EVALUATION OF CUSHIONING MATERIALS FOR TRANSPORTATION OF APPLE CULTIVARS FROM ORCHARD TO COLLECTION CENTRE

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ABSTRACT

After harvesting, apple fruits experience a variety of loading conditions that potentially lead to mechanical damage and bruising, which reduce the quality and shelf life of the products. Studies were carried out at Horticulture Research Station, Rajikot, Jumla for three consecutive years (2012-2014) to evaluate the effect of different cushioning materials for packaging and transportation of fruits of three cultivars of apple from orchard to collection centre, thereafter on storage. Fruits were harvested on 3rd week of September; healthy fruits of almost uniform size and shape were selected for the study. About 25 kg fruits were hold in conical bamboo baskets using different cushioning materials; transported to collection centre by porters on their back. Data on number of damaged fruits was recorded one day after transportation. Again, undamaged healthy 20 fruits from the same experiment were selected and stored in plastic crates under room condition for 3 months (11.80C and 65% RH). The result revealed that during transportation minimum number of bruised fruits was recorded in Red delicious (13.3%). With regard to cushioning materials, minimum number of bruised fruits (11.3%) was observed in bamboo basket without grass liner. After three months of storage, maximum spoilage was observed in Golden delicious (16.8%) while minimum in Red delicious (10.1%). With regard to cushioning material, minimum spoilage (7.2%) was observed in bamboo basket with grass liner. Highest physiological weight loss in storage was observed in Golden delicious (17.2%) and lowest in Red delicious (11.4%). Consumers overall acceptability was higher in Royal delicious at maturity stage while higher in Red delicious after storage. Therefore, grass and woolen shawl were identified as most effective cushioning materials during apple transportation from orchard to collection centre under Jumla condition of Nepal.

Key Words: Bruising, Spoilage, PWL, TSS, Firmness, TA, Starch index, Hedonic rating, shrivel

INTRODUCTION

Apple (Malus domestica Borkh.) is an economically important fruit crop of the temperate zones. It has been cultivated for thousands of years in Europe and Asia. There are more than 7500 cultivars of apple and it is one of the most grown fruit in all over the world (Martinelli et. al. 2008). Consumption of apple has shown better health to prevent a variety of chronic diseases and lung cancer, asthma, diabetes and ischemic heart disease (Hansen et. al. 2009). It is due to the large content of structural cell walls and polysaccharides along with the various phyto-chemical antioxidants (Device et. al. 2010). Apple is a leading deciduous fruit grown successfully in rain shadow or low rainfall high hill areas from east to far west of Nepal. Red delicious, Royal delicious and Golden delicious are the leading commercial cultivars grown by the farmers. In Nepal, apple can be grown in 54 districts; however, only 12 districts grow apple commercially of which Jumla ranks the number one in terms of area and production (Subedi et. al. 2012). Apple farming is the boon of the farmers of Jumla because of its economical, social, and environmental advantages. Apple growers have not been receiving anticipated level of income because of traditional system of postharvest handlling. In Nepal, the productive area, production and productivity of apple in F. Y. 2013/2014 was 5141ha, 35920.7tons and 6.9tons/ha respectively. Nepal imports 56,447 tons of apple

annually valued at Rs 1.92 billion (ABPSD, 2014). In Nepal, large amount of fruit losses occurs after harvest and minimizing this loss could save over 25% of produce (Gurung, 1998). Gautam et. al. (2004) reported that 58.2% apple fruits were damaged during harvesting, handling, transportation and distribution due to inadequate post harvest technology. All the apple production area lies in higher hills, where usually the fruits are harvested from the orchard and transported to farmhouse for sorting, grading and packaging. Conical shaped bamboo baskets (Doko) are commonly used containers to carry apple fruits for transportation to collection centers by porters on their back in Nepal. Fruits bruise easily due to compression, impact and vibration forces during transportation that potentially lead to bruising damage. Rough surface of the bamboo basket causes bruising and scaring on the surface of fruit. Further, the sharp edge of the basket and its conical shape causes both bruising and compression damage to the fruits. Moreover, the conical shape of bamboo basket results compression damage, which lies towards the lower side of the basket. The damage may not be apparent and visible to necked eyes immediately after transport; however effects are apparent during storage. The storability of apple is the reflection of the impact of container and cushioning material during transportation. Therefore, this study was carried out to find the effectiveness of different cushioning material for minimization of fruit damage during transportation from orchard to collection centre on standard apple cultivars.

