pectate and also facilitating the cross linkage of pectic polymers. Akhtar *et al*. (2010) showed that the firmness of loquat fruits treated with 2% and 3% $CaCl_2$ was significantly higher than untreated ones or treated with 1% $CaCl_2$. Manganaris *et al*. (2007) found the firmness of whole peach fruit was increased after immersion in 62.5mM $CaCl_2$ solution. Calcium treated canned peach halves firmness increased from 34.2 to 44.7% than the untreated fruits (Manganaris *et al*., 2005). Luna-Guman and Barrett (2000) found that $CaCl_2$ and calcium lactate gave the similar level of firmness primarily during storage, but the maintenance of firmness tended to be higher in calcium lactate treated fresh cut cantaloupes throughout the storage. Hernandez-Munoz *et al.* (2006) observed that the loss of firmness in untreated fruit after 4 days decreased by 40% whereas the firmness of calcium gluconate treated fruit decreased only by 20%. Amparo Qulies *et al*. (2007) observed the influence of calcium salts on the micro-structure of the parenchyma of fresh cut fuji apples and reported that the cell walls, tonoplast and plasmalemma became more stronger, compact and thicker. Calcium infiltration treatment at 2.5% considerably increased the firmness of papaya fruits followed by 3.5 and 1.5% respectively when compared to the control.

Calcium dip treatment also had a significant increase in the firmness levels but was less when compared to the calcium infiltration treatment (Mahmud *et al.*, 2008). Rico *et al.* (2007) observed that calcium treated carrot slices required a higher potency to be ruptured, which means that the middle lamella was stronger or cell turgor was higher. Kumar *et al.* (2005) treated different cultivars of canola fruit with 1% solution each of $CaCl_2$ and stored at ambient temperature (18±2°C). They reported that $CaCl_2$ was more suitable for improving the fruit texture. A calcium lactate dip treatment was given at 25 or 60°C resulted in expressively firmer fruit samples during storage.

Mature green guava fruits of cultivar 'Allahabad Safeda' were harvested. Postharvest treatments of calcium chloride (1, 2, 3%), gibbrellic acid (25, 50, 75 ppm) were applied on fruits. The fruit treated with calcium chloride (2%) maintained higher fruit firmness throughout the stipulated storage period of 4 weeks as compared to the other treatments (Mahajan *et al.*, 2011). Antunes *et al*. (2008) reported that fresh-cut melon fruits treated with 1% or 1.5% $CaCl_2$, kept better their quality attributes than non-treated fruits. Different Apple cultivar were treated with 0 and 9 % $CaCl_2$ solution for the period of 12 minutes and stored for the period of 150 days at 5±1°C with 60-70 % relative humidity. Samples treated with 9% $CaCl_2$ showed better firmness results then the control treatment (Jan *et al.*, 2013) Werner *et al.* (2009) reported that guava dipped in 1% solutions of calcium chloride for 15 minute retained their quality for 12 days, showing that decreased pectin methylesterase activity and lower weight loss during storage. Refrigerated guava dipped in 0.5% and 1% calcium solutions maintained its shelf life up to 16 days (Gonzaga-Neto *et al.*, 1999).

Luna-Guzman *et al.* (2000) reported that 1.5 or 2.5% $CaCl_2$ treated samples of musk melon were scored significantly more bitter and firmer then the just cut samples. Calcium lactate treated samples were firmer but less bitter than just cut samples. Significant lower moisture content (amount of moisture released by the melon cylinder when biting on it) was observed using 2.5% $CaCl_2$, 1% or 2.5% calcium lactate. Saftner *et al.* (2003) observed that the sensory evaluation of calcium chelate and calcium propionate samples were taste free and did not give a lip feel. Luna-Guzman and Barrett (2000) reported that fresh-cut cantaloupe was treated with 2.5% calcium lactate and calcium chloride ($CaCl_2$) solutions. Both calcium salts preserved the melon firmness during cold storage. Insignificant differences were observed in the physiological behavior of the treated fresh-cut compared to just-cut samples.

Martin-Diana *et al*. (2005) found insignificant differences on sensory attributes (off-flavours or texture) between samples treated with calcium lactate and calcium chloride. However, when warm temperatures were used, significant improvements in sensory attributes were observed. Mahajan *et al*. (2011) found that the mean sensory quality score was significantly highest (7.11 out of 9) in fruits treated with calcium chloride (2%) and the control fruits recorded the lowest score (5.94 out of 9). Initially, the fruits treated with calcium chloride were rated as desirable after four weeks of storage. Calcium application has been reported to improve the organoleptic quality of mango (Wills and Tirrnazi, 1982).

Optimally matured guava fruits were sorted and graded for uniform size, color and were treated with different levels of calcium salts which include 3% calcium chloride, 4.5% calcium chloride, 0.4% calcium propionate, 0.8% calcium propionate and were stored at low temperature storage (7±1°C, 90-95% RH) condition. The results showed that 3% calcium chloride and 0.8% calcium propionate were effective in extending the shelf life with maximum retention in color, texture, titratable acidity and most other quality attributes.

The percent weight loss increased with the progression in storage period rather slowly in the beginning but at a faster place as the storage time increased. Calcium applications are known to be effective in terms of membrane functionality and maintenance of integrity with lower losses of proteins and phospholipids and decrease ion leakage which could be responsible for the lower weight loss found in calcium treated plums. (Lester and Grusak, 1999). The influence calcium additives on the weight loss is usually estimated to improve the water vapour barrier properties by enhancing film resistance to water transmission and giving hydrophobicity (Han *et al*., 2004).

Calcium infiltration treatments of papaya at concentrations 2.5% and 3.5% reduced the weight loss. It was also found that there was a difference between the weight loss of fruits dipped in 2.5% calcium and the control in the beginning of storage, which slowly reduced during storage (Mahmud *et al.,* 2008). Dhruba and Gautam (2006) reported that the cumulative weight loss of tomato when treated with (0.25% and 1.0%) $CaCl_2$ was significantly lower when compared to the control. After 10 days of storage they determined that the cumulative weight loss in 1.00, 0.75, 0.50, 0.25% calcium treated fruits was 12.14, 12.80, 14.86 and 17.02 %, respectively as compared to 19.03% in controlled fruits.

Al Eryani raqeeb *et al*. (2009) reported that the calcium infiltration treatments of papaya fruits reduced the weight loss during storage period of 21 days when compared to the control. Calcium treatment at 2.5% significantly reduced weight loss when stored for 7 and 14 days compared to other concentrations (1.5% and 3.5%) and control. However, after 21 days of storage, this treatment was significant as compared to the control and 1.5% but not with 3.5% calcium treatment. Mahajan and Dhatt (2004) stated that pear fruit treated with $CaCl_2$ have reducing the weight loss most effectively as compared to non-treated fruit within 75 days of storage period. Akhtar *et al*. (2010) reported that the control and 1% $CaCl_2$, treatment showed maximum weight loss while minimum was recorded at 3% calcium chloride treatment for a Loquat fruit during storage at 4°C. Antunes *et al*. (2008) reported that weight loss was significantly reduced by $CaCl_2$ postharvest applications. After 6 days at 5ºC flesh melon cylinders treated with 1.5% $CaCl_2$ lost significantly lower weight than the other treatments.

Ascorbic acid is an essential nutrient and quality parameter and is very sensitive to degradation as compared to other nutrients within food storage and processing due to its oxidation. Calcium is said to delay the rapid oxidation of ascorbic acid. Akhtar *et al*. (2010) reported that loquat fruit treated with $CaCl_2$ retained higher amounts of ascorbic acid. The loss of ascorbic acid was 10.9% and 8.4% in treatments having 1% and 2% of $CaCl_2$ compared to control treatment having 19% loss while in 3% the loss was only 2.5%. During the storage period of ten weeks ascorbic acid content decreased progressively. Ruoyi *et al*. (2005) also stated that during fifty days storage ascorbic acid content of peaches was maintained with post-harvest treatments of 0.5% $CaCl_2$. Al Eryani Raqueeb *et al*. (2009) reported that there was a very little influence of calcium salts on the retention of ascorbic acid in papaya but $CaCl_2$ in combination with chitosan coatings had a significant effect. Mahmud *et al*. (2008) reported that the ascorbic acid level was maintained with post-harvest application of calcium.

2.10. Sugars in Guava Fruit

In all varieties of guava it was seen that concentration of sugar gradually increased in the green phase of fruit. More sugar level was increased at maturity stage of fruit formation. Mowlah and Itoo (1982) determined in white and red guava fructose was main sweetening

element. Fructose enhances in all stage of maturation process. During ripening process of guava reducing sugars increased and afterward start to decrease in fruit.

Agarwal *et al.* (2002) also reported that the TSS value increased during ripening and the highest of 12.7^{o}brix was observed when the fruits were 100% yellow and the lowest of 10.5o brix was observed when the fruits were 100% green. After the climacteric peak of ripening the significant increase in the total sugars was observed, may be attributed to the increase in the activity of enzymes responsible for starch hydrolysis and for reduction in the rate of sugar breakdown by respiration.

Rodriguez *et al.* (1971) determined that total soluble solids and sugars increase in the duration of fruit ripening. During fruit ripening increase in soluble solids and sugars in fruits is due to breakdown of starch to sugars. The reducing sugars in the peel and pulp increase up to the climacteric peak and subsequently decrease (Bashir *et al*., 2003). The highest values were 6 and 10 (g/100g fresh fruit) in the peel and 5 and 8 in the pulp of the pink and white guavas respectively. The remarkable changes in sugar content have been observed in climacteric fruits, during fruit ripening. Starch converts into glucose during fruit ripening (Wills *et al*., 1981). Mowlah and Itoo (1982) revealed that fructose, glucose, and sucrose were the important sugars in the pink and white -fleshed guavas. During the ripening of guava, level of fructose increased and with over ripening of fruits, it decreases gradually.

Significant increase in total sugars examined may be attributed to the increased actions of enzymes which increase hydrolysis of starch into sugar. When hydrolysis process of starch increases then more starch converted into sugar components. Skin of guava fruit is reported to contain more sugar as compared to flesh. Because in skin less amount of moisture is present as compared to pulp of fruit. Significant variations in sugar components at the ripening stage are shown by climacteric fruits. Carbohydrate or starches convert into sugars during ripening process in fruit. During ripening of fruit level of fructose increases in guava then its level starts to decline in over ripe fruits. Same observations were also studied in mango fruits (Abu-Goukh and Abu- Sarra, 1993).

Guava is mainly consumed as fresh fruit. Guava fruit is delicate in nature and cannot be stored for a long time. Its soft texture, limited post-harvest life, prone to diseases and chilling injury restricts it for commercialization. Due to increased consumer demands of fresh and minimally processed food products in the market, it is important to develop

new/innovative methods to maintain the keeping and nutritional quality of fruit and to curtail the alarming post-harvest losses which spoil even up to 50% of the fresh produce. The literature review highlighted that guava is sensitive towards low temperature and storage of guava below 10°C results in chilling injury and discoloration of fruit. In depth analysis of literature review reveled that very limited work has been carried out on shelf life extension of guava fruit by using pretreatments and modified atmosphere conditions in Pakistan. The summer crop mostly goes to waste because the temperature in the environment of Pakistan especially in production area of guava fruit ranges from 35 to 40°C, which ultimately increase the respiration rate of the fruit and reduce the shelf life. Thus by maintaining temperature at 10°C and increasing the level of CO_2 during storage decrease the respiration rate which result in escalation of shelf life of fruit. Different studies carried out to enhance the shelf life of fruit but the effect of pretreatment in combination with modified atmosphere storage in Pakistan levels has not yet been explored. Application of calcium chloride and calcium lactate as pretreatments and storage of guava fruit in modified atmosphere conditions under increased CO_2 level was studied.

CHAPTER 3

MATERIAL AND METHODS

3.1. Procurement of guava

Guavas were procured from selective growers around the Faisalabad and the fruits were picked at their maturation stage, with the color of the peel varying from dark green to light green. After harvesting, from selected plants, fruits were brought directly to the fruit and vegetable processing laboratory of National Institute of Food Science and Technology, University of Agriculture Faisalabad-Pakistan. Fruits were washed and cleaned for further processing.

3.2. Treatments

Guava fruits were dipped for 5 minutes in water solution containing $CaCl_2$ and Ca-Lactate at different concentration, separately at room temperature as mentioned below in Table 3.1. After dipping, the fruits were dried with hand towel. The study was divided in two phases.

3.2.1 Phase I

Effect of pretreatments with calcium salts on the storability of guava was determined in the Phase I. In the first phase treated guava were placed in chamber with normal air composition. The humidity and temperature of the chambers was maintained at 80% and 10$\pm$1°C. The treated guavas were analyzed for quality attributes at 0, 6, 12 and 18 days of interval. Every analysis was carried out in triplicate.

3.2.2. Phase II

In second phase the combined effect of calcium salts and increased CO_2 level on the storability of guava fruit were studied. The treated guava fruits were stored in modified atmosphere condition where CO_2 level was maintained at two levels 5% and 10%. The humidity and temperature in both the chambers were maintained at 80% and 10$\pm$1°C, respectively. The treated guavas were analyzed for quality attributes at 0, 6, 12, 18 and 24 days of interval. Every analysis was carried out in triplicate.

Table: 3.1. Treatment Plan

Treatment	Calcium Chloride (%)	Calcium Lactate (%)
T_0	-	-
T_1	1	-
T_2	2	-
T_3	3	-
T_4	-	1
T_5	-	2
T_6	-	3

3.3 Physical analysis

3.3.1. Weight Loss

Fruits were selected randomly from each treatment and weighed with electric balance before and during storage. The percent weight loss was determined by interval of 6 days. The weight loss was determined by the following formula (AOAC, 2003).

$$\text{Weight loss (\%)} = \frac{\text{(Intial weight – Final weight)}}{\text{Initial weight}} \times 100$$

3.3.2 Penetration force

Fruit texture analysis in term of penetration force was done with texture analyzer according to the method of Mizrach (2008). The texture of the guava fruit was measured by using the texture measuring system fitted with needle probe. The fruits were randomly selected from each treatment and placed at the base of texture analyzer (Mod. TA-XT2, stable micro system, Surrey, UK). The force required to penetrate the fruit surface up to a depth of 6mm was recorded and expressed in terms of the Kg.

3.4 Biochemical analysis

3.4.1 Total phenol determination and DPPH free radical scavenging activity

3.4.1.1. Preparation of sample

Weighed amount (200g) of samples were taken in glass bottles and the bottles were filled with the solvent (methanol) until a layer was formed above the sample. These samples were continuously shaken for 48 hours with the 3 hour interval at ambient temperature. After

this samples were filtered with filter paper and the extract obtained was concentrated to rotary evaporation for the removal of solvent from samples under vacuum. The distillation was stopped when the volume of extract remains 1mL. The solvent was further removed under purified gentle stream of N_2 gas. The sample was stored in freezer at -4℃ till further analysis.

3.4.1.2. Total phenolic content (TPC) determination

The total phenolic compounds were estimated by Folin-Ciocalteu method (Sun *et al*., 2006). From a known concentration of the sample solution 125 µL of sample was taken in a test tube. Then 500 µL distilled water was added in it. After that 125 µL of Folin-Ciocalteu reagent was added in it and gave a rest for 6 minutes. Then 1.25 mL of 7% sodium carbonate was added in it. Final volume was made 3mL by adding 1mL distilled water. The samples were allowed to stay for 90 minutes, for the completion of the reaction. The absorbance of the samples in triplicate was noted at 760 nm by using a UV-VIS spectrophotometer. Gallic acid was run as a standard along with the samples and its absorbance was taken at 725 nm. Its solution was prepared by taking 25 mg and dissolved in 25 mL distilled water. Concentrations of gallic acid ranging from 0 to 500 µg/ mL were prepared and its standard curve was used for the calculation of the total phenolic contents in the samples.

3.4.1.3. Antioxidant activity of guava: (1,1-diphenyl-2-picrylhdrazyl (DPPH) scavenging activity)

The free radical scavenging activity of guava fruit extracts was measured by spectrophotometer at 517 nm (Conforti *et al*., 2006). A methanol solution of DPPH was prepared immediately before the assay. Various concentrations of each guava extract (40-240µg/mL) were taken in different test tubes using duplicates and then 1mL of DPPH solution was added in each test tube containing extract. The reaction mixtures were shaken vigorously and allowed to stay for 30 min at room temperature in dark place. The absorbance of the samples was measured by a spectrophotometer at 517 nm. Trolox was used as a standard antioxidant to validate the assay.

3.4.2. Total soluble solids (TSS)

The total soluble solids of the thoroughly mixed guava fruit pulp was directly recorded by using hand refractometer (Model BS Eclipse 3-45) at room temperature (AOAC,

2003). A drop of fruit pulp was placed on the prism of refractometer and reading was observed. The results were expressed as percent soluble solids (°Brix).

3.4.3. Titratable acidity

Titratable acidity of the fruit pulp was determined according to the method described by AOAC (2003). 5g thoroughly mixed guava pulp sample was taken and made the volume 100 ml with distil water. Filtered the above solution and then 10 ml from the filtrate was taken and 2-3 drops of phenolphthalein indicator was added and titrated against standardized solution of 0.1N NaOH till light pink color appeared. The acidity in percentage was calculated by following formula:

$$\text{Acidity (\%)} = \frac{\text{eq.wt of acid} \times \text{normality of base} \times \text{Titre (ml)}}{\text{Wt. of sample} \times \text{Aliquot taken}} \times 100$$

3.4.4. pH

The pH of guava was determined with the help of digital pH meter (Model Ino-Lab720 Germany). The electrodes of pH meter were immersed in the thoroughly mixed pulp sample so that the tips of electrodes were covered. The pH was noted directly from the screen of pH meter (Fisk *et al.*, 2008).

3.4.5. Respiration rate

Rates of respiration were measured by the static system. For respiration, 3 guava per treatment were weighed and sealed together in a 3 L container for 1 h. Container used for respiration rate has an optimum size hole on lid which was tightly sealed with polythene bag. For CO_2 measurement a sensor attached with CO_2 gas analyzer (Model No. 8560 USA) was used to assess the % age of CO_2 produced in the container with in 1 hour (Pal and Buescher, 1993). The respiration rate was calculated using the following formula:

$$\text{Respiration rate (mL } CO_2 Kg^{-1}h^{-1}) = \frac{\%CO2. \times \text{void volume (mL)}}{\text{Sample weight (kg)} \times \text{sealed time (h)}} \times 100$$

3.4.6. Ethylene gas production

Rate of ethylene gas production was measured by the static system. For ethylene measurement, 3 three guavas per treatment were weighed and sealed together in a 3 L container for 1 h. Container used for respiration rate has an optimum size hole on lid which was tightly sealed with polythene bag. For ethylene gas measurement a sensor attached with ethylene gas analyzer (Draeger CMS Part No. 6406580) was used to determine the quantity of gas produced.

The ethylene gas was calculated using the following formula:

$$\mu L\ C_2H_4 Kg^{-1}h^{-1} = \frac{ppm\ C_2H_4 \times void\ volume\ (mL)}{Sample\ weight\ (kg) \times sealed\ time\ (h)} \times 100$$

3.4.7. Determination of Organic acids and Sugars

3.4.7.1. Sample preparation

The guava fruits were cleaned and seeds of the fruit were removed. Sections of fresh weighing about 50 g with peel were cut and blended in 40 mL distill water using a household blender for homogenization. The homogenate was centrifuged at 10,000 rpm for 15 min, and supernatant was filtered using whatman filter papers. The extract was then filtered through a 0.45 µm filter and stored at -4°C till analysis.

3.4.7.2. Organic acid determination

Organic acids (ascorbic acid, citric acid, malic acid and tartaric acid) was determined by HPLC by following the method of Akalin *et al*. (2002).

A standard stock solution was prepared by combining acids in following portions (1000mg/L citric acid, 2000mg/L malic acid, 700mg/L ascorbic acid and 400mg/L tartaric acid). The stock solution and the corresponding dilutions were made in ultrapure water and stored in dark places between the experiments, at refrigeration temperature.

Analysis was made by HPLC with UV detector (Perkin Elmer-series 200) at 214 nm using a reverse phase C-18 column (25 cm x 4.6 mm id). The operating conditions were: mobile phase, aqueous 0.5% (wt/vol) $(NH_4)_2HPO_4$ (0.038 M)-0.2% (vol/vol) acetonitrile (0.049 M), then both solution were added 50:50 % of each to make the final mobile phase, adjusted to pH 2.24 with H_3PO_4; flow rate 0.3mL/min and column temperature was ambient. The mobile phase was prepared by dissolving analytical grade $(NH_4)_2HPO_4$ in water, acetonitrile and H_3PO_4. HPLC-grade solvents/reagents were purchased from Sigma Chemical Company (St. Louis, MO). Mobile phase was vacuum filtered through a 0.45-µm membrane filtration assembly and degasses with vacuum degasser. 20µl of sample was injected into HPLC for the analysis. Individual standard was run to observe the retention time of specific organic acids. Then standard mixtures of organic acids of different concentration were run and retention time and peak area of respective standards was calculated as depicted in Fig.1. Then unknown samples were run on HPLC by using same set of conditions. The spiked samples were also run on HPLC in order to confirm the retention time and response of each organic acid.

3.4.7.3. Sugars

The sugars (fructose, glucose and sucrose) were determined by high performance liquid chromatography (HPLC). Analysis was made by HPLC with RI detector (Perkin Elmer-series 200) at 214 nm using polar bonded phase NH_2 column (25 cm x 4.6 mm id). The mobile phase was acetonitrile:water (80:20) and the flow rate was 1.5 ml min^{-1}. The injection volume was 20µl. Identification and quantification of sugars were done by comparing retention times and peak areas of samples to peak areas of standards as peak area was directly proportional to the concentration of the standard throughout the concentration range used. The temperature of column during analysis was maintained at 40°C.

Standard stock solutions of sugars (fructose, glucose and sucrose) were prepared by combining sugars in ultrapure water. The first one contained glucose 100 mg/ml, the second one fructose 100 mg/ml, the third one is sucrose 50 mg/ml, the dilution was carried on to make a suitable dilution for doing the working calibration curve which need as depicted in Fig. 2. The prepared standard solutions of sugars were stored at 4°C.

All the samples before injection in the HPLC sonicated for at least 15 minutes in ultrasonic bath to remove air bubbles and passed through filtration assembly (0.45 um filter size).

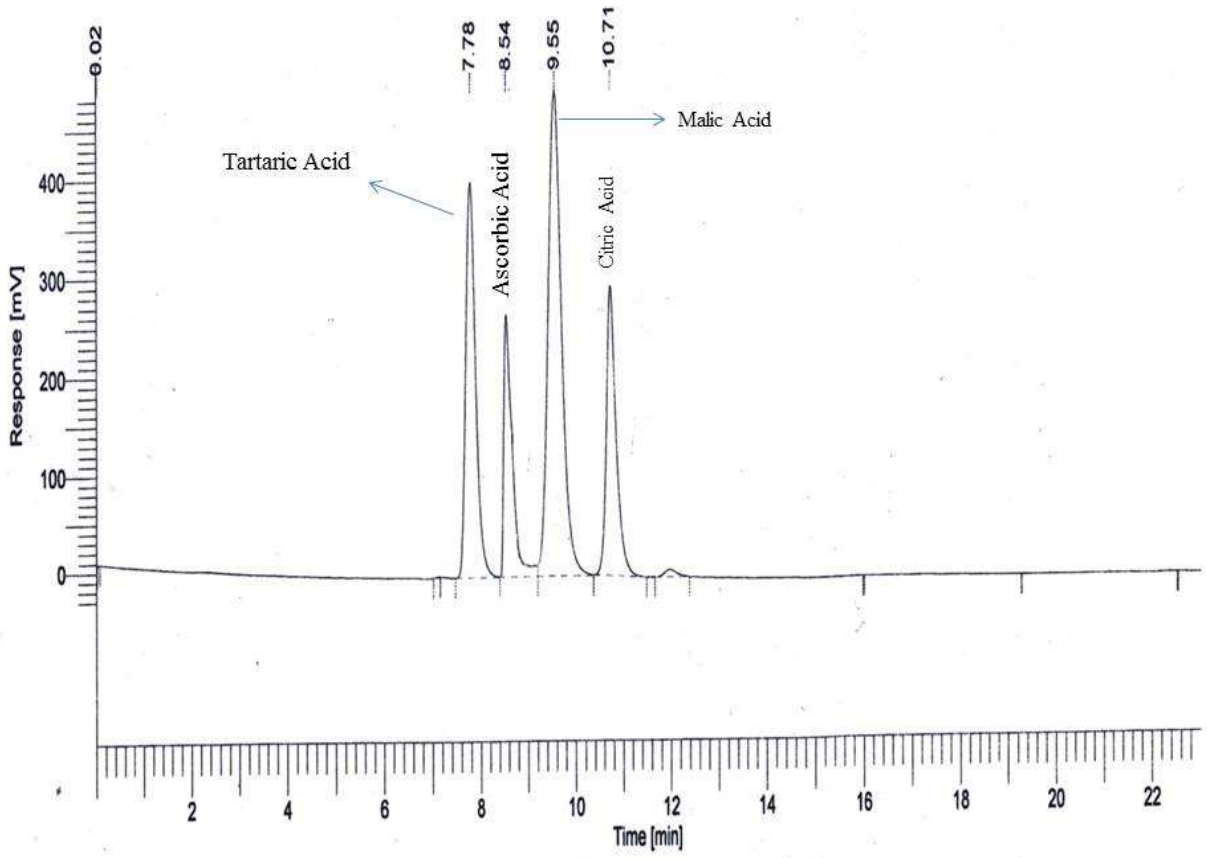
3.5. Sensory evaluation

Sensory evaluation of chemically treated guava fruit was carried out by a trained taste panel (3 members), employing 9-point hedonic scale (9 = like extremely; 1 = dislike extremely) following the guidelines of Meilgaard *et al*. (2007) as given in Appendix-I. Accordingly, sensory response for various quality traits of guava fruit like color, flavor, texture, taste and overall acceptability was recorded. All the evaluations were conducted by the panelists in separate booths under clear white fluorescent light in the Sensory Evaluation Laboratory of NIFSAT, University of Agriculture, Faisalabad. On evaluation day, guava samples were served in respective tureens with random codes to the panelists. During the evaluation process, they were also provided with mineral water for neutralizing and rinsing their taste receptors for rational assessment. The panelists were requested to rate the product quality by scoring for the selected parameters.

3.6. Statistical analysis

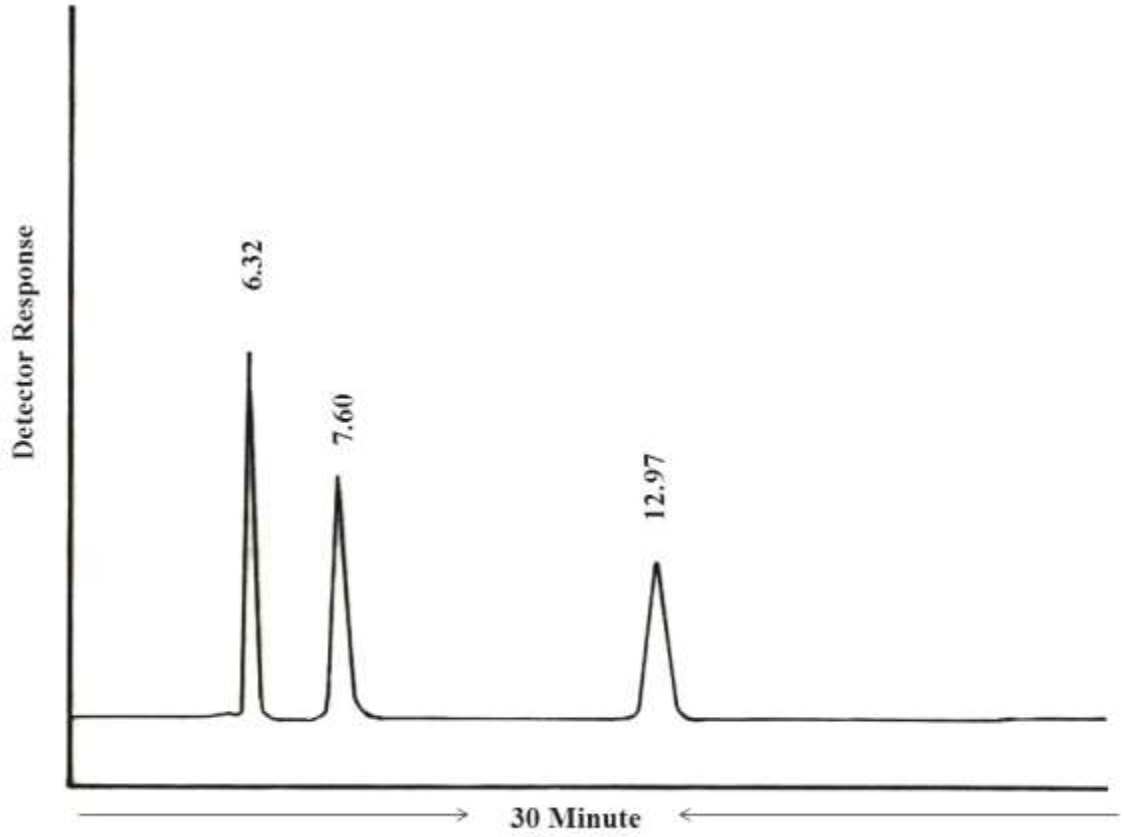
All determinations were conducted three times. Level of significance was determined (ANOVA) using 2-factor factorial CRD following the principles outlined by Steel *et al.* (1997) by statistical system. Tukey Test was employed to determine the statistical significance ($P \leq 0.05$) of differences between the means.

Fig.1 Standard chromatogram of organic acids



Chromatogram of organic acids analyzed by HPLC with UV detector at 214 nm using a reverse phase C-18 column (25 cm x 4.6 mm id), mobile phase $(NH_4)_2HPO_4$: Acetonitrile (50:50), flow rate 0.3mL/min, column temperature ambient

Fig. 2 Standard Chromatogram of Sugars



(Left to Right Fructose, Glucose and Sucrose)

Chromatogram of sugars analyzed by HPLC with RI detector at 214 nm using polar bonded phase NH_2 column (25 cm x 4.6 mm id), mobile phase acetonitrile:water (80:20), the flow rate 1.5 ml min^{-1}, Column temperature 40°C

CHAPTER 4

RESULTS AND DISCUSSION

Guava is the most important tropical and subtropical fruit with high nutritive value and can be cultivated under different soil and climatic conditions. It is one of the major fruit of Pakistan grown throughout the country. It bears fruit twice a year but the best quality fruit is obtained in winter. It is widely consumed in fresh state because of its palatable flavor and taste as well as containing various nutritional benefits for the consumer. It is a climacteric fruit exhibiting respiratory and ethylene peaks during ripening. Guava is highly perishable fruit that undergoes rapid post-harvest ripening in few days under ambient conditions. At ambient temperature its shelf life is only 3-4 days. Inadequate facilities in post-harvest handling, transportation, storage and marketing result in 20 to 40 percent losses of fruit. Keeping in view the above factors the study was carried out with the objective to increase shelf-life of fruit leading to an increase in processing and export. Locally grown guava from farmers were purchased and dipped in solution of calcium chloride and calcium lactate @ 1, 2 and 3%, respectively. The treated guava was divided in 3 parts and stored in climate chamber with modification in CO_2 level of 0 (Phase I) , 5 and 10% (Phase II) separately while the temperature (10 ± 1°C) and humidity (80%) were same in all 3 chambers. The change in quality parameters like TSS, pH, acidity, weight loss%, firmness, sugars (glucose, fructose and sucrose), total phenolic content, antioxidant activity, organic acids (citric acid, ascorbic acid malic acid and tartaric acid) respiration rate, ethylene gas production and sensory evaluation was determined by using standard procedures before and after the application of chemicals using a 6 days interval.

