Nutritional and sensorial evaluation of maqui jam (*Aristotelia chilensis*)

Evaluación nutricional y sensorial de mermelada de maqui (*Aristotelia chilensis*)

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Nelson Loyola López
Magister in Horticulture por Washington State University, Estados Unidos de América
Institución: Universidad Católica del Maule, Departamento de Ciencias Agrarias, Facultad de Ciencias Agrarias y Forestales
Dirección: Avenida San Miguel 3605, Talca, Región del Maule, Chile
Correo electrónico: nloyola@ucm.cl; nelsonloyola@hotmail.com

Jose Miguel Allendes
Ingeniero Agrónomo, Universidad Católica del Maule, Chile
Institución: Independiente
Dirección: Campus San Isidro - km. 6 Los Niches, Curicó
Correo electrónico: jose.allendes@alu.ucm.cl

Carlos Acuña Carrasco
Laboratorista Químico, Universidad de Chile, Chile
Institución: Indepenciente.
Dirección: Campus San Isidro - km. 6 Los Niches, Curicó
Correo electrónico: cacunac@gmail.com

Mariela Arriola Herrera
Magister en Gestión Tecnológica con Énfasis en Biotecnología, Universidad de Talca, Chile
Institución: Independiente
Dirección: Campus San Isidro - km. 6 Los Niches, Curicó
Correo electrónico: mariela.arriola@gmail.com

ABSTRACT

Aristotelia chilensis is a species of native tree from Chile which is located from Limarí province to Aysen province. It is characterized by having a berry-shaped- fruit of a dark violet color, astringent and refreshing, characterized by a significant nutritional value in regards to the content of Vitamin C and antioxidants. At present, its use in Chile is very limited, so that innovative ideas are needed to take advantage of it and spread the nutritional value this native fruit has. Three treatments were designed. The first one belonged to pure maqui jam, the second jam with green apple and the third maqui jam with plum. The jams were subjected to a laboratory analysis of Vitamin C by titration method three times, one to the fresh raw material and to the processed product at 35 and 65 days of being stored, respectively. To have knowledge of its antioxidant benefits, the levels of polyphenol were measured at the same times it was done for Vitamin C. Besides, an evaluation of sensorial attributes such as color, flavor, aroma and texture and of its level of acceptability was conducted by 13 previously trained panelists. The results obtained showed that 44 to 46% of Vitamin C was lost after processing, and that there was no effect regarding one-month storage. Regarding the amount of total polyphenol, there was an increase of it after jams were processed, but with a significant degradation after being stored for one month. In regards to the results of the sensorial evaluations,

there was a higher level of acceptability for the pure maqui jam, being observed an intense color, a sweet-sour flavor and a fruity fragrance. It is possible to make maqui jam, keeping its main contribution such as total polyphenol, as well as its presentation as a product with excellent organoleptic properties. It can be made maqui jam, keeping his main contribution polyphenols such as, in addition with its words.

Keywords: *Aristotelia chilensis*, maqui jam, organoleptic characteristics, Vitamin C, total polyphenol.

RESUMEN

Aristotelia chilensis es una especie de árbol nativo de Chile que se ubica desde la provincia de Limarí hasta la provincia de Aysén. Se caracteriza por tener un fruto en forma de baya de color violeta oscuro, astringente y refrescante, caracterizado por un importante valor nutricional en cuanto al contenido de Vitamina C y antioxidantes. Actualmente su uso en Chile es muy limitado, por lo que se necesitan ideas innovadoras para aprovecharlo y difundir el valor nutricional que tiene esta fruta nativa. Se diseñaron tres tratamientos. El primero fue de pura mermelada de maqui, el segundo de mermelada de manzana verde y el tercero de mermelada de maqui con ciruela. Las mermeladas fueron sometidas a un análisis de laboratorio de Vitamina C mediante el método de titulación en tres ocasiones, una a la materia prima fresca y al producto procesado a los 35 y 65 días de ser almacenadas, respectivamente. Para conocer sus beneficios antioxidantes, se midieron los niveles de polifenoles al mismo tiempo que se realizó para la vitamina C. Además, se realizó una evaluación de atributos sensoriales como color, sabor, aroma y textura y de su nivel de aceptabilidad mediante 13 panelistas previamente capacitados. Los resultados obtenidos mostraron que entre el 44 y el 46% de la vitamina C se perdía después del procesamiento y que no hubo ningún efecto respecto al almacenamiento de un mes. En cuanto a la cantidad de polifenoles totales, hubo un aumento del mismo luego del procesamiento de las mermeladas, pero con una degradación significativa luego de un mes de almacenamiento. En cuanto a los resultados de las evaluaciones sensoriales, hubo un mayor nivel de aceptabilidad para la mermelada de maqui pura, observándose un color intenso, un sabor agridulce y una fragancia frutal. Es posible elaborar mermelada de maqui manteniendo su principal aporte como son los polifenoles totales, así como su presentación como un producto con excelentes propiedades organolépticas. Se puede elaborar mermelada de maqui, manteniendo su principal aporte los polifenoles como, además de sus palabras.

Palabras clave: *Aristotelia chilensis*, mermelada de maqui, características organolépticas, vitamina C, polifenoles totales.

1 INTRODUCTION

Maqui *(Aristotelia chilensis)* is an endemic wildlife species of Chile, located from Limarí Province in the north, in the Region of Coquimbo, and south in the Province of Aysen in the region of the same name, found in moist soils of the Central Valley, in the foothills of the mountains near the coasts, in the Andes or in forest margins. It belongs to the Eleaocarpaceae family (Moreno, 2009). Its fruit is a fleshy deep violet berry of about 5 mm in diameter, astringent, somehow acid and refreshing with many nutritional and medical properties, highlighting its high content of vitamin C, 90 mg per 100 g, and with 27,600 umoles per 100 grams of fruit and EAG 1,664 mg / 100 g of fruit in terms of total polyphenols, which makes it important for consumption (FONDEF, 2006).

The approximate area occupied by maqui, from the Region of Coquimbo to the Aisen is 170,000 ha, according to the cadastre of native forest, with yields ranging from 160-280 kg of fresh fruit per hectare (CONAF-CONAMA, 2008).

At present, it should be noted that there is a strong tendency to consume healthy and nutritious food, and there is a high demand for products of mediterranean origin, for their organoleptic and health characteristics, where Chile has a climate and a clear trend of increasing demand for these products (PASO, 2010).

The general consumption of berries as functional[1]foods, especially of native origin, show a steady growth from 1996 to 2005, with a 6.2% worldwide annual growth demand for it, mostly concentrating among Europe with 429,000 tons, North America with 164,000 tons and well below Asia with 15,000 ton, Central America with 10,000 ton and the rest of the continents with 300-400 ton (FIA, 2009). It is important to consider that maqui demand is significantly increasing, reaching in 2011 quantities near 50,000 kg, which means opportunities for generating products based on this wild fruit, containing an additional value and maintaining its nutritional properties (PASO , 2012).

There is an opportunity for maqui *(chilensis)* as a product with nutritional and medical potentials, without neglecting its exquisite berries, which can be exploited to develop an agro-industrial product with a higher added value such as jams of high level of consumption, preserving its organoleptic and nutritional characteristics.

