INFLUENCE OF RIPENING STAGE AND DE-ASTRINGENCY TREATMENT ON THE PRODUCTION OF DEHYDRATED PERSIMMON SNACKS

Influence of ripening on persimmon snacks

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Abstract

BACKGROUND: Seasonal persimmon (*Diospyros kaki L.*) crops have steadily increased in Spain; this has been linked to a significant increase in the post-harvest production waste. Therefore, development of valorised products is of great interest. In this study, a hot air-drying technique was used to obtain persimmon snacks. Slices from astringent and non-astringent persimmons (submitted to de-astringency treatment) at three different ripening stages were dried at 40 and 60 ºC to reach 15% ± 3 water content.

RESULTS: After the drying treatment, dehydrated samples were harder, turned into a more orange hue angle, and had a reduced soluble tannin content. Dehydrated samples obtained from the astringent

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fruit at the most advanced ripening stage had similar soluble tannin content as the samples obtained from non-astringent fruit, especially at 60 ºC. Besides, a high correlation was observed between the level of astringency perceived by consumers and the decrease of soluble tannin content. Although, in the first ripening stage, consumers preferred the snacks obtained from non-astringent fruits; in the last ripening stage, snacks produced from astringent fruits were equally accepted than the non-astringent ones.

CONCLUSION: Therefore, well-accepted persimmon snacks are obtained from both astringent and non-astringent fruits when advanced ripening stages of persimmon are used.

Keywords: Astringency**,** *Diospyros kaki*, physicochemical properties, tannins, sensory analysis, hot air drying.

INTRODUCTION

The featured role of food to improve health by decreasing the risk of diseases has highlighted a new class of foods, now known as functional foods.[1] The beneficial value of functional foods depends on the presence of dietary fibres, total and major phenolics, essential minerals, and trace elements. Fruits and vegetables are essential parts of a human diet and a rich source of these nutritional compounds.[2] Some of these compounds have beneficial effects on human health because of their ability to prevent or control various illnesses.[1] Among the fruits, persimmon (*Diospyros kaki L.*) is a popular fruit with a relatively high dietary fibre content, bioactive and antioxidant compounds and minerals. [3]

The persimmon is an edible fruit native to East Asia. Over recent years, diffusion of persimmons growth, outside of the traditional production countries, has made it a promising crop worldwide, including Mediterranean countries such as Spain.[4] There are over 400 species of persimmon, varying in shape and colour, although they are generally classified into two main groups: astringent and non-astringent varieties. Among the persimmon varieties, the "Rojo Brillante" is valued as a fresh fruit owing to its high productivity and commercial quality.[5] However, as the fruit's appearance has strict quality control, a significant proportion of persimmon has no commercial value as a fresh product, with 25 - 30% of the crop production wasted.[6] Moreover, no management system can take advantage of the persimmon waste, thus generating economic and environmental problems.

An additional disadvantage of "Rojo Brillante" is its high degree of astringency; because of the high soluble tannin content of the fruit, precipitation with salivary proteins makes the product inedible at stages of maturity when the pulp is still firm.[7] Even though soluble tannin content decreases as the state of ripening progresses, the removal of astringency is necessary to commercialize firm fruit.[8] Therefore, different techniques are applied, such as anaerobic treatments (CO_2), precipitating tannins while maintaining firmness without damaging the product.[9]

Nevertheless, the ripening stage is a key factor influencing the effectiveness of the treatment. It has been reported that the de-astringency process occurs slower in fruits at advanced ripening stages, than in early and middle stages.[10] This may involve an extra cost when arriving to marketing, generating persimmon fruits out of the quality control if the de-astringency treatment is not applied properly, especially in advanced ripening stages.

An interesting way of valuing waste from the agro-food industry is based on obtaining products or ingredients with high added value. It could be beneficial for producers to develop dried fruits as an alternative. Dried fruits are increasingly valued and might be very convenient for consumers, which is an important motivation for their consumption.[11] Drying is one of the oldest and the most important food preservation methods practiced by humans. This process improves the food stability, as it reduces the water and microbiological activity of the material while minimising physical and chemical changes during its storage.[12] There are several studies related to the drying kinetics of dehydrated persimmon slices applying different techniques and temperatures of drying.[12–14] Although drying processes lead to a significant loss of bioactive compounds, dehydrated fruits can still be a valuable source not only of energy, but also of antioxidant activity. [11] Besides, methods such as hot air drying, produce a reduction in persimmon's total polyphenols without affecting dietary fibres, minerals, and trace elements content.[15] Hence, the dehydrated persimmon portions may contribute to the human health and could be also used as ingredients in products such as muesli, breakfast cereals, and snacks.

Therefore, the aim of this study was to explore using hot air drying, at two different temperatures (40 and 60 ºC), with astringent and non-astringent (fruit submitted to de-astringency treatment) persimmon slices, to produce a healthy and well-accepted snack, which could increase persimmon production profitability. Three different ripening stages were used to obtain the final product, evaluating the effect of the ripening stage on the mechanical and optical properties, soluble tannin content, and sensory acceptability of consumers.

MATERIAL AND METHODS

Sample preparation

Persimmon (*Diospyros kaki* Thunb. cv. Rojo Brillante) unseed fruits, astringent (A) and non-astringent (NA) samples (treated by 95% CO_2 over 24 h at 20 ºC) at three different commercial ripening stages (Figure 1), were provided by the Instituto Valenciano de Investigaciones Agrarias (IVIA, Spain). These three commercial ripening stages were from fruits harvested from a local grove in L'Alcudia (Valencia, Spain) between mid-November and early December 2018. The criterion for harvesting each ripening stage was the visual evolution of skin colour corresponding to ripening IV (yellow-orange), V (orange), and VI (intense orange).[16] The fresh fruits were washed and transversally cut into slices (5 mm thick) with a mandolin (OXO good grips mandolin slicer 2.0, USA), without removing the peel; the stalk and the opposite end were discarded. Hot air drying was conducted in a cabinet dryer (Binder model FED 260 standard, Germany) using an air velocity of 2 m s^{-1} at 40 and 60 ºC, until reaching 15% ± 3 water content (23 and 9 h were needed, respectively). The final point were set based on the literature [12,17–19] and previous experimental trials. These groups of fruits are named as shown in Figure 1A.

Water content, Water activity, and ºBrix determinations.

The fresh samples and persimmon snacks were ground in a crushing machine; the water content and water activity were measured by a Vaciotem, J.P. Selecta vacuum oven (60 ± 1 ºC; pressure < 100 mm Hg) and an Aqualab CX-2 Decagon Device, respectively. A refractometer (Hand-held refractometer, ATAGO ATC-1, Japan) was used to measure the ºBrix of the fresh samples. Three replicates were measured per sample.

Mechanical properties

The mechanical behaviour of the fresh samples slices, and persimmon snacks was measured using a puncture test on a Universal Texture Analyser (Stable MicroSystems, TA.XT2, Ltd, Godalming, England). A cylindrical (2 mm diameter) punch was used, applying a relative deformation of 85% and a distance rate of 1 mm s^{-1}. The parameters analysed in the puncture test were the maximum force (F_{max}) (N) and the area under the curve (N mm^{-1}). Twelve replicates were performed per sample.