RESULTS

PHASE I

4.1. Total Soluble Solids (°Brix)

It is evident from mean squares regarding total soluble solids (TSS) of chemically treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.1.

From means as depicted in Table 4.2, it is deduced that the maximum value for TSS in the treated guava sample was recorded in T_1 and T_4 as 10.38 followed by 10.37 in T_2. However, the lowest recorded value was observed in T_6 as 10.35. Likewise, for T_3 and T_5 same value of TSS was observed (10.36).

Over the storage, a gradual increase in the value for TSS was noticed that ranged from 9.77 at initiation which progressed to 10.31, 10.77 at 6^{th} and 12^{th} days, respectively. However the recorded value for the parameter was 10.61 at the termination of 18 days of study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in TSS value during the course of storage till 12 days and then the TSS of the fruits started to decrease. The maximum increase in the TSS value was noted for T_0 which varied from 9.77 to 10.35 and 10.82 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further development in storage, recorded values for the trait were 10.49 at 18^{th} day. Likewise, For T_1 and T_4, TSS values differed from 9.80 and 9.77 to 10.79 and 10.81 at 0 to 12^{th} days, respectively. Furthermore, the noted value for the parameter was then decreased to 10.59 and 10.6 at the termination of 18 days study. The least increase in the TSS values was noticed for T_3 and T_6 which varied from 9.80 to 10.72 and 9.73 to 10.74 at initiation to 12^{th} days of storage, respectively. Thereafter, TSS of the T_3 and T_6 decreased to 10.67 and 10.66 at the termination of storage period.

4.2. pH

It is evident from mean squares regarding pH of chemically treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.3.

From means as depicted in Table 4.4, it is deduced that the maximum value for pH in the treated guava sample was recorded in T_0 as 4.12 followed by 4.10 in T_1 and T_4, respectively. However, the lowest recorded values were observed in T_3 and T_6 as 4.06. Likewise, for treatments T_2 and T_5 observed values for the trait were 4.08 and 4.09, correspondingly.

Over the storage, a gradual increase in the value for pH was noticed that ranged from 3.87 at initiation which progressed to 3.99, 4.15 at 6^{th} and 12^{th} days, respectively. However the recorded value for the parameter was 4.35 at the termination of 18 days study.

Table 4.1. ANOVA: Effect of chemical treatments on TSS of guava

Source	df	SS	MS	F
Treatment	6	0.0119	0.00198	2.60*
Days	3	12.0475	4.01582	5287.29**
Treatment x Days	18	0.1162	0.00646	8.50**
Error	56	0.0425	0.00076	
Total	83	12.2181		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.2. Effect of chemical treatments on TSS of guava

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	9.77 H	10.35 F	10.82 A	10.49 E	**10.36 AB**
T_1	9.8 H	10.34 FG	10.79 AB	10.59 D	**10.38 A**
T_2	9.80 H	10.3 FG	10.76 AB	10.62 D	**10.37 AB**
T_3	9.80 H	10.26 G	10.72 BC	10.67 CD	**10.36 AB**
T_4	9.77 H	10.36 F	10.81 AB	10.60 D	**10.38 A**
T_5	9.77 H	10.32 FG	10.76 AB	10.62 D	**10.36 AB**
T_6	9.73 H	10.25 G	10.74 ABC	10.66 CD	**10.35 B**
Mean	**9.77 D**	**10.31 C**	**10.77 A**	**10.61 B**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Table 4.3. ANOVA: Effect of chemical treatments on the pH of guava fruit

Source	df	SS	MS	F
Treatment	6	0.03860	0.00643	40.63*
Days	3	2.70273	0.90091	5689.95**
Treatment x Days	18	0.01636	0.00091	5.74*
Error	56	0.00887	0.00016	
Total	83	2.76656		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.4. Effect of chemical treatments on the pH of guava fruit

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	3.86 L	4.05 H	4.20 D	4.39 A	**4.12 A**
T_1	3.88 L	4.02 HI	4.16 DE	4.35 ABC	**4.10 BC**
T_2	3.86 L	3.99 IJK	4.14 EFG	4.35 ABC	**4.08 D**
T_3	3.87 L	3.96 K	4.10 G	4.31 C	**4.06 E**
T_4	3.87 L	4.03 HIJ	4.17 DE	4.36 AB	**4.10 B**
T_5	3.88 L	3.98 JK	4.15 EF	4.35 ABC	**4.09 CD**
T_6	3.86 L	3.95 K	4.11 FG	4.33 BC	**4.06 E**
Mean	**3.87 D**	**3.99 C**	**4.15 B**	**4.35 A**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in pH value during the course of storage. The maximum increase in the pH value was noted for T_0 which varied from 3.86 to 4.05 and 4.20 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 4.39 at 18th day. Likewise, for T_1 and T_4, variations in the values differed from 3.88 and 3.87 to 4.02 and 4.03 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter was 4.35 and 4.36 at the termination of 18 days study. The least increase in the pH values were noticed for T_3 and T_6 which varied from 3.87 to 4.31 and 3.86 to 4.33 at initiation to termination, respectively.

4.3. Acidity

It is apparent from mean squares regarding the acidity of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.5.

From means as depicted in Table 4.6, it is inferred that the maximum value for acidity in the treated guava sample was recorded in T_3 as 0.43 followed by 0.41 in T_6. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 0.38, 0.39 and 0.39, respectively. Likewise, for T_5 observed value for the trait was 0.40. Over the storage, it can be found that a gradual decrease in the value for acidity was noticed that ranged from 0.51 at initiation and declined to 0.43, 0.37 at 6th and 12th days, respectively. However the recorded value for the parameter was 0.30 at the termination of 18 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in acidity during the course of storage. The maximum decrease in the pH value was noted for T_0 which varied from 0.51 to 0.41 and 0.34 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait was 0.27 at 18th day. Likewise, for T_1 and T_2, variations in the values differed from 0.50 and 0.52 to 0.43 and 0.44 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter was 0.28 and 0.29 at the termination of 18 days study. The least decrease in the acidity was noticed for T_3 and T_6 which varied from 0.52 to 0.51 and 0.34 to 0.35 at initiation to termination, respectively.

Table 4.5. ANOVA: Effect of chemical treatments on the acidity of guava fruit

Source	df	SS	MS	F
Treatment	6	0.02092	0.00349	52.31*
Days	3	0.49015	0.16338	2450.73**
Treatment x Days	18	0.01110	0.00062	9.25*
Error	56	0.00373	0.00007	
Total	83	0.52590		

* = Significant ($p<0.05$), ** =Highly Significant ($p<0.01$)

Table 4.6. Effect of chemical treatments on the acidity of guava fruit

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	0.51 A	0.41 CD	0.34 H	0.27 J	**0.38 C**
T_1	0.50 A	0.43 BCD	0.36 GH	0.28 IJ	**0.39 C**
T_2	0.52 A	0.44 BC	0.39 EF	0.29 IJ	**0.40 B**
T_3	0.52 A	0.44 B	0.40 DE	0.34 H	**0.43 A**
T_4	0.50 A	0.42 CD	0.36 GH	0.29 IJ	**0.39 C**
T_5	0.51 A	0.43 BCD	0.38 FG	0.29 I	**0.40 B**
T_6	0.51 A	0.44 BC	0.40 DE	0.35 H	**0.41 A**
Mean	**0.51 A**	**0.43 B**	**0.37 C**	**0.30 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

4.4. Weight Loss%

It is evident from mean squares regarding weight loss of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be considerable as depicted in Table 4.7.

From means as depicted in Table 4.8, it is realized that the maximum value for weight loss in the treated guava sample was recorded in T_0 as 2.01 followed by 1.95 and 1.96 in T_1 and T_4, respectively. However, the lowest recorded values were observed in T_3 and T_6 as 1.82 and 1.84 correspondingly. Likewise, for treatments T_2 and T_5 same values were observed (1.92).

Over the storage, it can be found that a gradual increase in the weight loss (%) was noticed that varied form 1.14 % at 6^{th} day which progressed to 2.00 %, at 12^{th} day. However the recorded value for the parameter was 2.61 % at the termination of 18 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in weight during the course of storage. The maximum weight loss was noted for T_0 which varied from 1.19 % to 2.13 % and 2.73 % at 6^{th} to 12^{th} and 18^{th} days, respectively. Likewise, for T_1 and T_4, variations in the values differed from 1.15 and 1.18 to 2.66 and 2.66 at 6^{th} to 18^{th} days, respectively. The weight loss % for T_3 and T_6 varied from 1.10 to 2.46 and 1.10 to 2.48 at 6^{th} to 18^{th} days, respectively.

4.5. Firmness (Kg Force)

The results as depicted in Table 4.9, revealed that mean squares regarding the firmness of treated guava that significant variation was recorded for the effect of treatments and storage period. Moreover, their interaction was also significant.

From means as depicted in Table 4.10, it is inferred that the maximum value for firmness in the treated guava sample was recorded in T_3 as 5.914 followed by 5.886 in T_6, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 5.254, 5.533 and 5.553, respectively. Likewise, for treatments T_2 and T_5 observed value for the trait was 5.661 and 5.671, correspondingly.

Over the storage, it can be found that a gradual decrease in firmness was noticed that ranged from 8.426 at initiation which declined to 6.304, 4.421 at 6^{th} and 12^{th} days, respectively. However the recorded value for the parameter was 3.404 at the termination of 18 days study.

Table 4.7. ANOVA: Effect of chemical treatments on the weight loss % of guava fruit

Source	df	SS	MS	F
Treatment	6	0.2515	0.0419	155.34**
Days	2	22.8130	11.4065	42271.1**
Treatment x Days	12	0.0470	0.0039	14.53*
Error	42	0.0113	0.0003	
Total	62	23.1228		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.8. Effect of chemical treatments on the weight loss % of guava fruit

Treatment	6 Day	12 day	18 Day	Mean
T_0	1.19 G	2.13 D	2.73 A	**2.01 A**
T_1	1.15 GH	2.03 E	2.66 B	**1.95 BC**
T_2	1.13 HI	1.99 E	2.64 B	**1.92 D**
T_3	1.10 I	1.90 F	2.46 C	**1.82 E**
T_4	1.18 GH	2.04 E	2.66 B	**1.96 B**
T_5	1.14 GHI	2.01 E	2.62 B	**1.92 CD**
T_6	1.10 I	1.93 F	2.48 C	**1.84 E**
Mean	**1.14 C**	**2.00 B**	**2.61 A**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Table 4.9. ANOVA: Effect of chemical treatments on the firmness of guava fruit

Source	df	SS	MS	F
Treatment	6	3.663	0.610	256.40**
Days	3	308.464	102.821	43188.7**
Treatment x Days	18	1.502	0.083	35.06*
Error	56	0.133	0.002	
Total	83	313.762		

* = Significant ($p<0.05$), ** = Significant ($p<0.01$)

Table 4.10. Effect of chemical treatments on the firmness of guava fruit (Kg Force)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	8.428 A	5.715 E	3.894 H	2.977 K	**5.254 D**
T_1	8.421 A	6.077 D	4.334 G	3.3 J	**5.533 C**
T_2	8.425 A	6.429 C	4.458 G	3.33 J	**5.661 B**
T_3	8.415 A	6.693 B	4.767 F	3.779 HI	**5.914 A**
T_4	8.433 A	6.086 D	4.316 G	3.376 J	**5.553 C**
T_5	8.429 A	6.439 C	4.463 G	3.352 J	**5.671 B**
T_6	8.431 A	6.687 B	4.714 F	3.714 I	**5.886 A**
Mean	**8.426 A**	**6.304 B**	**4.421 C**	**3.404 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in firmness during the course of storage. The maximum decrease in firmness was noted for T_0 which varied from 8.428 to 5.715 and 3.894 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait was 2.977 at 18th day. Likewise, for T_1 and T_2, variations in the values differed from 8.421 and 8.425 to 6.077 and 6.429 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter in T_2 was 3.30 and 3.33 at the termination of 18 days study. The least decrease in the firmness was noticed for T_3 and T_6 which varied from 8.415 to 3.779 and 8.431 to 3.714 at initiation to termination, respectively.

4.6. Glucose (g/100g)

It is evident from mean squares regarding glucose of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be meaningful as depicted in Table 4.11.

From means as depicted in Table 4.12, the maximum value for glucose in the treated guava sample was recorded in T_3 (3.08) where as T_6 and T_2 both were having same value 3.07. However, the lowest recorded values observed in T_0, T_4 and T_5 were 3.03, 3.05 and 3.05, correspondingly. Likewise, for T_1 observed value was 3.06.

Over the storage, it can be found that a gradual increase in the value for glucose was noticed that ranged from 2.73 at initiation which progressed to 3.20, 3.22 at 6th and 12th days, respectively. However the recorded values for the parameter were 3.08 at the termination of 18 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in glucose value during the course of storage till 12 days and then the glucose of the fruits started to decrease. The maximum increase in the glucose value was noted for T_2, T_3 and T_6 which varied from 2.74 to 3.26, 2.74 to 3.25 and 2.72 to 3.25 at 0 to 12th day, respectively. Moreover, with further developments in storage (18 days), the values decreased to 3.08, 3.15 and 3.15 in T_2, T_3 and T_6, respectively. There was a decreasing trend of glucose in fruits after 18 days were observed. Likewise, for T_1, T_4 and T_5 variations in the values differed from 2.74 to 3.22, 2.73 to 3.20 and 2.71 to 3.24 at 0 to 12th days, respectively. Furthermore, the noted value for the parameter was then decreased to 3.05 and 3.04 and 3.07 in T_1, T_4 and T_5, respectively at the termination of 18 days study.

Table 4.11. ANOVA: Effect of chemical treatments on the glucose content of guava fruit

Source	df	SS	MS	F
Treatment	6	0.01946	0.00324	18.92*
Days	3	3.28048	1.09349	6378.71**
Treatment x Days	18	0.07307	0.00406	23.68**
Error	56	0.00960	0.00017	
Total	83	3.38261		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.12. Effect of chemical treatments on the glucose content of guava fruit (g/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	2.73 L	3.24 A-D	3.15 HI	3.00 K	**3.03 D**
T_1	2.74 L	3.21 B-G	3.22 B-F	3.05 J	**3.06 BC**
T_2	2.74 L	3.20 D-G	3.26 A	3.08 J	**3.07 AB**
T_3	2.74 L	3.17 G-I	3.25 AB	3.15 HI	**3.08 A**
T_4	2.73 L	3.22 A-E	3.20 D-G	3.04 J	**3.05 C**
T_5	2.71 L	3.19 E-H	3.24 A-C	3.07 J	**3.05 BC**
T_6	2.72 L	3.18 F-I	3.25 AB	3.15 I	**3.07 A**
Mean	**2.73 D**	**3.20 B**	**3.22 A**	**3.08 C**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

4.7. Fructose (g/100g)

It is evident from mean squares regarding fructose of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be meaningful as depicted in Table 4.13.

From means as depicted in Table 4.14, it is realized that the maximum value for fructose in the treated guava sample was recorded in T_3 was 3.49 where as T_2 and T_1 having same values as 3.47. However, the lowest recorded value observed in T_0 was 3.44. Likewise, for treatmentsT_4, T_5 and T_6 observed values for the trait were same (3.46).

Over the storage, it can be found that a gradual increase in the value for fructose was noticed that ranged from 3.31 at initiation which progressed to 3.57, 3.56 at 6^{th} and 12^{th} days, respectively. However the recorded value for the parameter was 3.43 at the termination of 18 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in fructose value during the course of storage till 12 days and then the fructose of the fruits started to decrease. The increase in the fructose value was noted for T_2, T_3 and T_6 which varied from 3.31 to 3.58, 3.32 to 3.57 and 3.31 to 3.56 at 0 to 12^{th} day, respectively. Moreover, with further developments in storage (18 days), recorded values for the traits were 3.43, 3.51 and 3.51in $_2$, T_3 and T_6, respectively. Likewise, for T_0, T_1, T_4 and T_5 variations in the values differed from 3.31to 3.50, 3.30 to 3.60, 3.31 to 3.54 and 3.30 to 3.55 at 0 to 12^{th} days, respectively. Furthermore, the noted value for the parameter was then decreased to 3.34, 3.38 and 3.40and 3.43in T_0, T_1, T_4 and T_5 at the termination of 18 days study.

4.8. Sucrose (g/100g)

The results revealed that mean squares regarding the sucrose of treated guava that significant variation was recorded for the effect of treatments and storage period. Moreover, their interaction was also significant as depicted in Table 4.15.

From means depicted in 4.16, it is inferred that the maximum value for sucrose in the treated guava sample was recorded same in T_2, T_3 and T_6 (1.94) followed by 1.91 in T_5, respectively. However, the lowest recorded value observed in T_0 was 1.89. Likewise, for treatments T_1 and T_4 same values were observed (1.90).

Table 4.13. ANOVA: Effect of chemical treatments on the fructose of guava fruit

Source	df	SS	MS	F
Treatment	6	0.01386	0.00231	9.20*
Days	3	0.95922	0.31974	1272.90**
Treatment x Days	18	0.08638	0.00480	19.10*
Error	56	0.01407	0.00025	
Total	83	1.07353		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.14. Effect of chemical treatments on the fructose of guava fruit (g/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	3.31 I	3.62 A	3.50 F	3.34 HI	**3.44 C**
T_1	3.30 I	3.58 A-C	3.60 AB	3.38 GH	**3.47 B**
T_2	3.31 I	3.56 B-E	3.58 A-C	3.43 G	**3.47 AB**
T_3	3.32 I	3.55 B-F	3.57 A-D	3.51 EF	**3.49 A**
T_4	3.31 I	3.58 A-C	3.54 C-F	3.40 G	**3.46 BC**
T_5	3.30 I	3.57 A-D	3.55 B-F	3.43 G	**3.46 B**
T_6	3.31 I	3.53 D-F	3.56 B-D	3.51 EF	**3.46 AB**
Mean	**3.31 C**	**3.57 A**	**3.56 A**	**3.43 B**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Over the storage, it can be found that a gradual decrease in sucrose was noticed that ranged from 1.67 at initiation which declined to 2.03, 2.06 at 6^{th} and 12^{th} days, respectively. However the recorded value for the parameter was 1.92 at the termination of 18 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in sucrose value during the course of storage till 12 days and then the sucrose of the fruits started to decrease. The increase in the sucrose value for T_2, T_3 and T_6 which varied from 1.66 to 2.00 and 2.19, 1.68 to 1.99 and 2.10 and 1.66 to 2.00 and 2.10 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 1.92, 2.00 and 2.00 in T_2, T_3 and T_6, correspondingly at 18^{th} day. In T_5, variation in the value differed from 1.66 to 2.01at 0 to 12^{th} days. Furthermore, the noted value for the parameter was then decreased 1.92 at the termination of 18 days study. The increase in the sucrose values for T_0, T_1 and T_4 which varied from 1.67 to 1.99, 1.67 to 2.04 and 1.65 to 2.01 at initiation to 12^{th} days of storage, respectively. Then sucrose of the T_0, T_1 and T_4 decreased to 1.84, 1.86 and 1.88 at the termination of storage period.

4.9. Total Phenolic Content (mgGAE/100g)

It is apparent from mean squares regarding the total phenolic content (TPC) of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.17.

From means depicted in Table 4.18, the maximum value for total phenolic content in the treated guava sample was recorded in T_3 and T_6 as 114.58 and 115 followed by 110.92 in T_5, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 104.17, 108.17 and 108.25, respectively. Likewise, for T_2 observed value for the trait was 110.33.

Over the storage, it can be found that a gradual decrease in the value for total phenolic content was noticed that ranged from 132.57 at initiation which declined to 115.52, 104.48 at 6^{th} and 12^{th} days, respectively. However at the termination of 18 days study the value for the parameter was 88.24.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in total phenolic content during the course of storage. The maximum decrease in the total phenolic content was noted for T_0 which varied from 131.67 to 107.67 and 94.67 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in

Table 4.15. ANOVA: Effect of chemical treatments on the sucrose of guava fruit

Source	df	SS	MS	F
Treatment	6	0.03460	0.00577	2.12^{NS}
Days	3	2.05245	0.68415	251.39**
Treatment x Days	18	0.15074	0.00837	3.08**
Error	56	0.15240	0.00272	
Total	83	2.39018		

NS = Non Significant ($p>0.05$), ** = Highly Significant ($p<0.01$)

Table 4.16. Effect of chemical treatments on the sucrose content of guava fruit (g/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	1.67 GH	2.08 A-C	1.99 B-F	1.84 FG	**1.89 A**
T_1	1.67 GH	2.04 A-D	2.04 A-D	1.86 EF	**1.90 A**
T_2	1.66 H	2.00 B-E	2.19 A	1.92 C-F	**1.94 A**
T_3	1.68 GH	1.99 B-F	2.10 AB	2.00 B-F	**1.94 A**
T_4	1.65 H	2.06 A-C	2.01 B-E	1.88 D-F	**1.90 A**
T_5	1.66 H	2.03 A-D	2.02 B-E	1.92 C-F	**1.91 A**
T_6	1.66 H	2.00 B-E	2.10 AB	2.00 B-F	**1.94 A**
Mean	**1.67 C**	**2.03 A**	**2.06 A**	**1.92 B**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Table 4.17. ANOVA: Effect of chemical treatments on the total phenolic content of guava fruit

Source	df	SS	MS	F
Treatment	6	1045.5	174.25	78.69**
Days	3	21922.1	7307.38	3300.11**
Treatment x Days	18	508.0	28.22	12.74**
Error	56	124.0	2.21	
Total	83	23599.6		

** = Highly Significant ($p<0.01$)

Table 4.18. Effect of chemical treatments on the total phenolic content of guava fruit (mgGAE/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	131.67 A	107.67 EF	94.67 H	82.67 I	**104.17 D**
T_1	133.00 A	113.00 CD	102.33 G	84.33 I	**108.17 C**
T_2	132.33 A	116.67 BC	105.33 EFG	87.00 I	**110.33 B**
T_3	133.33 A	119.33 B	108.33 DEF	97.33 H	**114.58 A**
T_4	133.00 A	113.00 CD	103.67 FG	83.33 I	**108.25 C**
T_5	132.33 A	117.67 BC	107.67 EF	86.00 I	**110.92 B**
T_6	132.33 A	121.33 B	109.33 DE	97.00 H	**115.00 A**
Mean	**132.57 A**	**115.52 B**	**104.48 C**	**88.24 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

storage, recorded values for the trait was 82.67 at 18th day. Likewise, for T_1, T_2 and T_4, variations in the values differed from 133.00 to 113.00, 132.33 to 116.67 and 133.00 to 113.00 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter in T_1, T_2 and T_4, was 84.33, 87.00 and 83.33 at the termination of 18 days study. The least decrease in the total phenolic content was noticed for T_3, T_5 and T_6 which varied from 133.33 to 97.33, 132.33 to 86.00 and 132.33 to 97.00 at initiation to termination of storage, respectively.

4.10. Antioxidant Activity (µmol TE/g)

It is apparent from mean squares regarding the antioxidant activity value of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.19.

From means as depicted in Table 4.20, the maximum value for antioxidant activity in the treated guava sample was recorded in T_6 and T_3 as 17.58 and 17.42 followed by 16.33 in T_2, respectively. However, the lowest recorded values were observed in T_0, T_4 and T_1 as 13.83, 14.67 and 15.25, respectively. Likewise, for T_5 the observed value for the trait was 15.67.

Over the storage, it can be found that a gradual decrease in the value for antioxidant activity was noticed that ranged from 34.33 at initiation which declined to 14.71, 9.76 at 6th and 12th days, respectively. However at the termination of 18 days study the value for the parameter was 4.48.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in antioxidant activity during the course of storage. The maximum decrease in antioxidant activity was noted for T_0 and T_4 which varied from 34.00 to 10.67and 8.33 and 34.33 to 13.67 and 8 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait was 2.33 and 2.67 at 18th day. Likewise, for T_1, T_2 and T_5 variations in the values differed from 34.67 to 14.33, 34.67 to 15.33 and 34.33 to 15.00 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter in T_1, T_2 and T_5 was 3.33, 4.67 and 4.00 at the termination of 18 days study. The least decrease in the antioxidant activity was noticed for T_6 and T_3 which varied from 34.00 to 7.00 and 34.33 to 7.33 at initiation to termination of storage, respectively.

Table 4.19. ANOVA: Effect of chemical treatments on the antioxidant activity of guava fruit

Source	df	SS	MS	F
Treatment	6	138.6	23.10	23.95*
Days	3	10696.3	3565.44	3697.49**
Treatment X Days	18	65.4	3.63	3.77*
Error	56	54.0	0.96	
Total	83	10954.3		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.20. Effect of chemical treatments on the antioxidant activity of guava fruit (µmol TE/g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	34.00 A	10.67 F-I	8.33 H-J	2.33 M	**13.83 E**
T_1	34.67 A	14.33 B-E	8.67 H-J	3.33 M	**15.25 CD**
T_2	34.67 A	15.33 BC	10.67 F-I	4.67 K-M	**16.33 BC**
T_3	34.33 A	16.67 BC	11.33 E-H	7.33 JK	**17.42 AB**
T_4	34.33 A	13.67 C-F	8.00 IJ	2.67 M	**14.67 DE**
T_5	34.33 A	15.00 B-D	9.33 G-J	4.00 LM	**15.67 CD**
T_6	34.00 A	17.33 B	12.00 D-G	7.00 J-L	**17.58 A**
Mean	**34.33 A**	**14.71 B**	**9.76 C**	**4.48 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

4.11. Citric Acid (mg/100g)

It is apparent from mean squares regarding the citric acid of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.21.

From means depicted in Table 4.22, the maximum value for citric acid in the treated guava sample was recorded in T_3 and T_6 as 342.58 and 341.92 followed by 338.67 in T_2, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 331.50, 335.00 and 334.42, respectively. Likewise, for treatment T_5 observed value for the trait was 337.17.

Over the storage, it can be found that a gradual decrease in the value for citric acid was noticed that ranged from 373.76 at initiation which declined to 344.76, 324.24 at 6^{th} and 12^{th} days, respectively. However at the term nation of 18 days of study the value for the parameter was 306.52.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in citric acid during the course of storage. The maximum decrease in the citric acid was noted for T_0 which varied from 374.00 to 338.67 and 316.00 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait was 297.33 at 18^{th} day. Likewise, for T_1, T_4 and T_5, variations in the values differed from 371.33 to 343.67, 374.00 to 341.00 and 373.00 to 343.00 at 0 to 6^{th} days, respectively. Furthermore, the noted value for the parameter in T_1, T_4 and T_5 was 304.33, 303 and 307 at the termination of 18 days of study. The least decrease in the citric acid were noticed for T_2, T_3 and T_6 which varied from 374.00 to 307.67, 374.67 to 313.00 and 375.33 to 313.33 at initiation to termination of storage, respectively.

4.12. Ascorbic Acid (mg/100g)

It is apparent from mean squares regarding the ascorbic acid of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.23.

From means depicted in Table 4.24, the maximum value for ascorbic acid in the treated guava sample was recorded in T_3 and T_6 as 141.92 and 142.00 followed by 138.83 in T_5, respectively. However, the lowest recorded values were observed in T_0 as 131.83.

Table 4.21. ANOVA: Effect of chemical treatments on the citric acid of guava fruit

Source	df	SS	MS	F
Treatment	6	1180.2	196.7	18.88*
Days	3	52561.7	17520.6	1681.97**
Treatment x Days	18	367.1	20.4	1.96*
Error	56	583.3	10.4	
Total	83	54692.3		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.22. Effect of chemical treatments on the citric acid of guava fruit (mg/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	374.00 A	338.67 C-E	316.00 H-J	297.33 M	**331.50 D**
T_1	371.33 A	343.67 BC	320.67 G-I	304.33 K-M	**335.00 B-D**
T_2	374.00 A	347.33 BC	325.67 F-H	307.67 J-L	**338.67 AB**
T_3	374.67 A	351.00 B	331.67 D-F	313.00 I-L	**342.58 A**
T_4	374.00 A	341.00 B-D	319.67 HI	303.00 LM	**334.42 CD**
T_5	373.00 A	343.00 BC	325.67 F-H	307.00 J-M	**337.17 BC**
T_6	375.33 A	348.67 BC	330.33 E-G	313.33 I-K	**341.92 A**
Mean	**373.76 A**	**344.76 B**	**324.24C**	**306.52 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Likewise, for treatments T_1, T_2 and T_4 observed value for the trait was 136.00, 138.58 and 135.58, correspondingly.

Over the storage, it can be found that a gradual decrease in the value for Ascorbic acid was noticed that ranged from 177.57 at initiation declined to 152.19, 124.48 at 6th and 12th days, respectively. However at the termination of 18 days study the value for the parameter was 97.05.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in ascorbic acid during the course of storage. The maximum decrease in the ascorbic acid value was noted for T_0 which varied from 176.67 to 142.33 and 117.00 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded value for the trait was 91.33 at 18th day. Likewise, for T_1, T_2 and T_4, variations in the values differed from 178.67 to 149.67, 176.67 to 154.00 and 178.67 to 149.67 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter T_1, T_2 and T_4 was 94.33, 97.67 and 94.00 at the termination of 18 days study. The least decrease in the ascorbic acid were noticed for T_3, T_5 and T_6 which varied from 177.67 to 103.67, 176.67 to 97.67 and 178.00 to 100.67 at initiation to termination of storage, respectively.

4.13. Malic Acid (mg/100g)

The results indicated from mean squares regarding malic acid of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.25.

From means depicted in Table 4.26, the maximum value for malic acid in the treated guava sample was recorded in T_0 as 140.25 followed by 137.33 and 137.08 in T_1 and T_4, respectively. However, the lowest recorded values were observed in T_3 and T_6 as 132.50 and 182.08. Likewise, for treatments T_2 and T_5 observed values for the trait were 135.17 and 134.92, correspondingly.