This study focuses on the experimental application of a nutritional and sensory evaluation of a jam made based on maqui fruit *(Aristoteliachilensis)* and an evaluation of the acceptability of the product by trained panelists, designed to boost consumption of this wild fruit in Chile, as a healthy and helpful product for Chilean agro- business. In this sense, the hypothesis was that; it is possible to make maqui jam *(Aristoteliachilensis)*, for human consumption, preserving its nutritional characteristics and its organoleptic aptitudes.

The general objective was; to evaluate the quality parameters of a jam made from maqui fruits *(Aristoteliachilensis)* and its sensorial acceptance. Likewise, the specific objectives were to evaluate the nutritional properties maqui jam has such as its content of ascorbic acid and polyphenols.

Evaluate its sensorial attributes of maqui jam such as: color, aroma, texture and flavor.

Assess the acceptability of the maqui jam by trained panelists.

[1] A food is considered to be functional when besides its nutritional properties, it contains some elements, whose day-by-day consumption in a well-balanced diet, contributes to be healthy.

2 MATERIALS AND METHODS

The experimental development of this research was held in the science laboratory of the Department of Agrarian Sciences of the Catholic University of Maule, located 6 km southeast of Curico, whose geographical coordinates are 35 ° 7 '0"South, 71 ° 9'0"West.

Maqui fruit *(Aristotelia chilensis)* was the raw material used, harvested in Vilches area, Maule Region, whose geographical coordinates are -35 ° 30'00 "; -70 ° 45'00 "; -35 ° 45'00 "; -71 ° 0'00 ". Fruits were collected in late January, showing a dark purple color and a content of soluble solids of 19 ° Brix, ready to be consumed or processed. Once harvested, they were stored at a temperature of 0 ° C to be later transferred into a cooler container, maintaining the same temperature to the storage location where they were frozen and kept in Smart Fresh bags, at a temperature of -0, 5 °C for a period of nine months.

The green apple *(Malus domestica)* of the kind Granny Smith and the plum *(Prunusdomestica)*, of the variety BlackAmber, were provided by DOLE company, located in the area of Tutuquén in the town of Curico, whose coordinates are latitude -34.9667; length-71.3167.

In regards to apples, they were stored in the refrigerators from the same company at a temperature of between -0.5 and 0.5 ° C, and were only moved at the time of making jam. In regards to plums, they were moved from the company in cooler container, maintaining a temperature of 0 ° C, to the storage place to be, together with maqui, frozen for a period of nine months in Smart Fresh bags at a temperature of -0.5 ° C and 0 ° C. Fruits were transported to the laboratory of Agricultural Sciences in a cooler container to maintain a temperature of 0 ° C, during 35 minutes, where the preparation of jams was carried out according to the flow line observed in Figure 1.

Description of the process to make jam

The raw material was transported to the laboratory of Agricultural Sciences for 35 minutes in a cooler container, where it was thawed at room temperature (25 ° C). The amount of fruit received was 7 kg of maqui, 2 kg of plum and 2 kg of green apple; these fruits were subjected to a ° Brix control to be taken as a reference in the process of making jam. The values obtained were 19 ° Brix for maqui, 12 ° Brix for apple and 14 ° Brix for plum jams.

The fruits were selected to eliminate damaged fruits that may affect the processing results to make jams, such as fruit rot or other defects resulting from the action of microorganisms. Once the fruit was selected it was subjected to a 20 ppm of chlorine in 4 L washing and then rinsed.

After a 10 minute sanitization of raw materials, apples were peeled and billeted, while the plum was billeted with skin in order to retain post-processing contents of nutrients.

Heavy fruit

The weighing process of the fruit was made considering a percent rate of 70/30 of fruit and sugar and a percentage distribution of maqui as main raw material, with a rate of 60/40 of apple and plum, corresponding to the process to make jams.

Maqui was weighed with pulp, seeds and skin; green apple were weighed in skinless pieces, while the plum were also billeted with skin; after the weighing they were chopped and mixed in the rates indicated.

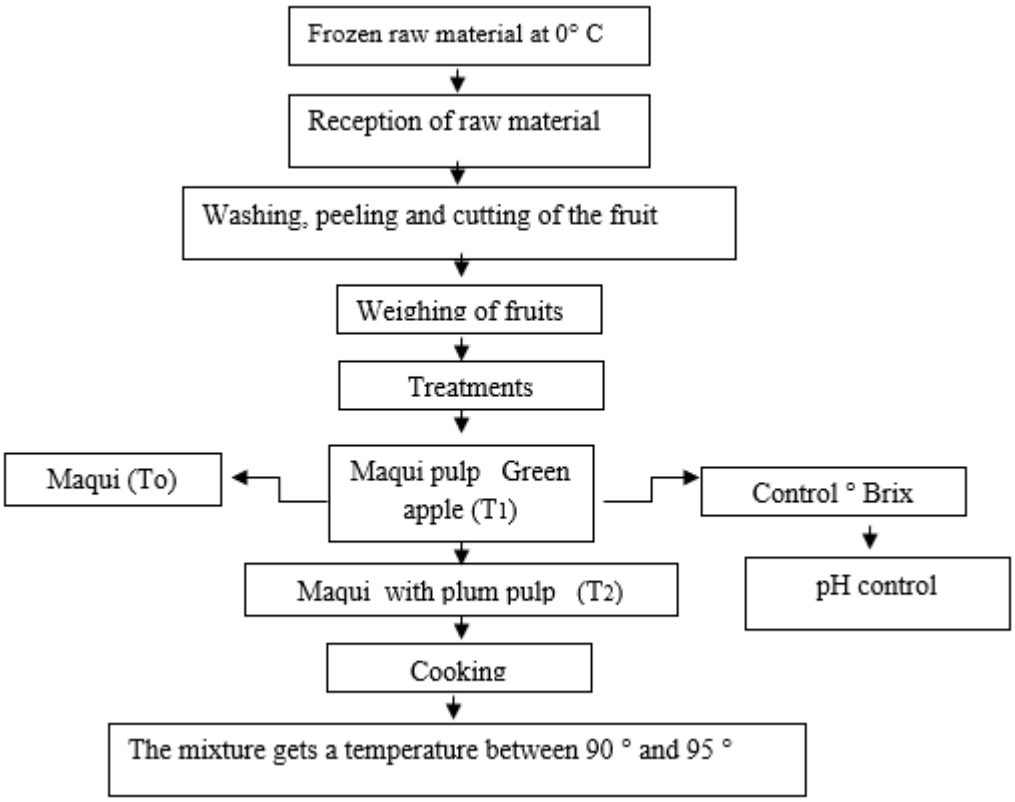
For the weighing process, an accurate balance, model 400C, was used, whereas to chop it, a blender Black and Decker SB-400 was used.