Optical properties

The optical properties (translucency and CIEL^* a^* b^* colour coordinates) of the fresh samples and persimmon snacks were obtained from the surface reflectance spectra (between 400 and 700 nm), measuring the pulp on black and white backgrounds using a Minolta CM-3600d spectrocolorimeter (Minolta Co., Tokyo, Japan), considering the standard light source D65 and the standard observer 10º. Translucency (K/S) was determined by applying the Kubelka-Munk theory for multiple scattering of reflection spectra.[20] This theory assumes that the flow of light that passes through the sample is related to the absorbed relationship to scattered light (equations (1) and (2)). The reflectance of an infinitely thick layer of the material (R_∞) calculated using Eq. (2) was used to obtain colour coordinates CIE$L^*a^*b^*$. [21]

$$K/S = \frac{(1 - R_\infty)^2}{2R_\infty} \tag{1}$$

where: K: absorption coefficient; S: scattering coefficient; and R_∞: reflectance of an infinitely thick layer of the material, calculated with Eq. (2),

$$R_\infty = 0.5\left(R + \frac{R_0 - R + R_g}{R_0 R_g}\right) - \sqrt{\left(0.5\left(R + \frac{R_0 - R + R_g}{R_0 R_g}\right)\right)^2 - 1} \qquad (2)$$

where: R: reflectance of the sample with an ideal white background; R_0: reflectance of the sample with an ideal black background; R_g: reflectance of the ideal white background.

Colour attributes of chrome (C_{ab}*), and hue angle (h_{ab}*) were obtained from the CIE$L*a*b*$ colour coordinates applying $C_{ab}* = (a*^2 + b*^2)^{1/2}$ and $h_{ab}* = \text{arctg}(b*/a*)$ equations, respectively.

Total soluble tannin content

The total soluble tannin content of fresh samples and persimmon snacks was determined with a spectrophotometer (CE 1021 1000 series, CECIL INSTRUMENTS Cambridge) using the Folin-Ciocalteu colorimetric method as described by Arnal and Del Rio. (2004)[22], with modifications. Persimmon samples (5 g) were homogenised in an Ultraturrax (IKA T18 digital, Germany) with 25 mL of ethanol (96%). Homogenates were centrifuged (30,024 g, 20 min, 4 °C) and filtered, while keeping the supernatant. More supernatant was extracted from the pellet, with 25 mL of ethanol (96%), and added to the first supernatant. The total volume of supernatant was brought to 100 mL with ethanol (96%). One millilitre of the extract and six millilitres of distilled water were mixed and vortexed in a test tube. Thereafter, 0.5 mL of Folin-Ciocalteu reagent was added; after 3 min, 1 mL saturated Na_2CO_3 (20%) was added and vortexed, followed by 1.5 mL distilled water was added. Absorbance was measured after 90 min at 725 nm to determine soluble tannin content. The calibration curve was performed at different concentrations of gallic acid in ethanol (96%). Results were expressed as g gallic acid equivalents (GAE) kg^{-1} of dry matter. Total soluble extractions were made in triplicate.

Sensory analysis

Sensory analysis was conducted in persimmon snacks over three different sessions, one per each ripening stage. There were 255 consumers (153 women and 102 men) in total (85 consumers / session) recruited among the employees and students of the Universitat Politècnica de València. The persimmon snacks were analysed in a sensory testing room equipped with individual booths. A slice of each sample (A and NA dried at 40 or 60 ºC) was presented in each session following a balanced complete block experimental design. The samples were served in small plastic dishes coded with random three-digit numbers. They were served at room temperature (20 ºC) in random order. Water and bread were supplied to cleanse the consumers' palettes between each sample.

The consumer acceptance test was performed using a nine-point hedonic scale (1 = dislike extremely to 9 = like extremely) following the International Standard ISO / FDIS 11136:2014 (E). For each sample, the consumers scored their degrees of liking in the following order: 'appearance', 'flavour', 'texture', and 'overall acceptability'. Additionally, the consumers were asked to check the following characteristics: "astringent", "I would buy it", and "I wouldn't buy it".

Statistical analysis.

All the data were analysed using the Statgraphics Centurion XVII software package (Statistical graph Co., Rockville, MD).

A categorical multifactorial experimental design with two factors, ripening stage, and type of sample (A and NA), was used to characterise the fresh samples. A categorical multifactorial experimental design with three factors, ripening stage; type of sample; and drying treatment, was used to characterise the persimmon snacks. In the consumer acceptance tests, one-way analysis of variance was applied (ANOVA). The honest significant difference (Tukey´s HSD test) with a 95% confidence interval was used to compare the mean values obtained ($p < 0.05$).

RESULTS AND DISCUSSION

Fresh samples

The water content, water activity, and ºBrix are presented in Figure 2. Regarding to the water content (Figure 2A), significant interactions ($p < 0.05$) are observed between the ripening stage and type of sample factors. M1AF presents a greater moisture content than M1NAF, M2AF, M2NAF, M3AF, and M3NAF. The parameter of water activity (Figure 2B) does not show significant interactions between factors, only the ripening stage factor presented a significant effect ($p < 0.05$); the samples corresponding to the first ripening stage presented significantly higher water activity values. ºBrix (Figure 2C) shows no significant interactions ($p > 0.05$) observed between the ripening stage and type of sample factors, only the type of sample factor had a significant effect ($p < 0.05$). The de-astringent treatment led to a reduction in the ºBrix values, as the total soluble tannin content was reduced because of the treatment.[23]

Mechanical parameters show no significant interactions ($p > 0.05$) between the F_{max} and factors (Figure 2D and 2E) but both factors had a significant effect ($p < 0.05$) on the fruits. The samples show a significantly ($p < 0.05$) greater firmness of the pulp in the first ripening stage, decreasing in the second and third ripening stage (Figure 2D); moreover, the A samples present higher F_{max} ($p < 0.05$) than NA (Figure 2E). The effect of CO_2 on firmness loss in persimmon fruit was also observed by other authors.[24] Regarding area parameter (Figure 2F), a significant interaction ($p < 0.05$) between the ripening stage and type of sample factors exists. This parameter represents the energy or work required to compress the sample and it is related with the sample toughness. The same as occurred in F_{max}, samples present a significantly higher area in the first ripening stage, decreasing in the second and third ripening stages. This effect of ripening on mechanical properties has also been reported in other studies,[25] because of the degradation of the primary cell wall.[9]

The colour parameters show no significant interactions between factors ($p > 0.05$) for the luminosity (L^*), only the ripening stage factor had a significant effect (Figure 2G). L^* values remain without significant differences ($p > 0.05$) up to the third ripening stage where a reduction occurs. The h_{ab}^* value and C_{ab}^* values show significant interactions between the ripening stage and type of sample factors ($p < 0.05$) (Figures 2H and 2I). The samples present an orange yellow hue angle (Figure 2H) with no significant differences ($p > 0.05$) except for the M2AF, turning into a more orange hue angle. A significantly lower value of C_{ab}^* (Figure 2I) is observed in the third ripening stage.

