IJLAI transactions on Science and Engineering

Quarterly Research Journal

ISSN: Applied

https://ijlaitse.com/index.php/site

Published by:

Ali Institute of Research & Skills Development (AIRSD)

Office No 1, Moiz Clinic Building, Khan Village Road,

New Gulgasht, Multan Pakistan.

Email: admin@ijlaitse.com

Change in the Nutritional Values of Apple Cultivars during Storage

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ABSTRACT

The experiment was conducted on three apple cultivars viz. Red Delicious, Royal Gala, and Golden Delicious to study the change in the nutritional values of apple cultivars during storage at 5±1°C for 150th days with 30th days of intervals. The physiochemical analysis consists of total sugar, sugar acid ratio, acidity and ascorbic acids. There was incremental increase in total sugar of apple cultivars with increasing refrigerated storage duration. Significant increase was recorded in sugar acid ratio of three apple cultivars storage. The gradually decrease were observed in the percent of acidity and ascorbic acid of all apple cultivars with increasing storage period. The investigations enable us to store the apple cultivars for more than 150th days at 5±1°Cto catch good market price.

Key words: apple; Total sugar: Sugar acid ratio; Percent of acidity; Ascorbic acid.

1. INTRODUCTION

The most lavishly edible fruit tree, Apple (*Pyrus malus*) has gained great significance in the recent years. The tree bears fruits which have not only great nutritional value but also is of great economic importance, as it is preserved and enable the planters and traders to get cash (Bokhari,2002). The great demand and preference for this fruit can be gauged from its wide ranging contents which nature has accumulated in this delicious fruit. Apple trees are being extensively cultivated in orchards in Khyber Pakhtunkhwa (Swat, Dir, Abbotabad, Mansehra, Chitral,) FATA (North Waziristan, South Waziristan, Kurram, Bajaure (Bokhari, 2002; Ali *et al.,* 2004). Likewise, it is grown in Punjab (Murree Hills, Rawalpindi, and

Kashmir) and Baluchistan (Quetta, Kalat, QillaSaifullah, Loralai, Mastung, Pishin and Ziarat (Ali *et al.,* 2004). The total area occupied by this plant has been increasing with the lapse of time due to high consumption. In these days the Apple trees orchards have occupied almost 11.13 thousand hectares of land. More than 80% yield is gained from the orchards in Baluchistan (chaudary, 1994).

In the same vein, the span and durability of the safe storage of apple has been intimately linked with its physical properties (Meisami*et al.,* 2009). Diverse researches have been conducted in different periods of time to show how the chemical composition and relative quantity of ingredients are changed by the physical properties of apple fruit. Fruit density, succulence and porous nature have been utilized as determiners of the chemical composition of the fruit (Gavlheiro *et al*., 2003). The rate and duration of maturity in the maximum of available fruits and vegetables depends on the relative density of the fruit, and thus this physical property is taken as maturity index for fruits (wolf et al; 1975 Zaltzman *et al*; 1987). The study of Zaltzman *et al* (1987) relates content juice with density; Jordon *et al*., (2000) has focused on the dry matter of the fruit as a function of the fruit density; the maturity and changes in quality of the fruit during storage vary as a result of marked differences in the densities of the fruits (Mitropoulos and Lambrinos, 2000). The aim of present study was carried out to determine the effect of storage upon nutritional value of apple cultivars to ensure maximum fruit quality and storage life and minimize post-harvest losses in apple.

2. MATERIALS AND METHODS

The apple cultivars Red delicious, Royal gala and Golden delicious were purchase from the market. The experiments were conducted at Department of Agriculture chemistry laboratory, Khyber Pakhtunkhwa Agriculture University of Peshawar. The fruits from different cultivars were divided into three groups each containing 50 fruits. One lot were analyzed for different quality attributes while the other will be shifted to cold storage and stored for 150 days at 5±1 ^{0}C and 60-70 % relative humidity. The data were recorded for the following post-harvest quality parameters at 0 and 150 days of storage. The data were analyzed by using completely randomized design (CRD) and means were further assessed for differences through Least Significant Difference (LSD) test. Statistical computer software, were applied for computing both the ANOVA and LSD (Steel and Torrie, 1980).

