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Effect of edible coatings and packaging materials on quality of mango (*Mangifera indica* L.) in cold storage

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Abstract

The present investigation entitled “Effect of edible coatings and packaging materials on quality of Mango (*Mangifera indica* L.) cv. Kesar in cold storage” was conducted during 2019-20 and 2020-21 at laboratory of Post Harvest Technology, Department of Horticulture, M.P.K.V., Rahuri, Dist. Ahmednagar (M.S). The experiment was laid out in Factorial Completely Randomize Design, which is replicated twice with two factors i.e. Factor A: edible coating, i.e. C₁-Control (without coated), C₂-Alginate (2%), C₃-Beeswax (2%), C₄-Aloe vera gel (75%), C₅-Tapioca starch (5%), C₆-Cinnamon oil (0.02%), C₇-Chitosan (0.5%), C₈-Acacia gum (5%), C₉-Pectin (2%). Factor B: packaging materials, i.e. P₁-Corrugated Fibre Box and P₂-Plastic crates. In this experiment, freshly harvested, mango fruits were selected for each treatment combination and coated with nine different coating and packed in CFB box and Plastic crates as per the treatments. The treated fruits were stored in cold storage (CS) (13 °C with 90-95% R.H). Observations were taken at 4 days intervals up to the end of shelf life. Fruit coated with chitosan 0.5% (T₇P₁) packed in CFB box recorded significantly lowest TSS, total sugars, non-reducing sugars, and higher acidity, ascorbic acid recorded.

Keywords: Mango, edible coatings, cold storage, packaging, CFB box, quality and Kesar

Introduction

Mango (*Mangifera indica* L.) is one of the oldest sub-tropical fruit which is rightly known as “King of Fruits”. It has intimate association with cultural religious, aesthetic and economic lives of Indians Since time immemorial and hence it is the national fruit of India. It is originated from South East Asia, the Indo Burma region, in foothills of the Himalayans (Mukhrjee, 1997) [9]. Mango is member of *Anacardiaceae* family. Mango can grow on wide variety of soils under varied climatic condition. Kesar is the important commercial cultivar of Mango and also leading variety for export. It is also preferred variety for mango pulp processors. It is a dual purpose variety used for both table and juice purposes, as juice are moderately abundant.

Edible coatings are one of the techniques used in post-harvest management of fruits. They reduce microbial proliferation, delay dehydration, and prevent a high rate of transpiration from fruits and vegetables (Adetunji *et al.*, 2014) [2]. Healthy and eco-friendly postharvest treatments/technologies are very demanding now-a-days (Prasad and Sharma, 2016) [11]. Films and edible coatings are defined as “a thin application of material that forms a protective barrier around an edible commodity and can be consumed along with the coated product” (Guilbert, 1986) [5]. Chitosan is natural coating material used in several fruit for prolonging their shelf life (Graham, 1990) [4]. Alginate coating as a biodegradable compound can be used to maintain the quality during the shelf life of fruits and vegetables (Somayeh *et al.*, 2019) [18]. (Sharma and Gautam, 2013) [16] Aloe vera gel is a novel edible coating for organic fruit storage technology. Starches are good oxygen barrier, used for edibal coating vegetables and fruits characterized by high respiration rates (Durango *et al.*, 2006) [3].

The gums are polysaccharides based products which are soluble in water. They include exudate gums (gum Arabic), extractive gums (locust bean and guar) and microbial. Pectin is a complex anionic polysaccharide composed of β -1, 4-linked d-galacturonic acid residues (Sanchez, 2016) [14]. Packaging is an essential and indispensable component at different steps of postharvest handling. Packaging essential to minimize physical damage to fresh produce in order to obtain optimal shelf-life. Many fruits like mangoes, apples, grapes, etc.

During recent days, the consumers are becoming more and more health conscious and ready to pay more for quality fruits, without chemical preservatives and extended shelf life. Today, due to increased demand for quality produce the interest of growers in production of high quality fruits is increasing.

Material and Methods

The present investigation entitled "Effect of edible coatings and packaging materials on shelf life and quality of Mango cv. Kesar (*Mangifera indica* L.)" was conducted during 2019-20 and 2020-21 at laboratory of Post Harvest Technology, Department of Horticulture, M.P.K.V., Rahuri, Dist. Ahmednagar (M.S). The experiment was laid out in Factorial Completely Randomize Design, which is replicated twice with two factors i.e. Factor A: edible coating, i.e. C₁-Control (without coated), C₂-Alginate (2%), C₃-Beeswax (2%), C₄-Aloe vera gel (75%), C₅-Tapioca starch (5%), C₆-Cinnamon oil (0.02%), C₇-Chitosan (0.5%), C₈-Acacia gum (5%), C₉-Pectin (2%). Factor B: packaging materials, i.e. P₁-Corrugated Fibre Boxe and P₂-Plastic crates. In this experiment, freshly harvested, mango fruits were selected for each treatment combination and coated with nine different coating and packed in CFB box and Plastic crates as per the treatments. The treated fruits were stored in cold storage (13 °C with 90-95% R.H). Observations were taken at 4 days intervals up to the end of shelf life.

Details of treatment combination

1.	C ₁ P ₁	Without coating + Corrugated fiberboard box
2.	C ₁ P ₂	Without coating + Plastic crates
3.	C ₂ P ₁	Alginate (2%) + Corrugated fiberboard box
4.	C ₂ P ₂	Alginate (2%) + Plastic crates
5.	C ₃ P ₁	Beeswax (2%) + Corrugated fiberboard box
6.	C ₃ P ₂	Beeswax (2%) + Plastic crates
7.	C ₄ P ₁	Aloe vera gel (75%) + Corrugated fiberboard box
8.	C ₄ P ₂	Aloe vera gel (75%) + Plastic crates
9.	C ₅ P ₁	Tapioca starch (5%) + Corrugated fiberboard box
10.	C ₅ P ₂	Tapioca starch (5%) + Plastic crates
11.	C ₆ P ₁	Cinnamon oil (0.02) + Corrugated fiberboard box
12.	C ₆ P ₂	Cinnamon oil (0.02) + Plastic crates
13.	C ₇ P ₁	Chitosan (0.5%) + Corrugated fiberboard box
14.	C ₇ P ₂	Chitosan (0.5%) + Plastic crates
15.	C ₈ P ₁	Acacia gum (5%) + Corrugated fiberboard box
16.	C ₈ P ₂	Acacia gum (5%) + Plastic crates
17.	C ₉ P ₁	Pectin (2%) + Corrugated fiberboard box
18.	C ₉ P ₂	Pectin (2%) + Plastic crates

Observations recorded Biochemical parameters

1. Total soluble solids (^oBrix)

TSS value is defined as the amount of sugar and soluble minerals present in fruits. Total soluble solids (TSS) were determined with the help of Hand refractometer (Erma Japan, 0 to 32^oBrix) and value was corrected at 20°C with the help of temperature correction chart (A.O.A.C., 1975).

2. Titrable acidity (%)

Acidity was estimated by the procedure described by Ranganna (1986) [13]. Ten grams of sample was ground well and transferred to volumetric flask and volume was made to 100 ml with distilled water. The contents were filtered through whatman No. 1 filter paper. An aliquot of 10 ml was taken into a conical flask and 2-3 drops of phenolphthalein indicator was added and then titrated

against 0.1N NaOH. Appearance of light pink colour denotes the end point. It was calculated using the following formula and expressed in percentage (Eq. wt. of citric acid = 0.064).

$$\text{Titrate} \times \text{Normality of NaOH} \times 0.064 \times \text{Volume made up} \\ \text{Titrate acidity (\%)} = \frac{\text{Weight of sample} \times \text{Aliquot taken}}{\text{Weight of sample} \times \text{Aliquot taken}} \times 100$$

3. Total sugars (%)

The total sugars of mango fruit were determined by the method of Lane and Eynon (1923) [8] as described by Ranganna (1977) [12]. In 250 ml conical flask, 50 ml of lead free solution prepared for estimation of reducing sugars was taken. To this, 10 ml of conc. HCl (1:1) added, invert the sucrose and kept for 24 hrs. The solution was taken in 250 ml volumetric flask and neutralized by adding 1N NaOH. The volume of the neutralized hydrolysate was made to 250 ml with distilled water. This hydrolysate was used for determination of total sugars by titrating it against the boiling mixture of Fehling's solution A and B (5 ml each) using methylene blue as indicator. Total sugars were by calculated using the following formula and the results are expressed on percent basis.

$$\text{Total sugars (\%)} = \frac{100 \times 250 \times 0.05 \times 250}{\text{Titre} \times \text{Weight of sample} \times 50}$$

4. Non-reducing sugars (%)

The non-reducing sugars were calculated as difference between total and reducing sugars by using the following formula.

$$\text{Non-reducing sugars (\%)} = \text{Total sugars (\%)} - \text{Reducing sugars (\%)}$$

6. Ascorbic acid (mg/100 g)

Ascorbic acid was estimated by Indophenol method (Ranganna, 1986) [13]. Ten grams of fresh fruit sample was ground well and blended with 3% Meta phosphoric acid (HPO₃) and the volume was made to 100 ml with HPO₃ solution. An aliquot of 10 ml was taken and titrated against standard dye solution (2, 6 dichlorophenol indophenol dye) till light pink colour persist for at least 15 seconds. Standardization of dye (dye factor) was done by titrating it against standard ascorbic acid diluted in 3% HPO₃ solution. The ascorbic acid was calculated using the following formula and expressed as mg ascorbic acid per 100 g fresh weight.

$$\text{Titre} \times \text{Dye factor} \times 0.064 \times \text{Volume made up} \\ \text{Ascorbic acid (mg/100 g)} = \frac{\text{Weight of sample} \times \text{Aliquot taken}}{\text{Weight of sample} \times \text{Aliquot taken}} \times 100$$

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

7. Statistical analysis

The design adopted was completely randomized design with factorial concept and the data were subjected to statistical analysis as per the procedure advocated by Panse and Sukhatme (1995) [10].