Figures 3A and 3B shows the spectral distribution of Kubelka-Munk's index (K/S ratio) of A and NA fresh samples, at the three ripening stages, respectively. The greater the increase of this ratio, the more translucent the samples become.[21] In the fresh samples, the advanced ripening stage shows a greater ratio of K/S, therefore, samples in the third ripening stage presented greater translucency, with no flesh changes because of the CO_2 treatment. This phenomena is because of the degradation of the primary cell wall and as a consequence production of water content was more exposed thereby increasing translucency.[9] Changes in sample translucency have a great impact on the colour of samples, since selective absorption occurs at differing degrees, changes in clarity, hue, and chrome will occur.[21] These effects explain the most notable colour changes of pulp in the third ripening stage of this study. However, since the Kubelka-Munk´s theory describes the ability of the materials to transmit light depends on their light scattering (S) and absorbing (K) properties, low K/S values imply that a more light is scattered by the samples indicating that the persimmon samples have closed structures, therefore, presented certain opacity.[26]

The soluble tannin content of fresh samples is shown in Table 1. The soluble tannin content of the A fresh samples decreases significantly ($p < 0.05$) as ripening progresses. Loss of astringency takes place during the ripening of persimmon fruits and has been associated with the production of acetaldehyde, which must be involved in gradual tannins insolubilisation.[27] The NA fresh samples show less soluble tannin content than the A samples, as a consequence of the de-astringency treatment; after the de-astringency treatment, soluble tannin compounds are transformed into their insoluble forms.[28] A less marked decrease for soluble tannins was found in M3NAF than in M2NAF and M1NAF; therefore, as reported by other authors, ripening state is an important factor which compromises the effectiveness of the de-astringency treatment.[10]

Persimmon snacks

Figure 1B shows the images of persimmon snacks obtained in the three ripening stages and dried at 40 and 60 ºC. The A and NA persimmon snacks dried at 40 and 60 ºC, over 23 and 9 h respectively, reached a final water content of 15% ± 3 with a water activity below 0.650. The low water activity inhibits the growth of most bacteria, yeasts, and moulds, reducing oxidative and enzymatic reactions and increasing product shelf-life.[29] The texture parameters show no significant differences ($p > 0.05$) in the maximum force (F_{max}) and the area values among all the persimmon snacks, ranging from 10.76 to 14.30 N and from 0.15 to 0.32 N mm^{-1}, respectively (data not shown). The values were higher than in the fresh samples because of the loss of water content caused by the drying treatment.[30]

Figure 4A, 4B, and 4C show the L^* values measured in the persimmon snacks. The multifactor ANOVA shows interactions between ripening stage: type of sample, ripening stage: drying treatment, and type of sample: drying treatment. As the ripening stage progresses (Figure 4A and 4B), a reduction in luminosity is seen, as with the fresh samples. Snacks dried at 60 ºC (Figure 4C) present lower luminosity than snacks dried at 40 ºC while the NA samples dried at 60 ºC show the lowest values. The L^* value slightly increases (Figure 4B) after drying at 40 ºC and remains constant after drying at 60 ºC compared to fresh samples (Figure 2G). The h_{ab}^* values (Figure 4D and 4E) have interactions between ripening stage: type of sample and type of sample: drying treatment. A reduction of h_{ab}^* values from the first ripening stage to the third ripening stage, turn to an orange hue angle (Figure 4D). Besides, A samples have a significantly ($p < 0.05$) lower hue angle than NA ones (Figure 4E). Comparing the snacks with fresh samples (Figure 2H), dehydration causes a decrease in the hue angle values. Chroma values, shown in Figure 4F, have an interaction between the ripening stage: drying treatment even though no significant differences ($p > 0.05$) are observed between the samples for M1 and M2. Only in the third ripening stage, snacks dried at 40 ºC show higher chroma values than snacks dried at 60 ºC (Figure 4F). In addition, the snacks at the third ripening stage (Figure 4F) show higher C_{ab}* values than fresh samples (Figure 2I). Several authors also observed the reduction of h_{ab*} values and the increase of C_{ab*} values during drying in different fruits, including persimmon.[31] The reduction in h_{ab*} values and the increase in C_{ab*} because of drying process can be observed in Figure 5. The development of these colour changes was likely to be related to non-enzymatic browning reaction.[32]

Figure 3C and 3D show the spectral distribution of Kubelka-Munk's index (K/S ratio) of A and NA persimmon snacks, respectively. Snacks dried at 60 ºC present more translucency than snacks dried at 40 ºC, therefore the higher drying temperature the greater translucency. This could be because of the high temperature effect on the cell wall degradation,[33] which could generate intracellular fluid leakage and the increase of the refractive index homogeneity in the tissue, thus leading to a greater translucency.[20] As reported by Talens et al. (2002),[20] the greater the sample translucency, the darker the sample as can be seen in *L** and C_{ab}* values (Figure 4A, 4B and 4F). Despite drying treatments caused a slight increase in the K/S values of M2A40, M2A60, M3NA60, M2NA60, and M2NA40 and a slight decrease in M1A40, M3A40, and M1NA40, the values were low for all the snacks, as occurred in the fresh samples. Similar results were observed by Agudelo et al. (2015)[26] in cocona chips.

Table 1 also shows the soluble tannin content of the persimmon snacks. After drying at 40 and 60 °C, a decrease in the soluble tannin content is observed over the fresh samples, specifically for snacks obtained from A persimmon. Previous researchers have indicated losses of bioactive compounds when samples are subjected to drying; the reductions or losses are attributed to the thermal degradation of phytochemicals [34] or the transformation of soluble forms of tannins into their insoluble forms.[35] Regarding the ripening stage, a significant decrease ($p < 0.05$) was observed for the snacks obtained from A persimmon from the first ripening stage to the third. M3A60 obtained the lowest values of all the A persimmon snacks.

Snacks obtained from NA persimmon have reduced the soluble tannin content than the fresh samples for the different drying treatments, both in M2 and M3 ripening stages (Table 1) with no significant differences ($p > 0.05$) observed among all the NA persimmon snacks. As seen in A persimmon snacks, the drying treatment favoured the formation of insoluble tannins. Moreover, M3A40 shows similar values to M3NAF, while M3A60 did not show significant differences ($p > 0.05$) with snacks obtained from NA persimmon at the different ripening stages.

Figure 6 (A, B, C and D) shows the results of the consumer acceptability test at the three different ripening stages. The attributes assessed in this test were appearance, flavour, texture, and overall acceptability. In the first ripening stage (Figure 6A), the appearance of M1A40 and M1NA40 have higher acceptability ($p < 0.05$) than M1A60 and M1NA60. The acceptability of the flavour of snacks (Figure 6B) M1NA40 and M1NA60 are greater ($p < 0.05$) than snacks M1A40 and M1A60, regardless of the drying temperature. For the texture attribute (Figure 6C) only the M1A60 obtained low score ($p < 0.05$) and the overall acceptability (Figure 6D) follows the same tendency as the flavour attribute.

In the second ripening stage, the appearance (Figure 6A) of M2A60 and M2NA60 have the lowest values ($p < 0.05$). For the flavour attribute (Figure 6B), M2A60 presents the lowest score ($p < 0.05$) and the same tendency was observed in the overall acceptability (Figure 6D). The texture attribute (Figure 6C) does not show significant differences ($p > 0.05$). For the third ripening stage (Figure 6), no significant differences ($p > 0.05$) are observed between the snacks for the different attributes.

