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MORPHOLOGICAL, PHYSICAL, ORGANOLEPTIC, CHEMICAL AND FUNCTIONAL CHARACTERIZATION OF NATIVE POTATOES

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Abstract: The present investigation began with the morphological characterization, describing the general shape of the tubers, depth of the "eyes", predominant and secondary color of the skin and pulp of 24 varieties of native potatoes. Most presented round shapes (10 ecotypes); "eyes" with medium depth (14 ecotypes); yellow skin without secondary color (8 ecotypes) and light yellow flesh (9 ecotypes). Regarding size, in general it was possible to observe that the native ecotypes presented heterogeneous tubers in size and weight (between 20 g and greater than 90 g). In the physical characterization, it was found that the maximum value of specific gravity of 1.11 corresponds to the Chaucha Amarilla and Calvache varieties; They are followed by the varieties Sta. Rosa, Coneja Blanca, Violeta, with an average value of 1.10. Regarding the cooking time, the tubers, which presented texture values greater than 10 kgf, and a weight greater than 90 g, required cooking times greater than 40 min. Tubers weighing between 20 and 80 g, and texture values between 7 and 9 kgf, required cooking times of less than 30 min. to achieve the appropriate texture for consumption. The Chaucha Amarilla, Chaucha Holandesa, Yema de Huevo and Sta. Rosa varieties began the sprouting process in the first week of storage, while the Chivolulo, Moronga and Tushpa varieties sprouted from the ninth week. From the sensory analysis it can be deduced that the varieties that the panelists liked the most were those with yellow skin and pulp colors. The native varieties, which reached a good level of acceptability in the attributes: size, shape, skin color, pulp, and those with unusual morphological characteristics in shape, skin color, and pulp, were subjected to chemical analysis. The highest dry matter content corresponded to the Coneja Blanca variety (27.32%), fiber from Chaucha Holandesa (6.07%), fat from the Quillu variety (0.68%),

protein from the Sta. Rosa variety (10.62%), and starch to the Ovaleña variety (87.49 %). Regarding the mineral content, the native varieties are rich in iron (16.47 mg / 100 g, Black Rabbit) and potassium (2103.33 mg / 100 g, Dutch Chaucha). The starch of the Chaucha Amarilla variety showed the highest amylose content (36.81 %), the maximum viscosity of the Puña variety (2070 UB) and the highest gelling index of the Sta. Rosa variety (430.00 UB). The photographs of the starches revealed their oval shape; the granules presented a maximum and minimum average diameter (microns) of 50.42; 30.37; 26.34 and 18.23 μm, for the Puña and Chaucha Holandesa varieties, respectively. The functional characterization was carried out in the varieties of pulp and/or peel of purple, red and intense yellow colors, and with a higher level of acceptability among consumers.According to the recommended daily dietary allowance of vitamin C (50 mg/100 g) (8), native potatoes could contribute to the daily requirement, from 15% (7.67 mg/100 g, Calvache) to 50% (26.22 mg / 100 g, Uvilla). From the results obtained for the carotene content, the highest values correspond to the Chaucha Amarilla variety (11.38 ug/g of sample), with an intense yellow flesh, followed by the Quillu variety (10.03 ug/g of sample). The Tushpa, Dolores and Macholulo varieties presented the highest values of polyphenols (646.33 - 516.25 - 518.59 mg gallic acid /100 g), the same ones that correlate with the highest concentration of anthocyanins.

INTRODUCTION

The greatest genetic diversity of wild and cultivated potatoes is found in the highlands of the Andes. In Ecuador, the native potato ecotypes are in a critical situation, both on the supply and demand sides. Native potato varieties (Solanum phureja.) that have been maintained and conserved for generations are in danger of extinction (5, 24).

For the countries of the Andean area, especially for Ecuador, native potato varieties are products with interesting commercial potential. Due to the globalization of markets, differentiation is an opportune strategy to be able to compete. Native potatoes are different from improved varieties in color, flavor, shape, and possibly nutritional content and quality. The high Andean communities that have preserved this cultural legacy now have the possibility of entering urban and modern markets, both local and international (2, 8).