MATERIALS AND METHODS

Studies were carried out for three successive years (2012-2014) at Horticulture Research Station, Rajikot, Jumla, Nepal to investigate the effect of different cushioning materials on bruising damage of fruits during transportation from orchard to collection centre and thereafter on storage. Fruits of Red delicious, Royal delicious and Golden delicious were harvested on 3rd week of September from the Mother Stock Maintenance Block of Gairagaun, Jumla (3 hours walking distance to the collection centre). Fruits were harvested from all sides of the tree and healthy fruits of almost uniform size, color and shape were selected for the study. Fruits were thoroughly cleaned with Muslin cloth after harvesting. Study was designed as factorial RCBD (3 cultivars, 5 cushioning materials) with four replications. About 25 kg fruits were weighted and packed in conical shaped bamboo baskets with green grass, woolen shawl, news paper, plastic sheet and without liner. Baskets were transported to collection centre by porters on their back. Data on number of damaged fruits due to bruising was recorded one day after transportation, as the damage may not be seen immediately after transport. Again, undamaged 20 fruits from each replicate were selected and stored under room condition for 3 months (11.80C and 65% RH) to find out effect of cushioning materials and variation in cultivars. Observations were made on physiological weight loss (PWL) and spoilage after storage. Consumer's acceptability was recorded by a panel of five judges on the basis of Hedonic ratting (1 to 9 scales in which 9 stands for like extremely and 1 stands for dislike extremely) (Juyun Lim, 2011). Firmness of fruit was measured with hand Penetrometer (FT-327, Italy) having plunger diameter of 11 mm. TSS was recorded with hand Refractometer (Erma, Japan) calibrated at 20°C. Titratable acidity was determined by titrating a 5 ml juice with 0.1 N NaOH using Phenolphthalein as an indicator (AOAC, 1990). Starch Iodine test was carried out to determine the conversion pattern of starch into sugars (M. S. Reid et. al. 1982). Iodine solution was prepared by dissolving 10 grams of iodine crystals and 25 grams of Potassium Iodide in 1 liter of water. Fruits (N=10) were cut at right angles to the core, approximately halfway from stem to calyx end; Iodine solution was applied to cut surface, drained away any excess and rated fruit staining after 2 minutes by using 0 to 6 scales (0 stands for full starch and 6 stands for free of starch). Observations were made for various physiochemical characteristics and quality attributes. Data were analyzed statistically using GenStat software version 10.3 (VSN International Ltd. Rothamsted Experimental Station, 2011).

RESULTS AND DISCUSSION

Number of Bruised Fruits (%)

Number of bruised fruits after transportation was highly significant among apple cultivars with and without cushioning materials. Maximum number of bruised fruits was observed on Golden delicious (20.3%) followed by Royal delicious (17.3%) while minimum (13.3%) on Red delicious (Table 1). Likewise, maximum number of bruised fruits (24.0%) was observed on bamboo basket without liner followed by plastic liner (19.0%) while minimum (11.3%) on grass liner (Table 2). Interaction effect of cushioning materials with cultivars on brushing was lowest on grass cushion followed by woolen shawl while highest on ordinary bamboo basket without cushion (Table 3). Different cultivars of apple may have differential tolerance to bruising and compression damages based on the nature of fruits such as skin thickness and texture. Apples bruise easily due to compression, impact and vibration forces (Gautam, 2004). Compression damage may occur in lower depth of the basket as a result of load of upper fruits, while impact damage may occur due to rough handling on the surface of fruit. Vibration forces usually occur during transportation, are difficult to avoid. These damages could be minimized if common sense is used for understanding of appropriate transportation system, packaging design and post harvest handling. This study also found the highest bruising damage on Golden delicious cultivar similar to the study conducted by Timm et. al. (1989). The highest bruising damage on bamboo basket without liner obtained from this study is also supported by the finding by Gautam et. al. (2004) and Shrestha (1996).