The appearance perception of the consumers could be related with the $L*$ values (Figure 4A, 4B, and 4C) and, with the translucency obtained in the persimmon snacks (Figure 3C and 3D), since both parameters were related. Snacks dried at 40 ºC present higher luminosity than those dried at 60 ºC and snacks dried at 60 ºC present more translucency than snacks dried at 40 ºC although in the third ripening stage the consumers did not detect the effect (Figure 6A). The evolution of flavour perception (Figure 6B) throughout the ripening stages could be related with the tannin insolubilisation and consequently a decrease in astringency caused by the drying temperature (Table 1). With texture no significant differences ($p > 0.05$) are detected in the acceptability by the consumers from the second ripening stage (Figure 6C) as occurred with the texture F_{max} and area parameters obtained in the characterization of persimmon snacks.

Regarding the overall acceptability (Figure 6D), although the most acceptable snacks in the first ripening stage are those obtained from the NA persimmon; as the ripening stage progressed, there are no significant differences ($p > 0.05$), with all snacks accepted at M3. Consequently, according to these findings, the flavour determines the overall acceptability of the persimmon snacks and relates to the transformation of soluble tannins to their insoluble forms leading to loss of astringency.

Therefore, as the state of ripening progresses, an acceptable persimmon snack can be obtained without the need for a previous de-astringency treatment.

The frequency of mention, of the added questions presented to the consumers in the acceptability test, are shown in Table 2. The consumers detect less astringency in the snacks obtained from A persimmon as the ripening stage progressed and when the snacks are dried at 40 ºC. The frequency of mention for the snacks dried at 60 ºC is low, regardless the ripening stage. These results correlated to the content of soluble tannins (Table 1), with the correlation coefficient (R^2) being 0.8038 (Figure 7). In addition, as the ripening stage progressed the frequency of mention of purchasing these products increases. In fact, 61% of consumers declared they were willing to buy the M3NA40. Similar percentages of purchase intention were found in other products derived from persimmon. [36,37] Table 2 shows how the NA snacks present higher frequency of mention for the "buy it" term. However, in the third ripening stage, both M3A40 and M3A60 snacks present a high frequency of mention for "buy it", like M3NA40 and M3NA60. This could be related with the appearance, texture, flavour, and overall acceptability attributes in the third ripening stage as no significant differences were found between samples at this ripening stage. The declaration "willing to buy" could be also connected with the soluble tannin content, as they show an inverse correlation (R^2= 0.8273), showing that consumers are willing to buy the less astringent samples (Figure 7).

CONCLUSION

This study proves that hot air-drying treatment is a useful technique when developing a well-accepted dehydrated persimmon snack and could avoid the application of a de-astringency treatment when advanced ripening stages of persimmon are used.

Drying considerably decreases the content of soluble tannins, especially in astringent samples. As the ripening stage progresses, a snack can be made from astringent persimmon with a soluble tannin content like the snacks obtained from non-astringent fruits, especially when drying at 60 ºC. The astringency perceived by consumers is correlated to the soluble tannin content during ripening. Although at the beginning of the season they prefer the snacks obtained from non-astringent persimmon; snacks produced from astringent persimmon at the third ripening stage are also well accepted.

Therefore, the development of dehydrated persimmon snacks from astringent and non-astringent “Rojo Brillante” fruit can be an alternative, to increase persimmon production profitability, especially at the end of the harvest season, when a de-astringency treatment may be less efficient.

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Table 1. Soluble tannin content at the three ripening stages (M1, M2 and M3) in astringent (A) and non-astringent (NA) fresh samples and persimmon snacks obtained by hot air drying at 40 and 60 ºC.

Ripening stage	Persimmon samples	Soluble tannin content (g gallic acid equivalents (GAE) kg^{-1} dm)
M1	AF	9.10^{a} (0.16)
	A40	4.81^{d} (0.25)
	A60	4.04^{e} (0.21)
	NAF	1.17^{i} (0.22)
	NA40	0.99^{i} (0.10)
	NA60	0.93^{i} (0.12)
M2	AF	7.42^{b} (0.26)
	A40	3.75^{f} (0.15)
	A60	3.31^{f} (0.23)
	NAF	1.68^{h} (0.07)
	NA40	0.99^{i} (0.07)
	NA60	1.02^{i} (0.06)
M3	AF	5.64^{c} (0.04)
	A40	2.53^{g} (0.24)
	A60	1.05^{i} (0.06)
	NAF	2.26^{g} (0.45)
	NA40	1.11^{i} (0.21)
	NA60	0.86^{i} (0.08)

Means in the same column without a common letter are significantly different ($p < 0.05$) according to the Tukey´s multiple range test. Values in parentheses are the standard deviations.

Table 2. Purchase intention and astringency perception of the persimmon snacks obtained by hot air drying at 40 and 60 ºC in the three ripening stages (M1, M2, and M3). A: astringent persimmon; NA: non-astringent persimmon.

Ripening stage	**Attributes**	**Frequency of mention**			
		A40	**A60**	**NA40**	**NA60**
M1	Astringent	44	19	1	3
	buy it	30	38	50	29
	not buy it	54	46	34	55
M2	Astringent	23	19	6	6
	buy it	40	35	51	47
	not buy it	42	46	31	35
M3	Astringent	24	14	6	3
	buy it	46	45	52	48
	not buy it	38	39	32	36