The data were recorded for the following post-harvest quality parameters at 0 and 150 days of storage.

Weight loss (%): Three fruits in each treatment were separated for weight loss test. The initial weight of each fruit will be noted with the help of electronic balance. The weight loss (%) will be calculated as under.

$$\text{Fruit weight loss} = \frac{\text{Intitial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \quad (1)$$

Percent juice content: Juice will be extracted from three randomly selected fruit from each treatment with the help of juice extracting machine, weighed and the percentage will be determined.

$$\text{Percent juice} = \frac{Weight\ of\ fruit\ juice}{Total\ Weight\ of\ fruit} \times 100 \quad (2)$$

Total soluble solids (^{0}Brix): Total Soluble Solids of the fruit were determined at 0 and 150 days' storage accordingly. Total soluble solids (TSS) will be measured with a hand refractometer. The juice from sample fruits were carefully swish and place small amount of juice onto the prism of the brix refractometer and covered with a transparent led. The rotation was seen through the eyepiece of the equipment.

Total sugars: Reducing and non-reducing sugars were determined by the method as designated in A.O.A.C (1990).

Percent acidity: Acidity will be determined by neutralization reaction (AOAC, 1990).

Sugar-Acid Ratio: Sugar and acid ratio were determined by the following formula:

$$\frac{sugar}{Acid} = \frac{TSS}{\%\ Acidity} \quad (3)$$

Ascorbic acid (mg/ml): Ascorbic acid was determined by the standard method as described in AOAC (1990).

Bitter pit (%): Percent bitter pit incidence were observed visually in each treatment by calculating the surface area of each fruit covered with the symptoms of bitter pit at time 0 and 150 days of cold storage.

3. Results and Discussion

Weight loss (%): The moisture loss in fruits reduces the visual quality and adds to the loss of turgor pressure and resulting softening (Vander- Beng, 1981).The maximum weight loss (2.90%), recorded in cultivar Red Delicious, then Royal Gala (2.72%) observed. The minimum weight loss of (2.50%) in Golden Delicious. The most elevated weight loss (4.22%) measured at 150 days and least weight loss (0%) at 0 day of cool storage. The statistical

analysis showed significant variation between apple cultivars and during storage however, their interaction was non-significant.Babos*et al*. (1984) who reported that the weight loss in fruit depend upon the structure of the skin and nature of waxes on the surface of the fruit. The minimum weight loss in Golden Delicious may be because of thicker waxy layer, qualities of this cultivar Veraverbeke et al., (2001). The similar result were reported by Ghafir et al., (2009) that the moisture and resulting weight loss in fruit increase directly with increase storage duration because of water loss and respiration.

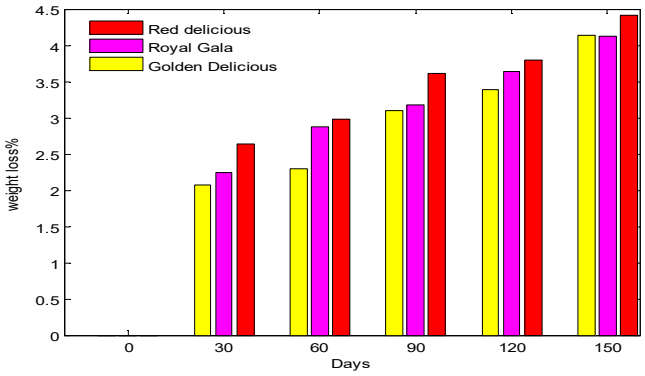

Fig. 1. Influence of storage on weight loss (%) of apple fruits.

Percent of juice:

The percent juice content of apple fruit depends on upon the water substance of the fruit developed starting from the earliest stage of water loss and thus can be decreased by extending relative humidity (Tu *et al.,2000).*At the initial stage theMaximum juice content (57.20%) measured in Red delicious followed by Golden delicious (56.62%) then by Royal gala (55.98%), while minimum percent juice found in Red delicious (42.53%). An incremental decrease was measured in the percent of juice substances with the incremental increase refrigerated storage duration. The stepwise significant decrease in percent juice content from (57.20%) to (42.53%) in fruit stored for 150 days.Since cultivar Red Delicious had the base weight loss, in this way, it is liable to have high percentage of juice. Also, cultivars showing more weight loss were less succulent (Dzonova *et al.,* 1970). The reducing in percent juice decrease is because of the water loss from the tissue which increments with refrigerated storage duration (Allan *et al.,* 2003).