Over the storage, it can be found that a gradual increase in the value for malic acid was noticed that ranged from 105.67 at initiation which progressed to 131.29, 146.10 at 6th and 12th days, respectively. However at the termination of 18 days study the value for the parameter was 159.43.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in malic acid value during the course of storage. The maximum increase in

Table 4.23. ANOVA: Effect of chemical treatments on the ascorbic acid of guava fruit

Source	df	SS	MS	F
Treatment	6	960.2	160.0	18.91*
Days	3	76169.8	25389.9	2999.65**
Treatment x Days	18	392.3	21.8	2.58*
Error	56	474.0	8.5	
Total	83	77996.3		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.24. Effect of chemical treatments on the ascorbic acid of guava fruit (mg/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	176.67 A	142.33C	117.00 G	91.33 J	**131.83 C**
T_1	178.67 A	149.67 BC	121.33 E-G	94.33 IJ	**136.00 B**
T_2	176.67 A	154.00 B	126.00 D-G	97.67 H-J	**138.58 AB**
T_3	177.67 A	156.33 B	130.00 DE	103.67 H	**141.92 A**
T_4	178.67 A	149.67 BC	120.00 FG	94.00 IJ	**135.58 B**
T_5	176.67 A	154.67 B	126.33 D-F	97.67 H-J	**138.83 AB**
T_6	178.00 A	158.67 B	130.67 D	100.67 HI	**142.00 A**
Mean	**177.57 A**	**152.19 B**	**124.48 C**	**97.05 D**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Table 4.25. ANOVA: Effect of chemical treatments on the malic acid of guava fruit

Source	df	SS	MS	F
Treatment	6	593.5	98.9	24.44*
Days	3	33443.9	11148.0	2754.20**
Treatment x Days	18	277.8	15.4	3.81*
Error	56	226.7	4.0	
Total	83	34541.8		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.26. Effect of chemical treatments on the malic acid of guava fruit (mg/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	106.00 J	136.33 GH	152.67 C-E	166.00 A	**140.25 A**
T_1	105.33 J	133.67 H	147.67 D-F	162.67 AB	**137.33 B**
T_2	105.00 J	131.00 HI	146.00 F	158.67 BC	**135.17 B**
T_3	105.67 J	126.00 I	142.00 FG	156.33 BC	**132.5 CD**
T_4	105.33 J	134.67 H	146.33 EF	162.00 AB	**137.08 B**
T_5	105.67 J	131.00 HI	146.33 EF	156.67 BC	**134.92 BC**
T_6	106.67 J	126.33 I	141.67 FG	153.67 CD	**132.08 D**
Mean	**105.67 D**	**131.29 C**	**146.10 B**	**159.43 A**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

the malic acid content was noted for T_0 which varied from 106.00 to 136.33 and 152.67 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded value for the trait was 166.00 at 18th day. Likewise, for T_1, T_2, T_4 and T_5, variations in the values differed from 105.33 to 133.67, 105.00 to 131.00, 105.33 to 134.67 and 105.67 to 131.00 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 were 162.67, 158.67, 162.00 and 156.67 at the termination of 18 days study. The least increase in the malic acid values were noticed for T_3 and T_6 which varied from 105.67 to 156.33 and 106.67 to 153.67 at initiation to termination of storage, respectively.

4.14. Tartaric Acid (mg/100g)

The results indicate mean squares regarding tartaric acid of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.27.

From means, the maximum value for tartaric acid in the treated guava sample was recorded in T_0 as 0.850 followed by 0.849 in T_1. However, the lowest recorded values were observed same in T_3 and T_6 as 0.844. Likewise, for treatments T_2, T_4 and T_5 observed values for the trait were 0.846, 0.849 and 0.846, correspondingly.

Over the storage, it can be found that a gradual increase in the value for tartaric acid was noticed that ranged from 0.786 at initiation which progressed to 0.838, 0.869 at 6th and 12th days, respectively. However at the termination of 18 days study the recorded value for the parameter was 0.894.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in tartaric acid value during the course of storage. The maximum increase in the tartaric acid was noted for T_0 which varied from 0.786 to 0.845 and 0.874 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded value for the trait was 0.898 at 18th day. Likewise, for T_1, T_2, T_4 and T_5, variations in the values differed from 0.786 to 0.840 and 0.872, 0.785 to 0.837 and 0.869, 0.787 to 0.841 and 0.871 and 0.786 to 0.836 and 0.870 at 0 to 6th and 12th days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 were 0.896, 0.894, 0.897 and 0.893 at the termination of 18 days study. The least increase in the tartaric acid values were noticed for T_3 and T_6 which varied from 0.786 to 0.898 and 0.786 to 0.890 at initiation to termination, respectively.

Table 4.27. ANOVA: Effect of chemical treatments on the tartaric acid of guava fruit

Source	df	SS	MS	F
Treatment	6	0.00048	8.044E-05	30.30*
Days	3	0.13699	0.04566	17201.1**
Treatment x Days	18	0.00017	9.238E-06	3.48**
Error	56	0.00015	2.655E-06	
Total	83	0.13779		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.28. Effect of chemical treatments on the tartaric acid of guava fruit (mg/100g)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	0.786 I	0.845F	0.874 D	0.898 A	**0.85 A**
T_1	0.786 I	0.840 FG	0.872 D	0.896 AB	**0.849 B**
T_2	0.785 I	0.837 GH	0.869 DE	0.894 ABC	**0.846 C**
T_3	0.786 I	0.834 H	0.865 E	0.891 BC	**0.844 D**
T_4	0.787 I	0.841 FG	0.871 D	0.897 A	**0.849 AB**
T_5	0.786 I	0.836 GH	0.870 D	0.893 ABC	**0.846 C**
T_6	0.786 I	0.835 H	0.865 E	0.89 C	**0.844 D**
Mean	**0.786 D**	**0.838 C**	**0.869 B**	**0.894 A**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

4.15. Respiration Rate ($mLCO_2Kg^{-1}hr^{-1}$)

The result indicate mean squares regarding respiration rate of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.29.

From means depicted in Table 4.30, the maximum value for respiration rate in the treated guava sample was recorded in T_0 as 23.05 followed by 22.83 in T_4. However, the lowest recorded values were observed in T_3 and T_6 as 21.75 and 21.08 respectively. Likewise, for treatments T_1, T_2 and T_5 observed values for the trait were 22.79, 22.50 and 22.33, correspondingly.

Over the storage, it can be found that a gradual increase in the value for respiration rate was noticed that ranged from 10.05 at initiation which progressed to 18.95, 32.19 at 6^{th} and 12^{th} days, respectively. However at the termination of 18 days study the value for the parameter was 28.16.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in respiration rate value during the course of storage. The maximum increase in the respiration rate was noted for T_0 which varied from 9.67 to 24.00 and 35.00 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded value for the trait was 23.63 at 18^{th} day. Likewise, for T_1, T_2, T_4 and T_5, variations in the values differed from 10.33 to 20.00 and 34.33, 10 to 19.33 and 31.67, 10.33 to 20.67 and 34.00 and 10.00 to 18.00 and 32.67 at 0 to 6^{th} and 12^{th} days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 26.50, 29.00, 26.33 and 28.67 at the termination of 18 days study. The least increase in the respiration rate values were noticed for T_3 and T_6 which varied from 9.67 to 32.00 and 10.33 to 31.00 at initiation to termination, respectively.

4.16. Ethylene Gas ($\mu LKg^{-1}hr^{-1}$)

It is evident from mean squares regarding ethylene gas of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.31.

From means depicted in Table 4.32, the maximum value for ethylene gas in the treated guava sample was recorded in T_3 and T_6 as 14.83 and 14.58 followed by 13.67 in T_2. However, the lowest recorded values were observed in T_0 as 10.35. Likewise, for treatments T_1, T_4 and T_5 observed values for the trait were 12.50, 12.83 and 13.50, correspondingly.

Table 4.29. ANOVA: Effect of chemical treatments on the respiration rate of guava fruit

Source	df	SS	MS	F
Treatment	6	35.29	5.88	4.70*
Days	3	6163.61	2054.54	1642.69**
Days x Treatment	18	408.93	22.72	18.16*
Error	56	70.04	1.25	
Total	83	6677.86		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.30. Effect of chemical treatments on the respiration rate of guava fruit ($mLCO_2Kg^{-1}hr^{-1}$)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	9.67 K	24.00 GH	35.00 A	23.63 GH	**23.07 A**
T_1	10.33 K	20.00 I	34.33 AB	26.50 FG	**22.79 A**
T_2	10.00 K	19.33 I	31.67 A-D	29.00 DEF	**22.50 A**
T_3	9.67 K	15.67 J	29.67 C-F	32.00 A-D	**21.75 AB**
T_4	10.33 K	20.67 HI	34.00 AB	26.33 FG	**22.83 A**
T_5	10.00 K	18.00 IJ	32.67 ABC	28.67 DEF	**22.33 AB**
T_6	10.33 K	15.00 J	28.00 EF	31.00 B-E	**21.08 B**
Mean	**10.05 D**	**18.95 C**	**32.19 A**	**28.16 B**	

Means carrying the similar letters are statistically non-significant
T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Over the storage, it can be found that a gradual increase in the value for ethylene gas was noticed that ranged from 2.81 at initiation which progressed to 16.38, 20.52 at 6^{th} and 12^{th} days, respectively. However at the termination of 18 days study the recorded values for was 13.86.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in ethylene gas value during the course of storage till 12 days and then the ethylene gas of the fruits started to decrease. The increase in the ethylene gas was noted for T_3 and T_6 which varied from 3.33 to 13.33 and 26.33 and 3.00 to 13.67 and 25.33 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait was same (16.33) at 18^{th} day. Likewise, for T_2, T_4 and T_5, variations in the values differed from 2.33 to 22.67, 3 to 16.67 and 3.00 to 19.67 at 0 to 12^{th} days, respectively. Furthermore, the noted value for the parameter was then decreased to 14.00, 13.00 and 14.33 at the termination of 18 days study. The least increase in the ethylene gas values were noticed for T_0 and T_1 which varied from 2.33 to 15.00 and 2.67 to 18.00 at initiation to 12^{th} days of storage, respectively. Then the ethylene gas of the T_0 and T_1 decreased to 10.33 and 12.67 at the termination of storage period.

4.17. Sensory Evaluation

Most important factors influencing the acceptability of product are its organoleptic properties. Product having good color, flavor, taste, texture and overall acceptability is accepted for consumption. Product quality depends upon its sensory characteristics then price is second factor influencing the acceptability of product.

4.17.1. Color

It is apparent from mean squares regarding the color of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.33.

From means as shown in Fig. 3, the maximum value for color in the treated guava sample was recorded in T_3 and T_6 as 5.25 and 5.00 followed by 4.50 in T_5, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 4.33, 4.33 and 4.33, respectively. Likewise, for treatments T_2 observed value for the trait was 4.41, correspondingly.

Table 4.31. ANOVA: Effect of chemical treatments on the production of ethylene gas in guava fruit

Source	df	SS	MS	F
Treatment	6	85.45	14.24	12.59*
Days	3	3612.04	1204.01	1064.60**
Treatment x Days	18	441.21	24.51	21.67*
Error	56	63.33	1.13	
Total	83	4202.04		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Table 4.32. Effect of chemical treatments on the production of ethylene gas in guava fruit ($\mu LKg^{-1}hr^{-1}$)

Treatment	0 Day	6 Day	12 day	18 Day	Mean
T_0	2.33 L	19.67 CD	15.00 F-J	10.33 K	**11.83 D**
T_1	2.67 L	16.67 D-H	18.00 D-F	12.67 JK	**12.50 CD**
T_2	2.33 L	15.67 E-J	22.67 BC	14.00 G-J	**13.67 ABC**
T_3	3.33 L	13.33 H-K	26.33 A	16.33 D-I	**14.83 A**
T_4	3.00 L	18.67 DE	16.67 D-H	13.00 I-K	**12.83 CD**
T_5	3.00 L	17.00 E-G	19.67 CD	14.33 G-J	**13.50 BC**
T_6	3.00 L	13.67 G-K	25.33 AB	16.33 D-I	**14.58 AB**
Mean	**2.81 D**	**16.38 B**	**20.52 A**	**13.86 C**	

T_0 = Control
T_1 = Calcium Chloride 1%
T_2 = Calcium Chloride 2%
T_3 = Calcium Chloride 3%
T_4= Calcium Lactate 1%
T_5= Calcium Lactate 2%
T_6= Calcium Lactate 3%

Over the storage, it can be found that an increase in the value for color was noticed that ranged from 4.24 at initiation which increased to 6.62 at 6th day, which declined to 4.90 and 2.62 at 12th and 18th day of storage, respectively.

Amongst treatments, a similar behavior was shown by treatments indicating a steady increase in color value till 6th day during storage then the color value start to decrease except in T_3 and T_6, the color value increased till 12th day and then it decreased at 18th day of storage. The maximum increase in the color value was noticed in T_0 at 6th day 7.67 which further decreased 3.66 and 1.66 at 12th and 18th day, respectively. Likewise, for T_1, T_2, T_4 and T_5 variations in the values differed from 4.33 to 6.67, 4.00 to 6.67, 4.00 to 7.33 and 4.00 to 7.00 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 2.00, 2.33, 2.33 and 2.33, respectively at the termination of 18 days study. The color value noticed for T_3 and T_6 were 4.33 and 4.67 at initiation which increased to 7.00 and 6.33 at 12th day, which thereafter decreased to 4.00 and 3.67 at 18th day of storage, respectively.

4.17.2. Flavor

It is apparent from mean squares regarding the flavor of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.34.

From means as shown in Fig. 4, the maximum value for flavor in the treated guava sample was recorded in T_3 and T_6 as 4.67 and 4.75 followed by 4.16 in T_2, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 4.08, 4.16 and 3.75, respectively. Likewise, for treatments T_5 observed value for the trait was 4.00, correspondingly.

Over the storage, it can be found that an increase in the value for flavor was noticed that ranged from 3.00 at initiation which increased to 6.42 at 6th day, which further declined to 4.62 and 2.57 at 12th and 18th day of storage, respectively.

Amongst treatments, a similar behavior was shown by treatments indicating a steady increase in flavor value till 6th day during storage then the flavor value start to decrease except in T_3 and T_6, the flavor value increased till 12th day and then it decreased at 18th day of storage. The maximum increase in the flavor value was noticed in T_0 at 6th day was 7.33 which further decreased 3.67 and 1.33 at 12th and 18th day, respectively. Likewise, for T_1, T_2,

Table 4.33. ANOVA: Effect of chemical treatments on the color of guava fruit

Source	df	SS	MS	F
Treatment	6	10.07	1.68	3.92**
Days	3	172.71	57.57	134.33**
Treatment x Days	18	47.452	2.64	6.15*
Error	56	24.00	0.43	
Total	83	254.238		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 3. Effect of chemical treatments on the color of guava fruit

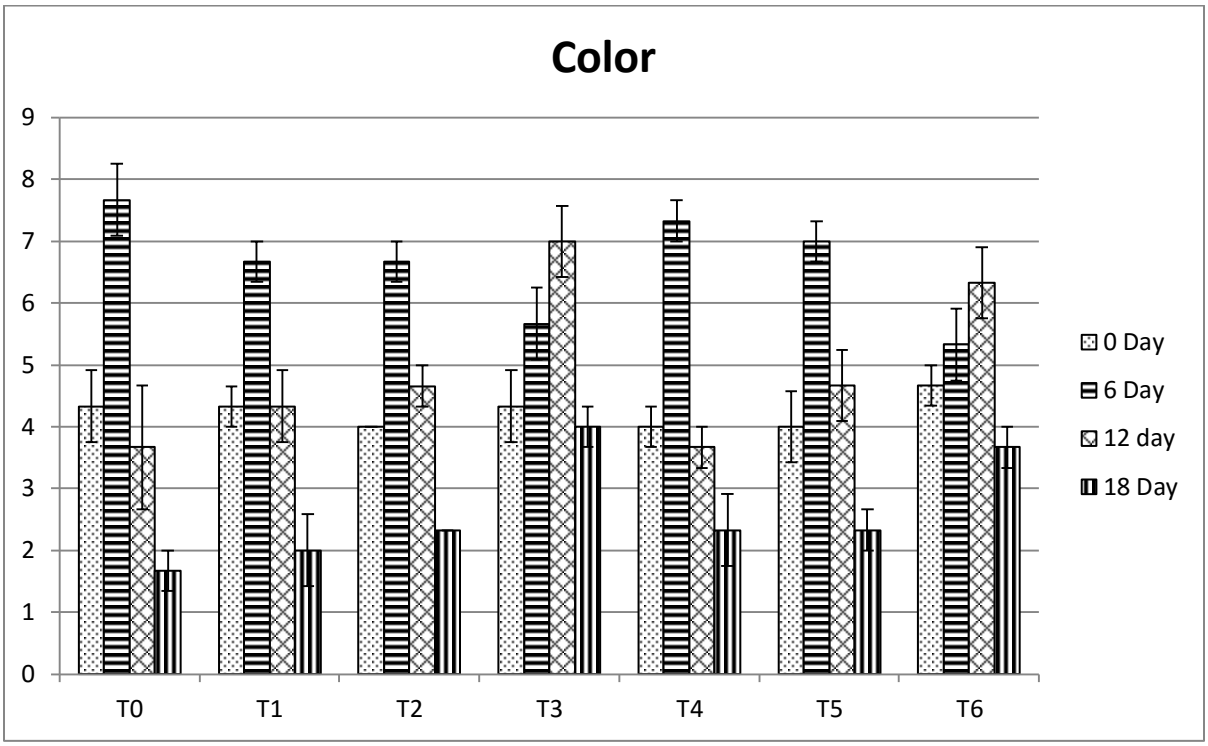
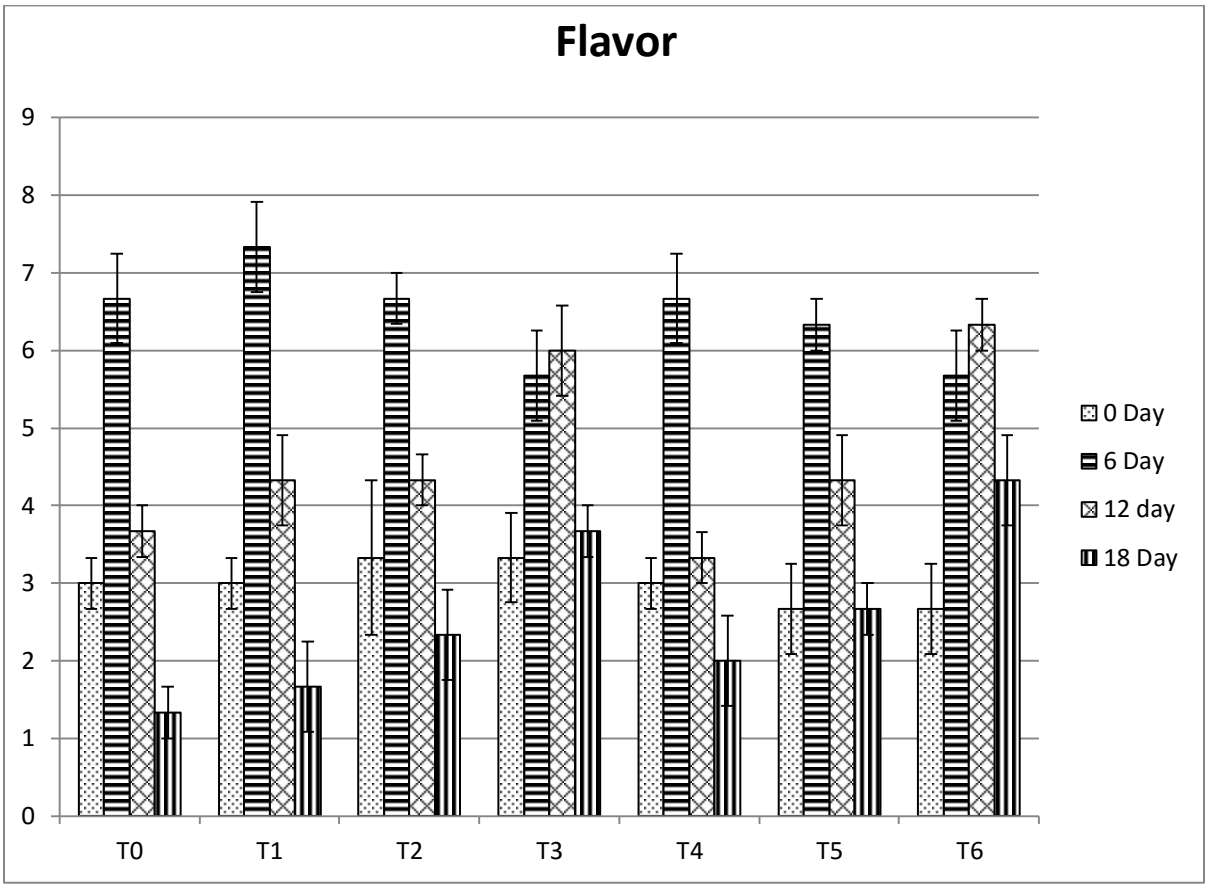


Table 4.34. ANOVA: Effect of chemical treatments on the flavor of guava fruit

Source	df	SS	MS	F
Treatment	6	12.57	2.095	5.50**
Days	3	193.75	64.58	169.53**
Treatment x Days	18	39.33	2.18	5.74*
Error	56	21.33	0.38	
Total	83	266.988		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Fig. 4. Effect of chemical treatments on the flavor of guava fruit



T_4 and T_5 variations in the values differed from 3.00 to 7.33, 3.33 to 6.67, 3.00 to 6.67 and 2.67 to 6.33 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 1.67, 2.33, 2.00 and 2.67, respectively at the termination of 18 days study. The flavor value noticed for T_3 and T_6 were 3.33 and 2.67 at initiation which increased to 6.00 and 6.33 at 12th day, which thereafter decreased to 3.67 and 4.33 at 18th day of storage, respectively.

4.17.3. Texture

It is apparent from mean squares regarding the texture of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.35.

From means as shown in Fig. 5, the maximum value for texture in the treated guava sample was recorded in T_3 and T_6 as 4.58 and 4.67 followed by 4.17 in T_5, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 3.75, 4.00 and 4.00, respectively. Likewise, for treatments T_2 observed value for the trait was 3.92, correspondingly.

Over the storage, it can be found that an increase in the value for texture was noticed that ranged from 2.48 at initiation which increased to 5.95 at 6th day, which further declined to 5.33 and 2.86 at 12th and 18th day of storage, respectively.

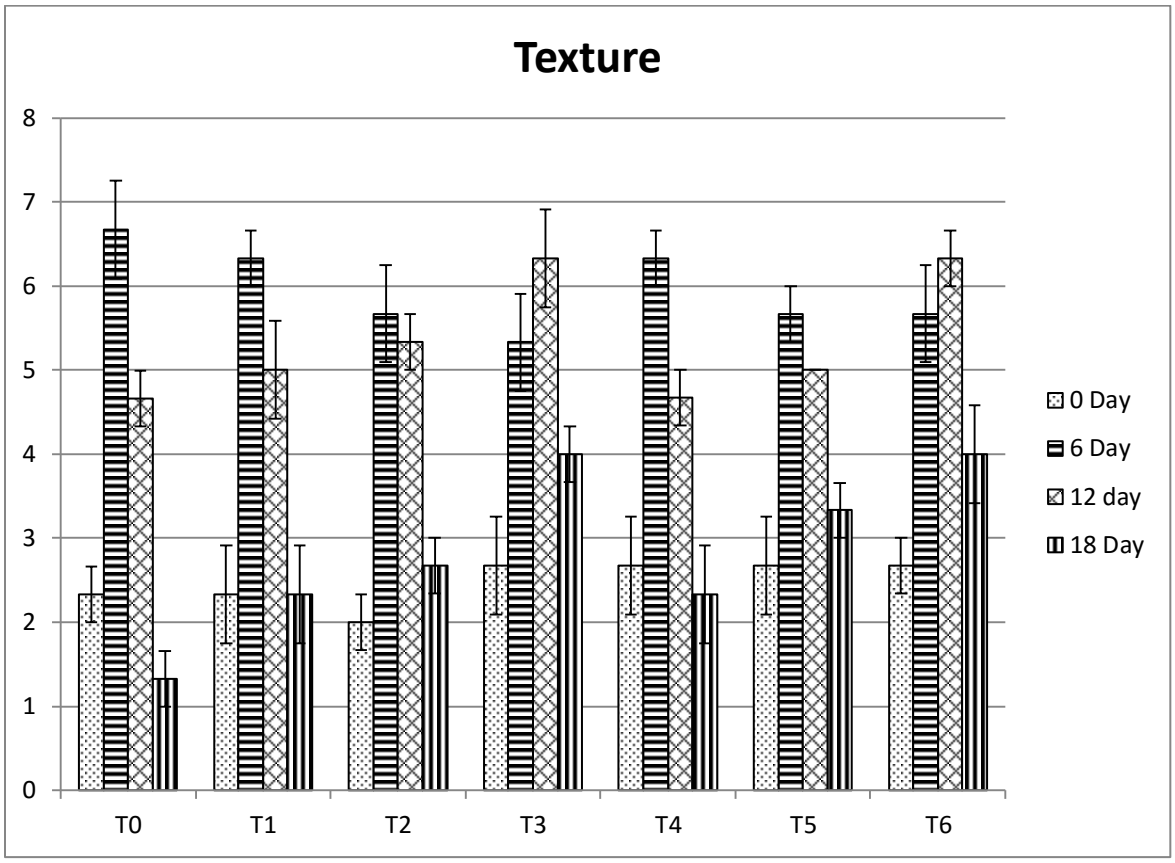
Amongst treatments, a similar behavior was shown by treatments indicating a steady increase in texture value till 6th day during storage then the texture value start to decrease except in T_3 and T_6, the texture value increased till 12th day and then it decreased at 18th day of storage. The maximum increase in the texture value was noticed in T_0 at 6th day was 6.67 which further decreased 4.67 and 1.33 at 12th and 18th day, respectively. Likewise, for T_1, T_2, T_4 and T_5 variations in the values differed from 2.33 to 6.33, 2.00 to 6.33, 2.67 to 6.33 and 2.67 to 5.67 at 0 to 6th days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 2.33, 2.67, 2.33 and 3.33, respectively at the termination of 18 days study. The texture value noticed for T_3 and T_6 were 2.67 and 2.67 at initiation which increased to 6.33 and 6.33 at 12th day, which thereafter decreased to 4.00 and 4.00 at 18th day of storage, respectively.

Table 4.35. ANOVA: Effect of chemical treatments on the texture of guava fruit

Source	df	SS	MS	F
Treatment	6	8.57	1.43	3.43*
Days	3	191.56	63.85	153.25**
Treatment x Days	18	23.52	1.31	3.14*
Error	56	23.33	0.42	
Total	83	246.99		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 5. Effect of chemical treatments on the texture of guava fruit



4.17.4. Taste

It is apparent from mean squares regarding the taste of treated guava that a non-significant variation was recorded for the effect of treatments. Moreover, storage days and interaction of treatments and days were found to be momentous as depicted in Table 4.36.

From means depicted in Fig.6, the maximum value for taste in the treated guava sample was recorded in T_3 and T_6 as 4.17 and 4.42 followed by 4.17 in T_1, respectively. However, the lowest recorded values were observed in T_0, T_2 and T_4 as 3.75, 4.00 and 3.83, respectively. Likewise, for treatments T_5 observed value for the trait was 4.00, correspondingly.

Over the storage, it can be found that an increase in the value for taste was noticed that ranged from 2.67 at initiation which increased to 6.14 at 6^{th} day, which later declined to 5.00 and 2.38 at 12^{th} and 18^{th} day of storage, respectively.

Amongst treatments, a similar behavior was shown by treatments indicating a steady increase in taste value till 6^{th} day during storage then the taste value start to decrease except in T_3 and T_6, the taste value increased till 12^{th} day and then it decreased at 18^{th} day of storage. The maximum increase in the taste value was noticed in T_0 at 6^{th} day was 7.33 which further decreased 3.67 and 1.33 at 12^{th} and 18^{th} day, respectively. Likewise, for T_1, T_2, T_4 and T_5 variations in the values differed from 3.00 to 6.67, 2.67 to 6.00, 2.67 to 6.67 and 2.33 to 6.33 at 0 to 6^{th} days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 2.67, 2.67, 1.67 and 2.00, respectively at the termination of 18 days study. The taste value noticed for T_3 and T_6 were 2.67 and 2.67 at initiation which increased to 6.33 and 6.33 at 12^{th} day, which thereafter decreased to 3.00 and 3.33 at 18^{th} day of storage, respectively.

4.17.5. Overall Acceptability

It is apparent from mean squares regarding the overall acceptability of treated guava that significant variations were recorded for the effect of treatments and storage period. Moreover, their interaction was also found to be momentous as depicted in Table 4.37.