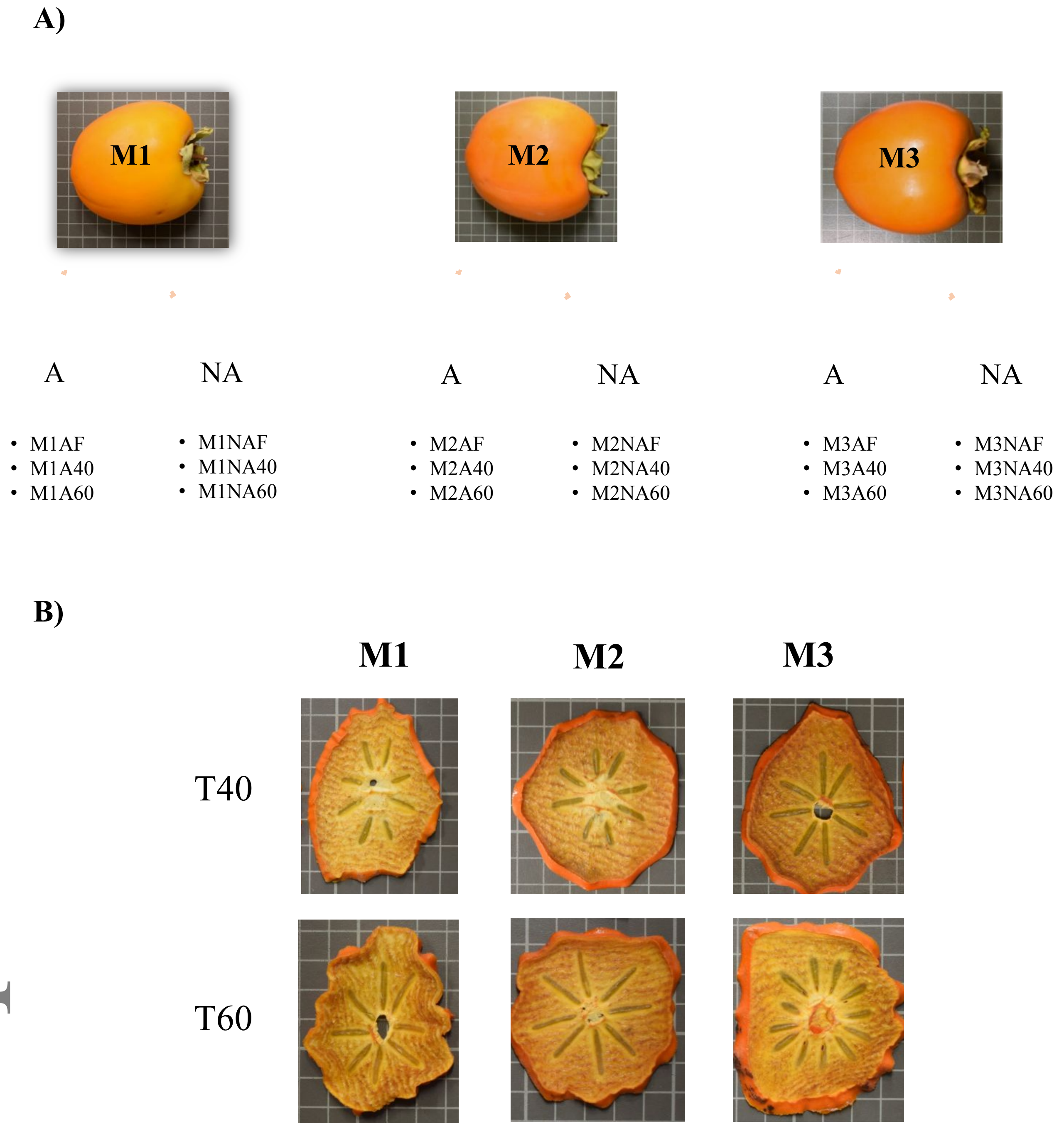

Figure 1. **A -** Schematic representation of persimmon samples analysed. A = astringent, NA = non-astringent. M1, M2, and M3 are referred to the three ripening stages. Letter F means fresh fruit; numbers 40 and 60 are related to the temperature of the air drying treatment. **B -** Images of persimmon snacks in the three ripening stages (M1, M2, M3) obtained by hot air drying at 40 (T40) and 60 ºC (T60).

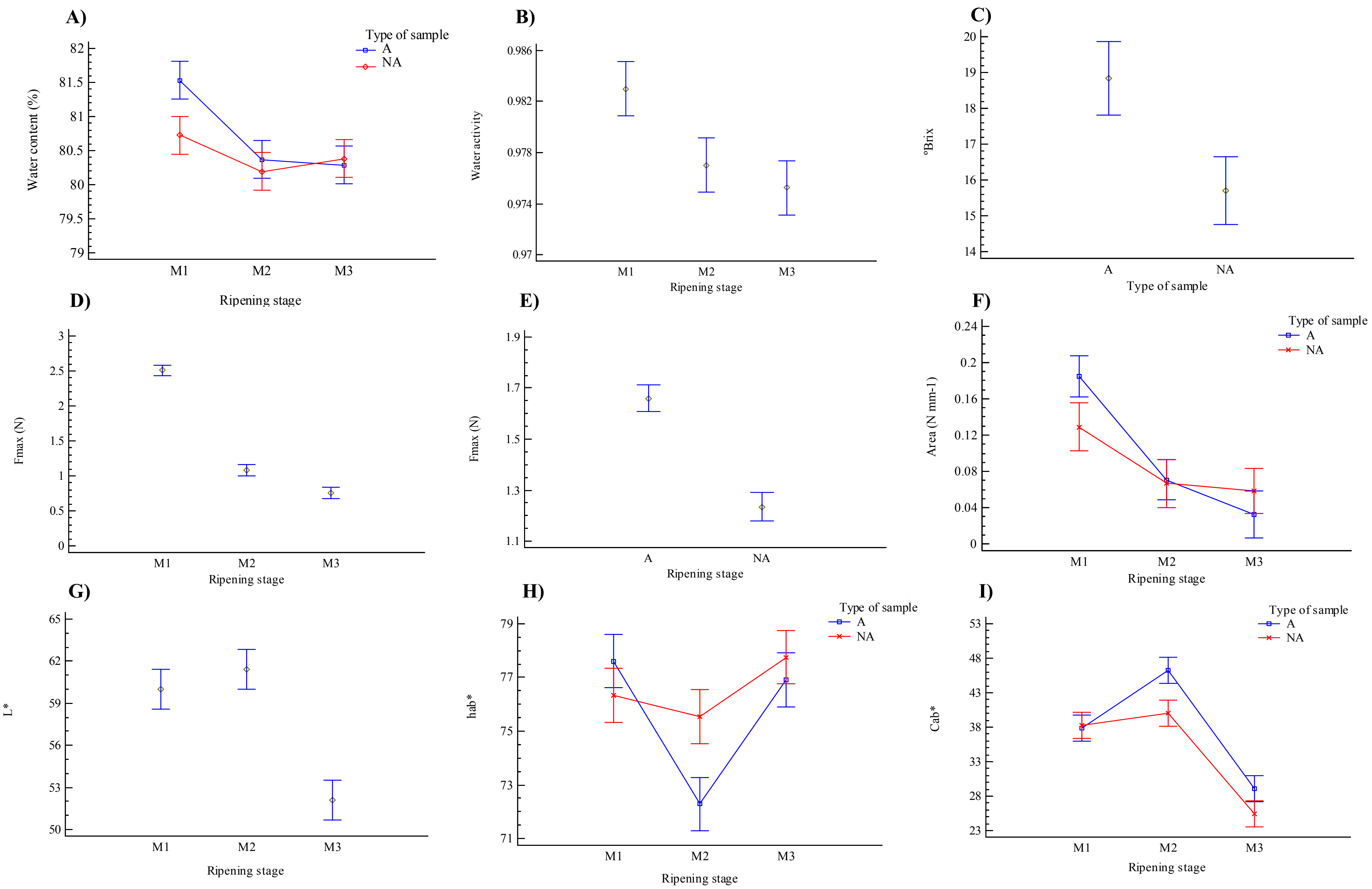
A)
Type of sample
A
NA
Water content (%)
82
81.5
81
80.5
80
79.5
79
M1
M2
M3
Ripening stage
B)
Water activity
0.986
0.982
0.978
0.974
0.97
M1
M2
M3
Ripening stage
C)
°Brix
20
19
18
17
16
15
14
A
NA
Type of sample
D)
Fmax (N)
3
2.5
2
1.5
1
0.5
0
M1
M2
M3
Ripening stage
E)
Fmax (N)
1.9
1.7
1.5
1.3
1.1
A
NA
Ripening stage
F)
Type of sample
A
NA
Area (N mm-1)
0.24
0.2
0.16
0.12
0.08
0.04
0
M1
M2
M3
Ripening stage
G)
L*
65
62
59
56
53
50
M1
M2
M3
Ripening stage
H)
Type of sample
A
NA
hab*
79
77
75
73
71
M1
M2
M3
Ripening stage
I)
Type of sample
A
NA
Cab*
53
48
43
38
33
28
23
M1
M2
M3
Ripening stage

Figure 2. Means and interactions plots with Tukey HSD intervals. A: Interaction between the ripening stage and the type of sample for water content of fresh samples. B: mean values for the water activity according to the ripening stage for the fresh samples. C: mean values for the ºBrix according to the type of sample for the fresh samples. D and E: mean values for the F_{max} according to the ripening stage and the type of sample for the fresh samples, respectively. F: Interaction between the ripening stage and the type of sample for area of fresh samples. G: mean values for the $L*$ according to the ripening stage of fresh samples. H: Interaction between the ripening stage and the type of sample for $h_{ab}*$ of fresh samples. I: Interaction between the ripening stage and the type of sample for $C_{ab}*$ of fresh samples.