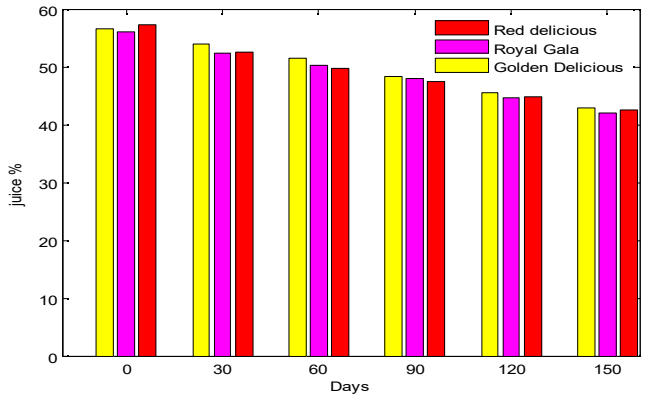

Fig.2. Influenced of storage on percent of juice of apple fruits.

Total soluble solids:

At refrigerated storage period significantly effect on total soluble solid while, the interaction influence was non-significant. A continuous increment was seen total soluble solids with expanding the cold storage life. Total soluble solids of apple and different fruit area important quality parameter, which is related with the texture and composition (Weibsel *et al.,*2004).The maximum value of total soluble solid (12.24 $Brix_o$) were measured in fruit stored for 150 days while, minimum total soluble solid (10.01 Brix) observed at initial of storage interval.Ali *et al.,* (2004) reported significant variation in total soluble solid, acidity and other physico-chemical qualities of apples reaped from various varieties however, the diverse cultivars under study displayed non-significant variation in total soluble solids. Beaudry *et al.,* (1989) reported that in most climacteric fruit, carbon is stored, as it were, as starch these fruit sweeten under post-harvest conditions because of starch degradation and change to dissolvable sugars depending on limit temperature. As Mahajan (1994) studied that the total soluble solids increased at refrigerated storage duration.

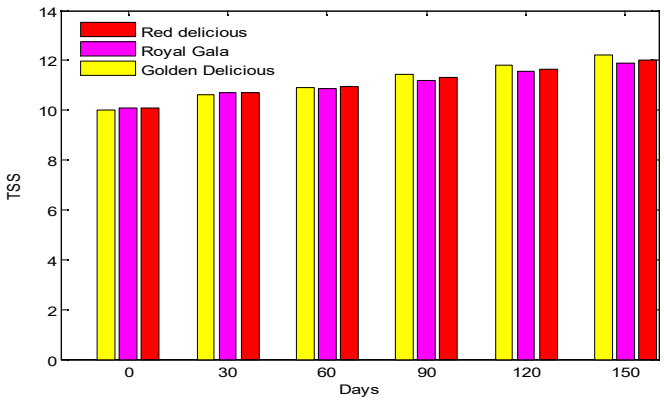

Fig.3. Influence of storage on TSS of apple fruits.

Total sugar

The data pertaining to total sugar arepresenting in mean table. The statistical analysis showed that there were significant variations in total sugar with along apple cultivars. Total sugar was significantly influenced at the refrigerated cold storage but interaction effect was non-significant. A significantly incremental increase in total sugar recorded with expanding the storage length of time. The maximum value of total sugar (15.88%) was noticed in Golden delicious followed by Red delicious than Royal gala (15.65%) and (15.64%) respectively, fruit stored for 150 days. The minimum total sugar (14.37%) was observed in Red delicious followed by Royal gala than by Golden delicious; in fruit initial stage of storage.

The sugars content, sucrose, glucose, fructose, and sorbitol, in fruit these substances add to the fruits sweetness, and are one of the real attributes of fruit quality and market value. The data show that there was an incremental increase in reducing sugar while non reducing sugar decrease at refrigerated storage period. The finding of Anjum *et al.,* (2000) are similar who reported an extension in reducing sugars while studying the apricot diet jams in the storage duration. The reducing sugars rate development may be a result of the conversion of sucrose to reducing sugar. The results were moreover similar to the report of srivastava and souza (1962) who recorded the effect of storage on non-reducing sugars in Japanese fruits. The reduction in non-reducing sugar may be a direct result of the change of non-reducing sugars to reducing sugar.

