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Effect of gum arabic and fruwash coatings on postharvest quality of summer squash (*Cucurbita pepo*)

PANKAJ KUMAR KANNAUJIA[1], RAM ASREY[2], AWANI KUMAR SINGH[3] and ELDHO VARGHESE[4]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

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ABSTRACT

The present investigation was carried out with the aim to find out the beneficial effects of edible coating on postharvest quality of summer squash (*Cucurbita pepo* L.) under cold storage condition. In our experiments, different edible coatings, viz. gum arabic (5, 10 and 15%) and fruwash were used in order to minimize the excessive moisture loss during postharvest handling and storage. Among the treatments, gum arabic (10%) coating showed better colour retention in terms of Lvalue followed by fruwash treatment. Fruits coated with 10% gum arabic found best for minimizing water loss (more than 50%), respiration rate (≈21%) with higher fruit firmness (7.55 N) as compared with other treatments including control. After 12 days of storage, malondialdehyde content in 10% gum arabic treated fruits (0.141 nmol/g) was recorded significantly lower than control (0.183 nmol/g fruit weight). Highest proline content (235.05 µg/g fruit weight) was recorded in 10% gum arabic while, it was lowest (140.06 µg/g fruit weight) in control. Proline content was ≈68% higher in 10% concentration and ≈30% in 15% gum arabic treated fruit as compared with control after 12th days of storage. Overall 10% gum arabic coated summer squash fruits had better postharvest quality retention characteristics.

Key words: Edible coating, Firmness, Malondialdehyde content, Respiration rate

Summer squash (*Cucurbita pepo* L.) is also known as marrow, chappan kaddu, bush squash etc., is an annual vegetable crop which belongs to Cucurbitaceous family, having a chromosome number 2n=40. Worldwide, it is grown commercially in many countries like USA, China, Europe, India, Japan, etc. Summer squash is main source of carbohydrates, dietary fibers, minerals and many essential vitamins. In India, it is confined to a limited scale in states like Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi and Uttar Pradesh. It is short duration (45–60 days after sowing ready for harvest) vegetables and that is why it is the most popular crop among farmers. Further, owing to short shelf-life and quality deteriorative phenomenon, summer squash cultivation is mainly concentrated in peri-urban areas. Unlike other squashes, it is mostly consumed at an immature stage for culinary purposes before seeds begin to enlarge and harden. The whole tender fruit is edible, without discarding seeds and seed cavity tissues. Thin, soft external rind and glossiness are major indicators of a pre-maturity condition. Among all cucurbits, squashes are highly perishable crop and shelf-life hardly last up to 2–3 days under ambient storage conditions. Loss of firmness and shriveling are serious and common postharvest problems in summer squash postharvest management. It is highly susceptible to chilling injury during cold storage; when stored without any treatment. Its fruit contains 90–95% moisture; due to these traits, there is a high loss of moisture during the short period of storage, which is unacceptable for marketing as well as for consumer preference due to a loss in textural integrity and freshness.

Edible coatings have got wide attention during the recent time due to their many benefits including use as a packaging material, as an alternative to artificial film. Edible coatings are used on produce surface in addition to or as a replacement for natural protective waxy coatings and to provide a barrier to water and oxygen movement from the food surface. Al-Juhaimi *et al.* (2012) reported that gum arabic coated (5, 10 and 20%) cucumber last up to 16 days when stored at 10–25ºC. This treatment also delayed softening of cucumber during storage for 16 days at 10–25ºC.

MATERIALS AND METHODS

The study was carried out at research farm of ICAR-IARI, New Delhi during 2015–16. Fruits of summer squash cultivar Pusa alankar and Australian green were obtained from CPCT farm, Indian Agricultural Research Institute,

Present address: [1]Scientist (pankajkannaujia@ymail.com), Horticultural Crop Processing Division, ICAR-CIPHET, Abohar, Punjab; [2]Principal Scientist (ramu_211@yahoo.com), Division of FS&PHT, ICAR-IARI, New Delhi; [3]Principal Scientist (singhawani5@gmail.com), CPCT, ICAR-IARI, New Delhi; [4]Scientist (eldhoiasri@gmail.com), Fishery Resources Assessment Division, ICAR-CMFRI, Kochi.

New Delhi. Fruwash coating was provided by Dr H M Chawla, Department of Chemistry, IIT, New Delhi. With a view to controlling shriveling in summer squash fruits caused by moisture loss, different surface coatings (Gum arabic and fruwash) were applied at a different concentration of gum arabic (5, 10 and 15%) and fruwash on the freshly harvested fruits at commercial maturity stage. Before coating application, freshly harvested fruits were dipped in hot water having temperature 38ºC for 30 min. Then fruits were air-dried and then different coatings were applied. The coated fruits were then dried and stored at 8±2ºC and 85–90% relative humidity. Physical, physiological and biochemical changes in stored summer squash were recorded at 3 days interval. The experiment consisted of three replications.

