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Effect of Gum Arabic on Quality and Antioxidant Properties of Papaya Fruit during Cold Storage

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Abstract: Coating of papaya fruit (*Carica papaya* L. *cv* Hongkong) with gum arabic (GA) has been found to enhance their shelf-life and postharvest quality. The objective of this study was to determine the effect of gum arabic on the antioxidant activity, physicochemical properties, sensory quality and microbial analysis of papaya fruits. Gum Arabic in aqueous solutions of 5% and 10% was applied as edible coating to green-mature papaya and stored at 13°C±1 for 15 days. The result of the study showed that papaya fruits coated with 10% GA and stored for 7 days had significantly ($P<0.05$) higher antioxidant capacity (TPC, TFC, FRAP, DPPH and ABTS) and sensory evaluation than the sample control or other treated fruits. In general GA affected significantly ($P<0.05$) the physicochemical properties (color, pH, TA, moisture and TSS) in papaya fruit at different concentrations with storage days the highest values were recorded in sample control (untreated) and the lowest values in GA10% and GA5%. In addition, the 10% concentration depicted a significant ($P<0.05$) decrease microbial records when stored with 10% GA. The results suggested that gum Arabic 10% preservative material, could delay the ripening process by inhibiting the respiration rate in the papaya fruit and improves the postharvest quality during cold storage.
Key Words: Papaya, Edible coatings, Antioxidant activity, Postharvest quality.

Introduction

Papaya (*Carica papaya* L.) fruit is a species of genus *Carica* from the family Caricaceae, which is widely disseminated in the tropical areas including Malaysia. Another name for it is common man's fruit and the reason for this is it is nutritious and affordable[1]. Cultivar Hongkong has become important in domestic and export markets. Its sale has some shortcomings such as a brief storage life which is a barrier for its export to faraway markets either by refrigeration or storage in containers. The fruits when ripe become soft so quickly and are they are prone to diseases and injuries due to exposure particularly as a result of low temperatures. After harvest, they soften at room temperature and their shelf life is only about 2 to 3 days[2] . They may be refrigerated for about two weeks on condition the fruits are not that ripe and for a few days at room temperature they can ripen. It is highly perishable and can end up with significant wastage. In addition, the high rate of success when chemical treatments are used also depends on initial spore load, the growth rate of the infection, temperature, humidity and the depth to which chemicals sprayed can penetrate to inside tissues[3]. One of the biopolymers is Gum arabic (GA), extracted from stems of Acacia tree comprising galactose, rhamnose, arabinose and glucoronic acid[4]. When used gum arabic showed some positive results and significantly delayed maturity of cold-stored apples[5]. In a previous study revealed that GA not only enhanced shelf-life but also maintained postharvest quality of repine-green tomatoes for up to 20 days during storage at 20 ^{0}C [6]. The objective of this study is to determine the potential of different concentrations of gum arabic coatings on the shelf life for *(Carica papaya* L. cv. Hongkong). The quality studied included physiochemical properties, antioxidant activity, microbial analysis and sensory evaluation of the fruit at the time of cold storage.

Material and Methods

Material: Papayas (*Carica papaya* L. *cv*. Hongkong) fruit at the mature-green stage of ripening (green with 25% yellow) were obtained from farms at Pusat Flora Cheras, Jabatan Pertanian and Hulu Langat Semenyih, Selangor, Malaysia. Papaya fruits were visually selected for uniformity in size (800–1000 g), colour and free diseases, and transported to the laboratory within 1 h. Before treatment was applied, fruit were washed with tap water min and air-dried at ambient temperature

Preparation of gum Arabic

The optimum concentrations of GA were selected based on previous studies 0, 5% and 10% [7]. It was conducted by dissolving 50 and 100 mg of GA powder in 1000 mL water. The solution was stirred with low heat 40 ^{0}C for 30 min using a hot plate magnetic stirrer, and subsequently the fruits were soaked for 5 minutes and later dried before it was moved to storage places at 13^{0}C±1.