Ecuadorian native potatoes have a diversity of shapes, colors and sizes. There are potatoes with yellow, red, pink or purple skin; of flattened, round, compressed, elongated shapes, with deep eyes, which in some cases are combined in colorful and original designs (1, 24).

The pink, red, blue, mauve and violet colors of certain vegetables are due to the presence of anthocyanins (12). In general, anthocyanins are found in the skin of vegetables; but they are also usually found in the fleshy portion of certain varieties (10). Anthocyanins belong to a huge group of compounds called polyphenols, of which flavonoids, present in certain purple and red plant foods, act as antioxidants, protecting the human body from the damaging effect of free radicals (8, 15).

The antioxidant micronutrients, anthocyanins, carotenoids, vitamin C and polyphenols, play a very important role in the defense against cancer, in whose prevention diet plays an important role (15).

MATERIALS AND METHODS

The varieties used were provided by the National Program of Andean Roots and Tubers – Potato Category (INIAP).

MORPHOLOGICAL CHARACTERIZATION

Tuber size, skin color and pulp, main and secondary tubers: They were carried out according to the descriptors of the International Potato Center, CIP (17).

PHYSICAL CHARACTERIZATION

- specific gravity According to Archimedes' principle, Alvarado 1996 (6).
- Internal texture of the whole tuber. The necessary pressure is measured, in kgf, to force a plunger (diameter 7.98 mm) into the pulp of the tuber, using a manual Fruit Pressure Tester FT 327, Durán, 2001 (14).
- Cooking time: The whole tubers were submerged in water in a ratio of 1:2, samples were taken every five minutes to determine the appropriate texture for consumption.
- Sprouting in storage: The tubers were stored at 16º and 55% RH, recording the growth of the shoots every seven days, Casantes, 1970 (16).

ACCEPTABILITY LEVEL

It was evaluated through consumer-oriented tests, with 20 untrained tasters from the Santa Catalina Experimental Station, INIAP, who were given whole cooked potatoes.

A 5-point hedonic scale was used where the expected value corresponds to 1 (I like it very much).

For data analysis, a complete randomized block design was used. For significant ecotypes, the 5% Least Significant Difference (LMD) test was used.

CHEMICAL CHARACTERIZATION

- Humidity: In an oven at atmospheric pressure. AOAC Method No. 925.09 (18)
- Fat: In a Goldfish equipment with 1 to 2 grams of sample.AOAC Method No. 920.39C. (18)
- Protein: By Micro Kjeldahl in 0.04 g of homogeneous sample. AOAC Method No. 920.87. (18)
- Crude fiber: AOAC Method No. 925.09. (18)
- Ash: By calcination in a muffle at 600º C.,AOAC Method No. 923.03. (18)
- **Minerals:**It was determined by atomic absorption spectrophotometry in a Shimadzu AA-680 Spectrophotometer with flame atomizer. Phosphorus was determined on a Spectronic 20D Photocolorimeter.
- **Amino acids:** By high performance liquid chromatography, SHIMADZU HPLC Equipment. The amino acids of the hydrolyzed proteins are recovered in citrate buffer pH 2.2 and injected into the HPLC. The different amino acids are separated according to the pH, in basic acid buffer solutions. Method adapted in the Department of Nutrition and Quality.
- **Amylose:**It was determined by the spectrophotometric method based on the formation of an I2 / KI complex, whose absorbance is read at 620 nm. The Shimadzu UVVIS 2201 Spectrophotometer was used and the Marrison and Laignelet Method (2000) was applied.
- Amylopectin: By difference, between the starch content (100%) and the amylose content
- **Size and microscopic appearance of starch granules:**Granule size was determined through measurements of the diameter of the major and minor

axes in 10 granules (19). The form of the starches was determined by observations in a Nikon HFX-DX microscope, with 4x, 10x and 20x magnification.