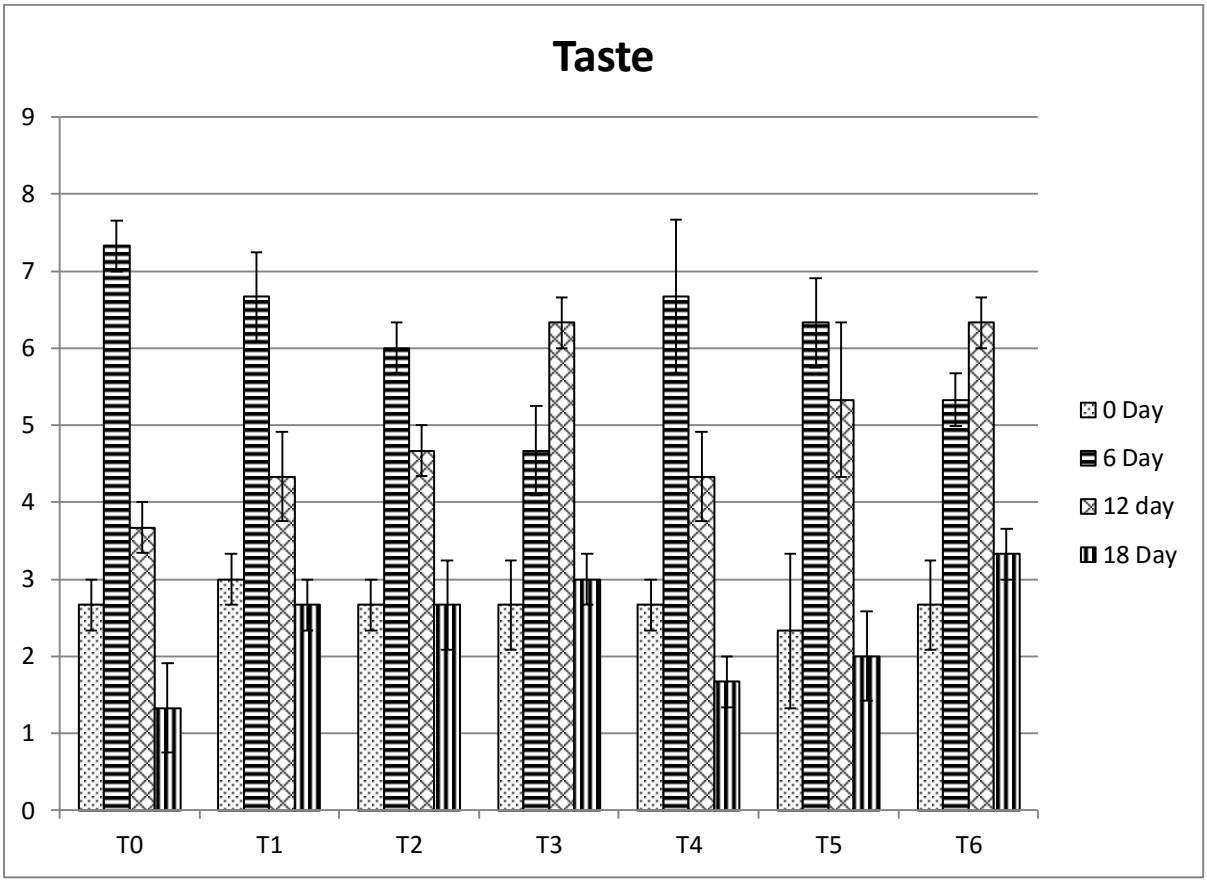
From means depicted in Fig.7, the maximum value for overall acceptability in the treated guava sample was recorded in T_3 and T_6 as 4.92 and 4.25 followed by 4.25 in T_2, respectively. However, the lowest recorded values were observed in T_0, T_1 and T_4 as 3.16, 3.91 and 3.91, respectively. Likewise, for treatments T_5 observed value for the trait was 4.25, correspondingly.

Table 4.36. ANOVA: Effect of chemical treatments on the taste of guava fruit

Source	df	SS	MS	F
Treatment	6	3.64	0.61	1.70^{NS}
Days	3	209.62	69.87	195.64**
Treatment x Days	18	40.55	2.25	6.31**
Error	56	20.00	0.36	
Total	83	273.81		

NS=Non Significant (p>0.05), * = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 6. Effect of chemical treatments on the taste of guava fruit



Over the storage, it can be found that an increase in the value for overall acceptability was noticed that ranged from 3.62 at initiation which increased to 5.90 at 6^{th} day, which later declined to 4.67 and 2.52 at 12^{th} and 18^{th} day of storage, respectively.

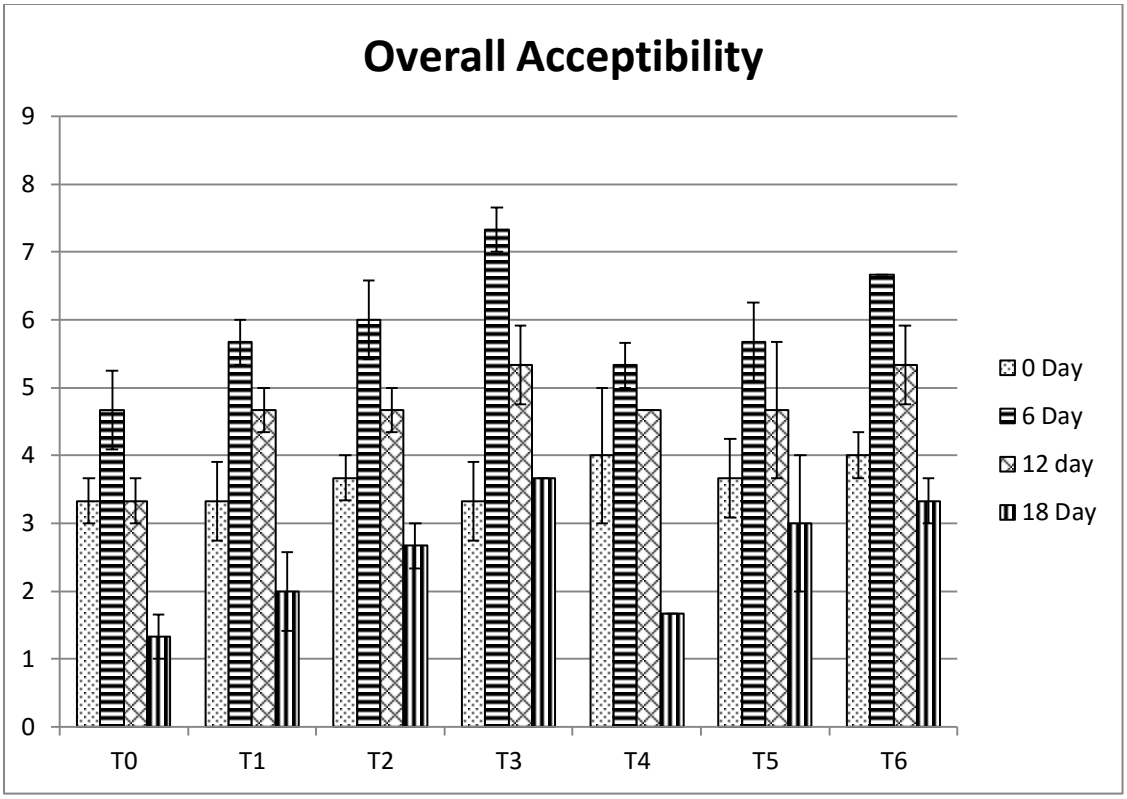
Amongst treatments, a similar behavior was shown by treatments indicating a steady increase in overall acceptability value till 6^{th} day during storage then the overall acceptability value start to decrease. The maximum increase in the taste value was noticed in T_3 at 6^{th} day was 7.33 which further decreased 5.33 and 3.67 at 12^{th} and 18^{th} day, respectively. Likewise, for T_1, T_2, T_4 and T_5 variations in the values differed from 3.33 to 5.67, 3.67 to 6.00, 4.00 to 5.33 and 3.67 to 5.67 at 0 to 6^{th} days, respectively. Furthermore, the noted value for the parameter T_1, T_2, T_4 and T_5 was 2.00, 2.67, 1.67 and 3.00, respectively at the termination of 18 days study. The overall acceptability value noticed for T_6 was 4.00 at initiation which increased to 6.67 at 12^{th} day, which thereafter decreased to 3.33 at 18^{th} day of storage, respectively.

Table 4.37. ANOVA: Effect of chemical treatments on the overall acceptability of guava fruit

Source	df	SS	MS	F
Treatment	6	25.73	4.29	15.67**
Days	3	131.65	43.88	160.28**
Treatment x Days	18	11.59	0.64	2.35*
Error	56	15.333	0.274	
Total	83	184.32		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 7. Effect of chemical treatments on the overall acceptability of guava fruit



Phase II

The treated guava fruits that were stored at 5 and 10% CO_2 level were evaluated for quality parameters and the results of the findings were described here.

4.18. Total Soluble Solids (Brix°)

It is obvious from mean squares regarding TSS of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.38.

From means depicted in 4.39 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for TSS in the treated guava sample was recorded in T_0 as 10.37 followed by 10.27 and 10.27 in T_4 and T_1, respectively. However, the lowest recorded values were observed in T_6 as 10.13. Likewise, for treatments T_2 and T_3 observed value for the trait were 10.24 and 10.13, correspondingly.

Over the storage, it can be found that a gradual increase in the value for TSS was noticed that ranged from 9.80 at initiation which progressed to 9.94, 10.33 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were 10.65 at the 18^{th} days of study and at 24^{th} day it reduced to 10.45.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in TSS value during the course of storage. The maximum increase in the TSS value was noted for T_0 which varied from 9.80 to 10.10 and 10.47 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 10.90 and at 18^{th} day and after word it reduced to 10.57 at 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 9.80 to 10.77 and 9.77 to 10.67 at 0 to 18^{th} days, respectively. Furthermore, the noted value for the parameter was decreased to 10.53 and 10.60 at the termination of 24 days study. The increase in the TSS values was noticed for T_3 and T_6 which varied from 9.73 to 10.30 and 9.87 to 10.30 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for TSS of treated guava was observed in T_0 as 10.30 followed by T_4 and T_1 as 10.16 and 10.18, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 10.13 and 10.06, respectively.

Moreover, during the storage a steady increase in the values for TSS was noticed that ranged from 9.80 at the initiation of the trial and progressed to 9.98 and 10.32 at 6th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 10.67 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for TSS was recorded which ranged from 9.83 at 0 day to 10.03 and 10.57 at 12th and 18th day for T_0, which further increase to 10.80 at 24th day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 9.80 and 9.77 at 0 day to 10.70 and 10.60 at 24th day, respectively. Similarly the variations in the TSS values for T_4 and T_5 were 9.77 to 10.73 and 9.80 to 10.70 at mentioned intervals, respectively.

4.19. pH

It is evident from mean squares regarding pH of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.40.

From means depicted in Table 4.41 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for pH in the treated guava sample was recorded same in T_0 and T_4 (4.04) and 4.03 in T_1.However, the lowest recorded values were observed in T_6 as 4.01. Likewise, for treatments T_2 and T_3 observed values for the trait were 4.02 and 4.00, correspondingly.

Over the storage, it can be found that a gradual increase in the value for pH was noticed that ranged from 3.87 at initiation progressed to 3.92, 4.02 at 6th and 12th days, respectively. However the recorded values for the parameter were 4.20 at the termination of 24 days study.

Amongst treatments as depicted in Table 4.41, a similar behavior was shown by all the treatments indicating a steady increase in pH value during the course of storage. The maximum increase in the pH value was noted for T_0 which varied from 3.86 to 3.94 and 4.04 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 4.15 and 4.23 at 18th and 24th day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 3.87 and 3.87 to 4.03 and 4.04 at 0 to 12th days, respectively. Furthermore, the noted value for the parameter was 4.22 and 4.21 at

Table 4.38. Mean sum of square of effect of treatments and modified atmosphere storage (MAS) on TSS of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.11060**	0.09194**
Days	4	2.71024**	2.50510**
Treatment x Days	24	0.01735*	0.01321*
Error	70	0.00867	0.00533
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.39. Effect of treatments and MAS on TSS of guava fruit during storage

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	9.83 IJ	10.10 G-I	10.47 B-F	10.90 A	10.57 B-E	**10.37 A**	9.83 IJ	10.27 E-G	10.03 G-J	10.57 A-C	10.80 A	**10.30 A**
T_1	9.80 IJ	9.93H-J	10.33 D-G	10.77 AB	10.53 B-F	**10.27 AB**	9.80 IJ	10.00 H-K	10.07 F-I	10.33 C-E	10.70 AB	**10.18 B**
T_2	9.77 J	9.87 IJ	10.33 D-G	10.73 AB	10.50 B-F	**10.24 B**	9.77 J	9.93 I-L	10.03 G-J	10.33 C-E	10.60 AB	**10.13 BCD**
T_3	9.73 J	9.90 IJ	10.23 F-H	10.47 B-F	10.30 E-G	**10.13 C**	9.73 J	9.87 I-L	9.90 I-L	10.20 E-H	10.60 AB	**10.06 D**
T_4	9.77 J	9.97 H-J	10.37 C-G	10.67 A-C	10.60 A-E	**10.27 AB**	9.77 J	9.93 I-L	10.03 G-J	10.33 C-E	10.73 AB	**10.16 BC**
T_5	9.80 IJ	9.97 H-J	10.37 C-G	10.63 A-D	10.47 B-F	**10.25 B**	9.80 IJ	9.97 H-L	9.97 H-L	10.30 D-F	10.70 AB	**10.15 BC**
T_6	9.87 IJ	9.87 IJ	10.23 F-H	10.40 C-G	10.30 E-G	**10.13 C**	9.87 IJ	9.87 I-L	9.93 I-L	10.20 E-H	10.53 B-D	**10.08 CD**
Means	**9.80 E**	**9.94 D**	**10.33 C**	**10.65 A**	**10.47 B**		**9.80 D**	**9.98 C**	**9.99 C**	**10.32B**	**10.67 A**	

Means carrying the similar letters are statistically non-significant

Table 4.40. Mean sum of square of effect of treatments and MAS on pH of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.00359**	0.00365**
Days	4	0.39948**	0.15626**
Treatment x Days	24	0.00030**	0.00036**
Error	70	0.00007	0.00005
Total	104		

** = Highly Significant ($p<0.01$)

Table 4.41. Effect of treatments and MAS on pH of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	3.86 L	3.94 J	4.04 H	4.15 DE	4.23 A	**4.04 A**	3.86 L	3.92 LM	3.97 IJ	4.04 EF	4.12 A	**3.98 A**
T_1	3.87 KL	3.94 J	4.03 H	4.13 EF	4.22 AB	**4.03 BC**	3.87 KL	3.92 MN	3.96 JK	4.03 E-G	4.09 BC	**3.97 B**
T_2	3.86 L	3.93 J	4.01 HI	4.11 FG	4.19 BC	**4.02 D**	3.86 L	3.90 M-O	3.94 KL	4.02 GH	4.07 CD	**3.96 C**
T_3	3.87 KL	3.89 K	3.99 I	4.09 G	4.18 C	**4.00 E**	3.87 KL	3.88 O-Q	3.93 LM	3.99 HI	4.04 EF	**3.94 D**
T_4	3.87 KL	3.93 J	4.04 H	4.14 E	4.21 AB	**4.04 AB**	3.87 KL	3.92 LM	3.96 JK	4.03 FG	4.11 AB	**3.97 B**
T_5	3.87 KL	3.93 J	4.02 HI	4.12 EF	4.20 BC	**4.03 CD**	3.87 KL	3.91 MN	3.94 KL	4.02 GH	4.08 BC	**3.96 C**
T_6	3.86 L	3.9 K	3.99 I	4.11 FG	4.18 C	**4.01 E**	3.86 L	3.89 N-P	3.93 LM	4.00 H	4.05 DE	**3.95D**
Means	**3.87 E**	**3.92 D**	**4.02 C**	**4.12 B**	**4.2 A**		**3.87 E**	**3.91 D**	**3.95 C**	**4.02 B**	**4.08 A**	

Means carrying the similar letters are statistically non-significant

the termination of 24 days study. The least increase in the pH values were noticed for T_3 and T_6 which varied from 3.87 to 4.18 and 3.86 to 4.18 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for pH of treated guava was observed in T_0 as 3.98 followed by T_4 and T_1 as 3.97 and 3.97, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 3.96 and 3.94, respectively.

Moreover, during the storage a steady increase in the values for pH was noticed that ranged from 3.87 at the initiation of the trial and progressed to 3.91 and 4.02 at 6^{th} and 18^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 4.08 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for pH was recorded which ranged from 3.86 at 0 day to 3.97 and 4.12 at 12^{th} and 24^{th} day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.87 and 3.86 at 0 day to 4.09 and 4.07 at 24^{th} day, respectively. Similarly the variations in the pH values for T_4 and T_5 were 3.87 to 4.11 and 3.87 to 4.08 at mentioned intervals, respectively.

4.20. Acidity

It is evident from mean squares regarding acidity of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.42.

From means depicted in Table 4.43 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for acidity in the treated guava sample was recorded in T_0 as 0.43 followed by 0.44 and 0.44 in T_4 and T_1, respectively. However, the values observed in T_6 as 0.46. Likewise, for treatments T_2 and T_3 observed values for the trait were 0.45 and 0.46, correspondingly.

Over the storage, it can be found that a gradual decrease in the value for acidity was noticed that ranged from 0.51 at initiation progressed to 0.48, 0.44 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were 0.38 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in acidity value during the course of storage. The maximum decrease in the

acidity value was noted for T_0 which varied from 0.51 to 0.47 and 0.41 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 0.39 and 0.36 at 18^{th} and 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 0.51 and 0.51 to 0.43 and 0.43 at 0 to 12^{th} days, respectively. Furthermore, the noted value for the parameter was same (0.38) at the termination of 24 days study. The least decrease in the acidity values were noticed for T_3 and T_6 which varied from 0.52 to 0.41 and 0.52 to 0.40 at initiation to termination, respectively.

Likewise, for 10% CO_2 concentration kept trial it was revealed that the maximum value for acidity as depicted in Table 4.43 of treated guava was observed in T_0 as 0.45 followed by T_4 and T_1 as 0.45 and 0.46, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 0.47 and 0.48, respectively.

Moreover, during the storage a steady decrease in the values for acidity was noticed that ranged from 0.51 at the initiation of the trial and progressed to 0.48 and 0.44 at 6^{th} and 18^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 0.42 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic decrease in the values for acidity was recorded which ranged from 0.51 at 0 day to 0.45 and 0.40 at 12^{th} and 24^{th} day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 0.51 and 0.51 at 0 day to 0.41 and 0.42 at 24^{th} day, respectively. Similarly the variations in the acidity values for T_4 and T_5 were 0.51 to 0.41 and 0.52 to 0.42 at mentioned intervals, respectively.

4.21. Weight Loss %

It is cleared from mean squares regarding the decrease in weight loss% of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.44.

From means depicted in Table 4.45 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for weight loss% was observed in the treated guava sample was recorded in T_0 as 1.84 followed by 1.76 and 1.77 in T_4 and T_1, respectively. However, the values observed in T_6 as 1.69. Likewise, for treatments T_2 and T_3 observed values for the trait were 1.72 and 1.68, correspondingly.

Table 4.42. Mean sum of square of effect of treatments and MAS on acidity of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.00223**	0.00164**
Days	4	0.05519**	0.03075**
Treatment x Days	24	0.00018**	0.00013*
Error	70	0.00004	0.00005
Total	104		

** Highly significant *significant

Table 4.43. Effect of treatments and MAS on acidity of guava

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	0.51 A	0.47 DE	0.41 I-K	0.39 L-N	0.36 O	**0.43 D**	0.51 AB	0.48 D-G	0.45 I-M	0.42 O-R	0.40 S	**0.45 E**
T_1	0.51 AB	0.48 C-E	0.43 HI	0.41 J-L	0.38 NO	**0.44 C**	0.51 A-C	0.48 D-F	0.46 G-K	0.44 K-Q	0.41 RS	**0.46 DE**
T_2	0.51 A	0.47 DE	0.45 F-H	0.42 I-K	0.38 M-O	**0.45 BC**	0.51 AB	0.49 C-E	0.47 F-I	0.44 J-O	0.42 P-R	**0.47 BC**
T_3	0.52 A	0.50 A-C	0.46 E-G	0.44 GH	0.41 J-L	**0.46 A**	0.52 A	0.49 B-E	0.48 D-F	0.46 F-J	0.44 K-Q	**0.48 A**
T_4	0.51 A	0.47 EF	0.43 HI	0.40 K-M	0.38 M-O	**0.44 C**	0.51 AB	0.48 D-G	0.44 K-P	0.43 N-R	0.41 RS	**0.45 DE**
T_5	0.52 A	0.48 C-E	0.45 F-H	0.42 I-K	0.38 M-O	**0.45 B**	0.52 A	0.48 D-F	0.45 I-M	0.43 L-Q	0.42 Q-S	**0.46 CD**
T_6	0.52 A	0.49 B-D	0.47 EF	0.43 H-J	0.40 K-N	**0.46 A**	0.52 A	0.50 A-D	0.47 E-H	0.45 H-L	0.43 M-Q	**0.47 AB**
Means	**0.51 A**	**0.48 B**	**0.44 C**	**0.41 D**	**0.38 E**		**0.51 A**	**0.48 B**	**0.46 C**	**0.44 D**	**0.42 E**	

Means carrying the similar letters are statistically non-significant

Over the storage, it can be found that a gradual increase in the weight lost % was noticed that ranged from 0.96 at 6th day and progressed to 1.55 and 2.06 at 12th and 18th days, respectively. However the recorded values for the parameter were 2.40 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in weight loss% during the course of storage. The maximum increase in weight loss% was noted for T_0 which varied from 1.04 to 1.64 and 2.17 at 6th to 12th and 18th day, respectively. Moreover, with further developments in storage, recorded values for the trait was 2.53 at 24th day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 0.99 and 0.98 to 1.57 and 1.58 at 6th to 12th days, respectively. Furthermore, the noted value for the parameter was 2.41 and 2.42 at the termination of 24 days study. The least increase in weight loss% values was noticed for T_3 and T_6 which varied from 0.90 to 2.33 and 0.92 to 2.35 at initiation to termination, respectively.

Likewise, for 10% CO_2 concentration kept trial it was revealed that the maximum value for increase in weight loss% of treated guava was observed in T_0 as 1.53 followed by T_4 and T_1 as 1.48 and 1.46 respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 1.41 and 1.36, respectively as depicted in Table 4.45.

Moreover, during the storage a steady increase in weight loss% was noticed that ranged from 0.86 at the 6th day of the trial and progressed to 1.13 and 1.64 at 12th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 2.11 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the weight loss % was recorded which ranged from 0.92 at 6th day to 1.23 and 2.21 at 12th and 24th day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 0.88 and 0.84 at 6th day to 2.14 and 2.07 at 24th day, respectively. Similarly the variations in the weight loss % for T_4 and T_6 were 0.89 to 2.17 and 0.83 to 2.05 at mentioned intervals, respectively.

Table 4.44. Mean sum of square of effect of treatments and MAS on weight loss % of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.03718 **	0.04274**
Days	4	8.25599 **	6.47229 **
Treatment x Days	24	0.00050*	0.00103*
Error	70	0.00011	0.00010
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.45. Effect of treatments and MAS on weight loss % of guava fruit

Treatment	CO_2 5%					CO_2 10%				
	Storage Days				Means	Storage Days				Means
	6	12	18	24		6	12	18	24	
T_0	1.04 N	1.64 I	2.17 E	2.53 A	**1.84 A**	0.92 O	1.23 K	1.76 F	2.21 A	**1.53 A**
T_1	0.99 O	1.57 J	2.10 F	2.41 B	**1.77 B**	0.88 PQ	1.18 L	1.65 H	2.14 C	**1.46 C**
T_2	0.94 P	1.53 KL	2.05 G	2.38 C	**1.72 C**	0.84 RS	1.12 M	1.62 I	2.07 D	**1.41 E**
T_3	0.90 Q	1.48 M	2.00 H	2.33 D	**1.68 E**	0.81 S	1.05 N	1.57 J	2.02 E	**1.36 G**
T_4	0.98 O	1.58 J	2.08 FG	2.42 B	**1.76 B**	0.89 OP	1.17 L	1.69 G	2.17 B	**1.48 B**
T_5	0.94 P	1.55 JK	2.05 G	2.37 C	**1.73 C**	0.85 QR	1.11 M	1.63 HI	2.11 C	**1.43 D**
T_6	0.92 PQ	1.5 LM	2.01 H	2.35 CD	**1.69 D**	0.83 RS	1.05 N	1.58 J	2.05 DE	**1.38 F**
Means	**0.96 D**	**1.55 C**	**2.06 B**	**2.40 A**		**0.86 D**	**1.13 C**	**1.64 B**	**2.11 A**	

Means carrying the similar letters are statistically non-significant

4.22. Firmness (Kg Force)

It is obvious from mean squares regarding firmness of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.46.

From means depicted in Table 4.47 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the minimum value for firmness in the treated guava sample was recorded in T_0 as 6.587 followed by 6.978 and 6.967 in T_4 and T_1, respectively. However, the values observed in T_6 as 6.326. Likewise, for treatments T_2 and T_3 observed values for the trait were 5.734 and 6.300, correspondingly.

Over the storage, it can be found that a gradual decrease in the value for firmness was noticed that ranged from 8.429 at initiation progressed to 7.942 and 7.520 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were 5.678 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in firmness value during the course of storage. The maximum decrease in the firmness value was noted for T_0 which varied from 8.424 to 7.348 and 6.709 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 5.706 and 4.748 at 18^{th} and 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 8.409 and 8.459 to 7.244 and 7.225 at 0 to 12^{th} days, respectively. Furthermore, the noted value for the parameter was 5.450 and 5.441 at the termination of 24 days study. The least decrease in the firmness values were noticed for T_3 and T_6 which varied from 8.423 to 6.300 and 8.425 to 6.326 at initiation to termination, respectively.

Likewise, for 10% CO_2 concentration kept trial it was revealed that the minimum value for firmness of treated guava was observed in T_0 as 6.819 followed by T_4 and T_1 as 7.074 and 7.049, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 7.375 and 7.653, respectively as depicted in Table 4.47.

Moreover, during the storage a steady decrease in the values for firmness was noticed that ranged from 8.429 at the initiation of the trial and progressed to 7.989 and 6.352 at 6^{th} and 18^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 5.885 for guava kept at 10% CO_2 concentration.

Table 4.46. Mean sum of square of effect of treatments and MAS on firmness of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	1.7100**	1.3751**
Days	4	28.7296**	25.0546**
Treatment x Days	24	0.1501**	0.1651**
Error	70	0.0195	0.0081
Total	104		

** = Highly Significant (p<0.01)

Table 4.47. Effect of treatments and MAS on firmness of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	8.424A B	7.348 E-G	6.709 H	5.706 MN	4.748 O	**6.587 D**	8.424 A	7.581 DE	6.833 F	5.953 I	5.303 K	**6.819 D**
T_1	8.409A B	7.728 DE	7.244 FG	6.007 J-M	5.450 N	**6.967 C**	8.409 A	7.858 CD	7.481 E	6.079 HI	5.420 K	**7.049 C**
T_2	8.443 AB	8.273 A-C	7.732 DE	6.439 H-J	5.734 L-N	**7.324 B**	8.443 A	8.095 BC	7.836 CD	6.673 F	5.827 IJ	**7.375 B**
T_3	8.423 AB	8.353 AB	8.035 A-D	6.642 H	6.300 H-K	**7.551 A**	8.423 A	8.252 AB	8.102 BC	6.803 F	6.687 F	**7.653 A**
T_4	8.459A	7.820 CD	7.225 G	5.944 K-M	5.441N	**6.978 C**	8.459 A	7.907 C	7.471 E	5.994 I	5.541 JK	**7.074 C**
T_5	8.420 AB	7.875 CD	7.691 D-F	6.171 I-L	5.748 L-N	**7.181 B**	8.42 A	7.975 BC	7.827 CD	6.356 GH	5.825 IJ	**7.280 B**
T_6	8.425 AB	8.196 A-C	8.003 B-D	6.474 HI	6.326 H-K	**7.485 A**	8.425 A	8.256 AB	8.065 BC	6.606 FG	6.593 FG	**7.589 A**
Means	**8.429 A**	**7.942 B**	**7.52 C**	**6.198 D**	**5.678 E**		**8.429 A**	**7.989 B**	**7.659 C**	**6.352 D**	**5.885 E**	

Means carrying the similar letters are statistically non-significant

Amongst treatments it was noticed that a systematic decrease in the values for firmness was recorded which ranged from 8.424 at 0 day to 6.833 and 5.303 at 12^{th} and 24^{th} day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 8.409 and 8.443 at 0 day to 5.420 and 5.827 at 24^{th} day, respectively. Similarly the variations in the firmness values for T_4 and T_5 were 8.459 to 5.541 and 8.420 to 5.825 at mentioned intervals, respectively.

4.23. Glucose content (g/100g)

It is evident from mean squares regarding glucose of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be significant as depicted in Table 4.48.

From means depicted in Table 4.49 related to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for glucose rate in the treated guava sample was recorded in T_0 as 3.06 followed by 3.04 and 3.03 in T_4 and T_1, respectively. However, the lowest recorded value was observed in T_6 as 2.99. Likewise, for treatments T_2 and T_3 observed values for the trait were 3.00 and 2.97, correspondingly.

Over the storage, it can be found that a gradual increase in the value for glucose was noticed that ranged from 2.72 at initiation progressed to 2.86, 3.06 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were 3.24 at the termination of 24^{th} days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in glucose during the course of storage. The maximum increase in the glucose value was noted for T_0 which varied from 2.73 to 2.92 and 3.13 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 3.28 and 3.22 at 18^{th} and 24^{th} day, respectively. Likewise, For $T_1$and T_4, variations in the values differed from 2.71 to 3.09 and 2.73 to 3.10 at 0 to 12^{th} days, respectively. Furthermore, the noted values for T_1 and T_4 were 3.21 and 3.23 at the termination of 24^{th} days study. The least increase in the glucose values were noticed for T_3 and T_6 which varied from 2.73 to 3.22 and 2.72 to 3.24 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for glucose value of treated guava was observed in T_0 as 3.00 followed by T_4 and T_1 as 2.99 and

Table 4.48. Mean sum of square of effect of treatments and MAS on glucose of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.01304*	0.01034*
Days	4	1.01019**	0.98476**
Treatment x Days	24	0.00267**	0.00107*
Error	70	0.00011	0.00003
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.49. Effect of Treatments and MAS on glucose content of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	2.73 R	2.92 M	3.13 FG	3.28 A	3.22 CD	**3.06 A**	2.73 R	2.85 M	3.03 I	3.19 D	3.27 A	**3.01 A**
T_1	2.71 R	2.88 NO	3.09 HI	3.21 D	3.25 A-C	**3.03 BC**	2.71 R	2.83 NO	2.98 J	3.13 E	3.25 AB	**2.98 C**
T_2	2.72 R	2.85 OP	3.04 JK	3.16 EF	3.27 AB	**3.00 D**	2.72 R	2.80 P	2.95 K	3.11 F	3.23 C	**2.96 E**
T_3	2.73 R	2.81 Q	3.00 L	3.11 GH	3.22 CD	**2.97 F**	2.73 R	2.76 Q	2.91 L	3.07 H	3.20 D	**2.93 G**
T_4	2.73 R	2.89 MN	3.10 GH	3.23 B-D	3.24 B-D	**3.04 B**	2.73 R	2.84 MN	3.00 J	3.15 E	3.26 AB	**2.99 B**
T_5	2.73 R	2.87 NO	3.07 IJ	3.18 E	3.26 AB	**3.02 C**	2.73 R	2.83 M-O	2.96 K	3.11 FG	3.24 BC	**2.97 D**
T_6	2.72 R	2.83 PQ	3.02 KL	3.13 FG	3.24 B-D	**2.99 E**	2.72 R	2.82 O	2.92 L	3.09 G	3.23 C	**2.95 F**
Means	**2.72 E**	**2.86 D**	**3.06 C**	**3.19 B**	**3.24 A**		**2.72 E**	**2.82 D**	**2.96 C**	**3.12 B**	**3.24 A**	

Means carrying the similar letters are statistically non-significant

2.98, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 2.96 and 2.93, respectively as depicted in Table 4.49.

