Journal Crop and Weed, 11(1):101-107(2015)

Effect of corn starch coating on storage life and quality of Assam lemon (*Citrus limon* Burn.)

A. GHOSH, K. DEY, AND N. BHOWMICK

Department of Pomology and Post Harvest Technology,
Uttar Banga Krishi Viswavidyalaya, Pundibari-736165, Cooch Behar, West Bengal

Received: 14-08-2014, Revised: 24-04-2015, Accepted: 28-04-2015

ABSTRACT

Lemon is one of the important citrus fruit. It is extremely sensitive to post harvest losses during storage. In this experiment cron starch coating of different concentration (1%, 2%, 3%, 4% , 5% and 6%) were used to study the storage life and post-harvest quality of Assam lemon fruits. The effect of this coating in fruits on total soluble solid, titrable acidity, ascorbic acid, total sugar, reducing sugar, juice content, physiological loss in weight, length, breadth and colour was assessed during storage. Among various treatments, coating with 4% corn starch was found very effective in maintaining higher TSS, acidity, ascorbic acid, total sugar, reducing sugar, juice content, length, breadth and lower physiological loss in weight compared to control. This treatment retained natural light-green colour up to 12 days of storage, which was acceptable to consumers.

Keywords: Assam lemon, corn starch, quality, storage life

Edible films and coatings are environment friendly alternative method to extend the postharvest life of fresh and minimally processed fruits and vegetables (Baldwin,1994; Olivas *et al.,* 2008; Pérez-Gago *et al.,* 2005; Vargas *et al.,* 2008). Citrus fruits are rich in vitamin C and other ingredients such as phenols and flavonoids which is very useful for human health (Hand Selen *et al.*, 2005). Although citrus fruits are non-climacteric but compounds in fruits depending on the temperature and storage duration. may change appreciably (Lester and Hodges, 2007).Among the citrus, lemon is the third most important citrus species after orange and mandarin (Porat *et al,* 2000). It is extremely sensitive during the storage (Chien *et al.,* 2007). Studies show reduce postharvest transpiration is the most important factor in increasing the storage life of citrus. Edible coatings have been widely studied in the last years because of evidence about their beneficial effects on fruits and vegetables. Modification of fruits tissue metabolism by affecting respiration rate, extension of storage life, firmness retention, transportation of antimicrobials, antioxidants, and other preservatives and microbial growth control are the main functional advantages attributed to the use of edible films and coatings (Garcia *et al.,* 2010). The main reason for applying coatings on fruits is to control loss of fruit juice in the postharvest stages (Hashemi and Taghinezhad, 2012). Juice loss usually occurs in the vapor phase. Water vapor permeability describes the movement of water vapor inside layer covered in different temperatures and moistures (Hugh and Krochta, 1994). Starch-based edible coatings can be the perfect alternative to post-harvest packing and preservation of different fruits such as sapota due to their low cost, biodegradability and superb mechanical properties (Dey *et al*., 2014). However, a little information in this regard is available on lemon cv. Assam lemon. Keeping the view, it was considered necessary to study the effect of corn starch coating on storage life and physico-chemical quality of Assam lemon.

