

Effect of Citric Acid on Browning of Fresh-cut Potatoes and on Texture after Frying

R.D.A. Amaral and B.C. Benedetti
Faculdade de Engenharia Agrícola
Universidade Estadual de Campinas
Campinas
Brazil

M. Pujolà and I. Achaerandio
Departament d'Enginyeria Agroalimentària i
Biotecnologia
Escola Superior d'Agricultura de Barcelona,
Universitat Politècnica de Catalunya
Castelldefels (Barcelona)
Spain

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Abstract

Fresh-cut potato (*Solanum tuberosum* L.) is a product widely consumed, but the susceptibility of this tuber to browning is a drawback and limiting factor for its shelf life. This study aimed to evaluate the predisposition of different potato cultivars for being minimally processed, the effect of citric acid in inhibiting browning and the quality of the fried potato during the product shelf-life. For this purpose, potatoes of cultivars Agata, Agria and Caesar were acquired from a local producer, selected, washed in tap water, manually peeled, cut into strips and immersed in citric acid (3%) for 5 minutes. Strips were centrifuged and vacuum packed in polyethylene bags and stored at $3\pm 1^{\circ}\text{C}$ for 17 days. Color (Croma), dry matter content and pH were analyzed every 2 days in fresh-cut samples. On days 2, 9 and 16 of storage, samples were fried in oil at 180°C for 5 minutes for Agata and 7 minutes for Agria and Caesar. In fried potatoes, texture was also analyzed. The use of citric acid decreased the pH of all samples and kept this trend during the entire period of storage. Fresh cut and fried samples of Agata had lower values of dry matter content. The other cultivars showed slight variations, increasing the values of these attributes, as well for values of Chroma for the fried potatoes, that were lower for Agata regardless the use of citric acid during the storage. There was an increase in the texture of fried potatoes in all samples during the storage, although this increase was lower in Agata. Agria and Caesar showed greater susceptibility to frying because they had higher dry matter content. The color, pH, dry matter content and texture allowed discrimination between Agata and the other cultivars.

INTRODUCTION

Potato is a widely consumed product and its minimally processed form play an important role in the commercialization. However, the shelf life of minimally processed potatoes is limited by enzymatic browning, a common secondary reaction of minimally processing, that causes an alteration in the sensorial visual properties of the product, decreasing more fast the food quality because it implies spoilage (Tomás-Barberán *et al.*, 2001; Cantos *et al.*, 2002). Furthermore, if browning occurs after the product is ready for consumption implies in considerable economic losses, because the costs of processing, packaging and storage have been incurred (He *et al.*, 2007).

To avoid this, antibrowning agents can be used, such as sulfites, though there is the purpose of governments to prohibit the use of these food additives because they are related to asthma attacks. Then, researching for others effective antibrowning agents are been done. A possibility is citric acid, which is also used for the prevention of browning, because it inhibits the polyphenol oxidase (PPO) by reducing the pH and by chelating the copper to the enzyme-active site (McEvily and Iyengar, 1992; Junqueira *et al.*, 2009).

It is very important understanding the effects of antibrowning treatments, like on metabolism, color changes, texture and chemical composition on the fresh-cut products, together with packaging and refrigeration, to reduce the rapid loss of quality and increase the shelf life product (Roculli *et al.*, 2007). For this purpose, this study aimed to evaluate the susceptibility of different potato cultivars for being minimally processed, the effect of citric acid in inhibiting browning and the quality of the fried potato during the product shelf life.

MATERIALS AND METHODS

Raw material

Potato tubers (*Solanum tuberosum* L.) of cultivars Agata, Agria and Caesar were acquired from local producer, selected, washed in tap water, dried and stored in the dark at ambient temperature prior to be processed.

Processing

Potato tubers free of defects were hand-peeled with a sharp knife and both extremes of each tuber were discarded. From the remaining tuber, samples were cut into strips (1 cm of thickness) and immersed in solution of citric acid (3% w/w) for five minutes at room temperature. Control treatment was composed of strips dipped in clean water for the same contact time. Then the strips were centrifuged in a manual centrifuge to eliminate water excess and vacuum packed in high density polyethylene bags of 100 g. Packages were stored at 3 ± 1 °C for 17 days. On days 2, 9 and 16 of storage, samples were fried in oil at 180 °C for 5 minutes to Agata and 7 minutes for Agria and Caesar.

Evaluations during the storage

Analyses in fresh-cut samples were carried out at every two days and on days 2, 9 and 16 for fried potatoes.

pH: directly measured by potentiometry, which consists in immersion of digital pH meter (Crison 206, Spain) on the homogenized sample, either fresh-cut and fried (AOAC, 1990). It was performed in triplicate.

