Journal of Applied Horticulture, 21(3), 223-230, 2019
DOI: https://doi.org/10.37855/jah.2019.v21i03.39
Journal of Applied Horticulture
ISSN: 0972-1045

Shelf life enhancement of fresh pears using tulsi (*Ocimum sanctum*) herbal edible coatings

Mitu Saini* and Pramod K. Raghav

*Department of Food and Biotechnology, Faculty of Agriculture and Veterinary Science, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India. *E-mail: mitusaini18@gmail.com*

Abstract

The present research was conducted to extend the shelf life of fresh pears by using beeswax and cornstarch herbal edible coatings. The coatings were prepared from cornstarch and beeswax by incorporation of aqueous Tulsi (*Ocimum sanctum*) extract. Cornstarch and beeswax have good moisture and gas barrier properties while Tulsi (*O. sanctum*) extract acted as an antimicrobial agent in this coating therefore herbal edible coated fruits have a longer shelf life as compared to uncoated fruits. Coated and uncoated fruits were stored at ambient temperature (31 ± 2 °C and 70 ± 8% RH) and low temperature (4 °C). Pears were analyzed for the quality parameters such as weight loss, firmness, TSS, titratable acidity, pH and sensory evaluation. The weight loss and firmness of coated fruits were less as compared to uncoated fruits. Beeswax herbal edible coating gave the best results in pear storage as compared to cornstarch herbal edible coating. On the other hand Cornstarch herbal edible coating also gave good results as compared to uncoated fruits, it enhanced the shelf life of pears for 45 days at ambient temperature and 60 days at low temperature (4^oC), in case of beeswax herbal edible coating it increased the storage life of pears for 45 days at ambient temperature and 70 days at low temperature (4^oC). Sensory evaluation of coated fruits such as color, texture, overall acceptability was better for both conditions as compared to uncoated. Therefore, it is concluded that the herbal edible coatings have the potential to extend the shelf life.

Key words: Pears, shelf life, quality parameters, herbal edible coating, *Ocimum sanctum* and Tulsi extract.

Introduction

Fruits and vegetables are the major source of carbohydrates, vitamins, dietary fibre, minerals, antioxidants and phytochemicals in the human diet and a trace amount of other important nutrients such as proteins and fat (Kumari *et al.*, 2016; Slavin and Lloyd, 2012). The ICMR (Indian Council of Medical Research) has recommended that every individual should consume at least 100 g fruits daily (National Institute of Nutrition, 2010).

Pears are a good source of nutrients and health promoting bioactive compounds such as carotenoids (flavonols, anthocyanins, kaemferol and isorhamnetin) and phenolic compounds (Andreotti *et al.*, 2006; Salta *et al.*, 2010). Pear (*Pyrus pyrifolia* var. Gola) is a climacteric fruits, in which the major negative changes are the results of maturation. In the ripening process, some changes are observed in color, firmness, acidity, sugar content, and aroma development (Alpalhao *et al.,* 2006). These nutritional properties of the fresh commodity increase the demand for fresh fruits and vegetables in the market.

Edible coatings have great potential for enhancing food quality and safety. Therefore there is a growing interest in the use of degradable coatings from polysaccharide, protein, and lipid biopolymers. Edible coatings are thin layers of material applied to the surface of the fruit and vegetable as an addition to or replacement for the natural protective waxy coating. Traditionally, edible coatings have been used to reduce water loss, but the recent development of formulated edible coatings with a wider range of permeability characteristics has extended the potential application to fresh produce.

Recent studies have reported the prolonged shelf life of pears using edible coatings that are used to improve the handling characteristics of the fruits and vegetables by slowing changes in oxygen, aromas, moisture and solute transport (Silva *et al.,* 2012; Kou *et al.,* 2014). The function of the edible coating can be improved by including herbs such as neem, mint, aloe vera, tulsi, basil, mentha, which act as antioxidants, antimicrobials, colorants, flavors, fortifying nutrients, and spices in edible coating formulation (Pranoto *et al.,* 2005).

The present investigation was undertaken for to study the effect of herbal coatings on shelf life and quality parameters of pear fruits.

Material and methods

The fruits were picked at green mature stage from Haridwar, Uttarakhand and transported to the Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan. Fresh, mature and clea fruits with uniform shape and size were selected. Fruts were washed with water for 5-7 min and air dried at ambient temperature before applying the herbal edible coating.

Preparation of tulsi (*Ocimum sanctum*) aqueous extract: The aqueous tulsi leaves extract (TLE) was prepared by using Soxhlet apparatus at 78 °C, distilled water used as a solvent. The tulsi leaves extract was evaporated and air dried at ambient temperature.

Herbal edible coating preparation: The herbal edible coatings were prepared from tulsi leaves extract (TLE), cornstarch and beeswax. For coating preparation, cornstarch and beeswax were used as a base material in the herbal edible coating.

Cornstarch herbal edible coating solution was prepared by dissolving 2.5 % (w/v) cornstarch and 1.5 g dried tulsi leaves extract (Aq.) in distilled water, agitated for 15 minutes at 90 ºC. The pH was adjusted to 5.6 with 50 % (w/v) citric acid solution. Glycerol was added as a plasticizer (2 mL/L solution).

The beeswax herbal edible coating was prepared by the beeswax (6 g), soy lecithin (10 g) added as an emulsifying agent and aqueous tulsi leaves extract (1.5 g). Beeswax was melted at 55-60 °C and mixed with aqueous tulsi leaves extract and 10% soy lecithin solution for 15-20 min with continuous stirring and cooled at ambient temperature.

Treatments details are as follows: T_1: Uncoated pear at ambient temperature (31±2 °C). T_2: Cornstarch (CS) herbal edible coated pear at ambient temperature (31±2 °C). T_3: Beeswax (BW) herbal edible coated pear at ambient temperature (31±2 °C). T_4: Uncoated pear (control) at low temperature (4 °C). T_5: Cornstarch herbal edible coated pear at low temperature (4 °C). T_6: Beeswax herbal edible coated pear at low temperature (4 °C). Each treatment consisted of ten fruits.

Application of herbal edible coating: The herbal edible coating was applied on pears by spraying method and then the residual coating solution was allowed to drip off for a minute. When the pears got dried completely after coating, they were stored at ambient temperature (31±2 °C) and low temperature (4 °C) for physiochemical analysis at different inervals.

Physical appearance changes: Appearance changes were photographically recorded with a digital camera (Nikon with 16.0 megapixels with 6x zoom). All photographs were taken at the same angle and distance.