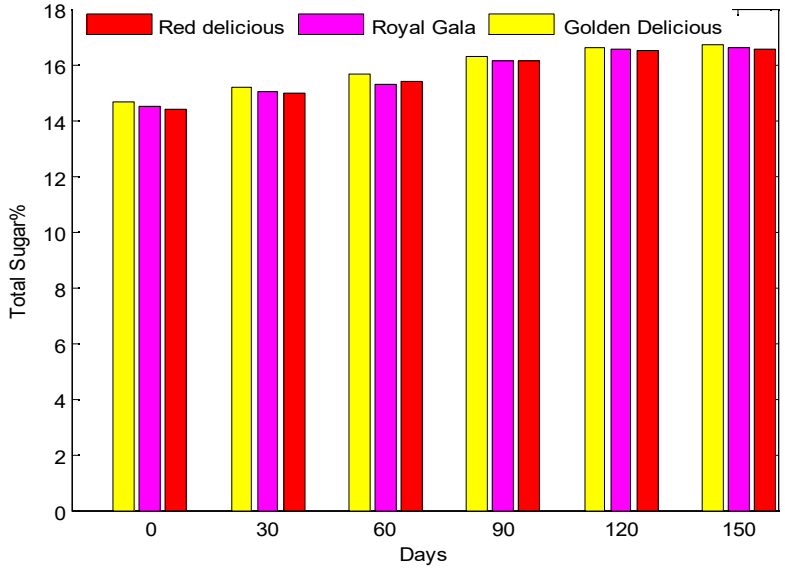

Figure 4. influenced of storage on total sugar of apple fruits.

Percent of acidity

The statistical analysis show that there was a significant difference among different cultivars apple at refrigerated storage condition, however interaction non significant during storage period. The highest amount percent of acidity (0.46%) was observed in Red delicious while the minimum (0.44%) same value were noticed in the Royal gala and Red delicious. A significant decline was seen in percent acidity of squeezed apple juice with increasing storage length of time. The most extreme percent acidity (0.55%), saw in initially stored fruit while the minimum (0.34%) was recorded for fruit stored for 150 days.

Riveria, (2005) conducted to study the percent acidity of the fruits relies on upon the rate of metabolism particularly respiration which devoured organic acids and in this way decrease acidity. Chang et al., (1999) have gone through extensive and meticulous study on the fruit being living organs that respires even after reaped from the tree and during storage which use the organic acids and therefore reduce the percent acidity of the fruits. The result were similar with the study of Crouch (2003) who reported that there was decrease in titratable acidity in apple after harvesting. Billisli et al., (19970), conduct a experiment on apple fruit stored for long periods were found that there to tolerate great loss of malic acid. Comprehensive study of Tahir and his companion (2003) furthermore found a checked complexity in acidity of apples after prolong storage.

