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Pectin from mango peels as edible coating to extend the shelf life of fresh mango

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Abstract The effectiveness of mango pectin derived from mango peels as edible coating to prolong the shelf-life of fresh mangoes was evaluated. Various pectin-based formulations were prepared and coated to freshly harvested mangoes. Coated and uncoated mangoes were stored at room temperature (25-27^{o}C) and chiller (8-10^{o}C). The physico-chemical properties were measured every 3 days up to 12 days and 24 days under ambient and chilled storage, respectively. Under ambient room condition, 2-4% mango pectin solution delayed the fruit ripening, reduced the increase of total soluble solids, texture softening, and prevented signs of disease manifestations in coated mangoes for up to 12 days as compared to uncoated/control mangoes. The uncoated/control mangoes were fully ripe and moderately damaged on day 6. Under chilled storage, mangoes coated with 2-4% mango pectin remained free from visible manifestation of diseases until day 24 with reduced rate of physical and chemical changes, compared with uncoated mangoes which incurred 50% damage and disease development on day 12. Therefore, under laboratory scale experiments, 2-4% pure mango pectin was an effective treatment in extending the shelf-life of fresh mangoes. This technology will help in reducing postharvest losses of fresh mangoes and will make the mango industry competitive in reaching more international markets. Efficacy of the pure mango pectin, under semi-commercial experimental trials, as edible coating to extend the shelf-life of fresh mangoes should be conducted to verify its adaptation.

Keywords*:* Edible coating, Fruit coating, Fruit ripening, Mango, Pectin

Introduction

The Philippines is the seventh largest exporter of fresh mango worldwide valued at U$91M (UN Comtrade, 2016). Major export destinations are Hongkong, South Korea, and Japan.While the country participates in the Mango Global Value Chain, most of the total mango produced amounting to 98% is absorbed by the domestic market. The export market of fresh mango could further expand provided that the quality of Philippine mango could meet the market standards of other countries such as the US, the UK, Canada, etc.

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Failure to comply with quality standards may impair the export growth. Poor postharvest management and lack of packaging technologies aggravated the high postharvest losses and rejection rates which climbed up to 50% (Fernandez-Stark *et al.*, 2017). Introduction of new technologies and protocol to maintain the quality and extend the shelflife of fresh mango are key strategies for generating higher value to position the Philippine fresh mango in the international market or even extend its current position in the domestic markets.

One of the potential solutions to extend the shelf-life of fresh mango is the application of naturally occurring product like pectin as edible coating. Pectins are polysaccharides that are naturally present in fruits and vegetables. Mango processing produced voluminous wastes that can be converted into highly valuable products like pectin. Nguyen *et al.* (2019) reported that mango processing releases large amounts of byproducts consisting of 35–60% of total fruit weight. This fraction includes peels, stones and sometimes parts of perishable pulp. He also reported that as mango peels constitute 15–20% of the fruit weight, the production of mango waste in Vietnam would be between 50,000 and 70,000 tons/year. The peels have high content of polysacchardies (Serna-Cock *et al.*, 2016) while the seeds have high bioactive compounds such as antioxidants, lipids that are free from trans fatty acids, protein with important functional properties (Torres-Leon *et al*., 2016). Serna-Cock *et al.* (2016) further reported, as cited by Torres-Leon *et al*. (2016), that mango peels contain high dietary fiber ranging from 51.2 to 78.4%. The same observation was reported by Gragasin *et al.* (2019).

In the Philippines, Gragasin *et al*. (2019) also reported that mango peels from carabao mango variety are excellent source of pectin containing around 21% pectin. This highly valuable product can be produced from voluminous wastes generated from mango processing plants all over the country. Around 22 million kgs of wastes mango peels are generated annually from mango processing in the Philippines. Disposal of these wastes cause environmental issues because they are dumped in municipal landfills which cause environmental degradation. Girotto *et al*. (2015) reported that these wastes contribute to green house gas emissions. Stricter policy on solid wastes management in the country make the mango processors problematic on how to dispose these wastes. Being totally dependent on imported pectin, utilization of these mango peels for pectin production can produce six folds of the Philippines' total requirements for pectin. Thus, it will help the Philippines in creating a new industry which will redound to job generation and poverty alleviation. This in turn will contribute to the Sustainable Development Goals of reducing poverty and hunger (Torres-Leon *et al*., 2018).