Result and Discussion

1. Total soluble solids (⁰Brix)

TSS showed significant difference with coatings treatments throughout the storage period in cold storage (Table 1). Effect of different coatings could be recorded up to 28 days for C₂, C₃, C₄, C₅, C₇, C₈ and C₉. The pooled data clearly showed that the treatment C₇ minimum TSS (16.59⁰B) which was followed by the treatment of C₃ (17.08⁰B), C₂ (17.46⁰B) whereas, maximum TSS (18.75⁰B) was recorded C₁ (control) up to 24th day of storage. Packaging material showed significant difference during storage. Rate of increase in TSS was slow in P₁ as compared to P₂. Highest TSS recorded by P₁ and P₂ was 17.26⁰B and 18.01⁰B at 28th day respectively. The interaction effect of different coating and packaging material during storage on fruit TSS was significant during storage. The data presented in the Table 1. showed that TSS of the fruits in the data shows increasing trend up to 28th day of storage. The minimum TSS (61.33⁰B) was observed in the treatment C₇P₁ (chitosan 0.5% + CFB box) which was followed by the treatment C₃P₁ (beeswax 2% + CFB box) (16.78⁰B), T₇P₂ (chitosan 0.5% + plastic crates) (16.86⁰B). Whereas, maximum (19.14⁰B) TSS was observed in control (C₁P₂) (uncoated fruit + plastic crates) treatment up to 24th day of storage.

All treatments coated with edible coating both beeswax and chitosan significantly delayed the increasing rate of the total soluble solids content. Significant difference among fruits before application of the coating, there is faster increasing trends for control treatments than coated fruits in terms of TSS. The delay in TSS content upon coating application could be related with the oxygen barrier property of edible coating and reduction of respiration as a result. Similar observation was reported by Yonemoto *et al.* (2002)^[20] who explained that lower levels of total soluble solids in fruits coated with chitosan may be due to protective oxygen barrier that reduces oxygen supply to the fruit surface which in turn inhibited respiration. Sharafat *et al.* (1990)^[15] found that as storage is prolonged, the rate of respiration, transpiration and other metabolic changes are more in control fruits than edible coated mango fruits. Kittur *et al.* (2001)^[7] Chitosan coatings were increase shelf-life and quality of banana and mango than polysaccharide-based coating.

2. Titrable acidity (%)

In cold storage pooled data clearly showed that the treatment C₇ maximum titratable acidity (0.32%) which was statistically at par with the treatment of C₃ (0.30%) at 28th day of storage. Whereas, minimum titratable acidity (0.22%) was observed in control C₁ at 24th day of storage. Packaging materials effect revealed non-significant result with respect to acidity during storage except at 16th day. Rate of decrease in acidity was slow in P₁ as compared to P₂. Highest acidity recorded by P₁ and P₂ was 0.29 and 0.26 percent at 28th day respectively. The interaction effect of different coating and packaging material, during storage on fruit titratable acidity was significant during storage. The data presented in the Table 2 showed that titratable acidity of the fruits in the pooled data shows decreasing trend up to 28th day of storage. The maximum titratable acidity (0.35%) was observed in the treatment C₇P₁ (chitosan 0.5% + CFB box), which followed by the treatment C₃P₁ (beeswax 2% + CFB box) (0.35%). Whereas, minimum titratable acidity (0.18%)

was observed in control C₁P₂ (control + plastic crates) treatment at 24th day.

At the end of the storage the minimum value was recorded for the control treatment and higher of titratable acidity was recorded for mango fruits coated with chitosan 0.5% and beeswax 2%. they found that edibal coating reduce the respiration rate of the fruits and thus rate of utilization of the respiratory substrates such as organic acids was so minimal. Tefera *et al.* (2008) similarly result higher acidity due to postharvest treatments that delay respiration could be a result of the reduced utilization rate of respiratory substrates such as organic acids.

3. Total sugars (%)

The data on effect of coating on total sugars (%) of mango in CS has been presented in Table 3. The pooled data clearly showed that the minimum total sugars were seen in C₇ (14.86%). It was followed by C₃ (15.03%) and C₂ (15.32%) treatment 28th day of storage. Maximum (16.11%) total sugars was observed in C₁P₂ (control + plastic crates) treatment 24th day of storage. Packaging material showed significant difference during storage in CS. Rate of increasing in total sugars (%) was slow in P₁ as compared to P₂. Highest total sugars recorded by P₁ and P₂ was 15.16 and 15.68 percent at 28th day. The interaction effect of different coating and packaging material during storage on fruit total sugars (%) was significant during storage. The pooled data presented in the Table3 showed that the minimum total sugars (14.64%) was observed in the treatment C₇P₁ (chitosan 0.5% + CFB box) which is followed by C₃P₁ (14.75%) maximum total sugars was observed (16.20%) in C₁P₂ (control + plastic crates) treatment at 24th day.

Considering the effect of coating and packaging the total sugar is one of the most important factor of fruit quality. The possible reasons and findings associated with increase in total sugar up to peak and slight decline with increase in storage period and lower percentage of total sugar in treated fruits of chitosan 0.5% and beeswax 2% accumulation of sugar as a consequence of starch hydrolysis, further at the over ripe stage the leaching of sugar was carried out because of hydrolysis process. Similar results was also recorded by Kapse (1993)^[6] and Singh *et al.* (2000)^[17].

4. Non-reducing sugars (%)

The data on effect of coating on non-reducing sugars (%) of mango in CS has been presented in Table 4. The pooled data clearly showed that the minimum non-reducing sugars were seen in C₃ (8.90%). It was followed by C₇ (8.97%) treatment 28th day of storage. Maximum (9.91%) non-reducing sugars was observed in C₁P₂ (control + plastic crates) treatment 24th day of storage. Packaging material showed significant difference during storage in CS. Rate of increasing in total sugars (%) was slow in P₁ as compared to P₂. Highest non-reducing sugars recorded by P₁ and P₂ was 9.12 and 9.64 percent at 28th day. The interaction effect of different coatings and packaging materials during storage on fruit non-reducing sugars (%) was significant during storage. The pooled data presented in the Table 4 showed that the minimum non-reducing sugars (8.60%) was observed in the treatment C₃P₁ (beeswax 2% + CFB box) which is followed by C₇P₁ (chitosan 0.5% + CFB box) (8.74%) maximum non-reducing sugars was observed (10.01%) in C₁P₂ (control + plastic crates) treatment at 24th day.

Non-reducing sugars content was continuously increased during the storage period up to peak than decline slightly in fruits of Kesar mango. This may be a consequence of release of sugar during starch hydrolysis. Mango is a climacteric fruit, rich in starch reserves and during post-harvest storage starch is hydrolyzed and liberating reducing sugars with enhancement of storage Kapse, 1993 and Singh *et al.*, 2000) [6, 17].

5. Ascorbic acid (mg/100 g)

In cold storage pooled data clearly showed that the treatment C₇ maximum ascorbic acid (35.87 mg/100g) which was statistically at par with the treatment of C₃ (35.48 mg/100g) at 28th day of storage. Whereas, minimum ascorbic acid (38.03 mg/100g) was observed in control C₁ at 24th day of storage. Packaging materials effect revealed significant result with respect to ascorbic acid during storage. Rate of decrease in ascorbic acid was slow in P₁ as compared to P₂. Highest ascorbic acid recorded by P₁ and P₂ was 34.28 mg/100g and 33.12 mg/100g at 28th day respectively. The interaction effect of different coating and packaging material, during storage on fruit ascorbic acid was significant during storage. The data presented in the

Table 5 showed that ascorbic acid of the fruits in the pooled data showed decreasing trend up to 28th day of storage. The maximum ascorbic acid (36.49 mg/100g) was observed in the treatment C₇P₁ (chitosan 0.5% + CFB box), which followed by the treatment C₃P₁ (beeswax 2% + CFB box) (35.98 mg/100g). Whereas, minimum ascorbic acid (38.05 mg/100g) was observed in control C₁P₂ (control + plastic crates) treatment at 24th day of storage.