Weight loss: Pears weight loss was determined by weighing the uncoated and coated materials every 10th day throughout the storage period. Results were expressed as the percentage weight loss (AOAC, 2000). Analyses were conducted in triplicate.

$$\text{Weight loss (\%)} = \frac{Wi - Wf}{Wi} \times 100$$

Where, *Wi* is Initial weight of the sample and *Wf* is Final weight of the sample.

Firmness: Fruit firmness was measured by using fruit penetrometer (WAGNER, FT-5/14) with a probe tip (1 cm diameter). Firmness was measured in “kgf” (AOAC, 2000) on each sampling date.

Total soluble solids (TSS): Total soluble solid (TSS) was determined by the method explained in AOAC (2000). The TSS was analyzed by using of Hand Refractometer (ERMA, Japan) in °Brix. Freshly prepared pear juice was used for analysis.

pH: Pear juice was freshly prepared. The pear juice was homogenized and then filtered for pH analysis. pH was determined by using digital pH meter (Ranganna, 2003).

Titratable acidity (TA): TA was determined by titration of 5 mL pear juice diluted with 25 mL distilled water to pH 8.2 with 0.1 N NaOH. Phenolphthalein used as an indicator and result expressed as percentage of malic acid.

$$\text{TA (\%)} \frac{\text{NaOH used (mL) x miliequivalent factor}}{\text{Sample (mL)}} \times 100$$

Sensory evaluation: The sensory evaluation was performed by using 9 point Hedonic scale, by semi-trained panel members having 10 or 12 panel members. The panel members were provided a 9 point hedonic scale questionnaire to test appearance/color, taste, texture, flavor, after taste and overall acceptability of coated pear and control. They were scored on a scale of 1-9 (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much and 9= like extremely).

Statistical Analysis: The ANOVA test (P<0.05) was performed for the statistical analyses of the data using SPSS software version 16.0.

Results and discussion

Physical appearance changes: The changes in physical appearance of fruit as influenced by storage time and herbal edible coating treatment are shown in Figs. 1 and 2. Generally, cornstarch and beeswax based herbal edible coating resulted in better appearance as compared to uncoated pear stored at both temperature *i.e.* 31±2 °C and 4 °C. There was a dull or yellowish appearance in uncoated pear on 15th day at ambient temperature (31±2 °C) but in another study was observed that the peel color of uncoated pear remained dark green in 6 days of storage at ambient temperature while the coated pear was found yellowish on 12th day (Mohamed and Shaaban, 2014). On the other hand the uncoated pear stored at low temperature (4 °C) could retain acceptable appearance until 45th day but surface of uncoated pear was dull and shrinked as compared to herbal edible coated pear. Hence the herbal edible coating influenced and maintained the appearance and color of pears at low temperature (4 °C) and at ambient temperature (31±2 °C) also.

All fruits exhibited changes in their physical appearance, but the fruits coated with cornstarch and beeswax herbal edible coating (T_2 and T_3) suffered minor changes compared to uncoated fruits (T_1) at ambient temperature (31±2 °C). In case of low temperature stored herbal edible coated fruits (T_5 and T_6) showed minimum changes as compared to uncoated fruits at low temperature (4 °C).

The use of edible coatings considerably reduces apparent changes in fruits like apples (Ochoa *et al.,* 2011), pears (Zhou *et al.,* 2011; Zhou *et al.*, 2008), papaya and strawberries (Telles-Pichardo *et al.*, 2013). These changes can be due to the modified atmosphere created in fruit, with high levels of CO_2 and low levels of O_2, slowing the maturation processes (Gonzales-Aguilar *et al.,* 2005).

Weight loss (%): There was a significant difference (P<0.05) in the weight loss of herbal edible coated and uncoated fruits during storage period at both temperature *i.e.* 31±2 °C and 4 °C. The weight loss increased in all the coated and uncoated fruits with the progress of storage time. On 15th day, minimum weight loss was found in coated samples with cornstarch and beeswax T_2, T_5, T_3 and T_6 respectively (2.48, 1.47, 2.01 and 1.38%) while maximum weight loss was observed in uncoated fruits *i.e.* T_1 and T_4 (2.69% and 2.89%) at ambient temperature and low temperature (31±2 °C and 4 °C) as shown in Fig. 3. This study evaluated the coating concentration on the weight loss of pears and found that the pears treated with beeswax and cornstarch herbal edible coating showed the lowest losses in T_3 (12.81%), followed by T_2 (13.36%) and the uncoated fruits T_1 (21.02%) on 45th day of storage at ambient temperature (31±2 °C).