Pectin is used as ingredient in biofilms, edible films, and coatings for foods and pharmaceutical. In particular, pectin has been reported as one of the main raw materials to obtain edible films due to its natural abundance, low cost, and renewable character (Valdes *et al*., 2015; Leon *et al.,* 2020). Edible coatings are currently used in highly perishable foods to protect their nutritional and organoleptic properties as coatings to extend their shelf-life and reduce the negative effects caused by processing, such as enzymatic browning, texture breakdown, and off-flavors development (Falguera *et al.,* 2011; Sanchez-Ortega *et al.,* 2014; Panahirad *et al.,* 2021). Nottagh *et al*. (2020) reported that edible coating acts as a barrier producing modified atmospheres, minimizing respiration rates, reducing moisture exchange, delaying deterioration, controlling microbial growth, and carrying functional ingredients. Torres-Leon *et al.* (2018) showed that by-poducts of mango are suitable for the production of low-cost biodegradable and active packaging that provided less gas transmission thereby causing longer extension of the shelf-life of treated fruits. Chaiwarit *et al*. (2020) found that mango peel waste can be used as a source of pectin and this pectin can be regarded as a potential biopolymer for film formulation as drug delivery systems or edible film for food packaging. Taberner *et al.* (2018) reported that pectin-based coatings formulated with pomegranate alone or in combination with CaAsc significantly reduced firmness loss of persimmon slices during 5 days of storage at 5 ℃ with respect to control samples. In mangoes, pectin-based edible coating are reported to reduce the rate of color development, texture softening, weight loss, carbon dioxide evolution, and acid production thus extending the shelf life of fruits stored at room temperature (Moalemiyan *et al.*, 2011). Likewise, composite coating on avocadoes can significantly reduce the rate of physical, chemical and physiological changes during storage, extending the shelf life of the fruit to over a month at 10˚C (Maftoonazad and Ramaswamy, 2008; Maftoonazad *et al.*, 2007).

Clearly, the use of edible films is a clean, versatile, and sustainable solution in extending the shelf-life of fruits and vegetables. The growing concerns on the accumulation of wastes from mango processing plants and their disposal will also be addressed by converting mango peels into highly valuable product like pectin (Gragasin *et al.*, 2019). As such, the present study investigated the effectiveness of the Philippine Center for Postharvest Development and Mechanization (PHilMech) mango pectin derived from mango peels as edible coating in extending the shelf-life of Philippine carabao mangoes.

Materials and methods

Formulation of pectin-based edible coating

PHilMech mango pectin was produced in accordance to the methods described by Gragasin *et al.* (2019) and used in formulation of pectin-based edible coating. Various formulations of pectin-based edible coatings were prepared in combination with different substances as used by several authors which correspond to the formulations shown in Table 1.

Table 1. Various formulations of mango pectin-based edible coatings

Formulations	**Ingredients**	**Reference**
C	Control, untreated	
F1	3.5% pectin, 0.5% glycerol, 0.05% sodium benzoate, 0.05% potassium sorbate	Treviño-Garza et al. (2015)
F2	2% pectin, 1.5% glycerol, 1% ascorbic acid in 2% calcium chloride solution	Moreira et al. (2015)
F3	3% pectin, 1.35% sorbitol, 1.2% beeswax 1% lecithin	Maftoonazad and Ramaswamy (2008)
F4	4% PHilMech mango pectin	Gragasin and Villota (2018)
F5	1.3% pectin, 0.4 % sorbitol, 0.3% beeswax, 1% lecithin	Moalemiyan et al. (2011)
F6	2% PhilMech mango pectin	Gragasin and Villota (2018)

Sample preparation

Freshly-harvested matured green mangoes of carabao variety aged 110-120 days after flower inductions were purchased from a reputable fruit trader in Manaoag, Pangasinan, Philippines. Each fruit has approximate weight of 200-250g. The mango samples were transported to the laboratory then washed with tap water twice, drained, and air-dried overnight. Damaged and bruised mangoes were excluded. The sorted samples were randomly arranged and assigned with numbers from 1 to 6 corresponding to the number of formulation treatments. Having the same numbers, all samples were aggregated and treated as samples under a particular treatment. The aggregated samples were coated by dipping in prepared pectin-based formulations for 2 mins. The coated samples were drained and air-dried at room temperature (26 ℃) for 1 hour. Uncoated mangoes were used as control samples. Samples were placed in aluminum trays and stored at 8-10 ℃ for chilled and at 25-27 ℃ for ambient storage conditions and allowed to ripen naturally. Temperature and RH were measured using Thermohygrometer (Senzei instruments-SI813, Penjuro Close, Singapore) throughout the storage period.

To monitor the efficacy of treatments in progress during storage period, samples of mangoes were withdrawn at time zero and every three days thereafter up to 12 and 24 days which were the set storage limits under ambient and chilled storage, respectively, for quality analyses.