Moreover, during the storage a steady increase in the values for glucose was noticed that ranged from 2.72 at the initiation of the trial and progressed to 2.82 and 3.12 at 6th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 3.24 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for glucose values was recorded which ranged from 2.73 at 0 day to 3.03 and 3.27 at 12th and 24th day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 2.71 to 3.25 and 2.72 and 3.23 at 0 day to at 24th day, respectively. Similarly the variations in the glucose values for T_4 and T_5 were 2.73 to 3.26 and 2.73 to 3.24 at mentioned intervals, respectively.

4.24. Fructose (g/100g)

It is evident from mean squares regarding fructose of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be significant as depicted in Table 4.50.

From means depicted in Table 4.51 related to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for fructose in the treated guava sample was recorded in T_0 as 3.52 followed by 3.50 and 3.50 in T_4 and T_1, respectively. However, the lowest recorded values were observed in T_3 as 3.46. Likewise, for treatments T_2 and T_6 observed values for the trait were 3.48 and 3.47, correspondingly.

Over the storage, it can be found that a gradual increase in the value for fructose was noticed that ranged from 3.31 at initiation progressed to 3.39, 3.51 at 6th and 12th days, respectively. However the recorded values for the parameter were 3.63 at the termination of 24th days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in fructose during the course of storage. The maximum increase in the fructose value was noted for T_0 which varied from 3.30 to 3.44 and 3.57 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 3.66 and 3.62 at 18th and 24th day, respectively. Likewise, For $T_1$and T_4, variations in the values

differed from 3.32 to 3.52 and 3.31 to 3.53 at 0 to 12th days, respectively. Furthermore, the noted values for T_1 and T_4 were 3.63 and 3.63 at the termination of 24th days study. The least increase in the fructose values were noticed for T_3 and T_6 which varied from 3.32 to 3.62 and 3.32 to 3.64 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for fructose value of treated guava was observed in T_0 as 3.49 followed by T_4 and T_1 as 3.48 and 3.47, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 3.45 and 3.43, respectively as depicted in Table 4.51.

Moreover, during the storage a steady increase in the values for fructose was noticed that ranged from 3.31 at the initiation of the trial and progressed to 3.37 and 3.45 at 6th and 18th day of storage, respectively. However, at the end of 24 days trial noted values for the trait were 3.61 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for fructose values was recorded which ranged from 3.31 at 0 day to 3.52 and 3.65 at 12th and 24th day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.32 to 3.62 and 3.31 and 3.60 at 0 day to at 24th day, respectively. Similarly the variations in the fructose values for T_4 and T_5 were 3.31 to 3.64 and 3.27 to 3.61 at mentioned intervals, respectively.

4.25. Sucrose (g/100g)

It is evident from mean squares regarding sucrose of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be significant as depicted in Table 4.52.

From means depicted in Table 4.53 related to storage conducted at 5% level of CO_2, it is deduced that the maximum value for sucrose in the treated guava sample was recorded in T_0 as 1.91 followed by 1.89 and 1.88 in T_4 and T_1, respectively. However, the lowest recorded values were observed in T_6 as 1.85. Likewise, for treatments T_2 and T_3 observed values for the trait were 1.86 and 1.83, correspondingly.

Over the storage, it was found that a gradual increase in the value for sucrose was noticed that ranged from 1.65 at initiation progressed to 1.76, 1.87 at 6th and 12th days, respectively. However the recorded values for the parameter were 2.04 at the termination of 24th days study.

Table 4.50. Mean sum of square of effect of treatments and MAS on fructose content of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.00569*	0.00830*
Days	4	0.39750**	0.31420**
Treatment x Days	24	0.00156**	0.00101*
Error	70	0.00018	0.00017
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.51. Effect of treatments and MAS on fructose of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	3.30 PQ	3.44 JK	3.57 EF	3.66 A	3.62 B-D	**3.52 A**	3.31 WX	3.41 N-Q	3.52 H-J	3.58 C-F	3.65 A	**3.49 A**
T_1	3.32 OP	3.41 KL	3.52 GH	3.62 B-D	3.63 A-C	**3.50 BC**	3.32 VW	3.39 P-S	3.46 K-M	3.56 E-H	3.62 A-C	**3.47 B**
T_2	3.31 OP	3.39 LM	3.50 HI	3.58 DE	3.63 A-C	**3.48 CD**	3.31 VW	3.36 R-U	3.44 L-O	3.53 G-I	3.6 B-E	**3.45 C**
T_3	3.32 OP	3.34 N-P	3.47 IJ	3.56 E-G	3.62 B-D	**3.46 E**	3.32 U-W	3.34 T-W	3.40 OPQ	3.50 I-K	3.57 E-G	**3.43 D**
T_4	3.31 OP	3.40 KL	3.53 F-H	3.63 A-C	3.63 A-C	**3.50 B**	3.31 VW	3.40 O-R	3.48 J-L	3.57 D-F	3.64 AB	**3.48 AB**
T_5	3.27 Q	3.37 L-N	3.49 HI	3.60 C-E	3.64 A-C	**3.47 DE**	3.27 X	3.38 Q-T	3.45 L-N	3.55 F-H	3.61 A-D	**3.45 C**
T_6	3.32 OP	3.35 M-O	3.48 I	3.57 EF	3.64 AB	**3.47 DE**	3.32 U-W	3.35 S-V	3.42 M-P	3.52 H-J	3.59 C-F	**3.44 CD**
Means	**3.31 E**	**3.39 D**	**3.51 C**	**3.60 B**	**3.63 A**		**3.31 E**	**3.37 D**	**3.45 C**	**3.55 B**	**3.61 A**	

Means carrying the similar letters are statistically non-significant

Table 4.52. Mean sum of square of effect of treatments and MAS on sucrose of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.01072**	0.01069**
Days	4	0.55562**	0.37891**
Treatment x Days	24	0.00140**	0.00096*
Error	70	0.00008	0.00006
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.53. Effect of treatments and MAS on sucrose of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	1.66 P	1.79 KL	1.94 F	2.08 A	2.04 BC	**1.91 A**	1.66 R	1.78 KL	1.87 F	1.95 D	2.04 A	**1.86 A**
T_1	1.63 P	1.77 LM	1.88 GH	2.04 CD	2.05 BC	**1.88 B**	1.63 R	1.73 NO	1.82 HI	1.90 E	2.02 B	**1.83 B**
T_2	1.67 P	1.75 MN	1.84 IJ	2.00 E	2.03 CD	**1.86 C**	1.67 R	1.71 O-Q	1.79 JK	1.86 FG	1.99 C	**1.80 C**
T_3	1.66 P	1.72 O	1.82 JK	1.96 F	1.99 E	**1.83 E**	1.66 R	1.70 Q	1.77 LM	1.84 GH	1.95 D	**1.78 E**
T_4	1.65 P	1.78 L	1.91 G	2.05 BC	2.07 AB	**1.89 A**	1.65 R	1.75 MN	1.84 GH	1.89 E	2.03 AB	**1.83 B**
T_5	1.65 P	1.75 MN	1.87 HI	2.01 DE	2.04 BC	**1.87 C**	1.65 R	1.72 N-P	1.80 IJ	1.87 F	2.01 B	**1.81 C**
T_6	1.66 P	1.74 NO	1.82 J	1.96 F	2.03 CD	**1.85 D**	1.66 R	1.70 PQ	1.80 IJ	1.84 GH	1.98 CD	**1.79 D**
Means	**1.65 E**	**1.76 D**	**1.87 C**	**2.01 B**	**2.04 A**		**1.65 E**	**1.73 D**	**1.81 C**	**1.88 B**	**2 A**	

Means carrying the similar letters are statistically non-significant

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in sucrose during the course of storage. The maximum increase in the sucrose value was noted for T_0 which varied from 1.66 to 1.79 and 1.94 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 2.08 and 2.04 at 18th and 24th day, respectively. Likewise, For $T_1$and T_4, variations in the values differed from 1.63 to 1.88 and 1.65 and 1.91 at 0 to 12th days, respectively. Furthermore, the noted values for T_1 and T_4 were 2.05 and 2.07 at the termination of 24th days study. The least increase in the sucrose values were noticed for T_3 and T_6 which varied from 1.63 to 1.99 and 1.66 to 2.03 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for sucrose value of treated guava was observed in T_0 as 1.86 followed by T_4 and T_1 as 1.83 and 1.83, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 1.80 and 1.78, respectively as depicted in Table 4.53.

Moreover, during the storage a steady increase in the values for sucrose was noticed that ranged from 1.65 at the initiation of the trial and progressed to 1.73 and 1.88 at 6th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 2.00 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for sucrose values was recorded which ranged from 1.66 at 0 day to 1.87 and 2.04 at 12th and 24th day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 1.63 to 2.02 and 1.65 and 2.03 from 0 day to 24th day, respectively. Similarly the variations in the sucrose values for T_4 and T_5 were 1.65 to 2.03 and 1.65 to 2.01 at mentioned intervals, respectively.

4.26. Total Phenolic Content (mgGAE/100g)

It is evident from mean squares regarding Total Phenolic Content of treated guava that significant variations were recorded for the effect of treatments and storage. The interaction of days and treatment was also found significant for this trait as depicted in Table 4.54.

From means depicted in Table 4.55 pertaining to treatments conducted at 5% concentration of CO_2, it is deduced that the maximum total phenolic content in the treated guava sample was recorded in T_3 as 122.00 followed by 121.13, 117.93, 117.60 115.73 and

115.27 in T_6, T_2, T_5, T_1 and T_4 respectively. However, the lowest recorded values were observed in T_0 as 112.40.

Over the storage, it can be found that a gradual decrease in the total phenolic content was noticed that ranged from 132.57 at initiation decreased to 122.67, 115.33 and 110.81 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 105.81 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in total phenolic content during the course of storage. The maximum decrease in the total phenolic content was noted for T_0 which varied from 131.67, 116.67, 110.33 and 104.67 at 0 to 6^{th}, 12^{th} and 18^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait was 98.67 at 24^{th} day. The least decrease in total phenolic content was noticed for T_3 which varied from 133.33, 126.33, 121.67, 116.67 and112.00 at 0, 6^{th}, 12^{th}, 18^{th}, and 24 days of storage, respectively.

Likewise, for 10% concentration kept trial it is deduced that the maximum total phenolic content in the treated guava sample was recorded in T_3 as 125.27 followed by 124.40, 122.93, 120.60, 119.40 and 118.33 in T_6, T_2, T_5, T_1 and T_4 respectively. However, the lowest recorded values were observed in T_0 as 116.93 depicted in Table 4.55.

Moreover, during the storage a steady decrease in the total phenolic content was noticed that ranged from 132.50 at the initiation of the trial and decreased to 126.24, 120.86 and 115.71 at 6^{th}. 12^{th} and 18^{th} days of storage respectively. However, at the end of 24 days trial noted values for the trait were 110.24 for guava kept at 10% CO_2 concentration.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in total phenolic content during the course of storage. The maximum decrease in the total phenolic content was noted for T_0 which varied from 131.67, 122.67, 116.33 and 109.33 at 0 to 6^{th}, 12^{th} and 18^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 104.67 at 24^{th} day. The least decrease in total phenolic content was noticed for T_3 which varied from 133.33, 129.33, 124.67, 123.67and 115.33 at 0, $6^{th,}$ 6^{th}, 12^{th}, 18^{th} and 24 days of storage, respectively.

Table 4.54. Mean sum of square of effect of treatments and MAS on total phenolic content of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	169.35*	149.41*
Days	4	2309.72**	1601.44**
Treatment x Days	24	10.70*	14.22*
Error	70	2.57	1.83
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.55. Effect of treatments and MAS on total phenolic content of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	131.67 AB	116.67 F-H	110.33 I-K	104.67 LM	98.67 N	**112.40 D**	131.67 A-C	122.67 G-J	116.33 L-N	109.33 PQ	104.67 R	**116.93 E**
T_1	133.00 A	121.33 D-F	112.67 H-J	108.33 J-L	103.33 L-N	**115.73 C**	133.00 AB	125.00 D-H	119.00 J-L	113.00 M-P	107.00 QR	**119.40 CD**
T_2	132.33 A	123.67 C-E	115.33 G-I	111.67 H-K	106.67 K-M	**117.93 B**	132.33 AB	127.33 C-F	123.33 F-J	119.33 I-L	112.33 N-P	**122.93 B**
T_3	133.33 A	126.33 CD	121.67 C-F	116.67 F-H	112.00 H-J	**122.00 A**	133.33 A	129.33 A-D	124.67 E-H	123.67 F-I	115.33 L-N	**125.27 A**
T_4	133.00 A	120.33 E-G	112.00 H-J	108.00 J-M	103.00 MN	**115.27 C**	133.00 AB	124.33 E-H	117.00 K-M	110.67 O-Q	106.67 QR	**118.33 DE**
T_5	132.33 A	123.67 C-E	115.00 HI	110.33 I-K	106.67 K-M	**117.60 B**	132.33 AB	126.33 D-G	121.33 H-K	112.33 N-P	110.67 O-Q	**120.60 C**
T_6	132.33 A	126.67 BC	120.33 E-G	116.00 GH	110.33 I-K	**121.13 A**	132.30 AB	128.67 B-E	124.33 E-H	121.67 H-J	115.00 L-O	**124.40 AB**
Means	**132.57 A**	**122.67 B**	**115.33 C**	**110.81 D**	**105.81 E**		**132.50 A**	**126.24 B**	**120.86 C**	**115.71 D**	**110.24 E**	

Means carrying the similar letters are statistically non-significant

4.27. Antioxidant Activity of (µmolTE/g)

It is evident from mean squares regarding antioxidant activity of treated guava that significant variations were recorded for the effect of treatments and storage. The interaction of days and treatment was also found significant for this trait as depicted in Table 4.56.

From means depicted in Table 4.57 pertaining to treatment conducted at 5% concentration of CO_2, it is deduced that the maximum antioxidant activity in the treated guava sample was recorded in T_1 and T_2 as 19.73 and 22.53. In T_4, T_5 and T_6 the observed values were 18.87, 21.93 and 25.67, respectively. However, the lowest recorded values were observed in T_0 and T_1 as 17.13 and 19.73, respectively.

Over the storage, it can be found that a gradual decrease in the antioxidant activity was noticed that ranged from 34.33 at initiation progressed to 28.86, 20.48 and 15.05 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded value for the parameter was 9.71 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in antioxidant activity during the course of storage. The maximum decrease in the antioxidant activity was noted for T_0 which varied from 34.00, 24.67, 15.67 and 8.00 at 0 to 6^{th}, 12^{th} and 18^{th} day, respectively. Moreover, with further developments in storage, recorded value for the trait was 3.33 at 24^{th} day. Likewise, the least decrease in antioxidant activity was noticed for T_6 which varied from 34.00, 31.67, 25.33, 21.33and 16.00 at initiation to termination, respectively.

Likewise, for 10% concentration, it is deduced that the maximum antioxidant activity in the treated guava sample was recorded in T_1 and T_2 as 22.73 and 25.53. In T_4, T_5 and T_6 the observed values were 22.33, 25.07 and 27.33, respectively. However, the lowest recorded values were observed in T_0 (20.47) and T_1 (22.73) as depicted in Table 4.57.

Over the storage, it can be found that a gradual decrease in the antioxidant activity was noticed that ranged from 34.33 at initiation progressed to 30.67, 23.62, and 19.52 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded value for the parameter was 14.33 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in antioxidant activity during the course of storage. The maximum decrease in the antioxidant activity was noted for T_0 which varied from 34.00, 27.67, 20.00 and 13.33

at 0 to 6th, 12th and 18th day, respectively. Moreover, with further developments in storage, recorded value for the trait was 7.33 at 24th day. Likewise, the least decrease in antioxidant activity was noticed for T_6 which varied from 34.00, 32.67, 27.33, 24 and 18.67at initiation to termination, respectively.

4.28. Citric Acid (mg/100g)

It is evident from mean squares regarding citric acid content of treated guava that significant variations were recorded for the effect of treatments and storage. The interaction of days* treatment was also found significant for this trait as depicted in Table 4.58.

From means depicted in Table 4.59 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum citric acid content (374.00) in the treated guava sample was recorded in T_0, T_2, T_3, T_5 and T_6 343.80, 351.07, 357.13, 350.93 and 355.40. However, the recorded values were observed in T_1 and T_4 as 371.00 and 348.00.

Over the storage, it can be found that a gradual decrease in the citric acid content was noticed that ranged from 374.95 at initiation decreased to 361.19, 352.00 and 336.71 at 6th, 12th and 18th days, respectively. However the recorded values for the parameter were 329.14 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in citric acid content during the course of storage. The maximum decrease in the citric acid content was noted for T_0 which varied from 374.00 to 356.00 and 341.67 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 328.67 and 318.67 at 18th and 24th day, respectively. The least decrease in citric acid content were noticed for T_3 which varied from 375.00 to 338.00 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum. Citric acid content of treated guava was observed in T_0, T_2, T_3, T_5 and T_6 as 350.33, 355.60, 360.07, 354.80 and 358.13, respectively. Likewise, for T_1 a recorded value for the parameter was 353.67 which were the lowest as depicted in Table 4.59.

Moreover, during the storage a steady decrease in the citric acid content was noticed that ranged from 374.95 at the initiation of the trial and decreased to 363.48, 356.76 and 344.05 at 6th, 12th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 336.71 for guava kept at 10% CO_2 concentration.

Table 4.56. Mean sum of square of effect of treatments and MAS on antioxidant activity of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	167.88*	114.37**
Days	4	2101.23**	1384.01**
Treatment x Days	24	13.60*	10.64**
Error	70	1.17	1.15
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.57. Effect of treatments and MAS on antioxidant activity of guava fruit (µmolTE/g)

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	34.00 A	24.67 EF	15.67 J	8.00 LM	3.33 N	**17.13 D**	34.00 AB	27.67 EF	20.00 JK	13.33 MN	7.33 O	**20.47 D**
T_1	34.67 A	27.67 C-E	18.00 H-J	11.67 K	6.67 MN	**19.73 C**	34.67 A	29.33 C-E	21.67 H-J	16.00 LM	12.00 N	**22.73 C**
T_2	34.67 A	30 BC	21.33 F-H	16.33 J	10.33 KL	**22.53 B**	34.67 A	31.67 A-D	23.67 HI	21.00 IJ	16.67 K-M	**25.53 B**
T_3	34.33 A	32.33 AB	25.67 E	21.67 FG	15.67 J	**25.93 A**	34.33 A	34 AB	28.00 EF	25.00 F-H	18.67 J-L	**28.00 A**
T_4	34.33 A	26.33 DE	17.00 IJ	11.00 KL	5.67 MN	**18.87 C**	34.33 A	28.67 DE	21.00 IJ	15.67 LM	12.00 N	**22.33 C**
T_5	34.33 A	29.33 B-D	20.33 G-I	15.33 J	10.33 KL	**21.93 B**	34.33 A	30.67 B-E	23.67 HI	21.67 H-J	15.00 MN	**25.07 B**
T_6	34.00 A	31.67 AB	25.33 E	21.33 F-H	16.00 J	**25.67 A**	34.00 AB	32.67 A-C	27.33 E-G	24.00 GHI	18.67 J-L	**27.33 A**
Means	**34.33 A**	**28.86 B**	**20.48 C**	**15.05 D**	**9.71 E**		**34.33 A**	**30.67 B**	**23.62 C**	**19.52 D**	**14.33 E**	

Means carrying the similar letters are statistically non-significant

Table 4.58. Mean sum of square of effect of treatments and MAS on citric acid of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	315.41*	165.51*
Days	4	6903.22**	4673.93**
Treatment x Days	24	37.87*	17.75^{NS}
Error	70	9.01	8.56
Total	104		

NS = Non Significant (p>0.05), * = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.59. Effect of treatments and MAS on citric acid of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	374.00 A	356.00 C-G	341.67 H-J	328.67 K-M	318.67 N	**343.80 C**	374.00 A	360.67 B-D	351.67 E-H	336.67 J-M	328.67 M	**350.33 E**
T_1	374.67 A	359.67 B-E	351.33 E-H	332.33J -L	322.33 MN	**347.93 B**	374.67 A	362.67 BC	356.33 C-F	341.00 I-L	334.33 K-M	**353.67 CD**
T_2	376.00 A	362.33 B-D	354.67 C-G	336.67J -L	327.67 L-N	**351.07 B**	376.00 A	364.33 BC	358.67 B-E	343.67 H-J	337.33 J-M	**355.60 BC**
T_3	375.00 A	366.00 AB	359.67 B-E	348.00 GH	338.00 I-K	**357.13 A**	375.00 A	366.67 AB	361.33 B-D	353.67 D-F	344.67 G-J	**360.07 A**
T_4	376.33 A	358.67 B-F	349.00 F-H	330.33 K-M	328.00 L-N	**348.00 B**	376.33 A	361.33 B-D	352.67 D-G	341.33 I-L	332.67 LM	**352.40 DE**
T_5	375.00 A	361.33 B-D	352.67 D-G	334.00 J-L	332.67J -L	**350.93 B**	375.00 A	362.67 BC	356.33 C-F	344.00 G-J	337.00 J-M	**354.80 CD**
T_6	373.67 A	364.33 A-C	355.00 C-G	347.00 G-I	336.67J -L	**355.40 A**	373.67 A	366.00 AB	360.33 B-E	348.00 F-I	342.33 I-K	**358.13 AB**
Means	**374.95 A**	**361.19 B**	**352 C**	**336.71 D**	**329.14 E**		**374.95 A**	**363.48 B**	**356.76 C**	**344.05 D**	**336.71 E**	

Means carrying the similar letters are statistically non-significant

Amongst treatments it was noticed that a systematic decrease in the citric acid content was recorded which ranged from 374.00 at 0 day to 360.67, 351.67 and 336.67 at $6^{th,}$ 12^{th} and 18^{th} day to the lowest 328.67.33 at 24^{th} days for T_0, respectively. Likewise, the minimum decrease for citrus acid content was observed for treatments T_3 with variations in the values for the trait were 375.00 and 344.67 at 0 day to at 24^{th} day, respectively.

4.29. Ascorbic Acid (mg/100g)

It is evident from mean squares regarding ascorbic acid content of treated guava that significant variations were recorded for the effect of treatments and storage. The interaction of days and treatment was also found significant for this trait as depicted in Table 4.60.

From means depicted in Table 4.61 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the ascorbic acid content in the treated guava sample in $T_{0,}$ T_2, T_4 , T_5, T_3 and T_6 were 141.67, 148.73,144.60, 147.80, 155.07 and 152.87, respectively. However, the recorded value was observed in T_1 as 145.67.

Over the storage, it can be found that a gradual decrease in the ascorbic acid content was noticed that ranged from 175.90 at initiation decreased to 162.52, 146.38 and 134.10 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 119.29 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in ascorbic acid content during the course of storage. The maximum decrease in the ascorbic acid content was noted for T_4 which varied from 174.00, 160.33 and 140.67 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 129.67 and 114.33at 18^{th} and 24^{th} day, respectively. The least decrease in ascorbic acid content was noticed for T_3 which varied from 177.33, 167.33, 155.00, 145.33 and 129.67 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it is deduced that the ascorbic acid content in the treated guava samples in $T_{0,}$ T_1 and T_2 were recorded 147.67, 151.00 and 154.40. While in T_3, T_4 and T_5 the observed values were 157.20,1 49.53 and 153.20, respectively. However, the lowest recorded values were observed in T_6 as 155.67 as depicted in Table 4.61.

Over the storage, it can be found that a gradual decrease in the ascorbic acid content was noticed that ranged from 170.90 at initiation decreased to 165.90, 153.29 and 137.62 at

6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 128.52 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady decrease in ascorbic acid content during the course of storage. The maximum decrease in the ascorbic acid content was noted for T_4 which varied from 174.00, 164.33 and 148.00 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 133.33 and 124.00 at 18^{th} and 24^{th} day, respectively. The decrease in ascorbic acid content was noticed for T_3 which varied from 177.33, 169.33, 159.67, 143.67 and 135.33 at initiation to termination, respectively.

4.30. Malic Acid (mg/100g)

It is evident from mean squares regarding Malic acid content of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. The interaction of days and treatment was also found significant for this trait as depicted in Table 4.62.

From means depicted in Table 4.63 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the content in the treated guava sample was recorded in T_4 125.47. In T_2, T_5 and T_6 the observed values were 122.73, 123.00 and 120.13, respectively. However, the observed values were T_0, T_1 and T_3 as 128.73, 125.67 and 119.00, respectively.

Over the storage, it can be found that a gradual increase in the malic acid content was noticed that ranged from 105.90 at initiation increased to 114.24, 129.10 and 131.14 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 137.19 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in malic acid content during the course of storage. The maximum increase in the malic acid content was noted for T_0 which varied from 106.00, 120.67 and 135 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 138.33 and 143.67 at 18^{th} and 24^{th} day, respectively. The least increase in malic acid content was noticed for T_3 which varied from 106.33 to 131.00 at initiation to termination, respectively. Likewise, for 10% concentration, it is deduced that the malic acid content in the treated guava sample was 121.13 in T_4. While the observed values in T_2,

Table 4.60. Mean sum of square of effect of treatments and MAS on ascorbic acid of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	328.2*	176.09*
Days	4	11189.8**	8540.26**
Treatment x Days	24	27.4*	15.77*
Error	70	5.6	5.22
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.61. Effect of treatments and MAS on ascorbic acid content of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	178 A	157.00 C-E	137.67 I-K	124.00 MN	111.67 P	**141.67 E**	178.00 A	162.33 B-E	145.67 G-I	131.67 M-O	120.67 Q	**147.67 E**
T_1	176.33 A	160.67 B-E	143.67 HI	131.00 K-M	115.00 OP	**145.67 CD**	176.33 A	164.33 B-D	150.33 FG	135.67 K-N	126.67 O-Q	**151.00 CD**
T_2	175.00 A	162.33 B-D	148.00 F-H	134.67 J-L	120.67 NO	**148.73 B**	175.00 A	166.33 BC	156.33 EF	139.67 I-L	131.67 M-O	**154.40 B**
T_3	177.33 A	167.33 B	155.00 D-F	145.33 HI	129.67 LM	**155.07 A**	177.33 A	169.33 B	159.67 C-E	143.67 G-J	135.33 K-N	**157.20 A**
T_4	174.00 A	160.33 B-E	140.67 H-J	129.67 LM	114.33 OP	**144.60 D**	174.00 A	164.33 B-D	148.00 GH	133.33 L-O	124.00 PQ	**149.53 DE**
T_5	177.00 A	163.33 BC	146.00 GH	133.67 J-L	118.00 N-P	**147.80 BC**	177.00 A	166.00 BC	155.67 EF	138.00 J-M	128.33 N-P	**153.20 BC**
T_6	173.67 A	166.67 B	153.67 E-G	140.33 H-J	125.67 MN	**152.87 A**	173.67 A	168.67 B	157.33 D-F	141.33 H-K	133.00 L-O	**155.67 AB**
Means	**175.90 A**	**162.52 B**	**146.38 C**	**134.10 D**	**119.29 E**		**175.90 A**	**165.90 B**	**153.29 C**	**137.62 D**	**128.52 E**	

Means carrying the similar letters are statistically non-significant

Table 4.62. Mean sum of square of effect of treatments and MAS on malic acid of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	170.91*	164.48*
Days	4	3513.18**	2209.56**
Treatment x Days	24	12.55**	12.16*
Error	70	2.35	2.55
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.63. Effect of treatments and MAS on malic acid content of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	106.00 P	120.67 KL	135.00 C-E	138.33 B-D	143.67 A	**128.73 A**	106.00 P	116.33 J-M	125.33 E-G	132.67 A-C	136.33 A	**123.33 A**
T_1	104.33 P	116.67 LM	131.67 E-G	133.67 D-F	140.33 AB	**125.67 B**	104.33 P	113.33 L-N	121.33 G-J	127.67 C-F	133.33 AB	**120.33 B**
T_2	108.67 P	112.67 M-O	128 G-J	129.33 F-I	137.67 B-D	**122.73 C**	108.67 P	110.67 N-P	118.00 I-L	123.67 F-H	130.33 B-E	**117.73 C**
T_3	106.33 P	109.67 OP	123.67 JK	124.67 I-K	131.00 E-H	**119.00 D**	106.33 P	107.33 OP	111.33 M-O	119.33 H-J	126.00 E-G	**114.00 D**
T_4	106.33 P	115.33 MN	132.00 E-G	134.67 C-E	139.33 A-C	**125.47 B**	106.33 P	114.00 K-N	121.67 G-I	129.67 B-E	134.33 AB	**121.13 B**
T_5	103.67 P	113.33 M-O	128.00 G-J	130.67 E-H	137.00 B-D	**123 C**	103.67 P	110.33 N-P	118.67 H-K	125.67 E-G	131.33 A-D	**118.40 C**
T_6	106.00 P	111.33 NO	125.33 I-K	126.67 H-J	131.33 E-H	**120.13 D**	106.00 P	107.67 OP	118.67 H-K	122.33 G-I	126.33 D-G	**115.13 D**
Means	**105.9 E**	**114.24 D**	**129.10 C**	**131.14 B**	**137.19 A**		**105.9 E**	**111.38 D**	**118.52 C**	**125.86 B**	**131.14 A**	

Means carrying the similar letters are statistically non-significant

T_5 and T_6 were 117.73, 118.40 and 115.13. However, the recorded values were observed in T_0, T_1 and T_3 as 121.33, 120.33 and 114.00 as depicted in Table 4.63.

Over the storage, it can be found that a gradual increase in the malic acid content was noticed that ranged from 105.90 at initiation increased to 111.38, 118.52 and 125.86 at 6th, 12th and 18th days, respectively. However the recorded values for the parameter were 131.14 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in malic acid content during the course of storage. The maximum increase in the malic acid content was noted for T_0 which varied from 106.00, 116.33 and 125.33 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 132.67 and 136.33 at 18th and 24th day, respectively. The least increase in malic acid content was noticed for T_3 which varied from 106.33 to 126.00 at initiation to termination, respectively.

4.31. Tartaric Acid (mg/100g)

It is evident from mean squares regarding tartaric acid content of treated guava that significant variations were recorded for the effect of treatments and storage. The interaction of days and treatment was also found significant for this trait as depicted in Table 4.64.

From means depicted in Table 4.65 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum tartaric acid content in the treated guava sample was 0.831 and 0.825 in T_4 and T_5. In T_0, T_2, T_3 and T_6 the observed values were 0.838, 0.823 and 0.819, respectively. However, the value observed in T_1 was 0.830.

Over the storage, it can be found that a gradual increase in the tartaric acid content was noticed that ranged from 0.786 at initiation increased to 0.812, 0.833 and 0.840 at 6th, 12th and 18th days, respectively. However the recorded values for the parameter were 0.860 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in Tartaric acid content during the course of storage. The maximum increase in the tartaric acid content was noted for T_0 which varied from 0.787, 0.826 and 0.847 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 0.858 and 0.875 at 18th and 24th day, respectively. The least increase

in tartaric acid content was noticed for T_3 which varied from 0.783 to 0.848 at initiation to termination, respectively.