Peel colour was measured using Hunter Lab System (model: Miniscan XE PLUS). The colour value was expressed as L value and lightness co-efficient ranges from black = 0 to white =100. Fruit firmness was determined by using a texture analyzer (model TA+Di, Stable Micro Systems, UK), using compression test and expressed in Newtons (N). For the measurement of physiological loss in weight (PLW) in summer squash, the fruits were weighted during storage at regular intervals with the help of an electronic balance and expressed in percentage. Respiration rate of squash fruits was measured by using autogas analyzer (Model: Checkmate 9900 O_2/CO_2, PBI Dansensor, Denmark) and expressed as ml CO_2/kg/h. Lipid peroxidation in terms of malondialdehyde (MDA) production was measured following the method of Eum *et al.* (2009) and results were expressed in nmol/g fruit weight. Proline contents in summer squash fruit were measured by following the method of Bates *et al.* (1973) with some minor modifications and expressed in µg/g fruit weight.

The experiment was conducted under a completely randomized design setup with two factors, viz. five treatments (including control) and five storage intervals. Two-way analysis of variance was performed on the data using PROC GLM of SAS 9.3 software (2014) and significant effects (P <0.05) were noted. Further, a significant difference amongst the means was determined by Tukey's HSD test.

Table 1 Effect of acacia gum and fruwash coating on physical and physiological quality attributes of summer squash

Treatment	Storage days	Colour (Lvalue)	Fruit firmness (N)	Physiological loss in weight (%)	Malondialdehyde (µg/g fruit weight)
Control	0	26.13j	9.63a	0.00a	0.023j
	3	27.08ghi	9.12abc	5.53ghij	0.045h
	6	29.37d	7.17hijkl	9.00cdef	0.082e
	9	32.79b	6.82ijk	13.15b	0.158b
	12	34.41a	5.77l	17.62a	0.183a
Gum arabic (15%)	0	26.13j	9.63a	0.00a	0.023j
	3	26.73hij	9.30abc	2.53l	0.039hi
	6	27.82efg	8.49cde	4.55ijkl	0.064fg
	9	30.00d	7.69efgh	6.58fghi	0.118d
	12	32.30bc	6.76ijk	9.18cd	0.155b
Gum arabic (10%)	0	26.13j	9.63a	0.00a	0.023j
	3	26.46j	9.37ab	2.89kl	0.031ij
	6	27.31fgh	8.77bcd	5.36hijk	0.060g
	9	28.33e	8.26def	7.50defgh	0.118d
	12	29.41d	7.55fghi	9.13cde	0.141c
Gum arabic (5%)	0	26.13j	9.63a	0.00a	0.023j
	3	26.84hij	9.33ab	3.38jkl	0.034i
	6	27.93ef	8.11defg	6.63efghi	0.072f
	9	30.13d	7.40ghi	8.04defg	0.123d
	12	32.79b	6.44kl	10.86bc	0.163b
Fruwash	0	26.13j	9.63a	0.00 a	0.023j
	3	26.73hij	9.35ab	2.94kl	0.036hi
	6	27.75efg	8.09defg	6.86defghi	0.072f
	9	29.58d	7.38ghij	10.71bc	0.117d
	12	31.93c	6.56jkl	11.07bc	0.161b
SEM		0.153	0.151	0.459	0.0016

Means with same superscript letter are not significantly different; SEM=Standard error of means

RESULTS AND DISCUSSION

Peel colour: Irrespective of treatments there is an increase in L value with the progression of storage period (Table 1). L value was found to be significantly (P ≤0.05) affected by gum arabic and fruwash treatments. The rate of increase of L value was found to be highest for control followed by higher and lower concentrations (15% and 5%) of gum arabic (GA). Among the treatments, medium dose of gum arabic (10%) showed the best result followed by fruwash. In respect of L value, up to 6^{th} day of storage, no significant difference was observed among the treatments except in control. Later on, control (34.41) and 5% (32.79) GA treated fruits showed a faster increase in L value compared to other treatments while it was slowest (29.41) in 10% GA followed by fruwash treated summer squash at the end of the storage period of 12 days.

Application of GA @10% has given the best results in terms of fruit colour retention for a longer period of 12 days of storage. The GA is reported to be effective in minimizing PLW and slow down the activities of chlorophyll degrading enzymes like chlorophyllase. The optimum concentration of 10% GA brought about the beneficial impact due to the above given explanation. The lower concentration could not be effective in minimizing PLW and suppressing chlorophyllase enzymes; whereas, a higher concentration of GA might have expressed the activity of polyphenol oxidase enzyme, which is known for colour deterioration in fresh as well as finished products. Our research findings are in agreements with Costa *et al.* (2006) and Hong *et al.* (2012), who worked on broccoli and guava, respectively. However, Ali *et al.* (2011) reported that retention of colour could be due to a slower rate of respiration.

