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ORIGINAL ARTICLE

Edible coatings in post-harvest papaya: impact on physical–chemical and sensory characteristics

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Abstract The aim of the present study was to characterize the physical–chemical and sensory attributes of two papaya varieties (Aliança and Golden THB) (*Carica papaya* L.) coated with different solutions of manioc starch and clove essential oil (*Syzygium aromaticum* L. Merr. et Perry). Four different treatments were studied in papaya fruits at ripening stage 1: T0 (control); T1 (fruits coated with a solution of manioc starch); T2 (fruits coated with clove essential oil at 0.175 mL L^{-1}); T3 (solution of manioc starch with clove essential oil—0.175 mL L^{-1}). The physical–chemical and sensory analyses were conducted in the fruits at ripening stage 5. The edible coatings did not influence the physical–chemical characteristics of the two varieties. Those fruits coated with manioc starch reported a good sensory acceptance not differing statistically from the control fruits in the majority of the attributes studied. By evaluating the purchase intention regarding the variety Aliança, all the treatments reported good levels of acceptance, with higher scores in the option "would certainly buy". After the sensory evaluation, treatment T3 reported a purchase intention of 80%. It was concluded that the edible coatings did not influence the physical–chemical characteristics of the fruits, however, they influenced the sensory acceptance of the tasters. For the variety Aliança, the application of treatment T3 is recommended, while for Golden THB, treatments T1 and T2 are recommended due to their similarity to the control.

Keywords *Carica papaya* L. · Manioc starch · *Syzygium aromaticum* L. · Purchase intention · Acceptability

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Introduction

The papaya (*Carica papaya* L.) is a climacteric fruit that matures in a short period of time due to natural biochemical processes (Dantas et al. 2013; Pereira et al. 2006; Ruggiero et al. 2011). Besides its high perishability, inadequate handling, poor storage conditions (Flores-López et al. 2016), and diseases incidence, such as anthracnose, compromise the final quality of the fruit, leading to significant losses due to consumer rejection. Postharvest operations that extend the fruit shelf-life should be implemented and several technologies are used to meet such purpose: modified atmosphere packaging, preservatives, irradiation and ozone radiation, application of films and coatings, and edible films (Kumari et al. 2017).

Edible coating is defined as a thin and uniform layer that is applied directly on the surface of the food. It is mainly composed of polysaccharides, proteins, and lipids (Guerreiro et al. 2017; Sanchís et al. 2016), edible components which are applied or formed directly onto food by spraying or immersion in accordance with good manufacturing practices (Hassan et al. 2018; Salgado et al. 2015).

The films extend the shelf life of vegetables at postharvest by protecting them from atmospheric variables, limiting the movement of the volatile components (Kumari et al. 2017) and humidity (Alali et al. 2018; Marquez et al. 2017), minimizing the adverse chemical reactions, and reducing the deterioration and microbial contamination

(Hashemi et al. 2017; Marquez et al. 2017; Tavassoli-Kafrani et al. 2016; Thakur et al. 2018). Other beneficial characteristics of coatings are their edibility and biodegradability (Tavassoli-Kafrani et al. 2016), the reduction of environmental pollution, and the commercialization of food without preservatives (Kumari et al. 2017).

Manioc starch is a biodegradable material of renewable origin, that has been studied in recent years as a coating for vegetables, either alone or associated with other compounds. According to Oliveira et al. (2015a), the films made from manioc starch are resistant, transparent, efficient barriers to water loss, and they present an intense brightness which confers a commercial attractive appearance to vegetables. Serpa et al. (2014) further complement that because they are from a natural source, their application does not require a safety period nor causes damage to the environment or human beings.

The clove (*Syzygium aromaticum* L. Merr. et Perry) is a condiment long used as a food additive and recognized as safe by the US Food and Drug Administration (Kheawfu et al. 2018). The essential oil extracted from the floral buds has been reported as promising in the control of microorganisms that cause postharvest diseases (Fialho et al. 2015; Mangany et al. 2015; Santamarina et al. 2016; Sharma et al. 2017), probably due to the presence of molecules such as eugenol and others in the oil. According to Sivakumar and Bautista-Baños (2014), essential oils containing a high percentage of phenolic compounds report higher antimicrobial properties, acting directly over the cellular metabolism, affecting the mycelial growth and germination of spores.

Associating an antimicrobial agent, such as clove essential oil (CEO), with the manioc starch solution (MSS) can increase the coating effectiveness in postharvest preservation. For instance, when studying the association of cinnamon essential oil with gum arabic, Maqbool et al. (2011) concluded that the coating acted as a biofungicide against the phytopathogen responsible for the anthracnose of banana and papaya fruits. Also, Zillo et al. (2018) observed that the severity of anthracnose is reduced when papaya fruits are coated with an association of carboxymethylcellulose and *Lippia sidoides* essential oil, preserving the fruit characteristics during post-harvest. The main challenge, however, lies in promoting the conservation of the fruit without changing its natural characteristics. In this sense, the objective of this study was to evaluate the sensory acceptance and physical–chemical characteristics of papaya fruits coated with different mixtures of manioc starch with clove essential oil.

