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Influence of hydrocolloid-based edible coatings on fruit firmness and quality of nectarine (*Prunus persica* var. *nucipersica*) cv. Snow Queen at low temperature storage

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ABSTRACT

Nectarine (*Prunus persica* var. *nucipersica*) is known for its characteristic flavor and fuzzless nature in contrast to its progenitor peaches. It is an important stone fruit with immense nutrients and antioxidant capacity. The smooth texture and glossy cosmetic appeal makes the nectarine popular among the consumers as well as growers. But the postharvest life of this functional fruit is only 3-4 days under ambient conditions due to its high perishability and its unfamiliarity among the growers as its newly introduced crop causes a significant postharvest loss to the growers. Hence, this experiment was conducted to enhance the marketability of commercially important nectarine cultivar Snow Queen fruit by coating them with various plants (hydrocolloids) based edible coating. Fruits were treated with various plant based edible coating such as carboxymethyl cellulose (1%, 1.5%) and GA (gum *Arabica)* (8%, 10%, 12%). The fruits were dipped in various coating material and dried under ambient condition and stored at cold storage conditions (1±1 ºC and 85-90% relative humidity). The observations on various physical, physiological and biochemical attributes were recorded at weekly interval. The results revealed that among the various edible coatings applied, 1% CMC and 10% GA were found to be effective in reducing the respiration rate and maintaining better fruit firmness than other concentrations of edible coating. These treatments were also better in maintaining other biochemical parameters and extended the shelf life of Snow Queen fruit to about 28 days under storage with better organoleptic properties.

Key words: Fruit firmness, Fruit quality, Hydrocolloids, Shelf life.

Nowadays, nectarine (*Prunus persica* var. *nucipersica*) is considered as an important functional fruit, which are grown throughout the warmer temperate regions of the world. In India, its commercial cultivation is confined to the states of J & K, HP, Uttarakhand and some North-Eastern states also (Sharma and Krishna 2016; Jayarajan *et al*. 2019). Nectarines are juicy and delicious fruits having low calorific value and no saturated fatty acids (Colaric *et al*. 2005). They contain fairly good amount of antioxidants vitamins and flavonoids, polyphenolic antioxidants like lutien, zeaxanthin and *β*-cryptoxanthin (Colaric *et al*. 2005). Because of these reasons, nectarines are considered as functional food attributing their ability to fight against chronic diseases as these are rich source of antioxidants which prevent oxidative stress by suppressing the ROS production in human plasma (Abidi *et al*. 2011). The cultivation of the crop is getting more popular due to its demand in the market because of its fuzzless texture and sweeter taste than its progenitor (Gil *et al*. 2002; Jayarajan and Sharma 2018; Jayarajan *et al*. 2019). (Accordingly, several nectarine varieties have been introduced in India, of which, Snow Queen is one of the important commercial varieties available in India (Jayarajan *et al*. 2019). The marketability period of nectarine is very lean because of its climacteric behavior attributing to high respiration and ethylene evolution rate (Jayarajan and Sharma 2018). Postharvest losses of about 25-30% occur during transportation and market chain which can be attributed to high metabolic activity and respiration rates (Kader *et al*. 2002; Jayarajan and Sharma 2018). The poor shelf-life of the fruits is further related to mis-handling, poor storage conditions and other improper postharvest handling practices (Kader *et al.* 2002). Moreover, the

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harvest of fruits falls in peak summer period which makes the postharvest life of nectarine further shorter because of higher temperature. Thus, special attention is inevitable for the postharvest management in order to prolong its shelf-life and retain the quality of fruit.