Dry matter content: samples of 5 g of homogenized tissue were dried at 70 °C for 24h (AOAC, 1990); dry matter content was measured by comparing the sample weight loss and analysis was conducted in triplicate for both, fresh-cut and fried samples.

Color: determined in strips before and after frying, with a chroma meter (Konica Minolta CR-400). The CIE L* (lightness), CIE a* (red-green) and CIE b* (yellow-blue) coordinates were read using a D₆₅ light source and 10° as standard observed. Chroma was calculated as $(C^*) = (a^{*2} + b^{*2})^{1/2}$. Five measurements were made in each sample (McGUIRE, 1992).

Texture: performed in fried samples using the texture analyzer (Model: TA.XT Plus, Stable Micro Systems Co. Ltd., UK) connected with a Warner-Bratzler blade set

with speed of $1 \text{ mm}\cdot\text{s}^{-1}$. Twenty measurements of each treatment were made and the results were expressed as the maximum force (N).

Statistical analysis

All data were subjected to analyses of variance (Minitab 16) to determine the statistical effects of storage on the treatments and the differences were determined using Tukey's test ($p < 0.05$).

RESULTS AND DISCUSSION

Storage had significant influence on pH of all samples analyzed (Table 1). The pH of all samples treated with solution of citric acid was lower compared with samples washed only with water and maintained this behavior during the whole period of storage. For the samples washed only with water (control) the pH varied from 5.87 to 6.14 immediately after the processing and decrease with the storage, but kept higher than in samples treated with citric acid. The pH of the fried samples of potatoes followed the same behavior as the raw ones (Table 2). Along time, the pH of all the samples were decreasing and the samples treated with citric acid showed lower pH values.

Dry matter content during the storage was very similar to initial values and the cultivar Agata presented the lowest values compared with the others varieties (Table 1). Storage had significant influence in samples of Agria soaked in citric acid. Erturk and Picha (2007) found different results with decreasing of dry matter content during storage in sweet potato slices from three bags types and two storage temperatures. After frying, the content of dry matter was higher than before frying, probably due to the loss of water that occurs on frying and the absorption of oil. According to Pedreschi *et al.* (2005) frying is a method used to creating unique flavors, colors and textures in processed foods, improving their overall palatability. At the end of the storage all fried samples had higher dry matter content than on the beginning. Agata and Agria washed with tap water did not show differences in values of dry matter on the second and ninth day of storage, but at the end of shelf-life was observed an increase in these values. This behavior was different for minimally processed samples which had not pronounced increases in the same period.

Initial values of Chroma varied from 22.36 (Agata) to 29.26 (Agria), showing variability between cultivars (Fig. 1). Cabezas-Serrano *et al.* (2009) found slightly lower values of Chroma to the same varieties (17.1 and 28.3, respectively). During the cold storage the values of Chroma were different for all samples, either with use the solution of citric acid or water. The more intense color of potatoes was obtained with the Agria samples. The others varieties showed similar intensity of color. As expected, after frying values of Chroma were higher than fresh cut products. Caesar had values more similar to Agria and Agata kept with the less intense color. Coelho *et al.* (1999) also reported higher values in color of potatoes between the cold storage and room temperature. Cantos *et al.* (2002) evaluated different varieties of potato (Monalisa, Spunta, Liseta, Cara and Agria) and observed that Agria was the least susceptible to browning.

Maximum force of fried potatoes varied for all cultivars, increasing during the storage (Fig. 2). At the beginning of analysis, the samples had similar values of maximum force, changing this behavior with the storage. Agria washed with tap water presented the lowest value (4.81 N) and Caesar washed with citric presented the highest (9.51 N). At the end of shelf-life, Caesar had the highest values and Agata the lowest. The same trend of increase was also observed in the dry matter content after frying, although correlation

tests have not been made. Pedreschi and Moyano (2005) evaluated the maximum force in samples of blanched and non-blanched samples and concluded that this parameter increase while moisture content decrease, corresponding to an increase in the crispness of the chips.

CONCLUSIONS

The use of citric acid decreased the pH of all samples and kept this trend during the entire period of storage.

Agata presented lower values of dry matter content and Chroma, regardless the use of citric acid.

Texture of fried potatoes increased during the storage in all samples analyzed, however Agria and Caesar showed greater susceptibility to frying.

Agria and Caesar had better values to the attributes analyzed which allowed discrimination for these varieties.

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Tables

Table 1. Values of pH and dry matter from fresh-cut potatoes after storage for up 17 days at 3 ± 1 °C.

