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Optimization of the functional properties of a drink based on tubers of purple mashua (*Tropaeolum tuberosum* Ruíz y Pavón)

Optimización de las propiedades funcionales de una bebida a base de tubérculos de mashua (*Tropaeolum tuberosum* Ruíz y Pavón) morada

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ABSTRACT

This work optimized the temperature and time of pasteurization of purple mashua (*Tropaeolum tuberosum* Ruíz and Pavón) tubers drink based on its antioxidant capacity, total phenolics, total flavonoids, anthocyanins content, and acceptability. For this, purple mashua tubers from the province of Acobamba-Huancavelica-Peru were weighed, washed, peeled, cut and placed in a juice extractor. The beverage of tubers was prepared using the juice of tubers, the thermal treatment of the samples was carried out at temperatures between 75 to 85 °C and time 10 to 25 min. The design was planned using a Rotational Composite Central Design and a response surface analysis was performed on the samples obtained. The content of total phenolics, anthocyanins, total flavonoids, and antioxidant capacity was influenced by the time and temperature of pasteurization. At higher temperatures and pasteurization times there was a reduction in the content of total phenolics, anthocyanins, total flavonoids, and antioxidant capacity. The greatest general acceptability of the panelists was at high pasteurization temperatures and times. The temperature of 77 °C and time of 13 minutes showed the maximum value of response variables with low degradation of the antioxidant compounds and good acceptability of mashua extract drinks.

Keywords: *Tropaeolum tuberosum*; thermal treatment; antioxidant capacity; anthocyanins content; acceptability.

RESUMEN

Este trabajo optimizó la temperatura y el tiempo de pasteurización de los tubérculos de mashua (*Tropaeolum tuberosum* Ruíz y Pavón) morada en función de su capacidad antioxidante, fenólicos totales, flavonoides totales, contenido de antocianinas y aceptabilidad. Para esto, se pesaron, lavaron, pelaron, cortaron y colocaron en un extractor de jugo los tubérculos mashua morados de la provincia de Acobamba-Huancavelica-Perú. La bebida de los tubérculos se preparó usando el jugo de los tubérculos, el tratamiento térmico de las muestras se realizó a temperaturas entre 75 y 85 °C y tiempo de 10 a 25 min. El diseño se planificó utilizando un diseño central compuesto rotacional y se realizó un análisis de superficie de respuesta en las muestras obtenidas. El contenido de fenoles totales, antocianinas, flavonoides totales y capacidad antioxidante fue influenciado por el tiempo y la temperatura de la pasteurización. A temperaturas más altas y tiempos de pasteurización hubo una reducción en el contenido de fenoles totales, antocianinas, flavonoides totales y capacidad antioxidante. La mayor aceptabilidad general de los panelistas fue a altas temperaturas y tiempos de pasteurización. La temperatura de 77 °C y tiempo de 13 minutos mostraron un valor máximo de las variables de respuesta con baja degradación de los compuestos antioxidantes y buena aceptabilidad de las bebidas de extracto de mashua.

Palabras clave: *Tropaeolum tuberosum*; tratamiento térmico; capacidad antioxidante; contenido de antocianinas; aceptabilidad.

1. Introduction

Mashua (*Tropaeolum tuberosum* Ruíz and Pavón) also known as izañu, añu, or apiñu is an Andean tuber cultivated by people from the high Andean areas. It is one of the four main products of their diet, due to its hardiness, yield and nutraceutical potential (INIA, 2009). The mashua tuber is distributed in the Peruvian highlands, with its chemical composition containing 84.54% humidity, 0.98% protein, 0.13% fat, 0.51% ash,

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and 9.97% of carbohydrate expressed on the wet basis of the product (Velásquez-Barreto and Velezmoro, 2018).

Mashua purple tubers contain phenolic compounds such as gallic acid, procyanidins, hydroxybenzoic and hydrocyanic acid, rutin, myricetin, anthocyanins, epicatechin, proanthocyanidins, (Chirinos *et al*., 2007). Chirinos *et al.* (2008) also found a total content of phenolic compounds of 14-24 mg/g in dry matter of purple mashua variety DP 0224 and an antioxidant capacity (ORAC) in the range of 271-446 µmol of Trolox equivalent (TE)/g in the dry matter of purple mashua.