So far, scientists have worked on several postharvest management strategies for the shelf-life extension of the nectarines, but still they are in infancy stage. The ultimate aim of any management practice is to reduce or inhibit the metabolic activities and to enhance the shelf-life with minimum deteriorative changes. From the health point of view, any treatment applied should be of minimal adverse effect to the consumers and should be safe to the consumers of all age groups. To keep the metabolic activity under check, cold storage or low temperature storage is widely practised in fruits (Sharma and Sharma 2015; Jayarajan and Sharma 2018). In addition, use of chemicals such as 1-MCP (Ahmad *et al*. 2013; Reddy *et al*. 2017), NO (Sharma and Sharma 2015; Jayarajan and Sharma 2018), polyamines (Galston and Sawhney 1990; Jhalegar *et al*. 2012), edible coatings (Kittur *et al*. 2001), and in-package ethylene absorbents (Jayarajan and Sharma 2019) etc. have been extensively reported to enhance the shelf-life. The practice of coating fruits is an age old practice with a view to increase shelf-life by reducing moisture loss and better glossy appeal to attract the buyers. Nowadays consumers are more concerned about side effects of harmful chemicals, hence demanding plant based safer alternatives and the plant based hydrocolloid coating are of high demand. The commercially available hydrocolloids are carboxymethyl cellulose (CMC), methyl cellulose (MC) and hydroxypropylmethyl cellulose (HPMC), guar gum (GG), locust bean gum (LBG), tara gum (TG), konjac maanan (KM), gum targacanth (GT), gum ghatti (GG) and gum Arabica (GA) and are applied after harvest. Hence, we attempted to treat the Snow Queen nectarine variety to evaluate the effectiveness of CMC (1%, 1.5%) and gum Arabic (8%, 10%, 12%) in extending the shelf-life at low temperature storage.

MATERIALS AND METHODS

The studies were conducted in the Division of Food Science and Postharvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi, India during the fruiting season of 2018-19. Fruit of Snow Queen variety was harvested at full maturity (ready-to-eat stage) from the orchard of Regional Horticultural Research Station, Dr Y S Parmar University of Horticulture and Forestry, Bajaura, H P, India. In this study, two commercially important hydrocolloids such as CMC (1%, 1.5%) and gum Arabica (8%, 10%, 12%) were applied as coating to freshly harvested nectarine fruits and stored at cold storage conditions (1±1^{o} C and 85-90% RH) for four weeks for further observations in weekly interval. In each treatment, 60 fruits were coated, replicated thrice. The fruits simply dipped in distilled water served as control.

All physical (fruit firmness) and physiological (respiration rate) attributes of the ten-randomly selected Snow Queen nectarine fruit were recorded at weekly interval, replicated thrice. Fruit firmness was determined using a texture analyzer (model: TA+Di, Stable Micro Systems, UK) using compression test, and expressed as N (Newton). The pre test, test speed and post test speed maintained was 2, 2 and 5 mmsec^{-1} respectively. Respiration rate was measured using the static head space technique. The respiration rate was determined by using auto gas analyzer (Model: Checkmate 9900 O_2/CO_2 PBI Dansensor, Denmark) and expressed as mL CO_2 kg^{-1} h^{-1} (Jayarajan and Sharma 2018).

The eating quality attributes such as total soluble solids (TSS), total titratable acidity (TA) and ascorbic acid content (AAC) were determined in ten-randomly selected nectarine fruit at weekly interval, replicated thrice. The total soluble solids of nectarine fruit samples were estimated using Fisher hand refractrometer and was expressed as ^{o}Brix. Total titratable acidity in the nectarines was determined by using 0.1 N NaOH as described by Ranganna (1999), and expresses as mg 100 g^{-1} FW. Ascorbic acid content of the fruit was determined using the method suggested by Ranganna (1999). Ten mL of nectarine juice sample was taken, the volume of which was made up to 100 mL with 3% HPO_3 and it was then filtered. The prepared fruit sample was taken in a conical flask and titrated against standardized 2, 6 dichlorophenol indophenol dye, and expressed as mg 100g^{-1} juice. The overall acceptability of the coated and non-coated nectarine fruits was done by five semi-trained panelists on the basis of Hedonic scale (0-9) in which 0 - indicated the lowest acceptability and 9, the highest.