Materials and methods

Fruits collection

The papaya fruits, from the varieties Golden THB and Aliança were respectively obtained in the municipalities of Mucuri and Eunápolis (Bahia state, Brazil). The fruits were harvested at maturation stage 1 (up to 15% of yellow surface) and with absence of superficial defects of fungal growth. All fruits were washed in running water, sanitized in a sodium hypochlorite solution (100 ppm) for 10 min, rinsed with running water and left to dry at room temperature.

Extraction of clove essential oil

The floral buds of clove were obtained in the municipality of Valença. The exsiccate used for the identification of the species was deposited in the Herbarium of the Universidade Federal do Recôncavo da Bahia (UFRB) under the registration number Hurb 14874. The extraction of the CEO was carried out according to the methodology described by Brito et al. (2018).

Preparation of coatings and application of the treatments

The formulation of the edible coating based on manioc starch (MSS) was prepared by dissolving 2.25 g of starch powder in 100 mL of distilled water, with agitation at 80 °C to achieve a complete homogenization of the solution. The fruits were randomly divided into four groups of 20 papaya fruits and submitted to the following treatments: T0—control (fruits without coating); T1—fruits coated with MSS at 2.25%; T2—fruits coated with CEO at 0.175 mL L^{-1}; T3—fruits coated with MSS with CEO at 0.175 mL L^{-1}. The fruits from treatments T1 and T3 were immersed in the coating solutions and the excess was drained. The treatment with pure essential oil was sprayed with the aid of a manual sprinkler until full surface coverage. The sprayed fruits were air dried, placed in plastic trays and stored at room temperature (25 °C ± 2 °C) at 75 ± 2% of relative humidity until they reached maturation stage 5 (> 75% of yellow surface), which is when the physical–chemical and sensorial analyses were carried out.

Evaluation of fruits quality

After the application of the coatings, the fruits were weighed daily so as to determine the loss of mass during storage. Upon reaching maturation stage 5, for each treatment studied, three independent samples, composed of 10 fruits each, were shredded to form a homogeneous sample. The following physical–chemical parameters were evaluated according to the methodologies described by IAL (2008): color of pulp, with a Minolta CR-400 colorimeter (Konica Minolta) using CIELAB scale (L*, a*, b*, c* and h*); the pH, using a digital potentiometer (Phtek digital pH meter, model PHS-3B); titratable acidity (expressed as % of citric acid); soluble solids, in a digital refractometer (Biobrix refractometer); total carotenoids (μg g^{-1}); vitamin C (mg 100 g^{-1} of ascorbic acid); reducing sugars, and total sugars (% of glucose).

Sensory analysis

The research project was previously approved by the Research Ethics Committee (registered under number 980.536) because it involves research with human beings. Untrained tasters (n = 80), consumers of papaya among employees and collaborators of Embrapa Madioca Fruticultura and UFRB, participated in the evaluation.

The profile of the consumers taking part in the tests was obtained through a questionnaire composed of questions concerning gender; age group; level of education; monthly family income; fruit preference level; frequency and form of consumption; preferred variety, size and maturation stage for consumption and purchase, and the factors they considered important for the purchase and consumption of fresh papaya. Subsequently, the tasters evaluated the fruits displayed on a bench simulating market conditions, and assigned a mark to the appearance of the fruits (hedonic scale of 9 points) and their intention to buy (5-point scale). Then, in the sensory booths, they received two slices of papaya (20 g), coded with a random three-digit number, accompanied by water to clean the palate. Global acceptance was assessed through the 9-point verbal hedonic scale ranging from "I like it very much" to "I greatly dislike it"; the 5-point scale used for the intention to purchase, which varied from "I would certainly buy" to "I would certainly not buy", and the diagnosis of the attributes using a structured scale of 9 points based on intensity, according to the methodology applied by Araujo et al. (2016).

Statistical analyses

The results of the physical–chemical analyses and the sensory acceptance test were submitted to an analysis of variance (ANOVA) and a comparison of the means through the Tukey test at 5% of probability, using the statistical program R (The R Foundation for Statistical Computing, 2013, version 3.0.1). The frequency results of the hedonic scores were expressed as percentages.

For the analysis of consumer data, the Friedman test was applied and the Newell and MacFarlane table was used to observe the minimum significant difference ($P < 0.05$) for the questions concerning the order of importance of the factors considered to be important to "consume" and "buy" the papaya (1 for what was considered "most important" and 5 for what was considered "least important").

PCA was performed using the SPSS software, version 20.0 (IBM Corporation, New York, USA). It was applied as an unsupervised technique for reducing the number of variables (6 variables corresponding to fruit appearance, pulp appearance, pulp color, flavor, aroma, and texture) to a smaller number of new derived variables (principal component or factors) that would adequately summarize the original information, i.e., the application of different edible coatings in papaya fruits from Aliança and Golden THB varieties.

Moreover, it allowed recognizing patterns in the data by plotting them in a multidimensional space, using the new derived variables as dimensions or principal components (PC).