The ascorbic acid content of mango cv. Kesar was found to be decreased in all coated fruit during the advancement of storage period in both storage condition however the rate was faster in uncoated fruit as compared to coated fruit. While uncoated fruits showed high ascorbic acid content than coated ones. A decline in ascorbic acid content of the mango fruits might be due to utilization of ascorbic acid in respiration process during ripening at ambient condition and cold storage. This might be due to the presence of oxygen at surrounding during storage, which increased in respiration rate, thus, resulted in the release of water. This, there by increased the degradation of ascorbic acid as ascorbic acid is readily oxidized in the presence of moisture maximum on ascorbic acid was recorded in coated fruit Similar trend was also observed by Wong *et al.*, (2016) [19].

Table 1: Effect of edible coatings and packaging materials change in total soluble solids (TSS) (OB) content of Kesar mango fruit during storage in cold storage

Treatment	0 DAS			4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	7.21	7.13	7.17	9.89	9.47	9.68	12.10	12.05	12.08	13.32	13.16	13.24
C ₂ : Alginate (2%)	7.23	7.15	7.19	9.03	8.84	8.93	10.18	10.05	10.11	11.21	11.53	11.37
C ₃ : Beewax (2%)	7.22	7.15	7.18	8.44	8.64	8.54	10.05	10.27	10.16	11.13	11.60	11.36
C ₄ : Aloe vera gel (75%)	7.25	7.17	7.21	8.57	8.69	8.63	9.99	10.36	10.17	11.13	11.27	11.20
C ₅ : Tapioca starch (5%)	7.24	7.10	7.17	8.61	8.94	8.77	10.08	10.34	10.21	11.57	11.58	11.57
C ₆ : Cinnamon oil (0.02)	7.26	7.13	7.19	10.23	9.93	10.08	11.07	11.75	11.41	12.88	12.82	12.85
C ₇ : Chitosan (0.5%)	7.24	7.14	7.19	8.40	8.79	8.59	9.58	10.16	9.87	10.92	11.17	11.04
C ₈ : Acacia gum (5%)	7.24	7.16	7.20	9.08	9.12	9.10	10.27	10.71	10.49	11.55	11.71	11.63
C ₉ : Pectin (2%)	7.26	7.10	7.18	9.33	10.28	9.80	10.55	11.74	11.14	12.08	12.15	12.11
SEm. (±)	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.02	0.04	0.03	0.07	0.06
CD at 1%	NS	NS	NS	0.09	0.04	0.07	0.21	0.09	0.15	0.10	0.30	0.21
B. Packaging materials												
P ₁ : CFB box	7.23	7.14	7.19	8.73	8.79	8.76	10.35	10.60	10.48	11.54	11.63	11.58
P ₂ : Plastic crates.	7.24	7.13	7.19	9.39	9.59	9.49	10.50	11.05	10.78	11.96	12.14	12.05
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.04	0.03
CD at 1%	NS	NS	NS	0.04	0.02	0.03	0.10	0.04	0.07	0.05	0.14	0.10
C. Interaction (A x B)												
C ₁ P ₁	7.23	7.14	7.18	9.78	8.10	8.94	12.50	12.00	12.25	13.00	12.78	12.89
C ₁ P ₂	7.19	7.13	7.16	10.00	10.84	10.42	11.70	12.10	11.90	13.65	13.54	13.59
C ₂ P ₁	7.21	7.14	7.18	9.03	8.50	8.77	10.00	9.40	9.70	11.05	11.34	11.20
C ₂ P ₂	7.26	7.16	7.21	9.02	9.17	9.10	10.35	10.69	10.52	11.38	11.72	11.55
C ₃ P ₁	7.21	7.14	7.17	7.80	8.18	7.99	10.00	10.00	10.00	11.00	11.39	11.20
C ₃ P ₂	7.23	7.16	7.20	9.07	9.10	9.09	10.09	10.54	10.32	11.25	11.81	11.53
C ₄ P ₁	7.25	7.18	7.21	8.08	8.18	8.13	9.93	10.04	9.98	11.11	11.06	11.09
C ₄ P ₂	7.25	7.16	7.20	9.05	9.20	9.13	10.05	10.68	10.37	11.14	11.49	11.31
C ₅ P ₁	7.23	7.09	7.16	8.11	8.59	8.35	9.80	10.00	9.90	11.23	11.25	11.24
C ₅ P ₂	7.26	7.11	7.18	9.10	9.28	9.19	10.35	10.67	10.51	11.90	11.90	11.90
C ₆ P ₁	7.24	7.13	7.18	9.66	9.80	9.73	11.18	11.50	11.34	12.66	12.64	12.65
C ₆ P ₂	7.28	7.13	7.20	10.80	10.06	10.43	10.95	12.00	11.48	13.10	13.00	13.05
C ₇ P ₁	7.24	7.18	7.21	8.00	8.50	8.25	9.25	10.31	9.78	10.81	11.00	10.91
C ₇ P ₂	7.23	7.11	7.17	8.80	9.07	8.94	9.90	10.00	9.95	11.02	11.33	11.18
C ₈ P ₁	7.24	7.20	7.22	9.10	9.22	9.16	10.40	10.52	10.46	11.09	11.41	11.25
C ₈ P ₂	7.24	7.13	7.18	9.06	9.02	9.04	10.14	10.90	10.52	12.00	12.00	12.00
C ₉ P ₁	7.26	7.11	7.18	9.04	10.00	9.52	10.10	11.63	10.87	11.90	11.80	11.85
C ₉ P ₂	7.26	7.10	7.18	9.62	10.55	10.08	11.00	11.85	11.42	12.25	12.49	12.37
SEm. (±)	0.03	0.03	0.03	0.03	0.02	0.03	0.07	0.03	0.06	0.04	0.11	0.08
CD at 1%	NS	NS	NS	0.13	0.06	0.10	0.29	0.13	0.21	0.15	NS	0.30

