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Packagings for the transportation of persimmon and their effects on sensory characteristics

Abstract – The objective of this work was to evaluate the effect of different packagings for the transportation of the Rama Forte persimmon (*Diospyros kaki*) cultivar on the sensory characteristics and consumer acceptance of the product during storage. Three types of packagings were evaluated: wooden crate; cardboard boxes; and a new packaging made of recycled polyethylene thermos-injected structure with 10% fodder fiber associated with a polypropylene tray, thermoformed in the exclusive design for persimmon. Check-all-that-apply (Cata) questions were used for the sensory characterization of fruits, revealing differences among samples throughout storage time regarding persimmon sensory attributes and consumer preference. Consumer acceptance of fruits from the wooden crate and cardboard box decreased from the first and fifth day onwards, respectively, as storage time progressed, differing from those from the new packaging, whose appearance was liked up to the ninth day. Persimmon transported in the new packaging showed superior quality throughout shelf life. The new packaging, with an appropriate design, maintains the sensory characteristics of persimmon for a longer time than the other studied packagings.

Index terms: *Diospyros kaki*, acceptance, check-all-that-apply questions, packaging, postharvest.

Embalagens para o transporte de caqui e seus efeitos em características sensoriais

Resumo – O objetivo deste trabalho foi avaliar o efeito de diferentes embalagens utilizadas no transporte da cultivar Rama Forte de caqui (*Diospyros kaki*) sobre as características sensoriais e a aceitação do consumidor do produto durante seu armazenamento. Foram avaliados três tipos de embalagem: caixa de madeira tipo K; caixa de papelão ondulado; e nova opção de embalagem feita de polietileno reciclado com 10% de fibra de bucha e bandeja de polipropileno, modulada no formato exclusivo para frutos de caqui. As perguntas "check-all-that-apply" (Cata) foram usadas para caracterização sensorial dos frutos, tendo revelado diferenças entre as amostras ao longo do tempo de armazenamento quanto aos atributos sensoriais do caqui e à preferência do consumidor. A aceitação do consumidor dos frutos das caixas de madeira e de papelão diminuiu a partir do primeiro e do quinto dia, respectivamente, com o aumento do tempo de armazenamento, tendo diferido da dos frutos da nova embalagem, cuja apparência foi aceita até o nono dia. A qualidade dos caquis transportados na nova embalagem foi superior ao longo da vida útil. A nova embalagem, com design apropriado, mantém as características sensoriais do caqui por mais tempo do que as outras embalagens estudadas.

Termos para indexação: *Diospyros kaki*, aceitação, check-all-that-apply questions, embalagens, pós-colheita.

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Introduction

Persimmon (*Diospyros kaki* L.) belongs to the Ebenaceae family and is a tree native to Asia, closely associated with China and Japan. In Brazil, it is an economically important crop, with a production of 192.327 thousand tons of fruit in 2013 (IBGE, 2015).

The fruit, besides its pleasant taste and attractive appearance, also has nutritional quality and is a good source of fibers, carbohydrates, vitamins, and minerals, characteristics that make it well accepted by the consumer market (Elias et al., 2008). However, being climacteric, persimmon is characterized by increasing CO_2 and ethylene production rates as it matures, which makes it more perishable and with a relatively short shelf life of 15–30 days under refrigeration (Chitarra & Chitarra, 2005; Pinto, 2010).

The poor postharvest quality of fruits is partly due to inadequate packaging, which does not follow the requirements regarding handling, protection against damages or contamination, and adequate distribution of the product (Pathare & Opara, 2014; Alves et al., 2015). Considering the demand for high quality fruits increases every year (Francilino et al., (2014), one of the main challenges, in the Brazilian agricultural sector, is reducing postharvest losses (Chitravathi et al., 2015). An alternative is the application of appropriate technologies to prevent the deterioration of fresh fruit and vegetables after harvest (Singh et al., 2014), which affects consumer preference.

Therefore, consumer attitudes when buying fruits have been continually investigated in order to better understand the attributes taken into account when choosing a product (Pinheiro et al., 2011). Wei et al. (2003) and Mascarenhas et al. (2010), while studying 2 domestic and 13 imported mandarins and 4 grape cultivars, respectively, concluded that appearance, flavor, and texture are the most important intrinsic fruit attributes for the consumer. Similarly, Harker et al. (2008) observed that poor quality apples may have reduced their demand, decreasing sales. Good external characteristics, therefore, affect product differentiation and are key in the purchasing decision of consumers (Chitarra & Chitarra, 2005).