The experiments were laid out in factorial CRD design with each treatment consisting of 60 fruits with 3 replications. However, observations on different attributes were recorded in ten-randomly selected fruit at weekly interval, which was replicated three times. The data obtained from the experiments were analyzed as per design and the results were compared from ANOVA (Analysis of variance) by calculating the Least Significant Difference, LSD (Panse and Sukhatme 1984). The data were analyzed using the software SAS-9 (SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

Effects on physical and physiological attributes

Fruit firmness (N): In general, fruit firmness decreased considerably during course of storage period. However, the rate of decline was higher in the control fruit than those coated with different concentrations of hydrocolloids (Fig 1). Among different coatings applied, the minimum fruit firmness was recorded in untreated (control) fruit (1.36 N) and maximum in fruit packed with 10% GA at the end of storage period (Fig 1).

Respiration rate: As a general trend, the respiratory rate of treated as well as non-treated nectarine fruit increased considerably and reached the climacteric peak and thereafter it declined. Irrespective of coatings applied, all fruits showed respiratory peak on 14th day of storage but the amount of CO_2 evolution differed, the highest being in untreated fruit

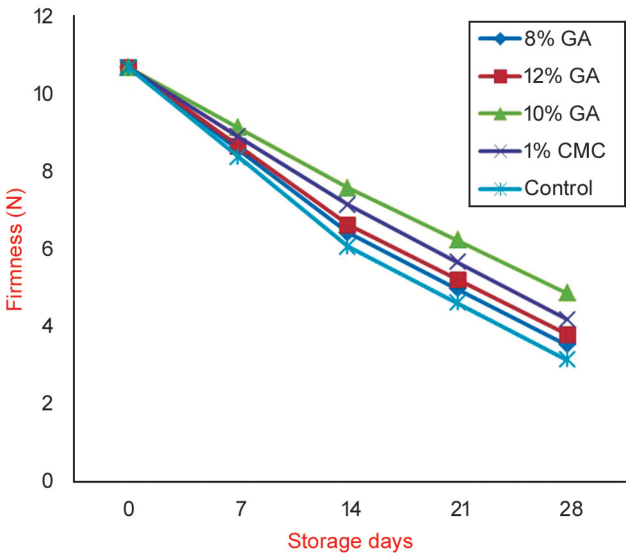

Fig 1 Effect of hydrocolloids based edible coating on fruit firmness (N) during cold storage (1 ± 1 °C and 85 -90 % RH)) of Snow Queen nectarine fruit. Each value is presented as the mean ± standard error (n = 15).

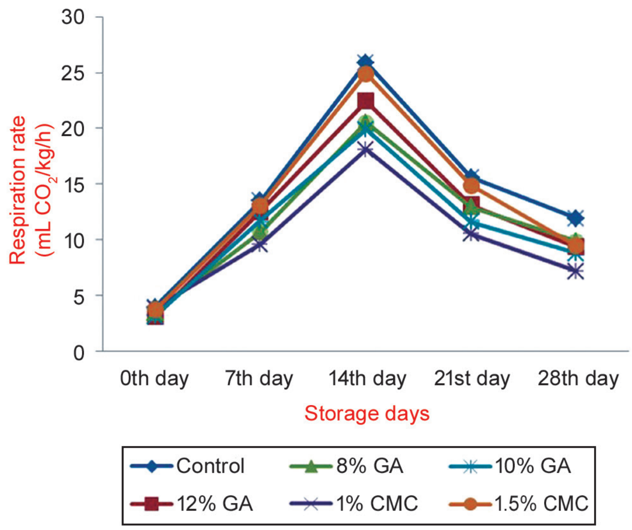

Fig 2 Effect of hydrocolloids based edible coating on respiration rate (mL CO_2kg-1h-1) of Silver Queen nectarine during cold storage (1 ± 1 °C and 85-90 % RH). Each value is presented as the mean ± standard error (n = 15).