Physiological Weight Loss (%)

Physiological Weight Loss (PWL) during storage was highly significant among apple cultivars (Table 1). Maximum PWL was observed on Golden delicious (17.2%) followed by Royal delicious (14.3%) while minimum on Red delicious (11.4%) after storage. Maximum PWL on Golden delicious might be due to thin peel (60μm) resulting more water loss due to higher evapo-transpiration and respiration (I. Homutová et. al. 2004). Chaudhary et. al. (2004) reported that apple fruits stored for six month under normal room condition observed lowest PWL in paper cushion on wooden boxes (47.6%) while maximum on floor storage (88%). Water loss among apple cultivars during storage varied resulting in significantly different weight loss even under similar storage conditions (Khan et. al. 2005). Saleh et. al. (2009) reported that fruits of Golden delicious, and Gala stored at 90% RH and 0º C for 180 days exhibited significant differences in physiological and anatomical parameters. Physical properties of fruit may also have significant influence on storage performance because it influences water loss, gas exchange and subsequent storage life (Meisami et. al. 2009). Differences in storage performance may be due to ethylene production, responsible for the changes in texture, firmness and fruit softening (Khan et. al. 2005).

Spoilage (%)

Spoilage loss during storage was highly significant among apple cultivars with and without cushioning materials (Table 1). After three months of storage, maximum spoilage was observed on Golden delicious (16.8%) followed by Royal delicious (13.1%) while minimum (10.1%) on Red delicious. Likewise, maximum spoilage (24.3%) was observed in fruits transported on ordinary bamboo basket without liner followed by plastic liner (14.4%) while minimum (7.2%) on grass liner (Table 2). Interaction effect of cushioning materials with cultivar on spoilage during storage was lowest on Grass cushion followed by woolen shawl while highest on ordinary bamboo basket without cushion (Table 3). The scratches or minor wounds may not be apparently visible right after transportation however it has significant influence during storage. The result indicates that different cultivars of apple have differential tolerance to bruising and compression damages based on the nature of fruits such as skin thickness and texture. Higher spoilage damage on Golden delicious might be due presence of thin peel thickness and soft texture, probability of damage to internal tissue by compression, impact and vibration forces is high during

transportation, resulting more spoilage loss during storage. Paudyal et. al. (2016) reported that maximum spoilage (32.5%) was observed on control while minimum (17.5%) on paper wrapped apple fruits after 60 days of storage.

Sensory evaluation

At maturity stage, overall acceptability was higher on Royal delicious (8.8) followed by Red delicious (8.7) while lower on Golden delicious (7.9). Red delicious maintained higher sensory score (4.8) while lower on Royal delicious & Golden delicious (4.4) after storage (Fig. 1E). Retention of better firmness, aroma, taste and crispiness was higher on Golden delicious after storage, however, showed unacceptable appearance due to more shriveled texture. Mann et. al. (2005) reported that the sensory attributes that fruit texture include firmness, crispness, mealiness and juiciness.

