EFFECT OF EDIBLE COATINGS AND PACKAGING MATERIALS ON SHELF LIFE AND QUALITY OF MANGO (*Mangifera indica* L.) CV. KESAR

by

Ms. Kharwade Soni Balasaheb
(Reg. No. 017/50)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

HORTICULTURE (FRUIT SCIENCE)

DEPARTMENT OF HORTICULTURE

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. - AHMEDNAGAR
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APPROVED BY

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MAHARASHTRA, INDIA
2023

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV., Rahuri

Date : / /2023

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF EDIBLE COATINGS AND PACKAGING MATERIALS ON SHELF LIFE AND QUALITY OF MANGO (*Mangifera indica* L.) CV. KESAR"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.) in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **HORTICULTURE (FRUIT SCIENCE),** embodies the results of a piece of *bona fide* research work carried out by **Ms. KHARWADE SONI BALASAHEB,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

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Place : MPKV., Rahuri

Date : / /2023 **(B.D. Bhakare)**

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I wish to end this note by expressing thanks to all those whom, I able to recall here and also to those I might have left unknowingly.

Place: MPKV., Rahuri.

Date: / /2023. (Kharwade S. B)

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LIST OF ABBREVIATIONS

%	:	Per cent
/	:	Per
@	:	At the rate of
<	:	Less than
µg	:	Microgram
µL	:	Microlitre
^{0}B	:	Degree brix
^{0}C	:	Degree Celsius
Anon.	:	Anonymous
AOAC	:	Association of Official Analytical Chemists
CFB	:	Corrugated Fibre Boxes
CO_2	:	Carbon di oxide
cv.	:	Cultivar
DOS	:	Days of storage
Ed.	:	Edition
et al.	:	and others
etc	:	Etcetra
FCRD	:	Factorial Completely Randomize Design
Fig.	:	Figure
g	:	Gram (s)
H_2O	:	Water
i. e.	:	ID est (that is)
J.	:	Journal
kg	:	Kilogramme (s)
L.	:	Linnaeus
m	:	Meter (s)
M.S.	:	Maharashtra State
MAP	:	Modified Atmospheric Packaging
mg	:	Milligram

min.	:	Minute
ml	:	Millilitre
mm	:	Millimetre
mM	:	Millimolar
MPKV	:	Mahatma Phule Krishi Vidyapeeth
No	:	Number
NS	:	Non significant
O_2	:	Oxygen
pH	:	Potenz (-log[H+])
PLW	:	Physiological loss in weight
ppm	:	Parts per million
RH	:	Relative humidity
Sci.	:	Science
Sel.	:	Selection
SEm	:	Standard error of mean
SIG	:	Significant
Treat	:	Treatment (s)
TSS	:	Total soluble solids
U	:	Unit
Univ.	:	University
UV	:	Ultra violet
V	:	Volt
Var.	:	Variety
Viz.,	:	Videlicet (Namely)
w/v	:	Weight by volume
β		Bita

ABSTRACT

"EFFECT OF EDIBLE COATINGS AND PACKAGING MATERIALS ON SHELF LIFE AND QUALITY OF MANGO (*Mangifera indica* L.)"

by
KHARWADE SONI BALASAHEB
A candidate for the degree
of
DOCTOR OF PHILOSOPHY (HORTICULTURE)
in
FRUIT SCIENCE
2023

Research Guide	:	**Dr. V. R. Joshi**
Department	:	**Horticulture**

The present investigation entitled "Effect of edible coatings and packaging materials on shelf life and quality of Mango (*Mangifera indica* L.) cv. Kesar" 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 Randomized Design, which is replicated twice with two factors i.e. Factor A: edible coating, *i.e.* C_1-Control (without coating), C_2-Alginate (2 %), C_3-Beeswax (2 %), C_4-Aloe vera gel (75 %), C_5-Tapioca starch (5 %), C_6-Cinnamon oil (0.02 %), C_7-Chitosan (0.5 %), C_8-Acacia gum (5 %), C_9-Pectin (2 %). Factor B: packaging materials, *i.e.* P_1-Corrugated Fibre Boxe and P_2-Plastic crates. In this experiment, freshly harvested, mature, firm 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 at two different storage conditions viz. ambient temperature (AT) (26-30^{0}C with 54-62 % R.H) and cold storage (CS) (13^{0}C with 90-95 % R.H). Observations were taken at 4 days intervals up to the end of shelf life.

The coated fruits of mango packed and were stored at ambient temperature and cold storage it was found that there was increase in TSS, pH, sugars, and β-carotene with corresponding decrease in acidity, ascorbic acid, fruit firmness upon prolonged storage of mango fruit under both storage condition. Physiological loss in weight, spoilage increase during storage periods in all the coated fruits under both storage condition. Fruits stored under cold storage conditions observed physico-chemical changes at a slower rate as compared to ambient temperature storage.

Fruit coated with beeswax 2% (T_2P_1) packed in CFB box at ambient temperature recorded significantly lowest PLW and higher firmness during storage. Fruit coated with chitosan 0.5% (T_7P_1) packed in CFB box recorded significantly lowest TSS, total sugars, non-reducing sugars, reducing sugars, pH, β-carotene and higher acidity, ascorbic acid and also recorded minimum shriveling spoilage delay fruit ripening and longest shelf life during storage. Higher sensory score for longer storage period was recorded in treatment T_7P_1 (chitoan 0.5%+ CFB box)and T_3P_1 (beeswax 2%+ CFB box).

Fruit coated with beeswax 2% (T_2P_1) packed in CFB box in cold storage recorded significantly lowest PLW and higher firmness during storage. Fruit coated with chitosan 0.5% (T_7P_1) packed in CFB box recorded significantly lowest TSS, total sugars, non-reducing sugars, reducing sugars, pH, β-carotene and higher acidity, ascorbic acid and also recorded no shriveling, minimum spoilage, delay fruit ripening and longest shelf life during storage. Higher sensory score for longer storage period was recorded in treatment T_7P_1 and T_3P_1.

The shelf life of control fruits (without coating) was found to be hardly 12 days at ambient temperature. The shelf life of fruit coated with chitosan 0.5% and beeswax 2% packed in CFB box was extended upto 16 days at ambient temperature during storage.

The shelf life of control fruits (without coating) was found to be hardly 20 days in cold storage. The shelf life of fruit coated with chitosan 0.5% and beeswax 2% packed in CFB box was extended upto 28 days in cold storage during storage.

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1. INTRODUCTION

Mango (*Mangifera indica* L.) is sub-tropical fruits which is rightly known as "King of Fruits". It is the national fruit of India because it has always had a close connection to the social, religious, artistic, and economic life of Indians. It is a native of South East Asia, mainly the Indo Burma region in the Himalayan foothills (Mukhrjee, 1997). Mango is member of *Anacardiaceae* family. Mangoes can grow on a wide variety of soils and in a wide variety of climatic conditions. For its growing, a temperature range between 24^0C and 27^0C is optimum. It can be grown in regions with annual rainfall of 25 to 250 cm. Mango trees thrive best in areas with bright, sunny days and moderate humidity during blossoming.

Since well over 4,000 years ago, the fruit has been produced on the Indian subcontinent and monarchs and regular people have both enjoyed it because of its nutritious content, flavour, attractive aroma, and health-improving properties. owing to its versatility, richness in variety, delicious taste, pleasant flavor, attractive appearance, high nutritive value, it enjoys the unique popularity all over the world. The mango is a delicious fruit that both kids and adults enjoy. It is more nutritional and a rich source of minerals, carbs, and vitamins, including vitamin A (4800 I.U.). On average, there are 50-60 mg of calories in every 100g. Mango fruit that is ripe is digestive, diuretic, and fattening. Mango fruit can be utilised for more than just eating, it can also be made into pickles, jam, mango powder (amchur), mango leather (ampapad), and mango fool (mango + milk + sweets) (Singh, 1992).

Currently, mango is cultivated in over 111 countries across five continents. India is the largest mango fruit producer in the world with an area of 2.29 million hectare, annual production of 20.79 MT and productivity of 8.7 MT per hectare which is far below than world average, in India, mangoes cover around 34.9% of the nation's total area cultivated with fruit. Uttar Pradesh, Andhra Pradesh, Maharashtra, Bihar, Tamil Nadu, Orissa, Kerala, Karnataka, West Bengal and Gujarat are Major mango growing states. Mango cultivation covers 0.16 million hectares in Maharashtra, with 5.59 million tones mango production and 4.8 MT per hectare productivity (Anonymous, 2021).

Mango's main variety for export and commercial cultivar is Kesar. Additionally, it is the variety that processors of mango pulp favour. Due to the Kesar variety's better production, regularity in bearing, outstanding fruit quality, pleasant flavour, and overall high economic value, more land is being planted with it not just in Gujarat but also in surrounding states like Maharashtra, Rajasthan and Madhya Pradesh. It is renowned for its quick development, improved consumer acceptability, appealing form and size, fruit pulp colour, and good keeping qualities. Excellent sugars and a good processing quality acid mix are present. The dominant commercial mango cultivar of Gujarat and Maharashtra is Kesar, sometimes known as the "queen of mangoes." It is often favoured for domestic markets, but it is increasingly popular in export markets.

Edible coatings are 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, Waewthongrak *et al*., 2015). Healthy and eco-friendly post-harvest technologies are very demanding now-a-days (Prasad and Sharma, 2016). A thin layer of substance that creates a barrier of protection around a food item and may be ingested with it is referred to as an edible coating. (Guilbert, 1986). Food products had long be preserved with edibal coating, which also improves their look. Fruit covered with wax is the most popular example and it's thought that China used them as early as the 12th century (Dalal *et al.,* 1971). Coatings are used to modify the environment and prevent PLW during storage and transport (Baldwin, 1994). In fact, there has been a lot of recent interest in the barrier qualities to gases (O_2, CO_2 and ethylene) exchange for coatings (Tripathi and Dubey, 2004). Fruit respiration can be managed, and microbial development can be reduced by developing films with specific permeability characteristics, particularly to O_2, CO_2, and ethylene (Cuq *et al*., 1995). Edibale coatings are a suitable substitute for protective coating wax (Zahid *et al*., 2012) because they are more environmentally friendly than film packaging, coatings are a desirable substitute (Rojas-argudo *et al.,* 2005). They are brushed, sprayed or dip directly on the food surface (Mchugh and Senesi, 2000). Edible coatings are having hydrophobic group, for example lipid-based or waxes, and hydrocolloids or hydrophilic group, for example polysaccharides-based, protein based or combination of both groups to improve function of edible coating (Warriner *et al*., 2009). Edible coating materials are generally made up of polysaccharides, proteins and lipids (Pascall and Lin, 2013).

Alginate is obtained from brown sea weed, which belongs to the *Pheophyceae* family. Alginate contains salts of Alginic acid. Alginate having a linear chain copolymer of D-mannuronic acid L-guluronic acid monomers, the chemical formula of alginate is $(C_6H_8O_6)n$. It is found in white, yellow, fibrous powder form. Alginate is commonly used in form of sodium alginate this is extracted from brown algae. Alginate is commonly used in form of sodium alginate this is extracted from brown algae. Alginate contain excellent barrier for moisture and water vapour (Robertson, 2009). Alginate coating, a biodegradable compound, can be utilized to preserve the quality of vegetables and fruit during storage (Somayeh *et al*., 2019).

Aloe vera plant constitute many multifarious ingredients including glycoproteins, phenolic compounds, lignins, amino acids, vitamins, hormones, polysaccharides, saponins, salicylic acid, and enzymes. These constituents give very much beneficial characteristics to Aloe vera. By this, aloe vera plant got a great importance in medicinal use, curing many diseases and solving most of health problems. It functions as an inflammatory reducer, an antibacterial, and an antifungal. Additionally, it is used to treat diabetes, ulcers, radiation damage, gastrointestinal issues, skin conditions, constipation, and wounds and burns that are healing. Aloe vera is also been a considerable product for cosmetic, pharmaceutical and food industries. Aloe vera have antimicrobial activity against bacterial pathogens from gram positive and gram negative. Due to its therapeutic and functional properties and useful aspects, using aloe vera as a bio-preservative in many food product is increased (Rajeswari *et al.,* 2012; Sharma and Gautam, 2013; Yagi *et al*., 1998). An innovative edible coat for organic fruit preservation is aloe vera gel. Films made of aloe vera gel have been found to delay oxidative browning, inhibit microbe growth, regulate respiration rate, maintain firmness, and prevent moisture loss in fruits (Castillo *et al*., 2010). (Padmaja and Bosco 2014a) They showed that aloe vera coating has antifungal properties and reduced the microbial growth of fungi and bacteria. Aloe vera gel coating had a considerable impact on how well jujube fruits were perceived by the senses.

A bioactive substance used for commercial or therapeutic purposes. A modified version of chitin, chitosan is a natural carbohydrate polymer, they are present in many different natural sources, including crustaceans, algae, insects, and fungus (Tolamite *et al*., 2000). (Cho *et al*., 2008; Matsuhashi and Kume 1997). It prevents a range of bacteria from growing (Sudarshan *et al*., 1992). A natural substance called chitosan is used as a fruit covering to extend shelf lives of fruits (Graham, 1990).

A polymeric carbohydrate called starch is made up of several glucose units connected by glucosidic linkages. The storage polysaccharide known as starch is a used raw material for a number of industrial applications and is present in cereals, tubers, vegetables, and legumes. The most popular sources of starch-rich foods are cassava, potatoes, bananas, etc. Both amylose and amylopectin are present. Starches are a good oxygen barrier and are used to edibal coat fruits and vegetables with high respiration rates (Durango *et al.,* 2006).

The gums are soluble in water since they are made of polysaccharides. They consist of microbial fermentation gums (xanthan and gellan), locust bean and guar extractive gums and exudate gums (gum Arabic) (Al-juhaimi, 2012). In plants, pectin is mostly present in fruits and vegetables like guava, apple, etc. An anionic polysaccharide made up of -1, 4-linked d-galacturonic acid residues, pectin is complicated (Sanchez, 2016).

Apples, citrus, tomato and cucumber have previously been covered (waxes). However, there is little information available on their usage on apricot, date, guava, mango, pineapple, banana, cherrie, melons, nectarines, or peaches. (Baldwin, 1994). However, in recent years, materials with protein and polysaccharide coatings have been developed for use on a variety of fruits. The cellulose- sucrose fatty acid esters on apricot are among these materials (Sumnu and Bayindirli, 1995), chitosan on strawberry (El-Ghaouth *et al*., 1991). cellulose covered mango (Baldwin *et al.,* 1999) and guava (McGuire and Hallman, 1995).

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 mango, apple, grapes, etc. are packed in small packs of 2-4 kgs, either in CFB boxes made of paper board or polymers like polypropylene. These boxes/cartons are light-weight with good compression strength. Plastic crates are typically injection moulded from HDPE or PP. While polypropylene has stronger scratch resistance, polyethylene has a higher impact strength and exhibits little UV damage. Through the use of permeable polymeric sheets, modified atmosphere packaging (MAP) refers to the creation of an MA around the produce. (Kader *et. al*., 1989). Anwar *et al.* (2003) and Singh *et al*. (2008), Packaging reduces water loss and delays ripening in mango fruit.

Mango is a climacteric fruit, therefore reducing respiration, reducing ethylene production and repairing mechanical damage can all postpone mango fruit ripening (Yahia *et al*., 2006). Organic material in living cells is continually broken down during respiration by using O_2 and releasing CO_2, H_2O and energy. Respiration is a metabolic process. Fruit respiration rate is a crucial factor to consider while creating storage conditions (Nakamura *et al*., 2004). The most crucial environmental element affecting the fresh fruit's shelf life is temperature. Fruit can have a prolong the shelf life when stored at low temperatures and high relative humidity because it slows down respiration. Additionally, a good storage environment has a significant influence on lowering post-harvest losses, extending the post-harvest life, and maintaining fruit quality and increase shelf life of fruit. The three main components for fruit of high quality are storage at an appropriate temperature, relative humidity, and packing materials. The ripening peak of mangoes, a highly perishable fruit with a very short shelf life, occurs on the third or fourth day after harvesting at ambient temperature (Narayana *et al*., 1996). Mango have a different shelf life depending on how they are stored. It lasts 4 to 8 days at ambient temperature and 2-3 weeks when stored in a refrigerator at 13^{o}C. (Carrillo *et al*., 2000). This small period severely limits the long-distance commercial transportation of this fruit (Gomer-Lim, 1997). Typically, mature green mango take 9 to 12 days to ripen after harvest (Herianus *et al.,* 2003).

Different effective pre-harvest methods to increased the shelf life are well studied. However, post-harvest treatment to increase shelf life are of immense importance as it will help to reduce or minimize the post harvest losses and cost on post harvest treatments. To minimize the post harvest losses, the post harvest treatments *viz.,* edible coating, packaging, cold storage are found to be effective.

During recent days, the consumers are becoming more and more health conscious and ready to pay more for quality fruits, without chemical and extended the shelf life. Today's growing interest among producers in the development of high-quality fruits is a result of the rising demand for excellent food. Very little information is available about edible coating for improving quality and increasing shelf life of mango under Maharashtra condition. There is a demand from extension agencies and the mango growers are also asking for the technology which will be useful for quality and shelf life mango fruits. Hence, considering the need and importance the present investigation " Effect of edible coatings and packaging materials on shelf life and quality of mango cv. Kesar (*Mangifera indica* L.)" cv Kesar is planned with following objectives.

1. To study the effect of edible coatings and packaging materials on shelf life of mango cv. Kesar.
2. To study the effect of edible coatings and packaging materials on quality of mango cv. Kesar.

2. REVIEW OF LITERATURE

The Mango is sub-tropical fruit crop, however grown in tropical region also. It is grown in different countries of the world. In India 2.29 million hectares are under mango cultivation which produces 20.79 million tones production (Anonymous, 2019). Among different states of India, Maharashtra having is 0.15 million hectares area under cultivation, which produces 5.14 million tones mango. Mainly growing districts are Ratnagiri, Ragarh, Sindgudurg, Alibaugh (Anonymous, 2019). The number of mango varieties under commercial cultivation in India viz. Dasehari, Chausa, Langara, Fazli, Bombay green of North India, for South India Neelum, Banglora, Banganpalli, Malgoa, and Suvarn-Rekha, while in Eastern part, Himsagar, Langara, Fazli, Kishan bhog and Zardola. The Maharashtra is belonging to west India, where 'Kesar', 'Alphanso' and 'Rajapuri' are the main varieties. Looking to the area under cultivation and production of mango varieties in Maharashtra, it is important to look in-to post harvest management practices viz. harvesting, grading, packaging, transportation, ripening and marketing in local, domestic and export market and to improve the management practices for extending shelf-life by applying various treatments and appropriate packaging materials. these aspects, definitely affect the quality of fruits which goes in the consumers hand because mango fruit is climacteric fruit which start fast ripening process and rate of respiration increasing with advancement of ripening, more over during packaging and transportation fruits passes through the several adverse condition.

Hence, the experiment was conducted to study the "Effect of edible coatings and packaging materials on shelf life and quality of Mango cv. Kesar (*Mangifera indica* L.)" The research works carried out by past workers is on various aspects of post harvest treatments and packaging reviewed in this chapter. Brief review of literature related to physico-chemical composition and changes during ripening in different storage conditions are presented under following heads.

2.1 Effect of different coating on shelf life and quality parameters of fruits.

2.2 Effect of different packaging on shelf life and quality parameters of fruits.

2.3 Effect of temperature on storage life of fruits.

2.4 Effect of different postharvest treatments on of fruit quality and physical parameters.

2.1 Effect of different coating on shelf life and quality parameters of fruits

Baldwin *et al.* (1999) reported that mango fruit coated with Polysaccharide-based coating and carnauba wax both coating created modified atmospheres, reduced decay, and improved appearance by imparting a shine and polysaccharide coating delayed ripening of mango fruit and increased concentrations of flavor volatiles. The carnauba wax coating significantly reduced water loss compared to uncoated and polysaccharide-coating treatments.

Bhaskara *et al.* (2000) studied chitosan effect on black mold rot pathogenic factors produced by *Alternaria alternata* in postharvest tomato they observed that stem scar application of chitosan inhibited growth and production of pathogenic factors by black mold rot (*Atternaria alternata*) in challenge tomato fruit stored at 20^0C for 28 days as compared to control.

Bautista-Banos *et al.* (2006) reported that both soil and foliar plant pathogens fungal, bacterial and viral may be controlled by chitosan application. In addition to its direct microbial activity, chitosan induces a series of defense reactions correlated with enzymatic activities. Due to its ability to form a semi permeable coating, Chitosan extends the shelf-life of treated fruit and vegetables by minimizing the rate of respiration and reducing water loss.

Cho *et al*. (2007) reported the natural polymers are much more suitable components for the production of food packaging than synthetic polymers, natural polymers are biodegradable. Biopolymers may be applied in the production of food coatings and packaging to replace undurable plastic packaging.

Po-Jung Chien *et al.* (2007) studied that effects of edible chitosan coating on quality and shelf life of sliced mango fruit and they reported that manually sliced mango was treated with aqueous solutions of 0, 0.5, 1 or 2 per cent chitosan placed into plastic trays, and over-wrapped with PVDC film and then stored at 6^0C. A chitosan coating retarded water loss and the drop in sensory quality, increasing the shelf life.

Wang *et al*. (2007) studied the quality and shelf life of mango coated by using chitosan and polyphenols they found that chitosan-based coatings used to delay ripening and prolong shelf-life of mango fruit stored at 15 ± 1^0C and 85-90 per cent RH for 35 days. Mango fruits were treated with 2 per cent chitosan solution or with 2 per cent chitosan costing containing 1 per cent tea polyphenols (TP- chitosan). Chitosan coating decrease the decay incidence and weight loss of mango fruit during storage. While coating the fruit with TP-chitosan was more effective at keeping quality of the fruit during storage

Castillo *et al.* (2010) they applied of aloe vera gel on table grapes vineyard 7 days before harvesting. The respiration rate and weight loss were reduced and ripening rate such as color and firmness were delayed in table grapes when stored for 35 days in cold storage after harvest reported that aloe vera gel is an excellent pre harvest treatment for maintaining the postharvest quality of table grapes.

Valera *et al.* (2011) studied that the use of edible coating and low temperature for keeping the quality on storage of mango 'Bocado' fruit. Fruits were treated with 2 per cent starch solution, 3 per cent methyl-cellulose, and 2 per cent chitosan solution and non-coated control, The result of this study suggests that the coating formulations increased the shelf life of mangoes without perceptible losses in quality. At 4-day intervals, fruits were evaluated for firmness and weight loss. All three coatings reduced weight loss even though there were not significantly differences among coated treatments.

Zambrano *et al.* (2011) studied the effects of three coatings on some quality aspect of mango fruit 'Bocado' during storage evaluated the effects of different edible coatings on mango fruit, Results indicated that total soluble solid, reducing sugar content and pH were significantly lower in coated fruits compared to controls.

Adetunji *et al.* (2012a) studied the effect of aloe vera gel on the postharvest life of oranges. They treated orange fruits with aloe vera gel and stored at the temperature of 27^0C. They reported that an increase in the weight loss, firmness and TSS in the untreated fruits while retained in the fruits treated with Aloe vera gel. The shelf life of oranges increased up to 5 days without any negative changes in its quality parameters.

Adetunji *et al*. (2012b) investigated the effects of edible coatings from Aloe vera gel on quality and postharvest physiology of *Ananas comosus* L. fruit during ambient storage. They applied aloe vera gel on pineapple for the extension of its postharvest life of pineapple stored at the temperature of 27 ± 2^0C and relative humidity of 55 to 60 per cent for seven weeks. The parameters of the study were weight loss, ascorbic acid, pH and firmness of the fruit which were significantly controlled and also found that aloe vera gel is edible, healthy and environment friendly and a very good alternative of postharvest chemicals.

Keqian *et al.* (2012) reported the effect of chitosan costing on physiochemical characteristics of 'pear" guava fruit. The fruit were treated with 0.5, 1.0 and 2.0 per cent chitosan coatings, respectively, and then stored at 11^0C and 90-95 per cent RH, Treatment with 20 per cent chitosan significantly delayed changes in chlorophyll content and soluble solids content during 12 days of storage.

Abd-alla and Haggag (2013) studied that the use of some plant essential oils i.e. basil oil, orange oil, lemon oil and mustard oil to reduce postharvest losses induced by *Colletotrichum gloeosporioides* (Penz.) in mango fruits. Results of the present study showed that orange oil at all tested concentrations were significant in reducing the fungal linear growth if compared with other tested essential oils. At low concentration 50 (µg/ml) orange oil caused 10.0 per cent reduction in fungal growth, while at 100 (µg/ml) caused 72.2 per cent and at high tested concentration 150 (µg/ml) caused a complete reduction in mycelium linear growth of pathogenic fungus.

Adetunji *et al.* (2014) studied the effect of chitosan coating combined Aloe vera gel on cucumber post-harvest quality during ambient storage. They observed that applied aloe vera gel with the combination of chitosan on the cucumber to improve its quality and extend it postharvest life. They stored the treated cucumber at the temperature of 25^0C for 7 weeks. The post-harvest quality attributes like TSS, firmness, ascorbic acid contents, acidity and weight loss were maintained with Aloe vera gel treatment as compared to the control.

Padmaja and Bosco (2014a) reported that application of aloe vera gel (1:3) on jujube after postharvest of Jujube fruits and stored it at the temperature of 5 ± 2^0C for 45 days. The organoleptic and physicochemical analysis of Jujube fruits showed that aloe vera gel maintained all the postharvest parameters of Jujube fruits treated with aloe vera gel while the untreated fruits lose their physical as well as chemical characteristics after 21 days of storage. They also found that aloe vera gel has antifungal properties and reduced the microbial growth of fungi and bacteria. Aloe vera gel also significantly affected the sensory evaluation of Jujube fruits.

Padmaja and Bosco (2014b) used Aloe vera gel (1:2) on the Sapota (Manilkara zapota) fruits to prolong its shelf life, reduce the fungal and bacterial growth and maintain all its quality attributes including sensory evaluation. They used dip technique for this purpose and dipped all the fruits in the Aloe vera gel for 7 minutes and then stored it in cool temperature of 5 ± 2^0C for 20 days. The comparison of both the treated and untreated fruits showed that the quality attributes of untreated sapota fruits loss all the quality attributes after 10 days of storage however the sapota fruits treated with aloe vera gel retained all its quality attributes up to 20 days.

Shweta *et al.* (2014) investigated the efficacy of chitosan and calcium chloride on post harvest storage period of mango with the application of hurdle technology. The result revealed that treated fruits and controls were stored at 15 ± 1^0C and 85 per cent RH with chitosan and calcium chloride separately and 60 days shelf life was recorded. But 65 days shelf life period was noticed when treated with chitosan and calcium chloride in combination i.e. with hurdle technology. Fruit firmness, weight loss, skin color, microbial counts, total soluble solids and total titratable acidity were evaluated. Calcium chloride was notably more effective when applied in combination of chitosan. But in all the controls, the decaying process was started after 7 days in similar conditions.

Gerefa *et al.* (2015) studied the effect of ginger and cinnamon essential oil treatments on mango anthracnose disease management, quality and shelf life extension of mango fruit. They revealed that minimum incidence (38.1%) and severity (26.67%) were recorded in ginger (0.45%) and cinnamon (0.075%) treated fruits 25 days after treatment respectively

Padmaja *et al*. (2015) aloe vera gel coated Sapota fruits packed in LDPE and stored at 15 ± 2^0C were studied. Reported that the dip treatment of aloe vera gel coating 1:2, 7 minutes had best retained the physico chemical characteristics than the other treatments performed and was found to be the most effective treatment in maintaining the fruit quality attributes along with the shelf life extension of about 20 days.

Yage *et al.* (2016) studied the preservation mechanism of chitosan-based coating with cinnamon oil for fruits storage based on sensor data they reported that the antifungal property of cinnamon oil should be mainly due to its main constituent, trans-cinnamaldehyde. It is also proportional to the concentration of oil and the attachment time. Compared to the normal cell, the wizened mycelium of A. flavours around the inhibition zone is observed, and the growth of spores could be inhibited completely. These indicate that the preservation mechanism of chitosan-oil coating should be due to the micropores structure of chitosan coating as the carrier and the antifungal activity of oil, which could slow the respiration rate and control the decay of fruits during the storage period. The antioxidant mechanism of chitosan-based coating and cinnamon oil, such as the *in vitro* and *in vivo* antioxidant activity and mechanism of cinnamon oil, the influence mechanism of chitosan-oil coating on the defense-related enzymes, free radical scavenging activity, and the permeability and integrity of fruit cell membrane in fruits.

Valentina and Giovanna (2016) studied the effect of chitosan and sodium alginate edible coatings on the postharvest quality of fresh-cut nectarines during storage they reported that alginate coating showed lower values of firmness and lightness during storage and lower values of total soluble solid content at the end of storage. The chitosan coating decreased the metabolism activity of fruit during storage and showed lower weight loss, and higher values of lightness, firmness and total soluble solid content compared with the other treatments. Moreover, the chitosan coating controlled the growth of microorganisms. The chitosan coating appears to be a promising preservation alternative and an effective method to improve the quality and shelf life of nectarines in marketing conditions.

Kannan (2016) reported that coated guava fruit with edible materials (2 % neem oil + 2 % corn starch or 2 % rice starch) to delay the ripening and to extend the storage life. The treated fruit were packed in LDPE and stored at low temperature (6^0C) and ambient condition (25^0C). In general, all treatments caused significant decrease in physiological loss in weight, fruit firmness, pectin content and total acidity. Fruit stored at ambient condition (25^0C) developed faster ripening, pleasant flavor and over softening on further storage. The optimum temperature for storage of guava fruit was 6°C and 90-95 % RH for maintaining highly acceptable sensory quality. At this temperature the fruit had attractive colour, pleasant flavor and acceptable quality and can be stored up to 5-6 weeks.

Amulya *et al*. (2016) studied the effect of edible coating (1 % bee wax in rice bran oil) and modified atmosphere packaging on quality of mango during storage and revealed that bee wax coated mango fruits in combination with modified atmosphere packaging condition created by LDPE bags of 210 ± 1 gauge thickness (0 % perforation) could store the Cv ‘Moovandan’ for 20 days in cold storage under set condition with acceptable quality. While the fruits stored under ambient condition of the same treatment lasted only for seven days.

Joslin and Athmaselvi (2016) effect of polysaccharide based edible coating made up of sodium alginate and pectin (2 %) was studied on the shelf life of sapota fruits and the coating of the fruits is done by dipping method and fruits were stored at refrigerated temperature (4 ± 1^0C) coated sapota fruits showed that, the polysaccharide coating was effective in maintaining the organoleptic properties of the fruits.

Ajeethan and Mikunthan (2016) studied the effect of aloe vera gel to extend the shelf life of ampalavi mango fruits. They revealed that the ripening was delayed due to the coating. The weight loss percentage was significantly higher in control fruits (8.46 %), whereas, the lower weight loss percentage (1.13 %) was found in 100 per cent gel coated fruits after 12 days of storage.

Wong *et al.* (2016) conducted an experiment on quality of chok anan mango as affected by tapioca-sago starch coating solutions stored at room temperature. They proved that all tapioca-sago coating prolonged the storage life of chok anan mangoes by delaying the yellow peel color development and activity of fruit softening as well as slowing down the decrement of the ascorbic acid content as compared to uncoated sample throughout the 13 days of storage. Mangoes coated starch solutions were more effective in delaying the ripening process by inhibiting the pathogen development, retarding the fruit weight loss as well as slowing down the changes of soluble solids and acidity content at the end of storage (day 13).

Li *et al*. (2017) Strawberry is coated with three polysaccharide-based edible coating (alginate, chitosan and pallulan) during cold storage (4^0C), from the studies it was able to conclude that a significantly delay in fruit softening and rot and reduces change in TSS and titratable acidity during 16^{th} day of storage. Polysaccharide coating also maintained higher ascorbic acid and total phenolic contents then control from 2^{nd} day of storage and significantly inhibited fruit decay and respiration after 12^{th} day of storage.