Extraction of antioxidants

Papaya were peeled, cut into 1 cm slices and crushed in a food processor to produce uniform slurries. The slurry was prepared fresh to preserve the extracted antioxidant compounds. In the extraction process, about 1 g of papaya slurries were weighed in universal bottles and 10 mL solvent was added. Solvents used were 50% methanol; samples (papaya slurries with solvents) were then homogenized using homogenizer (T 250, IKA, Germany) at 24,000 rpm for 1 min. All extracted samples were centrifuged by using tabletop centrifuge (MLX 210, Thermo-line, China) at 4750 *g* for 10 min. The supernatants were collected for further analysis.

Total phenol content (TPC)

The determination of antioxidant activity through TPC was carried out according to the method of [8]. About 100 µL papaya extracts was added with 0.5 mL diluted Folin-Ciocalteu reagent. The samples (papaya extracts with Folin-Ciocalteu reagent) were left for 5 min before 1 mL 7.5% sodium carbonate (w/v) was added. The absorbances were taken at 765 nm wavelength with spectrophotometer after 2 hours. Calibration curve of gallic acid was set up to estimate the activity capacity of samples. The result was expressed as mg of gallic acid equivalents per 100 g of fresh sample (mg GA/100 g of FW).

Total flavonoid content (TFC)

The TF content was determined by the colorimetric method as described by[9]. A total 0.5 mL of the extract was mixed with 2.25 mL of distilled water in a test tube, followed by the addition of 0.15 mL of 5% (w/v) $NaNO_2$ solution. After 6 min, 0.3 mL of a 10% $AlCl_3 \cdot 6H_2O$ solution was added, and the reaction was allowed to stand for another 5 min before 1.0 mL of 1 M NaOH was added. The mixture was mixed well by vortexing, and the absorbance was measured immediately at 510 nm using a spectrophotometer (Epoch, Biotek, USA). The results were expressed as milligrams of quercetin equivalents (QE) per 100 g of fresh sample (mg QE/100 g of FW).

Ferric reducing antioxidant power (FRAP)

The determination of antioxidant activity through FRAP was carried out according to the method of [8]. FRAP reagent was prepared fresh using 300 mM acetate buffer, pH3.6 (3.1 g sodium acetate trihydrate, plus 16 mL glacial acid made up to 1:1 with distilled water); 10 mM TPTZ (2,4,6-tris (2-pyridyl)-*s*-triazine), in 40 mM HCLl; and 20 mM FeCl3•6H2O in the ratio of 10:1:1 to give the working reagent. About 1 mL FRAP reagent was added to 100 µL papaya extracts and the absorbances were taken at 595 nm wavelength with spectrophotometer after 30 minutes. Calibration curve of Trolox was set up to estimate the antioxidant capacity of samples. The result was expressed as mg of Trolox equivalents per 100 g of fresh sample (mg TE/100 g of FW).

DPPH Radical scavenging activity

The determination of antioxidant activity through DPPH scavenging system was carried out according to the method of [8]. Stock solution was prepared by dissolving 40mg DPPH in 100 mL methanol and kept at -20°C until used. About 350 mL stock solution was mixed with 350 mL methanol to obtain the absorbance of 0.7±0.01 unit at 516 nm wavelength by using spectrophotometer (Epoch, Biotek, USA). About 100 µL papaya extracts with 1 mL methanolic DPPH solution prepared were kept overnight for scavenging reaction in the dark. Percentage of DPPH scavenging activity was determined as follow: DPPH scavenging activity (%) = $[(A_{blank} - A_{sample}) / A_{blank}] \times 100$. Where A is the absorbance

ABTS assay

The ABTS radical cation was generated by the interaction of ABTS (250 µM) and $K_2S_2O_8$ (40 µM). After the addition of 990 µL of ABTS solution to 10 mL of fruit extract in methanol or 20 mM acetate buffer (pH 4.5), the absorbance at 734 nm was monitored[10]. The following formula was used: Percentage (%) of reduction power = $[(A_{blank} - A_{sample}) / A_{blank}] \times 100$.