Fruit firmness: That firmness of summer squash vegetable during storage decreased rapidly with the advancement of the storage period in all the treatments (Table 1). The insignificant difference in firmness among the treatments was observed up to 3 days of storage. After that, a marked decrease in fruit firmness was observed in control fruits. However 6 days after storage, higher firmness was recorded in fruits treated with the coating material. At the end of 12th day of storage, highest firmness (7.55 N) was found in 10% GA while it was least (5.77 N) in control. GA (10%) treated summer squash fruits retained ≈31% higher firmness over control.

Application of GA @10% concentration gave the best results in terms of maintaining fruit firmness for a period of 12 days storage. Again it is interesting to note that the lower and higher concentration of GA could not retain better fruit firmness compared to its medium concentration of 10%. The higher firmness in gum arabic and fruwash coated summer squash fruits could be due to the fact that coatings act as a barrier to retain moisture and nutrient loss and lower PLW. The coating can also inhibit the activity of cell wall degrading enzymes, viz. polygalacturonase (PG) and pectin methylesterase (PME) hydrolysis and depolymerization of pectin substances present in the fruits; that can maintain the cell wall composition and retain the fruits more firmly compared with untreated one. Reduction in respiration rate in gum arabic coated summer squash is responsible for delay in fruit tissue softening. Our findings are supported by Yaman and Bayoindirli (2002) and Serrano *et al.* (2006), while they worked on cherries and broccoli, respectively.

Physiological loss in weight: The coating of gum arabic and fruwash has significantly affected the water barrier properties of treated summer squash kept in cold storage (Table 1). Unlike the fruit firmness effect of coating was noticeable on 3rd day and reflected at its peak on 12th day of storage. Again the medium dose of 10% of GA proved the best in respect of keeping the PLW at its low level. On the 12th day of storage highest PLW (17.62%) was recorded under control, while it was about 50% less (9.13 and 9.18%) with 10% and 15% of gum arabic.

Edible coatings of gum arabic and fruwash on summer squash significantly reduced weight loss during storage, which could be due to the hydrophobic components present in the coatings which reduced water vapour permeability of the fruit surface, therefore the movement of solutes and water is restricted. Lower respiration rate of coatings treated fruits might be due to semi-permeable barrier film property of gum arabic coatings which reduced the availability of oxygen and increased the carbon dioxide which could further reduce the metabolic activity of summer squash during storage. Significant variation was observed among the concentration of coatings which could be due to the difference in the coating thickness that is why medium and higher concentration were effective to reduce water loss. However, a higher concentration of coatings has a chance of ethanol production due to low oxygen and higher carbon dioxide production. Our results of experiments are supported

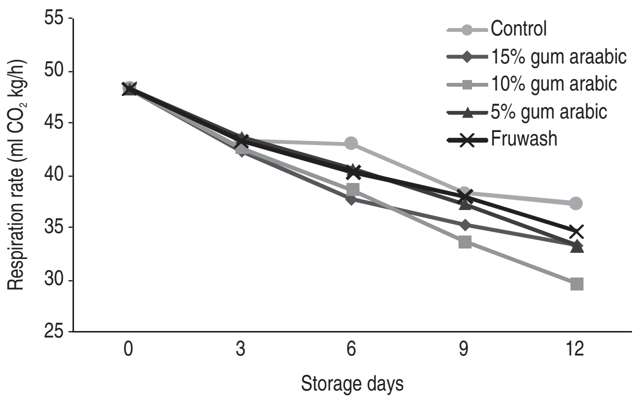

Fig 1 Effect of acacia gum and fruwash coating on respiration rate of summer squash.

by the findings of Yaman and Bayoindirli (2002), Srinivasa *et al.* (2006), Ribeiro *et al.* (2007) and Hernandez-Munoz *et al.* (2008).

Respiration rate: Respiration rate is a major limiting factor which causes lower shelf-life of produce during storage due to the consumption of stored energy resulting in faster senescence. Therefore, it is necessary to check the respiration to prolong the shelf-life. The effect of coating material on respiration rate reveals that all the treatments were effective in reducing the respiration rate (Fig 1). Initially, the treatment effect was least pronounced, but 6th day onward all the coating treatments gave good result to check the respiration rate. At the end of the experiment, among the different treatments ≈21% lower respiration rate was found in 10% GA followed by 10.72% in 15 and 5% GA treated fruits as compared with control.