Email:nileshbhowmick@gmail.com

MATERIALS AND METHODS

Fully mature but green lemon fruits were collected from the University Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar and immediately brought to the laboratory of the Department of Pomology and Post-harvest Technology for storage after necessary treatments. The fruits after washing in running tap water dried in the shade for few minutes. The fruits were subjected to edible coating of following treatments T_1- Corn starch 1%, T_2- Corn starch 2%, T_3- Corn starch 3%, T_4- Corn starch 4%, T_5- Corn starch 5%, T_6- Corn starch 6% and T_7- Control. Corn starch (Himedia ,Mumbai, India) coating solution was prepared by dissolving 1%, 2%,3%,4%,5% and 6% (w/v) starch in distilled water with agitation for 10 min at 90^0C respectively. The pH value was adjusted to 5.6 with 50% (w/v) citric acid (Merck) solution and the solutions were equilibrated for 10 min. Glycerol (Merck) 87% was added as a plasticizer at a concentration of 2ml litter^{-1} solution. The coating of sample was done by following the method of Janna (2012). Fruit samples were analysed for physico-chemical properties at an interval of 3 days. The decay percentage of fruits were calculated as the number of decayed fruit divided by initial number of all fruit multiplied by hundred.The percentage of weight loss were calculated based on initial weight and weight at subsequent intervals. The fruit colour was recorded with the help of Royal Horticulture Society mini colour chart (5^{th} edition, 2007). The length and breadth (centimetre scale) of lemon fruits were measured as an index for shrinkage and it was measured by digital vernier callipers at zero time of storage (beginning) and 3 days interval during the storage period. After peeling and removal of seed, juice was extracted from the pulp through a mechanical juice extractor and strained. Volume of the juice was measured with the help of a measuring cylinder and the juice content was expressed in percentage (%) with respect to fruit weight. Total soluble solids (TSS), total sugar and reducing sugar were estimated by the method described by Mazumdar and Majumder (2003). The acidity and ascorbic acid were estimated by the method described by Rangana (1977). Analysis of variance (one way classified data) for each parameter was performed SAS software. Mean separation for different treatment under different parameter were performed using Least Significant Different (LSD) method (Pd" 0.05). Normality of residuals under the assumption of ANOVA was tested using Shapiro-Wilk procedure. Angular transformation was done for percentage data (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Decay percent

The coatings reduced decay compared to control fruit for all the treatments and fruit treated with 4 % corn starch coating (T_4) showed minimum decay (34.93%) after 12 days of storage than uncoated fruits (T_7) which showed maximum decay (68.52%).The decrease in decay percentage was probably due to the effect of the coating on delaying senescence, which makes the commodity more vulnerable to pathogenic infection as a result of cellular or tissue integrity (Tanada-Palmu and Grosso, 2005).

Physiological loss in weight

Physiological loss in weight increased in all the treatments as the storage period progressed (Table 2). On 3 days after treatment, the physiological loss in weight was found minimum (18.19%) in fruits treated with T_4 (4% starch) followed by T_6 (33.76%), where as, it was maximum (68.68%) in T_7. However, on 12 days after treatment, the physiological loss in weight was found minimum (26.64%) in T_4 followed by T_6 (40.86%) where as it was maximum (83.41%) in T_7. Physiological loss in weight for all the corn starch treated fruits were statistically *at par* at 3^{rd} and 6^{th} days after storage. The reduction in weight loss was probably due to the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates (Baldwin *et al*., 1999). Fruits coated with 4% corn starch had less weight loss during storage as compared to fruits under control. Oluwaseun *et al.* (2013) observed that corn starch coated cucumber showed a significant delay in weight loss compared to uncoated ones.

Fruit colour

Fruit colour of lemon fruits changed from different shades of green to yellowish-green during storage (Table 3). At the time of the harvesting, fruits were green (G-G- 143-A) followed by yellowish green (Y-G-G 144-A) in colour. At the end of the storage, fruits become yellow (Y-G-G 144-B) and reduced their marketability. Fruits treated with 4% corn starch (T_4) remain green (G-G 143-B) up to 6 days after treatment, compare to other treatments. This could be due to corn starch coating (4%) being more effective in delaying the ripening of mature lemon fruits compared to other treatment and control. Castricini *et al*. (2012) observed that papaya coated with cassava starch and carboxy methyle starch helped to maintain the colour during storage. Generally the yellowness increased with storage time due to ripening of fruits Ruzaina *et al.* (2013).

Fruit length and breadth

T_4 (4 % starch) showed a lower percentage of shrinkage compared to fruits of control (Table 4). The shrinkage percentage of T_4 was 6.49 % (from 15.40 cm to 14.40 cm) for fruit length and 14.48 % (from 5.25 cm. to 4.49 cm.) for fruit breadth. Treatments have no effects on breadth at 12^{th} days after storage and 3^{rd} days for length. It might be due to the anti-senescent action of coatings which had an inhibitory effect on ethylene biosynthesis and retard the activity of enzymes responsible for ripening, cell degradation was prevented which in turn facilitated reduced moisture loss and lesser respiratory gas exchange, hence delay in senescence and lower the shrinkage percentage (Sudha *et al*., 2007).