Likewise, for 10% concentration, it is deduced that the tartaric acid content in the treated guava sample was 0.824 and 0.817 in T_4 and T_5. In T_0, T_2, T_3 and T_6 the observed values were 0.829, 0.818, 0.811 and 0.812, respectively. However, the recorded values were observed in T_1 as 0.825 as depicted in Table 4.65.

Over the storage, it can be found that a gradual increase in the tartaric acid content was noticed that ranged from 0.786 at initiation increased to 0.807, 0.823 and 0.831 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 0.848 at the termination of 24 days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in tartaric acid content during the course of storage. The maximum increase in the tartaric acid content was noted for T_0 which varied from 0.787, 0.817 and 0.833 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 0.846 and 0.861at 18^{th} and 24^{th} day, respectively. The least increase in tartaric acid content was noticed for T_3 and T_6 as these varied from 0.783 to 0.837 and 0.788 to 0.837 at initiation to termination, respectively.

4.32. Respiration rate of Guava Fruit ($mLCO_2Kg^{-1}hr^{-1}$)

It is evident from mean squares regarding respiration rate of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be significant as depicted in Table 4.66.

From means depicted in Table 4.67 related to storage conducted at 5% concentration of CO_2, it is deduced that the value for respiration rate in the treated guava sample was recorded in T_0 as 27.47 followed by 26.93 and 26.53 in T_4 and T_1, respectively. However, the lowest recorded values were observed in T_6 as 22.60. Likewise, for treatments T_2 and T_3 observed values for the trait were 24.27 and 22.07, correspondingly.

Over the storage, it can be found that a gradual increase in the value for respiration rate was noticed that ranged from 10.05 at initiation progressed to 16.86, 26.81 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were 36.91 at the termination of 24^{th} days study.

Table 4.64. Mean sum of square of effect of treatments and MAS on tartaric acid content of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	0.00084**	0.00067*
Days	4	0.01645**	0.01159**
Treatment x Days	24	0.00006*	0.00005^{NS}
Error	70	0.00002	0.00003
Total	104		

NS = Non Significant (p>0.05), * = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.65. Effect of treatments and MAS on tartaric acid of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	0.787 S	0.826 K-N	0.847 D-F	0.858 B-D	0.875 A	**0.838 A**	0.787 S	0.817 I-K	0.833 D-F	0.846 BC	0.861 A	**0.829 A**
T_1	0.785 S	0.816 N-P	0.838 F-J	0.844 E-H	0.864 AB	**0.83 B**	0.785 S	0.813 KL	0.830 D-G	0.837 CD	0.857 A	**0.825 B**
T_2	0.786 S	0.806 P-R	0.828 J-M	0.835 G-K	0.857 B-D	**0.823 CD**	0.786 S	0.806 LM	0.822 G-J	0.829 D-G	0.846 BC	**0.818 C**
T_3	0.783 S	0.800 R	0.822 L-O	0.828 J-M	0.848 D-F	**0.817 E**	0.783 S	0.795 NO	0.812 KL	0.824 F-I	0.837 CD	**0.811 D**
T_4	0.788 S	0.819 M-O	0.840 E-I	0.845 E-G	0.866 AB	**0.831 B**	0.788 S	0.814 J-L	0.829 D-G	0.835 DE	0.854 AB	**0.824 B**
T_5	0.787 S	0.812 O-Q	0.833 H-L	0.837 F-K	0.859 BC	**0.825 C**	0.787 S	0.806 LM	0.819 H-K	0.828 E-H	0.846 BC	**0.817 C**
T_6	0.788 S	0.804 QR	0.824 L-N	0.832 I-L	0.850 C-E	**0.819 DE**	0.788 S	0.800 MN	0.813 J-L	0.821 G-K	0.837 CD	**0.812 D**
Means	**0.786 E**	**0.812 D**	**0.833 C**	**0.840 B**	**0.860 A**		**0.786 E**	**0.807 D**	**0.823 C**	**0.831 B**	**0.848 A**	

Means carrying the similar letters are statistically non-significant

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in respiration rate during the course of storage. The maximum increase in the respiration rate was noted for T_0 which varied from 9.67 to 20.67 and 33.33 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 39.67 and 34.00 at 18th and 24th day, respectively. Likewise, For $T_1$and T_4, variations in the values differed from 10.33 and 29.67 to 10.33 and 30.00 at 0 to 12th days, respectively. Furthermore, the noted values for T_1 and T_4 were 38.67 and 39.67 at the termination of 24th days study. The least increase in the respiration rate were noticed for T_3 and T_6 which varied from 9.67 to 35.67 and 10.33 to 36.00 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for respiration rate of treated guava was observed in T_0 as 27.53 followed by T_4 and T_1 as 26.73 and 26.53, respectively. Likewise, for T_2 and T_3 recorded values for the parameter were 23.87 and 21.80, respectively depicted in Table 4.67.

Moreover, during the storage a steady increase in the values for respiration rate was noticed that ranged from 10.05 at the initiation of the trial and progressed to 16.67 and 34.10 at 6th and 18th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 36.67 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for respiration rate was recorded which ranged from 9.67 at 0 day to 33.00 and 35.33 at 12th and 24th day for T_0, respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 10.33 and 10.33 at 0 day to 38.67 and 36.00 at 24th day, respectively. Similarly the variations in the respiration rate for T_4 and T_5 were 10.33 to 39.00 and 10.00 to 37.33 at mentioned intervals, respectively.

4.33. Ethylene Gas ($\mu LKg^{-1}hr^{-1)}$

It is clear from the mean squares of ethylene gas of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be significant as depicted in Table 4.68.

From means depicted in Table 4.69 related to storage conducted at 5% concentration of CO_2, it is inferred that the maximum value for ethylene gas in the treated guava sample

Table 4.66. Mean sum of square of effect of treatments and MAS on respiration rate of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	67.75**	76.30*
Days	4	2721.90**	2699.24**
Treatment x Days	24	14.14*	13.06*
Error	70	1.13	1.26
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table. 4.67. Effect of treatments and MAS on respiration rate of guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	9.67 O	20.67 KL	33.33 D-F	39.67 A	34.00 DE	**27.47 A**	9.67 O	19.67 J	33.00 EF	40.00 A	35.33 C-E	**27.53 A**
T_1	10.33 O	18.33 LM	29.67 GH	35.67 B-E	38.67 AB	**26.53 A**	10.33 NO	18.00 J-L	30.00 F	35.67 B-E	38.67 A-C	**26.53 A**
T_2	10.00 O	16.33 MN	25.33 IJ	33.00 E-G	36.67 A-D	**24.27 B**	10.00 O	16.00 K-M	24.67 HI	32.67 EF	36.00 B-E	**23.87 B**
T_3	9.67 O	14.00 N	20.67 KL	30.33 FG	35.67 B-E	**22.07 C**	9.67 O	14.67 LM	20.67 J	29.67 FG	34.33 DE	**21.80 C**
T_4	10.33 O	19.00 K-M	30.00 FG	35.67 B-E	39.67 A	**26.93 A**	10.33 NO	18.67 JK	30.00 F	35.67 B-E	39.00 AB	**26.73 A**
T_5	10.00 O	15.67 MN	26.33 HI	34.33 C-E	37.67 A-C	**24.80 B**	10.00 O	16.00 K-M	26.33 GH	35.00 DE	37.33 A-D	**24.93 B**
T_6	10.33 O	14.00 N	22.33 JK	30.33 FG	36.00 B-E	**22.60 C**	10.33 NO	13.67 MN	21.33 IJ	30.00 F	36.00 B-E	**22.27 C**
Means	**10.05 E**	**16.86 D**	**26.81 C**	**34.14 B**	**36.91 A**		**10.05 E**	**16.67 D**	**26.57 1C**	**34.10 B**	**36.67 A**	

Means carrying the similar letters are statistically non-significant

Table 4.68. Mean sum of square of effect of treatments and MAS on production of ethylene gas in guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	7.93**	9.04*
Days	4	1625.87**	1584.36**
Treatment x Days	24	24.09**	23.51**
Error	70	1.25	0.86
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.69. Effect of treatments and MAS on production of ethylene gas in guava fruit

Treatment	CO_2 5%						CO_2 10%					
	Storage Days					Means	Storage Days					Means
	0	6	12	18	24		0	6	12	18	24	
T_0	2.33 P	11.67 I-K	20.67 DE	23 B-D	16.33 GH	**14.8 A**	2.33 T	8.67 N-P	16.33 I-K	26.67 A	16.67 H-K	**14.13 A**
T_1	2.67 OP	9.33 K-M	17 F-H	27 A	20 D-F	**15.2 A**	2.67 T	7 O-R	13.67 KL	23.33 B-D	19.67 F-H	**13.27 AB**
T_2	2.33 P	8 L-N	13.67 H-J	25 A-C	21.67 CD	**14.13 AB**	2.33 T	5.33 Q-T	11.33 L-N	20.33 D-G	23 C-E	**12.47 BC**
T_3	3.33 OP	6 M-O	11.33 J-L	20.67 DE	25.33 AB	**13.33 B**	3.33 ST	4.33 R-T	8.67 N-P	17.33 G-J	26.67 A	**12.07 C**
T_4	3.33 OP	9.33 K-M	18 E-G	26.67 A	17.33 E-G	**14.87 A**	3 ST	8 O-Q	14.33 J-L	24 A-C	20 E-G	**13.87 A**
T_5	3.33 OP	7.67 MN	15 G-I	24.33 A-C	20.67 DE	**14.13 AB**	3 ST	6 P-S	12 LM	21.33 C-F	21.33 C-F	**12.73 BC**
T_6	3.33 OP	5.33 N-P	11.67 I-K	21.67 CD	25.33 AB	**13.4 B**	3 ST	5.33 Q-T	9.67 M-O	18 G-I	26.33 AB	**12.47 BC**
Means	**2.81 E**	**8.19 D**	**15.33 C**	**24.05 A**	**20.95 B**		**2.81 D**	**6.38 C**	**12.29 B**	**21.57 A**	**21.95 A**	

Means carrying the similar letters are statistically non-significant

was recorded in T_1 as 15.20 followed by 14.87 and 14.80 in T_4 and T_0, respectively. However, the lowest mean value was observed in T_3 as 13.33. In the same way, for treatments T_2 and T_6 observed values were 14.13 and 13.40, correspondingly.

Over the storage, it can be found that a gradual increase in the value for ethylene gas was noticed that ranged from 2.81 at initiation progressed to 8.19, 15.33, and 24.05 at 6^{th}, 12^{th} and 18^{th} days, respectively. However the recorded values for the parameter were 20.95 at the termination of 24^{th} days study.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in ethylene gas production during the course of storage. The maximum increase in the ethylene gas production was noted for T_1 which varied from 2.67 to 9.33, 17.00 and 27.00 at 0 to 6^{th}, 12^{th} and 18^{th} day, respectively. Moreover, with further developments in storage, recorded value for the trait was 20.00 at 24^{th} day. Likewise, For T_0 and T_4, variations in the values differed from 2.33 and 3.00 to 20.67 and 18.00 at 0 to 12^{th} days, respectively. Furthermore, the noted values for T_0 and T_4 were 16.33 and 17.33 at the termination of 24^{th} days study. The least increase in the ethylene gas values were noticed same for T_3 and T_6 which varied from 3.33 to 25.33 at initiation to termination, respectively.

Likewise, for 10% concentration kept trial it was conceded that the maximum mean value for ethylene gas production of treated guava was observed in T_0 as 14.13 followed by T_4 and T_1 as 13.87 and 13.27, respectively. Likewise, for T_5, T_2, T_6 and T_3 recorded values for the parameter were 12.73, 12.47, 12.47 and 12.07 respectively as depicted in Table 4.69.

Moreover, during the storage a steady increase in the values for ethylene gas production was noticed that ranged from 2.81 at the initiation of the trial and progressed to 6.38, 12.29 and 21.57 at 6^{th}, 12^{th} and 18^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 21.95 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the values for was recorded which ranged from 2.33 at 0 day to 16.33 and 16.67 at 12^{th} and 24^{th} day for T_0, respectively.

Likewise, for treatments T_1 and T_2 variations in the values for the trait were 2.67 and 2.33 at 0 day to 19.67 and 23.00 at 24^{th} day, respectively. Similarly the variations in the

ethylene gas values for T_4 and T_5 were 3.00 to 20.00 and 3.00 to 21.33 at mentioned intervals, respectively.

4.34. Sensory Evaluation of Guava Fruit

Most important factors influencing the acceptability of product are its organoleptic properties. Product having good color, flavor, taste, Texture and overall acceptability is accepted for consumption. Product quality depends upon its sensory characteristics then price is second factor influencing the acceptability of product.

4.34.1 Color:

It is obvious from mean squares regarding color of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.70.

From means depicted in Fig. 8 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for color in the treated guava sample was recorded in T_3 as 5.73 followed by 5.40 and 5.20 in T_2 and T_1, respectively. However, the lowest recorded values were observed in T_0 as 4.93. Likewise, for treatments T_6 and T_5 observed value for the trait were 5.46 and 5.00, correspondingly.

Over the storage, it can be found that a gradual increase in the value for color was noticed that ranged from 3.52 at initiation which progressed to 6.09, 7.23 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were reduced to 5.76 at the 18^{th} days of study and at 24^{th} day it reduced to 3.57.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in color value during the course of storage. The increase in the color value noted for T_0 varied from 3.33 to 6.66 and 6.66 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 5.33 at 18^{th} day and after word it reduced to 2.66 at 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 3.66 to 7.00 and 4.00 to 6.66 at 0 to 12^{th} days, respectively. Furthermore, the noted values for the parameter were decreased to 3.33 and 2.66 at the termination of 24 days study. The change in the color values were noticed for T_3 and T_6 which varied from 3.66 and 3.66 at initiation which increased to 8.00 and 7.67 at 12^{th} day which afterward decreased to 4.67 and 4.33 at the 24^{th} day of storage, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for color of treated guava was observed in T_6 as 6.06 followed by T_3 and T_2 as 6.00 and 5.93, respectively. Likewise, for T_0 and T_1 recorded values for the parameter were 5.13 and 5.73, respectively.

Moreover, during the storage a steady increase in the values for color score was noticed that ranged from 3.47 at the initiation of the trial and progressed to 6.19 and 7.42 at 6^{th} and 12^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 4.48 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the score for color was recorded which ranged from 3.33 at 0 day to 6.33 and 6.33 at 12^{th} and 18^{th} day for T_0, which further decrease to 3.66 at 24^{th} day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.66 and 3.33 at 0 day to 7.33 and 8.00 at 12^{th} day, which afterward reduced to 4.33 and 4.66 at 24^{th} day of storage, respectively. Similarly the variations in the color values for T_4 and T_5 were 3.00 to 7.33 and 4.00 to 7.33 from 0 day to 12^{th} day which thereafter reduced to 3.67 and 4.67 at 24^{th} day of storage, respectively.

4.34.2. Flavor:

It is obvious from mean squares regarding flavor of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.71.

From means depicted in Fig. 9 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for flavor in the treated guava sample was recorded in T_6 as 5.13 followed by 4.80 and 4.60 in T_3 and T_5, respectively. However, the lowest recorded values were observed in T_0 as 3.73. Likewise, for treatments T_1 and T_2 observed value for the trait were 4.26 and 4.80, correspondingly.

Over the storage, it can be found that a gradual increase in the value for flavor was noticed that ranged from 3.00 at initiation which progressed to 6.33, 5.57 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were reduced to 4.52 at the 18^{th} days of study and at 24^{th} day it reduced to 3.00.

Table 4.70. Mean sum of square of effect of treatments and MAS on color of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	1.4190*	2.1651*
Days	4	56.3095**	56.1286**
Treatment x Days	24	0.8873*	0.9508*
Error	70	0.3143	0.3048
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table 4.71. Mean sum of square of effect of treatments and MAS on flavor of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	3.5492*	1.8413*
Days	4	47.2952**	50.3667**
Treatment x Days	24	1.1563*	1.0833*
Error	70	0.2857	0.3619
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 8. Effect of treatments on color of guava fruit during storage

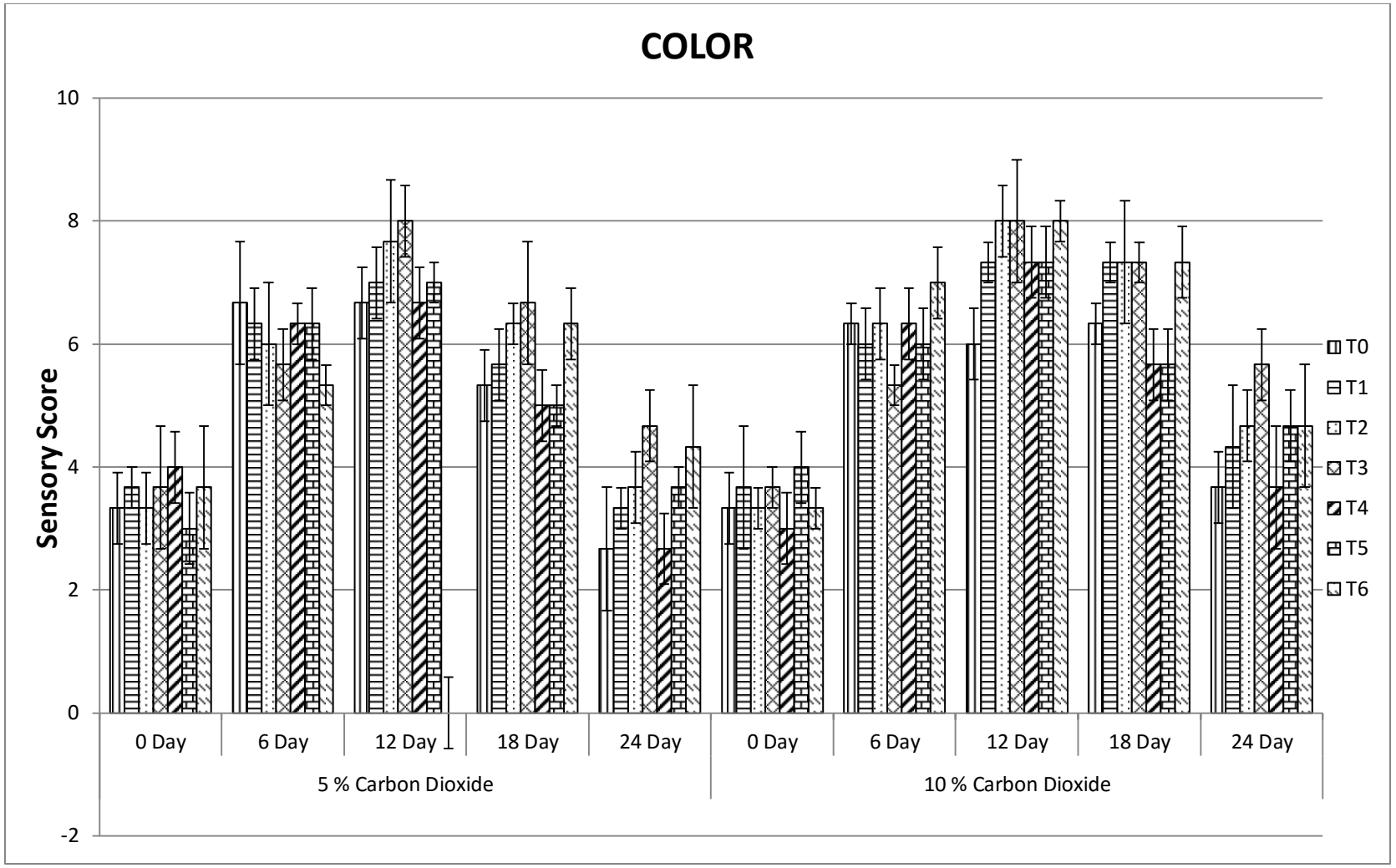
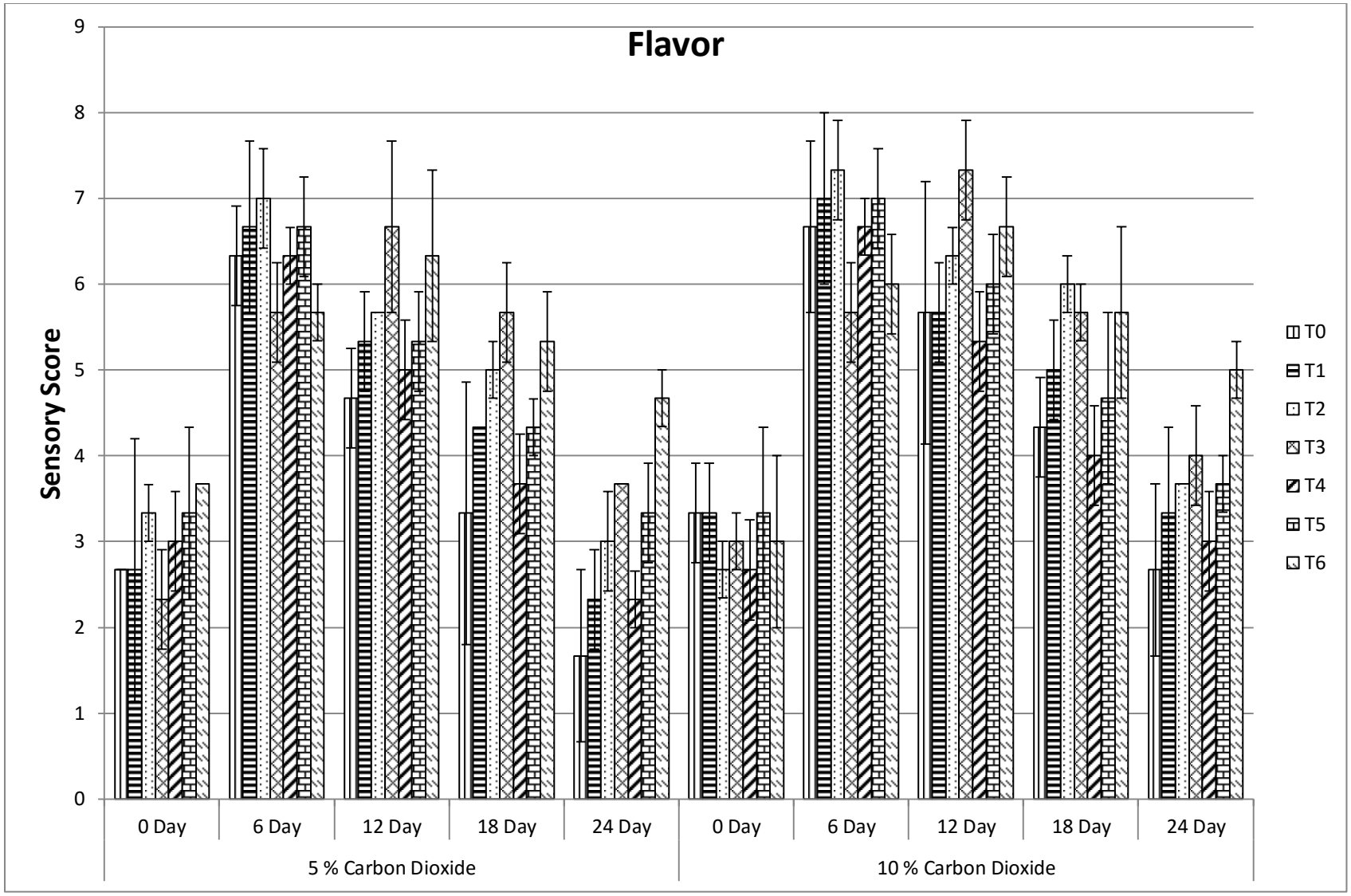


Fig. 9. Effect of treatments on flavor of guava fruit during storage



Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in flavor value during the course of storage. The increase in the flavor value noted for T_0 varied from 2.66 to 6.33 and 4.66 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 3.33 at 18th day and after word it reduced to 1.66 at 24th day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 2.66 to 5.33 and 3.00 to 5.00 at 0 to 12th days, respectively. Furthermore, the noted values for the parameter were decreased to 2.33 and 2.33 at the termination of 24 days study. The change in the flavor values were noticed for T_3 and T_6 which varied from 2.33 and 3.66 at initiation which increased to 6.66 and 6.33 at 12th day which afterward decreased to 3.66 and 4.66 at the 24th day of storage, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for flavor of treated guava was observed in T_6 as 5.26 followed by T_3 and T_2 as 5.13 and 5.20, respectively. Likewise, for T_0 and T_1 recorded values for the parameter were 4.53 and 4.87, respectively.

Moreover, during the storage a steady increase in the values for flavor score was noticed that ranged from 3.04 at the initiation of the trial and progressed to 6.62 and 6.14 at 6th and 12th day of storage respectively. However, at the end of 24 days trial noted values for the trait were 3.61 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the score for flavor was recorded which ranged from 3.33 at 0 day to 6.66 and 5.66 at 6th and 12th day for T_0, which further decrease to 2.66 at 24th day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.33 and 2.66 at 0 day to 5.66 and 6.33 at 12th day, which afterward reduced to 3.33 and 3.66 at 24th day of storage, respectively. Similarly the variations in the flavor values for T_4 and T_5 were 2.66 to 5.33 and 3.33 to 6.00 from 0 day to 12th day which thereafter reduced to 3.00 and 3.67 at 24th day of storage, respectively.

4.34.3. Texture:

It is obvious from mean squares regarding texture of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.72.

From means depicted in Fig. 10 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for texture in the treated guava sample was

recorded in T_6 as 4.73 followed by 4.73 and 4.53 in T_3 and T_5, respectively. However, the lowest recorded values were observed in T_0 as 4.00. Likewise, for treatments T_1 and T_2 observed value for the trait were 4.40 and 4.53, correspondingly.

Over the storage, it can be found that a gradual increase in the value for texture was noticed that ranged from 3.00 at initiation which progressed to 6.28, 6.38 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were reduced to 3.47 at the 18^{th} days of study and at 24^{th} day it reduced to 2.90.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in texture value during the course of storage. The increase in the texture value noted for T_0 varied from 3.33 to 6.66 and 5.66 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 2.66 at 18^{th} day and after word it reduced to 1.66 at 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 3.00 to 6.33 and 2.66 to 5.33 at 0 to 12^{th} days, respectively. Furthermore, the noted values for the parameter were decreased to 2.66 and 2.33 at the termination of 24 days study. The change in the texture values were noticed for T_3 and T_6 which varied from 3.00 and 3.00 at initiation which increased to 7.33 and 7.00 at 12^{th} day which afterward decreased to 3.66 and 3.66 at the 24^{th} day of storage, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for texture of treated guava was observed in T_6 as 5.53 followed by T_3 and T_2 as 5.26 and 5.46, respectively. Likewise, for T_0 and T_1 recorded values for the parameter were 4.53 and 5.20, respectively.

Moreover, during the storage a steady increase in the values for texture score was noticed that ranged from 3.19 at the initiation of the trial and progressed to 6.95 and 6.95 at 6^{th} and 12^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 3.90 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the score for texture was recorded which ranged from 3.33 at 0 day to 7.00 and 6.00 at 6^{th} and 12^{th} day for T_0, which further decrease to 2.66 at 24^{th} day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.33 and 3.33 at 0 day to 7.33 and 7.66 at 12^{th} day, which afterward reduced to 3.66 and 4.33 at 24^{th} day of storage, respectively. Similarly the variations in the texture values for T_4 and T_5 were 2.66 to 6.33 and 3.33 to 6.33

from 0 day to 12th day which thereafter reduced to 3.33 and 4.00 at 24th day of storage, respectively.

4.34.5. Taste

It is obvious from mean squares regarding taste of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.73.

From means depicted in Fig. 11 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for taste in the treated guava sample was recorded in T_6 as 6.00 followed by 6.06 and 5.66 in T_3 and T_5, respectively. However, the lowest recorded values were observed in T_0 as 4.93. Likewise, for treatments T_1 and T_2 observed value for the trait were 5.73 and 5.93, correspondingly.

Over the storage, it can be found that a gradual increase in the value for taste was noticed that ranged from 3.23 at initiation which progressed to 6.33, 7.47 at 6th and 12th days, respectively. However the recorded values for the parameter were reduced to 6.00 at the 18th days of study and at 24th day it reduced to 5.33.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in taste value during the course of storage. The increase in the taste value noted for T_0 varied from 3.33 to 6.67 and 6.67 at 0 to 6th and 12th day, respectively. Moreover, with further developments in storage, recorded values for the trait were 4.66 at 18th day and after word it reduced to 3.33 at 24th day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 3.33 to 7.33 and 3.00 to 7.66 at 0 to 12th days, respectively. Furthermore, the noted values for the parameter were decreased to 5.33 and 4.33 at the termination of 24 days study. The change in the taste values were noticed for T_3 and T_6 which varied from 3.33 and 3.33 at initiation which increased to 8.00 and 7.66 at 12th day which afterward decreased to 6.67 and 6.33 at the 24th day of storage, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for taste of treated guava was observed in T_6 as 6.00 followed by T_3 and T_2 as 6.06 and 5.93, respectively. Likewise, for T_0 and T_1 recorded values for the parameter were 4.93 and 5.73, respectively.