Edible coatings have semi-permeable barrier film property and have hydrophobic components which could reduce water vapour permeability of the fruit surface, therefore solutes and water barrier property created on the fruit surface which reduces the metabolic activity of summer squash during storage. In our experiments, respiration rate was found least in 10% gum arabic treated fruits followed by a higher and lower concentration of 15 and 5% GA treated fruits as compared with control. The GA coating material might slow down the senescence process by inhibiting the polygalacturonase (PG) enzyme activity of summer squash during storage. Reduction in respiration rate could also be because of higher firmness in coatings treated fruits due to the minimal activity of cell wall degrading enzymes (Yaman and Bayoindirli 2002, Ali *et al.* 2011).

Malondialdehyde content: During storage, a huge amount of free radicals and reactive oxygen species (ROS) are generated in the cell and accumulates thus they harm the cell membrane by the destruction of cell integrity and its structure. Malondialdehyde is one of the final products in the lipid peroxidation process that can severely harm cell membrane. If the cell membrane permeability increases, resulting in an increase of electrolyte leakage rate. The increase of the MDA content can be reduced by using GA and fruwash coating material, thus the cell membrane of summer

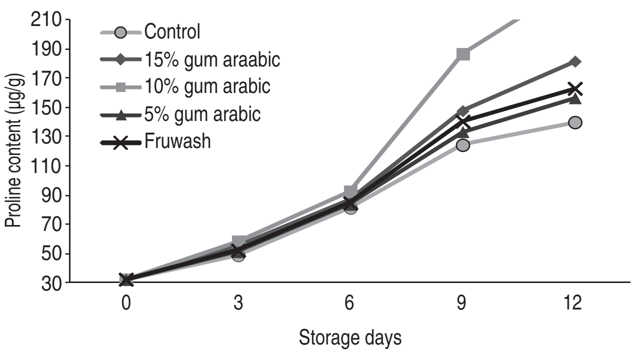

Fig 2 Effect of acacia gum and fruwash coating on proline content of summer squash.

squash vegetable may execute its normal physiological function. The MDA content in summer squash significantly increased 3rd day onward in all treatments during storage (Table 1). The result showed that all coating treatments have lower MDA content as compared with control. At the end of 12th day storage, the MDA content in 10% GA treated fruits (0.141 nmol/g FW) was recorded significantly lower than control (0.183 nmol/g). Other concentrations (15, 5%) of GA and fruwash also produced significantly less MDA content in squashes during the entire storage period.

Reduction in the production of MDA content could be due to the higher antioxidant activity and phenolic content in GA treated fruits. Some authors also suggested that reduced enzymatic activity in coatings applied fruits could be the possible reason for lower MDA content during storage at low temperature. Low-temperature long term storage condition and stage of harvesting also influence the oxidative damage of produce during storage (Hodges *et al.* 2004). Coating of horticultural produce significantly reduced the oxidative damages caused by ROS and MDA content hence, cellular membrane integrity maintained during storage (Xing *et al.* 2011, Hong *et al.* 2012).

Proline content: Proline is a heterocyclic amino acid that protects plant tissue against osmotic stress like chilling injury and other stresses. It is evident from the data depicted in Fig 2 that proline accumulation in the stored summer squash fruit was significantly affected by coating treatment and concentration as well. The proline accumulation showed a definite rising trend with the advancement of storage intervals in all the treatments during cold storage. At the end of the experiment among the different treatments, highest (235.05 µg/g fruit weight) proline content was recorded in 10% GA while it was lowest (140.06 µg/g fruit weight) in control. At the termination of storage on 12th day proline content was ≈68% higher in 10% GA and ≈30% in 15% GA treated fruit as compared with control summer squash.

Proline is a multifunctional amino acid which is synthesized mainly from glutamate in plants under stress conditions. In our experiments freshly harvested summer squash fruits were subjected to hot water treatments at a temperature of 38ºC for 30 min. Therefore, it is presumed that proline was synthesized in fruits during hot water treatments. Gum arabic application @10% retained 68% higher level of proline. Minimum PLW was also recorded with 10% GA in our earlier results which could have helped in regulation of proline metabolism during storage. Choudhary *et al.* (2005) also explained that proline biosynthesis is activated its catabolism during dehydration, whereas rehydration triggers opposite regulation. Furthermore, the catabolic process like respiration and ethylene evolution rate might have also been suppressed by 10% GA application which in turn resulted in higher retention of proline.

Edible coating treatment has a beneficial effect on postharvest quality attributes of summer squash during storage. 10% of gum arabic gave the best result during storage in terms of lower moisture loss, diminuted rate of firmness loss and lower physiological activity, viz. respiration rate. At the end of 12 days storage proline content was ≈68% higher in 10% gum arabic and ≈30% in 15% gum arabic treated fruit as compared with control summer squash. Medium dose of acacia is most suitable for less production of malondialdehyde content compared to its higher and lower doses. Summer squash fruit treated with 10% GA retained higher quality attributes as compared to other treatments.

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