Results and discussion

Impact of edible coatings in the physical–chemical composition of papaya

It is important to understand whether the application of edible coatings in fruits alters their physical–chemical characteristics. In the present work, the application of different edible coatings did not induce significant changes ($P > 0.05$ for all the parameters evaluated) in the pH, acidity, soluble sugars, ascorbic acid, carotenoids, reducing sugars, total sugars, or color parameters (L*, a*, b*, c*, and h*) of the papaya varieties tested (Table 1). Since the edible coatings were applied on the fruits surface, no interactions with the pulp occurred. Several studies also highlight the inert effect of edible coatings in the chemical composition of several fruits. Thakur et al. (2018) applied rice starch edible coatings in plums and did not observe significant differences in the amount of soluble sugars or acidity during storage. Choi et al. (2016) also observed the same result in plums when applying hydroxypropyl methylcellulose associated with oregano and bergamot essential oils. These authors noticed that the soluble sugars increased during storage, however, in the last day assessed, the results of all treatments were similar (Choi et al. 2016). Regarding works carried out with papaya, Oliveira et al. (2015b) evaluated the physical–chemical characteristics with the application of different edible coatings and verified changes in the ascorbic acid and total soluble sugars.

Table 1 Physical–chemical parameters of papaya fruits submitted to different edible coatings (mean ± standard deviation; n = 3)

Variety	Treatment*	pH	Acidity (% of citric acid)	Soluble solids (°Brix)	Ascorbic acid (mg 100 g^{-1})	Carotenoids (µg g^{-1})	Reducing sugars (% of glucose)	Total sugars (% of sacarose)	L*	a*	b*	c*	h*
Aliança	T0	5.23 ± 0.26	0.09 ± 0.02	11.52 ± 1.58	58.74 ± 10.3	30.77 ± 7.38	9.28 ± 1.06	8.36 ± 1.29	56.91 ± 5.66	22.50 ± 1.72	42.75 ± 2.44	49.34 ± 0.86	60.44 ± 4.02
	T1	5.46 ± 0.21	0.09 ± 0.04	11.61 ± 1.30	61.93 ± 6.05	28.71 ± 8.06	10.61 ± 0.91	9.82 ± 1.54	54.35 ± 4.09	22.53 ± 1.99	39.32 ± 0.89	46.80 ± 1.11	57.70 ± 4.46
	T2	5.54 ± 0.27	0.10 ± 0.03	11.07 ± 1.60	58.08 ± 6.93	30.26 ± 7.06	9.45 ± 0.94	8.46 ± 1.80	56.99 ± 3.04	21.43 ± 4.37	40.10 ± 2.86	45.91 ± 4.26	61.36 ± 4.93
	T3	5.65 ± 0.20	0.10 ± 0.03	11.32 ± 1.43	60.49 ± 7.41	31.73 ± 12.3	10.14 ± 0.96	8.74 ± 2.08	54.55 ± 3.55	21.59 ± 3.53	39.57 ± 0.87	46.33 ± 2.37	58.96 ± 5.47
	CV (%)	4.31	27.62	13.01	13.10	29.47	9.82	19.25	7.54	14.09	4.89	5.38	7.97
Golden THB	T0	5.39 ± 0.18	0.08 ± 0.02	10.23 ± 0.91	64.52 ± 7.31	27.51 ± 2.21	8.03 ± 0.35	7.65 ± 0.79	60.81 ± 1.07	23.30 ± 3.49	42.69 ± 1.82	47.77 ± 1.47	63.33 ± 1.33
	T1	5.63 ± 0.11	0.07 ± 0.01	10.66 ± 1.15	61.62 ± 3.33	25.88 ± 1.08	8.46 ± 0.31	7.85 ± 1.74	60.11 ± 3.44	24.60 ± 3.81	42.30 ± 3.55	47.71 ± 0.37	62.59 ± 2.44
	T2	5.59 ± 0.20	0.08 ± 0.01	10.71 ± 1.28	66.00 ± 7.42	30.67 ± 2.28	8.58 ± 0.49	8.10 ± 1.39	58.30 ± 1.80	22.63 ± 2.59	42.37 ± 2.56	47.74 ± 2.75	62.58 ± 1.31
	T3	5.60 ± 0.16	0.07 ± 0.01	10.80 ± 1.35	65.21 ± 6.50	25.87 ± 5.62	9.13 ± 1.25	8.52 ± 2.08	58.42 ± 2.89	25.22 ± 2.85	40.63 ± 1.87	46.76 ± 1.29	60.51 ± 3.45
	CV (%)	2.99	20.75	11.17	9.89	11.90	8.32	19.58	4.17	13.46	4.61	3.57	3.71

Within the same column, mean values with the same letter do not differ statistically ($P > 0.05$)

*T0—control; T1—fruits coated with a solution of manioc starch; T2—fruits coated with clove essential oil; T3—fruits coated with a solution of manioc starch with clove essential oil

Nevertheless, the ratio soluble sugars/titratable acidity did not change (Oliveira et al. 2015b). Zillo et al. (2018) studied papaya fruits coated with carboxymethylcellulose associated with *Lippia sidoides* essential oil and verified that the coatings modified the post-harvest parameters when compared to control fruits after 5 days of storage.