Patel *et al.* (2017) studied the effect of organic coating on shelf life and quality of organically grown Mango cv. Kesar and results showed that among the different organics and coating, application of 80 % N through neem cake + azotobacter + PSB (50 g each /tree) and 5 % acacia gum coating were found to be most beneficial for improving quality and shelf life of fruits.

Abonesh *et al*. (2018) two mango varieties (Apple and Tommy Atkins) coated with beeswax and chitosan at different concentrations (0.5, 1.5, 2 %), results showed that, beeswax 2 per cent and chitosan 2 per cent coating significantly reduce physiological loss in weight (%), TSS (^{0}Brix), titratable acidity (%), pH, disease incidence (%), disease index (%), maintain firmness (N) and prolong shelf life of fruits.

Tamiru (2018) studied effect of aloe vera gel coating, and combined with citric acid treatments on shelf life and quality of mango during storage and they find out potential application of natural aloe vera gel with citric acid coatings for enhancing the postharvest shelf life and maintaining quality of mango fruit.

Monserrat *et al*. (2018) studied effect of an edible coating based on chitosan and oxidized starch on shelf life of *Carica papaya* L., and its physicochemical and antimicrobial properties. They reported that edible coatings exhibited a positive effect on papaya shelf life kept at room temperature, preserving its properties during a longer storage time than uncoated fruits. Coating helped to provide larger papaya pulp firmness, indicating that uncoated papaya reached a final stage of ripening after 5 days, whereas the coated fruit reached this stage after 15 days at room temperature. Volatile compounds characteristic of papaya fermentation, such as ethyl butanoate, appeared after 5 days, whereas coated fruits generated it after 10 days. In addition, butyric acid generation was about 10 times higher in uncoated than in coated papayas throughout the 15 days of storage. Papaya surfaces with edible coating showed higher homogeneity values than the uncoated fruit at all storage times. Microbial population of papaya surfaces decreased during storage in the coated fruits, whereas the opposite occurred in uncoated papayas. Therefore, this coating can successfully increase papaya shelf life.

Deepika *et al.* (2018) they reported that the maximum change was observed in case of uncoated materials. The minimum change in TSS was 22.9 per cent in 4% carboxymethyl cellulose coated samples. The physiological weight of samples decreases gradually during storage and minimum weight loss of 13.7 per cent was obtained in case of 4 per cent carboxymethyl cellulose coated. The size loss was minimum 13 per cent for 4 per cent carboxymethyl cellulose coated fruits. The ascorbic acid loss was also observed during storage and it was minimum 10 per cent for 4 per cent carboxymethyl cellulose coated samples.

Prasad *et al.* (2018) they reported that edible coating it positively affects physical (moisture retention, glossiness, appearance, firmness), physiological (respiration rate, ethylene evolution rate), and biochemical attributes (cell wall degrading enzymes) attributes of horticultural commodities.

Wissam (2019) studied the effect of alginate and chitosan edible coating enriched with olive leaves extract on the shelf life of sweet cherries (*Prunus avium* L.) they proved to retard the ripening process of sweet cherries with a maximum retention of phenolic compounds compared with uncoated fruit samples. Moreover, the retention of phytochemicals was correlated with better antioxidant capacity in samples coated with chitosan enriched by olive leaves extract.

Abdul and Naveed (2019) they reported that aloe vera gel prevents loss of moisture and firmness, control respiration rate and maturation development, delay oxidative browning, reduce microorganism proliferation and other parameters like titratable acidity, soluble solids content, ascorbic acid content, firmness and decay percentage also controls significantly.

Somayeh *et al*. (2019) studies effectiveness of alginate coating on antioxidant enzymes and biochemical changes during storage of mango fruit. The results of this study showed that using sodium alginate coating at 3 per cent concentration had a significant effect on preventing water loss, color changes and preserving anti- oxidant properties, phenol and flavonoids compounds of mango fruit during storage.

Abdul *et al.* (2020) studied the antibacterial and antifungal activity of aloe vera plant. They observed that Aloe vera plant significantly restrict the growth of bacteria except tested fungi and fungi strain less sensitive in contrast to bacterial strain against aloe vera ethanol extract. Aloe vera plant is reliable and has potential to cure bacterial infection in contrast to conventional antibiotics.

2.2 Effect of different packaging on shelf life and quality parameters of fruits

Packaging are used to compact, protect and for easy handling of the commodities. In the modern market the appearance, design, shape and dimensions with attractive look are also necessary for sale commodities. For the mangoes the boxes are change according to varieties. Generally various types of CFB boxes are use for the mangoes. The use of CFB boxes for packaging for the domestic market is also the need of the hour due to scarcity of the wood and environmental concerns of the country. For export purposes, CFB boxes are already in extensive use. Paper scraps, newspapers, etc., are commonly used as cushioning material for the packaging of fruits which prevent them from getting bruised and spoiled during storage and transportation. Polythene (LDPE) lining has also been found beneficial as it maintains humidity, which results in lesser shrinkage during storage. Wrapping of fruits individually (Unpack) with newspaper or tissue paper and packing in honey comb structure helps in getting optimum ripening with reduced spoilage. Normally lid of the wooden boxes is nailed with an area of 5 to 7 cm high in the middle. This puts pressure on the fruits during transport and results into reduced quality. For the same purpose and to extend the shelf-life of the live commodities lots of research work were carried out by various scientists.

Chauhan *et al.* (1987) reported that the mango fruits harvested at tapka stage packed in wooden boxes with paper lining as cushioning materials after dipping in solution of AVG 10 ppm, tap water (35^0C) and cold water 10^0C for 10 min. has minimum PLW and decay. TSS and acidity was not significantly altered.

Krishnamurthy (1987) they found that after precooling, when the Alphanso mango fruits packed in bamboo basket, wooden basket and wire board basket, there was no much differences in ripening of mango fruit.

Chattopadhyay (1989) revealed that mango fruits cv. Himsagar, packed in the wooden boxes with cushioning materials resulted in better shelf-life, less decay losses and with good qualities as compared to packed without cushioning.

Roy and Joshi (1989) they find out of different types of packaging tried, corrugated fiber board boxes (CFB) with partition were the best for Alphanso mangoes. Further they observed that after transport by road and rail the fruits packed in CFB box were remain intact in their position, while those in other packaging materials were considerable bruised and disturbed with more PLW and spoilage during storage with low shelf-life.

Joshi (1993) used the different kind of ventilated CFB as an alternative to conventional ventilated wooden crates and were found to be more effective for transportation and storage of Alphanso mango fruits. The CFB boxes are not only light in weight, but also can be folded and reused. These boxes are recommended for packaging, transportation and storage in volumes of 1, 1.5, 2 and 5 dozens fruits.

Mani *et al*. (1993) Packaging should provide a convenient unit for marketing and packaging must maintain strength and shape of fruits for long periods.

Wasker *et al*. (1997) studied the effect of hydrocooling and bavistin dip on the shelf life and quality of mango during storage under various environment, adequate packaging protects the fruits from physiological pathological and physical deterioration in marketing channels and retains their attractiveness.

Paull and Chen (2004) reported that modified atmosphere packaging can be provided by using poly-ethylene film bags or proper boxes in mango fruits.

Gautam and Neeraja (2005) the shelf-life and quality of mango cv. Banganapalli fruit were studied using polythene bags of different gauges (150, 250 and 350) with different ventilation levels (0, 0.5, 1.0 and 2.0 %). The maximum shelf-life of Banganapalli mango was observed in polythene bags of 250 gauge with 1 % ventilation, which delayed ripening, rotting and maintained optimum fruit quality of mango fruit.

Antala *et al*. (2008) they find out that ‘Kesar’ mango fruits treated with Bavistin (1000 ppm), pre-cooled, wax coated and packed in CFB boxes in polythene having 100 gauge can successfully stored up to 28 days at 13^{0}C temperature with minimum physical, bio-chemical and organoleptic changes.

Castro *et al*. (2009) reported that, 'Espada Vermelha' mangoes were sealed in PVC packed and PE bags with or without potassium permanganate absorber and fruits were stored at 12^0C and 90 per cent RH, modified atmosphere packaging reduced fruit weight loss during storage.

Rathore *et al*. (2009) reported that Dasehari mango fruits packed in the card board box with four vent hole to maintain modified atmosphere shows the increasing trend in the TSS and weight loss of fruits, while decreasing trend was noticed in the acidity. Organoleptic score was also shows increasing trend up to 12 days of storage and then decrease. The fruits can be stored up to 15 days at room temperature with good physico-chemical as well as organoleptic qualities.

Desai (2010) studied the effect of post harvest treatment and packaging on shelf-life and quality of mango fruits (*Mangifera indica* L.) cv. Kesar amongst all post-harvest chemical treatments pre-cooling + $CaCl_2$ 6 % and Packaging treatment CFB Boxes with plastic Coating + honeycomb separator was found significant in delaying ripining in storage and extending shelf-life of mango fruits cv. Kesar at an ambient temperature. This treatment was tended to reduce the weight losses, volume losses and spoilage. The treatments also helped significantly to retained firmness of fruits and simultaneously bio- chemical qualities viz., total soluble solids, reducing sugar, total sugar, pH, acidity, ascorbic acid as well as sensory qualities viz., colour, taste, flavor, texture of pulp at ripen stage fruit stage. The other post harvest treatments of pre- cooling + GA_3 200 ppm and packaging treatment of CFB boxes + Honeycomb separator was also found significantly better in respect to physical, bio-chemical, sensory qualities as well as extending the shelf-life of mango fruits cv. Kesar moreover above treatmentsal so found economical than rest of the treatments.

Mulualem and Tilahun (2011) they reported that packaging and storage environments had significant interaction effects on the shelf life and most of the physiological and chemical qualities of papaya fruits.

Lemma *et al*. (2012) reported that the 1-MCP treatment and polyethylene packaging significantly reduced PWL. These treatments maintained better mango fruit quality in terms of firmness, juice content and TSS of mangoes. Thus, the result clearly showed that 1-MCP treatment and polyethylene packaging at ambient condition can extend storage life and maintain quality of mango fruits for about nine and six days, respectively.

Rose *et al.* (2016) studied the effect of polypropylene packaging and ethrel treatment on shelf life and quality of mango cv. Suvarnarekha. Results indicated that Polypropylene of 150 gauge with 1 per cent ventilation was the most suitable packaging material for mango cv. Suvarnarekha with reduced physiological loss in weight and spoilage thereby maintaining the quality and extending the shelf life up to 9 days at ambient conditions.

Mounika *et al.* (2017) studied the effect of different packaging materials to maintain shelf life of mango cv. Amrapali at ambient storage conditions and found that the fruits packed in different packaging materials had lower physiological loss in weight (PLW), more firmness, slower ripening, negligible spoilage, better colour development, as compared to control fruits.

2.3 Effect of temperature on storage life of fruits

Postharvest life of fruits and vegetables are primarily dependent on storage temperature, which not only regulates the physiological activities such as respiration, transpiration, ripening etc., but also affects the physico-chemical attributes during storage. Mango fruit stored at 30-37^{0}C had a storage life of approximately one week, while cool storage in temperature ranged 13^{0}C extended the post-harvest life for approximately two weeks. The storage behavior and shelf-life of mango fruit is considerably influenced temperature at the time of storage period. So present study has been carried out to study the storage behavior of mango fruits at two different storage conditions i.e. cool store and ambient temperature. The work so far done on the effect of all these storage conditions on mango fruit is reviewed as under.

Mann and Singh (1975a) concluded that the mango fruits, Cv. Dashehari, were picked when mature green and stored at 45-48^{0}F either immediately or after holding at room temperature for 2 or 4 days, and the effects on fruit quality and chemical composition were assessed after 15-35 days. Fruits stored either immediately or after 2 days' holding kept well for 25 days, with < 15 per cent weight loss and spoilage, but fruits stored after 4 days' holding kept for only 15 days.

Mann and Singh (1975b) carried out studies on cold storage of mango fruits cultivar Langra. Fully mature mango were picked at 5-days interval on 3 dates and stored at 45-48^{0}F and 85-90 per cent RH on the same day, or after 2 or 4 days' holding at room temperature, or after pre-cooling in water at 5^{0}C, and their storage quality and fruit composition were assessed at intervals up to 45 days. The palatability rating was highest in pre-cooled fruits, followed by those stored soon after picking. Fruits picked on the second date (28 June) were the most palatable for the first 25 days' storage, irrespective of pre-treatment; after 35 days, however, fruits picked first tasted best. Data are also presented on percentage weight loss and spoilage in storage, and changes in respiration rate, total soluble solid, acid, sugar, carotenoid and ascorbic acid content.

Kapse *et al*. (1979) stored Malda, Mulgoa and Neelum varieties of mango fruits at low temperature and observed that the fruits were in good conditions upto 30 days in case of Mulgoa and Neelum and 37 days in case of Malda and then they started decaying. The quality of low temperature stored fruits impaired considerably as there was no proper development of sugars, carotenoids, colour and taste and there was less reduction in acid content during entire period of storage.

Holdsworth (1983) recommended a storage temperature of 13^{0}C with a shelf-life of 2 to 3 weeks for mango fruit.

Ramana *et al*. (1984) investigated the cool storage and ripening behavior of early and late harvested (15 days after early harvest) Alphonso mango fruits and from the studies they found that total storage life of 28 days (22 days in CS at 12.8^{0}C and 90 to 95 % RH and 6 days at RT at 22 to 30^{0}C and 45 to 63 % RH) for early and 20 days (15 days in CS at 12.8^{0}C and 90 to 95 % RH and 5 days at RT at 22 to 30^{0}C and 45 to 63 % RH) for late harvested fruits as compared to room temperature stored fruits which recorded the shelf life of 16 and 14 days, respectively.

Gole (1986) studies on fruit development and some aspects of postharvest handling of mango fruits and they found at the shelf life of Alphonso, Pairi and seedling mango fruits at ambient temperature was found to be 12, 9 and 14 days, respectively. The fruits stored at ambient temperature recorded maximum physiological loss in weight, shrivelling and spoilage as compared to cool chamber and cool storage. Pairi fruits recorded maximum PLW at all the three storage conditions than Alphonso and seedling mango fruits. Biochemical changes with respect to TSS, pH, acidity, sugars, B-carotene, moisture and ascorbic acid were found to be the slowest in cool stored mango fruits irrespective of variety. There was very slow increase in TSS, pH and sugars while the reduction in acidity and ascorbic acid was also slower in cool stored fruits than the fruits stored in cool chamber and at ambient temperature storage. The PLW was least in all the varieties in cool storage but their palatability was also found low as compared to cool chamber and room temperature stored fruits. Cool stored Alphonso, Pairi and Seedling mango fruits recorded the maximum shelf life (24, 18 and 24 days) as compared to cool chamber (15, 10 and 16 days) and room temperature (12, 9 and 14 days) stored fruits.

Krishnamurthy (1988) studies on storage of mango fruits and found that storing hydrocooled Alphonso mango fruits at 15^0C for a period of 15 days followed by ripening at ambient temperature condition gave good ripe fruits of acceptable quality.

Medlicott (1990) studied the effects of harvest maturity of mangos (*Mangifera indica* L.) on storage tinder various low-temperature regimes and the influence of storage on quality development during subsequent ripening at higher temperatures were investigated. The capacity for storage of mango fruit depended on harvest maturity, storage temperature, and the time of harvest within the season. Development of peel and pulp color, soluble solids concentration, pH, and softening in Amelie, Tommy Atkins, and Keitt mangos occurred progressively during storage for up to 21 days at 12^0C. Based on the level of ripening change that occurred during 12^0C storage, immature fruit showed superior storage capacity than fruit harvested at more advanced stages of physiological maturity. On transfer to ripening temperatures (25^0C); however, immature fruit failed to develop full ripeness characteristics. Mature and half-mature fruit underwent limited ripening during storage at 12^0C, the extent of which increased with progressive harvests during the season. Ripening changes during storage for 21 days were less at 8 and 10^0C than at 12^0C. Chilling injury, as indicated by inhibition of ripening, was found at all harvest stored at 8^0C, and in early season harvests stored at 10^0C. Fruit from mid- and late-season harvests stored better at 10 than at 12^0C, with no apparent signs of chilling injury. Flavor of mangos ripened after low-temperature storage was less acceptable than of those ripened immediately after harvest.

Kapse (1993) investigated the integrated approach to post-harvest handling of mango cv. Kesar they found that the Kesar mango fruits harvested with 1 cm stalk, treated with 1000 ppm Bavistin, Pre-cooled at 12^0C can store fruits up to 19 days with control on respiration and transpiration rate, decreases in acidity, firmness, PLW and starch and increasing total sugar, reducing sugar, T.S.S. up to peak.

Wills *et al*. (1996) reported that fruits continue to respire even after harvest. The respiration of fruits and vegetables involves many enzymatic reactions. The rate of these physiological reaction increases exponentially with increase in temperature and may be described mathematically by use of temperature quotient (Q10). Vant Hoff, the Dutch chemist showed that, the rate of a chemical reaction approximately doubles with each 10^0C rise in temperature.

Hidalgo *et al*. (1996) studied the refrigerated storage and chilling injury development of mangoes cv. Manila, they found that the Manila mango fruits stored at 6 and 12^0C for 12 days showed chilling injury symptoms by the 4^{th} day of ripening and these symptoms were more pronounced in fruits stored at 6^0C. In general, mango pericarp showed the symptoms of chilling injury before the mesocarp did.

Waskar and Masalkar (1997) studied the effect of hydrocooling and bavistin dip on the shelf life and quality of mango during storage under various environments. revealed that the shelf life of Kesar, Totapuri, Vanraj mango fruits when hydrocooled at 12^0C and given postharvest dip of Bavistin (1000 ppm) could be extended upto 25, 36, 31 days respectively when stored in cool chamber as against 17, 21, 19 days respectively at room temperature storage.

Sharma and Azad (2000) Most of fruits ripen satisfactorily over a fairly wide range of temperatures but unsatisfactorily at temperatures beyond this range. Below a critical temperature many tropical and sub-tropical fruits develop a disorder known as ‘chilling injury’ which inhibits ripening. Many fruits fail to ripen beyond 30 to 35^0C. Storage at low temperature immediately after harvest reduces the rate of respiration resulting in reduction in vital heat, thermal decomposition, and microbial spoilage and also helps in retention of quality for a long period.

Reid (2002) reported that temperature is the most important environmental factor in shelf life of fresh fruits. Low temperature storage can decrease respiration rate and that can prolong the shelf life of fruit. Furthermore, proper storage environment has great impact on reducing postharvest losses, extension of postharvest life and retaining quality of fruits. Storage at suitable temperature, relative humidity and packaging materials are the key factors for good quality fruits.

Dhemre (2001) studies on extending the shelf life of mango (*Mangifera indica* L.) cv. Kesar found that fruits stored in cool chamber and cool store followed the same trend of physico-chemical changes but at a slower rate as compared to room temperature storage. The shelf life of control fruits (untreated) was found to be hardly16 and 22 days at room temperature and in cool chamber storage, respectively. The shelf life of room temperature and cool chamber stored mango fruits coated with control + captan (0.2 %), control + carbendazim (0.1 %), waxol (6 %), waxol (6 %) + captan (0.2 %) and waxol (6 %) + carbendazim (0.1 %) was extended up to 17, 17, 18, 19 and 20 days and 23, 24, 25, 25 and 26 days, respectively when stored at room temperature and cool chamber. The shelf life of untreated precooled and unprecooled mango fruits in cool store was found to be hardly 39 and 32 days, respectively. The shelf life of precooled and unprecooled mango fruits coated with control + captan (0.2 %), control + carbendazim (0.1 %), waxol (6 %), waxol (6 %) + captan (0.2 %) and waxol (6 %) + carbendazim (0.1 %) was extended upto 41, 42, 45, 47 and 50 days and 35, 37, 40, 42 and 46 days, respectively when stored in cool store.

Kader (2002) Mango fruit stored at temperatures between 5°C and 10°C for extended periods of time exhibit chilling injury. Chilling injury is characterized by surface and internal browning, pitting, water soaking, uneven ripening, failure to ripen, development of off-flavors and off-aroma, and increased incidence of surface mold and decay.

Dhemre and Waskar (2004) Effect of post harvest treatments on shelf life and quality of Kesar mango fruits during storage they found that the mango fruit of cv. Kesar treated with waxol (6 %) coupled with carbendazim (0.1 %) and pre-cooled at 10^0C and 90-95 per cent RH recorded the maximum shelf life up to 50 days in cool storage and also found minimum rotting per cent.

Waskar and Gaikwad (2005) studied the effect of various postharvest treatments on extension of shelf life of Kesar mango fruits, They reported that the shelf life of mango fruits could be extended upto 65 days when treated with a combination of $CaCI_2$ (2 %) + wax (6 %) + Bavistin (0.1 %) and stored in cool store, upto 35 days when stored in cool chamber and upto 24 days when stored at room temperature.

Waskar and Dhemre (2005) studied the effect of precooling on extending the postharvest life of Kesar mango fruits, they concluded that dipping treatments to fruits with waxol (6 %) + carbendazim (0.1 %) and precooling at 10^0C temp for 12 hours and storage in cool store at 10^0C temperature with 90-95 to per cent relative humidity is recommended for storage of Kesar mango fruits for domestic as well as export marketing for 50 days.

Nair and Singh (2006) they observed that mango is highly sensitive to lower temperature storage below 10-13^0C due to chilling injury. Thus, optimum temperature required for ripening of mango varied from cultivar type and agro-climatic conditions during growth and development of the fruit.

Bonfim (2011) evaluated the post-harvest conservation of Tommy Atkins mangoes, treated with different concentrations of 1-MCP, stored under refrigeration. The treatments were several concentrations of 1-MCP, 0, 100, 300 and 600 nL, L-1, for 12 hours in isolated chambers at temperature of 25^0C. They concluded that, 1-MCP and refrigeration associated were effective in keeping fruits stored for 28 days after harvesting; the 1-MCP concentration of 600 nL, L-1 was considered the most efficient in reducing the ripening of fruits at 10^0C and 25^0C.

Almeida *et al.* (2013) evaluated the quality of ‘Palmer’ mangoes previously stored at low temperature, after their transference to the environmental condition. Fruits harvested at physiological maturity were carefully transported to the laboratory where they were selected, standardized as per the colour, size, and absence of injuries and treated with fungicide before they were stored at 2^0C (75.7 % RH), 5^0C (73.8 % RH), 12^0C (82 % RH) for 7, 14 and 21 days. At the end of each period, the fruits were transferred to environmental condition (22.9^0C; 62.3 % RH), where they were kept for 1, 3, 5 and 7 days, simulating the trading period and evaluated for the occurrence of injuries and rottenness; peel and pulp colour; contents of soluble solids, titrable acidity and ascorbic acidity. The results indicated that ‘Palmer’ mangoes can be stored at 12^0C for 21 days without damage to ripening, but with limitations due to the occurrence of decay.

Khanbarad *et al*. (2013) a study was undertaken to observe the effect of pre-cooling on extending the shelf life of mango fruit Cv. Neelam. Fully matured, good quality mango fruits were subjected to chilled water dipping and hydro-cooling at 5 and 8^0C and compared with control treatments. Pre-cooled samples were shifted to two storage environments viz. ambient temperature (30 ± 3^0C) and cold store (13^0C at 85 to 90 % RH). Results showed that chilled water dipping was the best method with minimum pre-cooling time (26 min at 5^0C). The minimum physiological loss in weight (PLW) (9.98 %), TSS (17.90^0Brix), spoilage (10.47 %) and titrable acidity (0.34 %) were obtained for samples pre-cooled by chilled water dipping stored at cold storage. Maximum shelf life of 36 days was obtained for chilled water dipping at 5^0C, followed by control (no pre-cooling) samples, 26 days at cold storage and only 10 days at ambient storage condition.

Bhoomika *et al.* (2015) studied the response of post-harvest treatments on shelf-life and quality of mango cv. Kesar fruits. The results revealed that mango cv. Kesar fruits harvested at mature stage, dipped in 500 ppm ethrel treatment and cold stored at 12.5 ± 0.5^0C for 17 days + 2 days at 20^0C individually as well as in combination proved to be the best with respect to speed up the ripening process, lowering PLW and getting higher score on sensory evaluation and also having higher quality attributes. Besides, half mature fruits without ethrel treatment stored at 6.5 ± 0.5^0C had more firm fruits with better shelf-life but having poor quality due to higher physiological loss in weight.

Patil *et al*. (2016) studied the effect of temperature on ripening behaviour of mango cv. Alphonso, fruits ripened at different temperature conditions viz., 20^0C, 25^0C, 30^0C and ambient temperature (24-33^0C). They revealed that the changes in ripening, PLW, spoilage and shriveling were markedly reduced in 20^0C temperature storage condition as compared to other storage conditions but, showed considerable delayed ripening and fruits ripened at 25^0C or 30^0C temperature exhibited uniformity in ripening, better shelf life than those ripened at ambient condition.

Benson *et al.* (2019) they showed that waxing with either Shellac or Decco wax was effective in prolonging shelf life of Ngowe mango fruits by 3 and 6 days in ambient and cold storage respectively. Untreated fruits in ambient storage lost 5.3 per cent of the initial weight by day 7 compared to an average of 4.5 per cent for the waxed fruit (day 10). Waxed fruits in ambient had low CO_2 concentration (59.53 ml/kg hr) compared to a high (88.11 ml/kg hr) CO_2 concentration for the untreated fruits. Similarly, other ripening related changes including TSS, color, and firmness were significantly slowed down by waxing, especially under cold storage. Findings from this study show the effectiveness of waxing in delaying mango fruit ripening. Waxing can therefore be used to extend the shelf life and marketing period for mango fruit.

Lei Yi1 *et al.* (2019) studies influences of different storage conditions on postharvest quality of mango the fruits were stored at room temperature and the optimum cold storage temperature of mango at 13^0C. The fruits stored at 13^0C significantly showed the longer shelf life than those stored at room temperature.

Mussawer *et al.* (2019) conducted an experiment to study the effect of various temperatures on the postharvest quality and storage life of persimmon fruit. They observed that, the highest fruit firmness (3.23 kg/cm^2), moisture percent (64.22 %), titratable acidity (0.18 %) and ascorbic acid content (22.22 mg/100g) with minimum value of TSS (21.66 ^{0}brix), pH (6.29), weight loss (19.17 %), waste percent (17.77 %), color score (5.51) and taste score (5.50) were found in fruits on 36 days of storage durations at 10^0C.

Bhoomika *et al.* (2019) to study the effect of maturity stage, ethrel and cold storage on chilling injury and quality of Mango cv. Kesar fruits The mango fruits stored at 12.5 ± 0.5^0C for 17 days and transferred at 20^0C for 2 days under cold storage recorded higher sensory as well as colour score due to optimum PLW, ripening and shelf life.

Pawaskar (2019) reported that fruit treated with 1 % calcium lactate, packed in polypropylene and stored in cold storage recorded significantly lowest PLW and higher firmness during storage. Fruit treated with 50 ppm benzyl adenine, packed in LDPE and stored under cold storage recorded minimum spoilage and longest shelf life of 30 days in cv. Sardar and 27 days in cv. G-Vilas. At ambient condition, treatment combination with same chemical and packaging material revealed maximum shelf life of 11 days in cv. Sardar and 8 days in cv. G-Vilas. However, fruit under control recorded shelf life of 7 and 5 days in cv. Sardar and G-Vilas, respectively. Higher sensory score for longer storage period was recorded in fruit treated with 50 ppm benzyl adenine, packed in LDPE and stored under cold storage. Fruit treated with 50 ppm benzyl adenine, packed in LDPE and stored under cold storage revealed minimum changes in TSS, reducing sugars, titratable acidity and ascorbic acid and adjudged as better for these quality parameters at the end of storage period. Same treatment combination also reported minimum decrease in total sugars and pectin content and retained higher values for both at the end of storage period.

Kanade *et al*. (2020) studied the effect of precooling and storage temperatures on ripening pattern of mango cv. Alphonso they reported that ripening was fastest at ambient temperature, followed by 18, 15 and 12^0C temperature. The peak ripening was noticed after 14 days at ambient temperature and after 21 days at 18, 15 and 12^0C temperature, this could be due to low temperature and high humidity which hindered or slowed down the ripening process.

2.3.2 Storage of mango fruit at Room Temperature (RT)

Agnihotri *et al*. (1963) studied the physico-chemical changes in Dashehari mango during storage they find out Dashehari mango fruits stored at 32.3 - 37.7^0C recorded the postharvest life of 20-22 days at room temperature and consisted of three distinct stages viz., ripening, senescence and decay. On storage, the fruits started shrinking in dimensions and developed wrinkles on the surface and decreased in weight also. The average weight loss in control and waxed fruits was found to be 12.34 and 9.91 per cents, respectively.

Kapse *et al*. (1979) studied the storage behaviour of some mango varieties at ambient and low temperatures, from the studies it was able to conclude that Malda, Mulgoa and Neelum cultivars of mango when stored at room temperature, started decaying after 10 days. The physiological loss in weight (%) of these fruits during storage was found to be 15.20, 16.33 and 13.19 per cents, respectively at the end of shelf life

Kalra and Tandon (1984) studied the ripening behaviour of Dashehari mango fruits at different temperatures, (30^0C and 25^0C) and observed that after 8 days, the fruits ripened well under ambient conditions although there was slight shrinkage in few fruits, while at 30^0C, fruits were found to be shrivelled with subdued ripening and at

25^0C, the appearance of fruits was good and had slightly sour taste. The physiological loss in weight (%) after 10 days of storage was found to be the highest (26.2 %) at 30^0C and the lowest (13.0 %) at 25^0C, respectively.

Naik (1985) studied the physico-chemical changes in Alphonso and Ratna mango fruits during growth, development and storage and they revealed that the chemical changes in Alphonso mango fruits stored in cool chamber were slower than those at ambient temperature and the fruits stored at ambient temperature were more palatable than those ripened in cool chamber.

Gole (1986) studied on fruit development and some aspects of postharvest handling of mango fruits and they reported that the shelf life of Alphonso, Pairi and Seedling mango fruits at ambient temperature was found to be 12, 9 and 14 days, respectively. The fruits stored at ambient temperature recorded maximum physiological loss in weight, shriveling and spoilage as compared to cool chamber and cool storage.

Badar (1990) he find out the TSS, pH, sugars and total carotenoid pigments increased during storage at ambient temperature as compared to cool chamber storage while moisture titrable acidity, ascorbic acid and tannins decreased throughout the storage period irrespective of storage environments. Fruits ripened at ambient temperature were more palatable as compared to cool chamber storage but the physiological loss in weight (%) was higher at ambient temperature storage as compared to cool chamber storage.

3. 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).

3.1 Materials

3.1.1 Fruit

Mango fruit of cultivar Kesar procured from the field of "Instructional-Cum-Research Orchard of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. Dist. Ahmednagar, for the present investigation. For this purpose, fully matured healthy mango fruits cv. Kesar were harvested at proper, stage of maturity and brought to the laboratory for further studies.

Green mature fruits of uniform size and shape were selected. The fruits were selected free from mechanical damage, bruises, sun burns and fungal/insect attack. Which was harvested at the time when a few naturally ripe fruits started dropping, locally called tree ripen fruits as Pad or Sakh or Tapaka. Then fruits were washed with flowing tap water drained and then they were subjected to the nine edible coating.

3.1.2 Chemicals

All the chemicals used in this investigation were of analytical grade and were procured from Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.1.3 Packaging materials

Corrugated fiberboard (CFB) boxes were obtained from local market and plastic crates obtained from Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.2 Methods

3.2.1 Experimental Details

1.	Crop	Mango
3.	Variety	Kesar
4.	Statistical Design	Factorial Completely Randomized Design (FCRD)
5.	Replications	2
6.	Number of treatment combinations	18 (9×2)

Factor A :	(C)	Edible coating
1.	C_1	Without coating
2.	C_2	Alginate (2 %)
3.	C_3	Beewax (2 %)
4.	C_4	Aloe vera gel (75 %)
5.	C_5	Tapioca starch (5 %)
6.	C_6	Cinnamon oil (0.02)
7.	C_7	Chitosan (0.5 %)
8.	C_8	Acacia gum (5 %)
9.	C_9	Pectin (2 %)
Factor B :	**(P)**	**Packaging materials**
1.	P_1	Corrugated fiberboard box (CFB box)
2.	P_2	Plastic crates.