Table 4.72. Mean sum of square of effect of treatments and MAS on texture of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	1.5873*	2.3873*
Days	4	65.7762**	65.3714*
Treatment x Days	24	1.3373*	1.1214*
Error	70	0.4095	0.3238
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Table. 4.73. Mean sum of square of effect of treatments and MAS on taste of guava fruit

Source	df	MS (5 % CO_2)	MS (10% CO_2)
Treatment	6	3.5492*	2.3873**
Days	4	49.7476**	51.6524**
Treatment x Days	24	1.7476*	1.5579*
Error	70	0.3619	0.3810
Total	104		

* = Significant (p<0.05), ** = Highly Significant (p<0.01)

Fig. 10. Effect of treatments on texture of guava fruit during storage

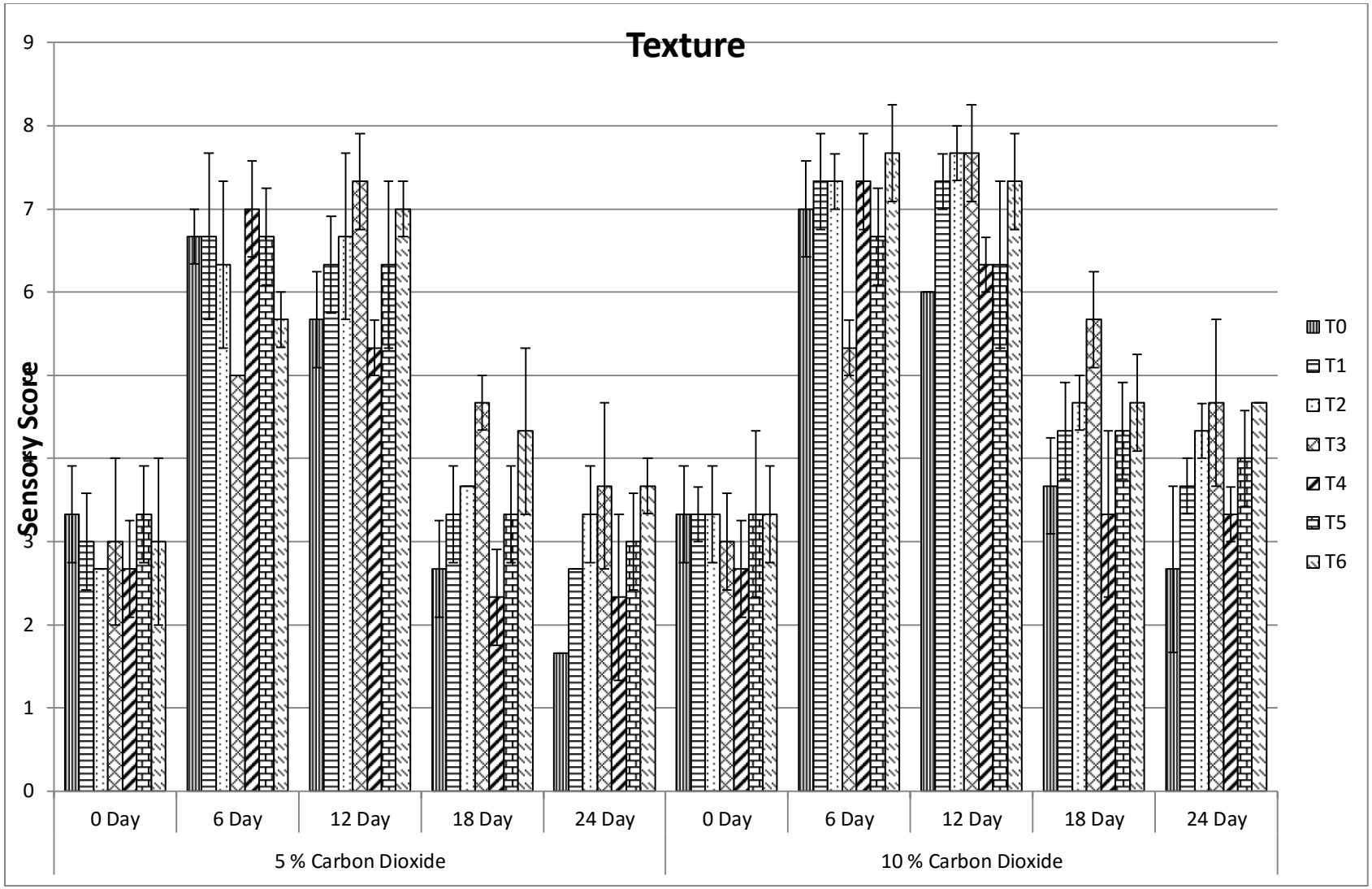
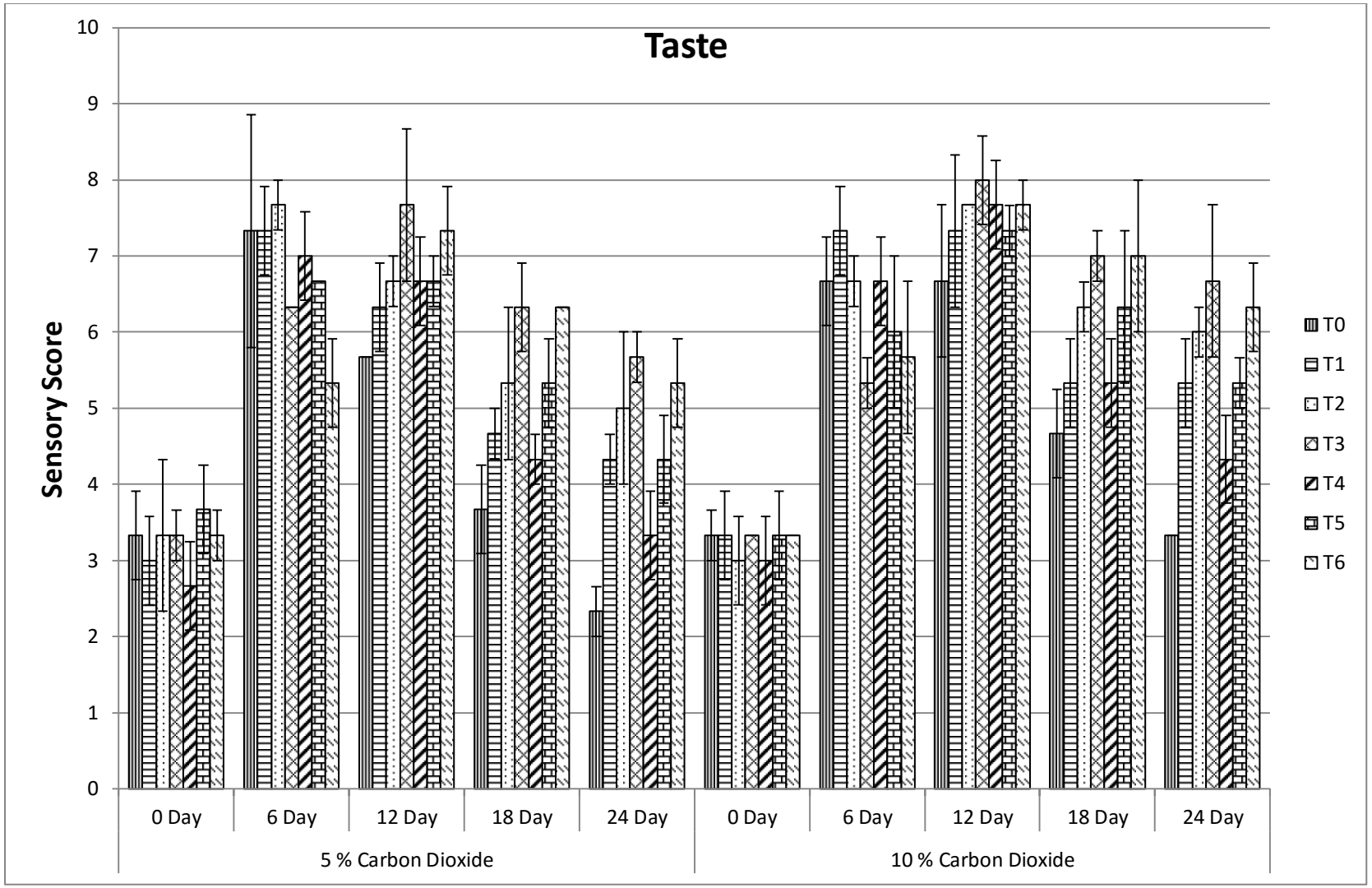


Fig. 11. Effect of treatments on taste of guava fruit during storage



Moreover, during the storage a steady increase in the values for taste score was noticed that ranged from 3.23 at the initiation of the trial and progressed to 6.33 and 7.47 at 6^{th} and 12^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 5.33 for guava kept at 10% CO_2 concentration.

Amongst treatments it was noticed that a systematic increase in the score for taste was recorded which ranged from 3.33 at 0 day to 6.67 and 6.67 at 6^{th} and 12^{th} day for T_0, which further decrease to 3.33 at 24^{th} day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.33 and 3.00 at 0 day to 7.33 and 7.66 at 12^{th} day, which afterward reduced to 5.33 and 6.00 at 24^{th} day of storage, respectively. Similarly the variations in the taste values for T_4 and T_5 were 3.00 to 7.66 and 3.33 to 7.33 from 0 day to 12^{th} day which thereafter reduced to 4.33 and 5.33 at 24^{th} day of storage, respectively.

4.34.6. Overall Acceptability:

It is obvious from mean squares regarding overall acceptability of treated guava that significant variations were recorded for the effect of treatments, storage and carbon dioxide. Moreover, their interaction was also found to be momentous as depicted in Table 4.74.

From means depicted in Fig. 12 pertaining to storage conducted at 5% concentration of CO_2, it is deduced that the maximum value for overall acceptability in the treated guava sample was recorded in T_6 as 5.06 followed by 4.66 and 4.66 in T_3 and T_5, respectively. However, the lowest recorded values were observed in T_0 as 3.80. Likewise, for treatments T_1 and T_2 observed value for the trait were 4.13 and 4.53, correspondingly.

Over the storage, it can be found that a gradual increase in the value for overall acceptability was noticed that ranged from 3.23 at initiation which progressed to 6.09, 5.66 at 6^{th} and 12^{th} days, respectively. However the recorded values for the parameter were reduced to 4.28 at the 18^{th} days of study and at 24^{th} day it reduced to 2.90.

Amongst treatments, a similar behavior was shown by all the treatments indicating a steady increase in overall acceptability value during the course of storage. The increase in the overall acceptability value noted for T_0 varied from 3.33 to 6.33 and 4.66 at 0 to 6^{th} and 12^{th} day, respectively. Moreover, with further developments in storage, recorded values for the trait were 3.00 at 18^{th} day and after word it reduced to 1.66 at 24^{th} day, respectively. Likewise, For T_1 and T_4, variations in the values differed from 2.66 to 5.33 and 3.66 to 4.66 at 0 to 12^{th} days, respectively. Furthermore, the noted values for the parameter were decreased

to 2.33 and 2.33 at the termination of 24 days study. The change in the overall acceptability values were noticed for T_3 and T_6 which varied from 3.00 and 3.33 at initiation which increased to 7.00 and 6.66 at 12^{th} day which afterward decreased to 3.33 and 4.33 at the 24^{th} day of storage, respectively.

Likewise, for 10% concentration kept trial it was revealed that the maximum value for overall acceptability of treated guava was observed in T_6 as 5.40 followed by T_3 and T_2 as 4.86 and 4.86, respectively. Likewise, for T_0 and T_1 recorded values for the parameter were 4.26 and 4.60, respectively.

Moreover, during the storage a steady increase in the values for overall acceptability score was noticed that ranged from 3.23 at the initiation of the trial and progressed to 6.14 and 6.19 at 6^{th} and 12^{th} day of storage respectively. However, at the end of 24 days trial noted values for the trait were 3.61 for guava kept at 10% CO_2 concentration.

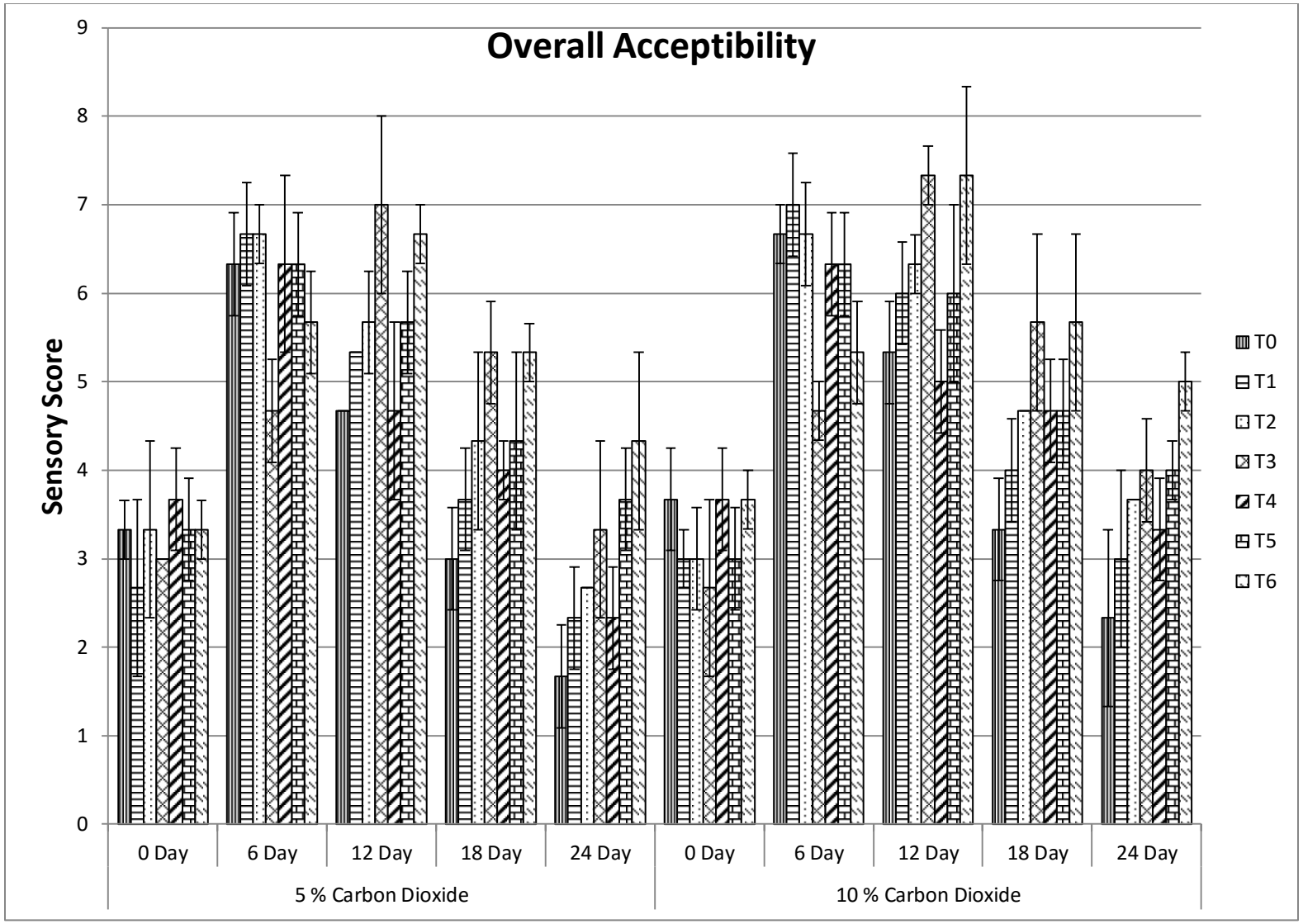
Amongst treatments it was noticed that a systematic increase in the score for overall acceptability was recorded which ranged from 3.66 at 0 day to 6.67 and 5.33 at 6^{th} and 12^{th} day for T_0, which further decrease to 2.33 at 24^{th} day of storage respectively. Likewise, for treatments T_1 and T_2 variations in the values for the trait were 3.00 and 3.00 at 0 day to 6.00 and 6.33 at 12^{th} day, which afterward reduced to 3.00 and 3.67 at 24^{th} day of storage, respectively. Similarly the variations in the taste values for T_4 and T_5 were 3.66 to 5.00 and 3.00 to 6.00 from 0 day to 12^{th} day which thereafter reduced to 3.33 and 4.00 at 24^{th} day of storage, respectively.

Table 4.74. Mean sum of square of effect of treatments and MAS on overall acceptability of guava fruit

Source	**df**	**MS (5 % CO_2)**	**MS (10% CO_2)**
Treatment	6	2.6635*	1.8190*
Days	4	42.3667**	39.8190**
Treatment x Days	24	1.5722*	1.8746*
Error	70	0.2952	0.3048
Total	104		

* = Significant ($p<0.05$), ** = Highly Significant ($p<0.01$)

Fig. 12. Effect of treatments on overall acceptability of guava fruit during storage



DISCUSSION

Total soluble solids and sugars (glucose, fructose and sucrose)

The study in hand showed that the total soluble solids (TSS) and sugars (glucose, fructose and sucrose) content present in guava (climacteric fruit) fruit increased during storage. This increase in said parameters may be due to the conversion of starch molecules into simple sugar molecules. The water loss from the fruits during storage may also be a reason for this increase. The mentioned traits were found to be increased during storage but after reaching a climacteric peak they began to drop. The rate of change in said parameters in present study also depended upon concentration of calcium salt, the high the amount of calcium chloride or calcium lactate the lower was the rate of change. The storage condition had also significant effect on the rate of change in the mentioned traits, the samples kept without CO_2 spoiled after 18 days of storage but the samples kept at 5 and 10% CO_2 level had shelf life more than 24 days. TSS of the fruits tends to decrease after reaching a certain value then began to decrease. This may be due to the complete hydrolysis of starch and no further conversion was found and afterward the decline occur which may be due to the use of sugar in the respiration of the fruits and formation of some other organic acids. The delay in the ripening of the fruits in calcium treated fruits may be due to the formation of calcium pectate which decreases the respiration rate of the fruits by decreasing the ethylene gas production. Mahajan *et al*. (2011), reported a significant role of calcium chloride in assuring consistent behavior in TSS of guava fruit during storage. Furthermore, Wills *et al*. (1982) stated that the increase in TSS during storage may possibly be due to the hydrolysis of starch into sugar.

Bashir *et al*. (2003) observed that total soluble solids (TSS) and total sugars increased in guava with decrease in flesh firmness. TSS increased 1.2-fold in guava during ripening. Rodriguez *et al*. (1971) observed a gradual increase in TSS and total sugars during guava fruit ripening. Increase in total sugars in fruits was observed after fruit firmness reached 1.21 kg/cm^2, which coincided with the climacteric peak of respiration. The remarkable increase in total sugars observed after the climacteric peak, may be attributed to the increase in activity of enzymes responsible for starch hydrolysis and for decline in the rate of sugar breakdown by respiration.

The results of present study are in close agreement with Rodriguez *et al*. (1971) who found that the glucose and fructose content of fruits increased during the storage and with progression of storage it decreased. The increase in reducing sugar with the progression in storage time was due to the degradation of starches to glucose and fructose by the activities of amylase and maltase (Wills *et al*., 1981). Tanden *et al*. (1985) mentioned that fructose content increased during ripening. Joshi and Roy (1988) also reported that percentage of reducing sugars increased during storage up to 25 days of cold storage in fruits and after that it declined sharply because of the onset of senescence.

Hakim *et al*. (2012) stated that non reducing sugar content of banana (climacteric fruit) was found very low initially. Then these increased to a peak value after 5 days of harvesting and then again dropped drastically. Mowlah and Itoo (1982) showed that glucose, fructose and sucrose were the main sugars in the white and pink-fleshed guavas. The level of fructose increased during guava fruit ripening and then decreased in the over-ripe fruits. Rodriguez *et al*. (1971) found that the sucrose content of fruits first increased during storage and after that it started to decrease. Mitra (1997) found that during the ripening of guava fruit, TSS and sugars increase in the skin and flesh.

pH and Acidity

The pH of the guava fruit in the present study escalated during the whole storage period but the rate of change in the pH of fruits was found to be dependent upon the storage condition and the amount of calcium salt treatment. The minimum change in the pH was observed in fruit samples that were stored in modified atmosphere having 10% CO_2 and chemically treated with 3% calcium chloride or calcium lactate. A comparable study on guava was made by Mahajan *et al*. (2011) who described a linear increase in the pH of fruit at the cost of decline in acidity during storage and further found higher changes in control treatments as compared to calcium chloride treated fruits. The increase in pH was mainly due to the reduction of acidity caused by the degradation of organic acids to sugars. Medlicott and Jeger (1987) described that in guava fruit the pH steadily enhanced during different maturity phases while acidity enhanced in the green and intermediary stage of maturation and decreased in the maturity stage. Increase in both parameters showed formation of organic acids during maturation. Increases in both parameters are linked with greater amounts of un-

dissociated organic acids, stored in the vacuole and fruits use these acids as respiratory substrate.

The result of our investigation regarding the acidity of fruit indicated that the acidity of the guava fruit decreased during the storage period in all samples but the rate of change in the acidity depended on the treatment received by the sample and the storage condition. Titratable acidity decreases until the attainment of its climacteric peak of respiration (Mitra, 1997). The maximum decrease in acidity was observed in control samples that were stored without CO_2. The acidity of fruits decrease with storage, this was due to the use acids a substrate for respiration process. The decrease in titratable acids during ripening and storage may be attributed to an increase in malic enzyme and pyruvate decarboxylation reaction. The fruits treated with calcium chloride maintained higher acidity during storage probably due to delay in. ripening process. The results of our findings are in line with the previous findings of Yamdagni *et al*. (1987). They found that titratable acidity decreased with ripening in the cultivars of Sardar, Allahabad Safeda and Baranasi Surkha. Nagi *et al*. (2011) found that the acidity decreased as the ripening of the guava fruit progressed. Chang *et al*. (1971) found that malic, citric, tartaric and glycolic acids contribute toward the total acidity of guava. The titratable acidity increases up to the climacteric peak and then declines. The ascorbic acid content are in maximum concentration when the fruit is mature green and then its concentration tends to drop rapidly as the fruit ripens (Bashir *et al*., 2003). The results of our study are in corroboration with the findings of Mahmud *et al*. (2008), who reported that the decrease in the acidity of $CaCl_2$ treated fruit was minimum during storage probably due to delay in ripening process. Mahajan *et al*. (2011) described the linear decline in acidity during storage and further observed higher changes in control treatments as compared to $CaCl_2$ treated fruits. Titratable acidity decreased throughout the storage period which may be due to the metabolic activities of the living tissues (conversion of acids to sugars) during which depletion of organic acids take place (Ball, 1997; Ramana, 1979) as a result of decrease in acidity the pH of the fruit increased.

Weight Loss (%) and Firmness (Kg Force)

The result of present study showed that weight loss percentage increased with the storage period while the rate of weight loss was found slow in first days of storage. However on later stages the weight loss increased at higher rate. The weight loss percentage in calcium

chloride treated fruits was concentration depended phenomenon. Loss of weight is detrimental in fruits because it lowers the overall acceptability of fruits. The effects of dehydration are noticeable visually which change the skin appearance and also toughen the skin of the fruits. Actually the loss of weight in fruits is dependent upon the storage conditions and the length of storage period for which these are stored. Calcium application on the fruits caused a positive effect on the membrane functionality and integrity maintenance which decreased the ion leakage that is responsible for the weight loss in fruits (Lester and Grusak, 1999).

Shaaban and Fatma (2006) stated that dipping guava fruits in calcium chloride (0.5-2.0%) reduced weight loss and respiration rate. These data can be explained by the fact that $CaCl_2$ is hydroscopic (absorbs moisture), which is believed to be one of the reasons for its effectiveness in controlling weight loss. Water vapour absorbed from the storage room helps to provide a continuous solution of $CaCl_2$ on the surface of the fruit throughout storage period. The present findings are in line with the earlier work of Mahajan *et al*., (2011) who reported a considerable reduction in weight loss by the application of $CaCl_2$ on guava. Furthermore, they described that the loss of weight was mainly due to the transpiration and respiration process and calcium have been effective to reduce ion leakage which could be responsible for the lower weight loss in plum (Lester and Grusak, 1999). This was mainly due to the binding of calcium to ploygalactonic acid and also aiding the cross linkages, thereby making the middle lamella strong and rigid, which might have delayed the senescence and rate of respiration and transpiration in guava fruits.

Calcium application has been reported to be effective in terms of membrane functionality and integrity maintenance with lower losses of phospholipids and proteins and reduced ion leakage which could be responsible for the lower weight loss in plums (Mahajan *et al*., 2011).

In an other study Azzolin *et al*. (2004) described that the weight loss percentage increased during the storage, with the highest values detected in control samples. This behavior was probably due to the disruption of tissues, leading to acceleration in the aging process, represented in this case by the high susceptibility of tissues to moisture loss. The low loss of weight were observed in fruits treated with $CaCl_2$ to 1%. Botelho *et al.* (2002), in a similar study with white guava Kumagai, no significant differences between treatments for

percentage of weight loss accumulated, however, tended to lower loss for the fruits treated with $CaCl_2$.

Mitra, (1997) described that moisture losses in guava in hot climates may results in 35% weight loss. In guava highest amount of vitamin C is present at the unripe green phase and it reduces as the fruit ripens. Dhruba *et al.* (2006) reported that the cumulative weight loss of tomato when treated with (0.25%-1.0%) $CaCl_2$ was significantly lower when compared to the control. After 10 days of storage they found the cumulative weight loss in 1.00, 0.75, 0.50, 0.25% calcium treated fruits was 12.14, 12.80, 14.86 and 17.02%, respectively as compared to 19.03% in controlled fruits.

Calcium infiltration treatments of papaya (climacteric fruit) at concentrations 2.5% and 3.5% decreased the weight loss progressively compared to the other treatments (1.5, 2.5, 3.5% dips and 1.5% infiltration with calcium chloride). Whereas, 2.5% calcium infiltration treatment showed higher ability in reducing weight loss significantly when compared to other treatments. The decline in weight loss using calcium infiltration @ 3.5% might be due to the fact that higher concentration caused hydration more than that for 2.5%. It was also observed that there was a difference between the weight loss of fruits dipped in 2.5% calcium and the control in the beginning of storage, but the difference was slowly reduced during storage (Mahmud *et al.*, 2008).

In the present study firmness of the fruits showed a declining trend during storage. The softening of fruits is due the hydrolysis of starch or due to the breakdown of insoluble protopectins. The fruits treated with 3% calcium chloride showed a high degree of firmness as compared to 1% $CaCl_2$ treated fruits. The sustaining of fruit firmness was due to the binding of calcium with free carboxyl group of polygalacturonate polymer, which strengthen and stabilize the cell wall. Akhtar *et al.* (2010) showed that the firmness of loquat (non-climacteric fruit) fruits treated with 2% and 3% $CaCl_2$ was significantly higher than the ones which was untreated or treated with 1% $CaCl_2$. Bashir *et al.* (2003) found that the firmness of guava fruit tend to decline progressively during ripening. The drop in firmness of fruit was eight-fold from the hard mature green stage to the final soft ripe stage.). During maturation process structure of cellulose and hemicelluloses also change. Actions of the softening enzymes like galactosidase, pectinesterase (PE) and cellulase enhances with ripening process (El-Buluk *et al.*, 1995). The decrease in firmness of fruit may be due to the

softening of the untreated fruits resulting from the breakdown of pectin molecules by the pectic enzymes.

Calcium is said to play a special role in maintaining cell wall structure in fruits and other storage organs by interacting with pectic acid in the cell wall to form calcium pectate and also facilitating the cross linkage of pectic polymers. The desired effect of calcium on maintaining fruit firmness may be due to the calcium binding to free carboxyl groups of polygalacturonate polymer, stabilizing and strengthening the cell wall The maintenance of higher firmness as a result of calcium chloride may be due to their ability to prevent the physiological weight loss during storage and to inhibit/delay ethylene production and/or action in different fruits.

Natural process of ripening, cause loss of firmness in the fruits after harvesting. This $CaCl_2$ has the role of linking the pectic cell wall components, mainly in the middle lamella (Luna-Guzman *et al*., 1999), favoring the maintenance of firmness. However, the increase in the concentration of $CaCl_2$ did not result in retention of firmness, confirming the hypothesis Conway *et al*. (1995), cited by Botelho *et al*. (2002), which suggests that the cell walls have limited binding sites, where higher concentrations of $CaCl_2$ in solution result in their saturation, causing injuries to the fruit, as well as phytotoxicity.

Akhtar *et al*. (2010) showed that the firmness of loquat fruits treated with 2% and 3% $CaCl_2$ was significantly higher than untreated or treated with 1% $CaCl_2$. Manganaris *et al*. (2007) found that the dip treatment with 62.5mM $CaCl_2$ increased the tissue firmness of whole peaches. Manganaris *et al*. (2005) described that calcium treated canned peach halves firmness increased 34.2-44.7% as compared to the non- treated fruits. Kumar *et al*. (2005) treated different cultivars of canola fruit with 1% solution of $CaCl_2$ and stored at ambient temperature (18 ± 2°C). They reported that $CaCl_2$ was more suitable for improving the fruit texture. A calcium lactate dip applied at either 25 or 60°C resulted in significantly firmer fruit samples during storage.

Total Phenolic content and Antioxidant Activity

The total phenolic content and antioxidant activity of present study decreased throughout the storage period but the rate of decline was dependent upon the amount of salt received and the storage condition. Mowlah and Itoo (1982) determined the stability of

polyphenol components in white and pink guavas and found that there were more polyphenol components in unripe guava however when guavas attained maturity their polyphenol contents were decreased. Reducing levels of polyphenolic compounds during ripening were also determined in banana (Ibrahim *et al*., 1994) and mango (Abu-Goukh and Abu-Sarra, 1993).

During ripening process from un-ripe to ripening stage, reduction in phenolic contents of guava was observed. According to their observations this process may be due to increased polyphenol oxidase actions in guava and due to the loss in astringency (Rop *et al.*, 2011). Reduction in astringency is related with increased polymerization of leucoanthocyanidins and breakdown of astringent compounds. During ripening period in high bush blueberries phenomena of reducing of phenolic compounds has already reported by Kalt *et al*. (2003).

Higher concentrations of phenolic compounds are present at the un-ripe stage and in lesser amount present at the fully-matured phase. Different factors affected on the concentration of phenolic compounds in guava like ripening stage, cultivar, environmental conditions, time of storage and harvesting conditions (Wang and Lin, 2000). Polyphonic components mainly affected by environmental conditions or other factors. These conditions may be agronomic and climatic. In agronomic conditions or factors; greenhouse, biological culture, and fruit yield is involved. In case of climatic factors, different factors like rainfall, type of soil, and exposure to sun is involved. Concentration of polyphenols in fruits also influenced by the degree of maturity as reported by Kondakova *et al*. (2009).

Phenolic compounds in pulp and peel of both guava types progressively decreased with decrease in flesh firmness. The decrease in astringency in guava ripening was associated with the increased polymerization of leucoanthocyanidins and hydrolysis of the astringent arabinose ester of hexahydrodiphenic acid and the increased polymerization of leucoanthocyanidins are related with decrease in astringency in guava ripening.

The result of present study regarding antioxidant activity are in close agreement with the findings of Oruma *et al*. (2008) who found that the antioxidant activity of guava fruit decreased during storage. The result of present investigation are also in lined with the previous findings of Kulkarni and Aradhya (2005) who reported that antioxidant activity of pomegranate arils (Non-climacteric fruit) decreased by 13% from 20 to 60 days of fruit development. The decline in scavenging property might be due to the decrease in the

phenolic contents, rapid consumption of anthocyanin's and compositional changes as a result of fruit development. DPPH scavenging activity of guava extract was found at different maturity stages. It was found that at un-ripe stage guava showed maximum DPPH scavenging capacity (40–45%), while the minimum value (38%) was observed at the fully-matured phase. Lim *et al*. (2006) found that more DPPH activity at the green phase of development of fruit may be associated to its greater levels of total phenolic contents. Free radicals play main functions in different types of permanent diseases such as heart diseases and cancer (Valko *et al*., 2004; Nakabeppu *et al*., 2006).