In this context, it is essential to increase fruit shelf life by developing packaging from materials that keep them properly, as shown by the results obtained by Peters-Texeira & Badrie (2005). For this purpose, a recycled polyethylene thermo-injected structure was developed and patented; it has 10% fodder fiber associated with a polypropylene tray, thermoformed in the exclusive design for persimmon fruit, in order to reduce losses during transportation and handling, aiming to keep the quality and consequent added value of the product. Moreover, this innovative design allows using recycled polymers and vegetable fibers with an ecological appeal, compared with the traditional wooden crate and cardboard boxes. However, its effect on fruit sensory characteristics still needs to be investigated considering the consumers' point of view.

The objective of this work was to evaluate the effect of different packagings for the transportation of the Rama Forte persimmon cultivar on the sensory characteristics and consumer acceptance of the product during storage.

Materials and Methods

Fruits from the persimmon cultivar Rama forte were harvested in 2013 from a commercial farm located in the municipality of Nova Friburgo, in the state of Rio de Janeiro, Brazil; after harvesting, their astringency was removed using the calcium carbide process, adopted at the farm. At the packaging house, the fruits were selected and standardized according to size, from small to medium; maturity, indicated by a reddish-orange color; and absence of injuries, including cuts, crushing, and rottenness. A total of 726 fruits were stored in three different packagings (Figure 1): wooden box (control), cardboard box, and new packaging.

The wooden box, with a 20-kg capacity and dimensions of 49.5x32 cm width x 19 cm height, was made of white pine material; in it, approximately 90 fruits were distributed in five layers wrapped with newspaper. The cardboard box, made of corrugated paperboard, had a 6.0-kg capacity and dimensions of 47x25 cm width x 24 cm height; in it, approximately 36 fruits were distributed in two layers, divided by a paperboard sheet. The new packaging was designed for a 3.0-kg capacity and was made of a recycled polyethylene thermos-injected structure with 10% fodder fiber associated with a polypropylene tray, thermoformed in the exclusive format for persimmon fruit; each tray had 18 fruits. The packagings were transported under 22°C, in a minivan, on a well-conserved roadway, to the laboratory of postharvest physiology at Embrapa Agroindústria de Alimentos, at a distance of 130 km from the farm. The fruits were

kept in the packagings for 24 hours and placed on a stainless steel countertop on the following day, at an average temperature of 18ºC and a relative humidity of 70% for 15 days. The study was approved by the human research ethics committee (Nº 868.547) of Universidade Federal do Rio de Janeiro.

Employees and trainees of Embrapa Agroindústria de Alimentos, who liked and consumed persimmon and were interested in participating in the study, were invited to evaluate the fruit, as consumers. Sixty participants (47% men and 53% women), whose ages ranged from 20 to 65 years, took part in every test, performed in sensory booths under white lighting and air conditioning.

The survey format check-all-that-apply (Cata) questions was used for product sensory characterization by consumers. This methodology has been widely adopted in several studies to gather information about consumer perception of specific products, such as chocolate milk desserts and cherry tomato cultivars produced under Brazilian organic farming conditions (Ares et al., 2010; Rocha et al., 2013); the effect of the order of the listed attributes has also been assessed (Ares et al., 2015).

A preliminary study was carried out with a panel of 15 selected and trained assessors, who were presented to 'Rama Forte' persimmon fruits with different characteristics in terms of appearance, aroma, flavor and texture, and then were asked to select the attributes and terms that best described each sample (Ares & Jaeger, 2015). To facilitate the characterization of the samples, the Cata list was composed of 37 terms: orange color, red color, uniform peel color, good appearance, bad appearance, big, small, bright peel, dull peel, black spots, unripe, ripe, stale appearance, shriveled, injured, characteristic aroma, sweet aroma, stale aroma, fermented aroma, unripe aroma, bad flavor, delicious, characteristic flavor, stale taste, fermented flavor, astringent, very astringent, sweet taste, bitter taste, firm texture, soft texture, very soft texture, firm peel, peel loose while chewing, gelatinous pulp, crumbly, and sandy texture.

For data collection, the participants were asked to express how much they liked the appearance of the fruits, using a 9-point hedonic scale, ranging from: 1, extremely disliked, to 9, extremely liked. They also answered the Cata questions, which comprised the 37 terms presented in the preliminary study, by marking all terms considered appropriate to describe the evaluated sample. This was done in two stages: at the beginning of the study, the assessors were only asked to check the appearance attributes (15 terms); and, then, when the fruits were ripe and appropriate for consumption (reduced astringency and firmness, and yellow-orange color changed to reddish), they were asked to taste the fruits and to describe how much they liked them by answering all the Cata questions.