Physiochemical properties of fruits

Moisture content was measured by drying sample at 105 ^{0}C overnight in oven Memmert (Germany). Titratable acidity (TA) was determined from 10 ml of sample diluted with 50 ml of water, titrated with 0.1 N NaOH and calculated as percent citric acid. Total soluble solids (TSS) were measured with an Abbe refractometer at 20^{0}C and pH was determined using pH meter using juice extracted directly from pulp. The pulp color was longitudinally determined on four points of each flat side of the fruit using a Minolta CR-300 colorimeter. The (L*) value represented the luminosity of the fruit, where 0 = black and 100 = white but the (a*) value ranged from the negative (green) to the positive (red) scale and the (b*) value ranged from negative (blue) to positive (yellow) [11].

Sensory evaluation

Under different storage settings 5%, 10% GA and untreated (control) for 0, 7, and 15 days respectively, the total samples of papaya fruit were evaluated in terms of the sensory aspect. Hedonic tests were conducted by 30 panelists from the Faculty of Science and Technology at University Kebangsaan Malaysia. It must be noted that the tests were conducted in a sensory laboratory involving six booths for tasting using fluorescent lights equal to daylight. In little plastics labeled with random digital codes fruit samples of fresh papaya were provided. The evaluation comprised the panelists being asked to taste it and encircled the suitable score of the total features in a certain evaluation form. In this study, the hedonic scale was implemented; on a scale of 1 to 7 there were tabulations of scores, where 1 indicates "extremely dislike" and 7 represents "extremely like"[12]. For reliability purposes, distilled water was given to the panelists for them to rinse the mouths between evaluations. The sensory features that were evaluated comprise color, flavor, sweetness, sourness, and overall acceptance

Microbiological analysis

On days 0, 7, and 15, the total plate, yeast and molds counts, and coliform were tabulated. From each treatment three papaya fruits (30 g) were stomached in a sterile stomacher bag. A 10 g aliquot of the blended material was sent to another stomacher bag, mixed with 90 ml buffer peptone water, and the homogenized process lasted for 60 sec. Besides this, ten-fold dilutions were also done in this diluent. Using petrifilms (3M microbiology) MN. , all counts performed Inoculated 3M of total plate count plate (TPC) were incubated at 37 ^{0}C for 24 h; and all 3M yeast and mold count plates were incubated at 25 ^{0}C for 48 h. Colonies were enumerated after incubation, and the results were reported as log CFU/g of sample. Finally, all tests were conducted in triplicates for every treatment and storage interval.

Statistical analysis

Data were expressed as the means of three independent experiments. Statistical comparisons of the results were performed by one-way ANOVA using SPSS ver.19. Significant differences (P<0.05) among the GA concentrations and storage period were analyzed by Duncan 'triplicates range test [13].

Results and Discussion

Total phenolic content and total flavonoids

The maximum amount of total phenolic content and total flavonoids content were observed in 10% gum arabic coated papaya fruit and reached to a peak after 7 days then decreased during the complete storage period 15 days (**Table 1).** However, untreated control and 20% gum arabic coated tomatoes showed a maximum value of total phenolic content and total flavonoids content after 7 days of storage and thereafter, a slow decrease until the end of storage days. While the papaya fruit treated with 10% gum arabic showed a slight but continuous increase in total phenolic content during complete storage period. The increase in total phenolic content is related with the enhancement of antioxidant capacity[14]. Therefore, the maximum amount of total phenolic content total flavonoids content in 10% gum arabic coated papaya fruits mean that those fruit maintained higher amounts of antioxidants than uncoated and fruit coated with higher concentrations of gum arabic. A low amount of total phenolic content and total flavonoids after 7 days in untreated control,and 5% gum arabic coated fruit might be due to the higher rate of respiration which resulted in the loss of total phenolic content and total flavonoids due to the degradation of certain phenolic compounds[15].