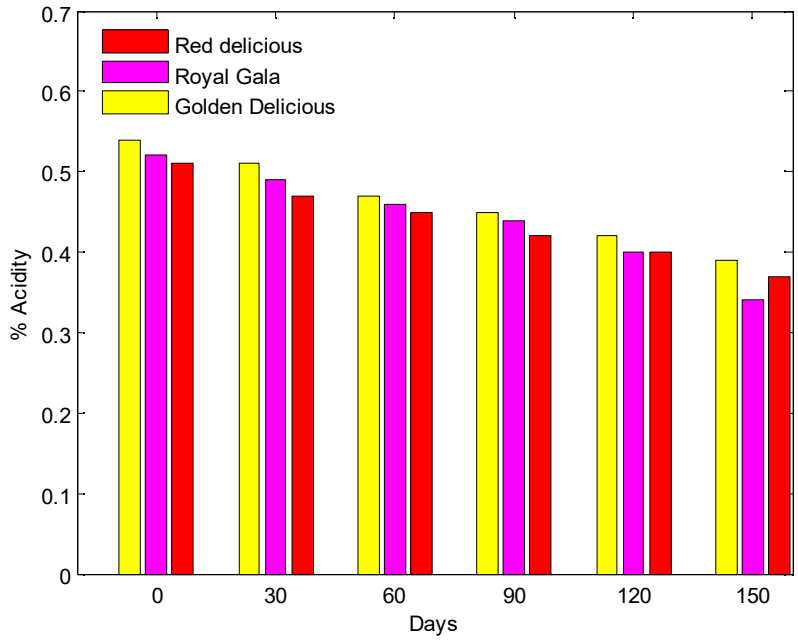

Figure 5 influenced of storage on percent acidity of apple fruits

Fruit pH

Perusal data pH placed in table. Statistical analysis showed significant differences in pH during at refrigerated cool storage period. But the effect was non-significant along with apple cultivars, while the interaction effect was also non-significant during storage period (Table 6a). A steady increase in pH was observed with expansion of storage time. The high pH value (4.27) was measured for fruits stored for 150 days and low pH value (3.62) at initial of refrigerated storage duration. However, there was anon-significant variation in pH between apple cultivars but, the pH decrease gradually with increasing storage durations. It is clear from the mean table.7 that the pH value rise during storage periods and rise with increase in temperature.

A comprehensive research was conducted by Ehsan *et al*., (2002). He watched a decrease marvel in pH of all treatment of blended jam produced from water melon and lemon during storage period. Chang *et al.,* (1999) who observed pH of the fruit depends on organic acid in the fruit, which are used in respiration, result lower acidity and high pH with increasing at refrigerated storage length of time. According to the study of Moing *et al.,* (2001) that he stored fruits, which had a low acidity substance, had a correspondingly high pH.

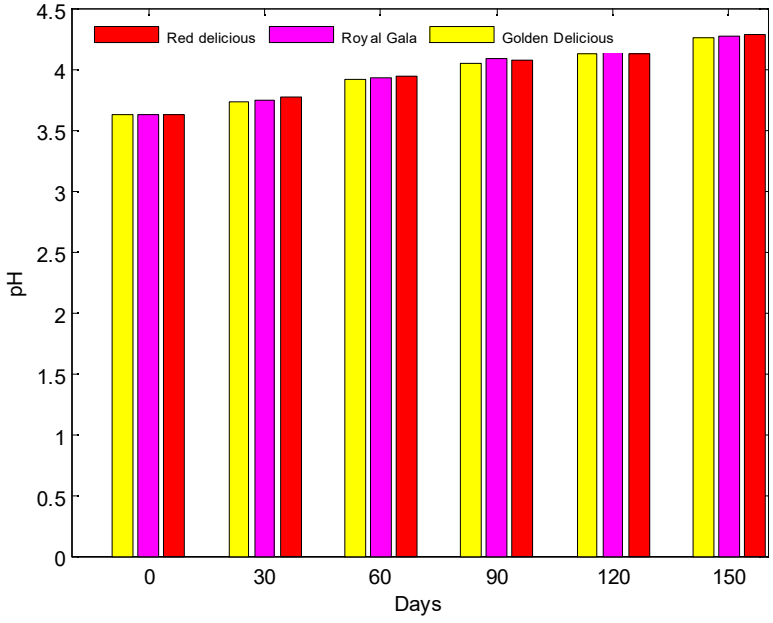

Figure 6 influenced of storage on pH of apple fruits

Sugar Acid Ratio

Data regarding sugar acid ratio are given in Table.7 The statistical analysis shows that there were significant differences sugar acid ratios along with apple cultivars and at refrigerated cooled storage period. However, the interaction was non-significant. The high mean value (25.62) was observed in Red delicious followed by Royal gala with (25.37) while these two cultivars are similar with each other. The low sugar acid ratio value (23.90) was observed in Golden delicious. At refrigerated storage period had significant influence on sugar acid ratio of apple fruit juice. There was an incremental increase in sugar acid ratio with increasing the storage lifetime. The sugar acid ratio of the apple juice was increasing from (19.32) to (31.86) at 150 days of refrigerated storage period. Peck *et al.,* (2004) studied that sugar acid ratio of apple and other fruit is a paramount quality parameter. Ali *et al.,* (2004) reported that Apple cultivars have been appeared to have significant variation in Total soluble solid and acidity. According to the comprehensive study of El-Zeftawi*et al.,* (1982) who reported that immature fruit ordinarily have a low sugar acid ratio as a result of low sugar and high acid levels, making fruit taste harsh. As fruit develop and mature starches are changed over into sugars, increasing the sugar content while, the acids decrease, bringing about a higher sugar acid ratio. Comparable results were also aliened with the finding of Ghafir*et al.,* (2009). He observed the expansion in sugar Acid ratio can be attributed to starch breakdown bringing about free sugars and decrease in organic acids because of its utilization in respiration.