Other works point out significant differences in the physical–chemical composition of different fruits with the application of edible coatings: strawberries coated with carboxymethylcellulose and garlic essential oil (Dong and Wang 2017); pomegranates with flaxseed gum and lemongrass essential oil (Dong and Wang 2017); raspberries coated with pectin and alginate rich in essential oils (Guerreiro et al. 2015), and different plum cultivars coated with alginate (Valero et al. 2013).

The results obtained are important, since regardless of the coating applied, it will ensure that the natural physical–chemical characteristics of the fruit will be preserved. However, this needs to be explored also from the sensory perspective, in order to verify if the application of edible coatings will influence the preference of consumers.

Characterization of the untrained tasters and papaya consumption habits

Prior to the sensory analysis of the papaya fruits with different edible coatings, we characterized the untrained tasters regarding socio-economic parameters and their consumption habits and preferences regarding papaya fruits.

The sample of untrained tasters was composed of 80 subjects. Forty-two percent of the tasters were male and 58% were female. The majority were between 18 and 25 years old (61.7%). Regarding their education level, 30.9% had completed their Higher Education degree, while 46.8% were still attending or completing it. The general consumer of papaya has a family income ranging from 1 to 5 minimum wages (the value for 2019 is R$ 998 per month—Brazilian currency). They prefer to consume medium-size fruits (62.8%), 35% at maturation stage 3 (up to 50% of the fruit surface yellow) and 28% at maturation stage 4 (between 50 and 75% of the fruit surface yellow). In these maturation stages (3 and 4), there are several biochemical processes which increase the sweetness of the pulp, as well as the production of volatiles, also improving the texture and taste of the fruits (Galo et al. 2014; Santana et al. 2004).

From the inquired tasters, 37.6% like papaya, while 33.3% really like the fruit, only 6.5% of the inquired answered "Not like or dislike". Only 6.5% of the tasters assumed to consume papaya daily, while the majority (31.2%) consume the fruit sporadically and 23.7% fortnightly. Papaya fruits are largely consumed *in natura*

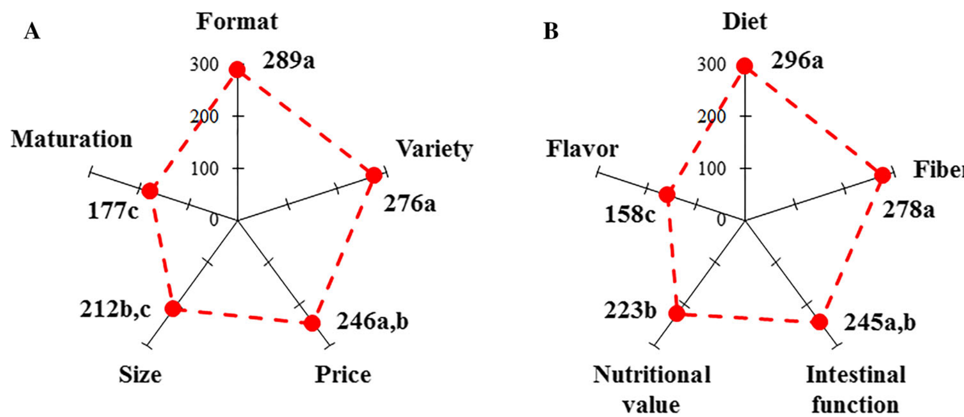

Fig. 1 Factors considered in the purchase of papaya fruits (**a**) and papaya pulp (**b**). The results are expressed as the sum of the scores (maximum score of 400) given by the untrained tasters (n = 80)

Table 2 Acceptance of the sensorial attributes of the papaya fruits submitted to different edible coatings

Variety	Treatment*	Fruit appearance	Pulp acceptance	Pulp color	Pulp aroma	Pulp flavor	Pulp texture in mouth
Aliança	T0	7.84 ± 1.24a	7.21 ± 1.56a	5.10 ± 1.87ab	4.12 ± 1.98ab	5.23 ± 1.88ab	5.08 ± 1.71a
	T1	6.43 ± 1.64b	6.91 ± 1.73a	4.91 ± 1.65b	4.21 ± 2.04a	5.14 ± 1.96b	4.21 ± 1.71b
	T2	6.92 ± 1.33b	6.35 ± 1.51b	4.41 ± 1.76b	3.35 ± 1.82b	4.35 ± 2.03b	4.55 ± 1.85ab
	T3	6.77 ± 1.07b	7.36 ± 1.61a	5.77 ± 2.00a	4.64 ± 2.26a	6.14 ± 2.16a	4.35 ± 1.93ab
	CV (%)	18.09	19.68	32.31	41.83	38.73	36.50
Golden THB	T0	7.87 ± 1.08a	6.87 ± 1.82a	4.81 ± 1.85a	3.90 ± 2.10	4.84 ± 1.85	3.59 ± 1.58b
	T1	6.96 ± 1.07b	6.52 ± 1.58a	3.81 ± 1.63b	3.75 ± 1.92	5.03 ± 2.14	4.90 ± 1.49a
	T2	6.09 ± 1.35c	6.53 ± 1.68a	3.87 ± 1.35b	3.81 ± 1.89	4.75 ± 2.08	4.15 ± 1.36ab
	T3	6.48 ± 1.20c	5.40 ± 2.06b	3.50 ± 1.56b	4.09 ± 2.16	4.43 ± 2.29	4.90 ± 1.95a
	CV (%)	14.35	23.75	35.67	44.80	36.80	34.35