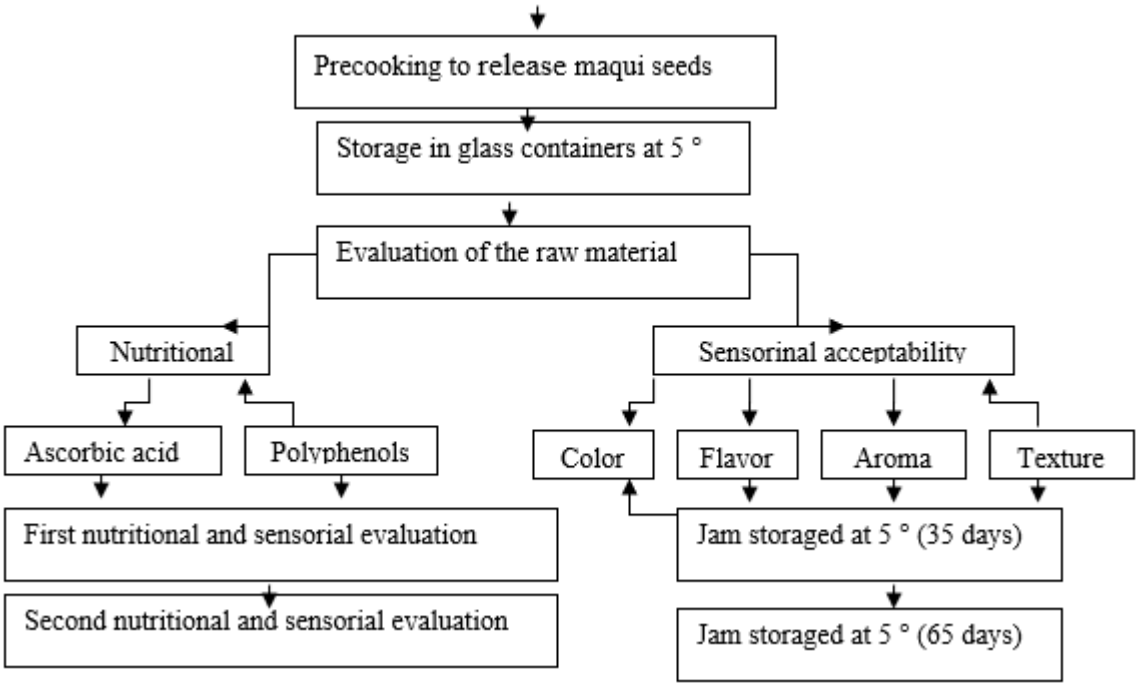
Maqui precooking

At this stage, a precooking was carried out for 10 minutes to release the seeds of the fruits of maqui, and then it was filtered through a colander, leaving jams with an approximate 40% of seeds, because 3,500 grams of maqui were completely removed, remaining the other 2,500 grams with seeds.

Once removed in the indicated proportions, the fruit and sugar were mixed in the quantities specified for each treatment.

Figure 1. Line process to make Maqui jam





Mixing ingredients

Mixing was performed at a rate of 400 grams of sugar per 1,000 gr of fruit, with the aim of favoring the nutritional value delivered by each of them, while highlighting organoleptic skills in the product.

Distribution was as follows for each treatment:

T_0 2500 g of maqui and 1000 g of sugar

T_1 900 gr of maqui, 600 gr of green apple and 600 gr of sugar

T_2 900 gr of maqui, 600 gr of plum and 600 grams of sugar

At the same time, a treatment evaluation was performed, by initially controlling ° Brix; obtaining a mixture of maqui 42 ° Brix, maqui-apple 40 ° Brix, plum-maqui 41 ° Brix simmer.

Cooking

Fruits mixed in their corresponding rates, the process of cooking jams began; this stage was the most complex and the one that demanded more attention and control to avoid generating unwanted effects in jam such as crystallization, caramelling, syneresis, due to either very long cooking times, acidity problems or of soluble solids. Every 10 minutes ° Brix control was carried out, as a parameter allowing defining the appropriate time of the process of making jams; complementarily, consistency was tested through a traditional method to measure it. This test was intended that by drawing on the product, the lines in both ends could not join, thereby proving ideal texture, in between viscous and gelatinous, that it was being looked at in every jam.

The data obtained for each jam during and at the end of each process are detailed in Tables 1,2 and 3.

Table 1. Antecedents of the process of making Maqui jam. October.

Development	**Month (October)**
Ingredients:	Maqui, sugar
initial ° Brix	42, 14 ° Brix
Cooking time	25 minutes (10 minute precooking)
° Brix at 15 minutes	52 ° Brix
° Brix at 25 minutes	57 ° Brix
Brix end (35 minutes)	63 ° Brix
pH jam	3
Performance	2.261 gr
Evaporated water in process	1.159 gr

Table 2. Antecedents of the process of making Maqui jam with green apple. October.

Development	**Month (October)**
Ingredients:	Maqui, apple, sugar
Initial° Brix	40.14Brix
Cooking time	30 minutes (10 minute precooking)
° Brix 15 minutes	49 ° Brix
° Brix at 25 minutes	55 ° Brix
Brix end (35 minutes)	65 ° Brix
jam pH	3.4
Yield	1.296 gr
Evaporated water in process	803 gr

Table 3. Antecedents of the process of making jam Maqui with Plum. October.

Development	**Month (October)**
Ingredients:	Maqui, plum, sugar
Initial° Brix	40.7 ° Brix
Cooking time	25 minutes (10 minute precooking of Maqui)
° Brix at 15 minutes	50 ° Brix
° Brix at 25 minutes	56 ° Brix
Brix end (35 minutes)	60 ° Brix
jam pH	3.2
Yield	1.551 g
Evaporated water in process	549 gr

The tools used in this process were the Atago refractometer, digital pH meter, pH 50 Fisher Scientific Accument, and 30 x 20 cm Stanley aluminum pots, where jams were prepared, a 30 cm Stanley metal strainer to remove seeds to maqui and a 40 cm wooden spoon to stir jams.

Packaging

For the storage of the product, glass containers with lid threads were used to store 500 g of the product in each of them. While the cooking of the product was made, the containers to be used for packaging the jam were sterilized. In this process, vials were exposed to a temperature ramping up to 130 ° C for 30 minutes.

Once the cooking and sterilization process were completed, the filling of the containers started, taking as a first task the measurement of them to get the actual weight of the jams.

The jam was deposited in each jar, leaving a 1.5 cm to 2 cm headspace between the product and cover that would allow the cap to be sterilized and emptied. Once containers were filled, they were put up side down for 10 minutes in order to expel air out from inside.

Evaluation of properties of fruit and jam

Physico-chemical properties

Measurements of soluble solids and pH were performed on 5 occasions using a refractometer, one at the raw material, other to the mixture ingredients before cooking, two during cooking and another at the end of the cooking process. Results were expressed in ° Brix. Measurements were performed in three repetitions to ensure clarity in the results. The three jams subjected to this analysis were 60 to 65 ° Brix.

At the end of the cooking process pH was measured to have another indicator that would allow an appropriate term for processing and subsequent storage, being the three jams in a range of 3 to 3.5.

Nutritional properties

An assessment of the nutritional properties was performed three times in the process of making jams. The first was made to the raw material, i.e. to the fruits of maqui, green apple and plum mixed in the rates used in the preparation of jam, to know the nutritional quality in the content of ascorbic acid and polyphenols each of these fruits would give and the changes they would experience once processed.