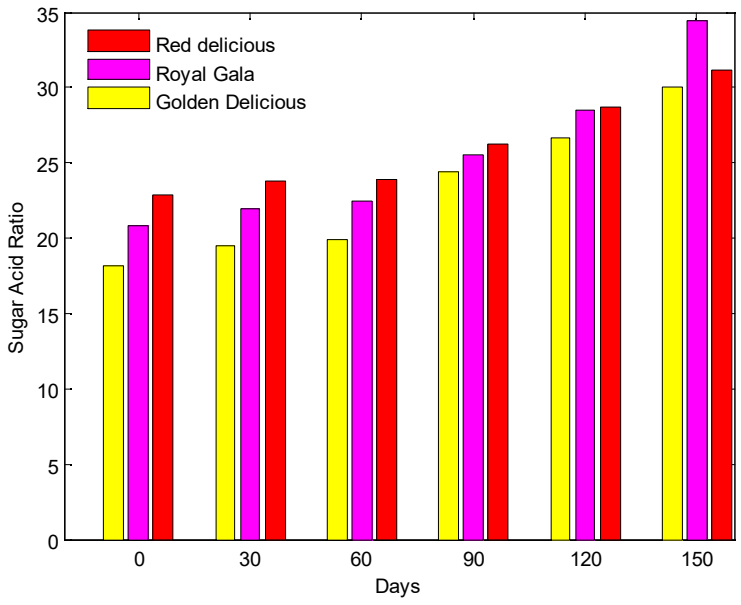

Figure 7 influenced of storage on sugar acid ratio of apple fruits

Ascorbic acid

The statistical analysis revealed that there were significant differences in the ascorbic acid by refrigerated storage period along with apple cultivars however, the interaction was non-significant. High mean value of ascorbic acid (5.24mg/100g) was observed in Red delicious followed by Royal gala 5.21mg/100g however; difference in these two cultivars was non-significant. While low ascorbic acid (5.03mg/100g) was record in Golden delicious. The ascorbic acid reduced significantly with incremental addition of storage life time so it decreased from the most highest valve of 7.70 mg/100g saw with 0 day storage to lowest of 4.15 and 3.57 mg/100g with 120 and 150 days storage respectively.

Lata, (2007) reported that Ascorbic acid is generally considered as an important nutritional quality characteristics in apple fruit. Ascorbic acid is a bioactive compound having antioxidant properties. Boyer and Liu, (2004)studied thatthe rich sources of vitamin c generally found in the peel of apple fruit, but less amount of vitamin c content in flesh. Similar result was reported by Hayat *et al.,* (2003) who conduct experiment on various apple cultivars fruits, the ascorbic acid declined significantly with stepwise increase in storage duration. He found that Red delicious had maximum vitamin c followed by Royal gala while minimum amount in Golden delicious. The vitamin c in the fruit and vegetables is very sensitive to storage condition such as low relative humidity, higher temperature, chilling injury and physical damage.Pardio-Sedas*et al*., (1994) studied that the decline in vitamin c contentswhich decreases the consumable quality and increases susceptibility to various physiological disorders during storage.