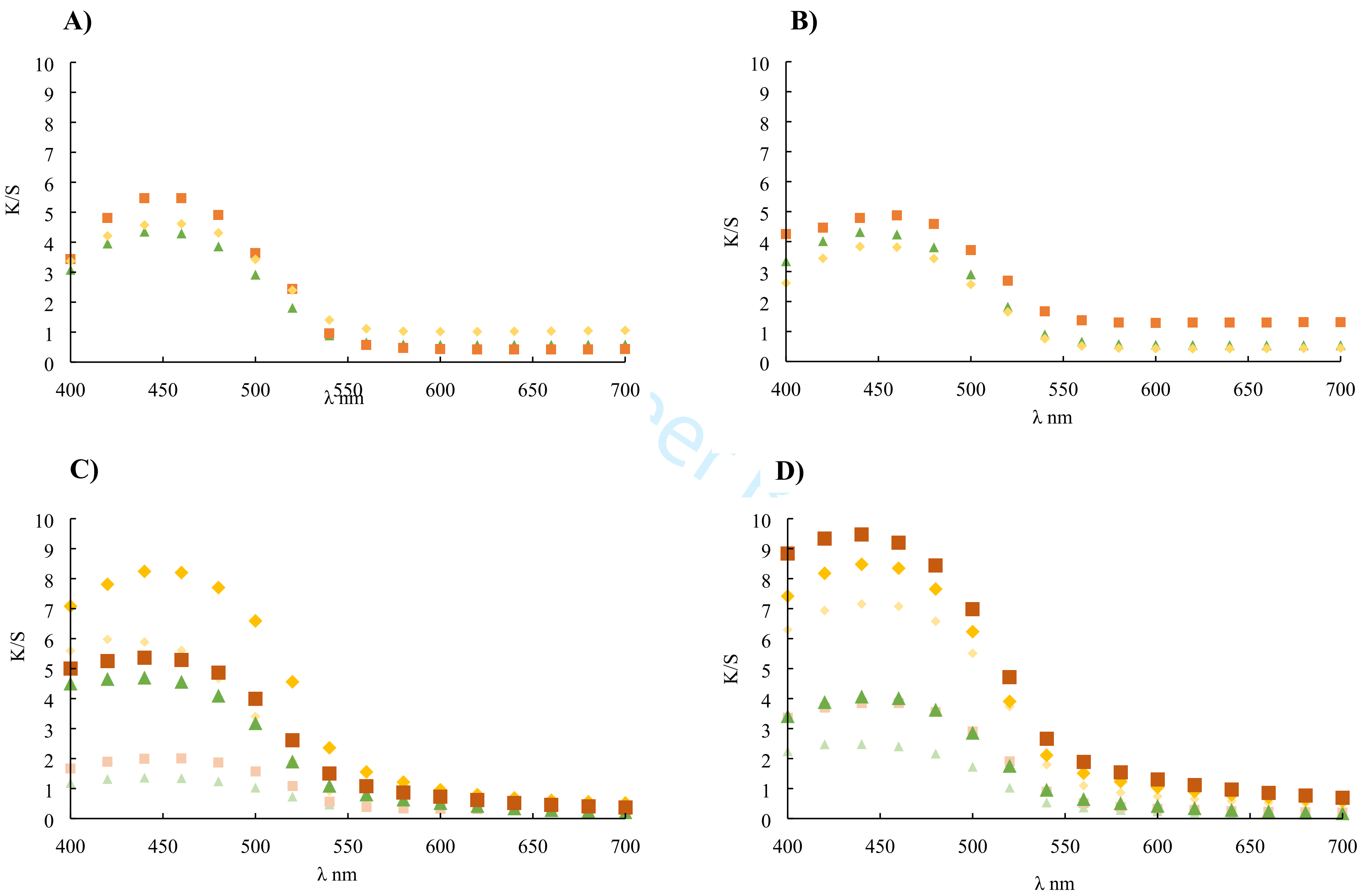
A)
B)
C)
D)
K/S
λ nm
0
1
2
3
4
5
6
7
8
9
10
400
450
500
550
600
650
700

Figure 3. Spectral distribution of Kubelka-Munk's index (K/S ratio) for samples at the three ripening stages. **3A** - M1AF (▲), M2AF (♦), and M3AF (■). **3B** - M1NAF (▲), M2NAF (♦), and M3NAF (■). **3C** - M1A40 (▲), M1A60 (▲), M2A40 (♦), M2A60 (♦), M3A40 (■), and M3A60 (■). **3D** - M1NA40 (▲), M1NA60 (▲), M2NA40 (♦), M2NA60 (♦), M3NA40 (■), and M3NA60 (■).