Organic Acids (Ascorbic acid, Citric acid, Malic acid and Tartaric acid)

The result of our study indicated that the citric acid and ascorbic acid content decreased while the malic acid and tartaric acid content increased during storage period but the rate of change depended on storage condition and chemical treatment. The organic acids presents in fruits influenced the flavor. Passam *et al*. (2011) found that the concentration of organic acid affect the perceived sweetness of the fruit. In guava fruit, citric acid was found in high amount followed by ascorbic acid, malic acid and tartaric acid, respectively. The citric acid content of guava fruit decreased as the fruit become matured and ripened. The results in our study are in line with the findings of Lara *et al*. (2013) who determined the changes in the citric acid concentration in lowbush blueberry (climacteric fruit) during fruit ripening. They observed that citric acid increased in fruit as they became red from green, and the contents of acid decreased as fruit over-matured. The results of present study are in close collaboration with Randhawa *et al*. (2014) who found that the citric acid content of citrus juice (non-climacteric fruit) decreased during storage with the progression in storage period.

Wu *et al*. (2005) determined the changes in citric acid and malic acid content in peach (climacteric fruit) fruit during different stages of fruit development. They determined the rate of change in the concentration of citric acid and malic acid during different stages of fruit development. They found that citric acid content in peach fruit increased during fruit development stage and afterward the citric acid content began to drop when fruit started to ripe and increase in the sweetness, while the malic acid content were low and decreased in peach during fruit development stage however with progression in maturation the malic acid content increased.

Lara *et al*. (2013) found the change in malic acid and tartaric acid contents in lowbush blueberry (climacteric fruit) during fruit ripening and they found an increase in malic and tartaric acid contents as the fruit became over-ripe. The results of present study are in close collaboration with Randhawa *et al*. (2014) who found that the malic acid and tartaric acid content of citrus juice increased during storage with the progression in storage period.

In guava fruits the ascorbic acid content decreased during storage period. During storage, enzymes like peroxidase, catalase, polyphenol oxidase and ascorbic acid oxidase reduce ascorbic acid content of guava fruits (Singh *et al*. 2005). The current findings are also in line with previous work of Mahajan *et al*., (2011) who reported that ascorbic acid contents varied significantly with storage and further illustrated that higher contents of trait was found in treatments with calcium application. A slow and steadier loss of ascorbic acid contents was noticed by Laufmann and Sams (1989) and they found that calcium treated fruits retained higher ascorbic acid as compared to control.

Bashir *et al*. (2003) found a steady decrease in ascorbic acid content in pulp and peel of guava during fruit ripening. At the final stage the amount of ascorbic acid retained was 86.3% in the pulp and 85.6% in the peel of guava fruit. The ascorbic acid content in guava fruit reaches a maximum level at the mature green stage and started to decline rapidly as the fruit ripens.

Soares *et al.* (2007) conducted study on increasing style in amount of ascorbic acid during maturation. It was seen in their research that concentration of ascorbic acid in green stage fruit was75mg per 100 g of sample. After that quantity of ascorbic acid increased from 126 to 170 mg/100g at mature and fully ripe stage of sample. This increase in ascorbic acid quantity in fruit may be due to degradation of starch or carbohydrate to glucose that enhances the synthesis of vitamin C. Lim *et al*. (2006) reported increased quantity of ascorbic acid from 30mg to 145mg/100g in mature fruit. Gomez and Lajolo (2008) found 55% increase in vitamin C concentration in guava at maturity stage, but in mango fruit 35% concentration of ascorbic acid reduced during ripening period.

Ascorbic acid is an important nutrient quality parameter and is very sensitive to degradation due to its oxidation (Veltmen *et al*., 2000) as compared to other nutrients during food processing and storage. Calcium is said to delay the rapid oxidation of ascorbic acid. Akhtar *et al*. (2010) reported that loquat fruit treated with $CaCl_2$ retained higher amounts of

ascorbic acid. Loss of ascorbic acid with $CaCl_2$ treatments with 1% and 2% was 10.9% and 8.4% as compared to 19% loss in control while in 3%, $CaCl_2$ treated fruits the loss was only 2.5%. But the ascorbic acid content decreased gradually during the 10 weeks storage period. Ruoyi *et al*. (2005) also stated that ascorbic acid content of peaches was maintained in fifty days storage with a post-harvest application of 0.5% $CaCl_2$.

Respiration rate and Ethylene gas production

The results of present study regarding respiration rate are in close agreement of the earlier reports of Bashir *et al*. (2003) who found that guava showed the typical climacteric pattern of carbon dioxide production. Similar findings were made by Osman and Ayub (1998) on guava fruit and found that rate of respiration was influenced by storage temperature and post-harvest treatments. Fruits stored at higher temperature exhibited a higher rate of respiration than fruits stored at lower temperature. Storage life of fruits stored at ambient temperature was only one week after that mold growth occurred which led to fruit softening and rots. Even though there was no significant difference in the CO_2 production between all treated fruits except control. Bashir and Abu-Goukh (2002) described that in guava respiration and ethylene production rate increases after the first day of harvest. Climacteric peak of guava reaches between 4 and 5 days of post-harvest and then declines.

Increased carbon dioxide level during storage reduces respiration rate and delays fruit ripening which extends storage life and maintains quality of fruits (Al-Redhaiman, 2005 and Kader, 2002). El-Rayes, (2009) found that when the dates (climacteric fruit) were stored under modified atmosphere where CO_2 level was increased their shelf life was also increased. They observed that the fruits kept in 20% CO_2 level at 0°C had shelf life of 173 days while the fruits when kept in normal atmosphere there life did not exceed more than 60 days. He also found that the rate of change in quality parameters like, total phenolic content, antioxidant activity, total sugars, total soluble solids, carotenoids content, flavonoids content, and skin color of fruit was slow down in sample that were stored in atmosphere where CO_2 concentration is high than the samples that were kept in normal atmosphere composition.

Brown and Wills (1983) found that carbon dioxide and ethylene production rates in guava showed a climacteric respiratory pattern. Similarly, Edmundo *et al.* (1998) found that in guava fruit growth season effected on the time to reach the climacteric peak. The guava fruits of the summer season reached climacteric peak for carbon dioxide and ethylene

production after 5 days of harvesting but in winter season it take 8 and 7 days to reach climacteric peak after harvesting when the fruits were stored at 20°C. They also found that the maturity of fruit have also impact on the climacteric pattern of carbon dioxide and ethylene gas production.

Ethylene has been shown to be involved in the regulation of flesh softening, skin color development and other ripening processes in guava fruit leading to limited shelf-life. Ethylene production in guava is strongly influenced by harvest maturity, cultivar and storage atmosphere (Pal *et al*., 2007).

The present findings are in agrrement with the results of Osman and Ayub (1998) who stated that rate of ethylene gas production showed a similar trend to that of CO_2 production rate. Ethylene production in guava fruit first increases and after that it started to decrease with the progression in storage period. In guava respiration and ethylene production rate increases after the first day of harvest. Climacteric peak of guava reaches between 4 to 5 days after harvest and then declines (Bashir and Abu-Goukh, 2002).

Similarly Kader (2003) recommended 2-5% O_2 and 0-1% CO_2 for CA storage of guava at 5-15°C. The short term exposure of guava fruit to high CO_2 levels (10, 20 and 30%) did not influence the respiration rates, but reduces ethylene production during ripening (Pal and Buescher, 1993). Treating guavas with 10% O_2 +5% CO_2 for 24 h before storage in air at 4°C for 2 weeks delayed color development and reduced chilling injury, compared to fruit held in air (Bautista and Silva,1997). Modified atmosphere conditions for long term storage of guava have not yet been defined. The available information on the tolerance limits of guava fruit to low O_2 and high CO_2 atmospheres is sporadic and inconclusive.

Sensory Evaluation

Sensory evaluation is an important tool in product development. Acceptance of a food product depends upon the consumer's perception of the color, taste, texture, flavor and overall acceptability into overall impression of quality. Although chemical, physical and microbiological tests are employed to check the quality of a food product, but these tests can't provide such kind of information whether consumer will accept it or not. The findings of present investigation are in line with the findings of Mahajan *et al*. (2011) who determined the change in the sensory parameters (color, flavor, taste, texture and overall acceptability) of calcium treated guava. They reported significantly the highest score (7.11 out of 9) in fruits

treated with calcium salts. The control fruits recoded the lowest results. Initially the fruits treated with $CaCl_2$ were desirable upto 3 weeks and after that sharp decline was noticed resulting in poor acceptability of fruits. Martin-Diana *et al*. (2005) found insignificant differences on sensory attributes (off flavours or texture) between samples treated with calcium lactate and calcium chloride. However, when warm temperatures were used, significant improvements in sensory attributes were observed. In a similar study, conducted by Wills *et al*. (1982) found that the calcium application improves the organoleptic quality of selected fruits. Manganaris *et al.* (2005) reported that there has been a significant difference observed with respect to the texture among calcium treated and untreated peaches (climacteric fruit). Luna-Guzman and Barrett, (2000) reported that 1.5 or 2.5% $CaCl_2$ treated samples of musk melon were scored higher for texture value than control samples. Saftner *et al*. (2003) found that sensory evaluation with calcium propionate and calcium chelate were taste free and did not impart a lip feel. Javid-Ullah *et al*. (2007) found that the calcium salts treatment did not effect on the sensory scores of color, flavor and texture of apple (climacteric fruit) fruits however during storage the treated fruits attained more score than the untreated fruits. Bashir *et al*. (2003) found that increased level of CO_2 maintained the texture and color of guava fruit.

CHAPTER 5

SUMMARY

Guava is very important climacteric fruit that contains antioxidants and high amount of vitamins C. Guava belongs to family Myrtaceae and came into existence from Southern Mexico or Central America. Shape of fruit is round, elliptical or pear shape. Color of pulp may be white, pink, yellowish depending upon the variety of fruit. Guava fruit contains fiber, water, minerals and vitamin C content in higher amount. Habitual utilization of fruits is linked with reduced risks of cancer, cardiovascular disease, stroke, cataracts, alzheimer, and some of the functional disorders associated with aging.

Guava is highly nutritious fruit and enriched with vitamin C, 3-4 time more than orange. It is also known as apple of poor people because its very low prices and the fruit is easily accessible to common man. In Pakistan the production of guava fruit is 552 million ton annually but unfortunately 30-40% of guava fruit is spoiled after its harvesting due to inappropriate guava fruit handling and storage because guava is delicate in nature and climacteric fruit which is spoiled after 3-5 days of harvesting. Guava fruit is perishable commodity which made it susceptible to chilling injury when stored at refrigeration temperature. Therefore some appropriate techniques are required to be developed for preserving these fruits in fresh form.

Current study was conducted to prevent the post-harvest loss of guava and escalate the shelf life of the guava fruit by applying chemical treatments and modified atmosphere conditions. In the current study guava was dipped in solutions of calcium chloride and calcium lactate @ 1, 2 and 3%, respectively for 5 minutes at room temperature. The treated fruits were divided into three lots. First lot of treated guava fruit was kept in normal air composition, while the second lot was kept in modified air chamber where the CO_2 level was maintained at 5% level and 3rd lot of treated guava fruits were kept in modified atmosphere chambers where CO_2 level was maintained at 10% and temperature and relative humidity was maintained at 10°C and 80%, respectively in all three lots.

The shelf life of chemically treated fruits that kept at 0% CO_2 was 18 days while the shelf life of guava fruits kept at 5 and 10% CO_2 level was 24 days. The dip treatments had effected on the change in the quality parameters of the fruits. The higher the concentration of the calcium chloride and calcium lactate the lower was the change in quality parameter and

vice versa. While the results of both calcium salts were almost same. Similarly, the CO_2 level effected storage life of the guava fruit. The guava fruits stored at 5 and 10% CO_2 level gave better results than the samples that were kept without CO_2.

The TSS (°Brix) of the guava fruits increased with the progression in storage in all samples that were kept at different storage conditions. TSS in control sample stored at 0% CO_2 was 9.77 at the start of storage period then it increased upto10.82 till 12th day and thereafter it decreased to 10.49 at 18th day. Similarly in T_6 (calcium lactate 3%) the TSS increased from 9.73 to 10.74 at 12th day which declined to 10.66. Similarly samples kept at 5% CO_2 the TSS increased from 9.83 to 10.90 at 18th day of storage and then after it decreased to 10.57 in T_0 (control samples). Likewise in T_6 (calcium lactate 3%) the increase in TSS was 9.87 to 10.30 at the initiation to termination of storage period. In samples stored at 10% CO_2 level the TSS increased gradually and in T_0 (control) and T_3 (calcium chloride 3%), it increased from 9.83 to 10.80 and 9.73 to 10.60, respectively from 0 to 24th day of storage.

The pH of the fruits continuously increased with the progression in the storage period. The pH of T_0 (control) kept at 0% CO_2 increased from 3.86 to 4.39 at the 18th day. While the pH of the T_3 (calcium chloride 3%) increased from 3.87 to 4.31 from start to 18th day of storage. Likewise, the change in the pH of guava fruits samples T_0 (control) kept at 5% CO_2 was 3.86 at the start of storage period which increased to 4.23 at 24th day. The pH of T_3 (calcium chloride 3%) increased from 3.87 to 4.18 at the termination of storage period. Similarly in samples stored at 10% CO_2 level the pH increased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it increased from 3.86 to 4.12 and 3.87 to 4.04 from 0 to 24th day of storage.

The acidity of the fruits decreased during the whole storage period. The acidity in T_0 (control) stored at 0% CO_2 was 0.51 at the start of storage period then it decreased to 0.27 at 18th day of storage, while the acidity decreased from 0.52 to 0.34 in T_3 (calcium chloride 3%) at the termination of 18th days of storage. Similarly, the acidity decreased from 0.51 to 0.36 and 0.52 to 0.41 in T_0 (control) and T_3 (calcium chloride 3%) samples kept at 5% CO_2 level at the end of storage period of 24 days. Likewise in samples kept at 10% CO_2 the acidity decreased gradually during storage and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 0.51 to 0.40 and 0.52 to 0.44, respectively from 0 to 24th day of storage.

The weight loss (%) of the fruits continuously increased with the progression in the storage period. The weight loss (%) of T_0 (control) kept at 0% CO_2 was 1.19 at 6th day which increased to 2.73 at 18th day. While the weight loss of the T_3 (calcium chloride 3%) increased from 1.1 to 2.46 % at 18th day of storage. Likewise the change in the weight loss of guava fruits samples T_0 (control) kept at 5% CO_2 was 1.04 to 2.53% and weight loss in the T_3 (calcium chloride 3%) increased from 0.9 to 2.33% at the termination of storage period. Similarly the change in the weight loss of samples kept at 10% CO_2 level was 0.92 to 2.21% from start to end of storage period in T_0 (control) and the increase in the weight loss value of T_3 (calcium chloride 3%) was 0.81 to 2.02 from start to the termination of storage period.

The firmness (Kg Force) of the fruits decreased during the whole storage period. The firmness in T_0 (control) stored at 0% CO_2 level was 8.428 at the start of storage period which decreased to 2.977 at 18th day of storage, while the firmness in T_3 (calcium chloride 3%) decreased from 8.415 to 3.779 at the termination of 18th days of storage. Similarly, the firmness decreased from 8.424 to 4.748 and 8.423 to 6.300 in T_0 (control) and T_3 (calcium chloride 3%) in samples kept at 5% CO_2 level at the end of storage period of 24 days, respectively. Likewise in samples stored at 10% CO_2 level, the firmness of the fruits decreased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 8.424 to 5.303 and 8.423 to 6.687, respectively from 0 to 24th day of storage.

The glucose content (g/100g) of the guava fruits increased with the progression in storage in all samples kept at different storage condition. The glucose content in T_0 (control) stored at 0% CO_2 was 2.73 at the start of storage period then it increased upto 3.15 till 12th day and there after it decreased to 3 at 18th day. Similarly, in T_6 (calcium lactate 3%) the glucose content increased from 2.72 to 3.25 at 12th day which declined to 3.15 at 18th day. Similarly in samples kept at 5% CO_2 the glucose content increased from 2.73 to 3.28 from 0 to 18th day of storage and then after it decreased to 3.22 in T_0 (control samples) at 24th days of storage. Likewise in T_6 (calcium lactate 3%) the increase in glucose content was 2.69 to 3.24 from start to termination of storage period. In the samples that stored at 10% CO_2 level the glucose content increased gradually and in T_0 (control) and T_3 (calcium chloride 3%), it increased from 2.73 to 3.27 and 2.73 to 3.20, respectively from 0 to 24th day of storage.

The fructose content (g/100g) of the guava fruits increased with the progression in storage in all samples kept at different storage condition. The fructose content in the T_0

(control) sample stored at 0% CO_2 was 3.31 at the start of storage period then it increased upto 3.5 till 12th day and there after it decreased to 3.34 at 18th day. Similarly in T_6 (calcium lactate 3%) the fructose content increased from 3.31 to 3.56 at 12th day which declined to 3.51 at 18th day. Similarly in samples kept at 5% CO_2 the fructose content increased from 3.30 to 3.66 at 18th day of storage and then after it decreased to 3.62 in T_0 (control samples) at 24th day. Likewise, in T_6 (calcium lactate 3%) the increase in fructose content was 3.32 to 3.64 from the start to termination of storage period. In the samples stored at 10% CO_2 level the fructose content increased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it increased from 3.31 to 3.65 and 3.32 to 3.57 respectively from 0 to 24th day of storage.

The sucrose content (g/100g) of the guava fruits increased with the advancement in storage in all samples kept at different storage conditions. The sucrose content of the fruits in T_0 (control) sample stored at 0% CO_2 was 1.67 at the start of storage period then it increased upto 1.99 till 12th day and there after it decreased to 1.84 at 18th day. Similarly, in T_6 (calcium lactate 3%) the sucrose content increased from 1.66 to 2.10 at 12th day which declined to 2 at 18th day. Similarly, in samples that kept at 5% CO_2 the sucrose content increased from 1.66 to 2.08 at 18th day of storage and then after it decreased to 2.04 in T_0 (control) samples. Likewise, in T_6 (calcium lactate 3%) the in sucrose content increased from 1.66 to 2.03 at the termination of storage period. In samples stored at 10% CO_2 level the sucrose content increased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it increased from 1.66 to 2.04 and 1.66 to 1.95, respectively from 0 day to 24th day.

The total phenolic content (mg GAE/100g) of the fruits decreased during the whole storage period. The total phenolic content decreased from 131.67 to 82.67 and 133.33 to 97.33 in T_0 (control) and T_3 (calcium chloride 3%) samples stored at 0% CO_2 level at the termination of 18th days of storage, correspondingly. Similarly, the decrease in the total phenolic content was 131.67 to 98.67 and 133.33 to 112.00 in T_0 (control) and T_3 (calcium chloride 3%) samples kept at 5% CO_2 level at the end of storage period of 24 days, respectively. Likewise, in samples stored at the 10% CO_2 level total phenolic content decreased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 131.67 to 104.67 and 133.33 to 115.33 from 0 to 24th day of storage, respectively.

The antioxidant activity (µmol TE/g) of the fruits decreased during the whole storage period. The antioxidant activity in T_0 (control) stored at 0% CO_2 was 34 at the start of storage

period there after it decreased to 2.33 at 18th day of storage. Similarly, in T_3 (calcium chloride 3%) antioxidant activity decreased from 34.33 to 7.33 at the termination of 18th days of storage. Likewise, the decrease in the antioxidant activity was 34 to 3.33 and 34.33 to 15.67 in T_0 (control) and T_3 (calcium chloride 3%) samples kept at 5% CO_2 level from start to the end of storage period of 24 days respectively. Likewise, in samples stored at 10% CO_2 the antioxidant activity decreased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 34 to 7.33 and 34.33 to 18.67 from 0 to 24th days of storage period.

The citric acid (mg/100g) content of the fruits decreased during the whole storage period. The citric acid content in T_0 (control) stored at 0% CO_2 level was 374.00 at the start of storage period and then it decreased to 297.33 at 18th day of storage, while the decrease in the citric acid was 374.67 to 313 in T_3 (calcium chloride 3%) from start to termination of 18th days of storage. Similarly the decrease in the citric acid were 374.00 to 318.67 and 375.00 to 338.00 in T_0 (control) and T_3 (calcium chloride 3%) respectively in samples kept at 5% CO_2 level from start to end of storage period of 24 days, respectively. Likewise, in samples stored at 10% CO_2 the citric acid decreased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 374.00 to 328.67 and 374.00 to 344.67 at the end of storage period of 24 days.

The ascorbic acid (mg/100g) content of the fruits gradually decreased during the whole storage period. In the samples stored at 0% CO_2 level ascorbic acid contents decreased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 176.67 to 91.33 and 177.67 to 103.67 at the termination of 18th days of storage, correspondingly. Similarly, the ascorbic acid decreased from 178.00 to 111.67 and 177.33 to 129.67 in T_0 (control) and T_3 (calcium chloride 3%) in samples kept at 5% CO_2 level at the end of storage period of 24 days, respectively. Likewise, ascorbic acid of guava stored at 10% CO_2 level decreased slowly and in T_0 (control) and T_3 (calcium chloride 3%) it decreased from 178.00 to 120.67 and 177.33 to 135.33 at the end storage period of 24 days, respectively.

The malic acid (mg/100g) content of the fruits continuously increased with the progression in the storage period. Malic acid of T_0 (control) kept at 0% CO_2 increased from 106 to 166 at the 18th day, while malic acid of the T_3 (calcium chloride 3%) increased from 105.67 to 156.33 at 18th day of storage. Likewise, the change in the malic acid of guava fruits samples T_0 (control) kept at 5% CO_2 was 106.00 to 143.67 and in the T_3 (calcium chloride

3%) was 106.00 to 131.00 from start to the termination of storage period. Similarly, malic acid content increased gradually in samples stored at 10% CO_2 level. The malic acid increased from 106.00 to 136.33 and 106.33 to 126.00 at 24th day in T_0 (control) and T_3 (calcium chloride 3%) at the end of storage period, respectively.

The tartaric acid (mg/100g) content of the fruits continuously increased with the progression in the storage period. Tartaric acid of T_0 (control) kept at 0% CO_2 increased from 0.786 to 0.898 at the 18th day. While the change in tartaric acid of the T_3 (Calcium Chloride 3%) was 0.786 to 0.891 from start to end of storage period of 18 days. Likewise, tartaric acid in T_0 (control) and T_3 (calcium chloride 3%) stored at 5% CO_2 increased from 0.787 to 0.875 and 0.783 to 0.848 at the termination of storage period, respectively. Similarly, tartaric acid content gradually increased in samples kept at 10% CO_2 and in T_0 (control) and T_3 (calcium chloride 3%) it increased from 0.787 to 0.861 and 0.787 to 0.837 at 24th day, correspondingly.

The respiration rate ($mLCO_2$ $Kg^{-1}hr^{-1}$) of the guava fruits increased with the progression in storage in all samples kept at different storage conditions. The respiration rate of T_0 (control) sample stored at 0% CO_2 was 9.67 at the start of storage period then it increased upto 35 at 12th day and there after it decreased to 23.63 at 18th day of storage. Similarly, in T_6 (calcium lactate 3%) the respiration rate increased from 10.33 to 31. Similarly, in samples that were kept at 5% CO_2 the respiration rate increased from 9.67 to 39.67 at 18th day of storage and then after it decreased to 34.00 in T_0 (control samples). Likewise, in T_6 (calcium lactate 3%) the respiration rate increased from 10.33 to 36 at the termination of storage period. In the samples stored at 10% CO_2 level the respiration rate increased gradually and in T_0 (control) and T_3 (calcium chloride 3%) it increased from 9.67 to 35.33 and 9.67 to 34.33, respectively from start to termination of storage period.

The ethylene gas production (μL $Kg^{-1}hr^{-1}$) of the guava fruits increased with the progression in storage in all samples kept at different storage condition. Ethylene gas production in T_0 (control) sample stored at 0% CO_2 was 2.33 at the start of storage period then it increased upto 15 till 12th day and there after it decreased to 10.33 at 18th day. Similarly, in T_6 (calcium lactate 3%) the ethylene gas production increased from 3 to 25.33 at 12th day which declined to 16.33. Similarly, in samples kept at 5% CO_2 the ethylene gas production increased from 2.33 to 23 at 18th day of storage and then after it decreased to

16.33 in T_0 (control samples). Likewise, in T_6 (calcium lactate 3%) the increase in ethylene gas production was 3 to 25.33 from start to termination of storage period. In the samples stored at 10% CO_2 level the ethylene gas production increased 2.33 to 26.67 at 18th day, then it decreased to 16.67 at 24th day of storage in T_0 (control) while the ethylene gas production gradually increased in the T_3 (calcium chloride 3%) from 3.33 to 26.67 from 0 day to 24th day of storage.

Most important factors that influenced the acceptability of product were its organoleptic properties. Product having good color, flavor, taste, texture and overall acceptability is accepted for consumption. Product quality depends upon its sensory characteristics then price is second factor influencing the acceptability of product. There is gradual decrease in the score of all parameters as mentioned during storage. However the T_3 and T_6 gave best results during the all storage days.

CONCLUSIONS

- The storage quality of chemically pretreated guavas fruits were better than non-treated guava fruits
- Among the post-harvest dip treatments, 3% calcium chloride was found to be most effective pretreatment in maintaining the post-harvest quality attributes and extending the shelf life of the guava followed by 3% calcium-lactate.
- Modified CO_2 level during storage gave better results than the storage with normal air composition
- Use of 10% carbon dioxide gave better results than 5% carbon dioxide level.
- The chemically treated fruits that were stored in normal atmosphere were spoiled after 18 days of storage.
- The shelf life of the guava fruits treated with calcium salts and stored under different levels of CO_2 was extended up to 24 days.
- Modified atmosphere storage at 10°C can stop the chilling injury of fruit.
- The pH of fruit samples tend to increase during the whole storage period
- The pretreatments with salt significantly effect on the weight loss, higher the concentration of salt the lower the loss and vice versa
- The acidity of fruits decrease with progression in storage period but the rate of change depended upon the concentration of salt and storage condition
- The texture (firmness) of the fruits decreased with the progression in the storage period, the 3% salt treated fruits retained better firmness that the others especially the non-pretreated fruits
- The total phenolic content and DPPH Free Radical Scavenging activity tend to decrease with storage period.
- The total soluble solids and sugars (Glucose, Fructose and Sucrose) of the guava fruit during storage tend to increase with storage time at 10 and 5 % CO_2 level.
- Citric acid and ascorbic acid present in guava fruit decreased with progression in the storage while the malic acid and tartaric acid increased with storage.
- The respiration rate and ethylene gas production in guava fruit exhibited climacteric pattern during storage.
- Score for sensory evaluation of fruits showed a declining trend during the whole storage period but the rate of change depended upon the concentration of salts and storage environment

- The guava fruit loss during peak season will be minimized by using this technique and producer was able to sale what he produces. The shelf life of guava fruit extended upto 24 days that is very beneficial for guava producers and guava exporters. This method helped to export guava fruit as fresh to far of place otherwise that was not possible.

- Modified atmosphere storage in combination with pretreatments minimizes the post-harvest losses. Not only additional cost of storage was covered by using this techniques but producer will get extra profit by this. Regarding the concern of consumer towards cost, he will have to pay a very little extra cost for this technique.

RECOMMENDATIONS

- Modified atmosphere storage should be used as improved preservation method for bulk handling of guava fruits for storage, long distance transportation, distribution and marketing for both domestic and export markets
- Treatment with calcium salts should be used to increase the flesh firmness and decrease the respiration rate
- Increased level of CO_2 should be used to decrease the ethylene gas production which ultimately increase guava fruit shelf life
- The relative humidity of storage should be kept above 80% otherwise weight loss of guava fruit and texture of fruits become loss
- The temperature used in storage must be above 8°C otherwise chilling injury occurred in fruits during storage
- The CO_2 storage level for Pakistani guava fruit in must determine where the best results were obtained or at what % of CO_2 negative impact on fruits occur
- Use oxygen and nitrogen in combination with CO_2 to extend the shelf life and acceptability of guava fruit as fresh
- The surplus quantity that was hard to handle must be converted into value added products to minimize the losses

Achievements, Future Research Directions and Limitation of Research Project

The production and increase in the shelf life of guava fruits depends heavily on research to uncover information on nutrition profile and changes in chemical composition of guava fruit during storage. Compared to the research work of other indigenous fruits of Pakistan, research on guava fruit has been very limited. It is useful to review the history of research on guava fruit and contemporary situation with the inevitable risk of omission of post-harvest loss of guava fruit. There is no doubt that guava is an excellent source of vitamins and high phenolic and antioxidant activity, an important fruit particularly in developing nations like Pakistan with high human population density and shortage of supply of highly nutritious fruits. The purpose of increasing the shelf life of guava fruit is to provide high quality of fruits a too far off place which is otherwise not possible because guava fruit has limited shelf life of 3-4 days in normal condition. Guava fruit is an excellent source of vitamin C and contained 4 times of contents as compared to citrus fruits. Escalation of shelf life of guava fruit is realized depends on several factors, including research to bring actual productivity closer to the potential limits and increased consumer acceptance of fresh fruits at distanced places. The use of pretreatments in fruits in combination with modified atmosphere storage in low economic country like Pakistan would be a good strategy in order to provide fresh fruit and earn good economic return. Although guava fruit offers excellent nutritional and dietetic properties in itself but limited shelf life, it can be stored in modified atmosphere or processed to different value added products. The pretreatments in combination with modified atmosphere storage will not increase the cost of storage but it reduces the post- harvest losses and the addition cost will be compensated by this. Future research should be carried out in order to explore functional attributes of guava fruit by using alternative concentration and combination of modified atmosphere storage gases e.g. nitrogen, CO_2 and O_2 etc. Researchers can consider different pretreatments and modified atmosphere storage in combination to escalate the shelf life of guava and other fruits to minimize the post- harvest losses. Researcher should also focus on the modified atmosphere packaging of guava fruit for escalation of shelf life of guava fruit.

In the present research project the major limitation for the using of techniques is the maturity time of fruits. The maturity time of fruits vary tree to tree and even fruit to fruit on same tree. Some fruits mature early and some late. Environmental factors are very important in this regard. It became hard to harvest fruits of different maturity level at different time. It also required skill labor. The mature green fruits stored best at 10℃ and if they are stored below 10℃ they are prone to chilly injury while the mature ripe fruits are stored best at refrigeration temperature. The maintaince of CO_2 level is also important. Different fruits have different tolerance level of CO2 if it exceed the limit then it cause the spoilage to fruits.

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APPENDICES

APPENDIX I

Performa for sensory evaluation of chemically treated guava fruit

Name of the judge…… Date……..

Character	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
Color							
Flavor							
Taste							
Texture							
Overall acceptability							

Signature……..

INSTRUCTIONS

Bite the sample and score for color, flavor, taste, texture and overall acceptability using the following 9-point Hedonic Scale:

Extremely poor	1
Very poor	2
Poor	3
Below fair above poor	4
Fair	5
Below good above fair	6
Good	7
Very good	8
Excellent	9

Note:

1. Bite sample of fruit and score for color, flavor etc.

2. Before proceeding to the next sample, rinse mouth with water.

3. Make inter comparison of the sample and record the score.

4. Don't disturb the order of samples.