Research on natural antioxidants has increased knowledge about healthy components that are available in foods (Sardarodiyan and Sani, 2016). These antioxidants can have certain anti-inflammatory, antitumor, antimutagenic, anti-cancer, antibacterial, and antiviral activities (Karker *et al*., 2016). These components can capture free radicals and final chain reactions before they can damage other molecules of vital importance (Singh *et al*., 2018). The effect of processing on the bioactive compounds present in food has been investigated, finding treatments such as blanching, pasteurization, sterilization, roasting, frying, refrigeration, freezing can reduce the content of bioactive compounds with antioxidant effect (Branco *et al*., 2016).

Industrial processing usually includes treatment at high temperatures like drying, sterilization, pasteurization, and roasting. These treatments are used to destroy pathogenic microorganisms and inactivate enzymes to increase the shelf life and availability of food for consumption (Branco *et al*., 2016). Pasteurization is a conservation method that is usually used due to its practicality and effectiveness. However, its use may involve the degradation of some compounds of interest such as vitamins, antioxidants, and amino acids (Brasili *et al*., 2017).

Degradation of bioactive compounds such as anthocyanins, total phenolics content, total flavonoids, and the antioxidant capacity of fruit juices and nectars by thermal treatment have been reported showing that the content of these compounds is altered by the intensity of the heat treatment (Brownmiller *et al*., 2008; Branco *et al*., 2016; Lu *et al*., 2018). Therefore, the evaluation of the thermal treatment variables such as temperature and time is of vital importance to reduce the degradation of the bioactive compounds.

Giving added value to some Andean tubers such as the purple mashua is of great importance for the Andean communities that cultivate this crop, and knowing the potential of this purple mashua tuber such as bioactive compounds and other components have been reported in some studies (Brizzolari *et al*., 2019; Apaza *et al*., 2020; Aguilar-Galvez *et al*., 2020). Therefore, this work had as objective: To optimize the temperature and time of pasteurization of purple mashua tubers drinks (*Tropaeolum tuberosum* Ruíz and Pavón) based on its antioxidant capacity, total phenolics, total flavonoids, anthocyanins content, and acceptability.

2. Material and methods

Mashua tubers characterization

The samples of purple mashua (purple variety) were collected from the province of Acobamba-Huancavelica-Peru. The chemical composition of the tubers was determined using the methods of AOAC (2012). The content of total phenolics, antioxidant capacity, total flavonoid, and anthocyanin content of the mashua tubers were determined using the methodology proposed by Chirinos *et al*. (2008).

Preparation of the sample

Purple mashua tubers were weighed, washed, peeled, cut, and placed in a juice extractor (model FPSTJE318C-053, Oster, Peru) to extract the juice from the tubers. The extracts obtained were subsequently diluted in water in a 1/3 ratio (extract/water); then the pH was adjusted to 3.5. Sucrose was added until a Brix of 13 was obtained (this parameter was determined in the previous study). The design of the runs was performed using the Central Composite Rotational Design (DCCR). Thermal treatment of the samples was carried out at temperatures between 75 to 85 °C and a time of 10 to 25 min, with a total of 12 treatments. These factors levels were chosen due to the altitude of the zone and the parameters of pasteurization that normally are used. The response variables of mashua drinks analyzed before and after the heat treatment was total phenolic content, antioxidant capacity, total flavonoid content, monomeric anthocyanins content, and acceptability.

Determination of antioxidant capacity

The methodology proposed by Onyeoziri *et al.* (2016) with certain modifications were used. For this work, 10 mL of sample was diluted in 100 mL

of distilled water. 1000 µL of DPPH solution was added into a glass tube, followed by 50 µL of diluted sample and 200 µL of methanol. The final reaction volume was 1250 µL. The absorbances were measured in a spectrophotometer (Model 4251/50, Zuzi, Spain) at 515 nm. Then, a calibration curve was prepared with 0.2 mM of Trolox at concentrations of 0, 20, 40, 60, 80, 100, and 200 µM. The results were expressed in TEAC (Trolox Equivalent Antioxidant Capacity).