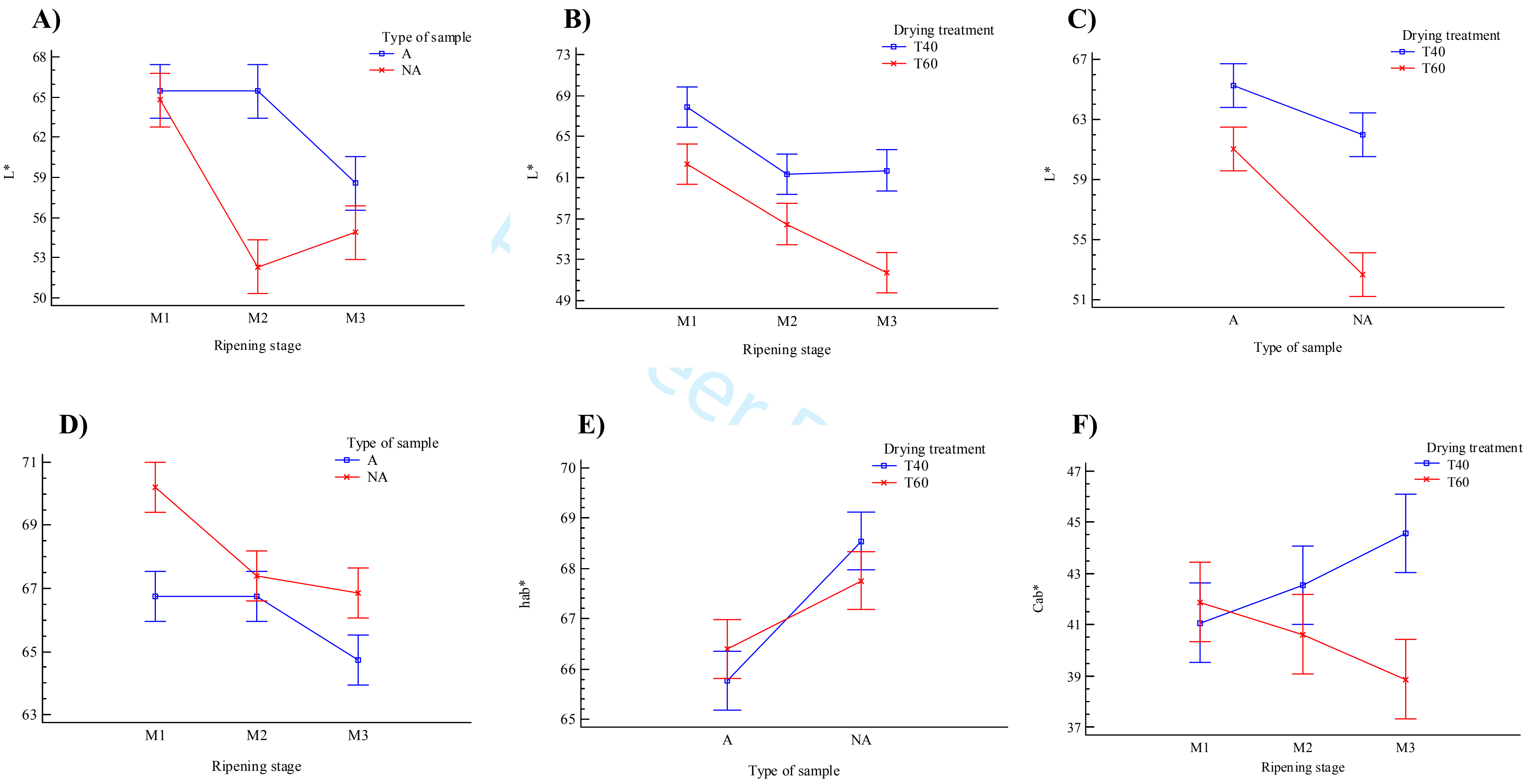
A)
Type of sample
A
NA
L*
68
65
62
59
56
53
50
M1
M2
M3
Ripening stage
B)
Drying treatment
T40
T60
L*
73
69
65
61
57
53
49
M1
M2
M3
Ripening stage
C)
Drying treatment
T40
T60
L*
67
63
59
55
51
A
NA
Type of sample
D)
Type of sample
A
NA
hab*
71
69
67
65
63
M1
M2
M3
Ripening stage
E)
Drying treatment
T40
T60
hab*
70
69
68
67
66
65
A
NA
Type of sample
F)
Drying treatment
T40
T60
Cab*
47
45
43
41
39
37
M1
M2
M3
Ripening stage

Figure 4. Means and interactions plots with Tukey HSD intervals. A, B, and C: Interactions between the ripening stage - the type of sample, the ripening stage - drying treatment, and the type of sample - drying treatment for *L** of persimmon snacks obtained by hot air drying at 40 and 60 ºC, respectively. C and E: Interaction between the ripening stage - the type of sample and the type of sample - drying treatment for h_{ab}* of persimmon snacks obtained by hot air drying at 40 and 60 ºC. F: Interaction between the ripening stage - drying treatment for C_{ab}* of persimmon snacks obtained by hot air drying at 40 and 60 ºC.

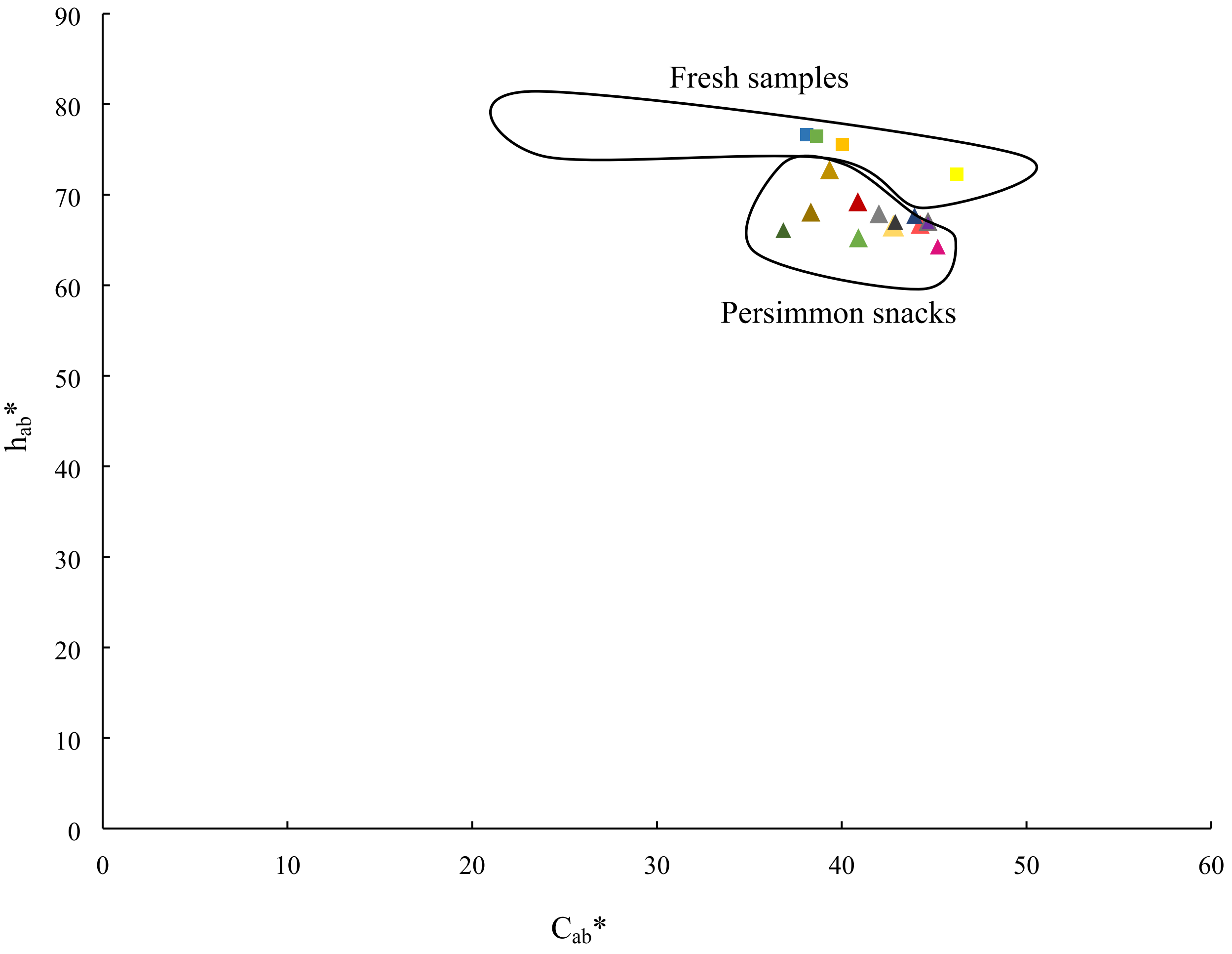

Figure 5. Comparison of h_{ab}* and C_{ab}* values between the fresh samples and the persimmon snacks obtained by hot air drying at 40 and 60 ºC. M1AF (■), M1NAF (■), M2AF (■), M2NAF (■), M3AF (■), M3NAF (■). M1A40 (▲), M1A60 (▲), M1NA40 (▲), M1NA60 (▲), M2A40 (▲), M2A60 (▲), M2NA40 (▲), M2NA60 (▲), M3A40 (▲), M3A60 (▲), M3NA40 (▲), and M3NA60 (▲).