Within the same column, mean values with different letters differ significantly ($P < 0.05$)

*T0—control; T1—fruits coated with a solution of manioc starch; T2—fruits coated with clove essential oil; T3—fruits coated with a solution of manioc starch with clove essential oil

(57.7%) but they are also included in fruit salads (25.4%) and in juices and vitamins (14.6%). Only 1.5% of the inquired tasters consumed the fruit in the form of sweets. The consumption of fruit *in natura* is also corroborated by the study conducted by Cazane et al. (2010).

On a scale of 1 to 5, the tasters were asked to order from the most to the least important factors that influence the fruit (Fig. 1a) and pulp (Fig. 1b) purchase. Regarding fruit, the factors format and variety were the most important (289 and 276 points, respectively), significantly higher ($P < 0.05$) than size and maturation stage (212 and 177 points, respectively) (Fig. 1a). Regarding the purchase of papaya pulp, the tasters considered diet and fiber as the most important factors (296 and 278 points, respectively), While the least important factors were the nutritional value and flavor (223 and 158 points respectively) (Fig. 1b).

Sensory analysis of papaya fruits with different edible coatings

Papaya fruits from both varieties and with different edible coatings were evaluated regarding fruit appearance, pulp appearance, color, aroma and flavor, as well as pulp texture in the mouth. The results obtained are reported in Table 2, and they point towards variations according to the variety and the edible coating applied. Regarding fruit appearance, the control samples (T0) reported higher sensory scores in both varieties (7.84 for Aliança and 7.87 for Golden THB). T0 scores were significantly higher than those reported in all the edible coatings studied. In the variety Aliança, T1 (fruits coated with a solution of manioc starch) received the lowest scores, while in Golden THB, it was T2 (fruits coated with clove essential oil) that received the lowest scores. The same trend was observed in the pulp appearance, but only in Golden THB (Table 2). In the Aliança variety the pulp from the fruits treated with T3 (fruits coated with a solution of manioc starch with clove essential

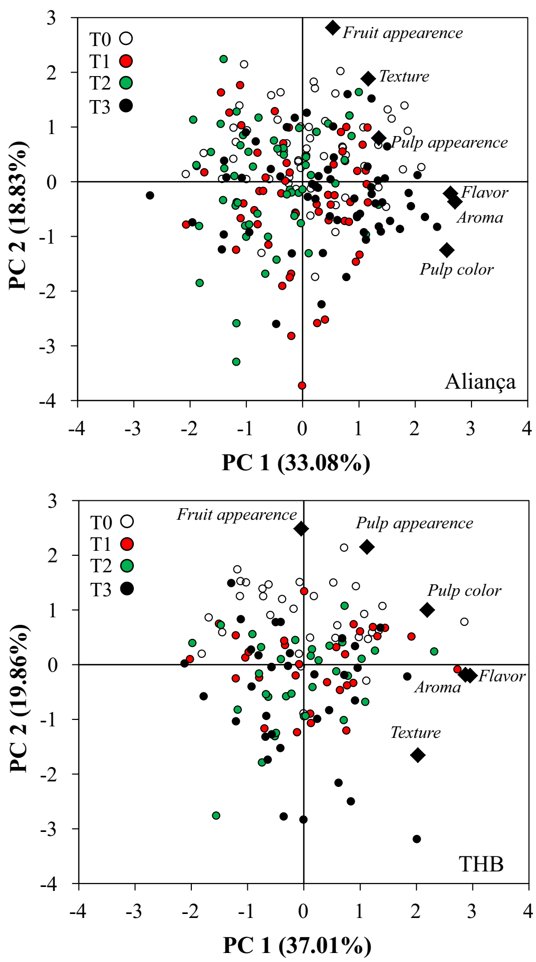

Fig. 2 Internal preference map obtained by PCA of individual untrained taster preference scores for the sensory parameters of Aliança and Golden THB papaya fruits submitted to different edible coatings (T0—control; T1—fruits coated with a solution of manioc starch; T2—fruits coated with clove essential oil; T3—fruits coated with a solution of manioc starch with clove essential oil). The PCA components explain 51.91% (Aliança) and 56.87% (Golden THB) of the total variance