Determination of total phenolic compounds

The methodology proposed by Singh *et al.* (2016) with certain modifications was utilized to evaluate the total phenolic compounds. 125 µL of the diluted sample (1/10) was put in a glass tube and subsequently, 0.5 mL of deionized water and 125 µL of the Folin-Ciocalteu reagent were added., left to rest for 6 min; then 1.25 mL of a 7% Na_2CO_3 solution was incorporated and the total volume was adjusted to 3 mL. This solution was incubated for 90 min and the absorbance was measured in a spectrophotometer (Model 4251/50, Zuzi, Spain) at 760 nm. The total phenol was expressed in gallic acid equivalent and a calibration curve of gallic acid was used from 20 to 500 µg/mL.

Determination of total flavonoid content

The determination of total flavonoid content was performed using the methodology proposed by Singh *et al.* (2016) with certain modifications. 0.25 mL of the diluted sample (1/10) was used, and 75 µL of a 5% $NaNO_2$ solution was incorporated. Subsequently, 150 µL of a fresh solution of 10% $AlCl_3$ was added, and 0.5 mL of a 1 M NaOH solution was incorporated. The final volume was adjusted with deionized water to 2.5 mL and incubated for 5 min. The absorbance measurement was performed using a spectrophotometer (Model 4251/50, Zuzi, Spain) at 510 nm. The catechin calibration curve was performed in the range of 10-500 µg/mL. The total flavonoids was expressed as (+) - catechin equivalent [EC, mg (+) - catechin/g sample].

Determination of monomeric anthocyanin content

The methodology proposed by Machado *et al.* (2017) was used with certain modifications to determine the monomeric anthocyanin content of the samples. A dilution was prepared at pH 1.0, 10 mL of the sample was diluted to 100 mL with buffer pH 1 (0.025 M chloride buffer). Another dilution was prepared at pH 4.5, 10 mL of the sample was taken and diluted to 100 mL with buffer pH 4.5 (0.4 M sodium acetate buffer). Then, the absorbance for pH 1 was determined in a spectrophotometer (Model 4251/50, Zuzi, Spain) at 510 nm and 700 nm. The absorbance was also determined for pH 4.5 at 510 nm and 700 nm. The concentration of monomeric anthocyanins was determined using equations 1 and 2.

$$Abs = (A_{510\,nm}\ pH\ 1.0 - A_{700\,nm}\ pH\ 1.0) - (A_{510\,nm}\ pH\ 4.5 - A_{700\,nm}\ pH\ 4.5) \ldots\ldots (1)$$

$$Concentration\ \left(\frac{mg}{L}\right) = \frac{A}{\varepsilon L}\ x\ 10^3\ x\ MW\ x\ Dilution\ factor \ldots\ldots (2)$$

Where: Abs: is the corrected absorbance, MW: Molecular weight (cyanidin 3-glucoside = 449.2 g/mol), ε: Molar extinction coefficient (cyanidin 3-glucoside = 26 900 g/mol), L: Length of the bucket (1 cm).

Sensory evaluation

The sensory evaluation of acceptability was carried out on the treatment runs. 60 untrained panelists were used to evaluate the samples. Samples were given to the panelists in the morning in random order. The rating was carried out with a hedonic scale of 7 points. Untrained Panelists were prepared to rinse their mouth with water after each sample evaluation.

Statistical analysis

Statistica 5.0 software was used to realize this analysis. The desirability function was used to determine the optimal parameters of pasteurization temperature and time. The optimal parameters of the factors and response variables were determined using the analysis of multi-response of the Software Design Expert 7.0.