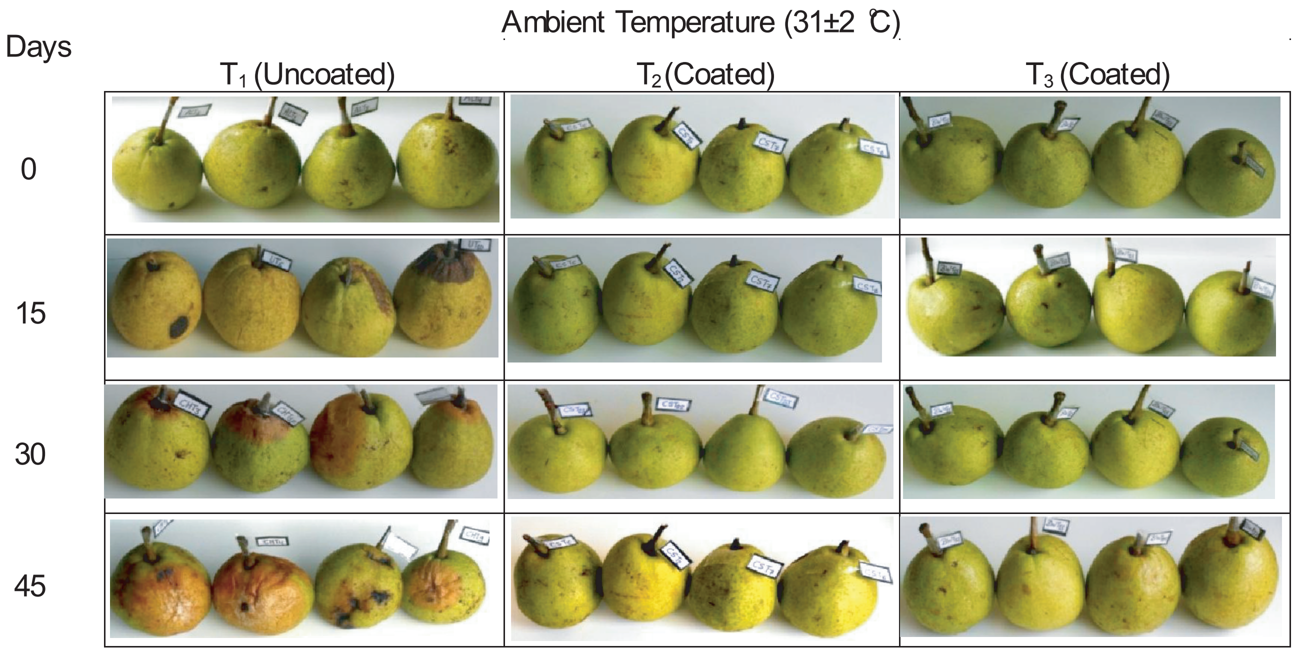

Fig 1. Physical appearance of coated and uncoated pears at ambient temperature (31±2 °C) during storage.

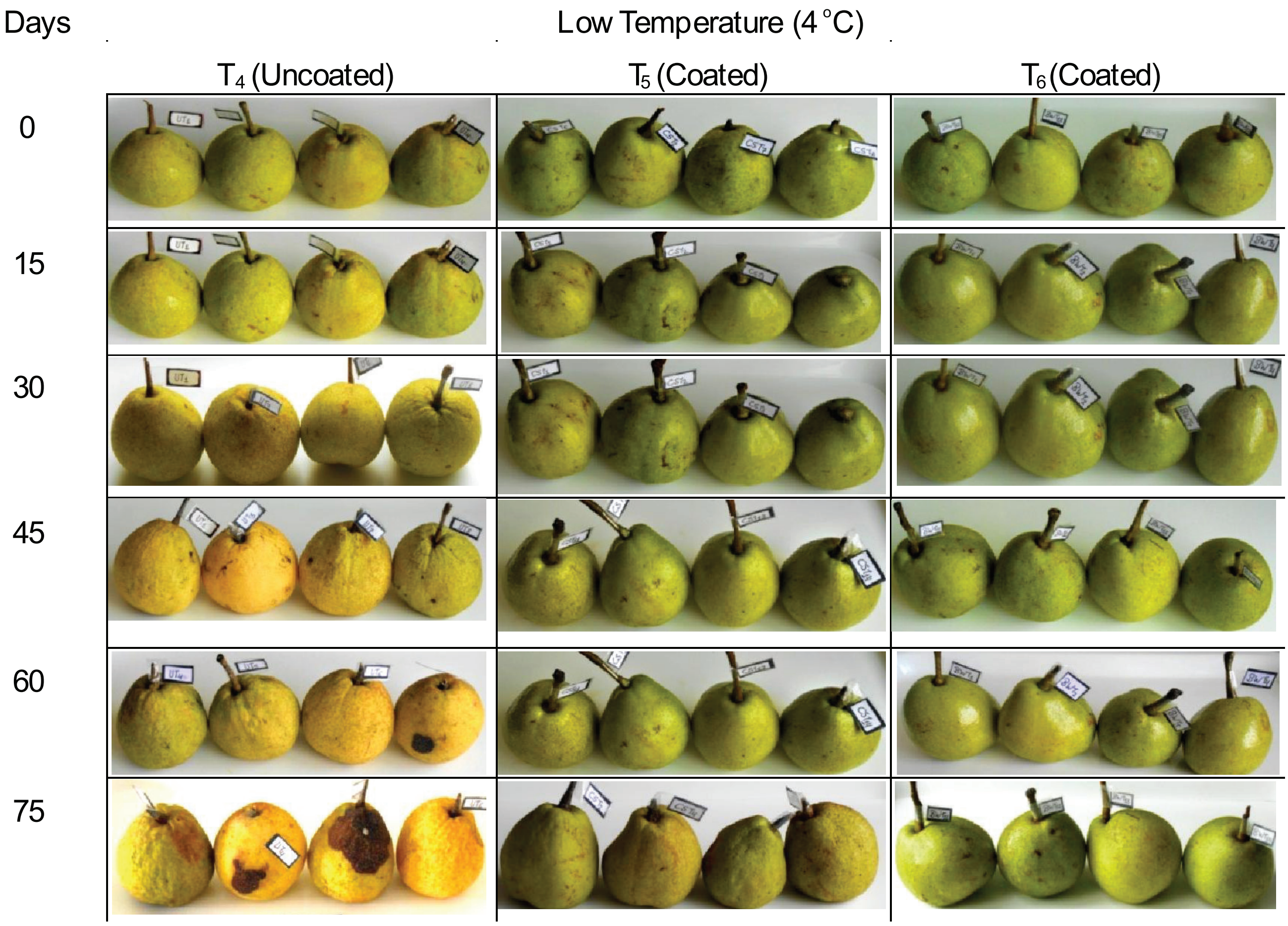

Fig 2. Physical appearance of coated and uncoated pears at low temperature (4 °C) during storage period.

On the other hand, similar trend of weight loss was found in coated fruits T_6 (13.05%), T_5 (15.85%) and T_4 (23.18%) on 70th day of storage at low temperature (4 °C). The weight loss of coated and uncoated fruits were statistically significant (P<0.05) during storage time. The weight loss percentage increased in coated and uncoated (control) pears as the storage time progressed. The weight loss in fresh fruits and vegetables is mainly caused by respiration and transpiration process (Zhu *et al.*, 2008). The wilting and shrivelling of fresh produce due to water loss decreases the commodity price in the market thus act as a limiting factor of marketability. Edible coatings decreases the rate of respiration and transpiration of fresh produce by formation of a semi-permeable membrane and this membrane act as a protective barrier against gases O_2, CO_2 and Ethylene (Dong *et al.,* 2004).

The minimum weight loss in coated pear with the cornstarch and beeswax based herbal edible coating at low (4 °C) and ambient temperature (31±2 °C) might be due the fact that the coatings serves as a good barrier against diffusion of moisture, O_2, CO_2 and solute movements, thereby reducing water loss and respiration rate (Sapper and Chiralt, 2018; Mahajan *et al*., 2018).