Juice percentage

Juice percentage showed (Table 5) highest (55.41 %) in T_4 (4% corn starch) followed by (51.34 %) in T_1 (1% corn starch) after 3 days of treatment. However, even after 12 days of storage, juice content was drastically

Table 1: Effect of corn starch coatings on decay (%)

	Days after treatments			
Treatments	**3**	**6**	**9**	**12**
T_1 (Corn starch- 1%)	8.18(16.53)b	18.15(25.17)b	28.57(32.31)c	57.22(49.14)b
T_2 (Corn starch-2%)	9.73(18.04)ab	20.02(26.59)ab	34.26(35.83)b	58.45(49.88)b
T_3 (Corn starch-3%)	10.99(19.30)ab	19.12(25.92)b	36.16(36.96)b	58.34(49.82)b
T_4 (Corn starch-4%)	3.54(10.48)c	7.28(15.62)c	14.85(22.53)d	34.93(36.23)c
T_5 (Corn starch-5%)	7.21(15.46)bc	18.2(25.22)b	38.34(38.27)b	60.22(50.91)b
T_6 (Corn starch-6%)	12.08(20.18)ab	18.19(24.23)b	38.09(38.12)b	58.29(49.78)b
T_7 (Control)	14.62(22.36)a	23.75(29.13)a	47.89(43.78)a	68.52(55.89)a
LSD (0.05)	**5.11**	**3.05**	**3.19**	**2.70**

Note: *Means with the same letter are not significantly different; Values in parenthesis are angular transformed value.*

Table 2: Effect of corn starch coatings on physiological loss in weight (%)

	Days after treatments				
Treatments	**3**	**6**	**9**	**12**	**Cumulative**
T_1 (Corn starch- 1%)	51.61ab	63.83ab	65.31ab	68.35ab	55.79c
T_2 (Corn starch-2%)	54.4ab	59.98ab	61.57abc	62.39abc	60.23b
T_3 (Corn starch-3%)	44.72ab	51.36ab	53.83abc	55.79abc	47.89d
T_4 (Corn starch-4%)	18.19b	24.22b	25.24c	26.64c	22.98g
T_5 (Corn starch-5%)	37.92ab	41.3ab	42.09bc	46.64abc	43.09e
T_6 (Corn starch-6%)	33.76ab	37.64b	39.07bc	40.86bc	38.76f
T_7 (Control)	68.68a	80.76a	81.94a	83.41a	72.39a
LSD (0.05)	**39.18**	**40.04**	**39.66**	**39.92**	**0.08**

Table 3: Effect of corn starch coatings on colour

	Days after treatments			
Treatments	**3**	**6**	**9**	**12**
T_1 (Corn starch- 1%)	Y-G-G 146-B	Y-G-G 146-B	Y-G-G 144-B	Y-G-G 144-B
T_2 (Corn starch-2%)	Y-G-G 144-A	Y-G-G 144-A	Y-G-G 144-B	Y-G-G 144-B
T_3 (Corn starch-3%)	Y-G-G 144-B	Y-G-G 144-B	Y-G-G 144-B	Y-G-G 144B
T_4 (Corn starch-4%)	G-G 143-B	G-G 143-B	Y-G-G 144-B	Y-G-G 144-B
T_5 (Corn starch-5%)	Y-G-G 144-A	Y-G-G 144-A	Y-G-G 144-A	Y-G-G 144-A
T_6 (Corn starch-6%)	Y-G-G 144-B	Y-G-G 144-B	Y-G-G 144-B	Y-G-G 144-B
T_7 (Control)	Y-G-G-N 144-A	Y-G-G-N 144-A	Y-G-G 144-B	Y-G-G 144-B

Table 4: Effect of corn starch coatings on length and breadth (cm)

	Days after treatments									
Treatments	**3**		**6**		**9**		**12**		**Shrinkage(%)**	
	Length	**Breadth**	**Length**	**Breadth**	**Length**	**Breadth**	**Length**	**Breadth**	**Length**	**Breadth**
T_1	14.43a	5.23ab	13.99ab	4.88ab	13.57ab	4.76ab	13.09ab	4.35a	9.29	16.83
T_2	14.65a	487b	14.35ab	4.56b	14.09ab	4.44b	13.67ab	3.99a	6.69	18.07
T_3	15.05a	5.08ab	14.56ab	4.81ab	14.47a	4.80ab	13.89ab	4.28a	7.71	15.24
T_4	15.40a	5.25a	15.05a	5.10a	14.77a	4.91a	14.40a	4.49a	6.49	14.48
T_5	14.88a	5.11ab	14.32ab	4.83ab	13.95ab	4.62ab	13.49ab	4.18a	9.34	18.20
T_6	13.25a	4.90ab	12.63b	4.66b	12.35b	4.44b	11.82b	4.12a	10.79	15.82
T_7	14.14a	4.93ab	13.50ab	4.6b	12.9ab	4.53ab	12.34ab	3.99a	12.73	19.07
LSD(0.05)	**2.30**	**0.39**	**2.30**	**0.41**	**2.08**	**0.43**	**2.28**	**0.58**		