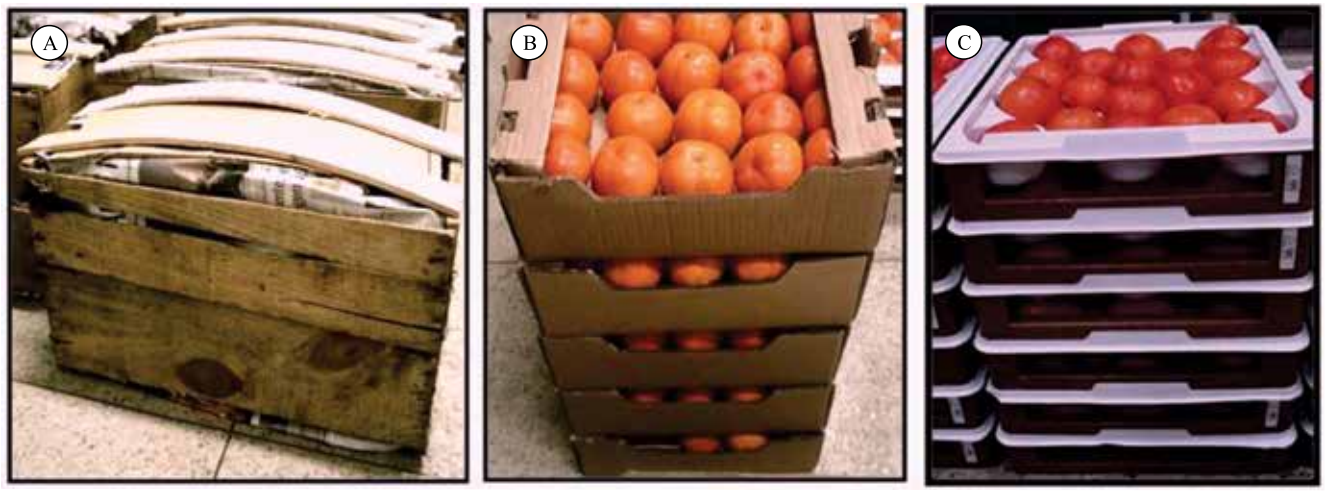

Figure 1. Packagings for the transportation of persimmon (*Diospyros kaki*) fruits used in the study: wooden box (A), cardboard box (B), and new packaging (C).

For the evaluation of appearance, batches of six fruits from each of the three packagings were prepared and used throughout the study. For tasting, fruits were selected at random, sanitized, cut into four pieces of the same size, and served on white dishes coded with three-digit numbers. The samples were monadically presented following a balanced design, and mineral water at room temperature was supplied to the participants. Data were collected on the first day of storage and then every two days, totalizing seven collections up to the fifteenth day of storage.

The frequency of each term of the Cata questions was determined by counting the number of evaluators who used it to describe persimmon, obtaining a frequency table. Cochran's Q-test was applied to each of the terms, considering sample and evaluators as a source of variation, in order to assess whether there were differences in the perception of persimmon during storage.

The multiple factors analysis (MFA) was used in the frequency table of the Cata responses, considering the preference data as a supplementary variable; this analysis was performed according to Danzart et al. (2004). The analysis of variance was carried out for liking scores for appearance and flavor, considering sample and consumer as a source of variation. To determine differences between treatments, Tukey's test, at 5% probability, was adopted. The regression analysis was used to investigate packaging effect on consumer acceptance (likes and dislikes) during storage.

Results and Discussion

The average liking scores of the evaluated samples, according to the 9-point hedonic scale, taking into account the different packaging materials and times of storage, are shown in Figure 2.

For fruits from the wooden box (WB), the average scores followed a linear model (Figure 2 A), i.e., consumer liking decreased as storage time progressed. On the first day of storage, the fruits received a low mean score of 5, indicating "not liked nor disliked". The fruits from the cardboard box (CB) and the new packaging (NP) showed quadratic adjustments model. Participants "slightly liked" the fruit packed in the CB up to the fifth day of storage, but, from that day onwards, the average scores decreased. However, the fruits packed in the NP had the highest average score of 6.6 for liking of appearance (Figure 2 A) on the first evaluation day, reaching 7.7 on the seventh day of storage, showing that the appearance of these fruits was greatly appreciated. The fruits transported in this packaging were liked up to the ninth day, when the average score was 7.1, which only dropped to 4.1 on the thirteenth day of storage. These results are indicative that consumers associate better quality to fruits with a lower amount of injuries, which leads to their greater acceptance, as previously reported by Anwar et al (2008) and Maia et al. (2008), who found that