Treatment	16 DAS			20 DAS			24 DAS			28 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	15.76	15.72	15.74	17.55	16.76	17.15	18.61	18.89	18.75	-	-	-
C ₂ : Alginate (2%)	12.76	13.25	13.01	14.55	15.05	14.80	15.49	15.66	15.58	17.73	17.19	17.46
C ₃ : Beewax (2%)	12.58	12.30	12.44	13.75	14.02	13.88	15.29	15.45	15.37	16.65	17.51	17.08
C ₄ : Aloe vera gel (75%)	13.53	12.75	13.14	15.53	14.93	15.23	16.73	16.25	16.49	18.25	18.07	18.16
C ₅ : Tapioca starch (5%)	14.23	13.75	13.99	15.75	14.71	15.23	16.58	16.21	16.39	17.62	18.53	18.07
C ₆ : Cinnamon oil (0.02)	14.85	14.75	14.80	16.65	16.78	16.71	17.67	17.80	17.73	-	-	-
C ₇ : Chitosan (0.5%)	11.95	13.35	12.65	13.82	14.21	14.01	15.48	15.62	15.55	16.40	16.79	16.59
C ₈ : Acacia gum (5%)	13.95	14.26	14.11	15.20	15.62	15.41	15.84	17.02	16.43	17.51	17.96	17.73
C ₉ : Pectin (2%)	14.68	15.33	15.00	15.96	16.23	16.10	16.58	17.20	16.89	18.35	18.32	18.33
SEm. (±)	0.07	0.04	0.06	0.03	0.01	0.02	0.03	0.05	0.04	0.05	0.04	0.05
CD at 1%	0.29	0.18	0.23	0.11	0.05	0.08	0.13	0.20	0.16	0.16	0.11	0.13
B. Packaging materials												
P ₁ : CFB box	13.25	13.39	13.32	15.02	14.86	14.94	16.07	16.16	16.11	0.22	0.16	0.18
P ₂ : Plastic crates.	14.37	14.49	14.43	15.82	15.87	15.84	16.87	17.20	17.04	17.06	17.46	17.26
SEm. (±)	0.03	0.02	0.03	0.01	0.01	0.01	0.02	0.02	0.02	17.94	18.07	18.01
CD at 1%	0.14	0.08	0.11	0.05	0.02	0.04	0.06	0.10	0.08	0.03	0.02	0.02
C. Interaction (A x B)												
C ₁ P ₁	15.00	15.09	15.04	17.10	16.46	16.78	18.21	18.50	18.36	-	-	-
C ₁ P ₂	16.52	16.35	16.44	18.00	17.05	17.53	19.00	19.28	19.14	-	-	-
C ₂ P ₁	12.00	13.00	12.50	14.04	14.60	14.32	14.98	15.27	15.13	17.20	16.88	17.04
C ₂ P ₂	13.52	13.50	13.51	15.05	15.50	15.28	16.00	16.05	16.03	18.25	17.50	17.88
C ₃ P ₁	12.00	11.90	11.95	13.50	13.73	13.62	15.10	15.00	15.05	16.25	17.31	16.78
C ₃ P ₂	13.15	12.70	12.93	14.00	14.30	14.15	15.48	15.90	15.69	17.05	17.70	17.38
C ₄ P ₁	13.06	12.26	12.66	15.06	14.56	14.81	16.46	16.00	16.23	18.00	17.78	17.89
C ₄ P ₂	14.00	13.24	13.62	16.00	15.30	15.65	17.00	16.50	16.75	18.50	18.35	18.43
C ₅ P ₁	13.45	13.20	13.33	15.40	14.41	14.91	16.15	15.42	15.79	17.00	18.05	17.53
C ₅ P ₂	15.00	14.30	14.65	16.10	15.00	15.55	17.00	17.00	17.00	18.25	19.00	18.62
C ₆ P ₁	14.50	14.50	14.50	16.79	16.06	16.43	17.33	17.20	17.27	-	-	-
C ₆ P ₂	15.19	15.00	15.10	16.50	17.50	17.00	18.00	18.40	18.20	-	-	-
C ₇ P ₁	11.80	12.90	12.35	13.13	13.76	13.45	15.00	15.10	15.05	16.15	16.50	16.33
C ₇ P ₂	12.10	13.80	12.95	14.50	14.65	14.58	15.96	16.13	16.04	16.64	17.07	16.86
C ₈ P ₁	13.40	13.23	13.32	14.90	14.73	14.82	15.25	16.47	15.86	17.11	17.67	17.39
C ₈ P ₂	14.50	15.29	14.90	15.50	16.50	16.00	16.43	17.57	17.00	17.90	18.25	18.08
C ₉ P ₁	14.01	14.40	14.21	15.22	15.46	15.34	16.15	16.44	16.30	17.70	18.00	17.85
C ₉ P ₂	15.35	16.25	15.80	16.70	17.00	16.85	17.00	17.95	17.48	19.00	18.63	18.82
SEm. (±)	0.10	0.06	0.08	0.04	0.02	0.03	0.05	0.07	0.06	0.07	0.05	0.06
CD at 1%	0.41	0.25	0.32	0.15	0.07	0.11	0.19	0.29	0.23	0.31	0.22	0.25

Table 2: Effect of edible coatings and packaging materials on changes in acidity (%) of Kesar mango fruit during storage in Cold storage

Treatment	0 DAS			4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	2.05	2.07	2.06	1.91	1.81	1.86	1.50	1.44	1.47	0.95	0.84	0.89
C ₂ : Alginate (2%)	2.05	2.07	2.06	1.91	1.86	1.89	1.66	1.61	1.64	1.12	1.14	1.13
C ₃ : Beewax (2%)	2.07	2.07	2.07	1.89	1.91	1.90	1.76	1.63	1.69	1.16	1.22	1.19
C ₄ : Aloe vera gel (75%)	2.05	2.05	2.05	1.93	1.85	1.89	1.62	1.49	1.55	1.08	1.11	1.09
C ₅ : Tapioca starch (5%)	2.06	2.05	2.06	1.89	1.84	1.86	1.51	1.52	1.52	1.08	1.08	1.08
C ₆ : Cinnamon oil (0.02)	2.06	2.05	2.06	1.95	1.83	1.89	1.52	1.47	1.50	1.12	1.08	1.10
C ₇ : Chitosan (0.5%)	2.06	2.04	2.05	2.01	1.91	1.96	1.75	1.66	1.71	1.18	1.23	1.20
C ₈ : Acacia gum (5%)	2.06	2.06	2.06	1.93	1.84	1.88	1.54	1.59	1.56	1.04	1.15	1.09
C ₉ : Pectin (2%)	2.05	2.06	2.06	1.85	1.84	1.84	1.55	1.53	1.54	1.11	1.06	1.09
SEm. (±)	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
CD at 1%	NS	NS	NS	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.07	0.06
B. Packaging materials												
P ₁ : CFB box	2.06	2.06	2.06	1.93	1.86	1.89	1.61	1.56	1.59	1.11	1.12	1.11
P ₂ : Plastic crates.	2.05	2.06	2.06	1.91	1.84	1.88	1.59	1.53	1.56	1.07	1.08	1.08
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
CD at 1%	NS	NS	NS	NS	NS	NS	NS	0.02	0.02	0.02	0.03	0.03
C. Interaction (A x B)												
C ₁ P ₁	2.05	2.08	2.06	1.90	1.79	1.84	1.47	1.49	1.48	0.95	0.87	0.91
C ₁ P ₂	2.05	2.07	2.06	1.92	1.83	1.87	1.54	1.40	1.47	0.95	0.80	0.88
C ₂ P ₁	2.07	2.07	2.07	1.93	1.87	1.90	1.68	1.63	1.65	1.14	1.16	1.15
C ₂ P ₂	2.04	2.07	2.05	1.90	1.86	1.88	1.64	1.60	1.62	1.10	1.12	1.11
C ₃ P ₁	2.07	2.05	2.06	1.90	1.92	1.91	1.77	1.64	1.70	1.16	1.22	1.19
C ₃ P ₂	2.07	2.10	2.08	1.88	1.89	1.88	1.75	1.62	1.69	1.16	1.23	1.20

C ₄ P ₁	2.05	2.07	2.06	1.95	1.86	1.90	1.64	1.54	1.59	1.09	1.14	1.11
C ₄ P ₂	2.05	2.04	2.05	1.92	1.84	1.88	1.61	1.43	1.52	1.07	1.08	1.07
C ₅ P ₁	2.05	2.06	2.05	1.89	1.86	1.87	1.53	1.54	1.53	1.08	1.10	1.09
C ₅ P ₂	2.07	2.05	2.06	1.90	1.82	1.86	1.50	1.50	1.50	1.09	1.05	1.07
C ₆ P ₁	2.07	2.05	2.06	1.96	1.84	1.90	1.53	1.48	1.50	1.17	1.12	1.14
C ₆ P ₂	2.06	2.05	2.06	1.94	1.83	1.88	1.52	1.46	1.49	1.08	1.05	1.06
C ₇ P ₁	2.08	2.03	2.05	2.03	1.92	1.97	1.75	1.67	1.71	1.19	1.23	1.21
C ₇ P ₂	2.05	2.05	2.05	1.99	1.91	1.95	1.75	1.66	1.70	1.17	1.22	1.20
C ₈ P ₁	2.07	2.06	2.06	1.94	1.86	1.90	1.57	1.57	1.57	1.05	1.14	1.09
C ₈ P ₂	2.05	2.06	2.05	1.92	1.82	1.87	1.50	1.61	1.55	1.03	1.16	1.10
C ₉ P ₁	2.05	2.08	2.06	1.88	1.85	1.87	1.55	1.53	1.54	1.19	1.10	1.14
C ₉ P ₂	2.05	2.05	2.05	1.82	1.83	1.82	1.55	1.53	1.54	1.04	1.03	1.03
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
CD at 1%	NS	NS	NS	NS	NS	NS	0.06	0.06	NS	0.07	NS	NS