Quality analyses of mangoes

The fruits were analyzed periodically in terms of their weight loss, texture, color, visual quality, total soluble solids, disease development.

Weight loss (WL) was measured by weighing the fruit at the day of analysis until the fruit is no longer marketable, using the formula:

$$WL (\%) = (Wa – Wb)/ Wa \times 100$$

where Wa is the weight of samples at the beginning of the storage time and Wb is the weight at the day of evaluation.

Textural properties were evaluated using a penetrometer (Shimadzu Table Top Type Tester EZ Test, Japan) equipped with load cell. The fruits were punctured with the puncture probe at constant speed. Force-deformation curves were recorded as the force required to puncture the fruits to describe their firmness.

The color of the fruits' peel and pulp were evaluated using a colorimeter (Konica Minolta, Chroma Meter, CR-400/410, Japan) and measured the L^*, a^* b^* values. Total change in color was calculated to determine the effect of storage period and treatments in color quality.

The change in visual quality or quality deteriation of the fruits during storage was evaluated using the rating scale described by Treviño-Garza *et al*. (2015) as shown in Table 2.

Table 2. Visual quality rating

Visual Quality Rating	Description
5	Completely damage (75-100% of fruit)
4	Severe damage (>50 but <70 % of fruit)
3	Moderate damage (>25 but <50 % of fruit)
2	Slight damage <25 % of fruit)
1	No damage

Discoloration, shriveling, and decay served as the indicators for deteriorative changes in monitoring the visual quality.

Total soluble solids of the fruits were measured using a hand-held refractometer (Atago 391880, Japan). The values were recorded as ^{o}Brix in progress of storage period.

Indicators and manifestations for the development of anthracnose and stem-end rot, the two major postharvest diseases of mango, were monitored daily for samples under ambient condition and every three days for samples in chilled conditions. Disease incidences were evaluated using the severity index rating for anthracnose and stem-end rot (Lizada *et al.,* 1986) as shown in Table 3.

Table 3. Disease development rating

Rating	Anthracnose	Stem-end rot
0	None	None
1	Evident specks on fruit	First evident discoloration on stem end
2	<10% evident symptom	<5% stem end discoloration
3	11-25% of fruit surface infected	6-10% stem end discoloration
4	26-50% of fruit surface infected	>10% stem end discoloration
5	>50 of fruit surface infected	

Analysis of data

Data generated in triplicates were analyzed for multiple comparisons of variance and differences among means were determined with least significant difference (LSD) at 5% level using Minitab 17 statistical software.

Results

Effect of PHilMech mango pectin-based edible coating on the qualities of coated mangoes

Total change in external color (∆E)

The total change in color of the peels of fresh mangoes applied with pectin-based edible coating are shown in Figures 1 and 2. Under ambient condition (Figure 1), the total change in color of uncoated/control mangoes increased significantly with the time of storage. This condition was due to the shift of external color from green to yellow as the fruits ripened. Untreated mangoes were fully ripe at 6th day of ambient storage. It was also evident that the change in color of coated samples was lowest with higher concentration of pectin in the formulation. Pure PHilMech mango pectin alone at 2%

concentration (F6) was very effective in delaying the total change in color of fresh mangoes indicating that the ripening process was retarded with this treatment.

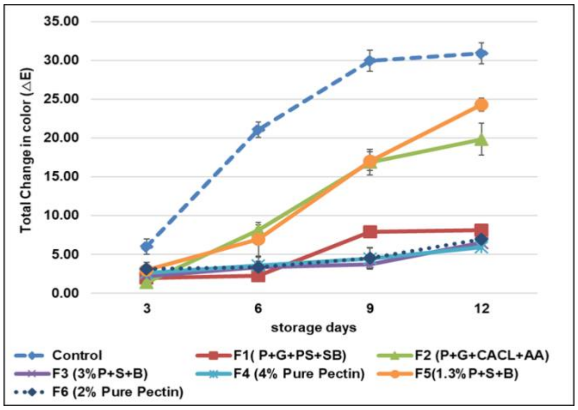

Figure 1. Effect of pectin-based edible coating on the total change in color of mango samples stored under ambient condition