Details of treatment combination

1.	C_1 P_1	Without coating + Corrugated fiberboard box
2.	C_1 P_2	Without coating + Plastic crates (Control)
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_1	Acacia gum (5 %) + Plastic crates
17.	C_9 P_1	Pectin (2 %) + Corrugated fiberboard box
18.	C_9 P_2	Pectin (2 %) + Plastic crates

3.2.2 Experimental methodology

3.2.2.1 Preparation of coating solutions

3.2.2.1.1 Alginate (2 %)

Sodium alginate (2 %) dissolved in the distilled water using the magnetic stirrer. After all the components were completely dissolved, the solution was cooled to room temperature.

3.2.2.1.2 Beeswax (2 %)

Beeswax (2 %) prepared by dissolving 4.0 g of wax in 200 ml of water and ethyl alcohol mixture (3:1) at 70^0C and stirred for 10 min by using magnetic stirrer.

3.2.2.1.3 Aloe vera gel (75 %)

To prepare 75 % Aloe vera gel, Aloe vera gel matrix was separated from the outer cortex of leaves and this colourless hydroparenchyma was grind in blender. The resulting mixture was filtered to remove the fibres. Then, 75 ml of Aloe vera gel was added in 25 ml of water and mixed it with blender.

3.2.2.1.4 Tapioca starch (5 %)

To prepare 5 % tapioca starch solution, 5 g of tapioca starch granules were soaked in distilled water for overnight and the solution was homogenized thoroughly in mixture and finally water was added to obtain required concentration.

3.2.2.1.5 Cinnamon oil (0.02%)

To prepare 0.02 % Cinnamon oil solution, 6 ml of cinnamon oil was mixed in 30 L distilled water. The solution was stirred until it became clear.

3.2.2.1.6 Chitosan (0.5 %)

To prepare 0.5 % solution chitosan, 5g of chitosan powder was dissolved with 50 ml of glacial acetic acid and 850 ml of distilled water. The pH of chitosan solution was adjusted to 5 with 1 M NaOH.

3.2.2.1.7 Acacia gum (5 %)

To prepare 5 % Acacia gum solution, 5 g of laboratory grade acacia gum powder was dissolved in 95 ml distilled water. The solution was heated at 40ºC and stirred until it became clear.

3.2.2.1.8 Pectin (2 %)

Pectin (2 %) dissolved in the distilled water using the magnetic stirrer. After all the components were completely dissolved, the solution was cooled to room temperature.

3.2.2.2 Application of coating solutions

The well matured (picked at colour break stage i.e. skin of the fruit changes from dark green to light green), uniform size mango fruit free from any disease, bruises and damage were selected. Selected fruit were washed under the running tap water to remove the adherent dirt material and then allowed to dry in shade prior to imposition of coating treatment. The coating of the fruits was done by dipping method. The fruit were dipped in respective, solutions for 1 minutes and air dried. Treated fruit were packed in respective packaging materials as per the treatments. Packed fruit were then stored at two different storage conditions viz., ambient temperature. (26-30^{0}C with 54-62% RH) and cold storage (13^{0}C with 54-62% RH).

3.2.2.3 Packaging

Fruit were then packed in export quality corrugated fiberboard (CFB) boxes and plastic crates. During packaging of the fruits, cut pieces of waste paper were used as cushioning material. Then the graded fruits were placed on cushioning material.

3.2.2.4 Storage

The corrugated fiberboard (CFB) boxes and plastic crates containing treated mango fruits were stored at two different storage conditions viz., at Cold store (CS), and Ambient temperature (AT). They were divided into two sets one for observations on physiological loss in weight and the other for physico-chemical analysis during storage.

Average temperature (^{0}C) and relative humidity (%) conditions in the storage in environment of mango fruits from May to July of 2019 and 2020.

Fig. 3.1 Flow chart of experimental work plan

Fresh mango

Sorting and cleaning

Edible coatings

Packaging

Storage

Ambient temperature | **Cold storage (13 °C)**

Quality Assessment

Physical

- PLW (%)
- Firmness (N)
- Spoilage (%)
- Shrivelling (%)
- Number of days required for ripening (days)
- Shelf life (days)

Chemical

- TSS (°B)
- Titratable acidity (%)
- Reducing sugar (%)
- Total sugar(%)
- β- carotene (mg/100g)
- Ascorbic acid (mg/100g)
- pH

Sensory

- Colour
- Flavour
- Taste
- Texture
- Overall acceptability

Sr. No.	Storage condition	Temperature range (^{0}C)	RH range (%)
1.	Cold store (CS).	13.00	90.00-95.00
2.	Ambient temperature (AT)	24.18-30.57	47.50-74.00

3.2.3 Observations recorded

The following physical and chemical constituents of Kesar Mango fruits were studied during the course of present investigation. Observation were recorded 4 days interval at the end of shelf life of fruit.

3.2.3.1 Changes in physical parameters

3.2.3.1.1` Physiological loss in weight (%)

Physiological Weight loss was calculated based on weighted before storage and noted as the initial weight as the final weight. Weight loss was determined by the following formula and expressed as percentage.

$$\text{Physiological weight loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.2.3.1.2 Shriveling (%)

Each fruit was thoroughly examined for any visible symptoms of shriveling during storage and accordingly shriveling percentage was calculated.

3.2.3.1.3 Spoilage (%)

Each fruit was thoroughly examined for any visible symptoms of infection i.e. disease on every fourth day during storage. Fruit showing any sign of rot or mould was considered as 100 % spoilage. The spoilage per cent calculated as,

$$\text{Spoilage (\%)} = \frac{\text{Number of fruit decayed}}{\text{Total number of fruits}} \times 100$$

3.2.3.1.4 Number of days required for fruit ripening

The degree of greenness and yellowness were recorded by observing manually according to a colour score and number of days required for fruit ripening were be noted when the fruits shows more than 50 % fruits are more yellow less green is note.

3.2.3.1.5 Shelf life (days)

Each fruit was thoroughly scrutinized for any visible symptoms of spoilage and the end of shelf-life was considered when the 20 per cent fruits were shown over ripening or spoilage symptoms.

3.2.1.3.6 Firmness (N)

Firmness of fresh mango fruit was measured using an Instron Universal Testing Instrument (Make: Shimadzu, Japan; Model: AX-G). Different probe assemblies were used for different tests. Machine was connected to computer via software, this software converts received signals, collects the data and converts it in graphical representation (texture profile) and prepare the reports of individual tests. The machine was fitted with 1kg N load cell and an 8-mm diameter compressive probe, adapting conditions from Bashir and Abu-Goukh (2003) and Reyes and Paull (1995). The probe was positioned at zero force contact with the 32 surface of the mango fruit. Probe penetration was set at 10 mm at a crosshead speed of 20 mm/min and readings were taken at 3 equidistant points on the equatorial region of the fruit. The force (N) required to penetrate the fruit surface up to a specific depth (mm) was recorded.

3.2.3.2 Chemical composition mango fruit.

3.2.3.2.1 Total soluble solids (^{0}Brix)

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^{0}Brix) and value was corrected at 20^{o}C with the help of temperature correction chart (A.O.A.C., 1975).

3.2.3.2.2 Titrable acidity (%)

Acidity was estimated by the procedure described by Ranganna (1986). 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).

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

3.2.3.2.3 Total sugars

The total sugars of mango fruit were determined by the method of Lane and Eynon (1923) as described by Ranganna (1977). In 250 ml conical flask, 50 ml of lead free solution prepared for estimation of reducing sugars was taken. To this, 10ml 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 per cent basis.

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

3.2.3.2.4 Non-reducing sugars (%)

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

Non-reducing sugars (%)= Total sugars (%) - Reducing sugars (%)

3.2.3.2.5 Reducing sugars (%)

Reducing sugars were determined by the method of Lane and Eynon (1923) as described by Ranganna (1977). 25g of crushed fruit sample was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized with 1N sodium hydroxide by using phenolphthalein indicator. Then 2 ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Appropriate quantity (2.5 ml) of 22 per cent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman"s No. 4 filter paper. The lead free solution was taken in burette and titrated against 10 ml of standard Fehling's solution (mixture of A and B 1:1) using methylene blue as an indicator till the formation of brick red precipitate and was noted as end point. The titration was carried out by keeping the Fehling's solution boiling on the heating mantle. It was calculated using the following formula and expressed in percentage.

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

3.2.3.2.6 β carotene (mg/ 100g)

The total carotenoid pigments (β-carotene) were determined with the method described by Roy (1973). The β carotene were estimated from sample with petroleum ether and acetone mixture (3:2 by volume) by grinding it with acid washed sand. the extract was decanted off into a 50 ml volumetric flask. The β carotenes in the clear extract were determined by using spectrophotometer of Milton Roy make at 450 nm. The results were expressed in terms of β carotene as mg per 100 g of sample.

3.2.3.2.7 Ascorbic acid (mg/100 g)

Ascorbic acid was estimated by Indophenol method (Ranganna, 1986). Ten grams of fresh fruit sample was ground well and blended with 3 % Meta phosphoric acid (HPO_3) and the volume was made to 100 ml with HPO_3 solution. An aliquot of 10ml 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 % HPO_3 solution. The ascorbic acid was calculated using the following formula and expressed as mg ascorbic acid per 100 g fresh weight.

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

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

3.2.3.2.8 pH

The pH of the fruit extract was determined with the help of pH meter (Model Systronics μ pH system 361). Standard solutions of pH 4.0 and 7.0 were used as reference to calibrate.

3.2.3 Organoleptic evaluation

The organoleptic or the sensory evaluation of mango fruits was done by a panel of five semi-trained judges on the basis of nine-point hedonic scale (9 - Like Extremely; 8 - Like Very much; 7 - Like Moderately; 6 - Like Slightly; 5 - Neither Like Nor Dislike; 4 - Dislike Slightly; 3 - Dislike Moderately; 2 - Dislike Very Much; 1- Dislike Extremely) for fruit appearance and colour, flavour, texture and taste (Amerine *et al*., 1965). The average of all the above characters was calculated and expressed as overall acceptance. A score of 5.5 and above is considered acceptable for consumer appeal of mango fruits.

3.2.4 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).

4. RESULTS AND DISCUSSION

The present research 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 observations recorded on various parameters when doing the investigation were statistically analyzed and the acquired results are shown with the proper headers and subheadings.

In this experiment, freshly harvested, mature, firm mango fruits were used for all treatment combination and coated with nine different coating namely C_1- Without coating, C_2- Alginate (2%), C_3- Beeswax (2%), C_4- Aloe vera gel (75%), C_5- Tapioca starch (5%), C_6- Cinnamon oil (0.02%), C_7- Chitosan (0.5%), C_8- Acacia gum (5%), C_9- Pectin (2%), packaging materials are P_1- CFB box and P_2- Plastic crates according to treatments. The coated mango fruits were stored at two different storage conditions viz. ambient temperature (AT) and cold storage (CS) (13^0C). Observations were carried out up until the end of the shelf life at intervals of 4 days.

4.1 Effect of different edible coatings and packaging materials on physical characteristics of mango cv. Kesar during storage

4.1.1 Physiological loss in weight (%)

The data on effect of various coating and packaging on PLW (physiological loss in weight) (per cent) recorded during storage for the year 2019, 2020 and pooled analysis are present in Table 1 (AT) and 2 (CS) and seen in Figs. 1 and 2 respectively.

The rate of physiological weight loss during storage has been found to be faster at ambient temperature (AT) than in cold storage (CS).

Regarding the physiological reduction in weight of fruits at AT, the treatments showed significant variations. It was clear from the pooled data the treatment C_3 (beeswax 2%) show minimum PLW (10.94%) which was followed by the treatment of C_7 (chitosan 0.5%) (11.45%) whereas, maximum PLW (22.66%) was observed in C_1 (without coating) at 16th days of storage.

Table 1. Effect of edible coatings and packaging materials on changes in physiological loss in weight (%) of Kesar mango fruit during storage at ambient temperature

Treatment	4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pool	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating												
C_1 : Without coating	5.93	6.33	6.13	9.98	11.63	10.80	15.57	17.15	16.36	22.50	22.83	22.66
C_2 : Alginate (2 %)	2.75	3.85	3.30	5.73	7.65	6.69	10.19	12.00	11.10	13.67	13.73	13.70
C_3 : Beewax (2 %)	2.53	3.93	3.23	5.58	6.76	6.17	10.25	8.85	9.55	10.85	11.03	10.94
C_4 : Aloe vera gel (75 %)	4.50	4.68	4.59	8.45	9.38	8.91	10.94	12.07	11.50	13.67	17.83	15.75
C_5 : Tapioca starch (5 %)	3.75	3.02	3.38	8.92	9.98	9.45	11.26	12.62	11.94	14.34	15.00	14.67
C_6 : Cinnamon oil (0.02)	4.94	3.40	4.17	8.78	9.50	9.14	13.67	14.50	14.08	18.90	19.03	18.96
C_7 : Chitosan (0.5 %)	2.25	3.39	2.82	6.78	6.62	6.70	9.30	10.50	9.90	10.78	12.13	11.45
C_8 : Acacia gum (5 %)	2.96	3.26	3.11	7.78	8.89	8.33	10.50	11.58	11.04	12.25	13.43	12.84
C_9 : Pectin (2 %)	4.88	3.86	4.37	9.60	8.04	8.82	12.62	11.43	12.02	16.80	14.38	15.59
SEm. (±)	0.05	0.08	0.07	0.01	0.04	0.03	0.04	0.04	0.04	0.06	0.03	0.05
CD at 1 %	0.19	0.34	0.26	0.05	0.17	0.12	0.15	0.17	0.15	0.24	0.11	0.18
B. Packaging materials												
P_1 : CFB box	3.31	3.06	3.18	7.18	8.03	7.61	10.56	11.10	10.83	13.75	14.54	14.15
P_2 : Plastic crates	4.35	4.88	4.61	8.73	9.39	9.06	12.62	13.49	13.06	15.97	16.43	16.20
SEm. (±)	0.02	0.04	0.03	0.01	0.02	0.01	0.02	0.02	0.02	0.03	0.01	0.02
CD at 1 %	0.09	0.16	0.12	0.02	0.08	0.06	0.07	0.08	0.07	0.12	0.05	0.08
C. Interaction (A x B)												
$C_1 P_1$	5.05	4.75	4.90	9.05	11.05	10.05	14.10	15.30	14.70	20.00	22.00	21.00
$C_1 P_2$	6.80	7.90	7.35	10.90	12.20	11.55	17.03	19.00	18.02	25.00	23.65	24.33
$C_2 P_1$	2.50	3.00	2.75	5.05	7.10	6.08	8.08	11.00	9.54	13.33	12.26	12.80
$C_2 P_2$	3.00	4.70	3.85	6.41	8.19	7.30	12.30	13.00	12.65	14.00	15.20	14.60
$C_3 P_1$	2.05	3.00	2.53	4.16	5.30	4.73	9.50	7.70	8.60	10.40	10.00	10.20
$C_3 P_2$	3.00	4.85	3.93	7.00	8.22	7.61	11.00	10.00	10.50	11.30	12.05	11.68
$C_4 P_1$	4.00	3.10	3.55	7.90	8.75	8.33	10.38	11.13	10.76	13.25	17.06	15.16
$C_4 P_2$	5.00	6.25	5.63	9.00	10.00	9.50	11.50	13.00	12.25	14.08	18.59	16.34
$C_5 P_1$	3.19	2.63	2.91	8.79	9.45	9.12	10.41	11.03	10.72	13.68	14.00	13.84
$C_5 P_2$	4.30	3.40	3.85	9.05	10.50	9.78	12.10	14.20	13.15	15.00	16.00	15.50
$C_6 P_1$	4.50	2.80	3.65	8.00	9.00	8.50	12.33	13.00	12.67	16.80	18.50	17.65
$C_6 P_2$	5.38	4.00	4.69	9.56	10.00	9.78	15.00	16.00	15.50	21.00	19.55	20.28
$C_7 P_1$	1.90	3.00	2.45	5.33	6.11	5.72	8.50	10.00	9.25	10.23	11.65	10.94
$C_7 P_2$	2.60	3.78	3.19	8.23	7.13	7.68	10.10	11.00	10.55	11.32	12.60	11.96
$C_8 P_1$	2.62	2.02	2.32	7.40	8.23	7.82	9.50	10.15	9.83	11.50	12.35	11.93
$C_8 P_2$	3.30	4.50	3.90	8.15	9.55	8.85	11.50	13.00	12.25	13.00	14.50	13.75
$C_9 P_1$	4.00	3.21	3.61	8.90	7.32	8.11	12.20	10.60	11.40	14.60	13.05	13.83
$C_9 P_2$	5.75	4.50	5.13	10.30	8.75	9.53	13.03	12.25	12.64	19.00	15.70	17.35
SEm. (±)	0.07	0.12	0.10	0.02	0.06	0.04	0.05	0.06	0.06	0.08	0.04	0.07
CD at 1 %	0.27	0.48	0.37	0.07	0.24	0.17	0.21	0.24	0.21	0.35	0.15	0.25

Table 2. Effect of edible coatings and packaging materials on changes in physiological loss in weight (%) of Kesar mango fruit during storage in cold storage

Treatment	4 DAS			8 DAS			12 DAS		
	2019	2020	Pooled mean	2019	2020	Pool	2019	2020	Pooled mean
A. Edible coating									
C_1 : Without coating	2.69	2.34	2.51	4.12	4.34	4.23	8.80	8.73	8.76
C_2 : Alginate (2 %)	1.63	1.13	1.38	2.00	3.03	2.51	6.08	8.15	7.11
C_3 : Beewax (2 %)	1.24	0.93	1.08	1.75	2.60	2.18	5.88	6.00	5.94
C_4 : Aloe vera gel (75 %)	1.66	1.44	1.55	2.49	3.05	2.77	7.60	6.55	7.08
C_5 : Tapioca starch (5 %)	1.32	1.70	1.51	2.12	3.05	2.58	7.90	6.39	7.15
C_6 : Cinnamon oil (0.02)	1.65	1.60	1.63	3.06	2.72	2.89	7.98	6.10	7.04
C_7 : Chitosan (0.5 %)	1.08	1.32	1.20	1.86	2.51	2.19	4.75	6.54	5.64
C_8 : Acacia gum (5 %)	1.21	1.53	1.37	2.05	2.53	2.29	7.20	6.26	6.73
C_9 : Pectin (2 %)	1.23	2.19	1.71	2.56	3.04	2.80	6.69	6.28	6.48
SEm. (±)	0.05	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.02
CD at 1 %	0.19	0.03	0.13	0.05	0.09	0.07	0.05	0.09	0.07
B. Packaging materials									
P_1 : CFB box	1.36	1.15	1.25	2.23	2.18	2.21	6.33	5.90	6.11
P_2 : Plastic crates	1.69	2.00	1.84	2.66	3.79	3.22	7.64	7.65	7.65
SEm. (±)	0.02	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01
CD at 1 %	0.09	0.02	0.06	0.02	0.04	0.03	0.02	0.04	0.03
C. Interaction (A x B)									
C_1 P_1	2.50	1.63	2.07	3.93	2.98	3.45	8.55	7.45	8.00
C_1 P_2	2.88	3.05	2.96	4.30	5.70	5.00	9.05	10.00	9.53
C_2 P_1	1.25	0.90	1.08	1.20	2.50	1.85	5.00	7.10	6.05
C_2 P_2	2.00	1.35	1.68	2.80	3.55	3.18	7.15	9.20	8.18
C_3 P_1	0.92	0.85	0.89	1.40	1.60	1.50	5.15	5.00	5.08
C_3 P_2	1.55	1.01	1.28	2.10	3.60	2.85	6.60	7.00	6.80
C_4 P_1	1.02	0.98	1.00	1.70	2.50	2.10	7.10	6.05	6.58
C_4 P_2	2.30	1.90	2.10	3.27	3.60	3.44	8.10	7.05	7.58
C_5 P_1	1.00	1.15	1.08	1.73	2.10	1.92	6.80	5.60	6.20
C_5 P_2	1.64	2.25	1.95	2.50	4.00	3.25	9.00	7.18	8.09
C_6 P_1	1.60	1.10	1.35	3.05	1.90	2.48	7.10	5.01	6.06
C_6 P_2	1.70	2.10	1.90	3.07	3.54	3.31	8.86	7.19	8.03
C_7 P_1	1.29	0.80	1.05	2.38	1.90	2.14	4.50	5.90	5.20
C_7 P_2	0.87	1.83	1.35	1.34	3.12	2.23	5.00	7.17	6.09
C_8 P_1	1.48	1.05	1.27	2.55	1.95	2.25	6.39	5.49	5.94
C_8 P_2	0.93	2.00	1.47	1.55	3.11	2.33	8.00	7.03	7.51
C_9 P_1	1.15	1.85	1.50	2.15	2.20	2.18	6.35	5.50	5.93
C_9 P_2	1.30	2.52	1.91	2.98	3.88	3.43	7.02	7.05	7.04
SEm. (±)	0.07	0.01	0.05	0.02	0.03	0.03	0.02	0.03	0.02
CD at 1 %	0.27	0.05	0.18	0.07	0.13	0.07	0.12	0.09	0.07

Table 2 contd….

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 : Without coating	10.43	8.88	9.65	12.50	13.31	12.90	19.34	17.65	18.50	-	-	-
C_2 : Alginate (2 %)	8.37	7.60	7.99	10.71	9.95	10.33	10.76	11.60	11.18	12.76	12.94	12.85
C_3 : Beewax (2 %)	7.08	7.15	7.11	9.25	9.53	9.39	11.26	10.10	10.68	12.26	13.35	12.80
C_4 : Aloe vera gel (75 %)	8.65	7.65	8.15	10.55	9.60	10.08	12.89	12.73	12.81	15.42	14.01	14.71
C_5 : Tapioca starch (5 %)	9.10	8.35	8.72	11.08	10.59	10.83	12.63	12.09	12.36	15.15	14.30	14.72
C_6 : Cinnamon oil (0.02)	11.04	9.00	10.02	12.80	11.42	12.11	13.60	12.69	13.14	-	-	-
C_7 : Chitosan (0.5 %)	6.77	6.68	6.72	8.25	9.08	8.66	10.58	10.95	10.76	11.84	13.77	12.80
C_8 : Acacia gum (5 %)	8.12	8.82	8.47	10.04	10.60	10.32	12.88	13.48	13.18	14.50	14.85	14.68
C_9 : Pectin (2 %)	7.78	7.95	7.86	10.11	10.85	10.48	12.87	13.53	13.20	15.63	11.74	13.68
SEm. (±)	0.02	0.04	0.03	0.05	0.01	0.03	0.07	0.04	0.06	0.01	0.01	0.01
CD at 1 %	0.10	0.15	0.12	0.19	0.05	0.13	0.29	0.15	0.22	0.03	0.04	0.03
B. Packaging materials												
P_1 : CFB box	8.02	7.17	7.60	9.99	9.91	9.95	12.04	12.01	12.02	13.08	12.44	12.76
P_2 : Plastic crates	9.16	8.84	9.00	11.18	11.18	11.18	13.91	13.50	13.71	14.79	14.69	14.74
SEm. (±)	0.01	0.02	0.01	0.02	0.01	0.02	0.03	0.02	0.03	0.01	0.01	0.01
CD at 1 %	0.05	0.07	0.06	0.09	0.02	0.06	0.14	0.07	0.10	0.02	0.02	0.02
C. Interaction (A x B)												
$C_1 P_1$	9.85	8.00	8.93	11.50	12.56	12.03	18.22	17.05	17.63	-	-	-
$C_1 P_2$	11.00	9.75	10.38	13.50	14.05	13.78	20.47	18.25	19.36	-	-	-
$C_2 P_1$	7.39	7.00	7.20	10.25	9.00	9.63	8.73	10.89	9.81	11.96	12.50	12.23
$C_2 P_2$	9.35	8.20	8.78	11.16	10.90	11.03	12.80	12.30	12.55	13.56	13.37	13.47
$C_3 P_1$	6.15	6.50	6.33	8.00	8.50	8.25	10.51	9.00	9.76	11.41	12.20	11.81
$C_3 P_2$	8.00	7.80	7.90	10.50	10.56	10.53	12.00	11.20	11.60	13.10	14.50	13.80
$C_4 P_1$	7.30	6.80	7.05	9.30	9.10	9.20	11.56	12.00	11.78	14.56	12.32	13.44
$C_4 P_2$	10.00	8.50	9.25	11.80	10.10	10.95	14.21	13.45	13.83	16.27	15.70	15.99
$C_5 P_1$	8.20	7.69	7.95	10.10	9.85	9.98	11.25	11.33	11.29	13.40	13.00	13.20
$C_5 P_2$	10.00	9.00	9.50	12.05	11.33	11.69	14.00	12.85	13.43	16.89	15.60	16.25
$C_6 P_1$	10.64	8.80	9.72	12.60	10.80	11.70	13.20	12.03	12.62	-	-	-
$C_6 P_2$	11.43	9.20	10.32	13.00	12.03	12.52	14.00	13.34	13.67	-	-	-
$C_7 P_1$	6.50	5.36	5.93	7.69	8.65	8.17	10.00	9.85	9.93	11.22	12.83	12.03
$C_7 P_2$	7.03	8.00	7.52	8.80	9.50	9.15	11.15	12.05	11.60	12.45	14.70	13.58
$C_8 P_1$	9.19	7.41	8.30	10.63	10.27	10.45	12.20	12.95	12.58	14.00	13.20	13.60
$C_8 P_2$	7.05	10.23	8.64	9.44	10.93	10.19	13.55	14.00	13.78	15.00	16.50	15.75
$C_9 P_1$	7.00	7.00	7.00	9.87	10.44	10.16	12.68	13.00	12.84	15.00	11.02	13.01
$C_9 P_2$	8.55	8.90	8.73	10.35	11.25	10.80	13.05	14.05	13.55	16.26	12.45	14.36
SEm. (±)	0.04	0.05	0.04	0.07	0.02	0.05	0.10	0.05	0.08	0.01	0.01	0.01
CD at 1 %	0.14	0.21	0.17	0.27	0.07	0.19	0.42	0.21	0.31	0.05	0.06	0.05

Packaging materials exhibited significant difference during storage. Rate of increase in PLW was slow in P_1 as compared to P_2. Highest PLW recorded by P_1 and P_2 was 14.15 and 16.20 per cent at 16th day respectively.

The interaction effect of coatings and packaging materials, during storage on fruits PLW was significant during storage. The data in Table 1 demonstrated an increasing trend in PLW of the fruits up to the 16th day after storage. The minimum PLW (10.20%) was found in C_3P_1 (beeswax 2% + CFB box) treatment, which was followed by C_7P_1 (chitosan 0.5% + CFB box) (10.94%), C_3P_2 (beeswax 2% + plastic crates) (11.68%). Whereas, maximum (24.33%) PLW was showed in C_1P_2 (without coating fruit + plastic crates) treatment.

Throughout the duration of storage, in cold storage PLW Table 2 exhibited a noticeable difference with coating treatments. Effect of various coatings could be recorded up to 28th days for C_2, C_3, C_4, C_5, C_7, C_8 and C_9. It was visible from the pooled data that, the treatment T_3 and T_7 minimum PLW (12.80%) which was followed by the treatment of C_2 (12.85%) whereas, maximum PLW (18.50%) was recorded C_1 (without coating) up to 24th day of storage.

During storage, the packaging materials showed significant difference. Compared to P_2, the rate of PLW increase was slower in P_1. Highest PLW recorded by P_1 and P_2 was 12.76 and 14.74 per cent at 28th day respectively.

The interaction effect of different coating and packaging during storage on fruit PLW was significant during storage in CS. Table 2 showed that PLW of the fruits in the data showed increasing trend up to 28th day during storage. The minimum PLW (11.81%) was observed in C_3P_1 (beeswax 2% + CFB box) treatment which was followed by the C_7P_1 (chitosan 0.5% + CFB box), (12.03%), C_2P_1 (alginate 2% + CFB box) (12.23%) treatment. Whereas, maximum (19.36%) PLW was recorded in C_1P_2 (without coating + plastic crates) treatment up to 24th day during storage.

Fruit after harvest leads to an independent life, as they are taken from the plant and the usual flow of water, nutrients and other organic components is interrupted. Although the removal of the organ from the plant results in harvest lesions, degradation can be mitigated by using the appropriate post-harvest treatments. The continuous rise in PLW could be caused by the fruit losing moisture through respiration and transpiration.

Because of their close interaction with the atmosphere, uncoated fruits may have greater rates of respiration and evapo-transpiration, which might cause their increased PLW. Mango also reported similar results. Castillo *et al.* (2010), Valentina and Giovanna (2016), Ajeethan and Mikunthan (2016), Abonesh *et al*. (2018), Abdul and Naveed (2019) and Somayeh *et al*. (2019).

Fruit peel can be covered with waxing materials to prevent water loss, reduce O_2 and CO_2 exchange, and ultimately reduce weight loss. Similar studies by Togrul and Arslan (2004) and Abonesh *et al.* (2018) found that coating acts as an extra barrier on top of the fruit peel, reducing transpiration and respiration from the fruits. Beeswax hydrophobic feature, which stops water and other molecules from flowing between the inside and external environments of fruits, may help to explain this. Wax coating decreased the rate of respiration and transpiration, Thai *et al.* (2002) and Abonesh *et al.* (2018) reported similar outcomes.

Higher relative humidity with modified atmosphere created within the package were possible causes for significant reduction of PWL for packaged mango fruits. Wills *et al.* (1998) they concluded that faster air movement around fruits may result in higher water loss. The result agrees with reports of many researchers Cocozza *et al*.,(2004), Silva *et al*., (2004) and Alye, (2005). Singh *et al*. (2003) and Anwar *et al.* (2008) they found that fruit packaging reduces water loss and delays ripening in mango fruit. According to Ben-Yehoshua (1985), the main function of packaging is to reduce respiration rate and water loss by transpiration and injurious atmosphere inside the package, which could affect the fruits metabolism.

According to the findings, the physiological weight loss in the storage condition increased as the storage temperature is raised. At storage with ambient temperature, the PLW increased the quickest and most significantly. The continuous rise in PLW values among all storage conditions may be due to fruit skin losing moisture through respiration and transpiration. The findings of this research support by Kapse *et al*. (1979), Karla and Tondon (1984), Gole (1986), Sethi (1987), Patil (1990), Padhye (1997), Devani *et al*. (2011) and Kanade *et al*. (2017) in mango.

By slowing the rate during which processes like respiration and transpiration occur, the low temperature and high humidity (%) typical of cold storage may be to responsible for the decrease in PLW. The result of this research support by Bakshi *et al*. (2013)

4.1.2 Shriveling (%)

The impact of different coatings and packing materials on shriveling (%) recorded during storage during the year 2019, 2020 and pooled analysis are showed in Table 3 (AT). The shriveling (%) in mango fruit was found to be increased during storage and shriveling (%) was recorded at ambient temperature (AT) no shriveling was observed in cold storage (CS).

The findings showed that mango fruit shrivelling (%) increased throughout the period of the storage time as the storage period advanced. Up to 11^{th} day, no shriveling was showed in mango fruit and 12^{th} day onwards have been showen in Table 3. This is because fruit at ambient storage started to shriveling from 12^{th} day and were discarded at 16^{th} day and shelf life of mango fruit was ended. The significant differences were recorded among the different treatments in respect of shriveling (%) of fruits at RT. It was evident from the pooled data that the treatment C_3 (beeswax 2%) minimum shriveling (3.50%) which was followed by the treatment of C_7 (chitosan 0.5%) (4%) whereas, maximum shriveling (8%) was recorded in C_1 (without coating) treatment at 16^{th} day after storage. The statistics made it evident that mango fruits with coatings beat untreated mangoes.

Packaging materials exhibited significant difference during storage. Compared to P_2, the rate of increase in shrivelling (%) was slower in P_1. Highest shriveling (%) recorded by P_1 and P_2 was 6.00 and 6.56 % at 16^{th} day.