Antioxidant activity

The maximum amount of total antioxidant contents in terms of FRAP, DPPH and ABTS was showed in 10% gum arabic coated fruit and reached to a peak after 7 days and then decreased until the end of storage period (Table 1). However, treated 10% gum arabic coated papaya fruits observed a maximum value of FRAP, DPPH and ABTS after 7 and 15 days, respectively, and thereafter, a slow decrease until the end of storage period. It has been shown that the main antioxidants in papaya fruits are carotenoids and phenolic compounds[16]. However, the antioxidant capacity of papaya fruits also depends on several other factors including genetics, cultivar, environmental conditions, maturity stage and storage conditions[15]. In general, a positive correlation has been reported between total phenolic content, total flavonoids and antioxidant capacity (FRAP and DPPH)[17]. The delayed increase in antioxidant activity in papaya fruit treated with 10% gum arabic concentration could be related to the delayed maturity of those fruit as compared to the control and 5% gum arabic coated fruit, and it was completely evident, in a previous study as well where the papaya fruit coated with concentrations of gum arabic slowed down the maturity process by delaying the biochemical and physiological changes occurring during cold storage[18]. In addition, there are other factors such as carotenoids and vitamin C also influences the effectiveness of antioxidants[19].

Table 1: Effect of different concentrations of gum Arabic (GA) on antioxidant activity of papaya fruit after 0, 7 and 15 days 0f storage at 13±1^{0}C, (for each fruit n=3).

Storage days	GA %	TPC mg/100 g FW	TFC mg/100 g FW	FRAP mg/100 g FW	DPPH %	ABTS %
0 day		35.23 ^{e}	32.45 ^{e}	89.34 ^{g}	36.23 ^{e}	52.36 ^{e}
7 days	0	39.65 ^{d}	38.58 ^{c}	132.09 ^{c}	50.40 ^{c}	61.28 ^{c}
	5	43.32 ^{b}	42.20 ^{b}	143.98 ^{b}	53.06 ^{b}	65.82 ^{b}
	10	47.09 ^{a}	45.36 ^{a}	148.70 ^{a}	63.88 ^{a}	68.31 ^{a}
15 days	0	36.35 ^{e}	34.26 ^{d}	112.54 ^{f}	46.23 ^{d}	53.24 ^{e}
	5	38.65 ^{d}	36.12 ^{cd}	117.25 ^{e}	49.15 ^{cd}	58.52 ^{d}
	10	41.79 ^{c}	37.48 ^{c}	121.65 ^{d}	52.18 ^{b}	62.50 ^{c}

$^{a-e}$ Mean with different letters within each column are significantly different (P< 0.05).

Table 2: Effect of different concentrations of gum Arabic on colour of papaya fruit after 0, 7 and 15 days of storage at 13±1^{0}C, (for each fruit n=3).

Storage days	GA%	Flesh Color		
		L*	***a****	***b****
0 day		52.34 [a]	19.84 [d]	26.67 [e]
7 days	0	45.73 [d]	26.57 [a]	32.12[ab]
	5	47.42 [c]	24.12 [b]	28.92 [d]
	10	48.88 [b]	22.00 [c]	32.36[ab]
15 days	0	45.23 [d]	26.54 [a]	33.71 [a]
	5	45.12 [d]	25.52[ab]	30.81[bc]
	10	47.29 [c]	24.35 [b]	29.95[cd]

[a-e] Mean with different letters within each column are significantly different (P <0.05).

Physiochemical properties of fruits

Color is one of the most important visual attributes of papaya fruit. It was observed that the lightness (L*) decreased gradually at the time of storage for both coated and uncoated papaya fruit (Table 2). The findings show that the highest decrease in lightness was seen in 10% GA papaya followed by 5% GA fruit, whereas at the end of the experiment, the fruit which was uncoated without GA maintained their values in terms of lightness. Also, there was a significant (P<0.05) decrease in lightness at the time of the storage. [20]reported that changes in the fruit flesh color of bitter gourd fruit were well pronounced with of decreased in L* values as fruit ripeness progressed. Papaya fruit which was untreated also had high a* and b* values throughout the time of storage on days 0,7 and 15.Besides this , 10% GA showed a steady decrease in L*, a* and b* values corresponding to increased storage time. Untreated ones (control) generally revealed the highest in L*, a* and b* values throughout storage (Table 2). On close examination of the difference in concentration between 10% GA and 5% GA may have resulted in the differences in L*, a* and b* value.