3. Results and discussion

Physicochemical characteristics of purple mashua

The percentages of moisture obtained (Table 1) are higher in the extracted juice than in whole mashua tubers because during the extraction process more liquid was extracted, separating the residue that is usually fiber. Chirinos *et al.* (2008) reported similar percentages of humidity in mashua tubers (83.4% to 87.1%). The percentages of proteins, fats, carbohydrates, and ashes (Table 1) obtained in the present work are like those obtained by Velásquez-Barreto and Velezmoro (2018). Concerning the percentage of proteins, fats, carbohydrates, and ashes of the mashua extract, it was lower than those found in whole tubers of purple mashua because, during the extraction and filtration of the extracts, solid

waste was left which reduced the content of these nutrients in the filtered extracts.

The content of anthocyanins, antioxidant capacity, total phenolics content, and total flavonoids of the mashua purple extracts were lower than the whole tubers of mashua purple because during the determination the whole tuber was used including the skin that increased the content of these components. The anthocyanin content of the purple mashua tubers (Table 1) was higher than those obtained by Chirinos *et al.* (2007) and Chirinos *et al.* (2008), where they found anthocyanin concentrations of 3.7 to 8.7 mg/100 g and 11.4 to 13.6 mg/g respectively. The antioxidant capacity in purple mashua tubers (Table 1) was different from that obtained by Chirinos *et al.* (2007) who report antioxidant capacities in ORAC from 259 to 446 µM/g. Moreover, Chirinos *et al.* (2008) obtained values of antioxidant capacity in ABTS from 165 to 601 µmol Trolox/g which are similar to those obtained in our work. Differences in the content of antioxidant capacity indicate that processes of synthesis and degradation of compounds with antioxidant properties occur and depend on the maturation and harvest process (Chirinos *et al.*, 2007). The content of total phenolics of the purple mashua tubers was like those obtained from Chirinos *et al.* (2007) and Chirinos *et al.* (2008) who obtained values of 14 to 24 mg/g and 10.9 to 57.4 mg/g respectively. The content of total flavonoids was lower than those obtained by Chirinos *et al.* (2008) who obtained total flavonoid values between 1.8 to 7.8 mg/g in different varieties of mashua tubers. This indicates that genotypic differences could affect the total flavonoid content of the mashua tubers studied and other factors such as temperature, cultivation area, rainy season.

Table 1
Proximal chemical characteristics of purple mashua tubers

Content	Whole tuber	Extract
Humidity (%)[a]	86.87±0.36	94.96±0.4
Proteins (%)[a]	1.23±0.041	0.51±0.01
Fats (%)[a]	0.13±0.0031	0.04±0.00
Carbohydrates (%)*	11.41	4.34
Ash (%)[a]	0.36±0.0073	0.15±0.03
Acidity (%)[b]	0.19±0.027	0.21±0.03
Brix	-	3.23±0.26
Anthocyanins (mg/g)[c]	34.58±0.127	26.69±0.0
Antioxidant capacity (µM trolox/g)[c]	169.16±0.158	142.35±0.
Total phenolics content (mg/g)[c]	39.87±0.046	37.57±0.0
Total flavonoids (mg/g)[c]	1.39±0.071	1.27±0.03

*Determined by difference, [a]Expressed in wet weight, [b]Expressed in citric acid, [c]Expressed in dry basis.

Total phenolic content

The content of total phenolics was from 171.82 to 271.82 mg/100 g in the drinks of purple mashua extracts (Table 2). These differences are due to the different effects of the evaluated variables. The content of total phenolics was reduced at higher temperatures than 75 °C and pasteurization times greater than 13 min. Besides, treatments performed at temperatures of 80 °C and pasteurization times of 25 min showed the highest loss of total phenolics content. These data agree with those found by Klopotek *et al.* (2005), where the authors found a reduction in the content of total phenolics in juices and nectar from pasteurized strawberries at a temperature of 85 °C and times of 5 min. Likewise, Ma *et al.* (2013) found the reduction of polyphenols in carrot juices and grape juices due to pasteurization. Polyphenols present in mashua purple extracts suffered a thermal degradation that involves different reactions and perhaps was consumed in the Maillard reaction pathway (Ma *et al.*, 2013). Besides, these results indicate that the pasteurization treatment may cause a degradation of polyphenols and the release of linked phenolic compounds.