The interaction impact of different coatings and packaging materials during storage on fruit shriveling (%) was significant. Table 3 showed that shriveling (%) of mango fruits in the data shows increasing trend up to 16^{th} day during storage. The minimum shriveling (3.00 %) was found in C_3P_1 (beeswax 2% + CFB box) treatment which was followed by C_3P_2 (beeswax 2% + plastic crates), C_7P_1 (chitosan 0.5% + CFB box), C_7P_2 (chitosan 0.5% + plastic crates), (4.00%) Whereas, maximum (8.00%) shriveling was observed in C_1P_1 (Without coating + CFB) and C_1P_2 (without coating + plastic crates) treatment up to 16^{th} day during storage.

Table 3. Effect of edible coatings and packaging materials on changes in shriveling (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pool	2019	2020	Pooled mean	2019	2020	Pool	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	7.00	6.50	7.50	8.50	8.00
C_2 : Alginate (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	4.00	4.50	7.00	6.00	6.50
C_3 : Beewax (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	3.00	3.50
C_4 : Aloe vera gel (75 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	5.00	4.50	6.00	8.00	7.00
C_5 : Tapioca starch (5 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	4.00	4.50	7.00	6.00	6.50
C_6 : Cinnamon oil (0.02)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	5.00	4.50	8.00	8.00	8.00
C_7 : Chitosan (0.5 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	4.00	4.00
C_8 : Acacia gum (5 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	7.00	6.50
C_9 : Pectin (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	5.00	3.50	6.00	7.00	6.50
SEm. (±)	-	-	-	-	-	-	-	-	-	0.17	0.19	0.18	0.09	0.05	0.07
CD at 1 %	-	-	-	-	-	-	-	-	-	0.68	0.77	0.69	0.37	0.19	0.28
B. Packaging materials															
P_1 : CFB box	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.56	4.22	3.89	6.00	6.00	6.00
P_2 : Plastic crates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.22	4.11	6.33	6.78	6.56
SEm. (±)	-	-	-	-	-	-	-	-	-	0.08	0.09	0.08	0.04	0.02	0.03
CD at 1 %	-	-	-	-	-	-	-	-	-	0.32	NS	NS	0.17	0.09	0.13
C. Interaction (A x B)															
$C_1 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.00	6.00	8.00	8.00	8.00
$C_1 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	8.00	7.00	7.00	9.00	8.00
$C_2 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	6.00	6.00
$C_2 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	4.00	5.00	8.00	6.00	7.00
$C_3 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	2.00	3.00
$C_3 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	4.00	4.00
$C_4 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	6.00	5.00	6.00	8.00	7.00
$C_4 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	8.00	7.00
$C_5 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	6.00	6.00
$C_5 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	4.00	5.00	8.00	6.00	7.00
$C_6 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	6.00	5.00	8.00	8.00	8.00
$C_6 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	8.00	8.00	8.00
$C_7 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	4.00	4.00
$C_7 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	4.00	4.00
$C_8 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	6.00	6.00
$C_8 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00	4.00	6.00	8.00	7.00
$C_9 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	4.00	3.00	6.00	6.00	6.00
$C_9 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	6.00	4.00	6.00	8.00	7.00
SEm. (±)	-	-	-	-	-	-	-	-	-	0.24	0.27	0.25	0.13	0.07	0.10
CD at 1 %	-	-	-	-	-	-	-	-	-	0.96	1.09	0.97	0.52	0.27	0.39

Nadeem *et al*. (2009) The crab chitosan (200 kGy) had showed the greatest behaviour during storage with no shrivelling or weight loss. Amulya *et al*. (2016) highest moisture per cent found in wax coated fruit. This could be as a result of the wax-coated mangorestricted metabolic activity at MAP set on by non-perforated LDPE and IP bags.

High storage temperature leads to accelerated moisture loss and subsequently to softening and shriveling of the fruit (Proulx *et al.*, 2005). Fruits maintained in cold storage remained firm and did not shrink. The high humidity and low temperature of the cold storage avoided fruit from shrivelling. Padhye (1997), Kshirsagar (2004), and Kanade *et al.* (2017) they observed similar findings.

4.1.3 Spoilage (%)

A better indicator of mango fruit shelf life is spoiled fruit. When the spoilage of fruit of any treatment reached to 15 per cent it was considered as the end of storage life and such treatments were discarded.

Impact of different coatings and packaging materials on spoilage (%) recorded during storage for the year 2019, 2020 and pooled analysis are shown in the Table 4 (AT) and Table 5 (CS) and depicted in Fig. 3 and 4 respectively.

Table 4 represents effect of coating and packaging on spoilage of fruit. Data of individual and two factor interactions showed that at initial and 7^{th} day spoilage percentage is zero, fruit started to spoil from 8^{th} day onwards. This is because fruits under ambient storage started to spoil from 8^{th} day and were discarded at 16^{th} day as shelf life was ended. The individual factors (coatings and packaging materials) effect showed significant variation in spoilage percentage during storage period.

Among the nine coating C_7 (chitosan 0.5%) was found superior by recording minimum spoilage (12.50%) followed by C_3 (beeswax 2%) (1300 %) and C_2 (alginate 2%) (15.00 %) under ambient temperature at end of storage. Maximum spoilage (19.50 %) was showed in C_1 treatment at the end of storage (16^{h} day).

P_1 was found superior to P_2 as it recorded minimum spoilage under AT. While, considering storage conditions fruit under ambient temperature recorded 15.33 % (P_1) spoilage at end of storage period (12^{th} day).

Table 4. Effect of edible coatings and packaging materials on changes in spoilage (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pool	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	0.00	0.00	0.00	0.00	0.00	0.00	7.00	5.00	6.00	16.00	17.00	16.50	20.00	19.00	19.50
C_2 : Alginate (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	7.00	14.00	16.00	15.00
C_3 : Beewax (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	7.00	6.00	12.00	14.00	13.00
C_4 : Aloe vera gel (75 %)	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	9.00	9.00	9.00	17.00	18.00	17.50
C_5 : Tapioca starch (5 %)	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	8.00	8.00	8.00	16.00	17.00	16.50
C_6 : Cinnamon oil (0.02)	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.50	9.00	7.00	8.00	17.00	16.00	16.50
C_7 : Chitosan (0.5 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	7.00	13.00	12.00	12.50
C_8 : Acacia gum (5 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00	5.00	8.00	6.50	16.00	15.00	15.50
C_9 : Pectin (2 %)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	7.00	7.00	16.00	17.00	16.50
SEm. (±)	-	-	-	-	-	-	0.03	0.05	0.04	0.12	0.08	0.10	0.08	0.12	0.10
CD at 1 %	-	-	-	-	-	-	0.14	0.19	0.16	0.48	0.34	0.39	0.34	0.48	0.39
B. Packaging materials															
P_1 : CFB box	0.00	0.00	0.00	0.00	0.00	0.00	1.33	1.11	1.22	8.67	8.00	8.33	15.11	15.56	15.33
P_2 : Plastic crates	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.67	0.89	7.56	9.11	8.33	16.22	16.44	16.33
SEm. (±)	-	-	-	-	-	-	0.02	0.02	0.02	0.06	0.04	0.05	0.04	0.06	0.05
CD at 1 %	-	-	-	-	-	-	0.06	0.09	0.07	0.23	0.16	NS	0.16	0.23	0.19
C. Interaction (A x B)															
$C_1 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.00	6.00	16.00	16.00	16.00	20.00	18.00	19.00
$C_1 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	8.00	4.00	6.00	16.00	18.00	17.00	20.00	20.00	20.00
$C_2 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	6.00	7.00	14.00	16.00	15.00
$C_2 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	8.00	7.00	14.00	16.00	15.00
$C_3 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.00	6.00	12.00	14.00	13.00
$C_3 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	8.00	6.00	12.00	14.00	13.00
$C_4 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	10.00	10.00	10.00	16.00	18.00	17.00
$C_4 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	8.00	8.00	18.00	18.00	18.00
$C_5 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	8.00	8.00	8.00	14.00	16.00	15.00
$C_5 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	8.00	8.00	8.00	18.00	18.00	18.00
$C_6 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	10.00	6.00	8.00	16.00	16.00	16.00
$C_6 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	8.00	8.00	18.00	16.00	17.00
$C_7 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	6.00	7.00	12.00	12.00	12.00
$C_7 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	8.00	7.00	14.00	12.00	13.00
$C_8 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00	6.00	8.00	7.00	16.00	14.00	15.00
$C_8 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00	4.00	8.00	6.00	16.00	16.00	16.00
$C_9 P_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	6.00	6.00	16.00	16.00	16.00
$C_9 P_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	8.00	8.00	16.00	18.00	17.00
SEm. (±)	-	-	-	-	-	-	0.05	0.07	0.06	0.17	0.12	0.14	0.12	0.17	0.14
CD at 1 %	-	-	-	-	-	-	0.19	0.27	0.22	0.68	0.48	0.56	0.48	0.68	0.56

Table 5. Effect of edible coatings and packaging materials on changes in spoilage (%) of Kesar mango fruit during storage in cold storage

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 : Without coating	5.00	5.00	5.00	16.00	18.00	17.00	19.00	20.00	19.50	-	-	-
C_2 : Alginate (2 %)	0.00	1.50	0.75	4.00	4.00	4.00	11.00	12.00	11.50	15.00	18.00	16.50
C_3 : Beewax (2 %)	0.00	0.00	0.00	7.00	6.00	6.50	12.00	13.00	12.50	14.00	16.00	15.00
C_4 : Aloe vera gel (75 %)	0.00	0.00	0.00	7.00	8.00	7.50	13.00	14.00	13.50	16.00	18.00	17.00
C_5 : Tapioca starch (5 %)	0.00	0.00	0.00	5.00	7.00	6.00	11.00	14.00	12.50	18.00	17.00	17.50
C_6 : Cinnamon oil (0.02)	0.00	0.00	0.00	5.00	10.00	7.50	16.00	15.00	15.50	-	-	-
C_7 : Chitosan (0.5 %)	0.00	0.00	0.00	2.00	2.00	2.00	11.00	14.00	12.50	14.00	15.00	14.50
C_8 : Acacia gum (5 %)	0.00	0.00	0.00	5.00	5.00	5.00	15.00	14.00	14.50	20.00	17.00	18.50
C_9 : Pectin (2 %)	0.00	1.00	0.50	4.00	6.00	5.00	18.00	15.00	16.50	20.00	19.00	19.50
SEm. (±)	0.08	0.03	0.06	0.03	0.08	0.06	0.09	0.05	0.07	0.04	0.05	0.05
CD at 1 %	0.34	0.14	0.24	0.14	0.34	0.24	0.37	0.19	0.28	0.16	0.23	0.18
B. Packaging materials												
P_1 : CFB box	0.44	1.00	0.72	5.11	6.67	5.89	13.11	13.11	13.11	16.29	16.00	16.14
P_2 : Plastic crates	0.67	0.67	0.67	7.11	8.00	7.56	14.89	16.00	15.44	17.14	18.29	17.71
SEm. (±)	0.04	0.02	0.03	0.02	0.04	0.03	0.04	0.02	0.03	0.02	0.03	0.02
CD at 1 %	0.16	0.06	NS	0.06	0.16	0.12	0.17	0.09	0.13	0.09	0.12	0.10
C. Interaction (A x B)												
$C_1 P_1$	4.00	4.00	4.00	16.00	16.00	16.00	18.00	18.00	18.00	-	-	-
$C_1 P_2$	6.00	6.00	6.00	16.00	20.00	18.00	20.00	22.00	21.00	-	-	-
$C_2 P_1$	0.00	3.00	1.50	2.00	4.00	3.00	10.00	10.00	10.00	14.00	18.00	16.00
$C_2 P_2$	0.00	0.00	0.00	6.00	4.00	5.00	12.00	14.00	13.00	16.00	18.00	17.00
$C_3 P_1$	0.00	0.00	0.00	6.00	4.00	5.00	12.00	12.00	12.00	14.00	16.00	15.00
$C_3 P_2$	0.00	0.00	0.00	8.00	8.00	8.00	12.00	14.00	13.00	14.00	16.00	15.00
$C_4 P_1$	0.00	0.00	0.00	6.00	8.00	7.00	12.00	12.00	12.00	16.00	16.00	16.00
$C_4 P_2$	0.00	0.00	0.00	8.00	8.00	8.00	14.00	16.00	15.00	16.00	20.00	18.00
$C_5 P_1$	0.00	0.00	0.00	4.00	8.00	6.00	12.00	12.00	12.00	16.00	16.00	16.00
$C_5 P_2$	0.00	0.00	0.00	6.00	6.00	6.00	10.00	16.00	13.00	20.00	18.00	19.00
$C_6 P_1$	0.00	0.00	0.00	2.00	10.00	6.00	14.00	14.00	14.00	-	-	-
$C_6 P_2$	0.00	0.00	0.00	8.00	10.00	9.00	18.00	16.00	17.00	-	-	-
$C_7 P_1$	0.00	0.00	0.00	0.00	2.00	1.00	10.00	12.00	11.00	14.00	14.00	14.00
$C_7 P_2$	0.00	0.00	0.00	4.00	2.00	3.00	12.00	16.00	14.00	14.00	16.00	15.00
$C_8 P_1$	0.00	0.00	0.00	4.00	4.00	4.00	12.00	14.00	13.00	20.00	16.00	18.00
$C_8 P_2$	0.00	0.00	0.00	6.00	6.00	6.00	18.00	14.00	16.00	20.00	18.00	19.00
$C_9 P_1$	0.00	2.00	1.00	6.00	4.00	5.00	18.00	14.00	16.00	20.00	16.00	18.00
$C_9 P_2$	0.00	0.00	0.00	2.00	8.00	5.00	18.00	16.00	17.00	20.00	22.00	21.00
SEm. (±)	0.12	0.05	0.09	0.05	0.12	0.09	0.13	0.07	0.10	0.05	0.08	0.07
CD at 1 %	0.48	0.19	0.35	0.19	0.48	0.35	0.52	0.27	0.39	0.23	0.32	0.26

Data of two factor interactions showed that at initial and 7th day spoilage percentage is zero, fruit started to spoil from 8th day onwards. Among the interactions between coatings and packaging materials, fruits coated with C_7P_1 recorded minimum spoilage (12.00 %) followed by C_3P_1, C_3P_2 and C_7P_2 (13.00 %) during storage. maximum spoilage was showed in C_1P_2 (20.00 %) at the end of storage (16h day).

Table 5 represents impact of different postharvest treatments on spoilage of fruit. Data of individual and two factor interactions showed that at initial and 15th day spoilage percentage is zero, fruit started to spoil from 16th day onwards. This is because fruit under cold storage started to spoil from 16th day and were discarded at 28th day as shelflife of fruit was ended. The individual factors (coatings) effect showed significant variation in spoilage percentage throughout the storage period. Among the nine coatings C_7 was found superior by recording minimum spoilage (14.50%), followed by C_3 (15.00 %) and C_2 (16.50 %) under CS at end of storage. Maximum spoilage was showed in C_1 (without coating) (19.50 %) at the end of storage (24th day).

P_1 was found superior to P_2 as it recorded minimum spoilage under CS. While, considering storage conditions fruit under cold storage recorded 16.14 per cent spoilage in P_1 at end of storage period (28th day).

The interaction (coatings and packaging) effect showed significant variation in spoilage percentage. Among the interactions between coatings and packaging materials, fruit coated with C_7P_1 recorded minimum spoilage (14.00 %), followed by C_3P_1, C_3P_2 and C_7P_2 (15.00 %) during in CS. maximum spoilage (21.00 %) was showed in C_1P_2 (without coating + Plastic crates) at the end of storage (24th day).

Spoilage of fruit is due to infestation of microbes during storage. After harvest there is a continuous biochemical change in fruits which leads to fruit softening. Soft fruits are more susceptible to microbe infestation. These uncoated fruit ripened earlier and became soft, as a result the infestation of microbes started at faster rate.

Chitosan coating minimises rotting and fungal growth without changing the properties of fruit. Diep and Lam (2003) Abonesh *et al.* (2018). According to Bibi and Baloch (2014), wax coating on fruit lowers the fruit's respiration throughout the ripening phase and the proliferation of microbes. According to Covas (2008), coatings are antibacterial and antioxidant. According to Nadeem *et al.* (2009), irradiation chitosan coated fruits showed reduced levels of fruit-spoiling fungi (*Colletotrichum gleosporioides*) after 5 weeks of storage compared to uncoated fruits after 2 weeks.

CFB box packaging showed minimum spoilage similar, results observed by Mounika *et al*. (2017) packaging films reduces spoilage and higher in fruits in control. This may be because anaerobic circumstances, enzyme breakdown, condensation of moisture on fruit surfaces, and other factors during storage period favoured the growth of microflora. Fruits become softer as they mature and experience senescent changes, which makes them more susceptible to rots caused by fungi. Likewise, Yameshita and Benassi (1998) observed similar results in guava. Early senescence, which is strongly correlated with high polygalacturonage and cellulase activity and causes rapid breakdown of protopectin and cellulose and early softening of fruits, may be the cause of the substantial spoilage loss in control fruits (Roe and Bruemmer, 1981).

The highest spoilage percentage was noticed in ambient temoerature (AT) as contrast to cold storage (CS). It's possible that it's because ambient storage had high temperatures that were suitable to microbial development and cause fruit spoilage. Similar results shown by Khanbarad *et al*. (2013), Makwana *et al*. (2014) and Kanade *et al*. (2017) in mango.

Storage at low temperature reduces respiration resulting in reduction in vital heat, thermal decomposition and microbial spoilage (Sharma and Azad, 2000). The lower ethylene production due modified atmosphere of packed fruit (Gonzalez *et al*., 1990).

4.1.4 Number of days required for fruit ripening (Days)

The data on number of days required for fruit of Kesar mango during storage for the year 2019, 2020 and pooled are presented in Table 6. At ambient temperature the ripening peak was noticed on 8^{th} day. The data it can be revealed that, in the pooled data delay ripening (12.00 days) was recorded in C_3P_1 (beeswax 2% + CFB box), C_3P_2 (beeswax 2% + Plastic crates), C_7P_1 (chitosan 0.5% + CFB box) and C_7P_2 (chitosan 0.5% + Plastic crates) treatment. Ripening of C_1P_2 (without coating + Plastic crates) mango fruit fast (7.75 days).

In cold storage 13^0C temperature ripening was observed on 16^{th} day. The data it can be revealed that, in the pooled data delay ripening (20.00 days) was recorded

Table 6. Effect of edible coatings and packaging materials on number of days required for fruit ripening of Kesar mango fruit during storage

Treatment	Ambient temperature			Cold storage		
	2019	2020	Pooled mean	2019	2020	Pooled mean
Interaction (A x B)						
$C_1 P_1$	8.00	8.00	8.00	16.00	16.00	16.00
$C_1 P_2$	7.50	8.00	7.75	15.00	16.00	15.50
$C_2 P_1$	12.00	11.00	11.50	22.00	18.00	20.00
$C_2 P_2$	12.00	11.00	11.50	22.00	18.00	20.00
$C_3 P_1$	12.00	12.00	12.00	22.00	18.00	20.00
$C_3 P_2$	12.00	12.00	12.00	20.00	18.00	19.00
$C_4 P_1$	12.00	10.00	11.00	20.00	18.00	19.00
$C_4 P_2$	10.00	10.00	10.00	20.00	18.00	19.00
$C_5 P_1$	12.00	10.00	11.00	20.00	18.00	19.00
$C_5 P_2$	10.00	10.00	10.00	20.00	16.00	18.00
$C_6 P_1$	11.00	10.00	10.50	18.00	16.00	17.00
$C_6 P_2$	10.00	10.00	10.00	16.00	16.00	16.00
$C_7 P_1$	12.00	12.00	12.00	22.00	18.00	20.00
$C_7 P_2$	12.00	12.00	12.00	22.00	18.00	20.00
$C_8 P_1$	11.00	10.00	10.50	20.00	18.00	19.00
$C_8 P_2$	12.00	10.00	11.00	20.00	18.00	19.00
$C_9 P_1$	12.00	10.00	11.00	18.00	18.00	18.00
$C_9 P_2$	12.00	10.00	11.00	18.00	16.00	17.00
SEm. (±)	0.24	0.02	0.17	0.17	0.27	0.22
CD at 1 %	0.96	NS	0.64	0.70	1.08	NS

in treatment C_2P_1, C_2P_2, C_3P_1, $C_7P_1$and C_7P_2. Ripening of C_1P_2 treatment (without coating + Plastic crates) (15.50 days) mango fruit fast.

At 13^0C temperature ripening was started on 16th day which was too late compared to ambient temperature. This might be due to high RH and low temperature prevalent in the treatments hindered or slowed down the ripening process. Ripening process commenced earliest (8^{th} day) in fruits at room temperature. Anwar *et al.* (2008) reported that fruit packaging reduces water loss and delays ripening in mango fruit.

4.1.5 Shelf-life (Days)

The data on shelf-life of Kesar mangoes during storage for the year 2019, 2020 and pooled are showed Table 7 and depicted in Fig. 3 (AT) and 4 (CS). Significant difference showed in shelf-life of mango fruits influenced by different coating at ambient storage (AT). The pooled data presented in the Table 7 showed that, significantly higher shelf-life (16.00 days) was recoreded fruits treated with chitosan (0.5 %) + CFB box (C_7P_1), chitosan (0.5 %) + plastic crates (C_7P_2), beeswax (2 %) + CFB box (C_3P_1), and beeswax (2 %) + plastic crates (C_3P_2) which was at par with fruit treated with alginate (2 %) + CFB box (C_2P_1) and alginate (2 %) + plastic crates (C_2P_2) (15.50 days). Minimum shelf-life (11.00 days) was showed in uncoating + plastic crates (C_1P_2) treatment.

Significant results in shelf-life of mango fruits influenced by different coating in cold storage (CS). The data in the Table 7 showed that, pooled data significantly higher shelf-life (28.00 days) was found in fruits coated with chitosan (0.5 %) + CFB box (C_7P_1), chitosan (0.5 %) + plastic crates (C_7P_2) and beeswax (2 %) + CFB box (C_3P_1), which was statistically at par with fruit treated with beeswax (2 %) + plastic crates (C_3P_2), alginate (2 %) + CFB box (C_2P_1), and alginate (2 %) + plastic crates (C_2P_2) (27.00 days). Minimum shelf-life (20.00 days) was showed in C_1P_2 (without coating + plastic crates) treatment.

In general, chitosan (0.5%) and beeswax (2% each) treatments gave fruits a higher shelf-life and improved quality compared to uncoated mango fruit and other treatments. Given that the cumulative effect of maintaining a number of quality attributes is the shelf-life extension, this could be connected to other qualities. Penchaiya *et al.* (2006) and Abonesh *et al.* (2018), they reported that the application of an edible coating increased the shelf-life of mango fruits. Several fruits use the well-known coating substance chitosan to extend their shelf lives (Graham, 1990). Nadeem *et al.* 2009 Chitosan is the best edible covering material and has been irradiated by crabs (200 kGy) to improve mango fruit shelf life.

Fruits packed CFB box recorded highest shelf life. This may be caused due to accumulation or maintenance of high relative humidity in the CFB box that reduced rate of transpiration. Similar results was found by Mounika *et al*. (2017) in mango.

Table 7. Effect of edible coatings and packaging materials on shelf life of Kesar mango fruit during storage

Treatment	Ambient temperature			Cold storage		
	2019	2020	Pooled mean	2019	2020	Pooled mean
Interaction (A x B)						
C_1 P_1	12.00	12.00	12.00	20.00	22.00	21.00
C_1 P_2	10.00	12.00	11.00	20.00	20.00	20.00
C_2 P_1	16.00	15.00	15.50	28.00	26.00	27.00
C_2 P_2	16.00	15.00	15.50	28.00	26.00	27.00
C_3 P_1	16.00	16.00	16.00	28.00	28.00	28.00
C_3 P_2	16.00	16.00	16.00	28.00	26.00	27.00
C_4 P_1	15.00	13.00	14.00	26.00	24.00	25.00
C_4 P_2	14.00	13.00	13.50	24.00	24.00	24.00
C_5 P_1	15.00	14.00	14.50	26.00	26.00	26.00
C_5 P_2	13.00	14.00	13.50	26.00	24.00	25.00
C_6 P_1	14.00	13.00	13.50	24.00	22.00	23.00
C_6 P_2	13.00	13.00	13.00	22.00	22.00	22.00
C_7 P_1	16.00	16.00	16.00	28.00	28.00	28.00
C_7 P_2	16.00	16.00	16.00	28.00	28.00	28.00
C_8 P_1	15.00	15.00	15.00	26.00	26.00	26.00
C_8 P_2	15.00	15.00	15.00	24.00	24.00	24.00
C_9 P_1	15.00	14.00	14.50	22.00	24.00	23.00
C_9 P_2	15.00	14.00	14.50	22.00	24.00	23.00

Compared to fruits stored at AT, fruits in CS had the longest shelf-life. This may be caused by the quickest possible field heat decrease, constrained metabolic and respiratory activity, lesser moisture loss, and fruit suppression of water loss and ethylene production (Hardenburg *et al*., 1990). The similar result reported by Padhye (1997), Devani *et al*. (2011) and Khanbarad *et al*. (2013). Lemma *et al*. (2012).

Packaging extend the shelf life and maintain quality of mango fruit for weeks on ambient storage condition.

4.1.6 Firmness (N)

Firmness (N) of mango fruit cv. kesar influenced by different postharvest coatings is presented in Table 8 (AT) and 9 (CS) for the year 2019, 2020 and pooled depicted in Fig. 8 (AT) and 9 (CS). From the data it was understood that, fruit firmness maintained decreasing trend with increasing storage period.

In pooled data individual effect of different coatings showed significant variation in data C_3 recorded higher firmness (3.97 N) followed by C_7 (3.91 N) and C_2 (3.56 N) whereas, minimum firmness (2.76 N) was showed in T_1at 16^{th} day of storage.

Packaging materials showed significant result during storage. Rate of decrease in firmness was slow in P_1 as compared to P_2. Highest firmness recorded by P_1 and P_2 was 3.19 N and 3.12 N at 16^{th} day respectively.

The interaction effect of edibal coatings and packaging materials during storage on fruit firmness (N) was significant during storage. The data presented in the Table 8 showed that firmness (N) of mago fruits in the data shows decreasing trend up to 16^{th} day of storage and maximum firmness (3.97 N) was observed in the treatment C_3P_1 (beeswax 2% + CFB box) which is satatisticaly at par with the C_3P_2 (beeswax 2% + Plastic crates), C_7P_1 (chitosan 0.5 % + CFB box) treatments. Whereas, minimum (2.75N) firmness was recoreded in C_1P_1 (without coating + CFB box) treatment up to 16^{th} day of storage

When that related to storage conditions, fruit held at room temperature proved to lose firmness more quickly than fruit placed in cold storage.

Individual effect of different coatings showed significant variation in pooled data. C_3 recorded higher firmness (3.78N) up to 28^{th} day of storage followed by C_7 (3.67 N) and C_2 (3.60 N) whereas, minimum firmness (3.23 N) was observed in C_1 (without coating) at 24^{th} day of storage.

Packaging materials exhibited significant difference during storage. Rate of decrease in firmness was slow in P_1 as compared to P_2. Highest firmness was recorded by P_1 3.38 N and P_2 3.20 N at 24^{th} day of storage.

Table 8. Effect of edible coatings and packaging materials on changes in firmness (N) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	16.10	16.05	16.08	12.21	11.85	12.03	7.85	8.10	7.98	5.08	5.05	5.07	2.92	2.60	2.76
C_2 : Alginate (2 %)	16.11	16.06	16.08	12.86	12.47	12.66	10.78	10.29	10.53	7.40	7.46	7.43	3.63	3.50	3.56
C_3 : Beewax (2 %)	16.11	16.04	16.07	13.02	12.74	12.88	10.78	10.43	10.60	7.91	7.81	7.86	4.32	3.62	3.97
C_4 : Aloe vera gel (75 %)	16.11	16.06	16.08	12.62	12.42	12.52	10.65	9.17	9.91	7.28	6.90	7.09	2.82	3.02	2.92
C_5 : Tapioca starch (5 %)	16.10	16.06	16.08	12.61	12.58	12.60	10.39	9.23	9.81	7.37	6.88	7.13	2.93	2.95	2.94
C_6 : Cinnamon oil (0.02)	16.11	16.06	16.08	12.32	12.01	12.16	8.91	8.31	8.61	5.37	5.90	5.63	2.71	2.21	2.46
C_7 : Chitosan (0.5 %)	16.10	16.06	16.08	12.93	12.77	12.85	11.07	10.29	10.68	7.90	7.55	7.72	3.95	3.88	3.91
C_8 : Acacia gum (5 %)	16.11	16.06	16.08	12.56	12.54	12.55	10.31	10.16	10.24	7.40	7.02	7.21	2.90	3.07	2.98
C_9 : Pectin (2 %)	16.11	16.06	16.08	12.30	12.13	12.21	10.20	8.73	9.46	6.90	6.42	6.66	3.05	2.75	2.90
SEm. (±)	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	0.07	0.11	0.09	0.08	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
B. Packaging materials															
P_1 : CFB box	16.11	16.06	16.08	12.70	12.51	12.61	10.21	9.49	9.85	7.01	6.81	6.91	3.30	3.08	3.19
P_2 : Plastic crates	16.10	16.05	16.08	12.51	12.26	12.38	9.99	9.34	9.66	6.90	6.74	6.82	3.19	3.05	3.12
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	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	0.03	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
C. Interaction (A x B)															
$C_1 P_1$	16.10	16.05	16.08	12.36	11.90	12.13	7.90	8.20	8.05	5.20	5.10	5.15	3.00	2.50	2.75
$C_1 P_2$	16.10	16.05	16.08	12.06	11.80	11.93	7.80	8.00	7.90	4.97	5.00	4.98	2.84	2.70	2.77
$C_2 P_1$	16.11	16.06	16.08	12.84	12.63	12.74	10.90	10.36	10.63	7.55	7.54	7.54	3.75	3.50	3.63
$C_2 P_2$	16.11	16.06	16.08	12.87	12.30	12.59	10.65	10.21	10.43	7.25	7.38	7.31	3.50	3.50	3.50
$C_3 P_1$	16.11	16.05	16.08	13.10	12.98	13.04	10.95	10.38	10.67	7.90	7.90	7.90	4.35	3.60	3.97
$C_3 P_2$	16.11	16.03	16.07	12.94	12.50	12.72	10.60	10.48	10.54	7.91	7.71	7.81	4.29	3.63	3.96
$C_4 P_1$	16.12	16.05	16.09	12.74	12.46	12.60	10.70	9.33	10.02	7.34	6.89	7.11	2.90	3.03	2.97
$C_4 P_2$	16.10	16.06	16.08	12.50	12.37	12.44	10.60	9.00	9.80	7.23	6.91	7.07	2.74	3.00	2.87
$C_5 P_1$	16.10	16.07	16.09	12.69	12.65	12.67	10.53	9.37	9.95	7.38	6.91	7.14	3.00	3.00	3.00
$C_5 P_2$	16.09	16.04	16.07	12.53	12.51	12.52	10.24	9.10	9.67	7.37	6.85	7.11	2.85	2.90	2.88
$C_6 P_1$	16.11	16.05	16.08	12.44	12.11	12.27	8.99	8.29	8.64	5.38	5.89	5.64	2.71	2.28	2.50
$C_6 P_2$	16.11	16.06	16.08	12.20	11.90	12.05	8.84	8.33	8.58	5.35	5.90	5.63	2.70	2.14	2.42
$C_7 P_1$	16.11	16.07	16.09	13.00	13.03	13.02	11.13	10.38	10.75	7.96	7.51	7.74	4.00	3.90	3.95
$C_7 P_2$	16.10	16.05	16.07	12.86	12.50	12.68	11.00	10.20	10.60	7.84	7.58	7.71	3.90	3.85	3.88
$C_8 P_1$	16.11	16.05	16.08	12.64	12.63	12.64	10.43	10.33	10.38	7.40	7.00	7.20	2.90	3.13	3.02
$C_8 P_2$	16.11	16.06	16.08	12.48	12.45	12.46	10.19	10.00	10.09	7.39	7.04	7.22	2.90	3.00	2.95
$C_9 P_1$	16.11	16.07	16.09	12.46	12.25	12.35	10.40	8.75	9.57	7.00	6.59	6.79	3.10	2.77	2.94
$C_9 P_2$	16.11	16.05	16.08	12.13	12.02	12.08	10.00	8.70	9.35	6.80	6.25	6.53	3.00	2.73	2.86
SEm. (±)	0.03	0.02	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	0.10	0.16	NS	0.11	0.08	0.09	0.09	0.08	0.08	0.07	0.07	0.07

