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Influence of ascorbic acid on physiological deterioration of pieces of cassava raw pulp

Arlindo Modesto Antunes*, Túlio Natalino de Matos, Vanesa Beny da Silva Xavier Reis, Pâmella de Carvalho Melo, André José de Campos and Ivano Alessandro Devilla

Department of Agricultural Engineering, State University of Goiás, 75 132- 400, Anápolis – GO, Brazil.

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Cassava (*Manihot esculenta*, Crantz) is originally from South America and possibly Brazil, grown to more than 500 years. Its roots can be exploited in various ways for human consumption. With the focus on post-harvest cassava, this experiment was developed with the objective of evaluating the use of ascorbic acid (AA), on physiological deterioration in cassava roots minimally processed during the storage period of six days, in order to extend the life of the final product as well as to ensure their food security during distribution, marketing and consumption. The experimental design was completely randomized design (DIC) in factorial scheme 4 x 6 (concentrations x days of analysis), with three repetitions each day, for each treatment. Treatment was observed with an increased loss of mass during storage regardless of the treatment with AA being that, the larger the dose applied minor was the loss of mass. There was no significance in the interaction of concentration treatments x days of analysis, showing significant difference only in the variables and soluble solids in different concentrations of, AA and variables pH, soluble solids and titratable acidity to the days of analysis.

Key words: Minimally processed, *Manihot esculenta* Crantz, ascorbic acid.

INTRODUCTION

Cassava (*Manihot esculenta*, Crantz), also known as cassava or manioc, mansa cassava (Borges et al., 2012), is originally from South America and possibly Brazil. It is cultivated for more than 500 years, initially by the Indians and later introduced in the African and Asian continents. This culture is one of the main energy food for thousands of people, especially in developing countries, where it is grown in small areas with low technological level (Nechet and Halfed-Vieira, 2010).

Cassava presents enormous versatility, since it can make use of its aerial part in animal nutrition as well as its roots which may cause among others, flour, starch and rind, as well as being consumed in natura. (Pereira et al., 1985). However, the fate of cassava depends on their classification, considering the content of cyanide: mad or bitter cassava and cassava mansa or sweet. Cassava is destined for flour industry. Cassava also called manioc is marketed mainly in the forms: with bark; just peeled and washed; frozen; cooked or precooked. Currently, the peeled cassava has good market acceptance which is

*Corresponding author. Email: arlindo.modesto1@hotmail.com

marketed in free fairs supermarkets and other commercial establishments, for a price of 25 to 50% higher than that of cassava with shell. But, can't be confused with minimally processed product, for failing to present food security because the product is not sanitized and not kept under refrigeration, which can increase their perishability (Cereda and Vilpoux, 2003).

Peeling and slicing are common practices before consumption of cassava, which makes it a little convenient product for the consumer. To see to that, after the harvest the roots of the cassava feature very short shelf life, and can become useless for marketing after few days of storage at room temperature. This high perishability of the roots generates storage difficulties, which has aroused the interest for the diversification of its use in processed form, once processed immediately such as roots, reduce post-harvest losses and offer new products that expand the possibilities of increase of consumption and production (Rinaldi et al., 2015; Vieites et al., 2012).

To do so, minimally processed products become increasingly popular for convenience, for the benefits of a fresh natural product, product quality being packaged in small portions can mainly be ready for consumption (Alves et al., 2010).

It is known that, the handling of the product during the minimum processing, mechanical product injury promotes the physiological and biochemical responses. These injuries decrease the quality and service life of the product since they promote increased respiratory rate and ethylene synthesis, total synthesis of phenolic compounds, loss of cellular integrity on cut surface with consequent descompartmentalization of enzymes and their substrates, promoting increased activity of the enzyme phenylalanine ammonia lyase, polyphenoloxidase and peroxidase. These enzymes directly involved with postharvest physiological deterioration with observed changes in color, taste, texture and nutritional quality, determining its acceptance by consumers or not (Menolli et al., 2008).