Firmness (kgf): The firmness of the uncoated (control) and coated pear was significantly not different (P>0.05) during storage at both temperatures *i.e.,* ambient and low temperature. Firmness decreased gradually with storage time at both temperatures. The firmness of uncoated pears reached 5.53 kgf (T_1) and 5.59 kgf (T_4) on 45th and 70th day at 31±2 °C and 4 °C. The coated fruits maintained initial firmness values. These results are similar to other researchers on "Huanghua" (Zhou *et al.*, 2008; Zhou *et al.*, 2011), "d'Anjou" (Xiao *et al.*, 2011) pears, and other fruits and vegetables such as papaya (Telles-Pichardo *et al.*, 2013) and cucumber (Raghav and Saini, 2018).

Pears with herbal edible coating had higher value of firmness [7.33 kgf (T_2), 6.57 kgf (T_3), 7.50 kgf (T_5) and 7.73 kgf (T_6)] during storage period on 45th day at ambient temperature (31±2 °C) and 70th day of storage period at low temperature (4 °C) as compared to uncoated fruits at same temperature and storage period as shown in Fig. 3. Thus firmness decreased gradually during storage period at the same temperature. The results indicated that the cornstarch and beeswax based herbal edible coating significantly retained the firmness of pear and acted as a barrier against water loss and nutrient. The cornstarch and beeswax based herbal edible coating maintained the maximum firmness of coated fruits until 45th and 70th day of storage at the ambient and low temperature (4 °C and 31±2 °C).

The previous research can explain of this phenomenon *i.e.*, as a consequence of disassembly of primary cell wall and middle lamella structures of fruits flesh could contribute to changes in fruit texture during storage (Yang *et al.,* 2007). In climacteric

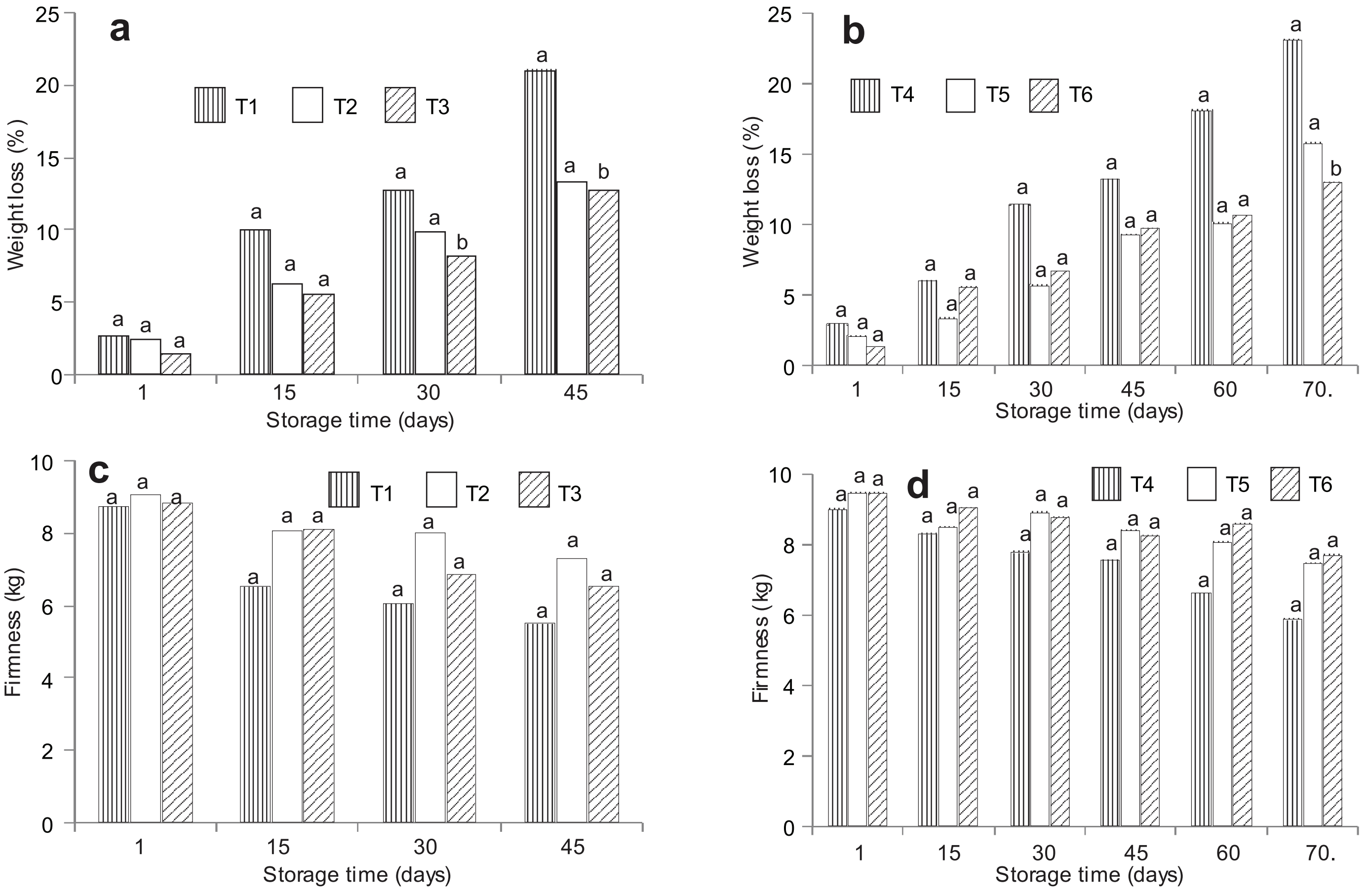

Fig. 3. Effect of herbal edible coating on Weight Loss (%) – (a) at ambient temperature (31±2 °C) and (b) at low temperature (4 °C); Firmness (kgf) – (c) at ambient temperature (31±2 °C) and (d) at low temperature (4 °C). Where, T_1 = Uncoated; T_2 = Coated with cornstarch herbal edible coating and T_3 = Coated with beeswax herbal edible coating at ambient temperature (AT). In low temperature (LT): T_4 = Uncoated; T_5 = Coated with cornstarch herbal edible coating and T_6 = Coated with beeswax herbal edible coating. Values are mean ± standard deviation. Means followed by the same letter are not significantly different at P < 0.05

fruits (pears), firmness during ripening generally attributed to degradation of the cell wall and loss of turgor pressure in the cells by water loss (Lin *et al.,* 2003). According to firmness data, mainly T_2 and T_3 at ambient temperature (31±2 °C) indicated that coating treatments maintain firmness. Similarly, coated pear fruits in T_5 and T_6 had less changes in firmness values at low temperature (4 °C) during storage. The process may be due to the inhibition of water loss and less activity of pectin-degrading enzymes closely related to fruit softening. This reduces the rate of metabolic processes during senescence (Zhou *et al.,* 2007). The herbal edible coating could be responsible for reduction in respiration rate and delaying the softening which resulted in retention of firmness during storage period.