Antioxidant capacity

The results of the antioxidant capacity measured by the DPPH method of the treatments of mashua extracts are presented in Table 2. The antioxidant capacity was 1442.61 to 1596.02 µM/100 g, where it is shown that the antioxidant capacity was higher in treatments carried out at temperatures between 77 and 85 °C and pasteurization times less than 12 min. However, pasteurization times greater than 12 min reduced the antioxidant capacity of the treatments. Brownmiller *et al.* (2008) found that the antioxidant capacity of clarified and pasteurized cranberry juices at temperatures of 95 °C for 3 minutes showed an increase from 1% to 7% in the initial antioxidant capacity of cranberry juices. Moreover, Hager *et al.* (2008) reported an increase of 24% and 25% antioxidant capacity in black raspberry juices pasteurized at 95 °C for 3 min clarified and not clarified respectively. This supposes that the antioxidant capacity of the mashua extracts could have increased due to the high temperatures and short pasteurization times applied. Some studies have shown that the increase in antioxidant capacity during thermal treatment may be due to the formation of the products of the Maillard reaction (Zhang *et al.*, 2018). On the other hand, by increasing the

pasteurization times and the pasteurization temperatures, the antioxidant capacity of the mashua extracts was reduced, perhaps due to the loss of other antioxidants such as anthocyanins and polyphenols (Table 2). These results are related to the results obtained by Klopote *et al*. (2005) for juices and nectar of pasteurized strawberries, where the reduction of the content of anthocyanins and total phenolics content were related to the reduction of the antioxidant capacity.

Total flavonoids

The total flavonoid content of the drinks of purple mashua extracts is presented in Table 2. This content was 7.76 to 9.34 mg/100 g. Pasteurization temperatures of 77 to 85 °C applied for times less than 15 min maintained the flavonoid content of the purple mashua extracts. Nevertheless, times greater than 15 minutes reduced the total flavonoid content. These differences in thermal treatments are perhaps due to prolonged times of heat treatment degrading the flavonoid content. Lu *et al*. (2018) reported the degradation of total flavonoids in orange juice because of the heat treatment temperature, this degradation was greater in high thermal treatment. Similar results were reported by Chaaban *et al*. (2017) who studied the thermal degradation of six flavonoids (rutin, naringin, mesquitol, eriodictyol, luteolin, and luteolin-7-O-glucoside) at temperatures from 50 to 130 °C and found that all flavonoids studied were sensitive to heat, and that sensitivity depended on the temperature and duration of thermal treatment. Likewise, they showed that the thermal stability of each flavonoid depended on its structure and treatment temperature. Similar effects of flavonoid degradation were reported by Aoyama and Yamamoto (2007) on Welsh onions subjected to boiling. This would explain why temperatures of 77 to 85 °C and pasteurization times greater than 15 min degrade the flavonoid content of mashua extracts in a greater proportion, and other factors such as pH could influence this behavior since low pH can degrade the structure of flavonoids at high temperature and a long time of pasteurization. It should be mentioned that the degradation of flavonoids depends on its structure. Buchner *et al*. (2006) observed that routine had greater stability compared to its aglycone (quercetin) and this is due to glycosylation in-ring C. Besides, Ioannou *et al*. (2012) mention that the degradation of the flavonoids is not only a function of the temperature and time of thermal treatment but also of other parameters like pH, presence of oxygen and other phytochemical compounds.

Monomeric anthocyanin content

The content of monomeric anthocyanins was from 230.70 to 350.18 mg/L (Table 2), where the anthocyanin content degradation was higher at temperatures of 77 °C and pasteurization time of 13 min. Although, it was lower at temperatures above 80 °C and times of 10 min. The degradation of anthocyanins from various sources has studied such as blueberry (Song *et al*., 2018), purple corn (Kapcum and Uriyapongson, 2018), black carrot (Kirca *et al*., 2007), purple potatoes (Qiu *et al*., 2018), where it is reported that anthocyanin degradation is greater at high processing or storage temperatures and its degradation increases with longer treatment times.