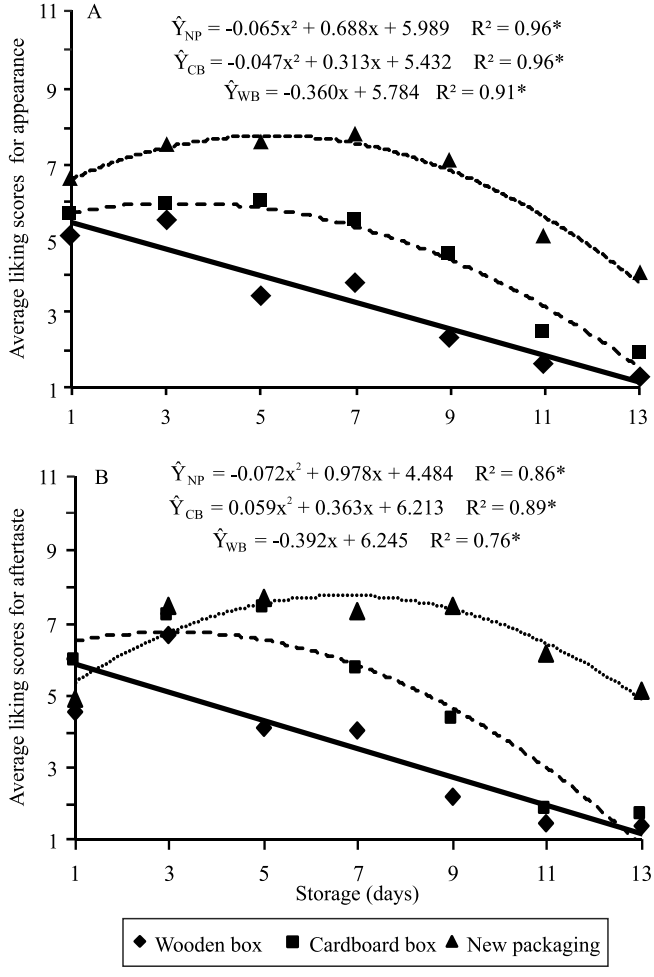

Figure 2. Average liking scores given by consumers for the appearance (A) and aftertaste (B) of persimmon (*Diospyros kaki*) fruits transported in different packagings and stored for 15 days at an average temperature of 18ºC and a relative humidity of 70%. WB, wooden box; CB, cardboard box; and NP, new packaging.

injury problems in fruits due to inadequate packaging reduced their commercial value.

The average liking scores for aroma, flavor, and texture are presented in Figure 2 B. The curves obtained for the individual packagings showed similar trends regarding liking of appearance (Figure 2 A), i.e., on average, consumers only liked the fruits transported in the WB on the third day of storage, disliking them after that time and extremely disliking them on the eleventh day of storage. The mean liking scores for persimmon in the CB also decreased over storage time, reaching an average "disliked" score of 4.3 from the ninth day onwards. On the first evaluation day, the participants of the sensorial analysis described the fruits from the NP as astringent because they were still unripe, which explains the average score of 4.9. The lower average liking of fruits from the NP and WB in the first evaluation (Figure 2 B) can be attributed to their astringency, according to the participants; to a lesser extent, this also applies to fruits from the CB. However, with maturity, the appreciation for the fruits transported in the NP increased, despite starting to decline after the ninth day of storage. Therefore, the NP kept the desirable sensory characteristics of persimmons compared with the WCr and CB, contributing to a greater consumer liking of the fruits during an extended period.

Mohammadi et al. (2015) found that sensory quality was associated with the degree of maturity of persimmon fruits, as verified in the present study. In addition, Chitarra & Chitarra (2005) reported increased acceptance of ripe fruits, because, in this stage, their color, odor, flavor, and texture changes, making them suitable for consumption. Senescence comes after, predominantly degrading the fruits, a normal and irreversible process that results in tissue death and contributes to consumer rejection.

The terms related to sensory characteristics and the frequency in which they were checked by the consumers to describe the fruits are presented in Table 1 until the thirteenth day of storage; only data from this period were shown because the fruits from the WB and CB were considered inappropriate for consumption in the last evaluation, i.e., at 15 days of storage. Considering the 15 terms related to appearance, differences ($p<0.05$) were observed regarding the frequency in which the attributes were selected at all storage times. It should be noted that the terms "good appearance", "bad appearance", "stale appearance", "injured", and "uniform peel color" differed significantly in all evaluated times, suggesting that assessors were able to detect differences in fruit appearance according to the packaging used for transportation. Furthermore, the significant differences for the terms "bright peel", "dull peel", "black spots", and "shriveled", in the six evaluation times, suggest that these attributes were useful to distinguish persimmons. In contrast, the terms "fermented aroma", "unripe aroma", "bad flavor", "astringent", "bitter taste", "fermented flavor", and "sandy texture" did not differ significantly, suggesting that differences regarding persimmon appearance were more perceived by consumers than aroma, flavor, and texture.