pH: The herbal edible coated and uncoated pear juice was analyzed for their pH value regularly during storage period. The results revealed that the pears stored at ambient temperature demonstrated gradual increase in pH with the increase in storage time for herbal edible coated and control pears. There were no significant differences found between coated and uncoated fruits, although the corn starch, beeswax and tulsi extract based herbal

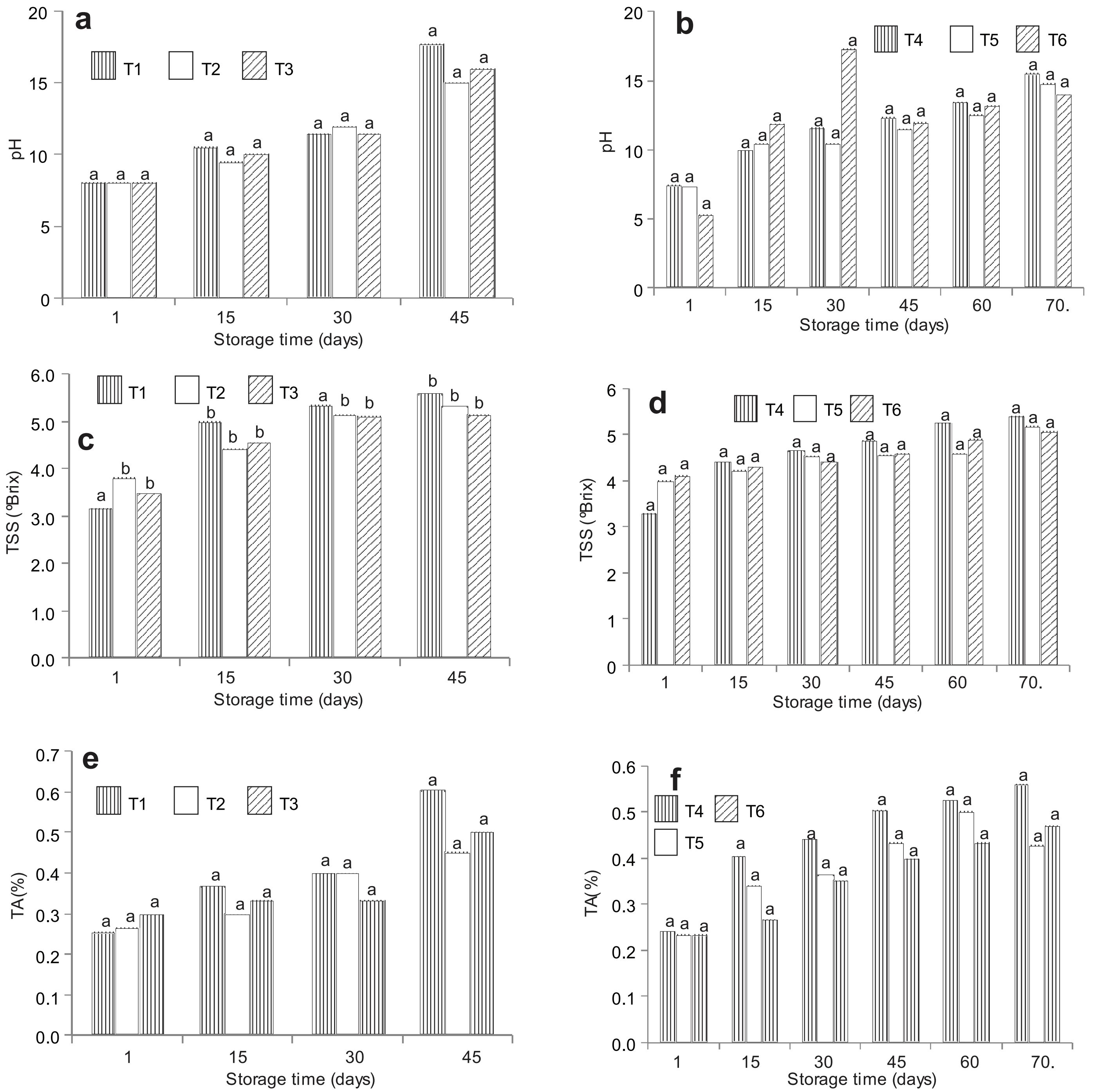

Fig. 4. Effect of herbal edible coating on pH – (a) at ambient temperature (31±2 °C) and (b) at low temperature (4 °C); TSS (ºBrix) – (c) at ambient temperature (31±2 °C) and (d) at low temperature (4 °C); TA (%) – (e) at ambient temperature (31±2 °C) and (f) at low temperature (4 °C) of pears during storage. Where, T_1 = Uncoated; T_2 = Coated with cornstarch herbal edible coating and T_3 = Coated with beeswax herbal edible coating at ambient temperature (AT). In low temperature (LT): T_4 = Uncoated; T_5 = Coated with cornstarch herbal edible coating and T_6 = Coated with beeswax herbal edible coating. Values are mean ± standard deviation. Means followed by the same letter are not significantly different at $P < 0.05$.

edible coating indicated higher pH at the end of 45th and 70th day of storage at ambient (31±2 °C) and low-temperature (4 °C).

Uncoated fruits showed an increase in pH greater than that of the coated samples, which indicates that the use of herbal edible coatings slows down changes in the pH of the pears. Comparing the herbal edible coatings used, beeswax indicated smaller changes in the pH. Hernandez-Munoz *et al.* (2008) observed that the organic acids provide most of the hydrogen ions contributing to lower pH in unripe fruits. An effective edible coating would retain lower pH in the fruit.

Nandane *et al.* (2017) reported that the pH seems to be influenced by the concentration of SPI (Soy Protein Isolate) and that of HPMC (Hydroxypropyl methylcellulose). According to his study the with the increased edible coating concentration the pH is lowered in pears. Moraes *et al.* (2012) found that the pH of control pears samples significantly increased (P<0.05) as compared to coated samples with alginate and carrageenan 0.5% during storage. Oluwaseun *et al.* (2013) found similar results in chitosan-*Aloe vera* coated cucumbers and cornstarch and carboxy-methyl cellulose coated cucumbers, respectively. Saha *et al.* (2016) also reported the similar result with guar based edible coating in cucumber decreased the pH as compared to uncoated cucumber. The pH decreased due to the edible coating forming a semi-permeable membrane on the surface of fruits and vegetables which modified the internal atmosphere *i.e.,* the endogenous CO_2 and O_2 concentration, thus retarding the ripening process. The reduction of pH can be attributed to the utilization of accumulated citric acid in the pear endocarp. General decrease has been observed in coated fruits as compared to uncoated fruits (control) where herbal edible coated in combination of corn starch, beeswax and mint extract.