Treatment	16 DAS			20 DAS			24 DAS			28 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	0.61	0.54	0.57	0.44	0.31	0.37	0.25	0.19	0.22	-	-	-
C ₂ : Alginate (2%)	0.84	0.80	0.82	0.56	0.44	0.50	0.44	0.32	0.38	0.27	0.28	0.27
C ₃ : Beewax (2%)	0.89	0.93	0.91	0.57	0.52	0.55	0.44	0.40	0.42	0.32	0.28	0.30
C ₄ : Aloe vera gel (75%)	0.84	0.67	0.75	0.53	0.50	0.51	0.41	0.35	0.38	0.27	0.26	0.26
C ₅ : Tapioca starch (5%)	0.85	0.69	0.77	0.58	0.34	0.46	0.45	0.22	0.34	0.31	0.27	0.29
C ₆ : Cinnamon oil (0.02)	0.66	0.80	0.73	0.47	0.41	0.44	0.35	0.29	0.32	-	-	-
C ₇ : Chitosan (0.5%)	0.92	0.86	0.89	0.51	0.58	0.54	0.48	0.44	0.46	0.32	0.32	0.32
C ₈ : Acacia gum (5%)	0.90	0.78	0.84	0.53	0.48	0.50	0.37	0.33	0.35	0.25	0.26	0.25
C ₉ : Pectin (2%)	0.91	0.80	0.85	0.58	0.44	0.51	0.37	0.32	0.34	0.28	0.20	0.24
SEm. (±)	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
CD at 1%	0.06	0.05	0.05	0.07	0.05	0.06	0.05	0.05	0.05	0.02	0.02	0.02
B. Packaging materials												
P ₁ : CFB box	0.85	0.80	0.82	0.54	0.45	0.49	0.41	0.32	0.37	0.31	0.27	0.29
P ₂ : Plastic crates.	0.80	0.73	0.76	0.52	0.44	0.48	0.38	0.31	0.35	0.27	0.26	0.26
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
CD at 1%	0.03	0.02	0.02	NS	NS	NS	0.02	NS	NS	0.01	NS	0.01
C. Interaction (A x B)												
C ₁ P ₁	0.66	0.63	0.65	0.45	0.33	0.39	0.30	0.21	0.26	-	-	-
C ₁ P ₂	0.55	0.46	0.50	0.42	0.28	0.35	0.20	0.16	0.18	-	-	-
C ₂ P ₁	0.88	0.86	0.87	0.55	0.46	0.50	0.43	0.34	0.38	0.28	0.29	0.28
C ₂ P ₂	0.80	0.74	0.77	0.58	0.43	0.50	0.46	0.31	0.38	0.27	0.26	0.26
C ₃ P ₁	0.87	0.93	0.90	0.59	0.53	0.56	0.44	0.41	0.42	0.34	0.27	0.31
C ₃ P ₂	0.92	0.93	0.92	0.56	0.52	0.54	0.44	0.40	0.42	0.30	0.28	0.29
C ₄ P ₁	0.91	0.68	0.79	0.52	0.41	0.47	0.40	0.29	0.35	0.29	0.24	0.26
C ₄ P ₂	0.76	0.66	0.71	0.53	0.59	0.56	0.41	0.40	0.41	0.25	0.28	0.27
C ₅ P ₁	0.86	0.71	0.79	0.59	0.36	0.47	0.45	0.24	0.34	0.35	0.25	0.30
C ₅ P ₂	0.84	0.67	0.75	0.58	0.33	0.45	0.46	0.21	0.33	0.28	0.28	0.28
C ₆ P ₁	0.68	0.86	0.77	0.52	0.45	0.48	0.40	0.33	0.36	-	-	-
C ₆ P ₂	0.64	0.75	0.70	0.43	0.38	0.40	0.31	0.26	0.28	-	-	-
C ₇ P ₁	0.91	0.88	0.89	0.55	0.61	0.58	0.51	0.48	0.49	0.35	0.34	0.35
C ₇ P ₂	0.93	0.85	0.89	0.47	0.55	0.51	0.45	0.40	0.43	0.29	0.31	0.30
C ₈ P ₁	0.93	0.83	0.88	0.51	0.48	0.49	0.35	0.33	0.34	0.25	0.27	0.26
C ₈ P ₂	0.87	0.74	0.80	0.55	0.48	0.51	0.39	0.33	0.36	0.24	0.25	0.25
C ₉ P ₁	0.93	0.83	0.88	0.60	0.44	0.52	0.41	0.32	0.36	0.31	0.22	0.26
C ₉ P ₂	0.89	0.78	0.83	0.56	0.44	0.50	0.33	0.32	0.33	0.25	0.18	0.21
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
CD at 1%	0.09	0.07	0.07	NS	0.07	0.08	0.07	0.07	0.07	0.03	0.03	0.03

Table 3: Effect of edible coatings and packaging materials on changes in total sugars (%) of Kesar mango fruit during storage in cold storage

Treatment	0 DAS			4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	5.00	5.23	5.11	7.02	7.31	7.16	8.30	8.22	8.26	9.56	9.56	9.56
C ₂ : Alginate (2%)	5.01	5.23	5.12	6.97	7.31	7.14	7.68	7.92	7.80	8.69	9.01	8.85
C ₃ : Beewax (2%)	5.05	5.21	5.13	6.84	6.71	6.77	7.57	7.84	7.70	8.68	8.61	8.64
C ₄ : Aloe vera gel (75%)	5.00	5.23	5.11	6.98	7.34	7.16	7.91	8.04	7.97	8.98	9.27	9.12
C ₅ : Tapioca starch (5%)	5.00	5.21	5.10	7.11	7.03	7.07	8.32	7.93	8.12	9.07	9.12	9.09
C ₆ : Cinnamon oil (0.02)	5.00	5.20	5.10	7.11	7.30	7.20	8.19	8.02	8.10	9.09	9.20	9.14
C ₇ : Chitosan (0.5%)	5.07	5.20	5.13	6.84	7.09	6.96	7.67	7.85	7.76	8.63	8.62	8.62
C ₈ : Acacia gum (5%)	5.01	5.19	5.10	7.08	7.16	7.12	8.15	8.02	8.09	8.91	8.72	8.82
C ₉ : Pectin (2%)	5.01	5.18	5.10	7.04	7.12	7.08	8.29	7.90	8.09	9.17	9.14	9.15
SEm. (±)	0.02	0.02	0.02	0.02	0.01	0.02	0.03	0.01	0.02	0.01	0.02	0.01
CD at 1%	NS	NS	NS	0.08	0.05	0.07	0.11	0.04	0.08	0.05	0.07	0.06
B. Packaging materials												
P ₁ : CFB box	5.01	5.20	5.10	6.96	7.07	7.02	8.06	7.96	8.01	9.01	8.96	8.98
P ₂ : Plastic crates.	5.02	5.22	5.12	7.03	7.22	7.13	7.95	7.97	7.96	8.94	9.09	9.02
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD at 1%	NS	NS	NS	0.04	0.03	0.03	0.05	NS	0.04	0.02	0.03	0.03
C. Interaction (A x B)												
C ₁ P ₁	5.00	5.20	5.10	6.86	7.18	7.02	8.43	8.20	8.31	9.59	9.53	9.56
C ₁ P ₂	5.00	5.25	5.13	7.18	7.44	7.31	8.17	8.23	8.20	9.53	9.59	9.56
C ₂ P ₁	5.01	5.20	5.11	6.97	7.17	7.07	7.79	7.91	7.85	8.69	8.91	8.80
C ₂ P ₂	5.01	5.25	5.13	6.96	7.44	7.20	7.56	7.92	7.74	8.69	9.11	8.90
C ₃ P ₁	5.05	5.20	5.13	6.84	6.71	6.78	7.54	7.82	7.68	8.70	8.60	8.65
C ₃ P ₂	5.05	5.21	5.13	6.84	6.71	6.77	7.59	7.86	7.72	8.65	8.63	8.64
C ₄ P ₁	5.00	5.20	5.10	7.01	7.20	7.10	8.01	8.03	8.02	9.12	9.09	9.10
C ₄ P ₂	5.00	5.26	5.13	6.96	7.48	7.22	7.80	8.04	7.92	8.85	9.44	9.15
C ₅ P ₁	5.00	5.20	5.10	7.04	6.76	6.90	8.56	7.90	8.23	9.03	9.10	9.07
C ₅ P ₂	5.00	5.21	5.11	7.17	7.29	7.23	8.07	7.95	8.01	9.11	9.13	9.12
C ₆ P ₁	5.00	5.20	5.10	7.07	7.38	7.23	8.12	8.03	8.07	9.10	9.17	9.13
C ₆ P ₂	5.00	5.20	5.10	7.14	7.21	7.18	8.26	8.01	8.13	9.08	9.22	9.15
C ₇ P ₁	5.05	5.20	5.13	6.84	7.01	6.93	7.70	7.86	7.78	8.66	8.58	8.62
C ₇ P ₂	5.09	5.20	5.14	6.84	7.16	7.00	7.64	7.85	7.74	8.60	8.66	8.63
C ₈ P ₁	5.01	5.17	5.09	7.00	7.03	7.02	8.27	8.02	8.15	9.05	8.55	8.80
C ₈ P ₂	5.00	5.20	5.10	7.15	7.29	7.22	8.04	8.02	8.03	8.77	8.89	8.83
C ₉ P ₁	5.00	5.20	5.10	7.03	7.23	7.13	8.14	7.90	8.02	9.12	9.14	9.13
C ₉ P ₂	5.02	5.17	5.09	7.04	7.00	7.02	8.44	7.90	8.17	9.22	9.13	9.18
SEm. (±)	0.02	0.02	0.02	0.03	0.02	0.02	0.04	0.02	0.03	0.02	0.02	0.02
CD at 1%	NS	NS	NS	0.12	0.08	0.09	0.16	NS	0.12	0.07	0.10	NS