Treatment	Storage (days)								
	0	2	6	8	10	14	15	17	
pH									
Agata	H ₂ O	5.87 a	5.64 b	5.48 c	5.39 de	5.42 d	5.35 ef	5.31 f	5.43 d
	Citric	5.09 c	5.08 c	5.08 c	5.08 c	5.11 bc	5.11 bc	5.14 b	5.23 a
Agria	H ₂ O	5.97 a	5.81 b	5.64 c	5.53 d	5.51 d	5.42 e	5.44 e	5.46 e
	Citric	5.37 a	5.31 a	5.21 bc	5.17 c	5.11 d	5.20 bc	5.22 bc	5.24 b
Caesar	H ₂ O	6.14 a	5.84 b	5.57 c	5.56 c	5.59 c	5.39 e	5.42 e	5.51 d
	Citric	5.21 ab	5.04 c	5.16 b	5.17 b	5.20 ab	5.21 ab	5.24 a	5.25 a
Dry matter									
Agata	H ₂ O	16.02 a	15.98 a	15.42 a	16.53 a	16.11 a	16.30 a	16.36 a	19.12 a
	Citric	17.02 a	17.08 a	19.40 a	16.67 a	16.64 a	16.51 a	15.66 a	16.79 a
Agria	H ₂ O	23.29 a	22.01 a	22.54 a	22.21 a	23.53 a	23.11 a	22.75 a	22.51 a
	Citric	22.99 a	21.22 b	23.61 a	23.38 a	22.71 a	22.18 ab	23.38 a	22.48 ab
Caesar	H ₂ O	23.23 a	23.25 a	22.63 a	23.54 a	23.53 a	23.81 a	23.67 a	22.73 a
	Citric	23.84 a	22.01 a	23.04 a	24.46 a	24.10 a	23.93 a	22.59 a	21.23 a

Different letters indicate significant differences between storage days on $P>0.05$.

Table 2. Values of pH and dry matter from fried potatoes after storage for up 17 days at 3 ± 1 °C.

Treatment	Storage (days)			
	2	9	16	
pH				
Agata	H ₂ O	5.57 a	5.34 b	5.34 b
	Citric	5.18 a	5.12 b	5.11 b
Agria	H ₂ O	5.56 a	5.34 b	5.34 b
	Citric	5.49 a	5.38 ab	5.20 b
Caesar	H ₂ O	5.60 a	5.34 b	5.28 b
	Citric	5.27 a	5.15 b	5.24 a
Dry matter				
Agata	H ₂ O	35.57 b	34.24 b	38.00 a
	Citric	32.90 c	40.29 a	36.02 b
Agria	H ₂ O	47.71 b	45.27 b	55.23 a
	Citric	47.71 c	56.97 a	53.55 b
Caesar	H ₂ O	46.91 c	52.97 b	57.78 a
	Citric	48.34 c	54.08 b	57.29 a

Different letters indicate significant differences between storage days on $P>0.05$.