Total soluble solids (ºBrix): The TSS for herbal edible coated fruits were 15.0 % (T_2), 16 % (T_3), 14.8 % (T_5) and 14.0 % (T_6) while the value for uncoated (control fruits) was 17.7 % (T_1) and 15.5 % (T_4). Fig. 4 indicated the TSS increased gradually throughout the storage time. However no significant differences (P> 0.05) were detected between all treatments. TSS increased with storage period at both temperatures. The same result was found in other research studies on pears where TSS increased during storage period (Nath *et al.*, 2012). In another study coatings and films significantly affected TSS (Mohamed and Shaaban, 2014). The TSS of coated and uncoated fruits stored under the ambient temperature increased at the end of the storage period. The increment of total soluble solids at the time of storage period

Table 1. Sensory evaluation of coated and uncoated pears after storage at 31±2 °C and 4 °C

Quality Attributes	Treatments	Storage time (day)					
		1st	15th	30th	45th	60th	75th
Appearance/ Color	T_1	8.1±0.54b	6.4±1.16a	5.1±0.92a	-	-	-
	T_2	8.4±0.43a	7.5±0.76a	6.8±074ab	6.4±0.89b	-	-
	T_3	8.6±0.38ab	7.7±0.75a	7.6±0.76a	5.4±0.89b	-	-
	T_4	8.2±0.71ab	8.4±0.48a	3.9±1.54a	6.5±0.80b	5.3±0.88b	-
	T_5	8.4±041a	8.8±0.32a	8.2±0.56ab	8.5±0.45b	7.2±0.57a	6.9±0.68a
	T_6	8.8±0.31a	8.7±0.47b	8.4±0.48a	7.6±0.76a	6.7±0.88a	6.5±0.8a
Texture	T_1	8.6±0.44a	8.3±0.36ab	6.5±0.80a	-	-	-
	T_2	8.5±0.62a	8.4±0.48a	7.2±0.93a	4.6±087a		-
	T_3	8.7±0.47b	8.6±0.44a	8.2±0.71b	5.2±1.31b	-	-
	T_4	8.7±0.34a	7.9±0.64a	6.2±0.88a	5.7±0.64a	-	-
	T_5	8.7±0.47b	8.9±0.21a	8.3±0.47a	8.4±041a	7.1±0.79b	6.5±0.80a
	T_6	8.9±0.29a	8.5±0.62a	8.5±0.62a	8.2±0.66b	7.2±0.73a	6.7±0.88a
Taste	T_1	8.5±0.62a	8.5±0.45a	3.9±1.54a	-	-	-
	T_2	8.7±0.47b	8.2±0.72a	7.3±0.88a	6.9±0.68a	-	-
	T_3	8.1±0.54ab	8.4±0.48a	7.7±0.74a	7.2±0.73a	-	-
	T_4	8.4±0.42b	7.3±0.65a	5.8±1.35a	4.6±087a	-	-
	T_5	8.7±0.34a	8.8±0.31a	8.1±0.62a	8.2±0.64a	7.3±0.72a	6.2±1.16a
	T_6	8.6±0.43ab	8.4±0.42b	8.1±0.49b	7.5±0.54a	6.5±0.80a	7.3±0.88a
After taste	T_1	8.4±0.48a	8.7±0.34a	4.6±087a	-	-	-
	T_2	8.7±0.47b	8.4±0.42b	7.3±0.88a	6.2±1.07a	-	-
	T_3	8.8±0.31a	8.6±0.43ab	8.4±0.46b	7.0±0.58ab	-	-
	T_4	8.5±0.62a	7.9±0.53a	6.2±1.16a	3.9±1.54a	-	-
	T_5	8.5±0.62a	8.1±0.49b	8.1±0.54ab	6.3±065a	5.5±0.80ab	3.9±1.54a
	T_6	8.9±0.29a	8.4±0.48a	7.9±0.64a	7.7±0.75a	6.2±0.88a	4.6±087a
Overall acceptability	T_1	8.8±0.14a	8.6±0.40a	8.5±0.48b	-	-	-
	T_2	8.4±0.15b	8.2±0.30b	7.0±0.65a	5.8±1.29ab	-	-
	T_3	8.5±0.21b	8.4±0.51a	7.7±0.75ab	7.1±0.53b	-	-
	T_4	8.3±0.23b	7.5±0.75b	6.0±0.60b	6.0±0.61a	-	-
	T_5	8.6±0.38ab	7.6±0.62a	8.1±0.59a	6.3±0.91a	6.5±0.80a	3.2±1.63b
	T_6	8.9±0.21a	8.5±0.62a	8.3±0.25b	7.02±0.24a	6.2±0.61ab	5.5±0.66b

Values with the same alphabet along the same row are not significantly different (P>0.05); uncoated (T_1 & T_4), coated (T_2, T_3, T_5 & T_6) pear; coated with herbal edible coating.

is natural as sugar the basic constituent of the TSS is used in respiration process for metabolic activities of the fresh fruits and vegetables (Ozden and Bayindirli, 2002). Mohamed *et al.* (2013) reported a non significant difference in total soluble solids percent loses due to coating with guar or xanthan as compared to control. During storage the increment in TSS might be associated with the transformation of pectic substances and starch hydrolysis and also with dehydration of fruits (Goncalves *et al.*, 2000; Park, 2002).

The less decline in coated fruits may most likely have occurred as result of slowing down of metabolic activity and respiration process in the pear fruits coated with the composite coating. With an increase in storage period, the starch converts into sugar in the tissues which increases the TSS (Bourtoom, 2008; Moalemiyan and Ramaswamy, 2012). Herbal edible coating delays this process as coating slows down the metabolism by reducing internal respiration rate and thus, avoiding drastic reductions in the levels of soluble solids of coated pear as compared to uncoated (control) which implies changes in TSS in coated fruits were slower than uncoated pear.