oil), reported a higher pulp acceptance (7.36), nevertheless, but with no significant differences compared to T0 (7.21). In Aliança, only T2 reported a significantly lower score regarding pulp acceptance (6.35). This aspect could be directly related to the pulp color, despite no significant differences were reported (Table 1). In Aliança, T3 reported higher scores in pulp color compared to the remaining treatments. However, in Golden THB, the same treatment (T3) reported the lowest scores (3.50), which clearly highlights the impact of variety. Regarding pulp aroma and flavor, in the Aliança variety, again, T3 received higher sensory scores (4.64 and 6.14, respectively). In the pulp from the Golden THB variety, higher scores regarding aroma and flavor were obtained in treatments T3 and T1, respectively (Table 2). However, in this variety, the differences among treatments were smaller than those in the pulp from Aliança. Regarding pulp texture in the mouth, T0 reported higher sensory scores in Aliança pulp (5.08), while in Golden THB pulp, T1 and T3 reported higher scores (4.90). Some authors previously reported important differences in the texture of strawberries, for instance, with the application of edible coatings (Shahbaz 2018). Other authors reported changes in the flavor, pulp color and general acceptance of papaya fruits coated with ginger oil and gum arabic (Ali et al. 2016).

Preference and purchase intention of the untrained tasters

From the results obtained in the sensory analyses, we created an internal preference map of the untrained tasters per variety (Fig. 2). The principal component analysis (PCA) obtained from Aliança and Golden THB varieties allowed explaining, respectively, 51.91% and 56.87% of the total variability. It is clear that T0 fruits from Aliança were preferred regarding both fruit and pulp appearance, as well as texture in the mouth (represented in the positive region of both principal components—PC). However, the untrained tasters clearly preferred the pulp of T3 treatment due to its color, flavor and aroma, while they did not show a great preference for the remaining treatments (T1 and T2). According to the internal preference map, it appears that treatment T2 was the least preferred in the variety Aliança (Fig. 2). Regarding Golden THB, the preferences were diffuse. However, in this variety, the tasters preferred T0 fruits due to their fruit and pulp appearance (Fig. 2).

Finally, the untrained tasters were inquired before the fruit sensory analysis and after the pulp one (Fig. 3) about their acceptance and intention to buy the fruit and pulp with different edible coatings. Before the sensory analysis, 91.1% of the tasters would certainly buy T0 fruits from Aliança while for T1, T2, and T3 the percentages were 55.4%, 60.7%, and 57.1%, respectively. The same trend was observed for Golden THB fruits: 87.9%, 69.7%, 30.3%, and 45.5%, for T0, T1, T2, and T3, respectively (Fig. 3). Clearly, the application of edible coatings influences the sensory aspect of the fruits, making them less appealing, especially in the Golden THB variety.

The purchase intention changed after the sensory analysis of the pulp, mainly in the Aliança variety. The purchase intention dropped 16.6% after the sensory analysis in T0, and 15.2% in T2, with this last treatment reporting the lowest purchase intention at 45.5%. Reporting a contrary trend were the treatments T1 (an 11.1% increase, to 65.5%) and T3 (a 29.9% increase, to 80.0%) (Fig. 3). In fact, more tasters would certainly buy T3 papayas (80%) than T0 (74.5%). Nevertheless, contrary results were obtained in the Golden THB variety. All the treatments received a

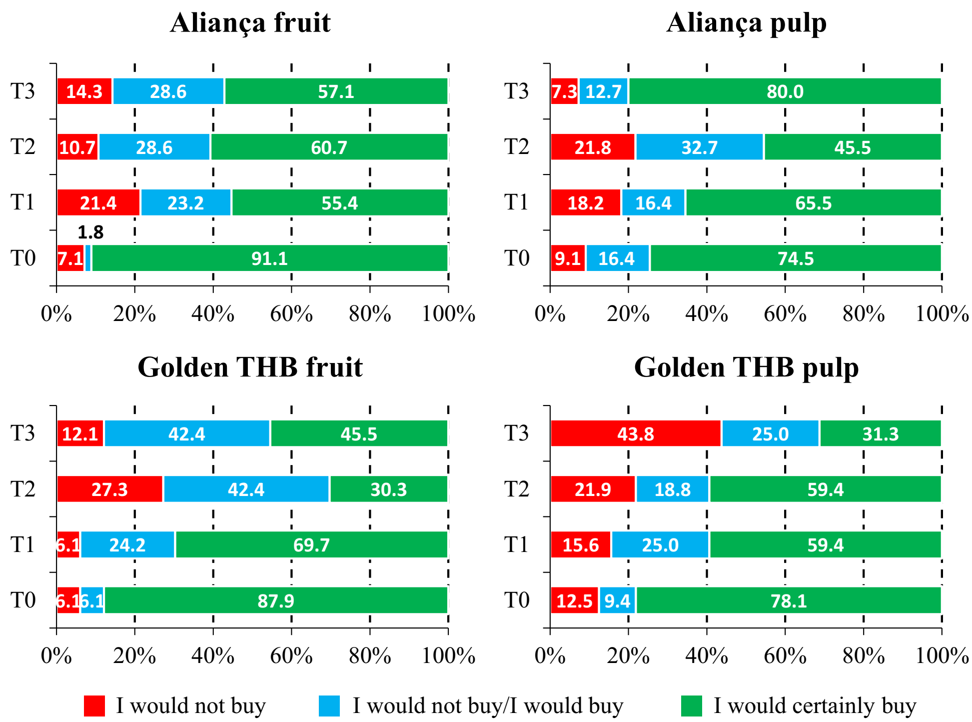

Fig. 3 Purchase intention of the untrained tasters before (fruit) and after (pulp) the sensory analysis of papaya fruits with different edible coatings (T0—control; T1—fruits coated with a solution of manioc starch; T2—fruits coated with clove essential oil; T3—fruits coated with a solution of manioc starch with clove essential oil)