Fruit Firmness

At maturity stage, a significantly higher fruit firmness was recorded on Golden delicious (9.1kg/cm2) followed by Red delicious (8.1kg/cm2) while lower (7.2kg/cm2) on Royal delicious (Fig. 2A). Firmness of apple fruits decreased gradually after storage Highest firmness was recorded on Golden delicious (5.9kg/cm2) followed by Red delicious (4.8kg/cm2) while lowest on Royal delicious (3.8kg/cm2). This evidence indicates that Golden delicious still has retained turgidity of the cells as compared to other cultivars. The softening of flesh during storage could be due to the degradation of soluble pectin by high activity of endo-poly-galacturonase enzyme in fruits (Mann et. al. 1990). Apple fruit texture and flavor are important traits that guide consumer preference (Daillant- Spinnler et. al. 1996). Apples that have crisp, juicy texture and prolong postharvest life are highly favored by the consumers (Jaeger et. al. 1998).

Juice content (%)

At maturity stage, a slightly variation on juice content was noticed with respect to apple cultivars. Highest juice content Golden delicious (73.9%) followed by Red delicious (70.1%) while lower (70.0%) on Royal delicious (Fig. 2B). Juice content of apples decreased after storage. After three months of storage, the juice content was 41% in Golden delicious followed by Red delicious (35.0%) and lowest in Royal delicious (33.5%). The loss of juice percent during storage was higher on Royal delicious (57.4%) followed by Red delicious (52.1%) while lower on Golden delicious (44.5%). More juice loss percent on Royal delicious might be due to over ripening resulting mealiness and softening of fruits.

Total Soluble Solids (0Brix)

At maturity stage, highest TSS was noticed in Golden delicious (12.7) followed by Royal delicious (10.7) and lowest (10.5) in Red delicious (Fig. 2C). TSS of apples increased during storage. Highest TSS was noticed on Golden delicious (14.6) followed by Royal delicious (14.3) and lowest (13.7) in Red delicious. TSS of apple is a major quality parameter which is correlated with texture and composition. Increase in TSS could be attributed to breakdown of starch into sugars or hydrolysis of cell wall polysaccharides (Weibel et. al. 2004).

Titrable Acidity (%)

At maturity stage, highest Titrable Acidity (TA) was recorded in Golden delicious (0.32%) followed by Red delicious (0.24%) and lowest (0.23%) in Royal delicious (Fig. 2D). The level of TA decreased during storage. Highest acidity was recorded on Golden delicious (0.23%) followed by Red delicious (0.19%) while lowest on Royal delicious (0.17%) after storage. Reduction of TA during storage might be due to conversion of organic acid into reducing sugars during ripening of fruit.

TSS:TA ratio

At maturity stage, highest TSS:TA ratio was recorded in Royal delicious (47.6%) followed by Red delicious (43.8%) and lower (39.6%) in Golden delicious (Fig 2.E). The level of TSS:TA ratio increased after storage. Higher TSS:TA ratio was recorded on Royal delicious (86.4) followed by Red delicious (73.8) while lower (63.6) on Golden delicious. This might be due to conversion of acid into sugars. Excessive increase in TSS:TA ratio in Royal delicious caused imbalance resulting poor sensory rating due to development of slight bitterness and mealiness. Mahajan (1994) reported that many biochemical changes take place during storage which disturbs the TSS:TA ratio ultimately rendering the fruit unacceptable.

Starch index

At maturity stage, higher starch index was recorded on Royal delicious (4.9) followed by Red delicious (4.3) while lower (3.9) on Golden delicious (Fig. 2F). The level of starch gradually decreased after storage. Higher starch index was recorded on Royal & Red delicious (6.0) while lower on Golden delicious (5.6). This might be due to conversion of starch into reducing sugars during ripening of fruits. Saleh et. al. (2009) reported that fruits stored at 90% RH and 0ºC for 6 months exhibited significant differences in physiological and anatomical parameters may be due to ethylene production, responsible for the changes in texture, firmness and fruit softening.

