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Technical note

Persimmon pulp and jelly: chemical characterization and rheological behavior

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Abstract

The persimmon (*Diospyros kaki* LF) belongs to the *Ebenaceae* family and is originally from Asia. Because the fruit is perishable, we aimed to processes it to avoid wasting. The jelly is one of the most widely used processes, because it follows a simple methodology, requires little equipment and brings harnessing of fruit unfit for the *in natura* consumption, transforming it in a product of increased durability. It was elaborated conventional jellies containing 70% and 60% of pulp. We proceeded to the chemical and rheological characterization of the persimmon pulp and obtained jellies. The pulp chemical analysis values are consistent with the expected. The values found in the jelly with 70% of pulp were: 0.81% of ATT, 66.33ºBrix for SST, pH of 4.01, 0.44% of pectin and 26.98% of moisture. The values found in the jelly with 60% of pulp were: 0.78% of ATT, 68.17 ºBrix for SST, pH of 4.13, 0.36% of pectin and 28.26% of moisture. The persimmon pulp behaved as a pseudoplastic fluid, since the apparent viscosity decreases with the increase in the deformation tax. Both jellies behaved as pseudoplastic fluid once the product was obtained.

Keywords: rheology; viscosity; persimmon.

Polpa e geléia de cáqui: caracterização química e comportamento reológico

Resumo

O caquizeiro (*Diospyros kaki* LF) pertencente à família *Ebenaceae*, é originário da Ásia. Pelo fato da fruta ser perecível buscou-se processa-lo para evitar o desperdício. A geléia é uma das formas de processo mais utilizadas por seguir uma metodologia simples, exigir poucos equipamentos e trazer aproveitamento de frutas impróprias para o consumo *in natura*, transformando-as em um produto de maior durabilidade. Foram elaboradas geléias convencionais contendo 70 e 60% de polpa. Procedeu-se a caracterização química e reológica da polpa de caqui e das geléias obtidas. Os valores das analises químicas da polpa estão de acordo com o esperado. Os valores encontrados na geléia com 70% de polpa foram: 0,81% de ATT, 66,33ºBrix para SST, pH de 4,01, 0,44% de pectina e 26,98% de umidade. Os valores encontrados na geléia com 60% de polpa foram: 0,78% de ATT, 68,17 ºBrix para SST, pH de 4,13, 0,36% de pectina e 28,26% de umidade. A polpa de caqui comportou-se como fluido pseudoplástico, visto que a viscosidade aparente diminui com o aumento na taxa de deformação. Ambas as geléias se comportaram como fluído pseudoplástico logo que o produto foi obtido.

Palavras chave: reologia; viscosidade; caqui.

Pulpa y jalea de caqui: caracterización química y comportamiento reológico

Resumen

El caqui (*Diospyros kaki* LF) pertenece a familia Ebenaceae, es originario de Asia. Debido a que la fruta es perecedera se buscó procesarla para evitar el desperdicio. La jalea es una de las formas de proceso más utilizadas debido seguir una metodología simple, necesitar de poco equipo y posibilitar el aprovechamiento de frutas inadecuados para el consumo in natura, convirtiéndolos en un producto de mayor durabilidad. Se prepararon jaleas convencionales que contiendo 70

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y 60 % de pulpa. Se procedió la caracterización química y reológica de la pulpa de caqui y de las jaleas obtenidas. Los valores de los análisis químicos de la pulpa están de acuerdo con las expectativas. Los valores encontrados en la jalea con un 70 % de pulpa fueran 0,8 % de ATT, 66,33° Brix para SST, pH de 4,01, 0,44% de pectina y 26,98% de humedad. Los valores encontrados en la jalea con un 60% de pulpa fueran 0,78% de ATT, 68,17° Brix para SST, pH 4,13, 0,36% de pectina y 28,26 % de humedad. La pulpa de caqui se comportó como un fluido pseudoplástico, visto que la viscosidad aparente disminuye al aumentar la taza de deformación. Ambas jaleas se comportaron como un fluido pseudoplástico una vez que se ha obtenido el producto.

Palabras clave: reologia, viscosidad, caqui.