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

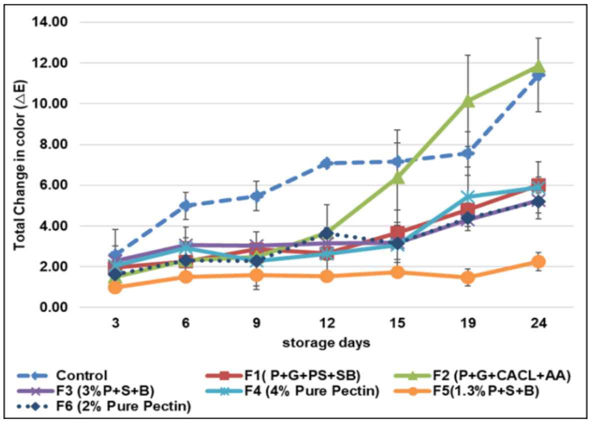

Figure 2. Effect of pectin-based edible coating on the total change in color of mango samples stored under chilled conditions

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Under chilled condition (Figure 2), the total color change in samples was slower in all treatments compared when stored in ambient condition. The color of F5 treated mangoes did not change significantly throughout the storage period followed by F1, F3, F4 and F6. F4 and F6 are pure PHilMech mango pectin at 4% and 2% concentrations, respectively. On the other hand, total change in color was more pronounced in control followed by F2.

Therefore, pure pectin at 2-4% concentration is shown to be very effective in slowing down the change in color of fresh mangoes from green to yellow both under ambient and chilled storage conditions indicating delays in ripening process.

Texture / Toughness

The effects of edible coating on the texture/firmness of mangoes stored under ambient and chilled conditions are shown in Figures 3 and 4, respectively. The forces (N) which described the hardness/softness of mango samples increased at a slower rate with time in all treatments stored in ambient condition but no significant differences were computed as shown in Figure 3.

On the other hand, pectin-based edible coating and chilling condition did not cause softening in mangoes when stored for 24 days under chilled condition regardless of treatments as shown in Figure 4.

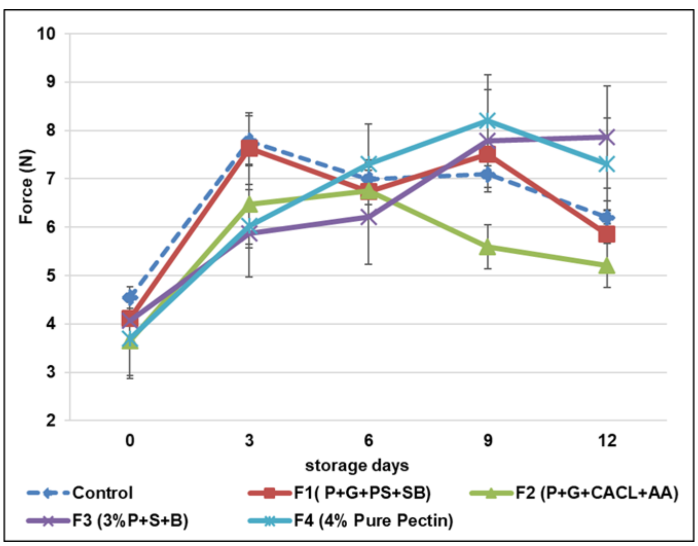

Figure 3. Effect of pectin-based edible coating on the texture of mango stored under ambient conditions

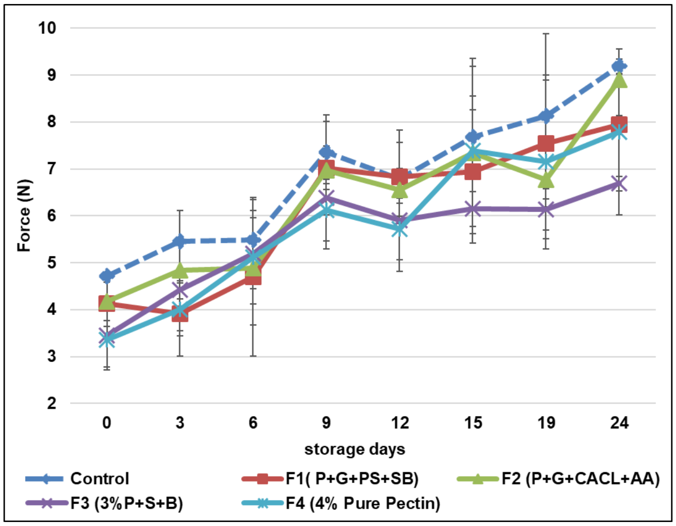

Figure 4. Effect of pectin-based edible coating on the texture of mango stored under chilled conditions

Control (uncoated)**, F1** (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Visual quality

The effects of edible coating on the visual quality rating (VQR) of mangoes stored under ambient and chilled conditions are shown in Figures 5 and 6, respectively. The rating explained the physical damage in mango samples as affected by the treatments with storage time.VQR increased in progress of time which was more prominent in mangoes stored under ambient condition indicating faster quality deterioration (Figure 5). Results of VQR under ambient condition showed that control and F5 samples started to turn yellow with about 50% damaged at day 6 that became severely damaged at day 12. Mangoes coated with F1, F3, F4 and F6 were still good at day 6 but slowly progressed to moderately damaged at day 12. However, mangoes coated with F1, F3, F4 and F6 did not turn yellow until day 12.