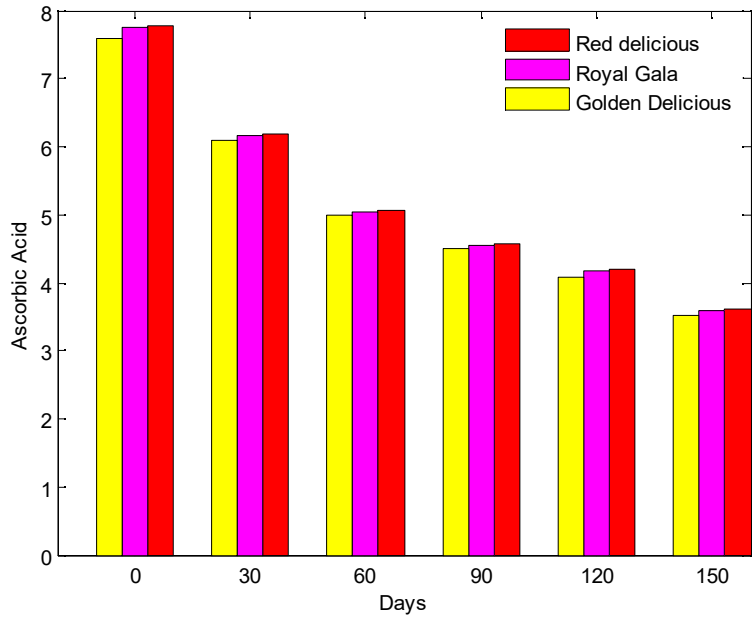

Figure 8. Influenced of storage on ascorbic acid of apple fruit

Bitter pit

The data related to the incidence of better pit placed in table 9. The statistical analysis showed that there were significant differences in the bitter pit by refrigerated storage period along with apple cultivars however, the interaction was non-significant. Significantly influences among the apple cultivars were observed the bitter pit incidence of apple fruits during storage. The maximum(8.08%) bitter pit was observed in Red delicious, while minimum bitter bit incidence were observed in Golden delicious followed by Royal gala 6.78 and 6.41% respectively. The incidence of the bitter pit increased from 0% to maximum after 150 days cold storage.

According to Ferguson and Watkins (1989) that Bitter pit is one of the main disorders for apple fruit that appears as depression brown lesions in the skin, particularly on the calyx end of the fruits, such type of physiological disorders increase during storage period, which has been related with Ca deficiency in the fruit cortex. The similar results has been observed by Croch, (2003) who reported that apple cultivar red delicious was more sensitive while the golden delicious and royal gala were less susceptible to pitter pit incidence. In another study of Pesis*et al*., (2009) studied the bitter pit incidence increase with increase storage duration, decrease calcium level and other nutrition as well as growth condition and maturity at harvested. The bitter pit symptoms were not visible at early stage of storage but 13.14% of symptoms after 5 months storage.

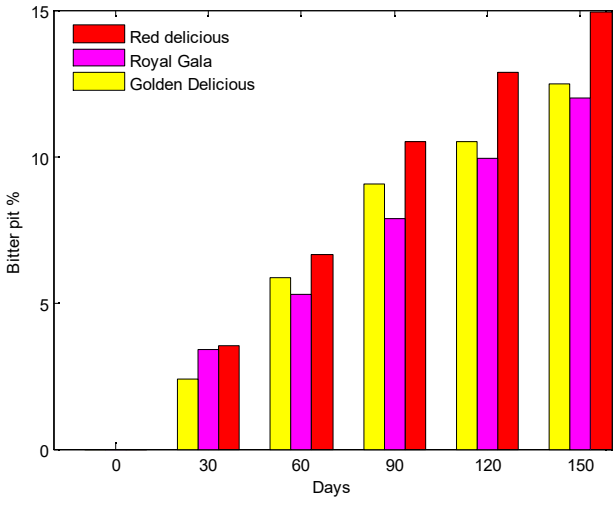

Figure 9 Influenced of storage on bitter pit of apple fruits

4. Conclusions

Significant decrease in apple fruit weight loss and juice were recorded at 5±1 ^{0}C. Gradually increases were seen in reducing sugars, total soluble solids and sugar acid ratio in the apple cultivars. The ascorbic acid, acidity, pH values and non-reducing sugar of apple fruit were decrease during refrigerated storage for 150thdays.The refrigerated storage decreases the incidence of bitter pit. Conclusions. Significant decrease in apple fruit weight loss and juice were recorded at 5±1 ^{0}C. Gradually increases were seen in reducing sugars, total soluble solids and sugar acid ratio in the apple cultivars. The ascorbic acid, acidity, pH values and non-reducing sugar of apple fruit were decrease during refrigerated storage for 150thdays. The refrigerated storage decreases the incidence of bitter pit.

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