Table 5: Effect of corn starch coatings on juice (%)

Treatments	Days after treatments			
	3	6	9	12
T_1 (Corn starch- 1%)	51.34b	49.47ab	46.36ab	40.78ab
T_2 (Corn starch-2%)	37.05d	34.37cd	32.11de	28.11de
T_3 (Corn starch-3%)	45.38c	44.44b	41.49bc	37.54bc
T_4 (Corn starch-4%)	55.41a	54.15a	51.57a	45.1a
T_5 (Corn starch-5%)	30.59e	29.97de	26.07ef	23.51ef
T_6 (Corn starch-6%)	41.55c	38.68c	37.16cd	32.44cd
T_7 (Control)	29.33e	25.43e	25.43f	19.45f
LSD (0.05)	**3.94**	**5.29**	**6.08**	**6.86**

Note: *Means with the same letter are not significantly different.*

reduced (19.45 %) in control (T_7), it was considerably higher (45.10%) with T_4. Coated fruits exhibit better juice content as edible coating providing a semi-permeable barrier to gases and water vapor and therefore, they can reduce respiration and water loss (Guilbert, 1986; Baldwin *et al.*,1995).

Total soluble solids (TSS)

Observation during storage of lemon fruits revealed that the TSS content of fruit increased up to a certain period and thereafter that it decreased in all the treatments as the storage period progressed (Table 6). On 3 days after treatment, the TSS content was found highest (6.93° brix) in T_4 followed by T_1 (6.55° brix), whereas, it was lowest (5.82° brix) in control (T_7). However, on 12 days after treatment, the TSS content was also found maximum (6.42° brix) in T_4 followed by T_2 (6.27° brix) and was minimum (5.52° brix) in T_7. Oluwaseun *et al.* (2013) observed that corn starch coated cucumber showed higher TSS compared to uncoated ones. These results are similar with Smith and Stow (1984) who concluded that coatings and/or films significantly affected TSS. Soluble solids content of coated and uncoated cucumber stored under ambient condition decreased at the end of the storage period. The loss of soluble solids during the storage period is as natural as sugars which are the primary constituent of the soluble solids content of a product, consumed by respiration and used for the metabolic activities of the fruits (Özden and Bayindirli, 2002).

Total sugar

Total sugar content increased for a certain period (6 days after treatment) and after that itdecreased in all the treatments as the storage period advanced (Table 7). On 3 days after treatment the total sugar content was found highest (6.22 %) in T_4 followed by T_3 (5.97 %), whereas, it was lowest (5.13 %) in T_7. However, on 12 days after treatment, total sugar content was found maximum (5.61 %) in T_4. The change of sugar content is occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain, 2011).

Reducing sugar

In general reducing sugar content showed an increasing trend upto 6th day of storage and then decreases on 9th day of storage (Table 8). The reducing sugar content was found highest (5.52 %) in T_4 on 3rd days of storage whereas the lowest content (4.55 %) was found in T_7. On 12th day of storage, T_4 showed highest (4.51 %) result and the lowest (2.38 %) result was observed in control. However, the data of all the starch coated fruits were statistically *at per* at 9th and 12th days of storage. The change of reducing sugar content is occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain, 2011).

Titrable acidity

The titrable acidity values of coated and uncoated fruit during storage decreased with storage time. The value was highest (0.8 %) in T_4 on 3 days after treatment and the lowest (0.57 %) in T_7 (Table 9). The coating has significant effect on 3, 6 and 9 days after storage and no effect on titrable acidity during 12th days after storage of lemon fruits. The low level of titrable acidity in control fruit compared to coated fruit suggests that the corn starch coating delayed ripening by providing a transparent coating around the fruit. It is also considered that coatings reduce the rate of respiration and may therefore delay the utilization of organic acids (Yaman and Bayoindirli, 2002).