One of the ways to avoid this deterioration is the use of resistant varieties. However to date, this material was not developed, thus the most affordable option is the use of conservation techniques in natura fresh roots (Borges et al., 2002). One of the most researched include antioxidants ascorbic acid (AA), being one of the most important vitamins (vitamin C) that can maintain the normal functions of the human body which is involved in several processes of cellular metabolism. This is used in trade due to its ability to reduce quinine and phenolic, preventing the formation of dimming (Pineli et al., 2005).

This used in the assessment of nutrients as an antioxidant in fruits, vegetables and juices. Chemical treatments in AA has been touted to be effective in prevention of browning of minimally processed products as in banana in dark just minutes after cutting and stripping being a process associated with elevated activity of polyphenoloxidase enzymes and peroxidase (Melo and Vilas Boas, 2006).

The aim of this study is to assess the physicochemical effects of AA on physiological deterioration in minimally processed cassava roots, during the storage period of six days, in order to extend the life of the final product as well as to ensure their food security during the distribution, marketing and consumption. In the development of the study, the quality and storage of cassava minimally processed when submitted to different concentrations of Ascorbic acid, by analyzing the physical-chemical parameters such as: loss of mass, firmness, pH, soluble solids and total titratable acidity was rated.

MATERIALS AND METHODS

Plant material

Cassava roots type table cultivar (BRS400), were produced in a private property located in the municipality of Anápolis, Goiás. The roots with about 20 months of age, were harvested by hand, packed in plastic boxes and then transported to the minimum processing unit at the State University of Goiás, where they were immediately processed.

Processing flowchart

For realization of the experiment, the following processes is described by means of a flow chart (Figure 1). This experiment was conducted in the laboratory of a physical properties of plant products, Agricultural Engineering course in the University Unit for science and Technology of the Universidade Estadual de Goiás-UEG, during the month of July 2016.

We used cassava properly sanitized with solution of sodium hypochlorite (NaClO) 1% for 10 min, then peeled, cut in chunks of 0.05 to 0.06 meters, separated into lots and immersed for 15 min in a solution of ascobic acid (AA) at concentrations of 1, 2 and 3%. Witness was used in the procedure of immersion in batch in distilled water. Later packed in expanded polystyrene (EPS) + film of polyvinyl chloride (PVC) and stored in refrigerated incubator stove type BOD, 10°C, 80 to 90% RH, for 6 days.

Analysis

Physical-chemical parameters were analysed as loss in weight, firmness, pH, soluble solids and titratable acidity. For such, procedure of the solution prepared was from cassava dough and distilled water at a ratio of 1:1.

Mass loss

During storage, the packages of minimally processed cassava were 0, 2, 4, 6 days of conservation (±10°C and 80 to 90% RH). The loss of fresh mass in the roots was determined in relation to the initial weight of the cassava in time zero, by gravimetry in BL 3200H precision balance (BL 3200H ±0.5 g, Shimazu, Japan). The percentage of loss in mass was studied from the equation 1:

$$PM (\%) = [(Pi-Pj)/Pi] * 100 \tag{1}$$

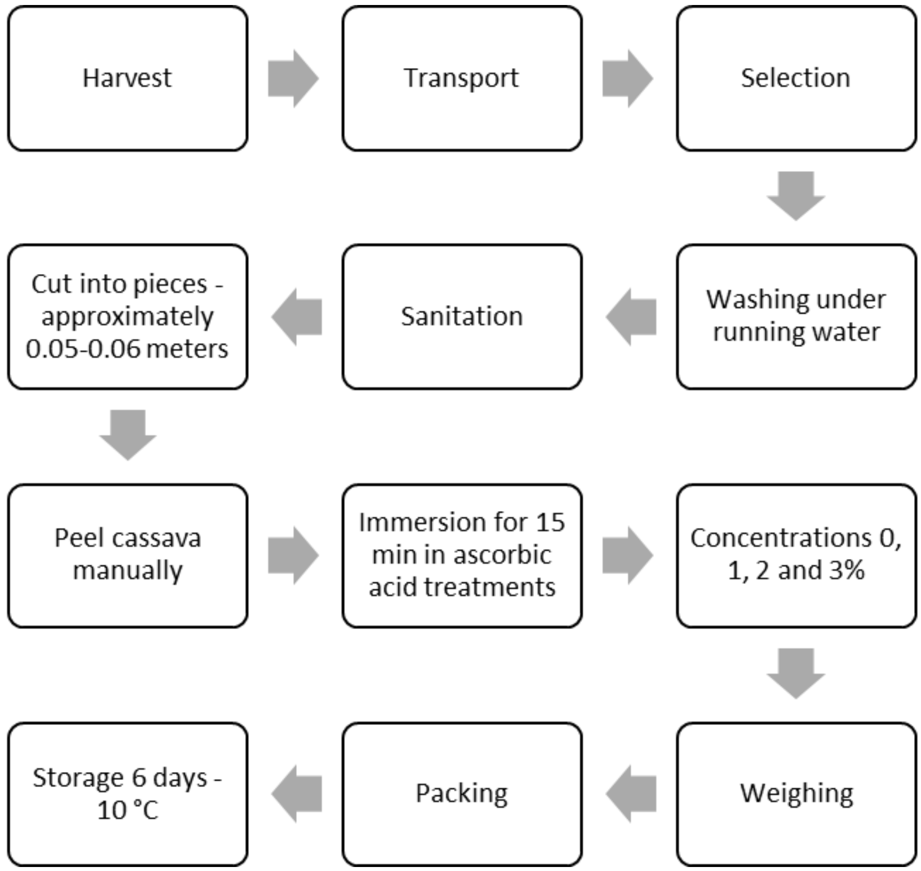

Figure 1. Processing flowchart.

Being:
PM = mass loss (%).
PI = initial weight of the fruit (g).
PJ = root weight in the subsequent period the Pi (g).

Firmness

This was used in texturometer brookfield-texture analyser CT3 50 k (USA), with the depth of penetration of 2 mm and speed of penetration of 6, 9 mm/s. The unit of measurement was used in centiNewtons (cN).

Hydrogen potential (pH)

This was carried out by potentiometry, using DMHP model pH meter-2 Digimed, as technique described by IAL (2008).

Soluble solids (SS)

This was held by reading, refratométrica in °Brix and Abbe refractometer (origin, accurancy) with digital brand bench quimis. As a recommendation of IAL (2008).

Titratable acidity (AT)

Form the content, titratable acidity was measured in 5 ml of the sample (cassava pulp) in a beaker of 1 to 10 ml, supplementing with 95 ml of distilled water, with standardized solution of 0.1 M sodium hydroxide and alcoholic solution of phenolphthalein indicator (three drops). The sample was titrated till rosy coloring appeared, as a recommendation of IAL (2008). The acidity was calculated using equation 2:

Acidity in molar percent solution is

$$\left(\frac{V}{m}\right) = \frac{v.F.100}{P.c} \tag{2}$$

Being:
V = number of millilitres of sodium hydroxide solution 0.1 M required.
F = factor of sodium hydroxide solution 0.1 M.
P = number of grams of the sample used for the titration.
c = correction for solution, 10 to 0.1 M NaOH solution.

Minimum processing

The process consist of steps; pre-wash, wash, peel, cut in cubes, rinse, final rinse, sanitation, drainage and packaging. The temperature of the product was monitored during all stages of process, with a digital infrared thermometer (HANNA-HI Model 99551). The temperature in the processing environment was ±25°C. All utensils and equipment used for the minimum processing steps have been sanitized.

Pre-wash

In order to remove the dirt from the coarser field, the cassava pre-washed was immersed in water for 10 min.

Selection

The cassava were selected and those attack by pathogens and pests, were discarded.