PH, titrable acidity (TA), moisture and total soluble solids (TSS) It was reported that untreated papaya fruit have higher pH content compared with other treatments (Table 3). In keeping significantly high pH (P<0.05), gum arabic treatments 10% GA and 5% GA proved to be better in comparison with untreated fruit. GA treatment GA 5% depicted less noticeable effect in keeping pH content with significant difference (P<0.05), compared to the control sample. The results revealed that for 7 and 15 days of storage there is a significant effect on pH by increasing GA concentration. In papaya fruits, the organic acids are predominantly citric and malic acids. During maturity and storage, the pH increase was due to metabolic processes [18]. Subsequently, it resulted in a decrease of the organic acids. There was a decrease in storage time from 0 days to 15 days of storage period for the titrable acidity values of treated and controlled fruit. In addition, the decrease was significantly (P<0.05) higher in controlled fruits in comparison with treated fruits GA 5% and 10% (Table 3). The (TA) values decreased with storage time in both the coated and uncoated fruits, while a slow decrease was observed with higher gum arabic concentrations. The highest levels of TA were recorded in the control sample after 15 days of storage, while the lowest levels were found in the 10% gum arabic (Table 3). However, 5% gum Arabic coating produced a small change in TA throughout storage. The TA contents decreased at a slower rate with the coatings of concentrations 5% GA. [21-22] reported that in papaya, the chitosan coatings slowed down the changes in titratable acidity, effectively delaying fruit ripening. The products' moisture content on storage is vital for the maintenance of quality. The changes in moisture content of papaya fruit treated with different treatment at different storage days are shown in (Table 3). At the 15 day, it shows that the control sample was significantly (P<0.05) higher (90.14) than other treated samples. In contrast, GA treatments 5% and 10% had the least moisture contents on 7 and 15 days; (88.22, 88.46) respectively, based on [23] whereby they reported a moisture of ripened papaya of 900 ± 30 g kg^{-1}). During the 15 days of storage period, there was an increase in TSS (Table 3). The eating quality of fruit increases as TSS improvements in contents occur. The total soluble solids was significantly (P<0.05) higher in control sample as compared to treated papaya fruits with gum Arabic. It must be noted that the lowest TSS was at the 7 and 15 days of storage in fruits treated with GA 10% (11.33 and 10.33). Besides this, the findings of the present study also revealed that GA5% treatment also lowers the TSS value in comparison to GA5% fruits, which indicate that GA delays the softening process in fruit. [18]

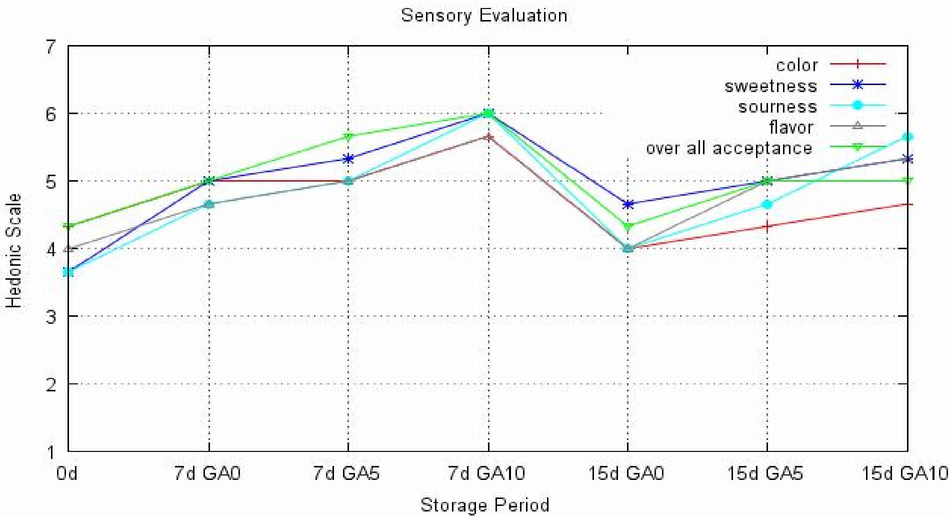
produced similar results in papaya and banana fruit. The reduction in the TSS of gum arabic treated fruit was because of the slowing down of respiration and metabolic activity which slowed down the ripening process as revealed by [24-25]. However, there are numerous confounding factors that could account for this, e.g. the fruit studied, its stage of ripeness, the storage conditions and the thickness of chitosan coatings.