Titratable acidity: The values of titratable acidity of herbal edible coated and uncoated fruits were reduced with storage period. During the storage, the lowest value of titratable acidity was 0.25% (T_1) and 0.24% (T_4) observed in the uncoated fruits, and values of coated fruits were 0.27% (T_2), 0.30% (T_3), 0.23% (T_5) and 0.23% (T_6). The highest titratable acidity reported in coated fruits *i.e.* 0.45% (T_2), 0.50% (T_3), 0.43 % (T_5) and 0.47% (T_6) as the highest values found in T_1 (0.60 %) and T_4 (0.56%) at the end of storage. The titratable acidity was found highest in coated fruit on 45th and 70th day with coating treatments at ambient temperature (31±2 °C). Omoba and Onyekwere (2016) reported same results of titratable acidity (%) in chitosan and lemongrass extract coated cucumbers. No significant difference was found in coated and uncoated fruits at both temperatures.

The maximum percentage of titratable acidity in pears was associated with the delayed ripening in cornstarch and beeswax herbal edible coated fruits due to a semi-permeable layer around fruits which decreased the metabolic rate. The decline in titratable acidity is an important process during ripening, as it renders the fruits less sour and acidic.

Since, the organic acids, such as citric acid, malic acid, are basic substrates for respiration, a decrement in acidity is expected in ripening fruits. Hong *et al.* (2012) has reported that the faster process of decline in acidity, faster the senescence. Cornstarch and beeswax based herbal edible coating applied on pears might have decreased the rate of respiration and caused utilization of organic acids at slower rate resulting in slower decline in acidity.

Sensory Evaluation: The sensory evaluation of coated and uncoated at the end of storage period is summarized in Table 1. In case of the sensory evaluation, it can be seen that the corn starch and beeswax based herbal edible coating significantly (P<0.05) improved the shelf life of the pears, maintaining the visual quality (appearance and color with scores 8.8) during the storage time (45th day) as compared to uncoated fruits. No significant difference (P>0.05) was found in texture, appearance, taste, texture, color, and flavor at the end of experiment at ambient temperature (31±2 °C). In pear, the main signs of aging and deterioration in quality are yellowing and shriveling as a result of water loss, but these were not observed in the corn starch and beeswax based herbal edible coated fruits as well as the control uncoated fruits on day 45th and 70th of storage at ambient and low temperature. No significant difference was observed in the overall acceptability of both treated and untreated fruits.

This study revealed that the cornstarch and beeswax herbal edible coating extended the shelf life of pears at ambient temperature (31±2 °C) and low temperature (4 °C). Herbal edible coated fruits were better for all quality parameters as compared to uncoated fruits at 45th and 70th day of storage at same temperature. The herbal edible coating was most effective in reducing weight loss, firmness, pH, TSS and titratable acidity and maintained the visual appearance. This coating had no significant effect on pH and similarly, no significant difference (P>0.05) was reported between the quality attributes considered in coated and uncoated fruits. The herbal edible coating is an effective and healthy option for shelf life enhancement of fresh pears.

References

Alpalhao, A., C.M. Oliveira, C. Neto et al. 2006. Efeito do 1-metilciclopropeno em pera ‘Rocha’ em diferentes estados de maturac¸˜ao armazenadas em atmosfera normal. in Simp´osio Nacional de Fruticultura, *Actas Portuguesas de Horticultura, Alcobac¸a*, Portugal., 1: 232-238.

Andreotti, C., G. Costa and D. Treutter, 2006. Composition of phenolic compounds in pear leaves as affected by genetics, ontogenesis and the environment. *Scientia Horticulturae,* 109: 130-137. 10.1016/j.scienta.2006.03.014.

A.O.A.C. 2000. *Official Methods of Analysis of Association of Official Analytical chemists*, 7Ed, published by Association of Official Analytical Chemists. U.S.A.

Bourtoom, T. 2008. Factor Affecting the Properties of Edible Film Prepared from Mung Bean Proteins. *Int. Fd. Res. J*., 15(2): 167-180.

Dong, H., L. Cheng, J. Tan, K. Zheng and Y. Jiang, 2004. Effect of chitosan coating on quality and shelf-life of peeled litchi vegetable. *J. Fd. Eng*., 64(3): 355-358.

Goncalves, E.D., P.L. Antunes and A. Brackmann, 2000. Controlled atmosphere storage of Asian pears cv. Nijisseiki. *Rev. Bras. Frutic*., 22: 226-231.

Gonzales-Aguilar, G.A., I.N. Monroy-Garcinia, F.G. Valencia, M.E. Diaz-Cinco and J.F. Ayala-Zavala, 2005. Covers edible chitosan, An alternative to prevent microbial spoilage and preserve quality of fresh-cut papaya, in Proceedings of the Symposium on “New Technologies for Preservation and Packaging of Fruits and Vegetables Fresh Cut Vegetables. 121- 133.

Hernandez-Munoz, P., E. Almenar, V. Del-Valle, D. Velez and R. Gavara, 2008. Effect of chitosan coating combined with postharvest calcium treatment on strawberry (*Fragaria x ananassa*) quality during refrigerated storage. *Food Chemistry,* 110, 428–435.

Hong, K., J. Xie, L. Zhang, D. Sun and D. Gong, 2012. Effects of chitosan coating on postharvest life and quality of guava (*Psidium guajava L.*) fruit during cold storage. *Sci. Hort*., 44: 172-178.

Kou, X.H., W.L. Guo, R.Z. Guo, X.Y. Li and Z.H. Xue, 2014. Effects of chitosan, calcium chloride, and pullulan coating treatments on antioxidant activity in pear cv. ‘Huang guan’ during storage. *Food and Bioprocess Technol*., 7(3): 671-681.

Kumari, S., N.K. Kumari, J. Jyothi, J.L. Lavanya and I. Swarnalatha, 2016. Study on drying behavior of Sapota (*Manilkara achras*) in solar tray dryer and hot air cabinet dryer. *IOSR Jour. Environ. Sci., Toxico. Food Technol.*, 10(4): 40-64. DOI: 10.9790/2402-1004014064 www.iosrjournals.org 40, Page.

Lin, H.T., Y.F. Xi and S.J. Chen, 2003. Postharvest softening physiological mechanism of Huanghua pear fruit. *Scientia Agricultura Sinica*., 36: 349-352.

Mahajan, B.V.C., R. Tandon, S. Kapoor and M.K. Sidhu, 2018. Natural coatings for shelf-life enhancement and quality maintenance of fresh fruits and vegetables - a review. *J. Postharvest Technol.*, 6(1): 12-26.