The second evaluation was performed once jam was made, which had 35 days of storage, to have a first impression as to what treatment had the highest contribution in nutrients and changes in relation to the results of the analysis of the raw material.

The third and final evaluation was made after 65 days jams were stored, whose purpose was to obtain a more extensive comparison of the nutritional quality provided by the various treatments through the time.

In all cases, the nutritional parameters measured were total of ascorbic acid and polyphenols, major nutrients and of major importance within maqui, together with the contribution of green apple and plum in making process of the jam (INTA, 2013).

Methodology used.

Ascorbic Acid according to method AOAC 967.21

This method is based on reduction of a solution of sodium salt of 2,6 - Dichloro Phenol Indophenol (DPI) by ascorbic acid. The latter is oxidized and becomes dehydroascorbic acid, reaction that occurs as titrant solution (DPI) is added to the solution containing ascorbic acid. The final point is determined by the appearance of a pink color due to the presence of DPI without reducing in an acid environment.

A 0.1 g of Dichlorophenol-Indophenol was accurately weighed on a 2.6 analytical balance and dissolved in an Erlenmeyer flask with distilled water to a level of 150 mL. Once prepared, it was covered with an alusa-foil paper, so that the reagent could not come into contact with light. It was left on a shaker for approximately 3 hours to achieve a maximum dissolution.

Once the stirring time elapsed, the reagent was refined; using a current filter paper and it was completed to a volume of 250 mL with water distilled, to later standardize the solution.

Standardization of DPI solution (2,6 Dichlorophenol-Indophenol).

At this stage, two reagents had to be prepared to be left at the concentration required by the methodology. The requested acetic acid was 80%, however, from the supplier it came with 99.8%. To prepare 100 mL of this reagent at 80%, the following exercise was performed (Zumbado, 2004):

$$100\ mL \longrightarrow \left.\begin{array}{l} 99{,}8\% \end{array}\right\} \quad X = 80\ mL\ de\ 99{,}8\%$$

Therefore, in 80 mL of 99.8% 20 mL of distilled water were added to bring the reagent at a concentration of 80% in a volume of 100 mL.

Another reagent to be prepared was ascorbic acid to reach a volume of 500 mL at a concentration 40 mg / 1000:

0,04 gr ⟶ 100 mL
X ⟶ 500 mL
X= 0,2 gr

It was needed 0.2 g of ascorbic acid to prepare 500 mL of solution.

Once the reagents were prepared in the concentrations indicated by the methodology, it was taken a an aliquot of 5 mL of 2,6 Dichlorophenol with a graduated pipette Erlenmeyer flask and 5 drops of acetic acid were added to 80% with dropper

2.6 DP is deep blue and by adding acetic acid it changed to dark red in an acid medium.

To titrate, it was used the ascorbic acid that was prepared using a gravimetric titrator was used. Drops to drops were added to switch the original dark red to colorless by the addition of this reagent. Once this point is reached, it was jotted down the volume of ascorbic acid spent in the titration, which was used as the value for its determination.

Once the solution was standardized, the samples began to be prepared to be submitted to the determination of Vitamin C by the AOAC 967.21 method described. Washing the fruit was previously done, using 20 ppm of sodium hypochlorite in 4 L to remove any polluting waste that the fruit could have, and then the raw material was subjected to grinding using a SB-400 Black and Decker blender, until smoothing dough was obtained from treatments (T0 maqui, T1 maqui and green apple, T2 maqui and plum). In the case of maqui, it was grinded with skin and seed, apples were peeled and the pulp plum with skin.

Once samples were prepared, 50 g of each treatment were weighed and were turned to 10 ° Brix, using a graduated pipette and Erlenmeyer flask with distilled water. Later, a filter paper was used to strain the juice from each sample to be ready for titration. In the titration of juice of each treatment, 1 mL 2.6 Dichlorophenol-Indophenol was measured with a graduated pipette in a small test tube, to which a drop of 80% acetic acid was added. Using the same instrument to standardize the solution, it was titrated with the juice from each treatment until observing a change of dark red to pink. The volume invested in each titration was registered.

Each titration was repeated 5 times in each treatment, the results were incorporated into a equation which allowed to determine the content of Vitamin C present in each of the treatments.

Determination of the content of Vitamin C, titration method AOAC 967.21

Equation used:

$$\frac{\text{Volume used in titration}}{\text{Volume used on standardization}} \text{ X } \text{Dilution factor} = \text{mg of ascorbic acid / 100 gr from sample}$$

Dilution: Initial ° Brix / 10 ° Brix

Total Polyphenols

In order to meet the antioxidant contribution possessed either by the fresh raw materials and those processed, an analysis was performed to determine the total polyphenols, considering that maqui is rich in these compounds.

The methodology used in the analysis of total polyphenols, was an analytical technique which was determined prior differential precipitation (Wu et al., 2004).

Out of a total amount of 9 appropriated samples, 6 were sent on November 14, 2013 to INTA certified laboratory, from the University of Chile in Santiago. In this first group, 3 were from raw material used in the manufacture of jam and identical rates to those used in the process itself. Its formation was performed in the laboratory of the Catholic University of Maule, at Los Niches, the same day the analysis of ascorbic acid was carried out.

The jars used to pack each sample were sterilized in an oven at a temperature of 130 ° C for 30 minutes. Once sterilized, jars were placed up side down on a paper towel to let them cool and then to fill them with the homogeneous dough made to complete the 200 gr paper required for each treatment. Once packaged, jars were chilled and then sent in a cooler, maintaining the cold chain until it reached INTA Laboratory. With the aforementioned samples, three other remaining samples were sent, corresponding to jams stored for 35 days.

After the 65 days jams were stored, a new shipment was sent to the same laboratory. The jars were already previously stored under refrigeration at 2-5 ° C, before being changed to a cooler and sent to INTA laboratory.

The samples were analyzed the next day after their shipment and the results were sent in an e-mail.

Sensorial evaluation of organoleptic attributes and of acceptability

This evaluation was performed twice, the product itself produced at such after 35 and 65 days of storage in each respect. This evaluation was conducted by previously trained panelists.

Regarding the selection of panelists, some criteria as were considered: skill, availability, interest and opportunity to assess the samples and in the necessary time allotted, i.e. 35 and 65 days

of storage, so that they could see the potential changes between treatments and over time (Anzaldúa, 1994).

To choose panelists, a personal interview to those who were interested was made, asking questions related to each of the before-mentioned criteria, allowing the determination of the capacity of each panelist to become a member of the team to assess the jam made. It is important to highlight that panelists had been previously trained in a course of sensory evaluation of products; a total of 13 people were met to conduct the analysis with the aim of having a comprehensive review of the sensorial evaluation of jams and the importance for the development of the project and for the food industry.

The method used in the booklets was the descriptive and qualitative analysis to measure attributes such as texture, flavor, color and aroma, through non-structured sensorial evaluation booklets and another form to analyze the level of jam acceptability by the panelists, according to a scale of 1-7 (Tables 4 and 5). Additionally, a third form of comparison of samples was designed in order to generate a selection criterion in the panelist and a higher concentration and consistency in the results.