CONCLUSION

Among three cultivars evaluated, Red delicious cultivar fruits had minimum level of damage during transportation, less physiological weight loss, lesser spoilage, prolonged shelf life and higher sensory rating during storage which was followed by Royal delicious. Fruits of Golden delicious were less preferred by the consumers because of sensitivity to damage and higher loss during transportation and storage. For transportation of fruits from field to collection center in conical bamboo basket lining with grass or woolen shawl was found better due to reduced scratching loss during transportation.

Table 1: Response of apple cultivars on average brushing and spoilage damage during transportation and storage at HRS, Rajikot, Jumla for 3 consecutive years (2012-2014)

Cultivars	Bruised fruits (%)	Spoilage (%)	PWL (%)
Red Delicious	13.3	10.1	11.4
Royal Delicious	17.3	13.1	14.3
Golden Delicious	20.3	16.8	17.2
F - Value	***	***	***
LSD (P< 0.05)	0.80	0.89	0.66

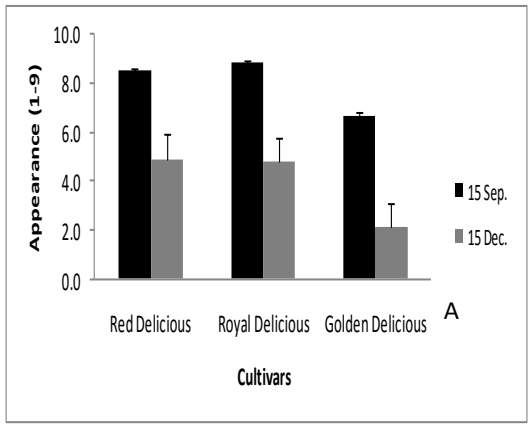
Table 2: Effect of cushioning materials on average brushing and spoilage damage of apple at HRS, Rajikot, Jumla for 3 consecutive years (2012-2014)

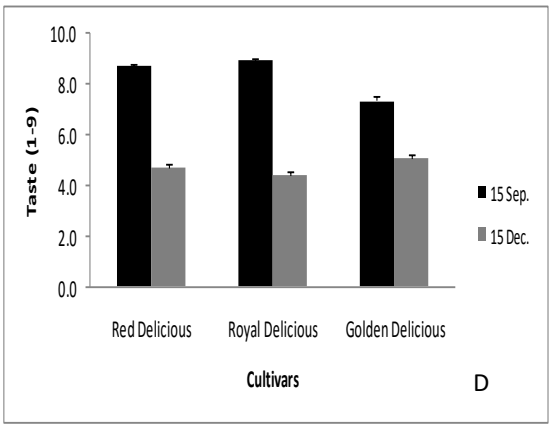
Cushioning materials	Bruised fruits (%)	Spoilage (%)	PWL (%)
Sole (Control)	24.0	24.3	14.4
Shawl	13.7	9.1	14.3
Paper	18.0	11.8	14.4
Grass	11.3	7.2	14.2
Plastic	19.0	14.4	14.3
F - Value	***	***	*
LSD (P< 0.05)	1.03	1.15	0.86

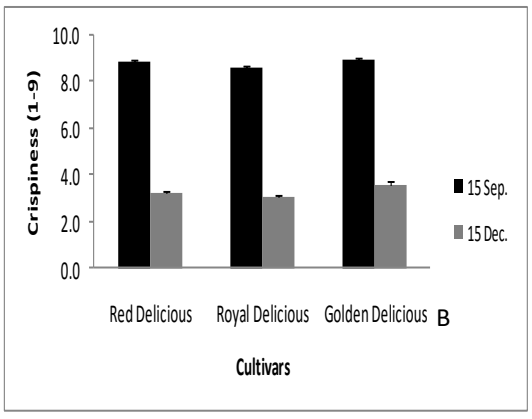
Table 3: Interaction effect of cushioning materials with apple cultivars on brushing and spoilage damage at HRS, Rajikot, Jumla for 3 consecutive years (2012-2014)