Table 2
Results obtained from the purple mashua extracted treatments

Run	Independent variables		Responses Variables				
	Temperature (°C)	Time (min)	Total phenolics (mg/100g)	Antioxidant capacity (µM/100g)	Total flavonoids (mg/100g)	Monomeric anthocyanins (mg/L)	Acceptability
1	77	13	253.64	1596.02	9.06	319.37	3.6
2	77	22	226.36	1522.16	8.11	280.29	4.1
3	83	13	262.73	1561.93	9.17	335.17	4.9
4	83	22	221.82	1505.11	8.71	268.27	5.2
5	75	17.5	235.45	1465.34	9.34	298.33	4.2
6	85	17.5	194.55	1516.48	9.32	247.98	5.5
7	80	10	249.09	1578.98	9.14	315.61	4.8
8	80	25	171.82	1567.61	7.76	230.70	5.3
9	80	17.5	267.27	1488.06	8.88	346.42	5.1
10	80	17.5	271.82	1442.61	8.59	341.16	5.3
11	80	17.5	262.73	1448.3	8.71	350.18	5.1
12	80	17.5	267.27	1465.34	8.76	348.67	5.2

Also, Kirca *et al.* (2007) found that the greatest degradation of anthocyanins occurs at a pH greater than 3 and temperatures between 70 and 90 °C. The degradation of anthocyanins maybe because of the breakage of the flavonols ion and as a result, it reduces the concentration of anthocyanins and loss of color. Buckow *et al.* (2010) mention that the thermal stability of anthocyanins is reduced by the number of hydroxyl groups in ring A, in the absence of dihydroxyl structures in ring B and the degree of glycosylation in position 3. Furthermore, Skrede *et al.* (2000) report that the stability of anthocyanins depends on the type of anthocyanins present. This behavior has been observed in delphinidin glycosides which showed a greater tendency to degradation at high temperatures due to their three ortho phenolic groups in the B ring in comparison with the derivatives of cyanidin that just have two ortho phenolic groups, which makes them more stable. On the other hand, the stability of anthocyanins at high temperatures is well known and is affected by long processing factors such as pH, the presence of anthocyanin degrading enzymes, ascorbic acid, free radicals or oxygen (Kirca *et al.*, 2007); which depend on the source of origin and processing conditions (Buckow *et al.*, 2010).

Sensorial evaluation

Table 2 shows the acceptances of purple mashua drinks that are showing that at temperatures above 80 °C and times greater than 10 min increases the acceptability due to the thermal degradation of certain compounds that reduced the acceptability of the panelists. Likewise, during the sensory evaluation, the panelists stated that they found a slightly bitter and spicy taste in the samples that were pasteurized at low temperatures and short times. Some types of glucosinolates have been found in some varieties of mashua tubers (Martín and Higuera, 2016). Bitter flavors and smells have been found in the Brassicaceae family and these have been related to the presence of glucosinolates and their associated hydrolyzed products (Kim and Ishii, 2006). The presence of these glucosinolates could affect the acceptability of pasteurized purple mashua extracts that were pasteurized at lower temperatures and shorter times. Despite that, pasteurized extracts at higher temperatures (>80 °C) and longer times (>10 min) increased the acceptability and perhaps due to the degradation of the glucosinolates that were present before the pasteurization process. Barba *et al.* (2016) report that glucosinolates are susceptible to degradation at high temperatures which is dependent on the type of heat treatment applied. Furthermore, the authors mention that degradation is greater at boiling temperatures. This could explain why extracts treated at high pasteurization temperatures may have had a greater degradation of glucosinolates and, therefore, greater acceptability.

Thermal treatment optimization

Table 3 shows the regression coefficients of the quadratic models for the content of total phenolics content, antioxidant capacity, total flavonoid content, anthocyanin content and general acceptability of pasteurized purple mashua extracts.