Treatment	16 DAS			20 DAS			24 DAS			28 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	11.33	13.43	12.38	15.53	15.14	15.34	16.13	16.09	16.11	-	-	-
C ₂ : Alginate (2%)	9.44	12.36	10.90	13.96	13.10	13.53	14.47	14.83	14.65	15.58	15.06	15.32
C ₃ : Beewax (2%)	9.17	10.33	9.75	12.84	13.67	13.25	13.67	14.82	14.24	15.08	14.98	15.03
C ₄ : Aloe vera gel (75%)	10.64	12.35	11.50	13.73	13.81	13.77	14.78	15.53	15.15	15.60	15.91	15.75
C ₅ : Tapioca starch (5%)	10.64	12.31	11.47	13.93	13.99	13.96	15.02	15.08	15.05	15.73	15.68	15.70
C ₆ : Cinnamon oil (0.02)	10.64	12.35	11.49	14.82	15.07	14.94	15.87	15.85	15.86	-	-	-
C ₇ : Chitosan (0.5%)	9.11	10.25	9.68	12.33	12.49	12.41	13.63	14.69	14.16	14.54	15.19	14.86
C ₈ : Acacia gum (5%)	9.54	12.18	10.86	12.45	13.61	13.03	14.62	15.25	14.93	15.18	15.65	15.41
C ₉ : Pectin (2%)	10.61	12.25	11.43	13.68	13.66	13.67	14.77	15.35	15.06	15.82	15.92	15.87
SEm. (±)	0.02	0.02	0.02	0.04	0.06	0.05	0.03	0.06	0.04	0.02	0.02	0.02
CD at 1%	0.07	0.09	0.08	0.14	0.25	0.19	0.12	0.23	0.17	0.10	0.10	0.09
B. Packaging materials												
P ₁ : CFB box	10.12	11.98	11.05	13.45	13.61	13.53	14.49	15.03	14.76	15.09	15.23	15.16
P ₂ : Plastic crates.	10.12	11.98	11.05	13.94	14.07	14.00	15.05	15.52	15.29	15.63	15.73	15.68
SEm. (±)	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.03	0.02	0.01	0.01	0.01
CD at 1%	NS	NS	NS	0.07	0.12	0.09	0.06	0.11	0.08	0.06	0.05	0.05
C. Interaction (A x B)												
C ₁ P ₁	11.21	13.41	12.31	15.26	15.00	15.13	16.05	15.98	16.01	-	-	-
C ₁ P ₂	11.46	13.45	12.45	15.80	15.29	15.54	16.20	16.20	16.20	-	-	-

C ₂ P ₁	9.53	12.42	10.97	13.83	13.00	13.41	14.33	14.52	14.42	15.35	14.92	15.13
C ₂ P ₂	9.36	12.30	10.83	14.10	13.20	13.65	14.60	15.15	14.88	15.80	15.20	15.50
C ₃ P ₁	9.17	10.35	9.76	12.57	13.43	13.00	13.33	14.65	13.99	15.00	14.50	14.75
C ₃ P ₂	9.17	10.32	9.74	13.10	13.90	13.50	14.00	15.00	14.50	15.15	15.45	15.30
C ₄ P ₁	10.66	12.42	11.54	13.41	13.61	13.51	14.56	15.10	14.83	15.20	15.75	15.48
C ₄ P ₂	10.62	12.29	11.46	14.04	14.00	14.02	15.00	15.95	15.48	16.00	16.06	16.03
C ₅ P ₁	10.63	12.21	11.42	13.45	13.48	13.47	14.53	14.90	14.72	15.45	15.30	15.38
C ₅ P ₂	10.64	12.40	11.52	14.41	14.50	14.46	15.50	15.25	15.38	16.00	16.05	16.03
C ₆ P ₁	10.64	12.45	11.55	15.00	14.98	14.99	15.65	15.70	15.68	-	-	-
C ₆ P ₂	10.63	12.25	11.44	14.63	15.17	14.90	16.08	16.00	16.04	-	-	-
C ₇ P ₁	9.13	10.24	9.68	12.00	12.18	12.09	13.26	14.48	13.87	14.17	15.11	14.64
C ₇ P ₂	9.09	10.26	9.68	12.65	12.80	12.73	14.00	14.90	14.45	14.90	15.28	15.09
C ₈ P ₁	9.55	12.17	10.86	12.19	13.23	12.71	14.23	14.90	14.57	14.90	15.30	15.10
C ₈ P ₂	9.53	12.20	10.86	12.70	14.00	13.35	15.00	15.60	15.30	15.45	16.00	15.73
C ₉ P ₁	10.60	12.17	11.39	13.31	13.57	13.44	14.43	15.05	14.74	15.55	15.76	15.65
C ₉ P ₂	10.62	12.34	11.48	14.05	13.75	13.90	15.10	15.65	15.38	16.08	16.08	16.08
SEm. (±)	0.02	0.03	0.03	0.05	0.09	0.07	0.04	0.08	0.06	0.03	0.03	0.03
CD at 1%	0.10	0.13	0.11	0.20	0.35	0.27	0.17	NS	0.24	0.15	0.14	0.13

Table 4: Effect of edible coatings and packaging materials on changes in non-reducing sugars (%) of Kesar mango fruit during storage in cool storage

Treatment	0 DAS			4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	2.94	3.09	3.01	4.18	4.36	4.27	4.95	4.38	4.66	5.76	5.40	5.58
C ₂ : Alginate (2%)	3.00	3.08	3.04	4.29	4.16	4.23	4.30	4.40	4.35	5.23	4.86	5.05
C ₃ : Beewax (2%)	2.96	3.10	3.03	4.47	4.62	4.54	4.43	4.47	4.45	5.12	5.18	5.15
C ₄ : Aloe vera gel (75%)	2.94	3.10	3.02	4.40	4.55	4.47	4.53	4.47	4.50	5.44	5.64	5.54
C ₅ : Tapioca starch (5%)	2.93	3.07	3.00	4.51	4.32	4.42	4.91	4.31	4.61	5.52	5.25	5.38
C ₆ : Cinnamon oil (0.02)	2.95	3.07	3.01	4.48	4.49	4.49	4.80	4.44	4.62	5.44	5.36	5.40
C ₇ : Chitosan (0.5%)	3.02	3.08	3.05	4.42	4.51	4.46	4.46	4.45	4.45	5.23	4.89	5.06
C ₈ : Acacia gum (5%)	2.96	3.06	3.01	4.57	4.50	4.53	4.82	4.50	4.66	5.40	4.88	5.14
C ₉ : Pectin (2%)	2.96	3.06	3.01	4.48	4.34	4.41	4.93	4.34	4.64	5.60	5.29	5.45
SEm. (±)	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.01	0.02	0.02	0.02	0.02
CD at 1%	NS	NS	NS	0.09	0.07	0.08	0.13	0.05	0.09	0.07	0.08	0.07
B. Packaging materials												
P ₁ : CFB box	2.95	3.06	3.00	4.38	4.37	4.37	4.75	4.42	4.58	5.46	5.12	5.29
P ₂ : Plastic crates.	2.97	3.09	3.03	4.46	4.49	4.47	4.61	4.42	4.51	5.37	5.27	5.32
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
CD at 1%	NS	0.03	0.03	0.04	0.03	0.04	0.06	NS	0.04	0.03	0.04	0.03
C. Interaction (A x B)												
C ₁ P ₁	2.92	3.05	2.98	4.03	4.28	4.16	5.12	4.38	4.75	5.81	5.35	5.58
C ₁ P ₂	2.95	3.13	3.04	4.34	4.45	4.39	4.77	4.38	4.58	5.72	5.45	5.58
C ₂ P ₁	2.97	3.05	3.01	4.30	4.16	4.23	4.30	4.42	4.36	5.26	4.85	5.06
C ₂ P ₂	3.02	3.11	3.06	4.28	4.16	4.22	4.30	4.39	4.34	5.20	4.88	5.04
C ₃ P ₁	2.96	3.08	3.02	4.47	4.50	4.49	4.60	4.47	4.54	5.13	5.09	5.11
C ₃ P ₂	2.96	3.13	3.04	4.46	4.74	4.60	4.26	4.46	4.36	5.11	5.28	5.20
C ₄ P ₁	2.95	3.08	3.01	4.37	4.41	4.39	4.67	4.48	4.58	5.60	5.34	5.47
C ₄ P ₂	2.92	3.12	3.02	4.43	4.70	4.56	4.39	4.46	4.43	5.28	5.94	5.61
C ₅ P ₁	2.92	3.05	2.99	4.46	4.11	4.29	5.15	4.30	4.73	5.47	5.25	5.36
C ₅ P ₂	2.95	3.08	3.01	4.56	4.53	4.55	4.66	4.33	4.49	5.57	5.25	5.41
C ₆ P ₁	2.93	3.05	2.99	4.47	4.57	4.52	4.72	4.44	4.58	5.49	5.32	5.40
C ₆ P ₂	2.97	3.10	3.03	4.50	4.42	4.46	4.88	4.45	4.67	5.40	5.41	5.40
C ₇ P ₁	3.00	3.08	3.04	4.42	4.43	4.43	4.51	4.44	4.48	5.28	4.85	5.06
C ₇ P ₂	3.04	3.08	3.06	4.42	4.58	4.50	4.41	4.45	4.43	5.19	4.93	5.06
C ₈ P ₁	2.96	3.05	3.00	4.50	4.38	4.44	4.97	4.50	4.74	5.57	4.72	5.15
C ₈ P ₂	2.95	3.08	3.01	4.63	4.62	4.63	4.66	4.49	4.58	5.22	5.04	5.13
C ₉ P ₁	2.94	3.06	3.00	4.43	4.46	4.44	4.74	4.31	4.52	5.53	5.29	5.41
C ₉ P ₂	2.98	3.05	3.01	4.52	4.23	4.38	5.13	4.37	4.75	5.67	5.29	5.48
SEm. (±)	0.02	0.02	0.02	0.03	0.02	0.03	0.05	0.02	0.03	0.02	0.03	0.03
CD at 1%	NS	NS	NS	0.13	0.10	0.11	0.19	NS	0.13	0.09	0.11	NS