(28 mL CO_2 kg^{-1} h^{-1}) and the lowest in fruit packed with 10% GA and 1.5% CMC (18 mL CO_2 kg^{-1} h^{-1}) (Fig 2).

While purchasing the fruits, the physical attributes such as firmness and appeal are important deciding factors. As mentioned earlier, firmness is one of those parameters which all look forward for buying any kind of fruits so as in nectarines. Firm and sound fruit fetches better price in markets, nectarines coated with 10% GA exhibited better firmness compared to all other treatments. As the fruit ripens, softening occurs due to break down of short chains of pectin by pectin methyl esterase and polygalactouronase activities (Jayarajan and Sharma 2018). The better firmness of the coated fruits may attribute to delay in ripening which was further related to reduce respiration rate. Our findings are in line with Tahir *et al*. (2018) who reported that strawberry fruits coated with guar (arabica) gum showed a better firmness than controlled fruits. The higher the respiration rate, the more will be the biochemical changes which directly related to the accelerated ripening and senescence, so to enhance the shelf-life it's important to keep the respiration under control. The nectarine when treated with 10% GA exhibited lower respiration rate along with 1% CMC and this must be attributed to the effect of hydrocolloids on respiration of horticultural products is related to their ability to create a barrier to oxygen diffusion through the coating and thereby acting as barrier for respiration. Similarly, Chacon *et al*. (2017) reported that when Roma tomato coated with guar gum have shown invariable reduction in respiration during the storage at ambient condition (22±1^{0}C).

Effects on eating quality attributes

Total soluble solids: Total soluble solids present in the Snow Queen nectarine were significantly affected by different coating materials, storage period alone and the combination of both. Irrespective of storage period, TSS was significantly influenced by the different edible coating, being the highest in fruit without any coating (9.153 °B) and lowest in fruit coated with 12% GA (6.577 °B) (Table 1). Regardless of treatment, storage period influenced the TSS present in the Snow Queen nectarine fruit, maximum being recorded on 14th day of storage (9.864 °B) and minimum on initial day of storage (5.027 °B) (Table 1).

Titratable acidity: The titratable acidity (TA) in Snow Queen nectarine fruits were significantly influenced by treatment and storage period individually and their interaction as well (Table 2). Irrespective of storage period, treatment significantly influenced the titratable acidity in nectarine fruit. The highest percentage of titratable acidity was observed in fruit coated with 10% GA (0.356 %) and the lowest in fruits without any coating (0.240%). Not only the storage period and treatment alone but their interactions have shown significant influence on titratable acid content

Table 1 Total soluble solids (°B) of Snow Queen nectarines as influenced by edible coatings during cold storage

Edible coatings	Storage period (day)					
	0th	7th	14th	21st	28th	Mean
Control	5.167	8.30	11.70	10.50	10.10	9.153
1% CMC	5.033	6.60	10.633	9.466	8.433	8.033
10% GA	5.83	6.13	10.06	9.23	8.14	7.883
12% GA	4.533	5.10	8.220	7.733	7.30	6.577
8% GA	4.80	5.76	9.26	8.60	8.10	7.306
1.5% CMC	4.80	6.40	9.30	8.70	8.30	7.500
Mean	5.027	6.38	9.864	9.038	8.396	

LSD (P=0.05) for Treatment (T) =0.076 ; Storage period (S) = 0.069 and Treatment (T) × Storage period (S) = 0.129

Table 2 Influence of edible coatings on titratable acidity (%) of Snow Queen nectarine at low temperature storage (1±1 oC and 85-90% RH)

Edible coatings	Storage period (day)					
	0th	7th	14th	21st	28th	Mean
Control	0.310	0.275	0.220	0.201	0.192	0.240
1% CMC	0.407	0.384	0.363	0.326	0.299	0.356
10% GA	0.369	0.332	0.303	0.281	0.236	0.304
12% GA	0.331	0.310	0.300	0.273	0.240	0.291
8% GA	0.316	0.290	0.272	0.229	0.209	0.263
1.5% CMC	0.313	0.283	0.242	0.217	0.198	0.251
Mean	0.341	0.312	0.283	0.254	0.229	