The mangoes stored under chilled condition (Figure 6) coated with pectin edible coatings have better visual quality than uncoated ones. VQR increased progressively with storage time in uncoated mangoes indicating progressive loss of quality. Uncoated mangoes were slightly damaged from day 9 and moderately damaged from day 15 to 24 days. VQR of coated samples remained highly acceptable with slight damages on day 24 in the chiller. These data revealed that edible coating delays the visual quality deterioration of mangoes under chilled condition for 24 days.

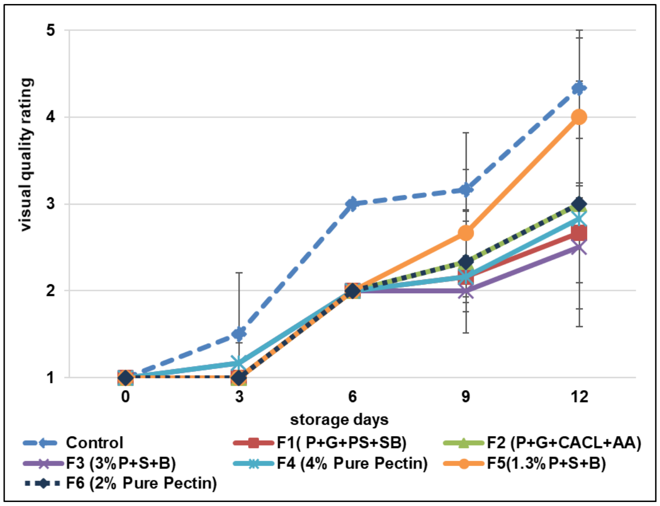

Figure 5. Effect of pectin-based edible coating on the visual quality of mango stored under ambient conditions

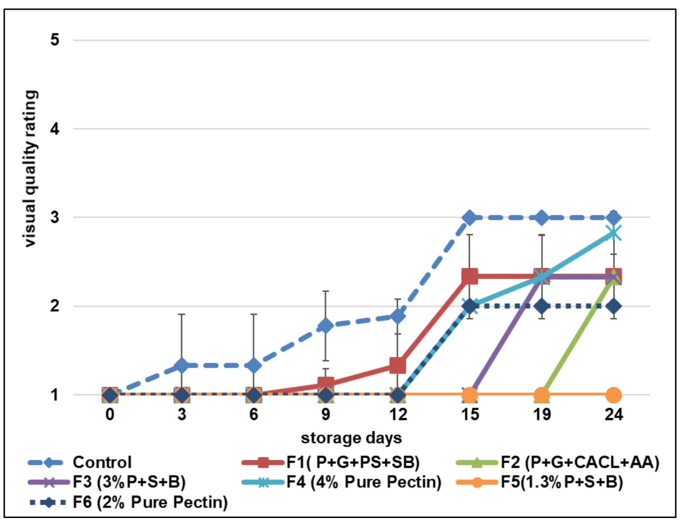

Figure 6. Effect of pectin-based edible coating on the visual quality of mango stored under chilled conditions

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Total soluble solids (TSS)

Total soluble solids (TSS) in ˚Brix is an important maturity index for fruits. Increasing TSS (˚brix) during storage was observed in all treatments both in ambient and chilled conditions are shown in Figures 7 and 8, respectively. It was observed that TSS of samples stored at ambient condition (Figure 7) was higher than samples stored in chilled condition (Figure 8) regardless of treatments. The TSS values leveled off in all treatments from day 9 onwards indicating that the sweetness of mangoes treated with edible coatings was similar with untreated mangoes when they ripen.

Under chilled condition (Figure 8), TSS increased from mature to ripening stages after 12 days. A two-fold increase in TSS of mangoes was observed after 19 days when stored under chilled condition. The increased in TSS was mainly due to the degradation of cell walls and hydrolysis of starch to sucrose in the ripening stage. No significant difference was observed on TSS in all treatments stored under chilled condition although the slowest change was noted on mangoes coated with 4% pure pectin (F4) and 3.5% pectin (F1).