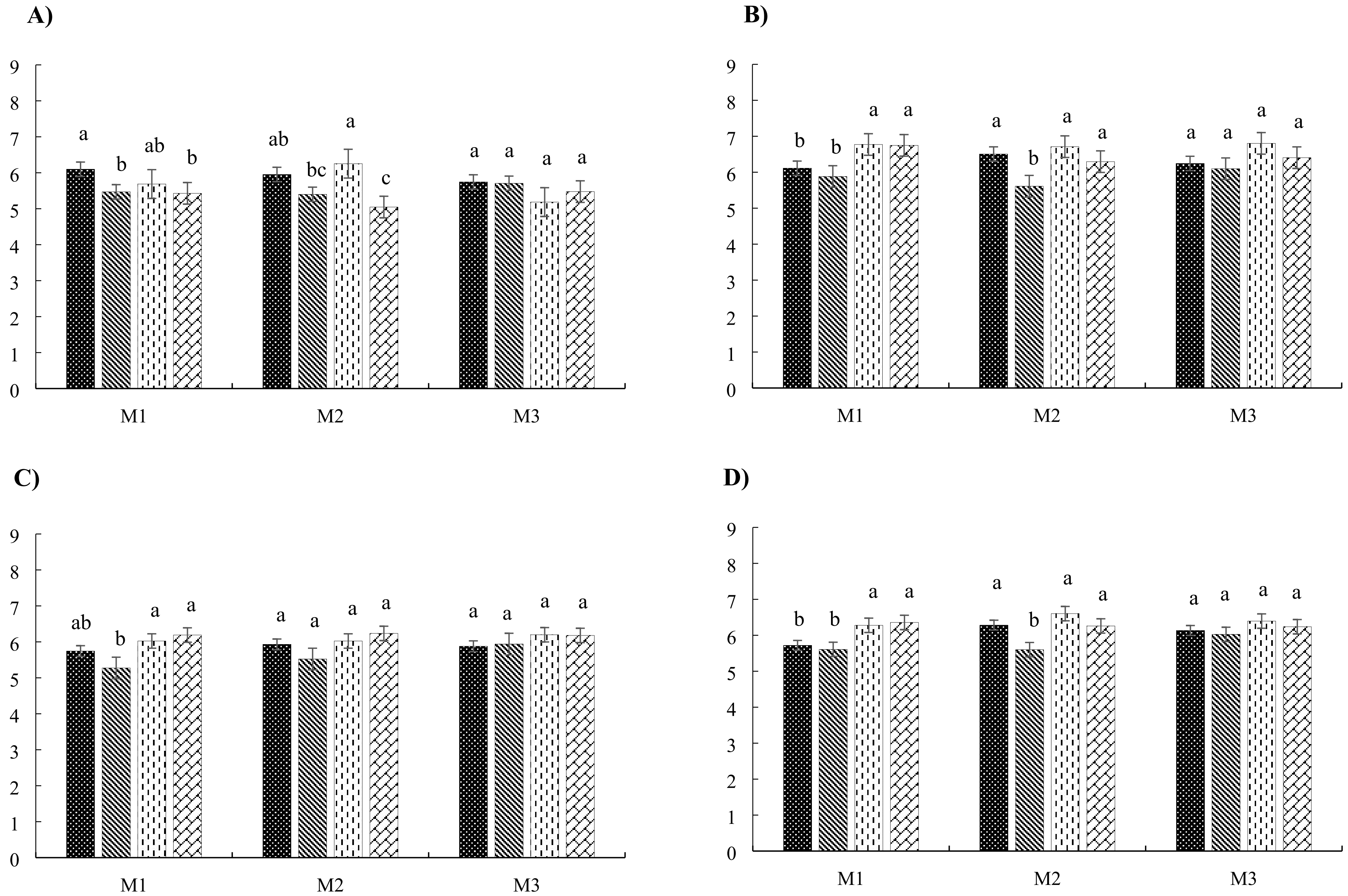
A)
B)
C)
D)
M1
M2
M3

Figure 6. Liking scores for appearance (A), flavour (B), texture (C), and overall acceptability (D) of persimmon snacks obtained by hot air drying at 40 and 60 ºC in the three ripening stages (M1, M2, M3). Different superscript in each bar differ significantly ($p < 0.05$) according to ANOVA (Tukey HSD multiple range test). - A40, - A60, - NA40, - NA60.

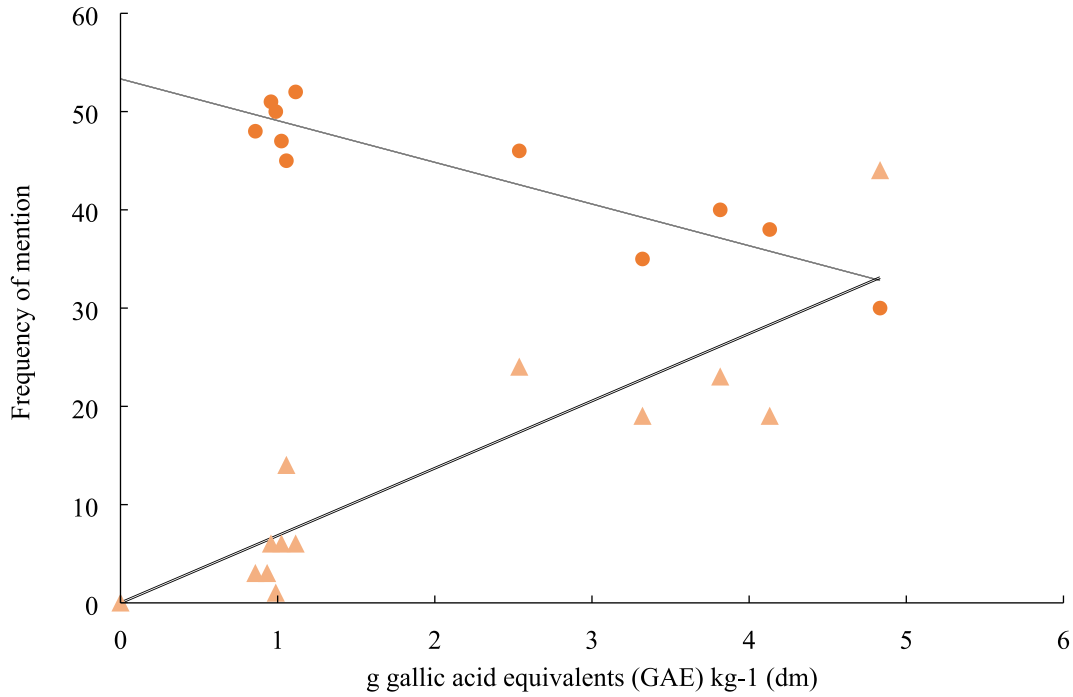

Figure 7. Correlation (R^2) between the frequency of mention of astringent (triangles) and "willing to buy" term (circles) and soluble tannin content of persimmon snacks obtained by hot air drying at 40 and 60 ºC in the three ripening stages (M1, M2, and M3).