Table 3: Effect of different concentrations of gum Arabic on physiochemical properties of papaya fruit after 0, 7 and 15 days 0f storage at 13±1^{0}C, (for each fruit n=3).

Storage days	GA %	pH	TA%	Moisture	TSS
0 day		5.92 ^{a}	0.11 ^{f}	86.22 ^{g}	9.33 ^{e}
7	0	5.21 ^{f}	0.16 ^{d}	88.30 ^{c}	12.00 ^{b}
	5	5.28 ^{e}	0.16^{de}	87.76 ^{e}	10.66 ^{d}
	10	5.45 ^{c}	0.15 ^{e}	87.62 ^{f}	10.32 ^{d}
15	0	5.38 ^{d}	0.20 ^{a}	90.14 ^{a}	13.00 ^{a}
	5	5.46 ^{c}	0.19 ^{b}	88.46 ^{b}	11.50 ^{bc}
	10	5.60 ^{b}	0.17 ^{c}	88.22 ^{d}	11.33 ^{c}

$^{a\text{-}g}$ Mean with different letters within each column are significantly different (P< 0.05).

Fig 1: Effect of different concentrations of gum Arabic on sensory evaluation of papaya fruit after 0, 7 and 15 days of storage at 13±1^{0}C.



where d is the Storage days, and 0, 5% and 10% is concentration of gum Arabic (GA)

Sensory evaluation

The sensory evaluation results of coated and uncoated fruits are presented in (Fig 1). The results showed significant (P<0.05) differences in taste pulp color, sweetness, sourness, flavour and over all acceptance. The fruits treated with 10% gum arabic attained maximum score by the panelists in all tested parameters. The fruits with 10% gum arabic coating had a gloss and no wrinkles, therefore scoring for pulp colour, which was significantly (P<0.05) higher than the other treated fruit. The fruits with 10% gum Arabic coating also had a good overall appearance but with some wrinkles. [26] showed that 15% gum arabic coated cucumber fruits had better sensory evaluation traits than the control and 5, 10, 15% gum arabic .The most attractive pulp with the characteristic reddish orange color of Hongkong papaya was found in the fruits with 10% gum Arabic, followed by 5% coated fruits, which were significantly (P<0.05) in the pulp colour. There were significant (P<0.05) differences in the sweetness, sourness, flavour and over all acceptance of the fruits with the different coating treatments. The fruits with 10% coating were rated the highest points. The flavour of the fruits with 10% gum arabic coating was rated excellent because the pulp was not only sweet and pleasant, but also possessed a characteristic aroma. The sensory attributes of the papaya fruits treated with 1.5% chitosan concentration demonstrated the overall acceptance, after 7 and 15 days of cold storage. [27] observed that 1.0% chitosan coated mangoes had better sensory traits than the control after 21 days of storage. The 10% GA sample depicted an increase in colour, sweetness, sourness, flavor and over all acceptance), and an increase in pH, higher TA, moisture, antioxidant and acceptable microbial depicting it as the best sample during 7 and 15 days of storage at 13^0C, whereas 5% GA sample was the least acceptable. The findings may vary considerably as they are different from commercial handling and pose different impact on shelf life.

Microbial analysis

The total plate count increasing quantity of colonies in PCA media of papaya fruit of untreated sample revealed that an increase in the quantity of colony after 7 days of storage occurred. In contrast, there was no significant ($P<0.05$) difference between untreated sample (control) and treated with GA 5%. The sample treated with 10% GA revealed a decrease in colony at 7 and 15 day with significant ($P<0.05$) difference as compared to untreated sample and GA treated 5%. It must be noted that in a natural setting, fruit crops produced cannot be expected to be free of microbial agents for a long period of time [18-29]. This may be the samples' antimicrobial effect of gum Arabic resulting in a decrease the number of colony. However going beyond this microbiological limit does not often result in visual defects as both microbiological and physiological activity may be the cause of spoilage of the products [30]. It is possible that exposure to 10% GA was adequate to result in the total populations' inactivity. Thus, papaya fruit coating with 10% GA decrease micro-organisms of the fruit when stored at 13^0C for 15 day of storage.