Besides the type of packaging, storage period also affected how consumers evaluated the fruits. The greatest difference was verified on the ninth day of storage, when the frequency count of 24 out of the 37 Cata terms differed among samples ($p<0.05$). It should be pointed out that, in practice, the fruits would already have been discarded, since their appearance is crucial at the time of purchase, because the consumer associates flavor with visual characteristics (Dutcosky, 2013).

The first and the second dimensions of the MFA carried out for appearance data, using terms 1 to 15 (Table 1), accounted for 87.84% of variance, i.e., F1 for 71.25% and F2 for 16.59% (Figure 3).

The first dimension was positively correlated with the terms "good appearance", "uniform peel color", "big", and "bright peel", as well as negatively correlated with "dull peel", "shriveled", "black spots", "small", and "stale appearance". It should be mentioned that these terms were observed in fruits on the seventh and ninth days of storage for the WB, on the ninth day for the CB, and only on the eleventh and thirteenth days for the NP, confirming the superiority of this innovative packaging for persimmon transportation, compared with the conventional WB and CB. This result can be explained by the fact that physical damage, as wounds on tissues, for example, accelerates ripening due to the increase in fruit respiratory activity and ethylene production, reducing its quality, first in the WB and then in the CB.

Regarding ripeness and fruit maturity, the second dimension was positively correlated with the terms "ripe" and "red color", and negatively with "unripe"

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Table 1. Frequency (number of times) the terms of the check-all-that-apply questions were checked per sample by consumers to describe persimmon (*Diospyros kaki*) fruits transported in three different packagings during 13 days of storage[(1)].