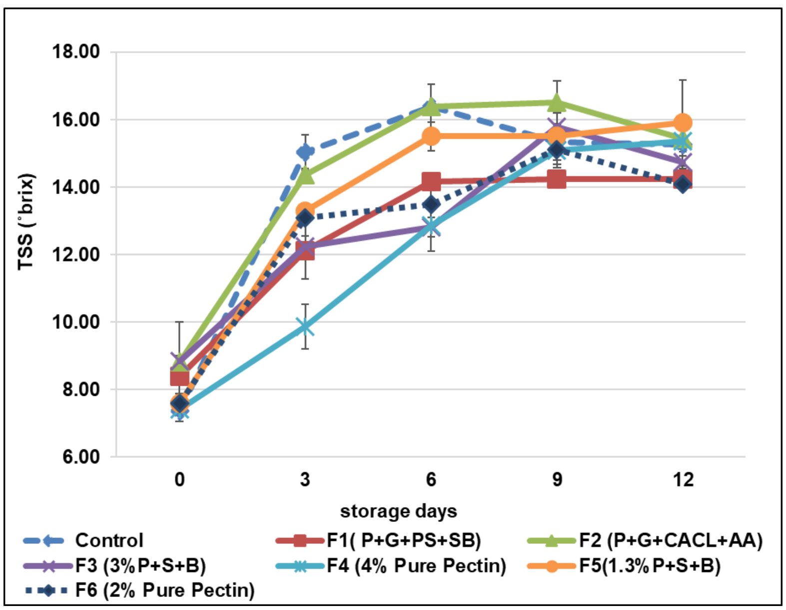

Figure 7. Effect of pectin-based edible coating on the total soluble solids (TSS) of mango stored under ambient conditions

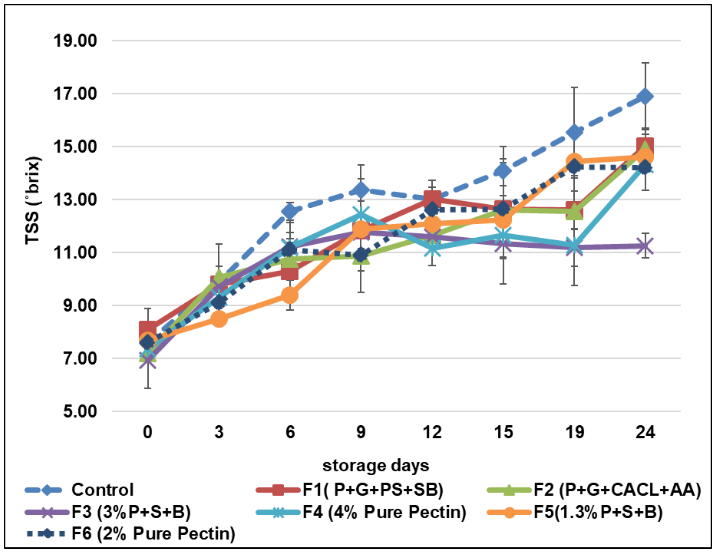

Figure 8. Effect of pectin-based edible coating on the total soluble solids (TSS) of mango stored under chilled conditions

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Development of postharvest diseases

The effects of edible coating on the development of disease in mangoes stored under ambient and chilled conditions are shown in Figures 9 and 10, respectively. Manifestations of stem-end rot and development of specks were monitored until 12 and 24 days under ambient and chilled storage, respectively, using the rating scale as discussed in the methodology. At ambient condition (Figure 9), no visible development of specks was observed in all samples until day 6. However, severe manifestations of diseases were evident in F5 coated mangoes on day 12 which evidently followed by uncoated mangoes while slight manifestations were noted in other treatments except for F4 and F6 (4% and 2% pure PHilMech mango pectin, respectively). Mangoes coated with pure pectin remained free from any disease manifestations until day 12. Therefore, 2-4% PHilMech mango pectin edible coating prevented the development of disease manifestation in fresh mangoes for at least 12 days under ambient storage, doubling the shelf-life of fresh mangoes without coating.

At chilled condition (Figure 10), specks on fruit were only observed in control and F1 treatments at very negligible degree which started to manifest on day 12. Disease manifestation was not observed in all pectin-coated mangoes.

Pectin-based edible coating and chilling therefore played an important role in preventing disease development in stored fresh mangoes.