Table 4: Total plate count, Yeast and molud and Total coliform for papaya fruit treated with different gum Arabic (GA) and stored at 13^0C for 0, 7 and 15 days, (for each fruit n=3).

Storage days	Control	GA 5%	GA 10%
Total plate count(cfu/g)			
0 day	$0.0 \times 10^{6\ Ca}$	$0.0 \times 10^{6\ Ca}$	$0.0\times 10^{6\ Ba}$
7 day	$2.9\times 10^{6\ Ba}$	$2.3\times 10^{6\ Ba}$	$1.1\times 10^{6\ Bc}$
15 day	$3.7\times 10^{6\ Aa}$	$3.9\times 10^{6\ Aa}$	$1.9\times 10^{6\ Ac}$
Yeast and molds(cfu/g)			
0 day	$0.0\times 10^{6\ Ca}$	$0.0 \times 10^{6\ Ca}$	$0.0\times 10^{6\ Ca}$
7 day	$2.1\times 10^{6\ Ba}$	$2.3\times 10^{6\ Ba}$	$1.0\times 10^{6\ Bb}$
15 day	$3.2\times 10^{6\ Aa}$	$3.9\times 10^{6\ Aa}$	$1.7\times 10^{6\ Ab}$
Total Coliform content (cfu/g)			
0 day	$0.0 \times 10^{6\ Ca}$	$0.0\times 10^{6\ Ca}$	$0.0\times 10^{6\ Ca}$
7 day	$2.3\times 10^{6\ Ba}$	$2.1\times 10^{6\ Bb}$	$1.1\times 10^{6\ Bc}$
15 day	$3.9\times 10^{6\ Aa}$	$3.8\times 10^{6\ Aa}$	$2.2\times 10^{6\ Ab}$

$^{A-C}$ Mean with different letters within each column are significantly different ($P<0.05$).
$^{a-c}$Mean with different letters within each row are significantly different ($P<0.05$)

The yeast and moulds untreated (control) papaya fruit depicted an increase in the number of growing yeast and molds colonies after 7 and 15 days of storage, these changes denote significant ($P<0.05$) difference compared to zero day. However, papaya fruit treated with 5% GA and 10%, illustrated a significant ($P<0.05$) decrease in the number of molds and yeast. Samples treated with GA showed decreased of moulds or yeast after storage for 7 days, whereas samples treated with 10% GA showed decrease after 15 days of storage (Table 4). Different GA treatments affected the growth of yeast and mold. Although the number of colony shows slight decrease, the numbers of yeasts and moulds observed were lower than bacteria. However, put forward the idea that possible problems related to health is associated with the moulds present in fruit and vegetables,due tomycotoxins and others which are believed to cause allergies when they can produce large numbers of conidia. Similarly [31] obtained results from samples of fresh and minimally-processed vegetables, and sprouts, where slightly processed carrots revealed a decreased number of colony grow on media following storage.

The total coliform content in the analysis of different types of foods Coliform is used as an indicator for organism[32]. The quality of the food is indicated by revealing the contamination. The development of the total coliform was affected by different chemical treatments. Papaya fruit samples stored without any chemical treatment (control) illustrated an increase in the total coliform growth number after 7 days of storage and these changes showed significant difference (P<0.05) compared to zero or 7 days. Papaya fruit treated with 10% GA showed a significant decrease (P<0.05) in the number of total coliforrn after 7 and 15 days. However, samples treated 10% GA depicted no significant changes. Between day 7 and day 15 samples that were untreated showed significant decrease (P<0.05) in the growth of total coliform (Table 4).

Conclusion

The findings of this study indicate that papaya fruit coated with 10% gum Arabic showed a significant delay in the change of physiochemical properties, antioxidant and antimicrobial activity. In papaya fruit, the use of GA also resulted in lower microbial activities such as total plate count, yeast and molds and coliform and higher antioxidant activity of TPC, TFC, FRAP, DPPH And ABTS during the final stage of the storage. In addition, sensory evaluation revealed that 10% GA coating maintained the overall quality of the papaya fruit during storage. Thus, commercial application of 10% GA can be considered for the maintenance of quality and the extension of shelf life of papaya during storage and marketing.

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