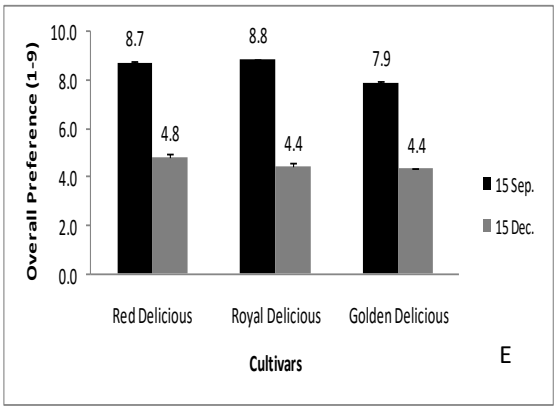
	Bruised fruits (%)					Spoilage (%)				
Cultivars	Cushioning materials									
	Sole	Shawl	Paper	Grass	Plastic	Sole	Shawl	Paper	Grass	Plastic
Red delicious	18	11	14	10	16	19	6	9	5	12
Royal delicious	24	14	20	10	20	24	9	11	7	14
Golden delicious	30	17	20	13	22	30	12	15	10	17
F Value	***					***				
LSD (P< 0.05)	1.8					2.0				
CV (%)	7.5					10.5				

Figure 1: Hedonic ratting of apple cultivars after harvesting and storage for 90 days under normal room condition (11.80C and 65% RH) at HRS, Rajikot, Jumla for two consecutive years (2013-2014)









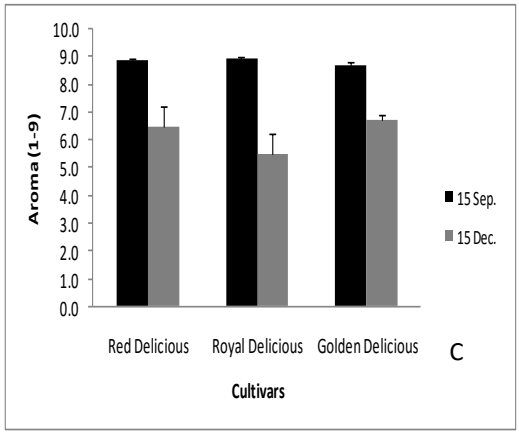
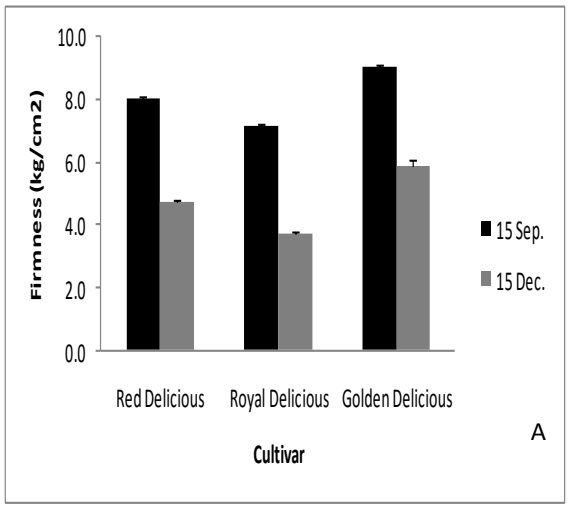
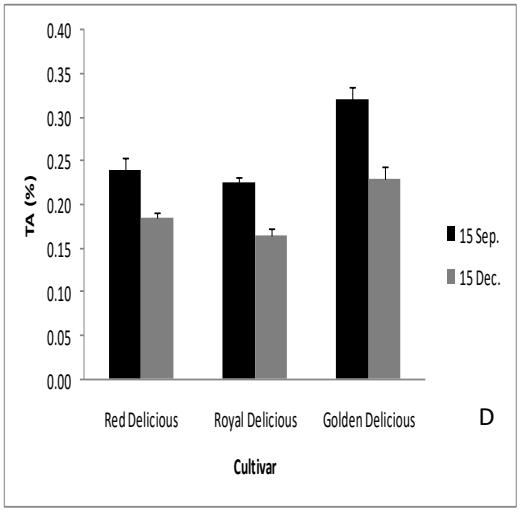
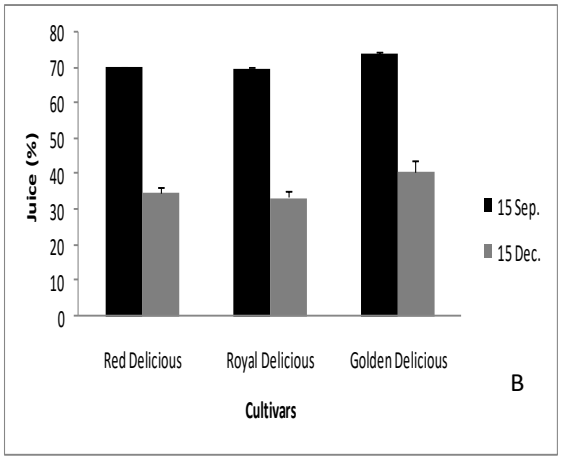
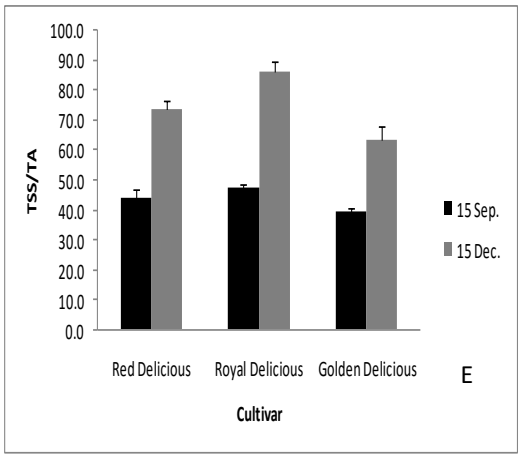