Introduction

The persimmon, which belongs to the genus *Diospyros* of the *Ebenaceae* family, possesses four species of commercial importance (GUIMARÃES, 2007). However, from the fruit culture point of view, all important varieties belongs to the *Diospyros kaki* L species, which is native from China, from where, centuries ago, was taken to Japan, being cultivated today in the whole world (MUÑOZ, 2002). Whichever the variety considered, the persimmon fruit is almost only pulp of gelatinous and cold appearance, concentrating good quantities of carotene (vitamin A) and vitamins of the B and C complex, the persimmon pulp is constituted, basically, of mucilage and pectin, responsible for the fruit characteristic appearance. Its sugar content, which varies between 14% and 18%, presents itself in a highly absorbable form of glucose, which means that it is superior to most fruits of popular consumption, in which the general contents do not surpass the 12% (GALVANI, EIDAM and AYALA, 2000). The persimmon tree is capable to adapt very well to diverse soil and weather conditions, and this allowed its distribution to all states of the South and Southeastern regions (FAGUNDES, DABUL and AYUB, 2006), where it became a crop of great importance, and to some states of the Northeast and Midwest regions, where unfortunately, did not achieve the same prominence (FIORAVANÇO and PAIVA, 2007).

The fruits loss in Brazil is of the order 20% to 40% of the production. Great part of this elevated percentage is due to the deficient management, production inadequate techniques, harvest and post-harvest. According to SILVA, LOPES and VALENTE-MESQUITA (2006) the industrial processing of fruits adsorbs great part of the harvest, which favors the consumption of these during the whole year, besides reducing the food waste; a good harnessing option is the jellies fabrication, which are used in bread, biscuits, yoghurt and confectionery.

The issues related to the fruits handling in industrial scale have as a practical solution the transformation of raw matter in fruit pulp, and posterior processing of this (FERREIRA et al., 2002). The data shortage about physical chemical and pulp rheological properties of tropical fruits has led the national industry to use parameters which are applied to orange juice, which, for having different behaviors do not achieve the same quality level (VIDAL et al., 2000). To each processing step become economically viable, is fundamental knowledge of the rheological properties that occupy prominent position, being useful not only as a quality measure, but also in projects, assessment and operation of equipment such as pumps, agitation systems, piping, etc. (SILVA et al., 2005).

Material and Methods

Persimmon jelly manufacture

The persimmons of the cultivar "Rama Forte" originated in São Jose dos Campos – SP were selected, washed in running water and immerse in a solution of 0.01% of sodium hypochlorite for 10 minutes. Afterwards were depulped in a Hauber/ Macanuda content removing device and the obtained pulp was frozen and kept at a temperature of -18^{o}C in cold chamber. The obtained pulp pH was adjusted to the range of 3.0 to 3.4 with the citric acid use (LAGO et al., 2006; MOTA, 2006). The jelly was elaborated defrosting the pulp at a temperature of 5 °C and using a proportion of pulp: sugar of 70:30 and 60:40, with addition of 0.5% of pectin. The pulp, already containing sucrose was heated until approximately 70 ^{o}C and was added pectin dissolved in water (8g/ 150ml) and the citric acid, kept under heating until 67°Brix. The jelly was potted still hot, in glass recipients (250ml).

Chemical and Rheological analysis

The pulp chemical analysis and of the persimmon jelly were done in the Plant Pilot of Food Technology of the Department of Agricultural Sciences of the Universidade de Taubaté- UNITAU, according the following methods:

- Moisture: A.O.A.C. (1980), Method- 16192
- pH: pHmeter Analion, Model PM 608.
- Total Soluble Solids (ºBrix): ADOLPO LUTZ (1980), method nº 13.6.4, with use of the refractometer ABBE of benchtop Reichert, Model Mark II Plus 13104950.
- Total Titratable Acidity (TTA): ADOLPO LUTZ (1980), method nº 016/IV.
- Pectin: RANGANA, 1977.

The determination of the rheological behavior of pulp and jellies was done with the use of rotating viscometer of the brand Brookfield Engineering Laboratories, with reading scale of 0 to 100% of torque, easily convertible in tension value of shearing through the factors of conversion obtained from a table fixed to the viscometer. In the tables of catalog of the apparatus is found the calibration factor, for which the reading of the torque wrench must be multiplied to obtain the viscosity. The obtained results were processed with the software ORIGIN 6.0, and the obtained curves adjusted to the rheological models of Casson, Ostwald-de-Waelle (Potency Law) Mizrahi-Berk and Herschel-Bulkley, for which, were analyzed the following statistical parameters: correlation coefficient (R^2), chi-square (X^2) and sum of the squares of residues (SSR). For this determination the jellies were kept under heating (70ºC) to delay the jellification.

Results and Discussion

Pulp and jellies characterization

The analysis results for the pulp and jelly characterization of persimmon are found in Table 1.

FAGUNDES, DABUL and AYUB (2006), working with the cultivar Fuyu obtained values of acidity between 0.08% and 0.10% which are in consonance with the value found by DANIELE et al. (2002), who worked with the same cultivar; now BLUM et al. (2008) found values inferior to 0.04%. ANTONIOLLI et al. (2001), with the cultivar Giombo, found acidity value of 0.12%. MUNOZ (2002) with the cultivar Rama Forte obtained a value of 0.17% of total titratable acidity, being this above of the one found in this study, for the same cultivar.