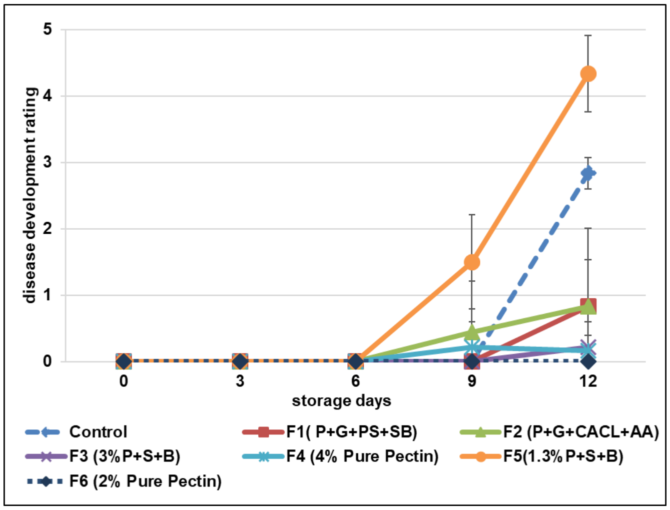

Figure 9. Effect of pectin-based edible coating on disease development of mango stored under ambient conditions

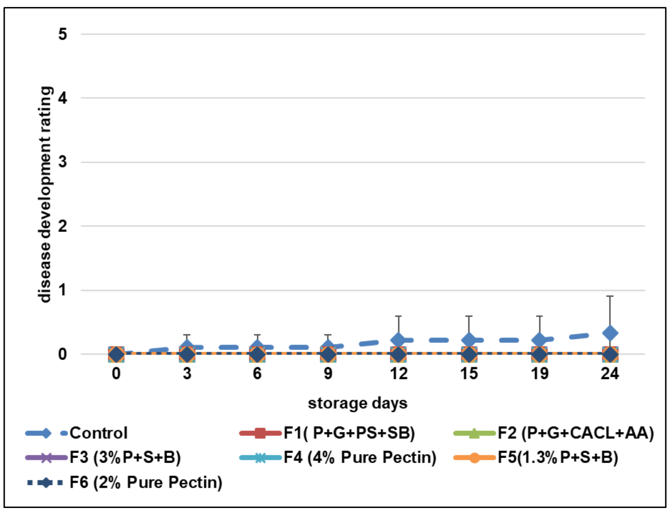

Figure 10. Effect of pectin-based edible coating on disease development of mango stored under chilled conditions

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Discussion

This research provided scientific basis towards the potential of the PHilMech pectin derived from mango peels as source of edible coating that could preserve the quality of fresh mangoes. The mango pectin based edible coating at 2%-4% aqueous concentration delay the ripening and quality deterioration of fresh mangoes (Figures 11 and 12). The occurrence of ripeness indicators was delayed. which included a slower rate of change in color, lesser loss of firmness with storage time, slower rate of quality deterioration in terms of shrivelling, and slower sugar development as manifested by lower concentration of total soluble solids compared with other treatments. The change in color was slower in mangoes coated with 2%-4% pectin based edible coating. This finding was in agreement with the report of Moalemiyan *et al.* (2011) that pectin-based edible coating delays or slows down the change in color of mango from green to yellow. The loss of firmness was least in mangoes coated with 4% PHilMech mango pectin. Jha *et al.* (2011) reported that toughness of the peel increased initially within 2–4 days and thereafter, it declined gradually with ripening period. The same observation was noted in the present study. Quality deterioration in terms of shrivelling was slower in mangoes coated with F1, F3, F4 and F6. It may have been due to reduced gas transmission caused by the edible coating. Baldwin *et al.* (1999) reported that polysaccharide coatings were less permeable to respiratory gases, such as O_2. Pure pectin at 2-4% concentration, therefore, extended the shelf-life of fresh mangoes up to 12 days, doubling the shelf-life if stored under ambient condition. Maftoonazad *et al.* (2007) also reported that pectin-based composite coatings reduced the physical, chemical, and physiological changes in avocadoes during storage, extending the shelf-life to over a month at 10^{o}C. The TSS of samples stored at ambient condition was higher than samples stored in chilled condition, similar to the studies of Girma *et al.* (2016). Moreover, the TSS of mangoes coated with F4 (4% pure pectin) under ambient condition were lower compared with control and other treatments until day 6 manifesting lowest rate of ripening because edible coating served as barrier hampering the gas exchange between the coated fruit and the external atmosphere (Da Silva *et al.,* 2019). Pectin-based edible coating with higher concentration of pectin in the formulation was effective in delaying the increased in TSS under chilled condition, thus lowering the rate of ripening (Moalemiyan *et al.,* 2011). Higher TSS in control samples and other coated samples (F2 and F5) can be attributed partly to water loss and drying of mango fruits. Lower TSS values for coated mangoes were also reported by other researchers (Diaz-Sobac *et al.,* 1996; Srinivasa *et al.,* 2002).