lower purchase intention, except for T2 (from 30.3 to 59.4%). Again, the varietal effect could play a part in the results, since each variety has their own characteristics, namely epidermis thickness and permeability.

Conclusion

The application of edible coatings (manioc starch and clove essential oil) in the surface of papaya fruits does not alter the physical–chemical characteristics of the fruits. From the sensory point of view, the edible coatings affect the fruits appearance, reducing their acceptability. However, the color, flavor and aroma of the pulp are considerably enhanced. We concluded that there is a varietal effect according to the edible coating applied, which could be related to the physical characteristics of the fruit, namely epidermis thickness and permeability. For fruits from the Aliança variety, the edible coating T3 would be the most suitable, since it reported similar results to those of T0 and it considerably improved the scores regarding the sensory characteristics of the pulp. For the Golden THB variety, the results obtained indicate that treatments T1 and T2 are recommended since these results are similar to those obtained in T0. This is a preliminary study, so in the future, more variables and varieties will be considered. The varietal aspect is an important asset and in future works, other applying methods, essential oils and suitable doses will be studied in order to obtain natural edible coatings that may preserve food matrices without changing their basic sensory characteristics.

References

Alali AA, Awad MA, Al-Qurashi AD, Mohamed SA (2018) Postharvest gum Arabic and salicylic acid dipping affect quality and biochemical changes of ‘Grand Nain’ bananas during shelf life. Sci Hortic 237:51–58

Ali A, Hei GK, Keast YW (2016) Efficacy of ginger oil and extract combined with gum arabic on anthracnose and quality of papaya fruit during cold storage. J Food Sci Technol 53:1435–1444

Araujo IMS, Garruti DS, Lima JR, Oliveira DT, Rocha RFJ, Viana ES (2016) Aceitabilidade sensorial de genótipos de mamoeiro do grupo Solo. Embrapa Agroindústria Tropical, Fortaleza

Brito SSS, Silva F, Malheiro R, Baptista P, Pereira JA (2018) *Croton argyrophyllus* Kunth and *Croton heliotropiifolius* Kunth: phytochemical characterization and bioactive properties. Ind Crop Prod 113:308–315

Cazane AL, Machado JGCF, Pigatto G (2010) Análise do consumidor de frutas no município de Tupã, Estado de São Paulo. Inf Econ 40:16–29

Choi WS, Singh S, Lee YS (2016) Characterization of edible film containing essential oils in hydroxypropyl methylcellulose and its effect on quality attributes of ‘Formosa’ plum (*Prunus salicina* L.). LWT Food Sci Technol 70:213–222

Dantas JLL, Junghans DT, Lima JF (2013) Mamão: O produtor pergunta, a Embrapa responde. EdEmbrapa, Brasília

Dong F, Wang X (2017) Effects of carboxymethyl cellulose incorporated with garlic essential oil composite coatings for improving quality of strawberries. Int J Biol Macromol 104:821–826

Fialho RO, Papa MFS, Pereira DAS (2015) Efeito fungitóxico de óleos essenciais sobre *Phakopsora euvitis*, agente causal da ferrugem da videira. Arq Inst Biol 82:1–7

Flores-López ML, Cerqueira MA, Rodríguez DJ, Vicente AA (2016) Perspectives on utilization of edible coatings and nano-laminate coatings for extension of postharvest storage of fruits and vegetables. Food Eng Rev 8:292–305

Galo JQB, Souza ML, Kusdra JF, Mattiuz CFM (2014) Conservação pós-colheita de mamão 'sunrise solo' com uso de quitosana. Rev Bras Frutic 36:305–312

Guerreiro AC, Gago CML, Faleiro ML, Miguel MGC, Antunes MDC (2015) Raspberry fresh fruit quality as affected by pectin- and alginate-based edible coatings enriched with essential oils. Sci Hortic 194:138–146

Guerreiro AC, Gago CML, Faleiro ML, Miguel MGC, Antunes MDC (2017) The effect of edible coatings on the nutritional quality of 'Bravo de Esmolfe' fresh-cut apple through shelf-life. LWT Food Sci Technol 75:210–219

Hashemi SMB, Khaneghah AM, Ghahfarrokhi MG, Eş I (2017) Basil-seed gum containing *Origanum vulgare* subsp. *viride* essential oil as edible coating for fresh cut apricots. Postharvest Biol Technol 125:26–34

Hassan B, Chatha SAS, Hussain AI, Zia KM, Akhtar N (2018) Recent advances on polysaccharides, lipids and protein based edible films and coatings: a review. Int J Biol Macromol 109:1095–1107