Ascorbic acid

The ascorbic acid content of coated and uncoated lemon fruits increased to a maximum up to 6 days of storage and then subsequently declined. The highest levels of ascorbic acid (52.51 mg 100g^{-1} pulp) was observed in T_4, followed by T_1 (45.17 %) and the lowest

Table 6: Effect of corn starch coatings on TSS (^{o}Brix)

Treatments	Days after treatments 3	6	9	12
T_1 (Corn starch- 1%)	6.55a	7.09a	6.38b	5.64b
T_2 (Corn starch-2%)	6.6a	6.88a	6.46ab	6.27a
T_3 (Corn starch-3%)	6.35ab	6.68ab	6.2bc	5.66b
T_4 (Corn starch-4%)	6.93a	7.19a	6.9a	6.42a
T_5 (Corn starch-5%)	5.87b	6.28b	6.11bc	5.49b
T_6 (Corn starch-6%)	5.88b	6.23b	6.07bc	5.61b
T_7 (Control)	5.82b	6.22b	5.9c	5.52b
LSD (0.05)	**0.64**	**0.55**	**0.46**	**0.52**

Note: *Means with the same letter are not significantly different.*

Table 7: Effect of corn starch coatings on total sugar (%) and reducing sugar (%)

Treatments	Days after treatment 3		6		9		12	
	TS	RS	TS	RS	TS	RS	TS	RS
T_1 (Corn starch- 1%)	5.67c	4.93bcd	5.92bc	5.34abc	5.25c	4.64a	4.53b	3.84ab
T_2 (Corn starch-2%)	5.83bc	4.77cd	6.63a	5.12c	5.7b	4.61a	5.39a	3.99ab
T_3 (Corn starch-3%)	5.97ab	5.29ab	6.34ab	5.74ab	5.92b	4.91a	5.59a	4.04ab
T_4 (Corn starch-4%)	6.22a	5.52a	6.68a	5.89a	6.31a	4.95a	5.61a	4.51a
T_5 (Corn starch-5%)	5.2d	5.09abc	5.45c	5.18bc	5.27c	4.75a	5.08ab	2.96ab
T_6 (Corn starch-6%)	5.2d	4.8bcd	5.68c	5.13c	5.15c	4.35ab	4.43b	3.28ab
T_7 (Control)	5.13d	4.55d	5.64c	4.75c	5.02c	3.67b	4.72b	2.38b
LSD(0.05)	**0.29**	**0.50**	**0.48**	**0.60**	**0.34**	**0.73**	**0.66**	**1.67**

Note: *TS: Total sugar; RS: Reducing sugar; Means with the same letter are not significantly different.*

Table 8: Effect of corn starch coatings on titrable acidity (%)

Treatments	Days after treatments 3	6	9	12
T_1 (Corn starch- 1%)	0.71ab	0.84a	0.71ab	0.61a
T_2 (Corn starch-2%)	0.77ab	0.85a	0.72ab	0.5a
T_3 (Corn starch-3%)	0.74ab	0.85a	0.75ab	0.47a
T_4 (Corn starch-4%)	0.8a	0.87a	0.78a	0.66a
T_5 (Corn starch-5%)	0.78ab	0.85a	0.77a	0.47a
T_6 (Corn starch-6%)	0.68bc	0.78ab	0.67ab	0.42a
T_7 (Control)	0.57c	0.71b	0.62b	0.35a
LSD(0.05)	**0.12**	**0.12**	**0.13**	**0.33**

Table 9: Effect of corn starch coatings on ascorbic acid (mg $100g^{-1}$ pulp)