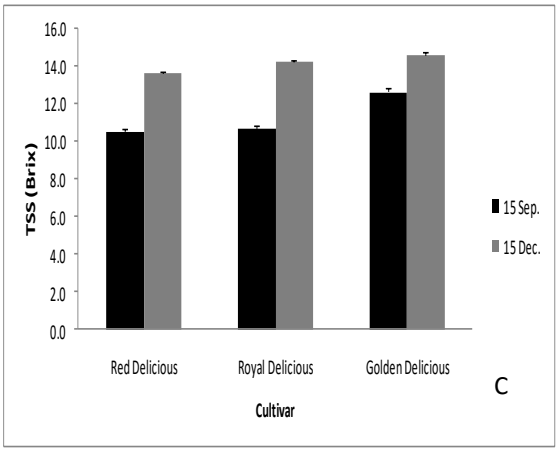
Figure 2: Quality parameters of apple cultivars after harvesting and storage for 90 days under normal room condition (11.80C and 65% RH) at HRS, Rajikot, Jumla for Two consecutive years (2013-2014)

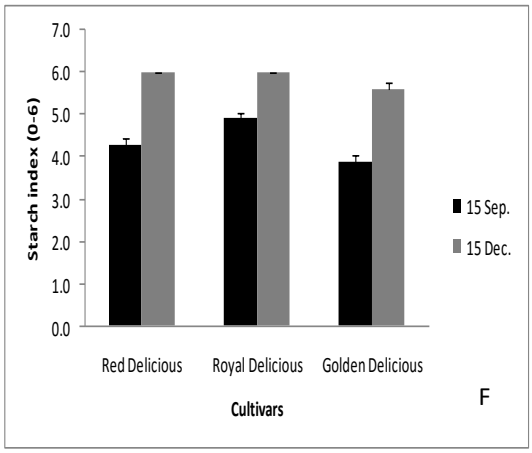












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