Instituto Adolf Lutz (IAL) (2008) Métodos físico-químicos para análise de alimentos. Ministério da Saúde, Brasília

Kheawfu K, Pikulkaew S, Rades T, Müllertz A, Okonogi S (2018) Development and characterization of clove oil nanoemulsions and self-microemulsifying drug delivery systems. J Drug Deliv Sci Technol 46:330–338

Kumari M, Mahajan H, Joshi R, Gupta M (2017) Development and structural characterization of edible films for improving fruit quality. Food Packag Shelf Life 12:42–50

Mangany MC, Regnier T, Olivier EI (2015) Antimicrobial activities of selected essential oils against *Fusarium oxysporum* isolates and their biofilms. S Afr J Bot 99:115–121

Maqbool M, Ali A, Alderson PG, Mohamed MTM, Siddiqui Y, Zahid N (2011) Postharvest application of gum arabic and essential oils for controlling anthracnose and quality of banana and papaya during cold storage. Postharvest Biol Technol 62:71–76

Marquez GR, Di Pierro P, Mariniello L, Esposito M, Giosafatto CVL, Porta R (2017) Fresh-cut fruit and vegetable coatings by transglutaminase-crosslinked whey protein/pectin edible films. LWT Food Sci Technol 75:124–130

Oliveira CM, Coneglian RCCC, Carmo MGF (2015a) Conservação pós-colheita de tomate cereja revestidos com película de fécula de mandioca. Hortic Bras 33:471–479

Oliveira EBL, Neto SEA, Galvão RO, Souza ML (2015b) Revestimentos alternativos na conservação pós-colheita de mamão. Encicl Biosf 11:2523–2530

Pereira MEC, Silva AS, Bispo ASR, Santos DB, Santos SB, Santos VJ (2006) Amadurecimento de mamão formosa com revestimento comestível à base de fécula de mandioca. Ciênc Agrotec 30:1116–1119

Ruggiero C, Marin SLD, Durigan JF (2011) Mamão, uma história de sucesso. Rev Bras Frutic 33:76–82

Salgado PR, Ortiz CM, Musso YS, Di Giorgio L, Mauri AN (2015) Edible films and coatings containing bioactives. Curr Opin Food Sci 5:86–92

Sanchís E, González S, Ghidelli C, Sheth CC, Mateos M, Palou L, Pérez-Gago MB (2016) Browning inhibition and microbial control in fresh-cut persimmon (*Diospyros kaki* Thunb. cv. Rojo Brillante) by apple pectin-based edible coatings. Postharvest Biol Technol 112:186–193

Santamarina MP, Roselló J, Giménez S, Blázquez MA (2016) Commercial *Laurus nobilis* L. and *Syzygium aromaticum* L. Merr. & Perry essential oils against post-harvest phytopathogenic fungi on rice. LWT Food Sci Technol 65:325–332

Santana LRR, Matsuura FCAU, Cardoso RL (2004) Genótipos melhorados de mamão (*Carica papaya* L.): avaliação sensorial e físico-química dos frutos. Ciênc Tecnol Aliment 24:217–222

Serpa MFP, Castricini A, Mitsibuzi GP, Martins RN, Batista MF, Almeida TH (2014) Conservação de manga com uso de fécula de mandioca preparada com extrato de cravo e canela. Rev Ceres 61:975–982

Shahbaz Y (2018) Application of carboxymethyl cellulose and chitosan coatings containing *Mentha spicata* essential oil in fresh strawberries. Int J Biol Macromol 112:264–272

Sharma A, Rajendran S, Srivastava A, Sharma S, Kundu B (2017) Antifungal activities of selected essential oils against *Fusarium oxysporum* f. sp. lycopersici 1322, with emphasis on *Syzygium aromaticum* essential oil. J Biosci Bioeng 123:308–313

Sivakumar D, Bautista-Baños S (2014) A review on the use of essential oils for postharvest decay control and maintenance of fruit quality during storage. Crop Prot 64:27–37

Tavassoli-Kafrani E, Shekarchizadeh H, Masoudpour-Behabadi M (2016) Development of edible films and coatings from alginates and carrageenans. Carbohydr Polym 137:360–374

Thakur R, Pristijono P, Golding JB, Stathopoulos CE, Scarlett CJ, Bowyer M, Singh SP, Vuong QV (2018) Development and application of rice starch based edible coating to improve the postharvest storage potential and quality of plum fruit (*Prunus salicina*). Sci Hortic 237:59–66

Valero D, Díaz-Mula HM, Zapata PJ, Guillén F, Martínez-Romero D, Castillo S, Serrano M (2013) Effects of alginate edible coating on preserving fruit quality in four plum cultivars during postharvest storage. Postharvest Biol Technol 77:1–6

Zillo RR, da Silva PPM, de Oliveira J, da Glória EM, Spoto MHF (2018) Carboxymethylcellulose coating associated with essential oil can increase papaya shelf life. Sci Hortic 239:70–77

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