Treatments	Days after treatments 3	6	9	12
T_1 (Corn starch- 1%)	45.17c	46.12cd	44.46bc	42.65bcd
T_2 (Corn starch-2%)	47.8b	48.54b	47.21b	44.48bc
T_3 (Corn starch-3%)	44.48c	48.36bc	44.82bc	42.96bcd
T_4 (Corn starch-4%)	52.51a	54.35a	52.3a	49.12a
T_5 (Corn starch-5%)	44.63c	47.05bcd	43.87c	41.68cd
T_6 (Corn starch-6%)	44.97c	48.79b	46.69b	45.11b
T_7 (Control)	42.57d	45.66d	43.68c	40.21d
LSD(0.05)	**1.76**	**2.27**	**2.78**	**3.16**

level (42.57 mg 100g^{-1} pulp) was obtained in T_7 on 3 days after storage. On 12 days after storage, it was observed that maximum (49.12 mg 100g^{-1} pulp) and minimum (40.21 mg 100g^{-1} pulp) results in T_4 and T_7, respectively. From the experimental result it is clear that coated fruits retained more amount of ascorbic acid content during storage of lemon fruits which is similar with the result of Oluwaseun *et al.* (2013). This was probably because corn starch coating acted as a gas barrier, inhibiting oxygen from entering the fruit, thus reducing the oxidation of ascorbic acid. Ascorbic acid is lost at later stage due to the activities of polyphenol oxidase and ascorbic acid oxidase enzymes during storage (Salunkhe *et al*., 1991).

It can be concluded from the present experiment that corn starch as an edible coating affects positively on the physico-chemical parameters of Assam lemon fruits. The coated samples show significant differences for most of the horticulturally important parameters as compared to control sample. Among the different treatments, Assam lemon fruit coated with 4 % corn starch showed a significant delayed and change of weight, length and breadth and retained better total soluble solids, total and reducing sugar, ascorbic acid content, juice content and colour during storage as compared to uncoated control fruit. This suggests that corn starch not only extends the shelf life but also preserves the quality during storage by providing strong and selective barriers to moisture transfer, oxygen uptake, losses of volatile aromas and flavor, pleasant visual aspect.

REFERENCES

Baldwin, E.A. 1994 . Edible coatings for fresh fruits and vegetables: past, present, and future. In. *Edible Coatings and Films to Improve Food Quality* (J. M. Krochta, EA. Baldwin., and M.O. Nisperos-Carriedo, Eds.) Technomic Publishing Co. Inc., Lancaster, PA, USA, pp.25-64.

Baldwin, E.A., Nisperos-Carriedo, M., Shaw, P.E. and Burns, J.K. 1995. Effect of coatings and prolonged storage conditions on fresh orange flavour volatiles, degrees brix and ascorbic acid levels. *J. Agric. Food Chem*., **43**:1321-31.

Baldwin, E.A., Burns, J.K., Kazokas W., Brecht, J. K., Hagenmaier, R. D., Bender, R. J. and Peris, E. 1999. Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. *Posthar. Biol. Technol.,* **17**:215-26.

Castricini, A., Coneglian, R.C.C. and Deliza, R. 2012. Starch edible coating of papaya: effect on sensory characteristics. *Ciênc. Tecnol. Aliment. Campinas,* **32**:84-92.

Chien, P., Sheu, F. and Lin, H. 2007. Coating citrus (*Murcott tangor*) fruit with low molecular weight chitosan increases postharvest quality and shelf life. *Food Chem.,* **100**: 1160–64.

Dey, K., Ghosh, A., Bhowmick, N. and Ghosh, A. 2014. Physico-chemical properties of sapota (*Manilkara achras* (Mill) Fosb.) fruits coated with corn starch. *J. Crop Weed*, **10**:43-49.

Garcia, L.C., Pereira, L.M., Sarantopoulos, C.I.G.L. and Hubinger, M.D. 2010. *Selection of an Edible Starch Coating for Minimally Processed Strawberry.* Food Bioprocess Technol. DOI 10.1007/s11947-009-0313-9.

Gomez K. A., Gomez, A. A. 1983. *Statistical Procedures for Agricultural Research* 2nd Ed., Wiley-Inter science Publication New York, USA. pp. 275-315.

Guilbert, S.1986. Technology and application of edible protective films. In. *Food Packaging and Preservation.* (Mathlouthi, M. Ed.), Elsevier Appl. Sci., pp.371–94.

Hand Selen, B., Nuray, K., Feryal, K. 2005. Degradation of vitamin C in citrus juice concentrates during storage. *J. Food Eng.* **74**: 211-16

Hashemi, J. and Taghinezhad, E. 2012. Effects of nano composite coating on the lemon quality. *Proc. Int. Conf. Agril. Eng.,* 8-12 July, 2012, Valencia, Spain. pp. 117-23.