Figures

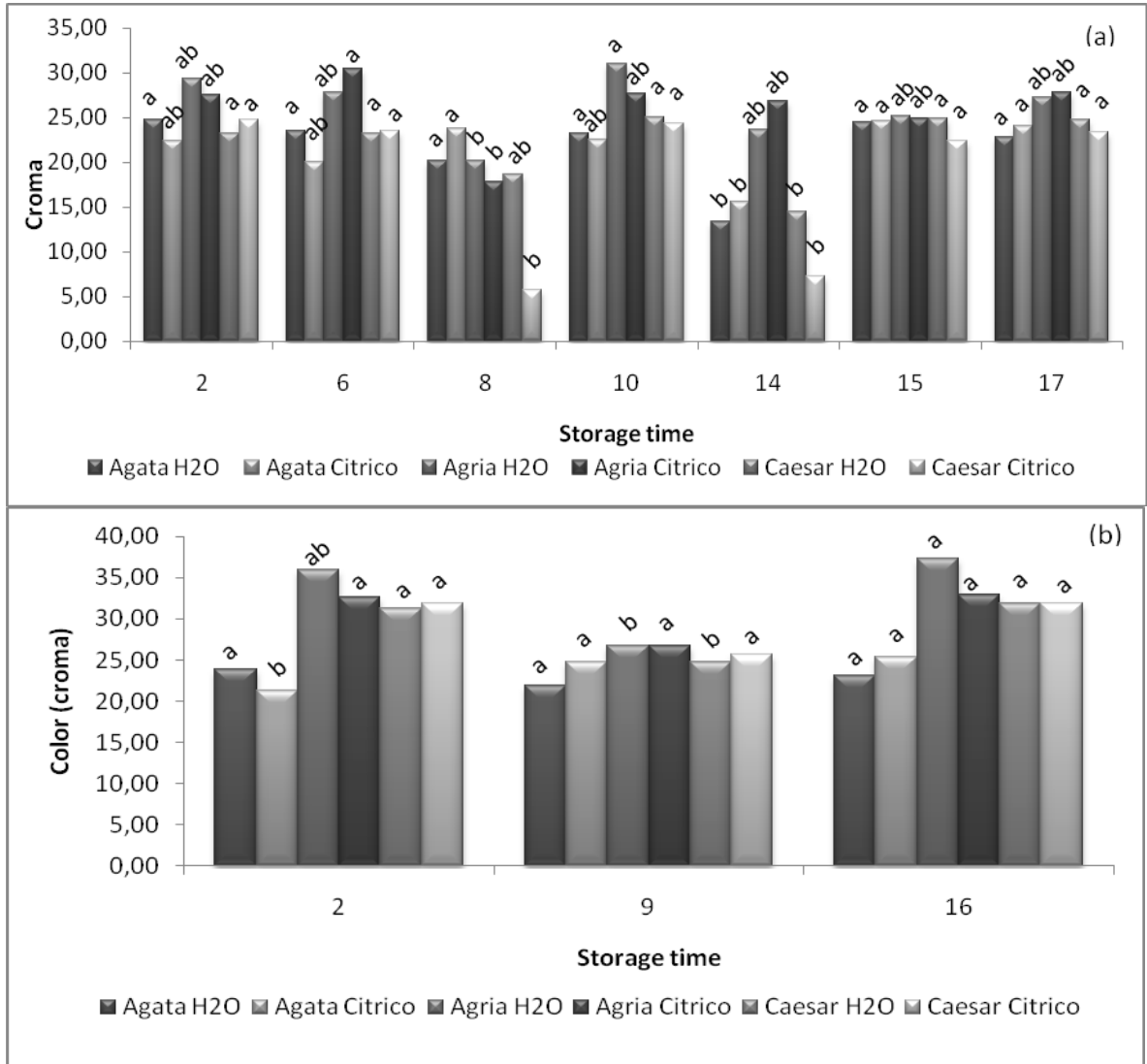


Fig. 1. Color from fresh-cut (a) and fried (b) potatoes submitted to citric acid after storage for up 17 days at 3±1 °C.

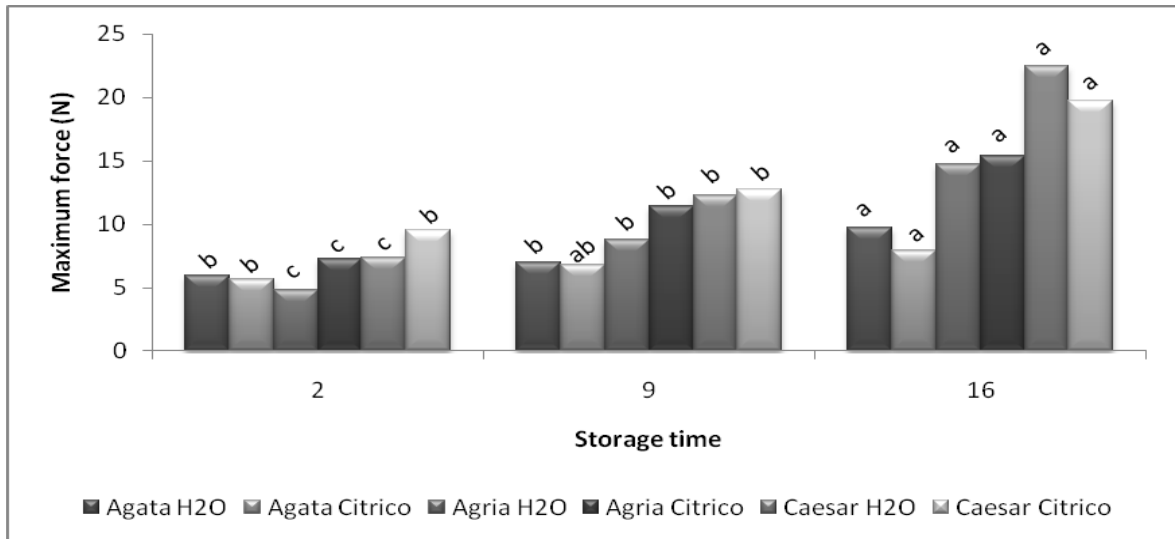


Fig. 2. Texture from fried potatoes submitted to citric acid after storage for up 17 days at 3 ± 1 °C.