Washing

The roots were washed in running water to remove any dirt attached to the roots which is very difficult.

Cut and peel

The cassava was cut in approximately 5 to 6 rowlocks cm long with a metal blade, subsequently to decortication. Shortly after peeling, the rowlocks suffered a longitudinal and transverse cutting.

Ascorbic acid treatments

In this step, the roots of cassava were immersed in a plastic container properly sanitized, with percentages of AA (concentration 99,9%), solution 1, 2 and 3% being the witness immersed only in distilled water.

Packaging

The cassava were wrapped in packages of expanded polystyrene (EPS) + film of polyvinyl chloride (PVC).

Conservation

The conservation was held under refrigeration for a period of 6 days. The temperature and relative humidity were 10°C and 80 to 90% RH, respectively.

Statistical design

The statistical design was completely randomized design in factorial scheme 4 x 6 (concentrations x days of analysis), with three repetitions each day, for each treatment. Data were subjected to analysis of variance (ANOVA), where significant results for the F test (P < 0.05) were subjected to the comparison test of medium for the qualitative variables, and the regression for quantitative variables. In all the statistical procedures described SISVAR 5.1 program was used.

RESULTS AND DISCUSSION

The loss of mass is a very important factor in storage vegetables. It occurs due to the length of time in storage and in respiration. The loss of mass is related to the loss of water, which is the main cause of deterioration and results in quantitative losses, losses in appearance (wilting and wrinkle), the textural qualities (softening, loss of freshness and juiciness), and on nutritional quality (Kader, 1992; Carvalho and Lima, 2002). Deterioration was analyzed from the physico-chemical aspects, being the loss of mass, titratable acidity, pH, soluble solids and firmness.

Table 1. R^2 in regression analysis.

Treatment	R^2
C0	0.9596 ^{ns}
C1	0.9347*
C2	0.9064*
C3	0.9643*

ns: not significant F test (P<0.05), * significant at F test (P<0.05).

This observed an increase in mass loss during storage, regardless of the treatment with AA being that the larger the dose applied minor was the loss of mass. The only treatment that showed no significance was the witness in accordance with Table 1. The small loss in mass by the witness can be explained by the use of the packaging, as this restricts in gas exchange of the product within the middle (Carvalho and Lima, 2002).

The results of the analysis of variance of the physico-chemical attributes of cassava are presented in Table 2. It is observed in this Table that there was no significance in the interaction of concentration treatments x days of analysis. There were significant differences between the following variables, firmness and soluble solids in different concentrations of AAd and these variables: pH, soluble solids and titratable acidity of the days of analysis. The decrease in firmness is related to the loss of the integrity of the cell wall, with its enzymatic hydrolysis due to the action of enzymes, such as pectinolitic polygalacturonase (PG) and pectinametilesterase (SMEs) (Chitarra and Chitarra, 2005). The function of PG act in breach of glycosidic pectic substances to form galacturonic acid, having its activity related to SMES since it dependent on the product of the reaction of this last.

According to Figure 2, the treatments with different concentrations presented a variation on the firmness, and the treatments with concentrations 1 and 3% showed highest firmness, when compared to others (2869.16 and 3029.58 cN, respectively) (Figure 3).

pH showed significant difference only to the variation in the days of analysis. According to Table 3, the treatment shows an average pH declined with the passage of time, until day 4 had an increase on the sixth day which dose not have differentiating initial pH. The behavior obtained from titratable acidity (AT) was reflected in the results obtained for pH. For pH, there were difference between the treatments in the days of analysis, and the values were lower when the acidity was higher and vice versa.

Table 2. Mean values obtained in analysis of variance for studied variables.