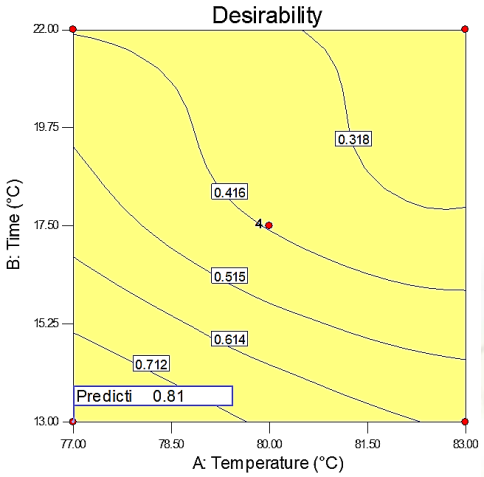

Figure 1. Desirability function for total response variables.

The quadratic models had a significant effect on the five studied variables ($p < 0.05$). Likewise, there was a lack of significant adjustment ($p < 0.05$) in response variables content of total phenolics, anthocyanin content, and acceptability, which indicates that the proposed model was insufficiently accurate to predict these variables. High values of R^2 were observed in the content variables of total phenolics content, total flavonoid, and anthocyanin content ($R^2 > 0.9$), except for antioxidant capacity (0.74) and acceptability (0.75). These results suggest that high variations of responses can be explained by response surface models. De Oliveira *et al.* (2009) report that the coefficient of determination greater than 0.8 and Loh *et al.* (2005) suggested that R^2 of 0.75 is adequate for prediction purposes. Also, the analysis of the residuals performed on the predicted data did not exceed 10% error, which indicates that the proposed quadratic models fit the experimental data very well.

Table 3
Variance Analysis of the model for the response variables of purple mashua pasteurized extracts

Regression coefficients	Total phenolics	Antioxidant capacity	Total flavonoids	Monomeric anthocyanins	Acceptability
β_0	-12570.8*	12578.52	165.7551*	-18744.7*	-137.958*
β_1	313.6*	-255.38	-3.7949*	463.9*	3.297*
β_2	48.7*	-104.39	-0.6205	80.0*	0.509
β_{12}	-0.3	0.32	0.0091	-0.5*	-0.004
β_{11}	-1.9*	2.16*	0.0229*	-2.9*	-0.019*
β_{22}	-0.9*	-1.58	-0.0055	-1.3*	-0.005*
p value	0.000	0.001	0.000	0.000	0.032
p value of lack of fit	0.0145	0.099900	0.243397	0.024775	0.008557
R^2	0.9114	0.74	0.9409	0.95919	0.752
R^2 ajusted	0.83756	0.52864	0.89172	0.92517	0.54529

Descriptors: 1=Temperature, 2=Time; *Significance at the level of 0.05.

The desirability function (Figure 1) optimized the total phenolics content (252.37 mg/100 g), antioxidant capacity (1559.16 µM/100 g), total flavonoids (9.28 mg/100 g), the content of monomeric anthocyanins (316.70 mg/L), and acceptability (3.93) at 77 °C and 13 min of pasteurization with a maximum desirability value of 0.81.

These parameters of temperature and time maximized the response variables and thereby permit to obtain drinks of extracts of purple mashua with good acceptability.

4. Conclusions

It was possible to obtain a functional drink with a high content of antioxidants. The content of total pheno-lics, anthocyanins, total flavonoids, and antioxidant capacity was influenced by the time and temperature of pasteurization. At higher temperatures and pasteurization times there was a reduction in the content of total phenolics, anthocyanins, total flavonoids, and antioxidant capacity. The greatest general acceptability of the panelists was at high temperatures and pasteurization times due to the degradation of compounds that provided a spicy and bitter taste probably related to the glucosinolate content of the drinks. The optimal temperatures and pasteurization times were 77 °C and 13 min. It is recommended to carry out an analysis of the compounds that produce abnormal flavors in the drinks of purple mashua extracts, as well as to evaluate the storage stability of the content of phenolics, anthocyanins, total flavonoids and antioxidant capacity of the obtained drinks.

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