The three booklets were given to the panelists at the time of the sensorial and acceptability evaluation together with samples of 25 g of product, which were offered in plastic wells, accompanied by a spoon, individual napkin, a glass of water and the color scale, all with the aim of favoring the achievement of their perceptions about the product.

Table 4. Primer for the structured sensorial evaluation of Maqui jam *(chilensis)*

PRIMER FOR SENSORIAL EVALUATION AND ACCEPTABILITY OF MAQUI JAM *(chilensis).*
You will receive samples of maqui jam and your opinion is requested in a sensorial evaluation primer attached. You are asked to answer with the highest clarity and concentration as possible, circling the answer you consider to be more in line with what you have tested, according to the 1-7 scale ranging from *unacceptable* to *excellent*
Name._____ Date: _____
Sample: _____
General Acceptance:

a)	Excellent	7
b)	Good	6
c)	More than fair	5
d)	Fair	4
e)	Less than fair	3
f)	Bad	2
g)	Unacceptable	1

Comments_____

Adapted from Meilgaard et al., (1999)

Table 5. Primer for the sensorial evaluation of the organoleptic attributes of Maqui jam *(chilensis)*

PRIMER FOR THE SENSORIAL EVALUATION OF THE ORGANOLEPTIC ATTRIBUTES OF MAQUI JAM *(chilensis).*

You will receive samples of maqui jam and your opinion is requested in a sensorial evaluation primer attached. You are asked to answer with the highest clarity and concentration as possible, marking with a vertical line in each parameter to assess the intensity perceived, from less to more intense from left to right respectively

Name: _____Fecha: _____

Sample: _____

Color: Light Purple Pink Dark Purple Pink

Taste: Sweet, Sour-sweet and Sour

Aroma: Mild, Strong

Texture: Viscose, Thick, Rigid

Indicate the presence of flavors / scents (mark with an X)

Natural (fruit) ____ Metal ____ rough_____ Sweet ____Astringent____ Sour

Aqueous ____ Old-rancid ___ others (specify) _____

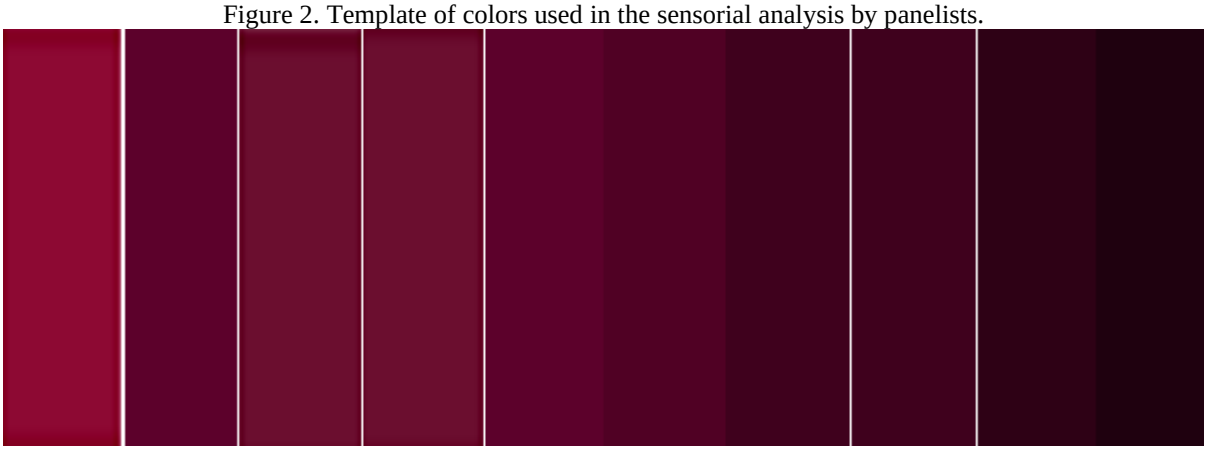
Comments: _____

Adapted from Meilgaard et al, (1999)

Template of colors used:

For clarity in results and to simplify the evaluation of the panelists, it was designed a range of possible colors found in jams degraded from light purple pink to dark purple pink, as shown in Figure 2.

Figure 2. Template of colors used in the sensorial analysis by panelists.



In addition to the above evaluation primers, a third one was drawn in order to make a comparison of the jam by the same panelists as to the attributes evaluated. This was done with the purpose of generating a base idea about which of the three jams would be more accepted from the organoleptic point of view, besides reducing the random factor in the responses, requesting panelists to have a high concentration and consistency in the results (Chart 6).

Chart 6. Primer for the comparative analysis of the samples evaluated.

PRIMER FOR THE COMPARATIVE ANALYSIS OF THE SAMPLES EVALUATED.

Once the primes for evaluation have been done, you are asked to compare the three samples I regard to color, flavor and texture by indicating which of them, according to your opinion and to what has been evaluated in the primers, have better attributes in each of the attributes evaluated, where number 1 stands for the one that shows the highest level of acceptability for the attribute and number 3 stands for the one that shows the least level of acceptability

You are requested to answer with a high level of concentration, even though there is a little significant difference. You are also requested to be coherent with what was evaluated in primers of acceptability and of sensorial analysis.

Name: _____

Date: _____

COLOR

Number 1 Kind of jam _____

Number 2 Kind of jam _____

Number 3 Kind of jam _____

FLAVOR

Number 1 Kind of jam _____

Number 2 Kind of jam _____

Number 3 Kind of jam _____

TEXTURE

Number 1 Kind of jam _____

Number 2 Kind of jam _____

Number 3 Kind of jam _____

Source: The author's own proposal, 2013.

Experimental design

In the process of making jam, two nutrient factors were measured; they were measured by the parameters of total ascorbic acid and polyphenol and those of organoleptic attributes such as color, aroma, flavor and texture.

Due to the fact that two studies were made in the process of making jam, either nutrients or organoleptic attributes, ANDEVA factorial varietal analysis and the design of repeated measures respectively.

The ANDEVA factorial varietal analysis is a simple method to use that permitted the comparison of the effects of the dependable variant that consisted on the total ascorbic acid and polyphenol, in terms of factors such as time (35, 65 days), physical state (fresh and processed), treatments, where the experimental unit was composed of 35 gr of fruit or product, according to what was demanded.

Results were analyzed to a varietal assessment and to a multiple comparative test Tukey ($p<=0,05$), through the software SPSS 18.0, to observe the significant differences existing between treatments.

The design with repeated measures was used in the results obtained the sensorial evaluation of jam, taking panelists as the experimental unit because they were the ones that offered the necessary information to attain the best result. In the present design, comparisons of the different treatments were carried out in a unique group of experimental. The results obtained were analyzed, considering a varietal assessment and a multiple comparative test Tukey ($p<=0,05$), through the software SPSS 18.0, to observe the significant differences existing between treatments.

Parameters evaluated: Total ascorbic acid and polyphenol.

Chart 7. **N**utritional evaluation carried out in three phases in the process of making jams

	First phase	Second phase	Third phase
Experimental Unit	gr of fruit	gr of product	gr of product
Weight of the samples	35gr	35gr	35gr
Number of repetitions	5	5	5

Parameters evaluated: Aroma, texture, flavor, color, acceptability.