Number	Terms	Day 1			Day 3			Day 5			Day 7			Day 9			Day 11			Day 13		
		WB	CB	NP	WB	CB	NP	WB	CB	NP	WB	CB	NP	WB	CB	NP	WB	CB	NP	WB	CB	NP
1	Orange color	45	47	54***	37	36	45^{ns}	33	32	38^{ns}	10	25	27^{ns}	12	19	20^{ns}	10	9	12^{ns}	5	4	11^{ns}
2	Red color	13	12	4***	27	28	22^{ns}	40	50	42^{ns}	43	48	44^{ns}	46	38	39^{ns}	39	38	39^{ns}	39	36	37^{ns}
3	Good appearance	29	37	47***	33	42	55***	16	50	71***	13	43	67***	3	19	50***	1	2	26***	0	0	14***
4	Bad appearance	22	9	4***	24	14	0***	49	14	2***	46	19	0***	53	31	5***	44	44	15***	51	50	30***
5	Big	34	34	38^{ns}	32	39	39^{ns}	29	39	51***	26	38	42***	20	33	35***	14	13	25*	19	21	25^{ns}
6	Small	9	8	5^{ns}	13	7	9^{ns}	13	7	3***	18	8	7***	20	11	10*	24	16	17*	14	11	10*
7	Bright peel	34	33	41^{ns}	35	32	47***	26	42	54***	27	32	55***	11	17	33***	5	14	23***	7	9	14*
8	Dull peel	14	11	10^{ns}	17	21	9*	31	19	14***	29	19	9***	36	29	20***	35	26	20***	38	35	28*
9	Black spots	42	26	9***	46	41	5***	42	42	10***	52	48	14***	56	51	24***	46	47	38***	50	50	49^{ns}
10	Unripe	26	26	30^{ns}	9	7	10^{ns}	3	2	2^{ns}	0	1	2^{ns}	0	0	0^{ns}	1	0	1^{ns}	1	2	4^{ns}
11	Ripe	22	19	17^{ns}	36	33	35^{ns}	42	63	64***	49	56	60*	31	33	56***	25	29	37*	24	25	35*
12	Stale appearance	12	3	1***	8	5	0***	41	6	1***	38	14	1***	50	25	4***	42	36	14***	29	50	24***
13	Shriveled	5	3	2^{ns}	10	5	2*	25	9	4***	31	7	0***	33	3	0***	26	11	6***	38	16	9***
14	Injured	18	7	1***	23	15	10***	34	13	2***	29	17	0***	33	20	0***	34	27	11***	35	31	17***
15	Uniform peel color	13	22	38***	13	18	42***	17	25	51***	13	21	51***	3	10	32***	1	0	10***	0	1	9*
16	Characteristic aroma	23	22	21^{ns}	55	34	34***	18	50	49***	27	35	42*	5	32	37***	16	20	23^{ns}	1	1	16***
17	Sweet aroma	12	17	11^{ns}	17	16	22^{ns}	39	38	38^{ns}	17	28	37*	3	13	24***	6	4	15*	1	2	9*
18	Stale aroma	0	0	0^{ns}	1	2	0^{ns}	1	1	1^{ns}	6	7	3^{ns}	3	10	3*	4	5	3^{ns}	8	4	4^{ns}
19	Fermented aroma	0	0	0^{ns}	1	1	0^{ns}	2	0	1^{ns}	2	0	0^{ns}	1	1	1^{ns}	0	0	0^{ns}	1	0	1^{ns}
20	Unripe aroma	6	8	10^{ns}	2	5	4^{ns}	0	0	0^{ns}	0	2	1^{ns}	0	0	0^{ns}	0	0	0^{ns}	0	0	0^{ns}
21	Bad flavor	11	4	6^{ns}	3	1	1^{ns}	3	1	1^{ns}	7	4	4^{ns}	4	4	0^{ns}	1	2	1^{ns}	1	1	1^{ns}
22	Delicious	10	6	7^{ns}	35	38	40^{ns}	71	54	66*	45	48	53^{ns}	32	21	44***	3	3	20***	1	2	6^{ns}
23	Characteristic flavor	18	26	21^{ns}	34	44	36^{ns}	57	57	57^{ns}	55	50	55^{ns}	37	40	44^{ns}	16	3	20***	1	4	0^{ns}
24	Stale taste	1	0	0^{ns}	1	0	0^{ns}	1	4	0^{ns}	10	10	4^{ns}	19	23	4***	20	20	10*	23	20	15*
25	Astringent	15	21	18^{ns}	19	20	16^{ns}	3	3	5^{ns}	2	5	4^{ns}	1	1	1^{ns}	0	0	0^{ns}	0	0	0^{ns}
26	Very astringent	21	9	26***	3	0	3^{ns}	0	0	0^{ns}	0	0	0^{ns}	0	0	0^{ns}	0	0	0^{ns}	0	0	0^{ns}
27	Sweet taste	19	23	17^{ns}	31	44	37*	67	57	57^{ns}	55	53	57^{ns}	44	34	49*	23	20	29*	13	13	13^{ns}
28	Bitter taste	6	2	5^{ns}	2	0	2^{ns}	0	2	0^{ns}	2	0	0^{ns}	0	1	0^{ns}	0	0	0^{ns}	0	0	0^{ns}
29	Fermented flavor	0	0	0^{ns}	2	1	1^{ns}	1	1	1^{ns}	4	4	2^{ns}	0	3	0^{ns}	1	1	1^{ns}	2	2	2^{ns}
30	Firm texture	34	33	3^{ns}	32	33	39^{ns}	7	18	26*	3	8	10^{ns}	1	1	7*	0	0	2^{ns}	0	0	1^{ns}
31	Soft texture	5	5	2^{ns}	15	19	13^{ns}	64	44	38***	36	33	42^{ns}	32	32	35^{ns}	33	14	8***	6	6	6^{ns}
32	Very soft texture	0	0	0^{ns}	1	1	1^{ns}	6	6	5^{ns}	25	14	12*	50	27	17***	33	33	17***	23	23	18*
33	Firm peel	37	32	37^{ns}	28	26	39*	11	23	34***	10	10	19^{ns}	1	3	11*	1	0	5*	0	0	1^{ns}
34	Peel loose while chewing	6	5	4^{ns}	11	15	9^{ns}	32	27	24^{ns}	52	44	40^{ns}	50	28	33***	33	34	23***	23	23	15***
35	Gelatinous pulp	7	7	5^{ns}	19	24	26^{ns}	30	26	30^{ns}	25	32	31^{ns}	50	19	21***	34	7	16***	8	22	10***
36	Crumbly	1	2	2^{ns}	4	4	2^{ns}	20	20	16^{ns}	33	34	24^{ns}	52	43	28***	33	34	22***	23	22	17*
37	Sandy texture	4	0	5^{ns}	1	1	1^{ns}	2	1	3^{ns}	1	3	3^{ns}	0	4	5^{ns}	0	1	3^{ns}	0	1	4^{ns}

[(1)]WB, wooden box; CB, cardboard box; and NP, new packaging. *** and *Significant differences according to Cochran's Q-test at 0.1 and 5.0% probability, respectively. ^{ns}Nonsignificant at 5.0% probability.

and “orange color”. The representations in the first two MFA dimensions for appearance terms during storage are shown in Figure 3 B; the numbers after each type of packaging represent the storage day, i.e., new packaging refers to persimmon fruits transported in the NP on the first day of storage. Only fruit samples from the NP and the CB, particularly from the former, were described as having “good appearance”, “uniform peel color”, and “bright peel” on the fifth and seventh days of storage, when participants liked fruits very much and the highest averages for preference were observed. The fruits from the NP maintained a good appearance for a longer period of time mainly due to the design of the packaging, whose thermoformed trays and exclusive shape kept the quality of the product, avoiding the mechanical damage caused by the traditional packaging. This result was also reported by Fadiji et al. (2016) for 'Golden Delicious' apples (*Malus* x *domestica* Borkh.); the authors concluded that packaging design had a significant effect on fruit injuries, reinforcing the importance of appropriate packaging at the different stages of distribution, in order to ensure that the product arrives with quality to the consumer.