The TSS content found is in accordance with the values described by ANTONIOLLI et al. (2001) which vary from 9 to 21 ºBrix for the different persimmons cultivars. It is observed in the bibliography that each cultivar presents different values for TSS: for the cultivar Giombo, PARK et al. (2004), found the value of 25.50ºBrix and ANTONIOLLI et al. (2001) discovered the value of 20.40 ºBrix. For the cultivar Quioto, BRACKMANN et al. (2003), found value of 15.4 ºBrix, being that BLUM and AYUB (2009) obtained the value of 16.3%, a bit superior. MIZOBUTSI et al. (2003) working with the Rubi cultivar, found the value 15.20 ºBrix. MUNOZ (2002) with the cultivar Rama Forte got to the value of 19.05ºBrix, being this above of the one found in this study with the same cultivar.

SHIMIZU et al. (2002) obtained pH values for the cultivars Rama Forte and Mikado of 5.14 and 5.88, respectively. However, MUNOZ (2002) with the cultivar Rama Forte, obtained pH value of 5.59, which is close to the value found in this study with the same cultivar.

RAUPP et al. (2008) processing dried persimmons of the cultivar Fuyu obtained moisture value in the *in natura* pulp of 82.1%, being this similar to the one found by PARK et al. (2004), of 81.91%.

The results obtained in the present study for pectin are in accordance with LEME JR (1968), who

Table 1. Average values of total titratable acidity (TTA) (% of citric acid), total soluble solids (TSS), pH, pectin and moisture for the persimmon pulp and jelly.

	TTA (%)	TSS (ºBrix)	pH	Pectin (%)	Moisture (%)
Pulp	0.14±0.01	16.0±0.0	5.93±0.01	0.06±0.00	83.21±0.04
Jelly 60:40[1]	0.78±0.03	68.17±0.28	4.13±0.03	0.36±0.01	28.26±0.01
Jelly 70:30[2]	0.81±0.02	66.33±1.04	4.01±0.02	0.44±0.01	26.98±0.03

1 - Jelly 60:40: made with 60 pulp parts for 40 sugar parts.

2 - Jelly 70:30- made with 70 pulp parts for 30 sugar parts.

states that the persimmon pulp is poor in pectin.

According to MOURA and coworkers (2007), the persimmon presents great variation in its chemical composition and these alterations, in its majority, depend on variety, maturation stage, weather, season in which is produce, among other factors.

The jelly total acidity must not exceed 0.8% (FALCÃO et al., 2007), and the minimum indicated is 0.3% (JACKIX, 1988). It is observed that the jellies obtained in this study presented acidity values within the recommended, being not observed losses in the gel formation, thus not affecting the jellification due to the pectin hydrolysis. MOTA (2006) studied blackberry jelly, and the acidity index of the jellies kept at the range of 1.79%, which is above of the value found in this study and above the cited recommendations. Similar behavior was observed by MENDONÇA, RODRIGUES and ZAMBIAZI (2000) in the study of brown sugar in apple jellies, where the acidity contents were 0.99%. FOLEGATTI et al. (2003) studied the industrial use of umbu and observed that the increase of pulp quantity, that is 50:50, in comparison to 40:60, resulted in acidity content increase of the product by 0.86% and 0.62% respectively, similar behavior was observed in the present study, which resulted in increase of acidity content of the products: 0.81% and 0.78% in the jellies 70:30 and 60:40, respectively.

As stated by MIQUELIM (2006), for conservation of products that uses fruits in their composition, the solids concentration above 65 ºBrix enables the conservation of these products at ambient temperature, thus avoiding the deterioration of the same. The persimmon jellies presented values of solids superior to 65 ºBrix, in line with this recommendation. SILVA, LOPES and VALENTE-MESQUITA (2006) in the elaboration of orange jelly, found value of 65 ºBrix, value identical to that found by DAMIANI et al. (2008), who elaborated a jelly from mango peels. FOLEGATTI et al. (2003) still in the study of industrial use of umbu, processed the jelly at the proportions of 40:60 and 50:50 and obtained values of 67.5 ºBrix and 67.1 ºBrix, respectively. The authors concluded that this difference probably occurred due to the difference of the raw matter composition. Similar behavior was observed in the present study, which resulted in total soluble solids contents of the products of 66.33% and 68.17%, in the jellies 70:30 and 60:40, respectively.