Chart 8. Sensorial evaluation carried out in two phases to jams

	Primera etapa	Segunda etapa
Experimental Unit	Panelists	Panelists
Weight of the samples	25 gr	25 gr
Number of repetitions	13	13

3 RESULTS AND DISCUSSION

Nutritional evaluation

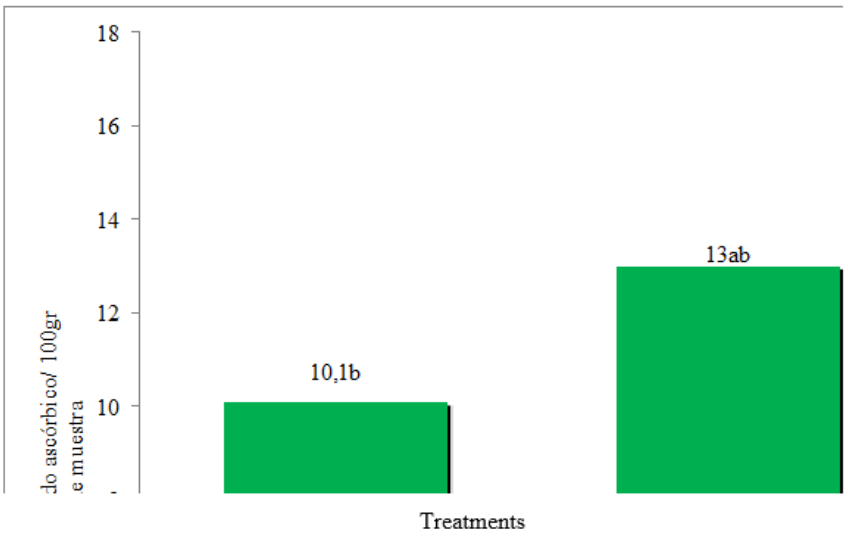
Analysis of the content of ascorbic acid in jams stored during 35 days.

The results obtained in the analysis show retention of about 30% more of the content of ascorbic acid in the case of jam from treatment T_1 and near 65% to treatment T_2, where maqui was mixed with apple and plum in each case. This last mixture T_2 was the one that showed the highest content of ascorbic acid with 16,8 mg/100 gr of the sample. Results were expressed in mg of ascorbic acid /100g of the sample (Figure 10).

The addition of another fruit component, i.e. apple and plum, used in treatments T1 and T2, to the process of making jams offered an additional quality to the product in regards to its content of ascorbic acid, bringing about its nutritional increase, mainly in treatment T_2, reinforcing what Gattás, (2011) stated that the addition of another component to this process is closely related to its nutritional gaining.

Jams produced from pure maqui, corresponding to T_0, and from maqui and plum in treatment T_2, process showed significant differences because treatment T_2 obtained average values of the content of ascorbic acid, probably because plum was added to the process with its skin, considering that its skin is the part of the fruit where the highest amount of Vitamin C is kept (Gattás, 2011).

Figure 3. The average values of ascorbic acid for each jam, expressed in mg of ascorbic acid /100 g of the sample.



* The average values that do not show a common letter are significantly different, according to Tukey test (p<=0,05).

When bibliographical date of apple and of skinless plum were compared, 12,4 and 9,5 mg of ascorbic acid were obtained in each case (FUNIBER, 2012), making evident the skin of the plum incorporated to the process of making jam had an important contribution of ascorbic acid, as shown in the results of the present assay.

Although the maqui jam with apple, offers a higher amount of Vitamin C, it was not so significant because its vitamin contribution was limited to that offered only by the pulp of the apple (Figure 3). It is also important to consider that the factors prior to the process, such as the cutting carried out to break the fruit into pieces and to peel it, besides its washing and its exposure to light and sun (Ramos et al., 2002).

Effects of the processing of the fruit in the content of ascorbic acid

The analysis of ascorbic acid were developed before and after the fruit processing with the objective of comparing to determine if there was any significant difference in the content of Vitamin C present un the jam made. The results shown in Chart 9 make evident a clear diminishing of the content of Vitamin C, of about 45%, after the fruit underwent a process of three treatments.

Chart 9. Average values of ascorbic acid, fresh and processed as jam.

	Fresh	Processed jam
Treatments	mg of ascorbic acid/ 100g of the sample	mg of ascorbic acid/ 100g of the sample
T_0	18,9	10,1
T_1	23,4	13
T_2	30	16,8

When the fruit for the three jams were cooked, it was observed a losing of the content of ascorbic acid from a 44 % to 46 % by cooking, reaching percentages almost similar to the ones suggested by Fellows, (1994), who stated the existence of a losing of Vitamin C due to the brief boiling time of the food, which can reach from 45 % to 55%; this could be the reason for the partial degrading of Vitamin C, due to the fact that jams were on a soft fire from 35 to 40.

The peeled and unpeeled fruit, plus its breaking into pieces and its washing, showed 53 % to 56% of Vitamin C in jams later made, percentages near to the ones established by Robert and Wiley (1997), who state that there is from 55 % to 75% of retention of Vitamin C by the boiling concept, when time is not long enough and far from the one established by Osborne y Voogt (1987), who state that as Vitamin C has a water-soluble character, it can lose until 100% of it, when non-appropriate conditions are followed in its breaking into pieces and its washing, avoiding an excessive exposure to the light and oxygen as well as to temperature changes and long-term cooking,

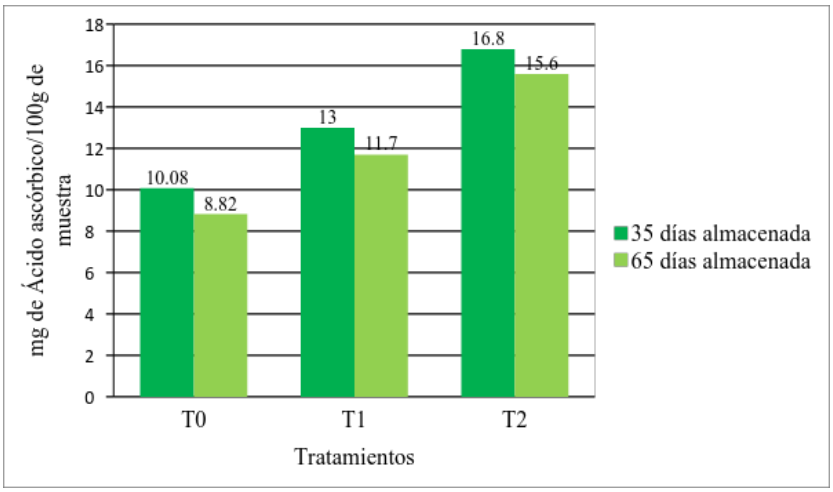
which are determining and important factors to be considered when food is made, especially those that are a good source of Vitamin C as the ascorbic acid is.

According to what Ramos, García and Pinedo (2002) point out, there is losing of Vitamin C by freezing, reaching a 20% to 30% by this concept, besides its losing by lixiviation for its washing, exposure to light and the material used in the cutting of the fruit, which reach almost a 20% to 30% of the losing by its cooking; it reaches 44% to 46%, which would explain the low levels of Vitamin C in the final content of the product.