LSD (P=0.05) for Treatment (T) = 0.003 ; Storage period (S) = 0.003 and Treatment (T) × Storage period (S) = 0.007

Table 4 Overall acceptability of Snow Queen fruits as influenced by edible coatings during low temperature storage

Edible coating	Storage period (days)					
	0	7	14	21	28	Mean
Control	8	7	5	4	3	5.4
1% CMC	6	7	9	8	7	7.4
10% GA	6	8	8	7	7	7.2
12% GA	6	6	8	7	6	6.6
8% GA	5	7	7	6	5	6
1.5% CMC	6	7.6	6	5	5	5.7
Mean	6.2	7.1	7.2	6.2	5.5	

LSD (P=0.05) for Treatment (T) =0.086; Storage period (S) = 0.078 and Treatment (T) × Storage period (S) = 0.196

of Snow Queen nectarine fruit. The maximum titratable acidity was found in fruits coated with 10% GA (0.407 %) and minimum in fruit packed without any coating (0.192 %).

Ascorbic acid content: The ascorbic acid content in Snow Queen nectarine fruits was significantly influenced by treatment and storage period individually and their interaction as well (Table 3). Irrespective of storage period, treatment significantly influenced the ascorbic acid in nectarine fruit. The highest ascorbic acid was observed in fruit coated with 10% GA (10.25 mg $100g^{-1}$) and the lowest in fruits without any coating (9.31mg $100g^{-1}$). Not only the storage period and treatment alone but their interactions have shown significant influence on ascorbic acid content of Snow Queen nectarine fruit.

Overall acceptability: The acceptability of Snow Queen fruits during low temperature was significantly influenced by treatment, storage interval individually as well as by their interaction. The highest acceptability was found in 1% CMC-coated fruits (7.4) and the lowest in non-coated blueberry fruits (5.4) (Table 4). The overall acceptability score decreased with the increase in storage period, being the highest on 14th day of storage (7.2) and the lowest on 28th day of storage (5.5). The higher overall acceptability score was found in 1% CMC-coated nectarine fruits over the other coatings or control fruits. The findings of Guerreiro *et al.* (2017) who reported that edible coatings improved the sensory quality of apple slices by protecting against microbial spoilage. The eating quality of fruit is mainly judged by sugar acid ratio. Our results showed that coated fruits maintained better sweetness and acidity till the end of storage period. The study is in line with findings of Gol *et al*. (2013) who reported that strawberry when treated with chitosan have shown better organoleptic properties than the untreated ones.

It may be concluded from the present study, that coating of Snow Queen nectarine fruit with 10% GA was most effective in maintaining fruit firmness and overall acceptability than control fruits. However, eating quality attributes were better when nectarines were coated with 1% CMC. Hence, coating of nectarine fruits either with 10% GA or 1% CMC can be recommended to enhance the shelf life of nectarine up to 28 days and maintaining the acceptable fruit quality.

Table 3 Impact of edible coatings on ascorbic acid (mg100g-1 pulp) of Snow Queen nectarine fruits during cold storage (1±1o C and 85-90% RH)

Edible coatings	Storage period (days)					
	0th	7th	14th	21st	28th	Mean
Control	9.890	9.450	9.286	9.053	8.906	9.316
1% CMC	11.147	10.700	10.320	9.756	9.356	10.256
10% GA	11.247	10.990	10.350	9.840	9.316	10.348
12% GA	11.060	10.756	10.176	9.633	9.233	10.172
8% GA	10.937	10.287	10.040	9.520	9.273	10.011
1.5% CMC	9.827	9.640	9.40	9.046	8.833	9.349
Mean	10.684	10.304	9.928	9.475	9.153	

LSD (P=0.05) for Treatment (T) =0.086; Storage period (S) = 0.078 and Treatment (T) × Storage period (S) = 0.196

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