Treatment	16 DAS			20 DAS			24 DAS			28 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	7.21	8.75	7.98	10.95	9.89	10.42	9.93	9.90	9.91	-	-	-
C ₂ : Alginate (2%)	5.43	6.10	5.77	9.72	8.39	9.06	9.42	9.51	9.46	9.66	9.16	9.41
C ₃ : Beewax (2%)	5.67	8.04	6.85	8.52	8.92	8.72	8.34	9.77	9.05	9.04	8.77	8.90
C ₄ : Aloe vera gel (75%)	6.80	8.04	7.42	9.42	8.89	9.15	9.26	10.58	9.92	9.59	9.87	9.73
C ₅ : Tapioca starch (5%)	6.82	7.95	7.38	9.58	9.02	9.30	9.46	9.83	9.64	9.69	9.63	9.66
C ₆ : Cinnamon oil (0.02)	6.85	7.92	7.39	10.39	10.10	10.24	9.86	9.70	9.78	-	-	-
C ₇ : Chitosan (0.5%)	5.34	6.05	5.70	8.12	7.74	7.93	9.01	9.37	9.19	8.74	9.20	8.97
C ₈ : Acacia gum (5%)	5.75	7.88	6.81	8.15	8.81	8.48	9.82	9.85	9.83	9.08	9.54	9.31
C ₉ : Pectin (2%)	6.77	7.84	7.30	9.32	8.75	9.04	8.82	9.90	9.36	9.66	9.74	9.70
SEm. (±)	0.02	0.03	0.02	0.04	0.06	0.05	0.03	0.06	0.04	0.03	0.03	0.03
CD at 1%	0.08	0.11	0.09	0.17	0.24	0.20	0.13	0.22	0.17	0.14	0.13	0.13
B. Packaging materials												
P ₁ : CFB box	6.29	7.63	6.96	9.12	8.74	8.93	9.07	9.59	9.33	9.10	9.14	9.12
P ₂ : Plastic crates.	6.29	7.61	6.95	9.58	9.15	9.37	9.57	10.05	9.81	9.59	9.69	9.64
SEm. (±)	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.03	0.02	0.02	0.02	0.02
CD at 1%	NS	NS	NS	0.08	0.12	0.09	0.06	0.11	0.08	0.08	0.07	0.07
C. Interaction (A x B)												
C ₁ P ₁	7.08	8.76	7.92	10.81	9.80	10.31	9.85	9.79	9.82	-	-	-
C ₁ P ₂	7.34	8.73	8.03	11.08	9.99	10.53	10.00	10.01	10.01	-	-	-
C ₂ P ₁	5.42	6.14	5.78	9.60	8.30	8.95	9.33	9.22	9.27	9.53	9.02	9.27
C ₂ P ₂	5.44	6.07	5.75	9.85	8.48	9.17	9.50	9.81	9.66	9.80	9.30	9.55
C ₃ P ₁	5.78	8.12	6.95	8.27	8.73	8.50	8.05	9.65	8.85	8.94	8.26	8.60
C ₃ P ₂	5.55	7.97	6.76	8.77	9.11	8.94	8.62	9.90	9.26	9.14	9.28	9.21
C ₄ P ₁	6.81	8.12	7.46	9.11	8.71	8.91	9.05	10.10	9.57	9.18	9.72	9.45
C ₄ P ₂	6.79	7.97	7.38	9.72	9.06	9.39	9.48	11.05	10.26	10.00	10.02	10.01
C ₅ P ₁	6.79	7.86	7.32	9.10	8.58	8.84	9.05	9.70	9.38	9.38	9.22	9.30
C ₅ P ₂	6.85	8.04	7.44	10.05	9.45	9.75	9.87	9.95	9.91	9.99	10.03	10.01
C ₆ P ₁	6.88	8.03	7.45	10.58	10.01	10.30	9.63	9.60	9.62	-	-	-
C ₆ P ₂	6.83	7.81	7.32	10.19	10.19	10.19	10.08	9.80	9.94	-	-	-
C ₇ P ₁	5.36	6.08	5.72	7.82	7.45	7.63	8.66	9.18	8.92	8.47	9.00	8.74
C ₇ P ₂	5.33	6.03	5.68	8.42	8.04	8.23	9.35	9.56	9.45	9.00	9.41	9.20
C ₈ P ₁	5.75	7.88	6.82	7.90	8.43	8.16	9.49	9.50	9.50	8.80	9.20	9.00
C ₈ P ₂	5.74	7.89	6.81	8.40	9.20	8.80	10.14	10.20	10.17	9.35	9.88	9.62
C ₉ P ₁	6.75	7.74	7.24	8.93	8.62	8.78	8.53	9.62	9.08	9.43	9.59	9.51
C ₉ P ₂	6.79	7.95	7.37	9.72	8.88	9.30	9.10	10.17	9.64	9.88	9.89	9.88
SEm. (±)	0.03	0.04	0.03	0.06	0.09	0.07	0.04	0.08	0.06	0.05	0.04	0.05
CD at 1%	0.12	0.15	0.13	0.23	0.35	0.28	0.18	0.32	0.24	0.20	0.18	0.18

Table 5: Effect of edible coatings and packaging materials on changes in ascorbic acid (mg/100g) of Kesari mango fruit during storage cold storage

Treatment	0 DAS			4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	80.21	80.22	80.21	71.50	70.60	71.05	64.27	63.26	63.76	53.63	53.02	53.32
C ₂ : Alginate (2%)	80.20	80.21	80.21	73.86	73.43	73.64	65.55	66.14	65.85	60.79	60.12	60.46
C ₃ : Beewax (2%)	80.21	80.22	80.21	74.79	74.45	74.62	66.10	66.83	66.47	61.40	58.96	60.18
C ₄ : Aloe vera gel (75%)	80.20	80.19	80.19	74.02	71.65	72.83	65.40	64.19	64.80	58.15	57.83	57.99
C ₅ : Tapioca starch (5%)	80.21	80.20	80.20	73.78	73.34	73.56	64.76	66.05	65.40	56.68	57.96	57.32
C ₆ : Cinnamon oil (0.02)	80.19	80.21	80.20	73.01	73.79	73.40	64.63	63.92	64.27	54.50	58.69	56.59
C ₇ : Chitosan (0.5%)	80.19	80.20	80.19	75.73	74.84	75.29	68.87	67.62	68.24	60.88	60.06	60.47
C ₈ : Acacia gum (5%)	80.22	80.20	80.21	74.03	72.92	73.47	66.47	65.33	65.90	59.65	58.17	58.91
C ₉ : Pectin (2%)	80.14	80.20	80.17	74.36	72.78	73.57	64.55	63.31	63.93	58.93	57.65	58.29
SEm. (±)	0.03	0.04	0.03	0.11	0.06	0.09	0.12	0.11	0.11	0.09	0.04	0.07
CD at 1%	NS	NS	NS	0.43	0.23	0.33	0.50	0.43	0.44	0.37	0.14	0.27
B. Packaging materials												
P ₁ : CFB box	80.21	80.20	80.21	74.38	73.62	74.00	66.12	66.20	66.16	58.87	58.59	58.73
P ₂ : Plastic crates.	80.18	80.20	80.19	73.42	72.56	72.99	65.12	64.16	64.64	57.71	57.51	57.61
SEm. (±)	0.02	0.02	0.02	0.05	0.03	0.04	0.06	0.05	0.05	0.04	0.02	0.03
CD at 1%	NS	NS	NS	0.20	0.11	0.15	0.24	0.20	0.21	0.17	0.07	0.13
C. Interaction (A x B)												
C ₁ P ₁	80.21	80.21	80.21	72.00	71.20	71.60	64.74	63.82	64.28	54.25	53.15	53.70
C ₁ P ₂	80.20	80.22	80.21	71.00	70.00	70.50	63.80	62.70	63.25	53.00	52.90	52.95
C ₂ P ₁	80.21	80.22	80.21	74.37	73.80	74.09	66.19	67.14	66.67	60.45	60.63	60.54
C ₂ P ₂	80.19	80.21	80.20	73.35	73.05	73.20	64.91	65.14	65.03	61.14	59.62	60.38