Time-storage effect in the content of ascorbic acid

The results obtained after the second analysis of ascorbic acid, after 65 storage days, allowed researchers to establish the storage time effects of jams in its content of Vitamin C. The results shown in Figure 4 make evident low loses in the three jams and in similar proportions; thus being stored for a month, its losing was no significant. The average values obtained in mg of ascorbic acid/100 gr are shown after 35 and 65 days jams were stored.

Figure 4. Average values in mg of ascorbic acid/100g of the sample obtained in the titration carried out after 35 and 65 days jams were stored at 5°C.



mg of ascorbic acid/ 100g of the sample

Treatments 35 days stored / 65 days stored

The storage time of the jams in a month, since the first analysis if Vitamin C, did not show any statistically significant losing in the content of ascorbic acid, showing a decrease in this period from 7 % to 12 %. The reason for this to happen could be an adequate storage of the jams, either by keeping temperature from 2 to 5°C or by the attention taken to avoid its exposure to light or by sealing the containers to avoid the oxidation of Vitamin C because if the entrance of oxygen (Osborne y Voogt, 1987).

It is important to highlight that the antioxidant content jams have, as it will be observed in the analysis if total polyphenol, especially the one coming from what flavonoids can offer, could delay the oxidation of Vitamin C during cool storage (Paladino y Zuritz, 2010), this is because there would exist a synergy between these components to avoid oxidation.

Analysis of the content of total polyphenol in jams after 35 days of storage

Jams stored at a temperature of 2 and 5°C during 35 days showed amounts of the content of total polyphenol (Figure 5).

It is observed a significant value in the jams from treatment T_0, which belongs to pure maqui jam; it showed a high content of total polyphenol with 956 mg of EAG/100 gr of sample, while treatments T_1 and T_2, with 536 and 468 mg of EAG/100 gr; regardless the fact that they showed a relevant polyphenol contribution, the were significantly less when compared to jams made in treatment T_0. The results of such analysis were expressed in mg of EAG/100 gr of sample.

Figura 5. Average total polyphenol present in the different jams, expressed in mg of EAG/100 gr of sample
* The average values that do not show a common letter are significantly different, according to Tukey test (p<=0,05)

The three jams offered to the process a considerable different content of total polyphenol, highlighting values obtained in treatment T_0, that is, that from pure maqui jam, which obtained the highest content of polyphenol with 956 mg of EAG/100 gr of the sample (Figure 5).

The highest content of total polyphenol obtained in jam from treatment T_0, could happen mainly because of the content of flavonoids of anthocyanins kind that maqui has, where Festy (2003), states that most of them are in the skin and seeds, components that were used in the present assay for making jam. Besides, it is important to consider that according to studies made by Fredes and Montenegro (2011), maqui has its major potentials in the content of polyphenol, with maturity rates of 18 and 19 °Brix, with a darkly purple color, similar parameters to those shown in the raw material used to make jams in the present study.

The mixture present in treatment T2; maqui jam with plum, showed the lowest amounts of polyphenol with 468 mg of EAG/100 gr of the sample, no matter if the plum was added to the process with skin. What was described had its major benefit in terms of the content of Vitamin C, more than with the content of total polyphenol. In the plum, the major content of polyphenol is found in the pulp, while Vitamin C is almost concentrated in the skin (Valero et al., 2012). It is also important to consider that the content of Vitamin E is an important antioxidant in plums, that through the method of total polyphenol was not reflected (Valero et al., 2012).

In the case of treatment T1, the content of polyphenol, aside from the anthocyanins from maqui, comes from the clorogenic acid offered by Granny Smith apple that could have brought it in the polyphenol present in the jam.

Effects of the making of jam in the content of total polyphenol

The results obtained in the analysis of total polyphenol carried out either to the raw material or to the jams at such, indicated a tendency to diminish the polyphenol components of the fruit, once the processing of the frit occurred, that is, jams showed a degradation of these components of 9 to 15% from the fresh state of the fruit to that of processed. The results are observed in Chart 10 and were expressed in mg EAG/100 gr of sample.

Chart 10. Average values of total polyphenol of fresh and processed fruit.

Treatments	Fresh	Processed
	mg EAG/100 gr of sample	mg EAG/100 gr of sample
T_0	1045	956
T_1	598	536
T_2	551	462

No significant differences were observed in the content of total polyphenol after the fruit underwent different thermal treatments; however, as observed in Chart 10, when fresh fruit was processed, the content of polyphenol decreased because of the degradation of these phenol components of 9 to 15% due to the fact that with the mechanical transformations undergone in the making of jam, mixturing, breaking into pieces, it would cause the releasing of these phenol components, it happened because of the breaking of the cell structures, letting polyphenol in a better position to be degraded, as they are subjected to a given temperature after cooking (Escribano et al., 2002).

According to authors such as Paulino et al., (2013), high temperatures over 40°C may affect stability of phenol components due to an enzymatic and chemical degrading as well as to the losing caused by volatilization and by thermal discomposing, what has been checked in the present study, after fruits underwent to temperatures over 90°C for 25 minutes in the process of making jams, where polyphenol degraded 9 to 15%.

According to Paulino et al., (2013), Paladino and Zuritz (2010), the anthocyanins present in the skin and the flavones present in maqui seeds are set free in bigger rates after the breaking of cell structures, either by breaking it into pieces, extracting them and cooking them. According to the authors referred to and to Paladino y Zuritz (2010), it is probable that in the present study, the

breaking of cell structures could have become a better contribution of the content of total polyphenol once the process was carried out.

In case of green apple and plum, used as raw material in treatments T1 and T2, probably the content presented with 536 and 462 mg of EAG/100 gr of the sample is related with the 60% offered by maqui at such, because apple and plum individually are not rich enough to offer high levels of total polyphenol.

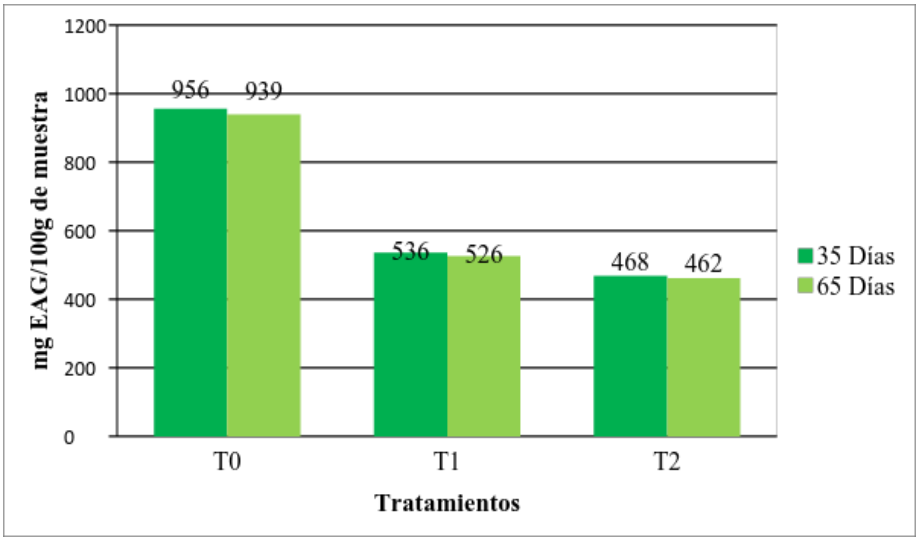
The least content of jam, from treatment T2, probably could have not been favored because another important factor in degradation, after processing, is the ascorbic acid, which could have brought an effect in the least content of the polyphenol of jams. It showed the best results in contributing ascorbic acid, with 16,8 mg of ascorbic acid /100 gr of sample (Barreiro y Sandoval, 2006).