FV	GL	Firmness	pH	Soluble solids	Titratable Acidity
Concentration	3	256376.388*	0.012414	3.712641*	0.026474
Day	3	50431.944	0.379069*	3.74203*	0.380552**
Concentration x Day	9	89490.74	0.077142	1.417845	0.023274
Residual	32	60018.229	0.042277	0.92094	0.013279
	CV(%)	8.64	3.36	27.34	13.43
	Overall Average	2836.25	6.110	3.510625	0.8581667

* significant at 5% de probability for the F-test, ** significant at 1% de probability for the F-test. CV(%): (standard deviation/mean)*100.

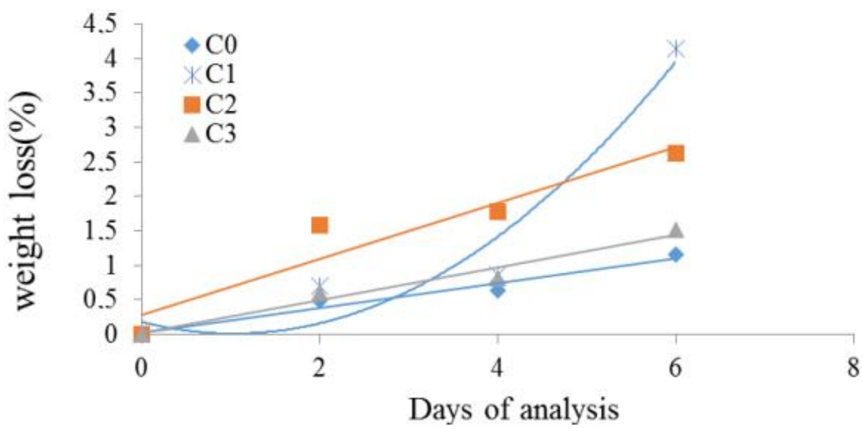

Figure 2. Mass loss rate with 0, 1, 2 and 3% of ascorbic acid during 6 days of storage at cassava type table.

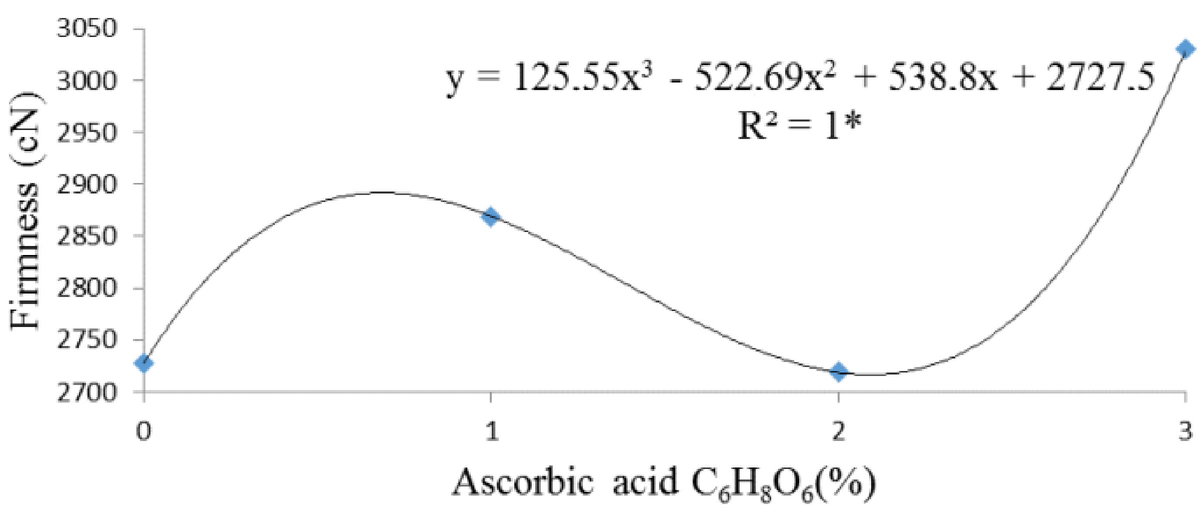

Figure 3. Regression of the values of steadfastness 0 concentrations, 1, 2 and 3% of Ascorbic acid in cassava.