Table 9. Effect of edible coatings and packaging materials on changes in firmness (N) 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 : Without coating	16.10	16.05	16.08	13.68	13.83	13.76	12.35	12.00	12.18	9.90	9.82	9.86
C_2 : Alginate (2 %)	16.11	16.06	16.08	15.15	14.18	14.67	13.41	13.52	13.47	11.90	11.38	11.64
C_3 : Beewax (2 %)	16.11	16.04	16.07	14.97	14.41	14.69	14.10	13.71	13.91	12.18	11.71	11.94
C_4 : Aloe vera gel (75 %)	16.11	16.06	16.08	14.54	14.23	14.38	13.74	13.32	13.53	11.00	11.09	11.04
C_5 : Tapioca starch (5 %)	16.10	16.06	16.08	14.70	14.04	14.37	13.42	13.23	13.32	11.47	11.12	11.30
C_6 : Cinnamon oil (0.02)	16.11	16.06	16.08	14.25	14.10	14.17	12.24	12.20	12.22	10.36	11.13	10.74
C_7 : Chitosan (0.5 %)	16.10	16.06	16.08	15.01	14.38	14.70	14.14	13.69	13.92	11.99	11.98	11.99
C_8 : Acacia gum (5 %)	16.11	16.06	16.08	14.67	14.27	14.47	13.66	13.22	13.44	11.38	11.05	11.21
C_9 : Pectin (2 %)	16.11	16.06	16.08	13.82	14.19	14.01	12.80	12.34	12.57	10.94	10.72	10.83
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	0.07	0.07	0.06	0.10	0.12	0.11	0.09	0.10	0.09
B. Packaging materials												
P_1 : CFB box	16.11	16.06	16.08	14.59	14.25	14.42	13.51	13.11	13.31	11.44	11.22	11.33
P_2 : Plastic crates	16.10	16.05	16.08	14.47	14.11	14.29	13.13	12.94	13.03	11.03	11.00	11.02
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	0.03	0.03	0.03	0.05	0.06	0.05	0.04	0.05	0.04
C. Interaction (A x B)												
C_1 P_1	16.10	16.05	16.08	13.58	13.90	13.74	12.66	12.01	12.33	10.00	9.85	9.92
C_1 P_2	16.10	16.05	16.08	13.78	13.77	13.77	12.05	12.00	12.03	9.80	9.80	9.80
C_2 P_1	16.11	16.06	16.08	15.19	14.23	14.71	13.59	13.37	13.48	12.00	11.48	11.74
C_2 P_2	16.11	16.06	16.08	15.11	14.13	14.62	13.23	13.67	13.45	11.80	11.28	11.54
C_3 P_1	16.11	16.05	16.08	15.00	14.45	14.72	14.20	13.92	14.06	12.25	12.00	12.13
C_3 P_2	16.11	16.03	16.07	14.95	14.37	14.66	14.00	13.51	13.75	12.10	11.41	11.76
C_4 P_1	16.12	16.05	16.09	14.53	14.20	14.36	14.00	13.42	13.71	11.50	11.18	11.34
C_4 P_2	16.10	16.06	16.08	14.55	14.25	14.40	13.48	13.22	13.35	10.50	11.00	10.75
C_5 P_1	16.10	16.07	16.09	14.71	14.12	14.41	13.87	13.30	13.58	11.67	11.12	11.40
C_5 P_2	16.09	16.04	16.07	14.69	13.95	14.32	12.98	13.16	13.07	11.27	11.13	11.20
C_6 P_1	16.11	16.05	16.08	14.59	14.42	14.50	12.32	12.31	12.31	10.63	11.14	10.88
C_6 P_2	16.11	16.06	16.08	13.90	13.79	13.84	12.16	12.10	12.13	10.10	11.12	10.61
C_7 P_1	16.11	16.07	16.09	15.03	14.38	14.70	14.24	13.80	14.02	12.10	12.05	12.08
C_7 P_2	16.10	16.05	16.07	15.00	14.38	14.69	14.05	13.58	13.81	11.89	11.91	11.90
C_8 P_1	16.11	16.05	16.08	14.83	14.33	14.58	13.75	13.44	13.59	11.75	11.31	11.53
C_8 P_2	16.11	16.06	16.08	14.50	14.20	14.35	13.57	13.00	13.28	11.00	10.80	10.90
C_9 P_1	16.11	16.07	16.09	13.89	14.23	14.06	12.97	12.46	12.71	11.08	10.85	10.96
C_9 P_2	16.11	16.05	16.08	13.75	14.16	13.95	12.64	12.22	12.43	10.80	10.60	10.70
SEm. (±)	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.03	0.03
CD at 1 %	NS	NS	NS	0.10	0.10	0.09	0.14	0.17	0.15	0.13	0.14	0.13

Table 9 contd….

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 : Without coating	7.91	8.26	8.09	6.09	5.76	5.93	3.33	3.13	3.23	-	-	-
C_2 : Alginate (2 %)	9.64	9.31	9.47	7.81	7.65	7.73	5.21	5.66	5.43	3.75	3.45	3.60
C_3 : Beewax (2 %)	9.83	9.47	9.65	8.03	7.47	7.75	6.16	5.43	5.79	3.90	3.67	3.78
C_4 : Aloe vera gel (75 %)	9.58	8.93	9.25	6.99	6.46	6.73	5.12	4.49	4.80	2.85	3.25	3.05
C_5 : Tapioca starch (5 %)	9.03	8.95	8.99	6.96	6.80	6.88	5.16	4.20	4.68	3.14	2.75	2.94
C_6 : Cinnamon oil (0.02)	8.13	8.13	8.13	6.48	5.94	6.21	4.06	3.31	3.68	-	-	-
C_7 : Chitosan (0.5 %)	9.90	9.34	9.62	8.00	7.64	7.82	6.07	5.48	5.77	3.56	3.78	3.67
C_8 : Acacia gum (5 %)	9.64	9.00	9.32	6.77	6.49	6.63	5.13	4.21	4.67	2.85	3.34	3.10
C_9 : Pectin (2 %)	9.44	8.20	8.82	6.68	5.93	6.30	4.27	3.86	4.07	2.75	3.05	2.90
SEm. (±)	0.04	0.03	0.04	0.01	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.03
CD at 1 %	0.18	0.12	0.14	0.05	0.11	0.08	0.09	0.10	0.09	0.08	0.13	0.10
B. Packaging materials												
P_1 : CFB box	9.36	8.95	9.15	7.18	6.72	6.95	4.99	4.49	4.74	3.31	3.45	3.38
P_2 : Plastic crates	9.10	8.74	8.92	7.00	6.65	6.82	4.90	4.35	4.62	3.21	3.20	3.20
SEm. (±)	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
CD at 1 %	0.08	0.06	0.07	0.02	0.05	0.04	0.04	0.05	0.04	0.04	0.07	0.05
C. Interaction (A x B)												
C_1 P_1	7.93	8.05	7.99	6.11	5.80	5.95	3.51	3.18	3.34	-	-	-
C_1 P_2	7.90	8.48	8.19	6.07	5.73	5.90	3.15	3.09	3.12	-	-	-
C_2 P_1	9.65	9.31	9.48	8.02	7.68	7.85	5.20	5.70	5.45	3.80	3.50	3.65
C_2 P_2	9.63	9.31	9.47	7.60	7.62	7.61	5.22	5.61	5.42	3.70	3.40	3.55
C_3 P_1	10.00	9.60	9.80	8.04	7.51	7.78	6.20	5.50	5.85	4.00	3.88	3.94
C_3 P_2	9.67	9.33	9.50	8.02	7.43	7.73	6.12	5.36	5.74	3.79	3.45	3.62
C_4 P_1	9.60	9.05	9.33	7.13	6.52	6.83	5.10	4.45	4.78	2.90	3.40	3.15
C_4 P_2	9.55	8.80	9.18	6.85	6.40	6.63	5.13	4.53	4.83	2.80	3.10	2.95
C_5 P_1	9.55	9.05	9.30	6.96	6.85	6.91	5.11	4.20	4.66	3.10	2.85	2.97
C_5 P_2	8.51	8.85	8.68	6.95	6.75	6.85	5.20	4.20	4.70	3.18	2.65	2.92
C_6 P_1	8.25	8.27	8.26	6.54	5.87	6.20	4.08	3.41	3.75	-	-	-
C_6 P_2	8.00	8.00	8.00	6.42	6.01	6.21	4.03	3.20	3.62	-	-	-
C_7 P_1	10.00	9.59	9.79	7.99	7.71	7.85	6.08	5.62	5.85	3.64	3.85	3.75
C_7 P_2	9.80	9.10	9.45	8.00	7.58	7.79	6.05	5.35	5.70	3.48	3.70	3.59
C_8 P_1	9.66	9.20	9.43	7.00	6.53	6.77	5.13	4.31	4.72	2.90	3.58	3.24
C_8 P_2	9.62	8.80	9.21	6.54	6.46	6.50	5.13	4.11	4.62	2.80	3.10	2.95
C_9 P_1	9.63	8.40	9.02	6.80	5.98	6.39	4.48	4.05	4.26	2.80	3.10	2.95
C_9 P_2	9.25	8.00	8.63	6.55	5.89	6.22	4.06	3.68	3.87	2.70	3.00	2.85
SEm. (±)	0.06	0.04	0.05	0.02	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.04
CD at 1 %	0.25	0.18	0.20	0.07	NS	0.12	0.13	0.14	0.13	0.11	0.18	0.14

The relationship between various coatings and packing materials and fruit firmness (N) during storage was significant. The data presented in the Table 9 showed that firmness (N) of mango fruits in the data shows decreasing trend up to 28th day of storage. The maximum firmness (3.94 N) was observed in C_3P_1 (beeswax 2% + CFB box) treatment, which was followed by C_7P_1 (chitosan 0.5% + CFB box), C_3P_2 (beeswax 2% + Plastic crates), C_7P_2 (chitosan 0.5% + Plastic crates) treatment, Whereas, minimum (3.12N) firmness (N) was observed in C_1P_2 (without coating + plastic crates) treatment up to 24th day of storage.

The duration of storage has increased the hardness of mango cv. Kesar shown a declining trend, with the change occurring more quickly in uncoated fruits than in any other coatings. The earlier changes seen compared to the uncoated could be the result of early softening caused by accelerated ripening. Structured polysaccharides are pectic materials that give fruits their firmness, and fruit softening happens when these pectin polymer loosen their grip on the cell wall of fruit during ripening (Mebratie *et al.,* 2015; Abonesh *et al.,* 2018). These processes include the solubilization of pectic substances, breakdown of starch into soluble sugars and the loss of water from the peel. Amer (1990), Kulkarni, *et al.* (2004) reported similar outcomes.

Fruits' rate of respiration is slowed down by the physical barriers created by chitosan and beeswax in edible coatings against O_2, CO_2 and water. The slower mango ripening was caused by a decrease in respiration rate, which also decreased the activity of hydrolysis enzymes. In similar manner Abonesh *et al.* (2018) they found that wax coating has an impact on the preservation of banana firmness.

Mounika *et al*. (2017) packaging delays the softening process in mango and finally retained Fruit firmness, which might be due to reduced transpiration loss and respiration activity and thus retained more turgidity of the cells. Decrease in mango fruit firmness during storage is presumably due to change in cell wall polysaccharides.

4.2 Chemical composition mango fruit.

4.2.1 Total soluble solids (^{0}Brix)

Effect of edible coatings and packaging on total soluble solids of mango fruits cv. Kesar during storage for the year 2019, 2020 and pooled was presented in Table 10 (AT) and in Table 11 (CS) depicted in Fig. 10 (AT) and 11 (CS). TSS of mango was increased significantly during storage period of postharvest coating treatments, packaging and storage conditions. When compared to cold storage (CS), ambient storage (AT) storage was shown to have a quicker rate of growth in the TSS of mango fruit. It was showed that with the increasing of storage period, the TSS of uncoated fruit increased at faster rate as than coated fruits.

The TSS of fruits at AT showed a significant variation between the various coating treatments. It was clearly showed from the pooled data that the treatment C_7 (chitosan 0.5% minimum TSS (15.75^{0}B) which was followed by the treatment of C_3 (beeswax 2%)) (15.88^{0}B), whereas, maximum TSS (19.42^{0}B) was observed in C_1 (without coating) at 16th days of storage.

Packaging materials exhibited significant difference during storage. Compared to P_2, the rate of TSS growth in P_1 was slower. Highest TSS recorded by P_1 and P_2 was 17.36^0 B and 18.02^0 B at 16th day respectively .

The interaction effect of coatings and packaging materials, during storage on fruit TSS was significant during storage. Table 10 showed that, TSS of mango fruits in the pooled data showed increasing trend up to 16th day of storage. The minimum TSS (15.25^{0}B) was found in C_7P_1 (chitosan 0.5% + CFB box) treatment, which was followed by C_3P_1 (beeswax 2% + CFB box) (15.38^{0}B), C_7P_2 (chitosan 0.5 % + plastic crates) (16.25^{0}B), T_3P_2 (beeswax 2% + plastic crates) (16.38^{0}B) treatment. Whereas, maximum TSS (19.69^{0}B) was found in C_1P_2 (without coating + plastic crates) treatment.

TSS showed significant difference with coatings treatments during storage period in cold storage (Table 11). Effect of different coatings could be recorded up to 28 days for C_2, C_3, C_4, C_5, C_7, C_8 and C_9. Pooled data showed that, treatment C_7 minimum TSS (16.59^{0}B) was recoreded which was followed by the treatment of C_3 (17.08^{0}B), C_2 (17.46^{0}B) whereas, maximum TSS (18.75^{0}B) was recorded C_1 (without coating) up to 24th day of storage.

Table 10. Effect of edible coatings and packaging materials change in total soluble solids (TSS) (°B) content of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	7.21	7.13	7.17	11.68	10.75	11.21	15.18	15.05	15.11	17.90	18.10	18.00	19.05	19.79	19.42
C_2 : Alginate (2 %)	7.23	7.15	7.19	9.66	8.62	9.14	11.87	12.03	11.95	15.37	15.50	15.43	16.59	17.89	17.24
C_3 : Beewax (2 %)	7.22	7.15	7.18	8.53	8.57	8.55	10.09	10.69	10.39	14.86	14.54	14.70	16.16	15.59	15.88
C_4 : Aloe vera gel (75 %)	7.25	7.17	7.21	9.55	10.70	10.13	13.81	13.21	13.51	14.89	16.36	15.62	17.72	18.24	17.98
C_5 : Tapioca starch (5 %)	7.24	7.10	7.17	10.07	10.68	10.37	13.88	13.20	13.54	14.58	15.86	15.22	17.55	19.05	18.30
C_6 : Cinnamon oil (0.02)	7.26	7.13	7.19	11.10	10.28	10.69	14.00	15.01	14.51	18.00	17.27	17.63	18.34	18.99	18.66
C_7 : Chitosan (0.5 %)	7.24	7.14	7.19	9.65	8.61	9.13	12.24	11.48	11.86	14.15	14.58	14.37	15.50	16.00	15.75
C_8 : Acacia gum (5 %)	7.24	7.16	7.20	9.20	9.45	9.32	13.44	12.80	13.12	15.78	14.69	15.23	17.80	17.85	17.82
C_9 : Pectin (2 %)	7.26	7.10	7.18	9.68	10.55	10.11	13.83	13.91	13.87	15.84	16.84	16.34	17.90	18.44	18.17
SEm. (±)	0.02	0.02	0.02	0.04	0.02	0.03	0.03	0.02	0.02	0.02	0.04	0.03	0.04	0.02	0.03
CD at 1 %	NS	NS	NS	0.14	0.08	0.11	0.11	0.07	0.08	0.08	0.17	0.12	0.18	0.07	0.13
B. Packaging materials															
P_1 : CFB box	7.23	7.14	7.19	9.78	9.23	9.51	12.88	12.35	12.61	15.29	15.56	15.42	17.14	17.59	17.36
P_2 : Plastic crates	7.24	7.13	7.19	10.02	10.37	10.19	13.41	13.73	13.57	16.12	16.38	16.25	17.66	18.38	18.02
SEm. (±)	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02
CD at 1 %	NS	NS	NS	0.07	0.04	0.05	0.05	0.03	0.04	0.04	0.08	0.06	0.08	0.03	0.06
C. Interaction (A x B)															
$C_1 P_1$	7.23	7.14	7.18	11.35	10.00	10.68	15.00	14.10	14.55	17.00	17.83	17.42	18.71	19.58	19.15
$C_1 P_2$	7.19	7.13	7.16	12.00	11.50	11.75	15.35	16.00	15.68	18.80	18.36	18.58	19.38	20.00	19.69
$C_2 P_1$	7.21	7.14	7.18	9.77	8.05	8.91	11.40	10.80	11.10	14.83	15.00	14.92	16.57	17.50	17.04
$C_2 P_2$	7.26	7.16	7.21	9.55	9.18	9.37	12.33	13.25	12.79	15.90	16.00	15.95	16.61	18.27	17.44
$C_3 P_1$	7.21	7.14	7.17	8.36	7.90	8.13	10.00	9.66	9.83	14.72	14.07	14.40	15.75	15.00	15.38
$C_3 P_2$	7.23	7.16	7.20	8.70	9.24	8.97	10.17	11.71	10.94	15.00	15.00	15.00	16.57	16.18	16.38
$C_4 P_1$	7.25	7.18	7.21	9.10	10.20	9.65	13.71	12.08	12.90	14.82	16.30	15.56	17.82	17.95	17.89
$C_4 P_2$	7.25	7.16	7.20	10.00	11.20	10.60	13.90	14.33	14.12	14.95	16.41	15.68	17.63	18.53	18.08
$C_5 P_1$	7.23	7.09	7.16	9.99	10.00	10.00	13.28	12.69	12.99	14.15	15.35	14.75	17.05	18.59	17.82
$C_5 P_2$	7.26	7.11	7.18	10.15	11.35	10.75	14.47	13.70	14.09	15.00	16.36	15.68	18.05	19.52	18.78
$C_6 P_1$	7.24	7.13	7.18	11.00	10.05	10.53	13.45	14.82	14.14	17.90	16.69	17.30	18.00	18.50	18.25
$C_6 P_2$	7.28	7.13	7.20	11.20	10.51	10.86	14.55	15.20	14.88	18.09	17.84	17.97	18.68	19.48	19.08
$C_7 P_1$	7.24	7.18	7.21	9.20	8.00	8.60	12.17	11.06	11.62	13.50	14.00	13.75	15.00	15.50	15.25
$C_7 P_2$	7.23	7.11	7.17	10.10	9.21	9.66	12.31	11.89	12.10	14.80	15.16	14.98	16.00	16.50	16.25
$C_8 P_1$	7.24	7.20	7.22	9.89	8.90	9.40	13.39	12.73	13.06	15.00	14.37	14.69	17.59	17.59	17.59
$C_8 P_2$	7.24	7.13	7.18	8.50	10.00	9.25	13.49	12.87	13.18	16.55	15.00	15.78	18.00	18.10	18.05
$C_9 P_1$	7.26	7.11	7.18	9.35	10.00	9.68	13.50	13.21	13.36	15.68	16.43	16.06	17.80	18.08	17.94
$C_9 P_2$	7.26	7.10	7.18	10.00	11.10	10.55	14.15	14.60	14.38	16.00	17.25	16.63	18.00	18.80	18.40
SEm. (±)	0.03	0.03	0.03	0.05	0.03	0.04	0.04	0.02	0.03	0.03	0.06	0.05	0.06	0.02	0.05
CD at 1 %	NS	NS	NS	0.20	0.12	0.16	0.15	0.10	0.12	0.11	0.24	0.18	0.25	0.10	0.18

Table 11. Effect of edible coatings and packaging materials change in total soluble solids (TSS) (^{0}B) 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 : Without coating	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

Table 11 contd….

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 : Without coating	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

Packaging materials showed significant difference during storage. Rate of increase in TSS was slow in P_1 as compared to P_2. Highest TSS recorded by P_1 and P_2 was 17.26^0B and 18.01^0B at 28^{th} day respectively.

Different coatings and packing materials had a significant interaction effect on fruit TSS during storage. Table 11 showed that TSS of mango fruits in the data shows increasing trend up to 28^{th} day of storage. The minimum TSS (16.33^0B) was observed in C_7P_1 (chitosan 0.5% + CFB box) treatment which was followed by the treatment C_3P_1 (beeswax 2% + CFB box) (16.78^0B), T_7P_2 (chitosan 0.5% + plastic crates) (16.86^0B). Whereas, maximum (19.14^0B) TSS was found in C_1P_2 (without coating + plastic crates) treatment up to 24^{th} day of storage.

The buildup of sugar as a result of starch hydrolysis and the leaching of sugar during the overripe stage could both be contributing factors to the increase in TSS (Meddicott *et al*., 1990b and Kumar, 1998). According to Ali *et al.* The faster respiration rate, enhances the synthesis and utilisation of metabolites, which leads to a higher TSS since there is a greater conversion of carbs to sugars. The conversion of starch into sugars, the redues in moisture content, the increase in respiration and metabolic activity, and the conversion of starch into sugars are all potential reasons of the rise in TSS concentrations.

Beeswax and chitosan edible coatings on all treatments considerably slowed the rate at which the TSS content increased. Before the coating was applied, there were notable variations in the fruits, with control treatments showing faster increases in TSS than coated fruits. The delay in TSS content after coating application may be related to the edible coating's oxygen barrier property and the resultant restriction in respiration. Yonemoto *et al.* (2002) made a similar observation and hypothesised that the lower levels of TSS in chitosan coated fruit may be due to a protective oxygen barrier that restricts O_2 supply to the fruit surface, so inhibiting respiration. According to Sharafat *et al.* (1990), when storage time increases.

In comparison to other storage environments, the rate of growth in total soluble solids was stronger at room temperature. The TSS value was significantly influenced by temperature, when temperature drops, the TSS value can vary less, and the converse also is accurate. The results were similar with the results obtained by Opal *et al*.

(2005). This might be due to the fact that high temperature and low humidity (ambient temperature) during storage of uncoated fruits resulted in faster hydrolysis of starch and other insoluble carbohydrates in to soluble sugar than coated fruit.

4.2.2 Titratable acidity (%)

In Tables 12 (AT) and 13 (CS), which have been combined, the impact of coatings and packing on the mango's titratable acidity has been shown for the years 2019, 2020 and pooled. Mango's titratable acidity was significantly reduced by using various coating and packing materials. Both storage conditions were observed to reduce the titratable acidity.

The pooled results clearly indicated that the treatment C_7 maximum titratable acidity (0.31 %) which is at par to C_3 (0.28 %) and C_2 (0.26%) treatments. Whereas minimum titratable acidity (0.20%) was observed in C_1 (without coating) at 16th day of storage at AT.

The impact of the packaging materials on the percentage of acidity during storage was significant. Compared to P_2, the rate of titratable acidity lowering in P_1 was slower. Under both storage conditions, P_1 was superior to P_2 as it influenced minimum changes in titratable acidity.

The interaction impact of different coating and packaging materials showed significant result with regard to acidity during storage. The data presented in the Table 12 showed that titratable acidity of mango fruits in the data shows decreasing trend up to 16th day of during storage. The highest titratable acidity (0.31%) was observed in the treatment C_7P_1 (chitosan 0.5% + CFB box), which is at par with C_7P_2 (chitosan 0.5% + plastic crates), C_3P_2 (beeswax 2% + plastic crates), C_3P_1 (beeswax 2% + CFB box), C_2P_2 (alginate 2% + plastic crates), C_2P_1 (alginate 2% + CFB box) treatment. Whereas, lowest (0.18%) titratable acidity was observed in C_1P_2 (without coating + plastic crates) treatment.

In cold storage pooled data indicated that the treatment C_7 maximum titratable acidity (0.32%) which is at par to C_3 (0.30%) treatment at 28th day of storage. Whereas, minimum titratable acidity (0.22%) recoreded in C_1 (without coating)at 24th day of storage.

Table 12. Effect of edible coatings and packaging materials on changes in acidity (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	2.05	2.07	2.06	1.08	1.05	1.06	0.41	0.38	0.39	0.32	0.28	0.30	0.21	0.19	0.20
C_2 : Alginate (2 %)	2.07	2.07	2.07	1.21	1.20	1.20	1.03	0.81	0.92	0.45	0.41	0.43	0.26	0.25	0.26
C_3 : Beewax (2 %)	2.05	2.07	2.06	1.18	1.25	1.21	1.01	0.81	0.91	0.43	0.42	0.42	0.29	0.27	0.28
C_4 : Aloe vera gel (75 %)	2.05	2.05	2.05	1.13	1.07	1.10	0.77	0.63	0.70	0.32	0.38	0.35	0.23	0.22	0.23
C_5 : Tapioca starch (5 %)	2.06	2.05	2.06	1.16	1.05	1.10	0.83	0.60	0.72	0.31	0.33	0.32	0.20	0.21	0.20
C_6 : Cinnamon oil (0.02)	2.06	2.05	2.06	1.12	1.10	1.11	0.47	0.44	0.45	0.34	0.33	0.34	0.25	0.22	0.23
C_7 : Chitosan (0.5 %)	2.06	2.04	2.05	1.28	1.23	1.26	0.99	0.88	0.93	0.45	0.46	0.45	0.31	0.30	0.31
C_8 : Acacia gum (5 %)	2.06	2.06	2.06	1.17	1.17	1.17	1.02	0.78	0.90	0.43	0.38	0.41	0.22	0.28	0.25
C_9 : Pectin (2 %)	2.05	2.06	2.06	1.16	1.11	1.13	0.98	0.79	0.88	0.46	0.41	0.43	0.25	0.24	0.25
SEm. (±)	0.01	0.02	0.01	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	0.05	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04
B. Packaging materials															
P_1 : CFB box	2.06	2.06	2.06	1.16	1.14	1.15	0.84	0.67	0.75	0.38	0.37	0.38	0.25	0.25	0.25
P_2 : Plastic crates	2.05	2.06	2.06	1.16	1.13	1.15	0.83	0.69	0.76	0.39	0.39	0.39	0.24	0.24	0.24
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	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	NS	NS	NS	NS	0.02	NS	NS	NS	NS	NS	NS	NS
C. Interaction (A x B)															
$C_1 P_1$	2.05	2.08	2.06	1.10	1.11	1.11	0.41	0.39	0.40	0.33	0.28	0.31	0.23	0.21	0.22
$C_1 P_2$	2.05	2.07	2.06	1.05	0.98	1.02	0.40	0.37	0.39	0.31	0.29	0.30	0.18	0.18	0.18
$C_2 P_1$	2.07	2.05	2.06	1.21	1.20	1.21	1.02	0.81	0.92	0.45	0.36	0.40	0.25	0.26	0.25
$C_2 P_2$	2.07	2.10	2.08	1.20	1.20	1.20	1.04	0.80	0.92	0.46	0.46	0.46	0.27	0.24	0.26
$C_3 P_1$	2.07	2.07	2.07	1.17	1.25	1.21	1.02	0.80	0.91	0.45	0.43	0.44	0.28	0.28	0.28
$C_3 P_2$	2.04	2.07	2.05	1.19	1.25	1.22	1.00	0.83	0.91	0.41	0.41	0.41	0.30	0.27	0.29
$C_4 P_1$	2.05	2.07	2.06	1.11	1.08	1.09	0.70	0.60	0.65	0.31	0.41	0.36	0.25	0.25	0.25
$C_4 P_2$	2.05	2.04	2.05	1.16	1.07	1.11	0.85	0.66	0.75	0.33	0.35	0.34	0.21	0.19	0.20
$C_5 P_1$	2.05	2.06	2.05	1.17	1.07	1.12	0.82	0.59	0.70	0.30	0.32	0.31	0.20	0.21	0.21
$C_5 P_2$	2.07	2.05	2.06	1.15	1.04	1.09	0.85	0.62	0.73	0.32	0.35	0.33	0.20	0.20	0.20
$C_6 P_1$	2.07	2.05	2.06	1.12	1.05	1.08	0.50	0.44	0.47	0.35	0.33	0.34	0.22	0.18	0.20
$C_6 P_2$	2.06	2.05	2.06	1.12	1.14	1.13	0.44	0.43	0.44	0.33	0.34	0.34	0.28	0.26	0.27
$C_7 P_1$	2.08	2.03	2.05	1.26	1.26	1.26	0.99	0.88	0.93	0.47	0.45	0.46	0.32	0.30	0.31
$C_7 P_2$	2.05	2.05	2.05	1.31	1.21	1.26	0.98	0.88	0.93	0.43	0.46	0.45	0.30	0.30	0.30
$C_8 P_1$	2.07	2.06	2.06	1.18	1.19	1.18	1.07	0.74	0.90	0.38	0.34	0.36	0.23	0.28	0.26
$C_8 P_2$	2.05	2.06	2.05	1.16	1.15	1.15	0.97	0.82	0.89	0.48	0.43	0.45	0.21	0.28	0.25
$C_9 P_1$	2.05	2.08	2.06	1.15	1.08	1.12	1.01	0.76	0.89	0.44	0.42	0.43	0.28	0.28	0.28
$C_9 P_2$	2.05	2.05	2.05	1.16	1.14	1.15	0.94	0.83	0.88	0.48	0.41	0.44	0.22	0.20	0.21
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	NS	0.07	0.06	0.06	NS	0.06	0.07	0.06	0.06	NS	0.06	0.06

Table 13. 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 : Without coating	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

Table 13 contd….

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 : Without coating	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

Packaging materials effect revealed non-significant result with regard to acidity during storage except at 16th day. Compared to P_2, the rate of acidity decline in P_1 was slower. Highest acidity recorded by P_1 0.29 and P_2 0.26 per cent at 28th day of storage.

The interaction impact of edibale coatings and packaging material, during storage on fruit titratable acidity was significant during storage. The data presented in Table 13 showed that titratable acidity of mango fruits in the pooled data shows decreasing trend up to 28th day during storage. The highest titratable acidity (0.35%) was observed in the treatment C_7P_1 (chitosan 0.5% + CFB box), which followed by C_3P_1 (beeswax 2% + CFB box) (0.31%) treatment. Whereas, minimum titratable acidity (0.18%) was observed in C_1P_2 (without coating + plastic crates) treatment at 24th day.

The end of the storage the minimum per cent was recorded for the uncoated fruit and higher of titratable acidity per cent was showed in fruit coated with 0.5% chitosan (0.32%) and 2% beeswax (0.30), they discovered that edibal coating decreased fruit respiration rate, which resulted in a drastically reduced level rate of respiratory substrate utilisation. Tefera *et al.* (2008) found a comparable rise in acidity as a result of coating treatments that slow respiration, which may be carried on by a lower rate of respiration substrates such organic acids being consumed.

All coated and uncoated fruits titratable acidity reduced as storage time rose, possibly resulting from the higher rate of respiration brought on by rising temperature, which may have used titratable acid as a substrate for this catabolic process. Their conversion into sugars and utilisation of oranic acids in other metabolic processes may be the cause of the decrease in acidity.

4.2.3 Total sugars (%)

Table 14 (AT) and 15 (CS) show information on the impact of coatings and packing on the total sugars (%) of mango fruit. Using various edibal coatings and packaging materials, the mango fruit's total sugar content (%) was significantly boosted. During both storage conditions, it was noted that the total sugar content (%) had grown.

Effect of coatings on total sugars of mango has been showed in Table 14 (ambient temperature). The pooled data clearly showed that the at 16th DAS the minimum total sugars were seen in C_7 (14.17%). It was followed by C_2 (14.20%). The maximum total sugars were noted in C_1 (without coating) (16.51%).