- **Amylographic behavior:**The rheological properties of the starch samples are recorded in a Brabender viscoamylograph (OHG Duisburg, Germany). 5% starch suspensions (dry basis) are transferred to the amylograph container. The suspensions are heated from 25ºC to 89ºC, at a rate of 1.5ºC per minute, maintained at 89ºC for 20 minutes, and then cooled at a rate of 1.5ºC per minute, to 55ºC, maintaining this temperature. for 20 min. Ruales and Nair method, 1994, (36)

- **Reducing sugars**: Spectrophotometric method The sample is treated fresh with 80% ethyl alcohol, picric acid is used, which will react with the reducing sugars, forming an intensely colored picramate that is read in the spectrophotometer at 510 nm, according to the Spectrophotometric method. Smith, (21).

FUNCTIONAL CHARACTERIZATION

This characterization was carried out on the purple, red and intense yellow pulp and/or peel varieties.

- **Ascorbic Acid Content (Vitamin C):**It was determined in fresh tubers, using an RQ flex 16970 Reflectometer. MERCK reflectometric method.

- **-Total carotenes:**They are determined spectrophotometrically at 450 nm on a Shimadzu UVVIS 2201 Spectrophotometer, based on the extinction coefficient (E1%) of carotenes in petroleum ether. Method adapted by Rodríguez et al., (2004).

- **Anthocyanins:**The determination of the pigments (anthocyanins) is made with an extract of acidified n-amyl alcohol, by means of absorbance readings at 544 nm, which corresponds to the maximum absorption spectrum of the pigments.

- **Total polyphenols:** These components are determined by spectrophotometry at 765 nm. (18).

STATISTIC ANALYSIS

For the physical, chemical and functional characterization, a complete random design was applied, with 3 observations. For significant treatments, the 5% DMS test (minimum significant difference) was applied. The program was used*Statgraphics Plus*, Version 4.0, 1994-1999 by Statistical Graphics Corp, USA., with which the Coefficient of Variation (CV) was determined in percentage, average value and standard deviation.

RESULTS AND DISCUSSION

MORPHOLOGICAL CHARACTERIZATION

SKIN COLOR

According to Coultate (1984), the pink, red, blue, mauve and violet colors of certain vegetables are due to the presence of anthocyanins that make up the group of polyphenols.

Based on the CIP Color Table, it was determined that seven varieties (Chaucha Amarilla, Chihuila Blanca, Chivolulo, Coneja Blanca, Leona Blanca, Quillu and Yema de Huevo) presented yellow skin, without secondary color.

Three varieties presented yellow skin, with the presence of secondary colors, with scattered red spots in the Moronga cultivar and scattered red-purple spots in the Ovaleña and Uvilla varieties.

The Dolores and Calvache varieties

presented reddish skin without secondary colors, while the Chaucha holandesa cultivar characterized cream pigmented eyebrows.

They characterized five varieties with purple skin, four with creamy white secondary colors, with spots around the eyes in Carrizo and with scattered spots in Huagrasinga; Leona Negra with cream pigmented eyebrows and Macholulo with intense purple flecks. While the Tushpa variety did not present secondary color.

Two varieties had black skin with secondary colors, with yellow spots, around the eyes in Black Rabbit, and with cream-pigmented eyebrows in Puña. Milagrosa and Orupiña presented pink skin without secondary colors. The cultivar Sta. Rosa had creamy white skin with no secondary color; while the Violet variety with pale yellow skin color, with pale red-purple spots around the eyes.

Based on the color descriptor, the varieties were selected: Chaucha Holandesa, Moronga, Milagrosa, Coneja Negra, Carrizo, Calvache, Puña, Huagrasinga, Dolores and Macholulo, for the determination of polyphenols and anthocyanins.