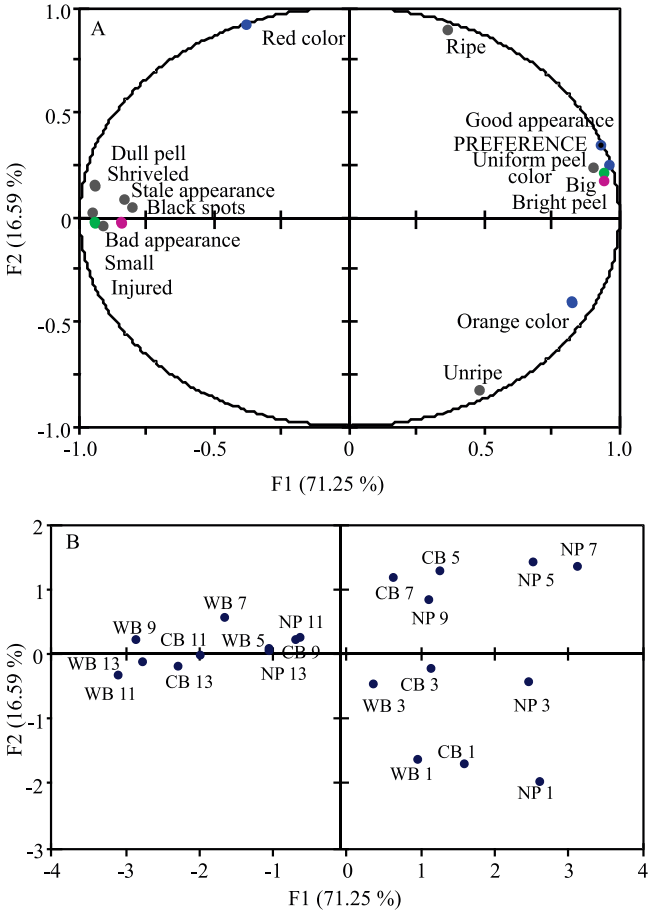

Figure 3. Multiple factor analysis performed for the terms related to the appearance of persimmon (*Diospyros kaki*) fruits in the check-all-that-apply (Cata) questions, considering consumer preference as a supplementary variable, representing the terms of the Cata questions (A) and the samples at the different storage times (B). The number following each type of package refers to days of storage. WB, wooden box; CB, cardboard box; and NP, new packaging.

The second dimension was negatively correlated with the terms “bad appearance” and “injured” for fruits from the WB and CB at the end of the study. The absence of these two terms to describe fruits from the NP is noteworthy, suggesting its superiority to maintain fruit integrity, which enabled longer shelf life. Investigating the types and intensity of mechanical damage after the harvest of 'Prata-Anã' (*Musa* spp.) banana packaged in cardboard box, wooden crate, and plastic box, in different stages of the marketing chain, Maia et al. (2008) also found that the wooden crate promoted greater damage to the fruit.

Regarding the attributes aroma, texture and flavor, the first and second MFA dimensions accounted for 69.66% of the variance of the data – F1 for 41.24% and F2 for 28.42% (Figure 4). Ares et al. (2010) reported that the first two dimensions of the MFA for chocolate milk desserts explained 57% of the variance of the experimental data. However, Henrique et al. (2015) found a higher sum for the first two dimensions (86.1%) while assessing cooked ham. These variations seem to be related to the product and to the consumer panel. In the present study, the first dimension was positively correlated mainly with “characteristic aroma”, “characteristic flavor”, “taste”, “sweet taste”, “sweet aroma”, “delicious”, “fermented flavor”, “sandy texture”, “soft texture”, “gelatinous pulp”, “peel loose while chewing”, and “crumbly”. These characteristics were perceived on the fifth and seventh days of storage for fruits from the WB, and on the seventh and ninth days for those from the CB and the NP. These internal characteristics indicated that ripening occurred at different times, as was the case for fruits from the WCr, which ripened before those from the other packagings. However, different results were reported by Castro et al. (2001), who found no differences ($p>0.05$) for the

soluble solids/titratable acidity ratio (one of the most used parameters for flavor evaluation) in 'Santa Clara' tomatoes (*Solanum lycopersicum* L.) after seven days of storage in plastic packaging, corrugated cardboard box, and wooden crate, when the fruit peel was 100% red.