Bezerra et al. (2002) also obtained an increased AT for a period of storage for butter cassava, minimally processed when they made the same assessment subject to the bleaching and packed in polyethylene packages. According to Dias et al. (2007), the increase of AT can be due to bacterial fermentation process with oxygen

Table 3. Average values of pH, soluble solids and titratable acidity of cassava table type evaluated during six days of storage at 10°C.

Days of analysis	pH	Titratable acidity (AT) (%)	Soluble solids (°Brix)
0	6.21ab	1.022a	3.133b
2	6.00bc	0.647c	3.534ab
4	5.92c	0.988a	4.291a
6	6.30a	0.775b	3.083b

Values followed by the same letters in the column do not differ among themselves by tukey test at 5% probability.

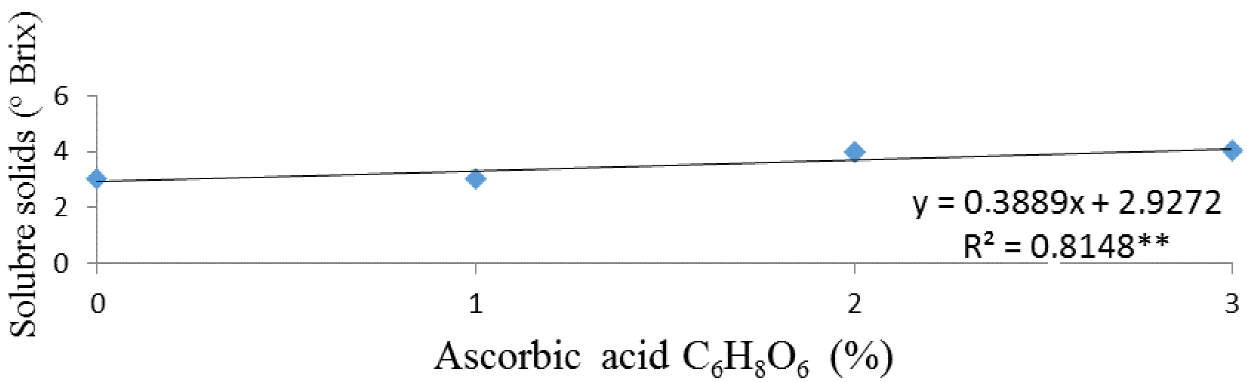

Figure 4. Regression of the values of steadfastness 0 concentrations, 1, 2 and 3% of ascorbic acid in cassava.

consumption and production of organic acids such as butyric, lactic, acetic, among others. Thus, the reduction of pH is related to the increase of AT.

Statistical analysis for variable soluble solid showed significant effect, which show an elevation of this variable during the experiment. Araújo (2010) reports similar behavior in minimally processed products studies caused mainly by the loss of water from the product. Still in Table 3 it can be observed that until the fourth day, there has been an increase in soluble solids, which is expected since there was also loss of mass during storage and also an increase in the concentration of soluble solids. On the sixth day, storage fell on this value that gives the degradation of sugars presented by metabolic processes, that occurred throughout the store.

The variable soluble solids was also significant for the treatment with different concentrations that obtained results expressed in Figure 4. According to the graph there was an increase in the soluble solids which increased the concentration of AA, showing values that ranged from 3.0 ºBrix (witness) to 4.0 ºBrix (Dose of 3%). Based on the data obtained, it was possible to notice that AA treatment was not effective for conservation of minimally processed cassava. The AA treatment was not effective in experiment performed with minimally processed butter cabbage using the same concentrations of 0, 1, 2 and 3% for Damatto Jr. et al.[s.d.].

Conclusion

According to the results, we can conclude that the AA did not have efficiencies in the preservation of the physical and chemical characteristics, desirable in minimally processed cassava. We also observed that there was no interaction of AA concentration with the days of analysis, and that the soluble solids increased with an increasing dose of AA .

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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