Hugh, T. R. and Krochta, J. M. 1994. Milk-protein-based edible films and coatings, *Food Tech*., **48**: 97.

Janna, C. 2012. An experimental design approach for edible starch-based coatings development. *Paper Presented* in *5th Int. Symp. Food Packaging,* Berlin, Germany, 14-16th November, 2012.

Lester, G.E. and Hodges, D.M. 2007. Antioxidants associated with fruit senescence and human health: Novel orange fleshed non-netted honey dew melon genotype comparisons following different seasonal production and cold storage durations. *Postha. Bio. Tech.*, **48**: 347-54.

Mazumdar, B.C. and Majumder, K. 2003. Determination of chemical constituents. In.

Methods on Physico-Chemical Analysis of Fruits, Daya Publishing House, Delhi. pp. 93-139.

Nandane, A.S. and Jain, R.K. 2011. Effect of composite edible coating on physicochemical properties of tomatoes stored at ambient conditions. *Indian J. Adv. Eng. Tech.,* **2**: 211-17.

Olivas, G.I., Dávila-Aviña, J.E., Salas-Salazar, N.A. and Molina, F.J. 2008. Use of edible coatings to preserve the quality of fruits and vegetables during storage. *Stewart Posthar. Rev.*, **3**:1-10.

Oluwaseun, A.C., Arowora, K .A., Bolajoko F.O., Bunmi, A.J. and Olagbaju, A.R., 2013. Effect of edible coating of carboxy methyl cellulose and corn starch on cucumber stored at ambient temperature. *Asian J. Agri Biol.,* **1**:133-40.

Özden, C. and Bayindirli, L. 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**: 320–26.

Pérez-Gago, M.B., Serra, M., Alonso, M., Mateos, M. and Río, M.A. 2005. Effect of whey protein- and hydroxypropyl methylcellulose-based edible composite coatings on color change of fresh-cut apples. *Postha. Bio. Tech.*, **36**: 77-85

Porat, R., Daus, A., Weiss, B., Cohen, L., Fallik, E. and Droby, S. 2000. Reduction of postharvest decay in organic citrus fruit by a short hot water brushing treatment. *Postha. Bio. Tech.,* **18**: 151-57.

Rangana, S. 1977. Ascorbic acid. *In. Manual Analysis of Fruit and Vegetable Products.* Tata McGraw-Hill Publish. Comp. Ltd., New Delhi, pp. 94-101.

Ruzaina, I., Norizzah, A. R., Halimahton, Z., Cheow, M. S., Adi, C. S., Noorakmar,M. S., A. W. and Mohd. Zahid, A. 2013. *Inter. Food Res. J.*,**20** : 265-74

Salunkhe, D.K., Boun, H.R., Reddy, N.R. 1991. Storage Processing and Nutritional Quality of Fruits and. Vegetables, In. *Fresh Fruits Veg.*. Boston: CRC Press Inc.

Smith, S.M. and Stow, J.R. 1984. The potential of a sucrose ester coating material for improving the storage and shelf-life qualities of Cox's Orange Pippin apples. *Ann. Appl Bio.,* **104**: 383-91.

Sudha, R., Amutha, R., Muthulaksmi, S., Baby Rani, W., Indira, K. and Mareeswari, P. 2007. Influence of pre and post-harvest chemical treatments on physical characteristics of sapota (*Achras sapota* L.) var. PKM-1. *Res. J. Agri. Bio. Sci.*, **3**(5):450-52.

Tanada-Palmu, P.S., Grosso, C.R.F. 2005. Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa)* quality. *Postha. Biol. Tech*., **36**:199-208.

Vargas, M., Pastor, C., Chiralt, A., Clements, D.J. and González-Martínez, C. 2008. Recent Advances in edible coatings for fresh and minimally processed fruits, *Critical Rev. Food Sci. Nutr.*, **48**: 496-511.

Vidrih, R., Zavrtanik, M., Hribar J. 1998 . Effect of low O_2, high CO_2 or added acetaldehyde and ethanol on postharvest physiology of cherries. *Acta Hort*., **2**: 693–95.

Yaman, O. and Bayoindirli, L. 2002. Effects of an edible coating and cold storage on shelf-life and quality of cherries. *Lebnsm. Wiss. Und. Technol*., **35**: 46-150.