The jellies pH must be controlled, it is suggested a maximum pH of 3.4, being that below 3.0 there is a tendency to syneresis (FALCÃO et al., 2007). In Table 1, it is observed that the obtained jellies presented value of pH above recommended. Probably the added citric acid was insufficient or was degraded during the process, yet it was not observed losses in gel formation, thus not affecting the jellification due to the pectin hydrolysis. However, comparing the analysis results of the jellies and of the pulp *in natura*, it was verified that with the processing, the pH reduced in function of the citric acid addition, which also provided acidity increase. MOTA (2006) studying blackberry jelly, noted that the obtained jellies pH kept at the range of 3.2 to 3.4, values close to those observed in the fruits pulp before the processing. FOLEGATTI et al. (2003) in the umbu study, mentions that increases in the quantity of added pulp, i. e. 50:50 in comparison to the 40:60, resulted in pH decrease of the products, from 2.82 to 3.05, respectively, similar behavior was observed in the present study, which resulted in pH contents of the products of 4.01 and 4.13 in the jellies 70:30 and 60:40, respectively.

Rheological behavior

The graphics of shear stress in function of the deformation rate obtained by different rotation frequencies of the persimmon pulp and jellies are found in the Figures 1 and 2. In these, the results presented are the averages of the experimental triplicates.

Observing the slope of the flow curve, it can be noted the apparent viscosity reduction as the

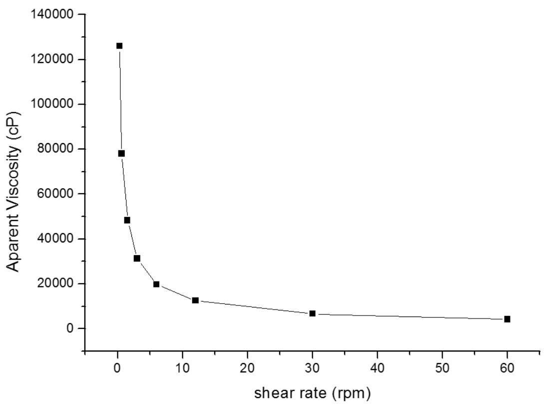

Figure 1. Rheological behavior of the persimmon pulp.

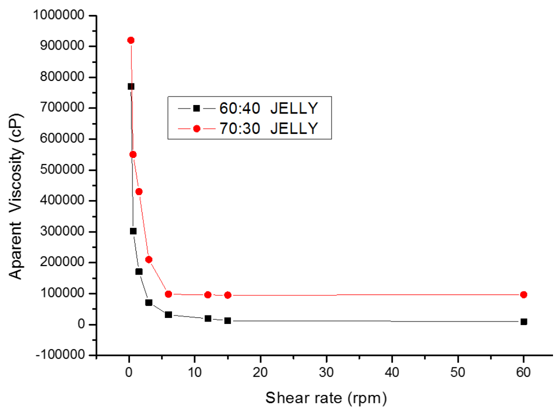

Figure 2. Rheological behavior of the persimmon jellies.

rotation frequency is increased, this occurs because the rotation frequency is directly related to the deformation rate, agreeing with the results obtained by FERREIRA et al. (2002), who was studying the rheological behavior of the cashew and guava pulps, visually confirming the pseudoplastic behavior of the sample – being this a typical behavior of fruits pulp, as observed by GASPARETTO and PELEGRINE (2000), COELHO (2007), HIDEGUCHI (2007), PELEGRINE and IODELIS (2008), PELEGRINE and MASCIGRANDE (2011).

The same non-Newtonian behavior was observed for pulps of banana, guava, mango and papaya fruits by RAO (1986). HAMINIUK (2005), studying integral pulps of strawberry guava and blackberry, also noted pseudoplastic behavior for the analyzed pulps.

As related by POMERANZ and MELOAN (1984) and HAMINIUK (2005) the rheological properties of the gels are normally characterized by texture and not by the apparent viscosity. As in the present study the product rheological behavior was analyzed still warm, it was through a viscometer.

Observing the slope of the flow curve, in Figure 2, it was observed reduction of the apparent viscosity as the rotation frequency was increased, which is directly related to the deformation rate. Therefore, the jellies behave as pseudoplastic fluid, once the product was obtained.

Conclusion

It can be concluded that was possible the obtaining of persimmon jelly within the recommended patters, using 60 and 70% of fruit pulp.

The elaborated jellies presented values of solids superior to 65ºBrix and pectin contents of 0.36% and 0.44%, respectively for the jellies with 60 and 70% of pulp.

The persimmon pulp behaved as pseudoplastic fluid, since the apparent viscosity decreases with the increase in the deformation rate.

Both jellies behaved as a pseudoplastic fluid as soon as the product was obtained.

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