Moreover, manifestations of postharvest diseases such as anthracnose and stem-end rots were delayed and prevented during the observation period.

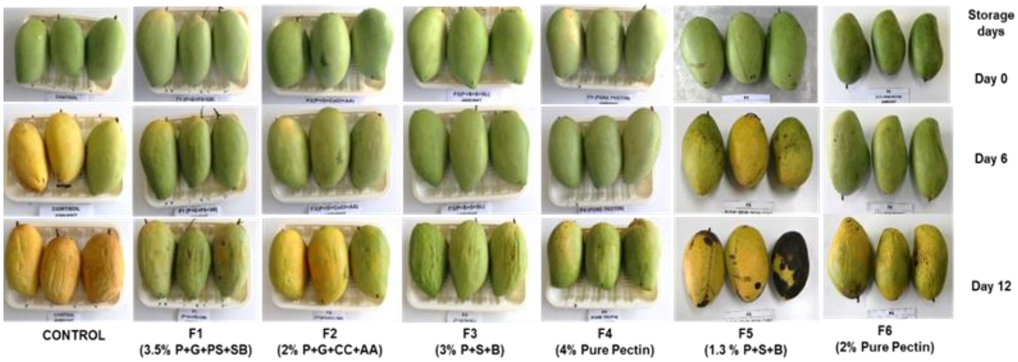

Figure 11. Effect of edible coating on the qualities of mango stored under ambient condition

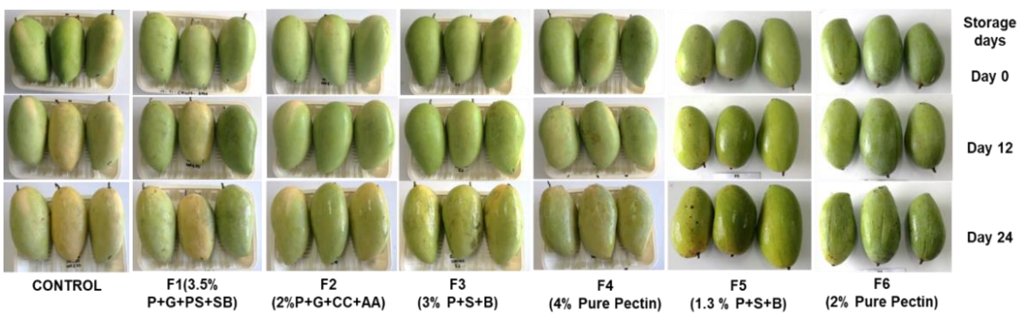

Figure 12. Effect of edible coating on the qualities of mango stored under chilled condition

Control(uncoated), F1 (3.5% pectin;0.5% glycerol;0.05% sodium benzoate;0.05% potassium sorbate)**, F2** (2% pectin and 1.5% glycerol as coating solution; 1% ascorbic acid in 2% calcium chloride as cross-linking solution), **F3** (3% pectin;45% pectin dry basis sorbitol; 40% pectin dry basis beeswax;1% soy lecithin)**, F4** (4% pure pectin)**, F5** (1.3% pectin;28% pectin dry basis sorbitol; 23% pectin dry basis beeswax;1% soy lecithin)**, F6** (2% pure pectin)

Overall results showed that 2-4% pure PHilMech mango pectin demonstrated promising treatments in extending the shelf-life of fresh mangoes. It provided 12 days protection in mangoes stored under ambient condition as compared with 6 days without coating and other pectin formulations. Likewise, this formulation afforded 24 days protection in mangoes stored under chilled condition as compared to 9 days without coating.

This technology in combination with refrigeration/chilling temperature will make the mango industry competitive in reaching other international markets like the US, Canada, and Europe. It is a holistic and regenerative approach to reduce postharvest losses in mangoes during its peak harvest. Utilization of pectin from mango peels generated from mango processing plants will also address the problem on serious environmental depletion through solid waste reduction (Gragasin *et al*., 2019; Girotto *et al*., 2015).

It is recommended to further evaluate the potential of PHilMech mango pectin-based edible coating at commercial scale of operation. It is also concluded that laboratory experiments showed pure PHilMech mango pectin at 2-4% aqueous formulations that could extend the shelf-life of fresh mangoes when stored under ambient or chilled conditions. This technology will help in expanding the position of Philippine mango both at domestic and foreign markets aside from reducing high postharvest losses specially during the peak harvest season.

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