Effect of the time of storage of jams in the content of total polyphenol

Jams underwent a second analysis of total polyphenol, after 65 days stored, aimed at knowing if there was any side effect related to the time in which jams were frozen at a temperature of 2 to 5°C.

The average results of total polyphenol obtained in the jams after 35 and 65 days stored showed that in this period of time the three jams diminished their content of total polyphenol that, as can be observed in Figure 6, did not represent any significant losing of them.

Figure 6. Average values of polyphenol reached after 35 and 65 days jams were stored at 5°C.



In the three cases, there was no significant losing of total polyphenol after a month jams were stored, showing a losing of the content of total polyphenol of 1,3 to 1,8%, probably because of the storage time, bringing about as a consequence an ever-rising decrease in the stability of food (Escribano et al., 2002).

Opposite to what Escribano et. al. (2002) stated, in the present study there was no considerably significant losing of nutrients, this probably happened because in the three cases jam were correctly stored, in ranges of temperature of 2 to 5°C, avoiding sudden temperature changes and an overexposure to oxygen that, according to Valderrama (2000), World favor as time passes by a show degrading of polyphenol, accompanied by an acid pH present in jams made from fruits of 3 to 3,5, that would interact as a counterpart against oxidation.

Beside the factors that favored the above-mentioned degrading s after processing, the ascorbic acid can be mentioned, which could have produced less contents of polyphenol in the jam from treatment T_2, which showed the highest contribution of ascorbic acid with 16,8 mg of ascorbic acid /100 gr of the sample, not being the same in the content of total polyphenol (Barreiro y Sandoval, 2006).

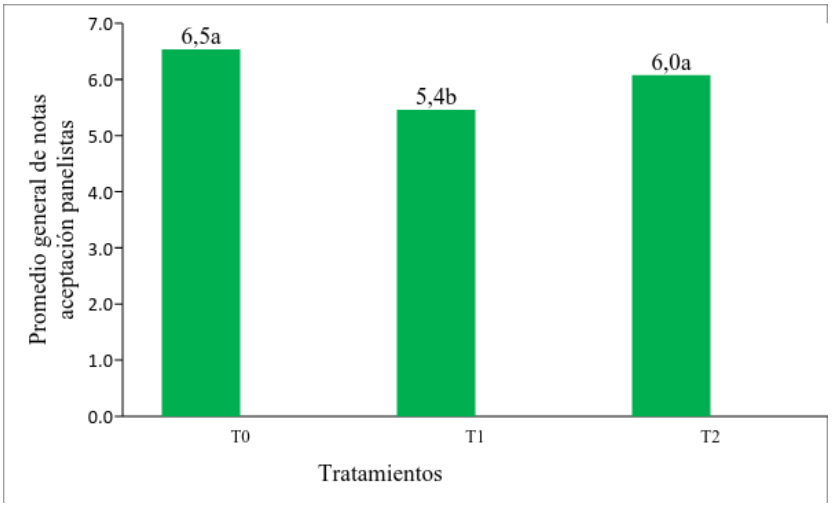
Sensorial evaluation of the jams made

First sensorial analysis of the jams stored during 35 days.

The level of acceptability of jams was analyzed by trained panelists, showing that the lowest level of acceptability was that of treatment T_1, obtaining a mark of 5,4, being categorized by panelists from “the most fair” to “good”; that is why panelists accepted jams from treatments T_2 and T_0, not existing differences between them. In regards to the level of acceptability from treatment T_2, the average mark was 6,0, being categorized by panelists as “good”; and related to treatment T_0, it was 6,5, equivalent from “good” to “excellent”. Results can be observed in Figure 7.

Average marks of the level of acceptability

Figure 7. Results of the average marks of the level of acceptability obtained from the sensorial evaluation carried out 35 days jams were stored.



Treatments
* The average values that do not show a common letter are significantly different, according to Tukey test (p<=0,05)

Average of the sensorial evaluation of attributes color, flavor, aroma, texture after 35 days jams were stored (Chart 10).

Chart 10. Average values of organoleptic attributes of jams 35 days alter being stored at 5°C.

Treatment	Color	Flavor	Aroma	Texture
T_0	9,38[a]	4,77a	5,23a	4,38a
T_1	9,31[a]	3,61a	3,46a	3,07a
T_2	9,53[a]	5,46a	3,38a	3,69a

* Those average values that are in a same column or in a same parameter, without a common letter, are significantly different, according to Tukey test (p<=0,05)

Sensorial evaluation of the jams stored during 65 days.

The results obtained in the second sensorial evaluation carried out 65 days after being stored showed that the least level of acceptance continued being jam from treatment T_1, obtaining a mark of 5,4, being categorized by panelists from “more than fair” to “good”; that is why panelists continued accepting jams from treatments T_2 and T_0. In regards to the level of acceptance of the jams from treatment T_2, the average appraisal was 6,0 that belonged to “good”; in regards to the appraisal for jams from treatment T_0, that was 6,5, being categorized by panelists from “good” to “excellent”.

There was no significant difference in terms of level of acceptability when compared to jams stored during 35 days, panelists kept the same evaluation mainly because he process of the conservation of fruits was with temperatures from 2 to 5°C, favoring an adequate maintenance of their organoleptic properties.

In regards to attributes such as color, flavor, aroma and texture of the jams with the tratments undergone, the values obtained using a non-structured primer were the ones shown in Chart 11.

Chart 11. Average values of organoleptic values in jams stored during 65 days at 5°C.

Treatment	Color	Flavor	Aroma	Texture
T_0	9,61[a]	4,92ab	5,53a	4,38a
T_1	9,38[a]	3,77a	3,69b	3,46b
T_2	9,46[a]	5,92a	3,69b	3,77ab

* Those average values that are in a same column or in a same parameter, without a common letter, are significantly different, according to Tukey test (p<=0,05)

4 CONCLUSIONS

The content of ascorbic acid increased with addition of another fruit to the process of making jams, where jam from treatment T_2, showed the highest value with 16,8 mg of ascorbic acid /100 gr of the sample.

Fruits showed significant loses of ascorbic acid from 44 to 46% immediately after its processing; however, after being stored for 65 days, fruits did not show significant loses of ascorbic acid.

The content of total polyphenol was not affected by storage, showing jams not significant loses of the content of total polyphenol after being stored for 65 days from 1,3 to 1,8%

Panelists showed preference for jam from treatments T_0 and T_2, not existing significant differences among them. In regards to the evaluation made from treatment T_0 obtained 6,5, being categorized by panelists from “good” to “excellent”, while jam from treatment T_2 obtained 6,0, being categorized by panelists as “good”.

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