Moalemiyan, M. and H.S. Ramaswamy, 2012. Quality retention and shelf-life extension in Mediterranean cucumbers coated with a pectin based Film. *J. Food Res*., 1(3): 159- 168.

Mohamed, A.Y., H.E. Aboul-Anean and A.M. Hassan, 2013. Utilization of edible coating in extending the shelf life of minimally processed prickly pear. *J. Appl. Sci. Res*., 9(2): 1202-1208.

Mohamed, A.Y.I. and F.K.M. Shaaban, 2014. Effect of Some Edible Coating on Quality of Fresh Pear Slices during Cold Storage. *Middle East Journal Applied Sciences*, 4(4): 1161-1170.

Moraes, K.S., C. Fagundes, M.C. Melo, P. Andreani and A.R. Monteiro, 2012. Conservation of Williams pear using edible coating with alginate and carrageenan. *Cienc. Tecnol. Aliment. Campinas*., 32(4): 679-684.

Nandane, A.S., R.K. Dave and T.V.R. Rao, 2017. Optimization of edible coating formulations for improving postharvest quality and shelf life of pear fruit using response surface methodology. *J. Food Sci. Technol*., 54(1):1–8. DOI: 10.1007/s13197-016-2359-9.

Nath, A., B.C. Deka, A. Singh, R.K. Patel, D. Paul, L.K. Misra and H. Ojha, 2012. Extension of shelf life of pear fruits using different packaging materials. *J. Food Sci. Technol*., 49: 556-563.

National Institute of Nutrition, 2010. Dietary Guidelines for Indians-A Manual. Hyderabad, NIN. 115 p.

Ochoa, E., S. Saucedo-Pompa, R. Rojas-Molina, H. de la Garza, A.V. Charles-Rodrıguez and Aguilar, C.N., 2011. Evaluation of a candelilla wax-based edible coating to prolong the shelf life quality and safety of apples. *Am. J. Agric. Biol. Sci.*, 6(1): 92-98.

Oluwaseun, A.C., A.A. Kayode, F.O. Bolajoko, A.J. Bunmi and A.R. Olagbaju, 2013. Effect of edible coatings of carboxy methyl cellulose and corn starch on cucumber stored at ambient temperature. *Asian Journal Agriculture Biology,* 1(3): 133-140.

Omoba, O.S. and U. Onyekwere, 2016. Postharvest physicochemical properties of cucumber fruits (*Cucumber sativus* L) treated with chitosan-lemon grass extracts under different storage durations. *Afr. J. Biotechnol*., 15(50): 2758-2766.

Ozden, C. and L. Bayindirli, 2002. Effects of combinational use of controlled atmosphere, cold storage and edible coating applications on shelf life and quality attributes of apples. *Euro. Food Res. Tech*., 214: 320-326.

Park, Y.M. 2002. Relationship between instrumental and sensory analysis of quality factors in apple and pear fruits. *Korean J. Hort. Sci. Technol*., 20: 394-398.

Pranoto, Y., S.K. Rakshit and V.M. Salokhe, 2005. Enhancing antimicrobial activity of chitosan films by incorporating garlic oil, potassium sorbate and nisin. *LWT Food Sci. Technol*., 38(8)**:** 859-865.

Ranganna, S. 2003. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd Edition, 1226.

Saha, A., S. Tyagi, R.K. Gupta and Y.K. Tyagi. 2016. Guar gum based edible coating on cucumber (*Cucumis sativus* L.). *Eur. J. Pharm. Med. Res*., 3(9): 558-570.

Salta, J., A. Martins, R.G. Santos, N.R. Neng, J.M.F. Nogueira, J. Justino and A.P. Rauter, 2010. Phenolic composition and antioxidant activity of Rocha pear and other pear cultivars - A comparative study. *J. Functional Food.,* 2: 153-157.

Sapper, M. and A. Chiralt, 2018. Starch-based coatings for preservation of fruits and vegetables. *Coatings*, 8(152): 1-20.

Silva, de K., Moraes, C. Fagundes, M.C. Melo, P. Andreani and A.R. Monteiro, 2012. Conservation of *Williams* pear using edible coating with alginate and carrageenan. *Ciencia e Tecnologia de Alimentos.*, 32(4): 679-684.

Slavin, J.L. and B. Lloyd, 2012. Health benefits of fruits and vegetables. *Adv. in Nutri.* (*Bethesda, Md*.), *3*(4): 506-516. https://doi.org/10.3945/an.112.002154.

Telles-Pichardo, R., K. Cruz-Aldaco, E. Ochoa-Reyes, C.N. Aguilar and R. Rojas, 2013. Edible coatings of wax and polyphenols from candelilla: an alternative of conservation of papaya (*Carica papaya* L.). *Acta Quımica Mexicana*., 5(10): 1-7.

Xiao, Z., Y. Luo and Q. Wang, 2011. Combined effects of sodium chlorite dip treatment and chitosan coatings on the quality of fresh-cut d'Anjou pears. *Postharvest Biol. Technol*., 62(3): 319-326.

Yang, Z., Y. Zheng, S. Cao, S. Tang, S. Ma and N. Li, 2007. Effects of storage temperature on textural properties of Chinese bayberry fruit. *J. Texture Stud*., 38(1): 166-177.

Zhou, R., S. Su, L.P. Yan and Y.F. Li, 2007. Effect of transport vibration levels on mechanical damage and physiological responses of Huanghua pears (*Pyrus pyrifolia Nakai*, cv. Huanghua). *Postharvest Biol. Technol.*, 46(1): 20-28.

Zhou, R., Y. Li, L. Yan and J. Xie, 2011. Effect of edible coatings on enzymes, cell- membrane integrity, and cell-wall constituents in relation to brittleness and firmness of Huanghua pears (*Pyrus pyrifolia Nakai*, *cv.* Huanghua) during storage. *Food Chem.*, 124(2): 569-575.

Zhou, R., Y. Mo, Y. Li, Y. Zhao, G. Zhang and Y. Hu, 2008. Quality and internal characteristics of Huanghua pears (*Pyrus pyrifolia* Nakai, cv. Huanghua) treated with different kinds of coatings during storage. *Postharvest Biol. Technol*., 49(1): 171-179.

Zhu, X., Q.M. Wang, J.K. Cao and W.B. Jiang, 2008. Effects of chitosan coating on postharvest quality of mango (*Mangifera indica* L. cv. Tainong) vegetables. *J. Food Process. Preserv*., 32(5): 770-784.

Received: March, 2019; Revised: May, 2019; Accepted: June, 2019