C ₃ P ₁	80.20	80.23	80.21	75.42	75.00	75.21	67.00	68.40	67.70	61.80	59.13	60.46
C ₃ P ₂	80.21	80.22	80.22	74.17	73.90	74.03	65.20	65.27	65.23	61.00	58.80	59.90
C ₄ P ₁	80.20	80.20	80.20	74.58	72.15	73.37	65.90	65.15	65.52	59.15	58.59	58.87
C ₄ P ₂	80.19	80.19	80.19	73.45	71.15	72.30	64.91	63.24	64.07	57.15	57.08	57.11
C ₅ P ₁	80.20	80.19	80.20	74.25	74.18	74.22	64.76	66.60	65.68	57.28	58.69	57.98
C ₅ P ₂	80.21	80.20	80.21	73.30	72.50	72.90	64.76	65.50	65.13	56.09	57.22	56.66
C ₆ P ₁	80.21	80.22	80.21	73.03	74.22	73.63	65.00	64.76	64.88	55.00	59.21	57.10
C ₆ P ₂	80.16	80.21	80.19	72.99	73.36	73.18	64.25	63.08	63.66	54.00	58.17	56.08
C ₇ P ₁	80.20	80.20	80.20	76.21	75.34	75.78	69.14	69.10	69.12	61.75	60.62	61.19
C ₇ P ₂	80.18	80.20	80.19	75.25	74.34	74.80	68.60	66.14	67.37	60.00	59.50	59.75
C ₈ P ₁	80.22	80.20	80.21	74.26	73.41	73.84	67.21	66.45	66.83	60.30	59.14	59.72
C ₈ P ₂	80.21	80.20	80.20	73.80	72.42	73.11	65.72	64.20	64.96	59.00	57.21	58.11
C ₉ P ₁	80.20	80.20	80.20	75.27	73.24	74.26	65.15	64.42	64.79	59.85	58.19	59.02
C ₉ P ₂	80.07	80.20	80.14	73.45	72.32	72.88	63.95	62.20	63.08	58.00	57.12	57.56
SEm. (±)	0.05	0.05	0.05	0.15	0.08	0.12	0.17	0.15	0.16	0.13	0.05	0.10
CD at 1%	NS	NS	NS	0.61	0.32	NS	0.71	0.61	0.63	0.52	0.20	0.38

Treatment	16 DAS			20 DAS			24 DAS			28 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C ₁ : Control	50.80	49.55	50.18	44.45	45.25	44.85	37.48	38.58	38.03	-	-	-
C ₂ : Alginate (2%)	52.92	51.66	52.29	46.30	46.45	46.38	43.94	43.55	43.74	35.16	34.65	34.91
C ₃ : Beewax (2%)	52.06	50.86	51.46	46.88	47.75	47.31	44.54	43.64	44.09	36.21	34.75	35.48
C ₄ : Aloe vera gel (75%)	50.89	49.86	50.38	45.46	45.05	45.26	43.74	42.60	43.17	32.84	31.88	32.36
C ₅ : Tapioca starch (5%)	50.73	49.90	50.32	44.65	45.25	44.95	43.58	42.80	43.19	32.45	31.88	32.16
C ₆ : Cinnamon oil (0.02)	50.54	49.98	50.26	44.58	45.75	45.16	39.76	39.18	39.47	-	-	-
C ₇ : Chitosan (0.5%)	52.87	52.07	52.47	47.33	48.15	47.74	45.51	44.70	45.10	36.78	34.96	35.87
C ₈ : Acacia gum (5%)	51.52	50.68	51.10	46.31	47.05	46.68	44.52	43.59	44.05	33.54	32.63	33.09
C ₉ : Pectin (2%)	50.63	49.64	50.13	44.75	45.23	44.99	42.45	42.77	42.61	32.48	31.64	32.06
SEm. (±)	0.02	0.02	0.02	0.06	0.02	0.04	0.05	0.08	0.06	0.05	0.03	0.04
CD at 1%	0.06	0.07	0.06	0.23	0.08	0.16	0.19	0.31	0.24	0.23	0.11	0.16
B. Packaging materials												
P ₁ : CFB box	52.10	50.95	51.52	46.18	46.79	46.48	43.58	42.66	43.12	34.81	33.76	34.28
P ₂ : Plastic crates.	50.78	49.98	50.38	45.09	45.64	45.36	42.09	42.10	42.09	33.61	32.63	33.12
SEm. (±)	0.01	0.01	0.01	0.03	0.01	0.02	0.02	0.04	0.03	0.03	0.01	0.02
CD at 1%	0.03	0.03	0.03	0.11	0.04	0.08	0.09	0.15	0.11	0.12	0.06	0.09
C. Interaction (A x B)												
C ₁ P ₁	51.55	50.05	50.80	45.00	46.00	45.50	38.20	37.90	38.05	-	-	-
C ₁ P ₂	50.05	49.06	49.55	43.90	44.50	44.20	36.75	39.25	38.00	-	-	-
C ₂ P ₁	53.58	52.16	52.87	46.60	47.00	46.80	44.97	43.90	44.44	35.73	35.12	35.42
C ₂ P ₂	52.25	51.15	51.70	46.00	45.90	45.95	42.90	43.20	43.05	34.60	34.18	34.39
C ₃ P ₁	52.63	51.36	52.00	47.05	48.50	47.78	45.15	44.13	44.64	36.71	35.25	35.98
C ₃ P ₂	51.49	50.35	50.92	46.70	47.00	46.85	43.93	43.15	43.54	35.71	34.25	34.98
C ₄ P ₁	51.55	50.39	50.97	46.10	45.60	45.85	44.33	43.10	43.72	33.58	32.37	32.97
C ₄ P ₂	50.24	49.33	49.79	44.82	44.50	44.66	43.14	42.11	42.62	32.10	31.39	31.74
C ₅ P ₁	51.50	50.22	50.86	45.30	45.80	45.55	44.20	43.10	43.65	33.10	32.65	32.88
C ₅ P ₂	49.97	49.58	49.78	44.00	44.70	44.35	42.95	42.50	42.73	31.80	31.10	31.45
C ₆ P ₁	51.12	50.52	50.82	45.20	46.20	45.70	41.02	39.25	40.14	-	-	-
C ₆ P ₂	49.96	49.44	49.70	43.95	45.30	44.63	38.50	39.10	38.80	-	-	-
C ₇ P ₁	53.53	52.50	53.02	47.95	48.69	48.32	46.10	45.19	45.65	37.28	35.70	36.49
C ₇ P ₂	52.21	51.63	51.92	46.70	47.60	47.15	44.92	44.20	44.56	36.28	34.23	35.25
C ₈ P ₁	52.11	51.17	51.64	47.02	47.60	47.31	45.14	44.00	44.57	34.15	33.13	33.64
C ₈ P ₂	50.94	50.19	50.56	45.60	46.50	46.05	43.90	43.18	43.54	32.94	32.14	32.54
C ₉ P ₁	51.30	50.14	50.72	45.40	45.70	45.55	43.09	43.34	43.21	33.10	32.14	32.62
C ₉ P ₂	49.95	49.14	49.54	44.10	44.75	44.43	41.82	42.20	42.01	31.86	31.14	31.50
SEm. (±)	0.02	0.03	0.02	0.08	0.03	0.06	0.06	0.11	0.09	0.08	0.04	0.06
CD at 1%	0.09	0.10	0.09	0.33	0.11	0.23	0.26	0.44	0.34	NS	0.15	NS

Conclusion

From the experiment to study the effect of edible coatings and packaging materials on quality of mango cv. Kesar. It can be concluded that, edible coating and packaging materials improves the quality of mango fruit. All the coated fruits showed significantly reduced weight loss and delayed changes in the ripening parameters such as TSS, acidity, sugars, ascorbic acid, of mango fruit. Coating and Packaging had significant interaction effects on the and

biochemical qualities of Kesar mango fruits in cold storage. In this experiment it can be concluded that while CFB box is a better alternate for plastic crates. From the presented research it can be said that edible coating technology is a eco-friendly and need of present era. Various food and food safety regulatory bodies and drug administration's have approved and prescribed the safe limits of edible coatings. The advantage of storage of fruit by using edible coating is

easily applicable with cheap and locally available raw materials.

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