Packaging materials exhibited significant difference thought storage. Compared to P_2, the rate of increase in total sugars (%) was slower in P_1. Maximum total sugars recorded by P_1 and P_2 was 14.84 and 14.98 per cent at 16th day.

Fruit total sugars (%) were significantly impacted by the interaction between various coatings and packing materials during storage. The data showed in the Table 14 the minimum total sugars (14.14%) was observed in the treatment C_7P_1 (chitosan 0.5% + CFB box) which is at par with the treatment C_7P_2, C_3P_1 and C_3P_2. Whereas, maximum (16.59 %) total sugars was found in C_1P_2 (without coating + plastic crates) treatment at 16th day.

The data on effect of coatings on total sugars (%) of mango in CS has been presented in Table 15. It was clear from the pooled data that, the minimum total sugars were seen in C_7 (14.86 %). It was followed by C_3 (15.03 %) and C_2 (15.32 %) treatment 28th day of storage. Maximum total sugars (16.11%) was seen in C_1P_2 (without coating + plastic crates) treatment 24th day of storage.

In CS, storage of the packaging materials displayed a noticeable difference. Compared to P_2, P_1's rate of total sugars (%) growth was slower. Highest total sugars recorded by P_1 and P_2 was 15.16 and 15.68 per cent at 28th day.

Fruit total sugars (%) were significantly impacted by the interaction between various coatings and packaging materials during storage Table 15 pooled data showed that minimum total sugars (14.64%) was found in C_7P_1 (chitosan 0.5% + CFB box) treatment which is followed by C_3P_1 (14.75%) highest total sugars was recorded (16.20%) in C_1P_2 (without coating + plastic crates) treatment at 24th day.

One of the most essential issues of fruit quality is taking into consideration how edible coatings and packaging materials affect the total sugar content. The possible causes and results of the findings include an increase in total sugar up to the peak, a slight decline with longer storage times and a lower percentage of total sugar in fruits coated with chitosan (0.5%) and beeswax (2%). Additionally, at the overripe stage, sugars was solubilized as a result of the hydrolysis process. The same outcomes were also noted by Kapse (1993) and Singh *et al*. (2000).

Table 14. Effect of edible coatings and packaging materials on changes in total sugars (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	5.00	5.23	5.11	8.69	9.13	8.91	12.78	13.52	13.15	14.28	14.34	14.31	16.34	16.68	16.51
C_2 : Alginate (2 %)	5.05	5.21	5.13	6.73	6.96	6.85	9.05	10.08	9.56	12.09	12.17	12.13	13.99	14.41	14.20
C_3 : Beewax (2 %)	5.01	5.23	5.12	6.73	6.96	6.84	9.05	10.07	9.56	12.09	12.05	12.07	14.07	14.53	14.30
C_4 : Aloe vera gel (75 %)	5.00	5.23	5.11	7.08	7.54	7.31	11.26	11.39	11.32	13.01	13.29	13.15	14.79	15.38	15.08
C_5 : Tapioca starch (5 %)	5.00	5.21	5.10	7.14	7.42	7.28	11.16	11.34	11.25	13.03	13.06	13.05	14.85	14.84	14.84
C_6 : Cinnamon oil (0.02)	5.00	5.20	5.10	7.67	8.52	8.10	12.00	12.69	12.35	14.09	14.17	14.13	15.87	15.25	15.56
C_7 : Chitosan (0.5 %)	5.07	5.20	5.13	6.88	6.79	6.83	8.89	10.08	9.49	11.98	11.79	11.88	14.30	14.04	14.17
C_8 : Acacia gum (5 %)	5.01	5.19	5.10	7.03	7.27	7.15	11.05	10.30	10.67	12.85	12.68	12.76	14.56	14.68	14.62
C_9 : Pectin (2 %)	5.01	5.18	5.10	8.10	8.12	8.11	11.14	11.05	11.10	13.30	13.25	13.28	14.92	14.91	14.91
SEm. (±)	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.03	0.02
CD at 1 %	NS	NS	NS	0.10	0.11	0.10	0.09	0.04	0.07	0.05	0.09	0.07	0.06	0.11	0.08
B. Packaging materials															
P_1 : CFB box	5.01	5.20	5.10	7.32	7.52	7.42	10.71	11.16	10.93	12.89	12.90	12.90	14.79	14.89	14.84
P_2 : Plastic crates	5.02	5.22	5.12	7.36	7.75	7.55	10.71	11.18	10.94	13.04	13.05	13.05	14.91	15.05	14.98
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	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	NS	0.05	0.05	NS	NS	NS	0.02	0.04	0.03	0.03	0.05	0.04
C. Interaction (A x B)															
$C_1 P_1$	5.00	5.20	5.10	8.58	8.65	8.61	12.84	13.51	13.17	14.13	14.18	14.16	16.25	16.62	16.43
$C_1 P_2$	5.00	5.25	5.13	8.80	9.62	9.21	12.73	13.53	13.13	14.43	14.50	14.46	16.43	16.74	16.59
$C_2 P_1$	5.05	5.20	5.13	6.73	6.92	6.83	9.08	10.05	9.57	12.04	12.10	12.07	13.93	14.43	14.18
$C_2 P_2$	5.05	5.21	5.13	6.73	7.00	6.87	9.03	10.10	9.56	12.14	12.25	12.19	14.05	14.40	14.23
$C_3 P_1$	5.01	5.20	5.11	6.72	6.95	6.84	9.05	10.05	9.55	12.00	11.90	11.95	14.00	14.47	14.24
$C_3 P_2$	5.01	5.25	5.13	6.74	6.96	6.85	9.06	10.09	9.58	12.18	12.19	12.18	14.14	14.58	14.36
$C_4 P_1$	5.00	5.20	5.10	7.04	7.45	7.24	11.19	11.37	11.28	12.97	13.26	13.11	14.74	15.33	15.03
$C_4 P_2$	5.00	5.26	5.13	7.12	7.64	7.38	11.33	11.42	11.37	13.06	13.33	13.20	14.85	15.43	15.14
$C_5 P_1$	5.00	5.20	5.10	7.09	7.30	7.20	11.10	11.34	11.22	12.93	13.11	13.02	14.80	14.50	14.65
$C_5 P_2$	5.00	5.21	5.11	7.19	7.54	7.36	11.21	11.35	11.28	13.13	13.02	13.07	14.91	15.17	15.04
$C_6 P_1$	5.00	5.20	5.10	7.60	8.46	8.03	11.95	12.68	12.31	14.05	14.24	14.14	15.90	15.13	15.51
$C_6 P_2$	5.00	5.20	5.10	7.75	8.58	8.16	12.05	12.71	12.38	14.13	14.10	14.12	15.84	15.38	15.61
$C_7 P_1$	5.05	5.20	5.13	6.90	6.76	6.83	8.90	10.10	9.50	11.96	11.72	11.84	14.23	14.05	14.14
$C_7 P_2$	5.09	5.20	5.14	6.86	6.81	6.84	8.89	10.07	9.48	12.00	11.85	11.93	14.37	14.04	14.20
$C_8 P_1$	5.01	5.17	5.09	7.02	7.20	7.11	11.15	10.31	10.73	12.87	12.59	12.73	14.47	14.65	14.56
$C_8 P_2$	5.00	5.20	5.10	7.05	7.34	7.19	10.95	10.29	10.62	12.82	12.76	12.79	14.65	14.70	14.68
$C_9 P_1$	5.00	5.20	5.10	8.20	8.00	8.10	11.13	11.06	11.10	13.10	13.00	13.05	14.83	14.81	14.82
$C_9 P_2$	5.02	5.17	5.09	8.00	8.23	8.12	11.15	11.05	11.10	13.50	13.50	13.50	15.00	15.00	15.00
SEm. (±)	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.04	0.03
CD at 1 %	NS	NS	NS	0.14	0.16	0.14	0.13	NS	0.10	0.07	0.12	0.09	0.08	0.15	0.11

Table 15. 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 : Without coating	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

Table 15 contd…

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 : Without coating	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

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) and Singh *et al*. (2000).

4.2.4 Non-reducing sugars (%)

Table 16 (AT) and 17 (CS) show the data on effect of coatings and packaging on non-reducing sugars (%) of mango. Using various coatings and packaging materials, the non-reducing sugars (%) in mango were significantly raised. The non-reducing sugars (%) was raised during storage in both storage conditions.

The data on effect of coatings on non-reducing sugars (%) of mango has been presented in Table 16 (AT). The pooled data revealed that the at 16^{th} DAS the minimum non-reducing sugars were seen in C_7 (8.14%) and followed by C_2 (8.53%) and C_3 (8.87%). The maximum non-reducing sugars (10.31%) were noted in C_1 (without coating) treatment.

Packaging materials revealed the notable difference in storage. Compared to P_2, the rate of increase in non-reducing sugars (%) was slower in P_1. Highest total sugars recorded by P_1 and P_2 was 8.96 and 9.04 per cent at 16^{th} day.

Fruit non-reducing sugars (%) were significantly affected by the interaction of various coatings and packing materials during storage. The information in Table 16 indicated that the minimum non-reducing sugars (8.10%) was observed in the C_7P_1 (chitosan 0.5% + CFB box) treatment is statistically at par with the treatment C_7P_2 (chitosan 0.5% + plastic crates) (8.18%). Whereas, maximum (10.37%) non-reducing sugars was recorded in C_1P_2 (without coating + plastic crates) treatment.

Table 17 provides data on the impact of edible coating on non-reducing sugars (%) in (CS) of mango fruit. The pooled data clearly illustrated that, the minimum non-reducing sugars were seen in C_3 (8.90%). It was followed by C_7 (8.97 %) treatment 28^{th} day of storage. Maximum (9.91%) non-reducing sugars was observed in C_1 (without coating) treatment 24^{th} day of storage.

When coated fruit stored in CS, the packaging materials showed a significan alteration. Compared to P_2, the rate of increase in total sugars (%) was slower

Table 16. Effect of edible coatings and packaging materials on changes in non-reducing sugars (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	2.94	3.09	3.01	5.53	5.55	5.54	7.51	7.30	7.40	8.78	8.57	8.67	10.13	10.48	10.31
C_2 : Alginate (2 %)	3.00	3.08	3.04	3.80	3.84	3.82	5.12	5.94	5.53	7.68	7.72	7.70	8.46	8.60	8.53
C_3 : Beewax (2 %)	2.96	3.10	3.03	3.74	3.87	3.80	5.14	5.98	5.56	7.86	7.64	7.75	8.76	8.99	8.87
C_4 : Aloe vera gel (75 %)	2.94	3.10	3.02	4.10	4.24	4.17	7.25	6.94	7.10	8.12	8.56	8.34	8.95	9.24	9.09
C_5 : Tapioca starch (5 %)	2.93	3.07	3.00	3.99	4.24	4.11	7.19	6.99	7.09	8.48	8.07	8.27	8.97	8.76	8.86
C_6 : Cinnamon oil (0.02)	2.95	3.07	3.01	4.64	5.16	4.90	7.46	7.87	7.67	8.62	8.95	8.78	10.00	9.26	9.63
C_7 : Chitosan (0.5 %)	3.02	3.08	3.05	3.99	3.72	3.86	5.03	5.97	5.50	7.77	7.46	7.61	8.10	8.18	8.14
C_8 : Acacia gum (5 %)	2.96	3.06	3.01	4.13	4.08	4.10	7.02	6.11	6.56	8.07	8.07	8.07	8.67	8.64	8.65
C_9 : Pectin (2 %)	2.96	3.06	3.01	5.15	4.84	4.99	7.09	6.80	6.95	8.38	8.76	8.57	8.97	8.89	8.93
SEm. (±)	0.02	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.03	0.02
CD at 1 %	NS	NS	NS	0.11	0.12	0.11	0.10	0.06	0.08	0.08	0.11	0.09	0.09	0.10	0.09
B. Packaging materials															
P_1 : CFB box	2.95	3.06	3.00	4.32	4.28	4.30	6.49	6.63	6.56	8.12	8.16	8.14	8.97	8.95	8.96
P_2 : Plastic crates	2.97	3.09	3.03	4.36	4.50	4.43	6.58	6.68	6.63	8.27	8.24	8.26	9.03	9.06	9.04
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	0.01	0.01	0.01
CD at 1 %	NS	0.03	0.03	NS	0.06	0.05	0.05	0.03	0.04	0.04	0.05	0.04	0.04	0.05	0.04
C. Interaction (A x B)															
$C_1 P_1$	2.92	3.05	2.98	5.40	5.00	5.20	7.00	7.10	7.05	8.58	8.38	8.48	10.05	10.43	10.24
$C_1 P_2$	2.95	3.13	3.04	5.67	6.09	5.88	8.01	7.50	7.76	8.98	8.75	8.86	10.21	10.54	10.37
$C_2 P_1$	3.00	3.08	3.04	3.79	3.81	3.80	5.16	5.92	5.54	7.64	7.70	7.67	8.38	8.63	8.50
$C_2 P_2$	3.00	3.09	3.04	3.81	3.86	3.84	5.08	5.97	5.52	7.73	7.74	7.73	8.54	8.58	8.56
$C_3 P_1$	2.93	3.05	2.99	3.74	3.86	3.80	5.13	5.98	5.55	7.75	7.53	7.64	8.72	9.00	8.86
$C_3 P_2$	2.98	3.15	3.06	3.74	3.88	3.81	5.16	5.98	5.57	7.98	7.76	7.87	8.79	8.98	8.89
$C_4 P_1$	2.95	3.08	3.01	4.09	4.14	4.11	7.19	6.93	7.06	8.09	8.54	8.31	8.92	9.18	9.05
$C_4 P_2$	2.92	3.12	3.02	4.12	4.34	4.23	7.32	6.96	7.14	8.16	8.59	8.38	8.97	9.30	9.14
$C_5 P_1$	2.92	3.05	2.99	3.99	4.14	4.06	7.17	7.01	7.09	8.43	8.10	8.27	8.97	8.48	8.72
$C_5 P_2$	2.95	3.08	3.01	3.99	4.34	4.16	7.21	6.97	7.09	8.53	8.04	8.28	8.97	9.04	9.01
$C_6 P_1$	2.93	3.05	2.99	4.55	5.12	4.83	7.45	7.86	7.65	8.60	9.04	8.82	10.06	9.25	9.65
$C_6 P_2$	2.97	3.10	3.03	4.73	5.21	4.97	7.48	7.88	7.68	8.65	8.85	8.75	9.95	9.27	9.61
$C_7 P_1$	3.00	3.08	3.04	3.99	3.71	3.85	5.05	5.97	5.51	7.74	7.42	7.58	8.05	8.15	8.10
$C_7 P_2$	3.04	3.08	3.06	3.99	3.74	3.87	5.02	5.97	5.49	7.80	7.49	7.65	8.15	8.21	8.18
$C_8 P_1$	2.96	3.05	3.00	4.12	4.02	4.07	7.15	6.12	6.63	8.07	8.12	8.10	8.62	8.60	8.61
$C_8 P_2$	2.95	3.08	3.01	4.13	4.14	4.13	6.89	6.10	6.49	8.07	8.02	8.04	8.72	8.68	8.70
$C_9 P_1$	2.94	3.06	3.00	5.25	4.74	5.00	7.13	6.80	6.97	8.17	8.60	8.39	9.00	8.80	8.90
$C_9 P_2$	2.98	3.05	3.01	5.05	4.93	4.99	7.05	6.81	6.93	8.58	8.92	8.75	8.94	8.98	8.96
SEm. (±)	0.02	0.02	0.02	0.04	0.04	0.04	0.03	0.02	0.03	0.03	0.04	0.03	0.03	0.04	0.03
CD at 1 %	NS	NS	NS	0.16	0.17	0.15	0.14	0.08	0.11	0.11	0.15	0.13	0.13	0.15	0.13

Table 17. 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 : Without coating	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

Table 17 contd…

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 : Without coating	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

in P_1. Highest non-reducing sugars recorded by P_1 and P_2 was 9.12 and 9.64 per cent at 28th day.

The interaction impact of coatings and packaging materials during storage on fruit non-reducing sugars (%) was significant during storage. The pooled data showed in the Table 17 minimum non-reducing sugars (8.60%) was observed in the treatment C_3P_1 (beeswax 2% + CFB box) which is followed by C_7P_1 (chitosan 0.5% + CFB box) (8.74%) maximum non-reducing sugars was observed (10.01%) in C_1P_2 (without coating + plastic crates) treatment at 24th day.

Throughout the storage period up until the peak, non-reducing sugars as a percentage steadily increased after slightly declining in mango fruit. This could be a result of the sugar being released during starch hydrolysis. Mangoes are climacteric fruits with abundant starch stores. and during post-harvest storage starch is hydrolyzed and liberating reducing sugars with increasing of storage (Kapse, 1993 and Singh *et al.*, 2000).

4.2.5 Reducing sugar (%)

The data on effect of coating and packaging on reducing sugar (%) of mango has been presented in Tables 18 (AT) and 19 (CS) for the years 2019, 2020 and pooled. The reducing sugars (%) of mango was significantly increased using different coatings and packaging materials. The reducing sugars (%) was found to be increased during both the storage conditions.

The data on effect of coatings and packaging on reducing sugarat AT of mango has been presented in Table 18. The pooled data clearly showed that the at 16th DAS the minimum reducing sugars were seen in T_7 (5.36%) it was followed by C_3 (5.42%). The maximum reducing sugars (6.20%) were noted in T_1 treatment.

Packaging materials exhibited significant difference during storage. Rate of increasing in reducing sugars (%) was slow in P_1 as compared to P_2. Highest reducing sugars recorded by P_1 and P_2 was 5.80 and 5.87 per cent at 16th day.

The interaction effect of different coatings and packaging materials during storage on fruit reducing sugars (%) was significant during storage at AT. The data presented in the Table 18 showed that reducing sugars of the fruits in the pooled data shows increasing trend up to 16th day of storage. The minimum reducing sugars (5.31%)

Table 18. Effect of edible coatings and packaging materials on changes in reducing sugars (%) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	2.07	2.14	2.10	3.16	3.59	3.37	4.56	4.94	4.75	5.50	5.78	5.64	6.21	6.19	6.20
C_2 : Alginate (2 %)	2.05	2.13	2.09	2.93	3.13	3.03	3.94	4.13	4.04	4.41	4.46	4.43	5.53	5.81	5.67
C_3 : Beewax (2 %)	2.06	2.13	2.09	2.99	3.09	3.04	3.91	4.09	4.00	4.23	4.40	4.31	5.31	5.54	5.42
C_4 : Aloe vera gel (75 %)	2.06	2.14	2.10	2.98	3.31	3.14	4.01	4.45	4.23	4.89	4.73	4.81	5.85	6.14	5.99
C_5 : Tapioca starch (5 %)	2.07	2.14	2.10	3.15	3.18	3.17	3.97	4.35	4.16	4.55	5.00	4.77	5.89	6.08	5.98
C_6 : Cinnamon oil (0.02)	2.05	2.13	2.09	3.04	3.36	3.20	4.54	4.83	4.68	5.47	5.23	5.35	5.87	6.00	5.93
C_7 : Chitosan (0.5 %)	2.05	2.13	2.09	2.89	3.06	2.98	3.86	4.12	3.99	4.21	4.33	4.27	5.37	5.35	5.36
C_8 : Acacia gum (5 %)	2.05	2.13	2.09	2.91	3.19	3.05	4.03	4.19	4.11	4.78	4.61	4.69	5.89	6.04	5.97
C_9 : Pectin (2 %)	2.05	2.13	2.09	2.95	3.28	3.12	4.05	4.25	4.15	4.93	4.49	4.71	5.95	6.02	5.98
SEm. (±)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01
CD at 1 %	NS	NS	NS	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.07	0.06	0.07	0.05	0.06
B. Packaging materials															
P_1 : CFB box	2.06	2.14	2.10	3.00	3.24	3.12	4.07	4.37	4.22	4.78	4.74	4.76	5.73	5.87	5.80
P_2 : Plastic crates	2.05	2.12	2.08	3.00	3.24	3.12	4.12	4.38	4.25	4.77	4.82	4.79	5.80	5.94	5.87
SEm. (±)	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	NS	NS	NS	0.02	NS	0.02	NS	0.03	0.03	0.03	0.02	0.03
C. Interaction (A x B)															
$C_1 P_1$	2.08	2.15	2.12	3.18	3.65	3.41	4.51	4.92	4.71	5.55	5.80	5.68	6.21	6.18	6.19
$C_1 P_2$	2.05	2.13	2.09	3.14	3.53	3.33	4.62	4.97	4.79	5.45	5.75	5.60	6.22	6.21	6.21
$C_2 P_1$	2.05	2.13	2.09	2.94	3.11	3.03	3.93	4.13	4.03	4.41	4.40	4.40	5.55	5.80	5.68
$C_2 P_2$	2.05	2.13	2.09	2.92	3.14	3.03	3.95	4.14	4.04	4.41	4.51	4.46	5.52	5.83	5.67
$C_3 P_1$	2.08	2.16	2.12	2.98	3.09	3.04	3.92	4.07	3.99	4.25	4.38	4.31	5.28	5.47	5.37
$C_3 P_2$	2.03	2.11	2.07	3.00	3.09	3.04	3.90	4.12	4.01	4.20	4.43	4.32	5.34	5.60	5.47
$C_4 P_1$	2.05	2.13	2.09	2.95	3.31	3.13	4.00	4.44	4.22	4.88	4.72	4.80	5.82	6.15	5.98
$C_4 P_2$	2.07	2.15	2.11	3.00	3.30	3.15	4.02	4.46	4.24	4.90	4.74	4.82	5.88	6.13	6.00
$C_5 P_1$	2.08	2.15	2.11	3.10	3.17	3.13	3.94	4.33	4.13	4.50	5.01	4.76	5.84	6.02	5.93
$C_5 P_2$	2.06	2.13	2.09	3.20	3.20	3.20	4.00	4.38	4.19	4.60	4.98	4.79	5.94	6.13	6.03
$C_6 P_1$	2.08	2.15	2.11	3.05	3.35	3.20	4.50	4.82	4.66	5.45	5.20	5.33	5.84	5.88	5.86
$C_6 P_2$	2.03	2.11	2.07	3.02	3.37	3.19	4.58	4.83	4.70	5.49	5.25	5.37	5.89	6.12	6.00
$C_7 P_1$	2.05	2.13	2.09	2.91	3.06	2.98	3.84	4.13	3.99	4.22	4.30	4.26	5.33	5.30	5.31
$C_7 P_2$	2.05	2.13	2.09	2.87	3.07	2.97	3.88	4.10	3.99	4.20	4.36	4.28	5.42	5.40	5.41
$C_8 P_1$	2.05	2.13	2.09	2.90	3.18	3.04	4.00	4.19	4.10	4.80	4.47	4.64	5.85	6.05	5.95
$C_8 P_2$	2.05	2.13	2.09	2.92	3.21	3.06	4.06	4.20	4.13	4.75	4.75	4.75	5.94	6.03	5.98
$C_9 P_1$	2.07	2.14	2.10	2.95	3.26	3.11	4.00	4.26	4.13	4.93	4.40	4.67	5.83	6.01	5.92
$C_9 P_2$	2.04	2.12	2.08	2.96	3.30	3.13	4.10	4.24	4.17	4.92	4.58	4.75	6.06	6.03	6.04
SEm. (±)	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	0.05	0.06	0.06	NS	NS	NS	0.07	0.10	0.08	0.10	0.07	0.08

Table 19. Effect of edible coatings and packaging materials on changes in reducing 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 : Without coating	2.07	2.14	2.10	2.84	2.95	2.89	3.35	3.84	3.59	3.80	4.16	3.98
C_2 : Alginate (2 %)	2.05	2.13	2.09	2.50	2.69	2.59	3.25	3.45	3.35	3.57	3.83	3.70
C_3 : Beewax (2 %)	2.06	2.13	2.09	2.55	2.55	2.55	3.26	3.44	3.35	3.45	3.75	3.60
C_4 : Aloe vera gel (75 %)	2.06	2.14	2.10	2.59	2.79	2.69	3.38	3.56	3.47	3.55	3.63	3.59
C_5 : Tapioca starch (5 %)	2.07	2.14	2.10	2.60	2.71	2.65	3.41	3.61	3.51	3.55	3.87	3.71
C_6 : Cinnamon oil (0.02)	2.05	2.13	2.09	2.62	2.80	2.71	3.39	3.57	3.48	3.64	3.83	3.74
C_7 : Chitosan (0.5 %)	2.05	2.13	2.09	2.42	2.58	2.50	3.21	3.41	3.31	3.40	3.73	3.57
C_8 : Acacia gum (5 %)	2.05	2.13	2.09	2.51	2.66	2.59	3.34	3.53	3.43	3.52	3.84	3.68
C_9 : Pectin (2 %)	2.05	2.13	2.09	2.56	2.77	2.67	3.36	3.56	3.46	3.57	3.85	3.71
SEm. (±)	0.01	0.01	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	0.04	0.06	0.04	0.05	0.05	0.06	0.05
B. Packaging materials												
P_1 : CFB box	2.06	2.14	2.10	2.58	2.71	2.64	3.31	3.55	3.43	3.55	3.85	3.70
P_2 : Plastic crates	2.05	2.12	2.08	2.57	2.73	2.65	3.34	3.56	3.45	3.57	3.82	3.69
SEm. (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
CD at 1 %	0.01	NS	0.01	NS	0.02	NS	0.03	NS	NS	0.02	0.03	NS
C. Interaction (A x B)												
$C_1 P_1$	2.08	2.16	2.12	2.83	2.90	2.87	3.31	3.82	3.56	3.79	4.18	3.98
$C_1 P_2$	2.05	2.13	2.09	2.84	2.99	2.92	3.40	3.85	3.63	3.82	4.15	3.98
$C_2 P_1$	2.05	2.13	2.09	2.50	2.67	2.59	3.19	3.44	3.32	3.56	3.83	3.69
$C_2 P_2$	2.05	2.13	2.09	2.50	2.70	2.60	3.30	3.46	3.38	3.58	3.83	3.70
$C_3 P_1$	2.08	2.16	2.12	2.54	2.55	2.55	3.24	3.40	3.32	3.44	3.75	3.60
$C_3 P_2$	2.03	2.11	2.07	2.56	2.55	2.55	3.29	3.47	3.38	3.46	3.75	3.60
$C_4 P_1$	2.05	2.13	2.09	2.64	2.79	2.72	3.34	3.55	3.45	3.52	3.76	3.64
$C_4 P_2$	2.07	2.15	2.11	2.53	2.79	2.66	3.41	3.58	3.49	3.57	3.51	3.54
$C_5 P_1$	2.08	2.15	2.11	2.58	2.65	2.62	3.41	3.60	3.51	3.56	3.86	3.71
$C_5 P_2$	2.06	2.13	2.09	2.61	2.76	2.69	3.41	3.63	3.52	3.54	3.88	3.71
$C_6 P_1$	2.08	2.15	2.11	2.60	2.81	2.71	3.40	3.59	3.50	3.61	3.86	3.73
$C_6 P_2$	2.03	2.11	2.07	2.65	2.80	2.72	3.38	3.56	3.47	3.68	3.81	3.75
$C_7 P_1$	2.05	2.13	2.09	2.42	2.58	2.50	3.19	3.42	3.30	3.39	3.73	3.56
$C_7 P_2$	2.05	2.13	2.09	2.42	2.58	2.50	3.23	3.40	3.31	3.41	3.74	3.57
$C_8 P_1$	2.05	2.13	2.09	2.50	2.65	2.58	3.30	3.52	3.41	3.48	3.83	3.66
$C_8 P_2$	2.05	2.13	2.09	2.52	2.67	2.60	3.38	3.53	3.45	3.55	3.85	3.70
$C_9 P_1$	2.07	2.14	2.10	2.60	2.78	2.69	3.40	3.59	3.50	3.59	3.85	3.72
$C_9 P_2$	2.04	2.12	2.08	2.52	2.77	2.65	3.31	3.54	3.42	3.55	3.84	3.69
SEm. (±)	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	0.07	0.06	NS	0.08	NS	0.07	NS	0.09	NS

Table 19 contd…

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 : Without coating	4.13	4.69	4.41	4.59	5.25	4.92	6.20	6.19	6.20	-	-	-
C_2 : Alginate (2 %)	3.78	4.32	4.05	4.32	4.75	4.53	5.05	5.32	5.19	6.04	6.21	6.12
C_3 : Beewax (2 %)	3.74	4.23	3.99	4.24	4.71	4.48	5.33	5.05	5.19	5.91	5.90	5.91
C_4 : Aloe vera gel (75 %)	3.84	4.31	4.08	4.31	4.92	4.62	5.52	4.95	5.24	6.01	6.04	6.02
C_5 : Tapioca starch (5 %)	3.82	4.36	4.09	4.36	4.98	4.67	5.56	5.25	5.40	6.04	6.05	6.05
C_6 : Cinnamon oil (0.02)	3.78	4.43	4.11	4.43	4.97	4.70	6.01	6.15	6.08	-	-	-
C_7 : Chitosan (0.5 %)	3.77	4.20	3.98	4.21	4.75	4.48	4.63	5.32	4.97	5.80	5.87	5.83
C_8 : Acacia gum (5 %)	3.79	4.30	4.05	4.30	4.80	4.55	4.80	5.40	5.10	6.10	6.11	6.11
C_9 : Pectin (2 %)	3.84	4.41	4.13	4.36	4.91	4.63	5.95	5.46	5.70	6.16	6.18	6.17
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 %	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.06	0.05	0.05
B. Packaging materials												
P_1 : CFB box	3.83	4.35	4.09	4.32	4.87	4.60	5.42	5.44	5.43	5.99	6.06	6.02
P_2 : Plastic crates	3.83	4.37	4.10	4.37	4.91	4.64	5.48	5.47	5.48	6.03	6.05	6.04
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01
CD at 1 %	NS	0.02	NS	0.02	0.02	0.02	0.02	0.01	0.02	0.03	NS	NS
C. Interaction (A x B)												
$C_1 P_1$	4.14	4.65	4.39	4.45	5.20	4.83	6.20	6.19	6.20	-	-	-
$C_1 P_2$	4.12	4.72	4.42	4.72	5.30	5.01	6.20	6.19	6.20	-	-	-
$C_2 P_1$	3.75	4.30	4.02	4.30	4.70	4.50	5.00	5.30	5.15	6.06	6.25	6.15
$C_2 P_2$	3.81	4.33	4.07	4.33	4.79	4.56	5.10	5.34	5.22	6.01	6.17	6.09
$C_3 P_1$	3.75	4.22	3.98	4.23	4.70	4.47	5.28	5.00	5.14	5.83	5.90	5.86
$C_3 P_2$	3.73	4.25	3.99	4.25	4.72	4.49	5.38	5.10	5.24	6.00	5.90	5.95
$C_4 P_1$	3.85	4.30	4.08	4.30	4.90	4.60	5.52	5.00	5.26	6.02	6.03	6.03
$C_4 P_2$	3.83	4.32	4.08	4.32	4.94	4.63	5.53	4.90	5.21	6.00	6.04	6.02
$C_5 P_1$	3.85	4.35	4.10	4.35	4.90	4.63	5.48	5.20	5.34	6.07	6.08	6.08
$C_5 P_2$	3.80	4.36	4.08	4.36	5.05	4.71	5.64	5.30	5.47	6.01	6.02	6.02
$C_6 P_1$	3.77	4.42	4.09	4.42	4.97	4.69	6.02	6.10	6.06	-	-	-
$C_6 P_2$	3.80	4.44	4.12	4.44	4.98	4.71	6.00	6.20	6.10	-	-	-
$C_7 P_1$	3.77	4.16	3.97	4.18	4.74	4.46	4.60	5.30	4.95	5.70	5.86	5.78
$C_7 P_2$	3.77	4.23	4.00	4.23	4.76	4.50	4.65	5.35	5.00	5.90	5.87	5.89
$C_8 P_1$	3.80	4.29	4.04	4.29	4.80	4.55	4.74	5.40	5.07	6.10	6.10	6.10
$C_8 P_2$	3.79	4.31	4.05	4.30	4.80	4.55	4.86	5.40	5.13	6.10	6.12	6.11
$C_9 P_1$	3.86	4.43	4.14	4.38	4.95	4.67	5.90	5.43	5.67	6.12	6.17	6.15
$C_9 P_2$	3.83	4.39	4.11	4.34	4.87	4.60	6.00	5.48	5.74	6.20	6.20	6.20
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	0.06	0.06	0.06	0.06	0.04	0.05	0.08	NS	0.07

was observed in the treatment C_7P_1 (chitosan 0.5% + CFB box) which was statistically at par with the treatment C_3P_1 (beeswax 2 % + CFB box) (5.37 %). Whereas, maximum reducing sugars (6.21%) was observed in C_1P_2 treatment.