PULP COLOUR

According to this descriptor and the color of the skin, the varieties that could be suitable for the preparation of potato flakes or "chips" differentiated with purple or lilac colors are: Leona Negra, Uvilla, Puña, Carrizo and Tushpa; the Chaucha Amarilla variety is suitable for making chips with an intense yellow color and the rest could be used for making chips with light yellow colors.

Of the materials under study, nine varieties presented light yellow pulp; seven cultivars without secondary color (Calvache, Chaucha Holandesa, Chihuila Blanca, Dolores, Leona Blanca, Milagrosa, Violeta), and two with sparse purple spots (Leona Negra and Uvilla). Four varieties presented cream flesh, three without secondary color (Chivolulo, Orupiña and Sta. Rosa) and one with sparse purple spots (Puña).

Four varieties presented white flesh, three without secondary color (Coneja Blanca, Coneja Negra and Huagrasinga), and one with scattered lilac spots (Carrizo).

One variety (Macholulo) had creamy white flesh with no secondary color. While Moronga, Ovaleña, Quillu and Egg Yolk, presented yellow pulp without secondary color. The Chaucha Amarilla variety presented intense yellow pulp and finallythe Tushpa cultivar had purple pulp with scattered spots and white pith.

This descriptor, as well as the one referring to the color of the skin, helped for the selection of varieties to be characterized from the functional point of view, thus the Tuhspa ecotype was selected, to determine the content of anthocyanins and polyphenols; Ovaleña, Quillu, Egg Yolk and Yellow Chaucha, for carotene analysis.

TUBER SHAPE

Of the varieties under study, ten had round tubers (Dolores, Huagrasinga, Orupiña, Ovaleña, Puña, Quillu, Tushpa, Uvilla, Yema de Huevo and Violeta), five were oblong (Carrizo, Coneja Negra, Leona Blanca, Leona Negra and Moronga), one compressed (Miraculous), four are elongated tubers (Calvache, Coneja Blanca, Chivolulo and Sta. Rosa). The Chaucha Amarilla and Chaucha Holandesa varieties presented elongated oblong tubers; Machululo is an elongated elliptic cultivar, while Chihuila Blanca has an unusual or rare tuberosate shape.The round varieties are appropriate for the preparation of chips; while the oblong and elongated ones are suitable for the preparation of sticks.

The general or rare shape of the tuber is related to the soil factor, as indicated by Alarcón and cited by Escobar (1997).

SIZE AND WEIGHT

The appropriate size to make potato flakes or "chips" fluctuates between 4 and 6 cm long, corresponding to the intermediate axis (equator line of the tuber) (26), for which the varieties could be used: Carrizo, Leona Negra, Chihuila Blanca, Chacha Amarilla, Ovaleña, Orupiña, Sta. Rosa, Macholulo and Violeta For French fries, elongated tubers of 6 cm or more (26) are preferred, such as Chaucha Holandesa, Chivolulo, Coneja, Ovaleña, Orupiña, Sta Rosa and Macholulo.

Depending on the weight, tubers are considered small, between 20 and 40 grams, medium between 41 and 60 grams; large between 61 and 90 grams and very large those whose weights exceed 91 grams (2).

The Milagrosa, Ovaleña, Orupiña, Sta. Rosa, Macholulo, Chaucha Amarilla and Violeta varieties were framed within the "very large" category, with an average weight of 168.46 g, which was correlated with the measurements of the largest diameter and minor. Coneja Blanca, Moronga, Carrizo, Tushpa, Huagrasinga, Leona Negra, Chihuila Blanca, Quillu and Calvache tubers with an average maximum weight of 114.98 g, were placed in the category of large tubers, with a diameter greater than 65.06 mm and less than 38.14mm.

The Puña Chaucha Holandesa and Chivolulo varieties were framed within the medium category, with an average weight of 52.68 g. The Coneja Negra, Leona Blanca, Uvilla and Egg Yolk tubers with a maximum average weight of 38.84 g, were placed in the category of small tubers, which corresponded to a diameter greater than 50.83 mm and less than 33, 21mm. In general, the native varieties presented heterogeneous tubers in size and weight.