The second dimension was positively correlated with the terms "firm texture", "unripe aroma", "astringent", "very astringent", "firm peel", "bitter taste", and "bad flavor", perceived in the fruits from the three packagings on the first day of storage and from the NP on the third day. These results were expected because, during storage, the fruits still had a high concentration of tannins (Antoniolli et al., 2000), which explains why consumers marked those attributes, particularly for the NP, followed by the WB and the CB. The second dimension was negatively correlated with "stale aroma", "stale taste", "very soft texture", and "crumbly", which were perceived in the last evaluations for fruits from the NP and on the ninth day for those from the CB.

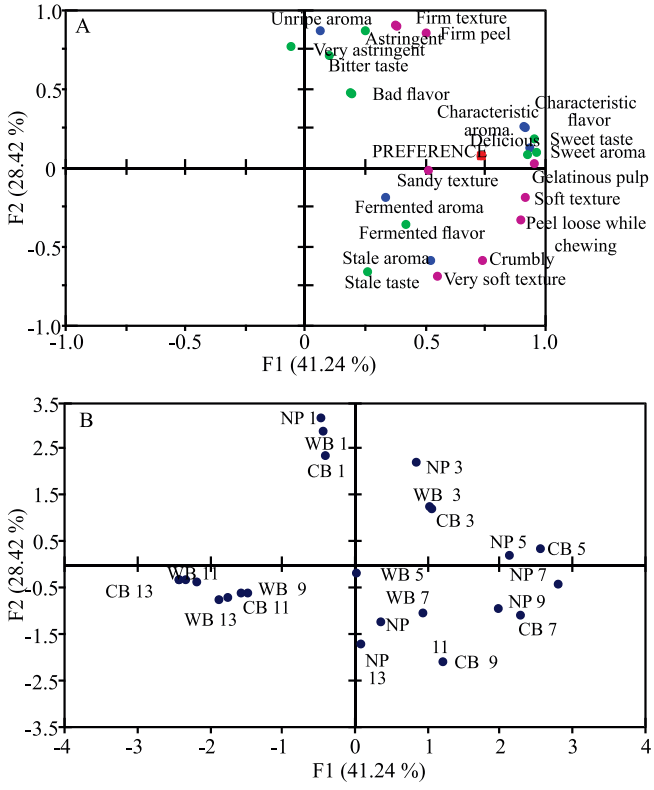

Figure 4. Multiple factor analysis performed for the terms characterizing aroma, texture, and flavor in the check-all-that-apply (Cata) questions, representing the terms of the Cata questions (A) and the samples at the different storage times (B). The number after each type of package refers to days of storage. WB, wooden box; CB, cardboard box; and NP, new packaging.

The superiority of the NP for persimmon transportation over the traditional CB and WB favored fruit integrity, allowing longer shelf life and greater acceptance by the consumer. The external characteristics of the fruit differentiated the products during storage, confirming that good quality might favor consumer purchase decision, as shriveled and smashed fruits, as well as those with uncharacteristic color and unpleasant appearance, are left on the grocery store shelves (Chitarra & Chitarra, 2005; Kasat et al., 2007). Souza et al. (2008) referred to appearance as the most important aspect when buying fruits. In addition, Echeverría et al. (2015) reported the importance of the aroma and flavor of peaches [*Prunus persica* (L.) Batsch] and nectarines (*P. persica* var. *nucipersica*) for consumer acceptance.

The mechanical injuries resulting from inadequate manipulation conditions in the field or during processing steps, storage, and commercialization are considered the main causes of fruit quality reduction, as reported for papaya (*Carica papaya* L.) by Godoy et al. (2010) and Figueiredo Neto et al., (2013) and for mango (*Mangifera indica* L.) by Sivakumar et al. (2011). For 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck], Miranda et al. (2015) found that mechanical damages reduced soluble solids, titratable acidity, ascorbic acid, and fresh mass, confirming the importance of adequate transportation for product quality.

Conclusions

1. The new packaging, with an exclusive design, is better than to the wooden and cardboard boxes for the transportation of Rama Forte persimmon (*Diospyros kaki*) fruits, and is able to extend shelf life up to 13 days of storage.

2. The check-all-that-apply questions allow the identification of differences in consumer perception of several sensory attributes of persimmon fruits, showing the superiority of the new package for transportation, compared with the wooden and cardboard boxes.

3. Regarding fruit quality, the obtained results indicate that the adoption of the new packaging, on a commercial scale, would benefit the entire persimmon chain, from the producer to the consumer.

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