Data on the impact of edible and packaging on reducing sugars (%) in CS of mango has been showed in Table 19. The pooled data indicated that the at 28th DAS the minimum reducing sugars were seen in C_7 (5.83%) followed by C_3 (5.91%), maximum reducing sugars (6.20%) was found in C_1 treatment at 24 th DAS.

Packaging materials exhibited non-significant difference during storage. Rate of increasing in reducing sugars (%) was slower in P_1 than in P_2.

Fruit reducing sugars (%) were significantly impacted by the interaction between various coatings and packaging materials during storage. The pooled data as seen in Table 19 found that the minimum reducing sugars (5.78%) was found in C_7P_1 (chitosan 0.5% + CFB box) treatment. Maximum (6.20%) reducing sugars was observed in C_1P_2 (without coating + plastic crates) treatment at 24 th days.

Study of how edible coatings and packing materials affect the total sugar content is one of the most important fruit quality issues. A rise in total sugar up until the peak, a modest fall with extended storage times, and a lower percentage of total sugar in fruits treated with chitosan (0.5%) and beeswax (2%), among other things, are some potential causes and outcomes of the findings. Additionally, the hydrolysis process at the overripe stage caused the sugars to become soluble. Singh *et al.* (2000). and Kapse (1993) also reported the same results.

4.2.6 β-carotene (mg/100g)

The data on impact of various coatings and packing materials on β-carotene (mg/100g) recorded during storage for the year 2019, 2020 and pooled analysis are present in Table 20 (AT) and 21 (CS) and depicted in Fig. 12 and 13 respectively.

When compared to cold storage (CS), the rate of β -carotene increased during the storage period was higher under ambient temperature (AT).

Regarding the β-carotene of fruits at AT (Table 20), there were significant variation between the various treatments. The pool data indicated that the treatment C_7 (chitosan 0.5%) minimum β-carotene (8.54 mg/100g) was found which is followed by C_3

(beeswax 2%) (8.65 mg/100g) treatment whereas, maximum β-carotene (10.87 mg/100g) was observed in C_1 (without coating) at 16th day after storage.

Packaging materials displayed significant variations during storage at ambient temperature. Compared to P_2, overall rate of rise in β-carotene was slower in P_1. Highest β-carotene recorded by P_1 9.42 mg/100g and P_2 9.93 mg/100 at 16th day after storage at AT.

The interaction between various coatings and packing materials and fruit β-carotene during storage found significant. The combined data shown in the Table 20 showed that β-carotene of the fruits in the data shows increasing trend up to 16th day of storage. The minimum β-carotene (8.25 mg/100 g) was observed in C_7P_1, (chitosan 0.5 % + CFB box) treatment is followed by C_3P_1 (beeswax 2% + CFB box) (8.31 mg/100g), T_7P_2 (chitosan 0.5% + plastic crates) (8.83 mg/100 g) treatment. Whereas, maximum β-carotene(11.01 mg/100 g) was observed in C_1P_2 (without coating + plastic crates) treatment.

β-carotene showed significant difference with coatings treatments throughout the storage in CS (Table 21). Effect of different coatings could be recorded up to 28 days for C_2, C_3, C_4, C_5, C_7, C_8 and C_9. The combined data showed that minimum β-carotene C_7 (8.71 mg/100g) treatment is followed by the treatment of C_3 (8.78 mg/100g) whereas, maximum β-carotene (9.69 mg/100g) was recorded C_1 (without coating) up to 24th day of storage.

Packaging materials displayed significant variations during storage. Compared to P_2, overall rate of rise in β-carotene was slower in P_1. Highest β-carotene recorded by P_1 and P_2 was 9.00 mg/100g and 9.68 mg/100g at 28th day after storage respectivly.

During storage, there was a significant interaction between various coatings and packaging materials and fruit β-carotene. The combined data seen in Table 21 indicated that β-carotene of the mango fruits in the data shows increasing trend up to 28th day of storage. The minimum β-carotene (8.37mg/100g) was observed in the C_7P_1 (chitosan 0.5 % + CFB box) treatment is followed by the treatment C_3P_1 (beeswax 2% + CFB box), (8.63 mg/100g). Whereas, maximum (10.00 mg/100g) β-carotene was observed in C_1P_2 (without coating + plastic crates) treatment up to 24th day after storage.

Table 20. Effect of edible coatings and packaging materials on changes in β-carotene (mg/100 g) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	0.28	0.29	0.29	4.95	5.27	5.11	7.75	7.75	7.75	9.65	9.76	9.71	10.97	10.76	10.87
C_2 : Alginate (2 %)	0.29	0.27	0.28	3.92	4.64	4.28	5.69	6.10	5.89	7.50	7.70	7.60	9.75	9.52	9.63
C_3 : Beewax (2 %)	0.29	0.28	0.28	3.26	3.95	3.60	5.64	5.65	5.65	7.26	7.59	7.43	8.91	8.40	8.65
C_4 : Aloe vera gel (75 %)	0.27	0.28	0.28	3.90	4.38	4.14	6.16	6.50	6.33	7.75	8.78	8.26	9.80	9.68	9.74
C_5 : Tapioca starch (5 %)	0.30	0.26	0.28	4.00	4.94	4.47	6.25	6.50	6.38	7.92	8.23	8.07	10.06	9.76	9.91
C_6 : Cinnamon oil (0.02)	0.29	0.28	0.28	4.24	4.91	4.58	7.44	7.56	7.50	8.96	8.94	8.95	10.43	10.31	10.37
C_7 : Chitosan (0.5 %)	0.28	0.28	0.28	3.14	3.65	3.40	5.38	5.79	5.58	7.13	7.53	7.33	8.78	8.30	8.54
C_8 : Acacia gum (5 %)	0.28	0.30	0.29	4.03	4.49	4.26	5.72	6.18	5.95	8.25	8.50	8.38	9.32	9.19	9.26
C_9 : Pectin (2 %)	0.26	0.23	0.24	3.81	4.60	4.20	6.75	6.93	6.84	9.20	9.20	9.20	10.09	10.20	10.14
SEm. (±)	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.04	0.05	0.05	0.03	0.06	0.05
CD at 1 %	NS	NS	NS	0.06	0.09	0.07	0.07	0.11	0.09	0.15	0.21	0.18	0.14	0.25	0.19
B. Packaging materials															
P_1 : CFB box	0.28	0.28	0.28	3.78	4.35	4.06	6.05	6.28	6.16	7.82	8.14	7.98	9.57	9.28	9.42
P_2 : Plastic crates	0.28	0.27	0.27	4.05	4.72	4.39	6.56	6.82	6.69	8.54	8.79	8.67	10.01	9.86	9.93
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02
CD at 1 %	NS	NS	NS	0.03	0.04	0.04	0.03	0.05	0.04	0.07	0.10	0.08	0.06	0.12	0.09
C. Interaction (A x B)															
C_1 P_1	0.28	0.28	0.28	4.90	5.00	4.95	7.50	7.50	7.50	9.30	9.52	9.41	10.92	10.52	10.72
C_1 P_2	0.29	0.30	0.29	5.00	5.55	5.27	8.00	8.00	8.00	10.00	10.00	10.00	11.03	11.00	11.01
C_2 P_1	0.29	0.27	0.28	3.83	4.46	4.15	5.38	6.00	5.69	7.00	7.40	7.20	10.00	9.33	9.67
C_2 P_2	0.28	0.26	0.27	4.00	4.81	4.41	6.00	6.19	6.10	8.00	8.00	8.00	9.50	9.70	9.60
C_3 P_1	0.29	0.28	0.28	3.00	3.80	3.40	5.38	5.50	5.44	7.00	7.09	7.04	8.63	8.00	8.31
C_3 P_2	0.29	0.28	0.28	3.51	4.09	3.80	5.90	5.80	5.85	7.53	8.10	7.81	9.19	8.80	9.00
C_4 P_1	0.28	0.28	0.28	3.80	4.35	4.08	6.00	6.00	6.00	7.50	8.55	8.03	9.60	9.35	9.48
C_4 P_2	0.25	0.28	0.27	4.00	4.40	4.20	6.31	7.00	6.66	8.00	9.00	8.50	10.00	10.00	10.00
C_5 P_1	0.30	0.27	0.28	3.90	4.83	4.36	6.10	6.00	6.05	7.84	8.00	7.92	9.62	9.31	9.46
C_5 P_2	0.30	0.25	0.28	4.10	5.05	4.58	6.40	7.00	6.70	8.00	8.45	8.23	10.50	10.21	10.36
C_6 P_1	0.28	0.28	0.28	3.98	4.83	4.40	7.15	7.37	7.26	8.00	8.57	8.29	10.05	10.00	10.03
C_6 P_2	0.30	0.27	0.28	4.50	5.00	4.75	7.72	7.74	7.73	9.92	9.30	9.61	10.80	10.61	10.71
C_7 P_1	0.28	0.29	0.28	3.06	3.50	3.28	5.00	5.50	5.25	6.85	7.06	6.96	8.50	8.00	8.25
C_7 P_2	0.29	0.26	0.28	3.23	3.80	3.51	5.75	6.08	5.91	7.41	8.00	7.70	9.07	8.60	8.83
C_8 P_1	0.28	0.30	0.29	3.91	4.18	4.05	5.43	6.00	5.72	8.00	8.10	8.05	9.00	9.00	9.00
C_8 P_2	0.28	0.30	0.29	4.15	4.80	4.48	6.00	6.35	6.18	8.50	8.90	8.70	9.64	9.39	9.51
C_9 P_1	0.28	0.27	0.27	3.62	4.19	3.91	6.50	6.65	6.58	8.90	9.00	8.95	9.80	10.00	9.90
C_9 P_2	0.24	0.20	0.22	4.00	5.00	4.50	7.00	7.20	7.10	9.50	9.40	9.45	10.38	10.40	10.39
SEm. (±)	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.04	0.03	0.05	0.07	0.06	0.05	0.09	0.07
CD at 1 %	NS	NS		0.09	0.13	0.11	0.09	0.16	0.12	0.22	0.30	0.25	0.19	NS	0.27

Table 21. Effect of edible coatings and packaging materials on changes in β-carotene (mg/100g) 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 : Without coating	0.28	0.29	0.29	1.32	1.16	1.24	2.65	3.03	2.84	4.45	4.68	4.57
C_2 : Alginate (2 %)	0.29	0.27	0.28	0.88	1.06	0.97	2.32	2.82	2.57	2.87	3.78	3.33
C_3 : Beewax (2 %)	0.29	0.28	0.28	0.75	0.96	0.85	2.19	2.68	2.43	2.72	3.60	3.16
C_4 : Aloe vera gel (75 %)	0.27	0.28	0.28	0.90	1.06	0.98	2.35	2.85	2.60	3.12	3.97	3.54
C_5 : Tapioca starch (5 %)	0.30	0.26	0.28	0.94	1.06	1.00	2.39	2.89	2.64	3.00	4.04	3.52
C_6 : Cinnamon oil (0.02)	0.29	0.28	0.28	0.90	1.10	1.00	2.35	2.85	2.60	4.02	4.55	4.29
C_7 : Chitosan (0.5 %)	0.28	0.28	0.28	0.75	0.89	0.82	2.19	2.24	2.21	2.71	3.47	3.09
C_8 : Acacia gum (5 %)	0.28	0.30	0.29	0.86	1.05	0.96	2.28	2.78	2.53	3.25	4.00	3.63
C_9 : Pectin (2 %)	0.26	0.23	0.24	0.81	1.05	0.93	2.33	2.90	2.61	3.35	4.16	3.75
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.03	0.03
CD at 1 %	NS	NS	NS	0.05	0.05	0.05	0.04	0.06	0.05	0.10	0.14	0.11
B. Packaging materials												
P_1 : CFB box	0.28	0.28	0.28	0.62	0.77	0.69	2.06	2.53	2.29	2.94	3.67	3.31
P_2 : Plastic crates	0.28	0.27	0.27	1.18	1.31	1.25	2.61	3.04	2.82	3.61	4.38	3.99
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01
CD at 1 %	NS	NS	NS	0.02	0.02	0.02	0.02	0.03	0.02	0.04	0.06	0.05
C. Interaction (A x B)												
$C_1 P_1$	0.28	0.28	0.28	0.82	0.85	0.84	2.31	2.78	2.54	3.90	4.16	4.03
$C_1 P_2$	0.29	0.30	0.29	1.83	1.47	1.65	3.00	3.29	3.15	5.00	5.20	5.10
$C_2 P_1$	0.29	0.27	0.28	0.62	0.80	0.71	2.05	2.54	2.30	2.60	3.56	3.08
$C_2 P_2$	0.28	0.26	0.27	1.14	1.31	1.22	2.58	3.09	2.84	3.14	4.00	3.57
$C_3 P_1$	0.29	0.28	0.28	0.48	0.66	0.57	1.92	2.42	2.17	2.40	3.20	2.80
$C_3 P_2$	0.29	0.28	0.28	1.02	1.26	1.14	2.45	2.95	2.70	3.03	4.00	3.52
$C_4 P_1$	0.28	0.28	0.28	0.66	0.80	0.73	2.11	2.61	2.36	2.73	3.70	3.22
$C_4 P_2$	0.25	0.28	0.27	1.14	1.32	1.23	2.58	3.09	2.84	3.50	4.23	3.87
$C_5 P_1$	0.30	0.27	0.28	0.66	0.83	0.74	2.11	2.61	2.36	2.73	3.77	3.25
$C_5 P_2$	0.30	0.25	0.28	1.23	1.30	1.26	2.66	3.17	2.92	3.27	4.30	3.79
$C_6 P_1$	0.28	0.28	0.28	0.67	0.82	0.74	2.12	2.61	2.37	3.76	4.10	3.93
$C_6 P_2$	0.30	0.27	0.28	1.13	1.38	1.26	2.58	3.08	2.83	4.28	5.00	4.64
$C_7 P_1$	0.28	0.29	0.28	0.48	0.60	0.54	1.93	2.05	1.99	2.39	3.17	2.78
$C_7 P_2$	0.29	0.26	0.28	1.02	1.18	1.10	2.45	2.42	2.44	3.04	3.78	3.41
$C_8 P_1$	0.28	0.30	0.29	0.57	0.80	0.68	2.02	2.51	2.27	3.00	3.56	3.28
$C_8 P_2$	0.28	0.30	0.29	1.16	1.30	1.23	2.54	3.05	2.80	3.50	4.44	3.97
$C_9 P_1$	0.28	0.27	0.27	0.62	0.80	0.71	2.00	2.62	2.31	3.00	3.81	3.41
$C_9 P_2$	0.24	0.20	0.22	1.00	1.30	1.15	2.65	3.19	2.92	3.70	4.50	4.10
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.05	0.04
CD at 1 %	NS	NS	NS	0.07	0.07	0.07	0.06	0.09	0.07	0.13	0.19	0.16

Table 21 contd…

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 : Without coating	6.85	6.60	6.73	8.81	8.55	8.68	9.73	9.65	9.69	-	-	-
C_2 : Alginate (2 %)	5.20	5.47	5.34	6.80	6.78	6.79	7.82	7.89	7.86	8.46	9.39	8.92
C_3 : Beewax (2 %)	5.02	5.34	5.18	6.62	6.54	6.58	7.49	7.43	7.46	8.61	8.95	8.78
C_4 : Aloe vera gel (75 %)	5.37	5.57	5.47	7.02	7.20	7.11	8.60	8.04	8.32	9.40	9.55	9.47
C_5 : Tapioca starch (5 %)	5.16	5.47	5.31	7.06	7.20	7.13	9.00	8.02	8.51	9.49	9.60	9.54
C_6 : Cinnamon oil (0.02)	6.35	6.26	6.30	8.50	8.50	8.50	9.75	9.68	9.71	-	-	-
C_7 : Chitosan (0.5 %)	4.84	5.18	5.01	6.70	5.88	6.29	7.55	7.40	7.48	8.38	9.04	8.71
C_8 : Acacia gum (5 %)	5.50	5.63	5.56	6.77	6.65	6.71	8.09	8.45	8.27	9.35	9.30	9.33
C_9 : Pectin (2 %)	6.03	6.60	6.31	7.40	7.63	7.51	9.53	9.33	9.43	10.90	10.41	10.65
SEm. (±)	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01
CD at 1 %	0.04	0.06	0.05	0.03	0.12	0.08	0.09	0.06	0.07	0.08	0.03	0.05
B. Packaging materials												
P_1 : CFB box	5.26	5.51	5.38	6.96	6.83	6.89	8.29	8.11	8.20	8.87	9.14	9.00
P_2 : Plastic crates	5.92	6.07	6.00	7.64	7.60	7.62	8.95	8.75	8.85	9.58	9.79	9.68
SEm. (±)	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
CD at 1 %	0.02	0.03	0.02	0.02	0.06	0.04	0.04	0.03	0.03	0.04	0.01	0.03
C. Interaction (A x B)												
$C_1 P_1$	6.50	6.20	6.35	8.61	8.10	8.36	9.45	9.30	9.38	-	-	-
$C_1 P_2$	7.20	7.00	7.10	9.00	9.00	9.00	10.00	10.00	10.00	-	-	-
$C_2 P_1$	4.92	5.23	5.07	6.52	6.40	6.46	7.64	7.63	7.64	8.17	9.10	8.63
$C_2 P_2$	5.49	5.72	5.61	7.09	7.15	7.12	8.00	8.15	8.08	8.75	9.68	9.22
$C_3 P_1$	4.70	5.11	4.91	6.24	6.11	6.18	7.18	7.10	7.14	8.30	8.50	8.40
$C_3 P_2$	5.33	5.58	5.45	7.00	6.97	6.98	7.80	7.75	7.78	8.93	9.40	9.16
$C_4 P_1$	5.04	5.28	5.16	6.64	6.80	6.72	8.20	7.70	7.95	9.00	9.28	9.14
$C_4 P_2$	5.69	5.85	5.77	7.40	7.60	7.50	9.00	8.38	8.69	9.80	9.82	9.81
$C_5 P_1$	4.89	5.20	5.05	6.69	6.80	6.75	8.60	7.76	8.18	9.10	9.29	9.20
$C_5 P_2$	5.43	5.74	5.58	7.43	7.60	7.52	9.40	8.29	8.84	9.88	9.90	9.89
$C_6 P_1$	6.00	6.00	6.00	7.90	8.20	8.05	9.43	9.35	9.39	-	-	-
$C_6 P_2$	6.70	6.51	6.61	9.10	8.80	8.95	10.08	10.00	10.04	-	-	-
$C_7 P_1$	4.50	5.00	4.75	6.42	5.52	5.97	7.10	7.08	7.09	8.05	8.68	8.37
$C_7 P_2$	5.18	5.35	5.27	6.98	6.25	6.62	8.00	7.73	7.87	8.70	9.40	9.05
$C_8 P_1$	5.10	5.25	5.18	6.53	6.30	6.42	7.81	8.10	7.96	9.00	9.00	9.00
$C_8 P_2$	5.90	6.00	5.95	7.02	7.00	7.01	8.38	8.80	8.59	9.70	9.60	9.65
$C_9 P_1$	5.70	6.30	6.00	7.10	7.20	7.15	9.20	9.00	9.10	10.50	10.10	10.30
$C_9 P_2$	6.35	6.90	6.63	7.70	8.05	7.88	9.85	9.65	9.75	11.30	10.72	11.01
SEm. (±)	0.02	0.02	0.02	0.01	0.04	0.03	0.03	0.02	0.03	0.03	0.01	0.02
CD at 1 %	0.06	0.08	0.07	0.05	NS	0.12	0.13	0.09	0.10	0.11	0.04	0.08

The rate of increase for β-carotene was discovered to be rapid in uncoated fruit fruit and slowed in fruit coated with edible coatings such as chitosan 0.5% and beeswax 2%. This could be due to the high temperature with low RH seen during AT storage, which increased biosynthesis while decreasing chlorophyll, and increased carotene while decreasing acid and increasing sugars levels. Ripe mangoes contain geraniol, and cell free extracts of these fruits showed a significantly higher carotene concentration after being incubated with geraniol and farnesol. Lengthy mango fruit storage in CS at high RH with low temperature delayed the ripening and resulted in reduced β-carotene concentrations in all coated treatment. The same results are published by Gole. (1986) and Badar (1990).

4.2.7 Ascorbic acid (mg/100 g)

The data on how packaging and coatings affect ascorbic acid (mg/100g) during storage for the year 2019, 2020 and pooled of mango has been presented in Table 22 (RT) and 23 (CS) and seen within Fig. 14 and 15 respectively. Ascorbic acid of mango was significantly decreased using various coating and packaging materials. The ascorbic acid was decreased during both the storage conditions.

The data on changes in ascorbic acid of mango fruit cv. Kesar was found influenced by different postharvest treatments (Table 22) at AT. The pooled data seen that the treatment T_7 maximum on ascorbic acid (38.30 mg/100g) followed by C_3 (37.93 mg/100g). Whereas minimum ascorbic acid (31.94 mg/100g) was observed in C_1 (without coating) at 16th day after storage.

During storage at AT, the impact of the packaging materials on ascorbic acid reported significant results. In P_1 compared to P_2, the rate of ascorbic acid breakdown was slower. Highest ascorbic acid recorded by P_1 and P_2 was 35.72 mg/100g and 34.69 mg/100g at 28th day respectively .

With regard to ascorbic acid during storage, the interaction between various coatings and packing materials produced significant results. The information shown in Table 22 indicated that ascorbic acid of mango fruits in the pooled data showed

Table 22. Effect of edible coatings and packaging materials on changes in ascorbic acid (mg/100g) of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	80.21	80.22	80.21	67.50	66.16	66.83	60.11	59.41	59.76	44.42	43.78	44.10	32.10	31.77	31.94
C_2 : Alginate (2 %)	80.20	80.21	80.21	74.99	70.36	72.67	64.88	63.28	64.08	52.28	52.00	52.14	37.82	34.95	36.39
C_3 : Beewax (2 %)	80.21	80.22	80.21	79.73	74.64	77.18	65.41	65.23	65.32	53.10	55.04	54.07	38.00	37.86	37.93
C_4 : Aloe vera gel (75 %)	80.20	80.19	80.19	75.10	73.25	74.18	63.65	64.24	63.94	49.85	49.00	49.42	32.98	33.07	33.03
C_5 : Tapioca starch (5 %)	80.21	80.20	80.20	74.50	71.86	73.18	63.92	62.90	63.41	50.77	50.05	50.41	33.87	33.72	33.79
C_6 : Cinnamon oil (0.02)	80.19	80.21	80.20	67.63	66.98	67.30	62.00	60.69	61.34	45.43	45.50	45.46	32.75	32.60	32.68
C_7 : Chitosan (0.5 %)	80.19	80.20	80.19	75.66	75.07	75.36	66.22	65.67	65.95	55.43	54.53	54.98	37.96	38.65	38.30
C_8 : Acacia gum (5 %)	80.22	80.20	80.21	74.72	74.15	74.44	64.01	64.88	64.44	50.92	51.60	51.26	37.26	36.25	36.75
C_9 : Pectin (2 %)	80.14	80.20	80.17	74.73	73.69	74.21	64.53	64.04	64.28	50.63	50.87	50.75	37.21	34.91	36.06
SEm. (±)	0.03	0.04	0.03	0.15	0.18	0.16	0.13	0.15	0.14	0.16	0.17	0.17	0.06	0.04	0.05
CD at 1 %	NS	NS	NS	0.60	0.72	0.63	0.54	0.62	0.55	0.66	0.70	0.64	0.24	0.16	0.19
B. Packaging materials															
P_1 : CFB box	80.21	80.20	80.21	74.32	72.94	73.63	64.73	64.17	64.45	51.12	51.20	51.16	35.92	35.52	35.72
P_2 : Plastic crates	80.18	80.20	80.19	73.36	70.65	72.00	62.98	62.57	62.77	49.51	49.33	49.42	35.18	34.21	34.69
SEm. (±)	0.02	0.02	0.02	0.07	0.08	0.08	0.06	0.07	0.07	0.08	0.08	0.08	0.03	0.02	0.02
CD at 1 %	NS	NS	NS	0.28	0.34	0.30	0.25	0.29	0.26	0.31	0.33	0.30	0.11	0.08	0.09
C. Interaction (A x B)															
C_1 P_1	80.21	80.21	80.21	68.00	67.11	67.56	61.72	60.41	61.06	45.18	44.92	45.05	31.00	32.50	31.75
C_1 P_2	80.20	80.22	80.21	67.00	65.22	66.11	58.50	58.40	58.45	43.66	42.64	43.15	33.20	31.05	32.12
C_2 P_1	80.21	80.22	80.21	75.65	74.61	75.13	65.80	64.10	64.95	53.90	53.99	53.95	38.64	35.56	37.10
C_2 P_2	80.19	80.21	80.20	74.33	66.11	70.22	63.95	62.45	63.20	50.66	50.00	50.33	37.00	34.35	35.68
C_3 P_1	80.20	80.23	80.21	80.00	75.45	77.72	66.00	65.85	65.93	53.50	55.71	54.60	38.50	38.54	38.52
C_3 P_2	80.21	80.22	80.22	79.46	73.83	76.64	64.82	64.61	64.72	52.70	54.38	53.54	37.50	37.19	37.34
C_4 P_1	80.20	80.20	80.20	75.60	74.51	75.05	65.25	65.25	65.25	50.69	50.00	50.35	33.86	33.66	33.76
C_4 P_2	80.19	80.19	80.19	74.61	72.00	73.30	62.05	63.22	62.64	49.00	48.00	48.50	32.10	32.48	32.29
C_5 P_1	80.20	80.19	80.20	74.56	73.11	73.83	64.20	63.65	63.93	51.15	51.00	51.08	34.73	34.23	34.48
C_5 P_2	80.21	80.20	80.21	74.45	70.61	72.53	63.64	62.15	62.90	50.38	49.10	49.74	33.00	33.22	33.11
C_6 P_1	80.21	80.22	80.21	68.25	67.05	67.65	62.10	61.37	61.74	46.05	46.00	46.03	33.50	33.20	33.35
C_6 P_2	80.16	80.21	80.19	67.00	66.90	66.95	61.90	60.00	60.95	44.80	45.00	44.90	32.00	32.00	32.00
C_7 P_1	80.20	80.20	80.20	76.16	75.70	75.93	67.30	66.42	66.86	56.66	55.87	56.26	38.56	39.30	38.93
C_7 P_2	80.18	80.20	80.19	75.16	74.43	74.79	65.15	64.92	65.04	54.20	53.20	53.70	37.35	38.00	37.68
C_8 P_1	80.22	80.20	80.21	75.44	74.66	75.05	64.70	65.60	65.15	51.67	52.25	51.96	37.08	36.98	37.03
C_8 P_2	80.21	80.20	80.20	74.00	73.65	73.83	63.32	64.15	63.73	50.17	50.95	50.56	37.43	35.52	36.48
C_9 P_1	80.20	80.20	80.20	75.25	74.25	74.75	65.55	64.88	65.22	51.25	51.05	51.15	37.42	35.71	36.57
C_9 P_2	80.07	80.20	80.14	74.22	73.14	73.68	63.50	63.20	63.35	50.00	50.68	50.34	37.00	34.10	35.55
SEm. (±)	0.05	0.05	0.05	0.21	0.25	0.23	0.19	0.21	0.20	0.23	0.24	0.24	0.08	0.06	0.07
CD at 1 %	NS	NS	NS	NS	1.02	0.89	0.76	NS	0.77	0.93	0.99	0.91	0.33	0.23	0.27

Table 23. Effect of edible coatings and packaging materials on changes in ascorbic acid (mg/100g) of Kesar 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 : Without coating	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

Table 23 contd….

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 : Without coating	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

decreasing trend up to 16th days of storage. The maximum ascorbic acid (38.93 mg/100g) was seen in the treatment C_7P_1 (chitosan 0.5% + CFB box), followed by C_3P_1 (beeswax 2% + CFB box) and C_7P_2 (chitosan 0.5% + plastic crates) treatment, Whereas, minimum (31.75 mg/100g) ascorbic acid was seen in C_1P_1 (without coating + CFB) treatment.

In cold storage pooled data as shown that the treatment C_7 maximum ascorbic acid (35.87 mg/100g) which is at par with the C_3 (35.48 mg/100g) treatment at 28th day after storage. Whereas, minimum ascorbic acid (38.03 mg/100g) was seen in the C_1 (without coating) treatment at 24th day after storage.

The impact of packaging materials on ascorbic acid during storage indicated a significant result. In P_1 compared to P_2, the rate of ascorbic acid deterioration was lower. Highest ascorbic acid recorded by P_1 and P_2 was 34.28 mg/100g and 33.12 mg/100g at 28th day respectively.

The interaction impact of various coatings and packaging materials, during storage on fruit ascorbic acid was significant during storage. The data pooled showed in the Table 23 seen that ascorbic acid of mango fruits in the pooled data showed decreasing trend up to 28th day after storage. The maximum ascorbic acid (36.49 mg/100g) was seen in the treatment C_7P_1 (chitosan 0.5% + CFB box), which is followed by C_3P_1 (beeswax 2% + CFB box) (35.98mg/100g) treatment. Whereas, minimum ascorbic acid (38.05 mg/100g) was noticed in the C_1P_2 (without coating + plastic crates) treatment at 24th day after storage.

In both storage conditions, it was determined that the ascorbic acid concentration of mango cv. Kesar declined with time in all coated fruit; however, untreated fruit gained ascorbic acid at a higher rate than coated fruit. While uncoated fruits showed high ascorbic acid concentration than coated ones. The utilization of ascorbic acid in respiration during ripening at room temperature and cold storage may be the cause of a decrease in ascorbic acid concentration in mango fruits. It could be that oxygen was present in the storage environment, which caused the respiration rate to increase and cause the release of water. This consequently accelerated ascorbic acid degradation since ascorbic acid is easily oxidised in the presence of humidity (Ottaway, 2010). Maximum on ascorbic acid concentration was found in coated fruit Similar result also seen by Wong *et at*. (2016).

4.2.8 pH

The data on the impact of edible coatings and packaging materials on changes in pH of mango fruits cv. Kesar during storage for the year 2019, 2020 and pooled at ambient storage (AT) is presented in Table 24 and at cold storage (CS) Table 25. It was found from the statistical analysis that the pH of mango found to be increased significantly in all treatments during storage period of postharvest treatments in storage conditions. It was discovered that ambient storage (AT) storage increased the pH of mango fruit more quickly than cold storage (CS). It was found that when the storage period increased, the pH of uncoated fruit increased at faster rate than coated fruits.

The significant differences was noticed among the various coatings treatments in respect of pH of fruits at AT (Table 24). The pooled data clearly showed that the treatment C_7 (chitosan 0.5%) minimum pH (4.04), which is at par with C_3 (beeswax 2%) (4.08) treatment whereas, maximum pH (4.43) was seen in T_1 (without coating) at 16th day of storage.

Packaging materials exhibited non-significant difference except at 4th day of storage at AT (Table 24).

The interaction effect of different coatings and packaging materials, during storage on fruit pH was significant during storage. The data presented in the Table 24 showed that pH of the fruits in the pooled data showed increasing trend up to 16th day of storage. The minimum pH (4.00) was observed in C_7P_1 (chitosan 0.5% + CFB box) treatment which is at par with C_3P_1 (beeswax 2% + CFB box) (4.05) treatment. Whereas, maximum (4.42) pH was seen in C_1P_2 (without coating + plastic carest) treatment.

pH showed significant difference with coatings treatments throughout the storage period in cold storage (Table 25). Effect of various coatings could be recorded up to 28th days for C_2, C_3, C_4, C_5, C_7, C_8 and C_9. The data showed that the treatment C_7 minimum pH (3.93) was recorded, which followed by the treatment of C_3 (4.04), T_2 (4.08) treatment whereas, maximum pH (4.27) was recorded T_1 (without coating) treatment up to 24th day of storage.

Table 24. Effect of edible coatings and packaging materials on changes in pH of Kesar mango fruit during storage at ambient temperature

Treatment	0 DAS			4 DAS			8 DAS			12 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
A. Edible coating															
C_1 : Without coating	2.70	2.75	2.73	3.27	3.40	3.33	3.61	3.73	3.67	4.20	4.17	4.18	4.45	4.42	4.43
C_2 : Alginate (2 %)	2.65	2.75	2.70	2.95	3.06	3.00	3.50	3.48	3.49	3.92	3.98	3.95	4.22	4.21	4.21
C_3 : Beewax (2 %)	2.70	2.80	2.75	3.17	3.29	3.23	3.63	3.63	3.63	3.97	4.09	4.03	4.03	4.13	4.08
C_4 : Aloe vera gel (75 %)	2.70	2.75	2.73	3.18	3.30	3.24	3.54	3.55	3.54	3.99	4.09	4.04	4.24	4.34	4.29
C_5 : Tapioca starch (5 %)	2.75	2.75	2.75	3.12	3.24	3.18	3.59	3.56	3.58	4.02	4.17	4.09	4.27	4.42	4.34
C_6 : Cinnamon oil (0.02)	2.75	2.80	2.78	3.15	3.31	3.23	3.56	3.52	3.54	4.08	4.18	4.13	4.33	4.43	4.38
C_7 : Chitosan (0.5 %)	2.70	2.75	2.73	2.94	3.04	2.99	3.43	3.46	3.44	3.88	3.98	3.93	4.02	4.07	4.04
C_8 : Acacia gum (5 %)	2.70	2.75	2.73	3.19	3.19	3.19	3.58	3.49	3.54	4.02	4.07	4.05	4.32	4.32	4.32
C_9 : Pectin (2 %)	2.73	2.78	2.75	3.15	3.30	3.23	3.55	3.58	3.56	3.97	4.08	4.02	4.23	4.36	4.29
SEm. (±)	0.02	0.03	0.02	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	0.05	0.04	0.05	0.05	0.04	0.04	0.06	0.05	0.05	0.05	0.05	0.04
B. Packaging materials															
P_1 : CFB box	2.72	2.77	2.75	3.11	3.22	3.17	3.53	3.55	3.54	4.03	4.05	4.04	4.25	4.26	4.26
P_2 : Plastic crates	2.69	2.76	2.73	3.14	3.25	3.19	3.57	3.55	3.56	3.98	4.13	4.05	4.21	4.33	4.27
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	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	0.02	0.02	0.02	0.02	NS	NS	0.03	0.02	NS	0.02	0.02	NS
C. Interaction (A x B)															
$C_1 P_1$	2.75	2.75	2.75	3.25	3.35	3.30	3.57	3.71	3.64	4.23	4.15	4.19	4.48	4.40	4.44
$C_1 P_2$	2.65	2.75	2.70	3.29	3.45	3.37	3.64	3.75	3.70	4.17	4.18	4.17	4.42	4.43	4.42
$C_2 P_1$	2.65	2.75	2.70	2.94	3.05	3.00	3.50	3.47	3.49	3.92	3.96	3.94	4.21	4.18	4.19
$C_2 P_2$	2.65	2.75	2.70	2.95	3.08	3.01	3.49	3.48	3.49	3.91	4.00	3.96	4.22	4.24	4.23
$C_3 P_1$	2.70	2.80	2.75	3.15	3.28	3.21	3.60	3.60	3.60	3.96	4.04	4.00	4.00	4.10	4.05
$C_3 P_2$	2.70	2.80	2.75	3.19	3.30	3.24	3.66	3.66	3.66	3.97	4.15	4.06	4.06	4.15	4.11
$C_4 P_1$	2.70	2.75	2.73	3.17	3.28	3.22	3.52	3.55	3.54	4.00	4.06	4.03	4.25	4.31	4.28
$C_4 P_2$	2.70	2.75	2.73	3.19	3.32	3.26	3.55	3.54	3.55	3.98	4.12	4.05	4.23	4.37	4.30
$C_5 P_1$	2.75	2.75	2.75	3.09	3.34	3.22	3.58	3.53	3.56	4.07	4.17	4.12	4.32	4.42	4.37
$C_5 P_2$	2.75	2.75	2.75	3.15	3.14	3.14	3.60	3.59	3.60	3.96	4.16	4.06	4.21	4.41	4.31
$C_6 P_1$	2.75	2.80	2.78	3.16	3.28	3.22	3.54	3.50	3.52	4.18	4.17	4.18	4.43	4.42	4.43
$C_6 P_2$	2.75	2.80	2.78	3.14	3.35	3.24	3.57	3.53	3.55	3.97	4.18	4.08	4.22	4.43	4.33
$C_7 P_1$	2.75	2.80	2.78	2.94	3.03	2.98	3.41	3.45	3.43	3.87	3.98	3.92	4.00	4.00	4.00
$C_7 P_2$	2.65	2.70	2.68	2.95	3.06	3.00	3.45	3.46	3.46	3.88	3.99	3.93	4.03	4.14	4.08
$C_8 P_1$	2.70	2.75	2.73	3.14	3.14	3.14	3.53	3.61	3.57	4.07	3.97	4.02	4.32	4.22	4.27
$C_8 P_2$	2.70	2.75	2.73	3.25	3.25	3.25	3.63	3.37	3.50	3.97	4.18	4.07	4.32	4.43	4.37
$C_9 P_1$	2.75	2.80	2.78	3.16	3.29	3.22	3.53	3.57	3.55	3.98	3.98	3.98	4.25	4.31	4.28
$C_9 P_2$	2.70	2.75	2.73	3.15	3.32	3.23	3.56	3.58	3.57	3.97	4.18	4.07	4.22	4.40	4.31
SEm. (±)	0.03	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	NS	0.06	0.06	NS	0.06	0.06	0.08	0.07	0.07	0.07	0.06	0.06

Table 25. Effect of edible coatings and packaging materials on changes in pH 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 : Without coating	2.70	2.75	2.73	2.91	2.97	2.94	3.20	3.27	3.23	3.47	3.51	3.49
C_2 : Alginate (2 %)	2.65	2.75	2.70	2.83	2.88	2.85	3.11	3.08	3.09	3.35	3.42	3.39
C_3 : Beewax (2 %)	2.70	2.80	2.75	2.83	2.89	2.86	3.15	3.20	3.18	3.40	3.45	3.42
C_4 : Aloe vera gel (75 %)	2.70	2.75	2.73	2.84	2.89	2.86	3.15	3.21	3.18	3.44	3.46	3.45
C_5 : Tapioca starch (5 %)	2.75	2.75	2.75	2.87	2.91	2.89	3.18	3.23	3.21	3.36	3.44	3.40
C_6 : Cinnamon oil (0.02)	2.75	2.80	2.78	2.87	2.89	2.88	3.14	3.23	3.18	3.41	3.46	3.43
C_7 : Chitosan (0.5 %)	2.70	2.75	2.73	2.85	2.85	2.85	3.13	3.06	3.09	3.35	3.41	3.38
C_8 : Acacia gum (5 %)	2.70	2.75	2.73	2.85	2.88	2.87	3.11	3.20	3.16	3.40	3.43	3.42
C_9 : Pectin (2 %)	2.73	2.78	2.75	2.86	2.89	2.88	3.17	3.21	3.19	3.42	3.47	3.44
SEm. (±)	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
CD at 1 %	NS	NS	NS	NS	NS	NS	0.05	0.05	0.05	0.04	0.05	0.04
B. Packaging materials												
P_1 : CFB box	2.72	2.77	2.75	2.85	2.88	2.87	3.14	3.19	3.17	3.40	3.45	3.42
P_2 : Plastic crates	2.69	2.76	2.73	2.86	2.91	2.88	3.15	3.18	3.17	3.40	3.44	3.42
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	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. Interaction (A x B)												
$C_1 P_1$	2.75	2.75	2.75	2.90	2.96	2.93	3.17	3.28	3.22	3.47	3.48	3.48
$C_1 P_2$	2.65	2.75	2.70	2.91	2.98	2.95	3.23	3.26	3.24	3.46	3.54	3.50
$C_2 P_1$	2.65	2.75	2.70	2.83	2.86	2.85	3.09	3.08	3.09	3.34	3.42	3.38
$C_2 P_2$	2.65	2.75	2.70	2.83	2.89	2.86	3.12	3.08	3.10	3.37	3.43	3.40
$C_3 P_1$	2.70	2.80	2.75	2.83	2.88	2.85	3.15	3.21	3.18	3.40	3.46	3.43
$C_3 P_2$	2.70	2.80	2.75	2.84	2.91	2.87	3.15	3.20	3.18	3.41	3.43	3.42
$C_4 P_1$	2.70	2.75	2.73	2.84	2.90	2.87	3.16	3.21	3.19	3.42	3.47	3.45
$C_4 P_2$	2.70	2.75	2.73	2.84	2.88	2.86	3.14	3.22	3.18	3.47	3.45	3.46
$C_5 P_1$	2.75	2.75	2.75	2.85	2.89	2.87	3.17	3.25	3.21	3.36	3.46	3.41
$C_5 P_2$	2.75	2.75	2.75	2.88	2.93	2.91	3.20	3.22	3.21	3.37	3.42	3.39
$C_6 P_1$	2.75	2.80	2.78	2.88	2.87	2.88	3.14	3.21	3.17	3.41	3.46	3.44
$C_6 P_2$	2.75	2.80	2.78	2.86	2.90	2.88	3.14	3.24	3.19	3.40	3.46	3.43
$C_7 P_1$	2.75	2.80	2.78	2.85	2.81	2.83	3.13	3.06	3.10	3.33	3.40	3.36
$C_7 P_2$	2.65	2.70	2.68	2.85	2.89	2.87	3.12	3.06	3.09	3.38	3.43	3.40
$C_8 P_1$	2.70	2.75	2.73	2.85	2.87	2.86	3.13	3.21	3.17	3.43	3.45	3.44
$C_8 P_2$	2.70	2.75	2.73	2.85	2.90	2.87	3.10	3.20	3.15	3.37	3.42	3.40
$C_9 P_1$	2.75	2.80	2.78	2.85	2.88	2.86	3.15	3.22	3.18	3.41	3.50	3.46
$C_9 P_2$	2.70	2.75	2.73	2.88	2.90	2.89	3.19	3.20	3.19	3.43	3.44	3.43
SEm. (±)	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 25 contd….

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 : Without coating	3.74	3.70	3.72	3.96	3.93	3.94	4.26	4.29	4.27	-	-	-
C_2 : Alginate (2 %)	3.46	3.52	3.49	3.59	3.65	3.62	3.71	3.75	3.73	4.04	4.13	4.08
C_3 : Beewax (2 %)	3.53	3.51	3.52	3.64	3.70	3.67	3.84	3.90	3.87	4.04	4.05	4.04
C_4 : Aloe vera gel (75 %)	3.55	3.62	3.58	3.68	3.69	3.69	3.87	3.97	3.92	4.13	4.18	4.16
C_5 : Tapioca starch (5 %)	3.60	3.64	3.62	3.74	3.76	3.75	3.88	3.88	3.88	4.09	4.19	4.14
C_6 : Cinnamon oil (0.02)	3.60	3.64	3.62	3.75	3.78	3.77	4.12	4.17	4.14	-	-	-
C_7 : Chitosan (0.5 %)	3.41	3.50	3.45	3.64	3.66	3.65	3.68	3.74	3.71	4.01	3.85	3.93
C_8 : Acacia gum (5 %)	3.50	3.53	3.51	3.67	3.73	3.70	3.81	3.85	3.83	4.19	4.18	4.18
C_9 : Pectin (2 %)	3.52	3.57	3.54	3.64	3.74	3.69	4.11	4.13	4.12	4.45	4.33	4.39
SEm. (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01
CD at 1 %	0.06	0.05	0.05	0.06	0.05	0.05	0.05	0.07	0.06	0.04	0.06	0.05
B. Packaging materials												
P_1 : CFB box	3.54	3.58	3.56	3.70	3.74	3.72	3.92	3.95	3.93	4.12	4.10	4.11
P_2 : Plastic crates	3.55	3.58	3.57	3.70	3.73	3.72	3.92	3.98	3.95	4.15	4.15	4.15
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	NS	NS	NS	NS	NS	NS	0.02	0.03	0.03
C. Interaction (A x B)												
$C_1 P_1$	3.79	3.75	3.77	3.92	3.90	3.91	4.29	4.33	4.31	-	-	-
$C_1 P_2$	3.70	3.66	3.68	4.00	3.95	3.98	4.23	4.25	4.24	-	-	-
$C_2 P_1$	3.45	3.50	3.48	3.57	3.63	3.60	3.70	3.75	3.73	4.06	4.11	4.08
$C_2 P_2$	3.47	3.53	3.50	3.60	3.67	3.64	3.71	3.76	3.73	4.02	4.15	4.08
$C_3 P_1$	3.54	3.49	3.52	3.65	3.70	3.68	3.88	3.86	3.87	4.00	4.05	4.03
$C_3 P_2$	3.52	3.52	3.52	3.62	3.69	3.66	3.80	3.94	3.87	4.08	4.04	4.06
$C_4 P_1$	3.55	3.63	3.59	3.69	3.71	3.70	3.88	3.95	3.92	4.11	4.15	4.13
$C_4 P_2$	3.54	3.61	3.58	3.67	3.67	3.67	3.86	3.98	3.92	4.15	4.22	4.18
$C_5 P_1$	3.61	3.64	3.62	3.70	3.76	3.73	3.87	3.82	3.84	4.13	4.18	4.16
$C_5 P_2$	3.59	3.64	3.62	3.78	3.75	3.77	3.88	3.95	3.92	4.05	4.21	4.13
$C_6 P_1$	3.58	3.64	3.61	3.73	3.84	3.79	4.09	4.15	4.12	-	-	-
$C_6 P_2$	3.61	3.64	3.63	3.77	3.72	3.75	4.15	4.19	4.17	-	-	-
$C_7 P_1$	3.41	3.50	3.45	3.64	3.68	3.66	3.66	3.72	3.69	3.98	3.80	3.89
$C_7 P_2$	3.41	3.49	3.45	3.64	3.64	3.64	3.70	3.76	3.73	4.03	3.90	3.97
$C_8 P_1$	3.40	3.54	3.47	3.66	3.70	3.68	3.79	3.86	3.82	4.15	4.15	4.15
$C_8 P_2$	3.59	3.52	3.55	3.67	3.75	3.71	3.83	3.85	3.84	4.23	4.20	4.21
$C_9 P_1$	3.51	3.52	3.51	3.70	3.76	3.73	4.10	4.13	4.12	4.43	4.30	4.36
$C_9 P_2$	3.53	3.62	3.58	3.59	3.73	3.66	4.12	4.14	4.13	4.47	4.35	4.41
SEm. (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD at 1 %	0.08	0.07	0.07	0.08	0.07	0.07	0.07	NS	NS	0.06	NS	NS

Packaging materials showed non-significant difference during storage except at 28th day of storage. Rate of increase in pH was slow in P_1 as compared to P_2. Highest pH recorded by P_1 and P_2 was 4.11 and 4.15 at 28th day respectively.

The interaction effect of different coatings and packaging materials during storage on fruit pH was non-significant during storage except at 28th day of storage. The data presented in the Table 25 showed that pH of the fruits in the data shows increasing trend up to 28th day of storage.

Medlicott and Thompson (1985) reported the tendency of increasing pH values and reduced acidity with prolonged storage time since the fruit with proceeding of the ripening process is going to diminish its predominant malic acid.

Comparing ambient storage (AT) to cold storage (CS), it was shown that the rate of pH rise of mango was quicker in AT storage than cold storage (CS). This could be because prolonged storage of mango fruit at high humidity and low temperature in cold storage, resulted in higher retention of acidity and lower values of pH in all treatments, while and low humidity and high temperature at AT storage caused organic acids to leak from the vacuole and recorded corresponding decrease in acidity (degradation of organic acids) during ripening of fruits. In actuality, this is because organic acids were used up more quickly, leading to greater temperatures and increased respiration, which raised pH and lowered acidity. The same results were reported by Gole (1986) at AT and CS.

4.3 Overall acceptability of mango fruits

Effect of different coatings and packaging materials on sensory attributes of mango cv. Kesar is presented in Table 26 (AT) and 27 (CS). Overall acceptability was stated as the average of all sensory characteristics, such as fruit appearance and colour, flavour, texture, and taste. A score of 5.5 or higher was rated as acceptable for mango fruit. In general overall acceptability score was increased from fruit ripening storage day and showed slight decrease at the end of shelf life.

At the first day, the fruit was considered unacceptable by the average overall acceptability score for all treatments, which was 4.0. On the 8th day after storage, fruit in all interactions with ambient temperature obtained acceptable scores. On the 16th day after storage, mango cv. Kesar organoleptic score was shown to be at its highest in C_7P_1 (7.52) follwed by C_3P_1 (7.25) and C_7P_2 (7.22) at AT. After 12 days of preservation, the treatment C_1P_2 (5.81) had the lowest sensory score.

On first day, the overall acceptability score for all treatments was on average 4.0, indicating that the fruit was not acceptable. The 16th storage day, fruit in all interactions under CS received satisfactory scores. The 28th storage day, mango cv. Kesar organoleptic grade was shown to be at its highest in C_7P_1 (7.45), then C_3P_1 (7.25), C_7P_2 (7.20) treatment. The 24th storage day, the lowest sensory score (5.53) was observed in C_1P_2 (without coating + plastic carets) treatment.

Nadeem *et al.* (2009) found chitosan as the best edible covering materials that is highly successful in enhancing the general quality parameters of mango fruits.

Table 26. Effect of edible coatings and packaging materials on overall acceptability of mango fruit cv. Kesar during storage at AT

Treatment	8 DAS			10 DAS			12 DAS			14 DAS			16 DAS		
	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean	2019	2020	Pooled mean
$C_1 P_1$	8.34	8.76	8.55	7.50	8.60	8.05	6.49	6.55	6.52	-	-	-	-	-	-
$C_1 P_2$	8.54	8.75	8.64	6.50	8.55	7.52	5.49	6.14	5.81	-	-	-	-	-	-
$C_2 P_1$	6.20	6.30	6.25	6.50	6.56	6.53	8.18	8.12	8.15	7.60	7.80	7.70	6.81	5.73	6.27
$C_2 P_2$	6.15	6.14	6.14	6.45	6.59	6.52	8.16	8.11	8.13	7.55	7.65	7.60	6.71	5.6	6.15
$C_3 P_1$	6.30	6.37	6.33	7.70	7.88	7.79	8.82	8.54	8.68	7.64	7.30	7.47	7.30	7.30	7.25
$C_3 P_2$	6.35	6.23	6.29	7.60	7.88	7.74	8.79	8.53	8.66	7.50	7.30	7.40	6.90	7.10	7.00
$C_4 P_1$	6.40	7.32	6.86	8.50	8.56	8.53	8.93	8.82	8.87	6.57	5.50	6.03	5.70	-	5.70
$C_4 P_2$	6.42	7.2	6.81	8.50	8.56	8.53	8.95	7.18	8.06	5.46	5.40	5.43	-	-	-
$C_5 P_1$	6.44	7.35	6.89	8.45	7.56	8.00	8.85	7.10	7.975	6.80	6.70	6.75	-	-	-
$C_5 P_2$	6.45	7.34	6.89	8.45	8.56	8.50	7.10	7.52	7.31	5.45	6.60	6.02	-	-	-
$C_6 P_1$	6.47	7.37	6.92	8.65	8.56	8.60	7.70	7.28	7.49	6.50	5.50	6.00	-	-	-
$C_6 P_2$	6.45	7.40	6.92	8.45	8.56	8.50	7.10	7.12	7.11	5.60	5.40	5.50	-	-	-
$C_7 P_1$	6.06	7.07	6.56	6.50	7.10	6.8	8.16	8.14	8.15	8.10	7.60	8.85	7.64	7.40	7.52
$C_7 P_2$	6.08	7.11	6.59	6.45	7.10	6.77	8.14	8.14	8.14	8.00	7.60	8.80	7.25	7.20	7.22
$C_8 P_1$	6.09	7.32	6.70	8.45	7.88	8.16	8.71	8.69	8.7	7.10	6.70	6.90	5.63	5.60	5.61
$C_8 P_2$	6.13	7.37	6.75	8.45	7.80	8.12	8.71	8.54	8.62	7.00	6.45	6.72	5.40	5.55	5.47
$C_9 P_1$	6.20	7.32	6.76	7.75	8.75	8.25	8.81	8.55	8.68	6.80	6.65	6.72	5.70	-	5.70
$C_9 P_2$	6.17	7.34	6.75	7.56	8.65	8.10	8.84	8.48	8.66	6.80	6.60	6.70	5.60	-	5.60

Table 27. Effect of edible coatings and packaging materials on overall acceptability of mango fruit cv. Kesar during storage in CS

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
C_1 P_1	7.50	8.18	7.84	6.97	7.47	7.22	5.50	6.51	6.01	-	-	-
C_1 P_2	7.48	8.10	7.79	6.85	6.49	6.67	5.50	5.56	5.53	-	-	-
C_2 P_1	6.00	7.41	6.71	8.24	8.56	8.40	7.41	7.69	7.55	6.86	6.8	6.83
C_2 P_2	6.03	7.01	6.52	8.12	8.58	8.35	7.46	7.46	7.46	6.75	6.75	6.75
C_3 P_1	7.23	8.44	7.84	8.38	8.54	8.46	8.41	8.52	8.47	7.20	7.30	7.25
C_3 P_2	7.12	8.90	8.01	8.37	8.50	8.44	8.45	7.72	8.09	6.80	6.90	6.85
C_4 P_1	7.85	7.29	7.57	8.43	8.57	8.50	7.20	6.56	6.88	6.56	-	6.56
C_4 P_2	7.09	7.50	7.30	8.42	8.55	8.49	6.50	6.48	6.49	-	-	-
C_5 P_1	6.03	7.49	6.76	8.31	8.40	8.36	7.47	6.54	7.00	6.50	-	6.50
C_5 P_2	6.50	8.53	7.52	8.68	8.68	8.68	7.00	6.83	6.92	6.40	-	6.40
C_6 P_1	7.23	8.20	7.72	8.32	7.44	7.88	6.70	5.90	6.30	-	-	-
C_6 P_2	8.25	8.10	8.18	6.35	7.47	6.91	6.25	5.80	6.03	-	-	-
C_7 P_1	6.32	7.55	6.94	8.60	8.60	8.60	8.33	7.85	8.09	7.30	7.60	7.45
C_7 P_2	6.26	7.70	6.98	8.50	8.49	8.50	8.29	7.89	8.09	7.20	7.20	7.20
C_8 P_1	7.23	8.35	7.79	8.50	8.30	8.40	7.28	7.43	7.36	6.42	6.22	6.32
C_8 P_2	7.28	8.37	7.83	8.40	8.40	8.40	6.50	6.90	6.70	-	-	-
C_9 P_1	8.43	7.55	7.99	7.32	8.35	7.84	6.18	6.70	6.44	-	-	-
C_9 P_2	8.37	8.18	8.28	7.18	8.53	7.86	6.16	6.40	6.28	-	-	-

5. SUMMARY AND CONCLUSION

The current investigation, which is "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).

5.1 Effect of different edible coatings and packaging materials on physio-chemical composition of mango fruit during storage

During storage, fruit coated with chitosan 0.5% recorded maximum shelf life but with respect to the physical parameters like PLW and firmness the treatment and beeswax 2% recorded desirable values under both (ambient temperature and cold storage) storage conditions.

Throughout the storage time, the mango fruit's physiological weight loss grew. Under ambient temperature, fruit coated with 2% beeswax and packed in CFB boxes showed lowest PLW. Under cold storage fruit coated with beeswax 2% and chitosan 0.5% and packed in CFB box (C_7P_1, C_3P_1) recorded minimum weight loss in cold storage.

Fruit firmness declined over the period of storage. Under ambient temperature and cold storage, fruit coated with beeswax 2% and chitosan 0.5% and packed in CFB box (C_7P_1 and C_3P_1) resulted higher firmness.

With longer periods of storage, mango fruit spoiled more quickly. Under ambient and cold storage, fruit started to go spoil on days 8 and 20 respectively. Maximum spoilage was observed in fruit stored at ambient temperature as compared to cold stored fruit. Fruit coated with chitosan 0.5% and packed CFB box (C_7P_1) recorded minimum spoilage under both storage conditions.

At ambient condition maximum shelf life of 16th days was recorded in fruit coated with beeswax 2% and chitosan 0.5% and packed in CFB box (C_3P_1 and C_7P_1) recorded. While, in cold storage condition same treatment combination of edible coatings and packaging material revealed maximum shelf life of 28 days. Fruit in C_1P_2 treatment, recorded shelf life of 12 and 20 days at ambient temperature and in cold storage respectively.

Quality parameters viz., TSS, reducing sugars, total sugar, β-carotene and pH indicated increasing trend acidity and ascorbic acid decreasing trend. Ambient condition exhibited rapid changes in values of these quality parameters. Fruit treated with chitosan 0.5 % and packed in CFB box (C_7P_1) recorded minimum changes in TSS, total sugars, non-reducing sugars, reducing sugars, titratble acidity, ascorbic acids β-carotene and pH under both storage conditions.

Conclusion

From the experiment to investigate the impact of edible coatings and packaging materials on the quality of mango cv. Kesar and the extension of the shelf life of mango fruit, it can be deduced that storage conditions, edible coatings, and packaging materials all enhance the shelf-life and quality of mango fruit.

Among all coating treatment chitosan (0.5%) coated mango fruit packed in CFB box was recorded higher shelf life up to 16^{th} days at ambient temperature and 28^{th} days in cold storage with better physical and chemical parameters.

Among all coating treatment beeswax (2%) coated mango fruit packed in CFB box was recorded higher shelf life up to 16^{th} days at ambient temperature and 28^{th} days in cold storage with better physical parameters.

Edible coatings by using organic resources like polysaccharides, starch, wax, oil, aloe vera, lipids etc. provide additional benefit to shelf-life of the fruit, as compare to uncoated mango fruits.

All of the edibale coated fruits showed significantly less PLW per cent and delayed ripening changes in mango fruit shrivelling and ripening characteristics such TSS, acidity, sugars (reducing sugars and non reducing sugar) ascorbic acid concetration, β-carotene, pH, fruit firmness, and spoilage.

Coatings and Packagings had significant interaction effects on the shelf-life and physiological and chemical qualities of Kesar mango fruits at ambient temperature and in cold storage. From this investigation, it could be stated that CFB boxes are a superior substitute for plastic crates.

Over all, packaging combined with coatings maintained the freshness of mango fruits. CFB box packaging with coatings were more effective compared to plastic crates and Overall, mango fruits scored significantly higher for acceptability.

According to the study that has been given, edible coating technology is both necessary and eco-friendly in the modern world. The permissible limits of edible coatings have been authorised and recommended by several regulatory authorities for food and food safety as well as medication administrations. The benefit of utilising an edible coating to store fruit is that it may be simply implemented using inexpensive local raw ingredients.

6. LITERATURE CITED

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7. VITAE

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DOCTOR OF PHILOSOPHY (HORTICULTURE)

in

FRUIT SCIENCE

2023

Title of thesis		:	**"Effect of edible coatings and packaging materials on shelf life and quality of mango (*Mangifera indica* L.) cv Kesar"**
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Plate 1. Postharvest treatment of Kesar mango fruit

1. **Mango fruit harvesting.**
2. **Green mature fruits of uniform size and shape were selected.**
3. **Fruits were washed with flowing tap water.**
4. **Mango air dried in laboratory**

Plate 2. Fruit packed in the packaging material (P_1– Corrugated fiberboard boxP_2- Plastic crates) andstored in the laboratory at Ambient temperature and in Cold storage

Plate 3: Application of edible coatings onKesar mango fruit

Plate 4: Effect of edible coatings and packaging materials on Kesar mango At Ambient temperature (After 12th day)

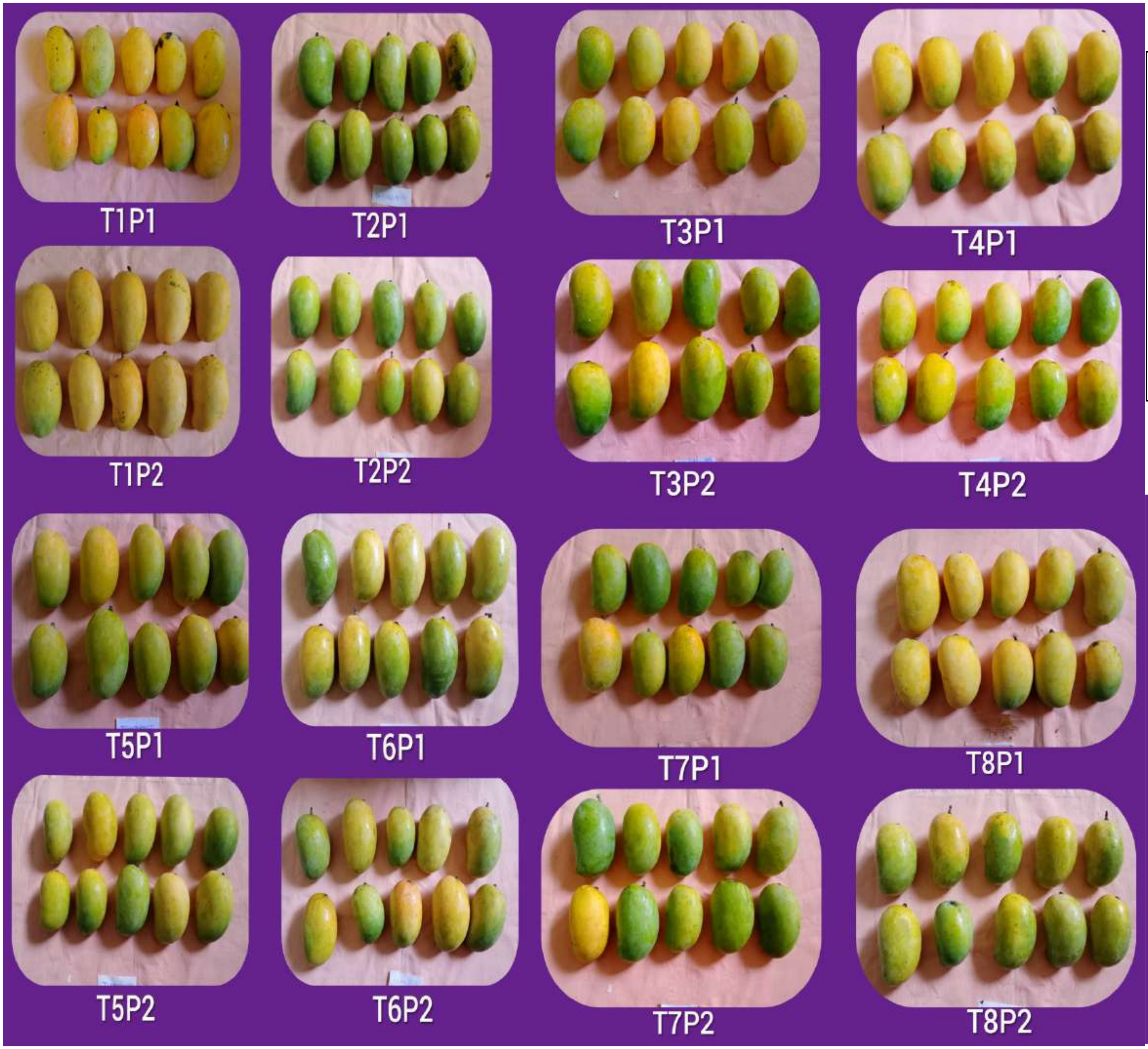

Plate 5:Effect of ediblecoatings and packagingmaterialsonKesarmango in cold storage (After 20th day)