DEPTH OF EYES

The depth of the "eyes" in native tubers is a variable characteristic, but it is important for agro-industrial processing and can influence pulp losses by peeling. Another characteristic to be considered for this purpose is the thickness of the shell (26).

From the above, the Milagrosa and Chihuila Blanca varieties would present considerable pulp losses during the peeling operation, since they show deep eyes; however, both varieties have a very thin skin, so peeling could be an optional activity. Of the remaining varieties, 14 presented medium eyes and eight, superficial eyes.

PHYSICAL CHARACTERIZATION

SPECIFIC GRAVITY (GE)

It was found that the maximum value of specific gravity (1.11a) corresponded to the varieties: Chaucha Amarilla and Calvache; followed by the varieties Sta. Rosa, Coneja Blanca, Violeta, with an average value of 1.10; Carrizo and Dolores with an average value of 1.09, the same ones that turned out to be higher than the specific gravity of the Super Chola control (1.07); while the lowest value of this parameter corresponded to the Leona Blanca ecotype. This last value (1.09) was similar to that reported by Alvarado, 1996 (6).

Because specific gravity correlates with dry matter content, varieties with a higher value of this parameter are desirable, as they provide a 1% increase in flake or chip yield for every 0.005 increase in gravity. specific (26).

INTERNAL TEXTURE

Four varieties (Calvache, Uvilla, Chaucha Amarilla and Chaucha Holandesa) presented internal texture values between 7.0 and 7.9 kgf; six (Puña, Egg Yolk, Moronga, Leona Negra, Sta. Rosa and Coneja Blanca) reached values between 8.0 and 8.9 kgf, with lower resistance to penetration and greater pulp softness.

The varieties with a harder internal texture (11-12.23 Kgf) and that would require more

cooking time are: Chihuila Blanca, Violeta, Ovaleña, Macholulo and Tushpa.

COOKING TIME

Cooking time was monitored every five minutes, from the start of boiling, until the tuber presented a suitable texture for consumption.

This parameter varied for the different materials under study from 20 to 55 minutes. The varieties with the greatest ease of cooking were found to be Dutch Chaucha, Black Rabbit and Egg Yolk.

The varieties that required a longer cooking time (50 and 55 min.) were those of the large category, with a larger diameter of 78.60 mm, a smaller diameter of 45.65 mm, and an average weight of 120.24 g. This parameter is important, since it represents a savingfuel and preparation time.

SPROUTING IN STORAGE

This is an indicative parameter of the average durability for consumption. The Chaucha Amarilla, Chaucha Holandesa, Yema de Huevo and Sta. Rosa varieties begin the sprouting process in the first week of storage, while the Chivolulo, Moronga and Tushpa varieties begin their sprouting from the ninth week.

ACCEPTABILITY LEVEL

Size: The varieties that the panelists liked the most due to their size were: Orupiña, Super Chola, Sta. Rosa, Coneja Negra, Ovaleña and Yema de Huevo, with average scores of less than 2, ranking in ranges a and b. In preference for size, it is followed by the varieties: Chaucha Holandesa, Tushpa, Violeta, Chihuila Blanca, Moronga, Quillu, Chivolulo and Calvache bc. The Uvilla variety, with an average rating of 3.5f, was the least liked by the panelists. The panelists showed a preference for medium-sized varieties

Form: The preference of the panelists for the control Super Chola was verified, with an average acceptance of 1.65a. In order of preference, Super Chola was followed by the following varieties: Sta. Rosa (compressed form), Coneja Negra (oblong) and Milagrosa (compressed), with an average rating equal to 1.70b.

The round-shaped varieties that were located in the bc range were: Egg Yolk, with an average score equal to 1.85; Orupiña, Ovaleña and Violeta, with average grades equal to 1.95.

The rare shape of the tubers influenced their acceptance by the panelists, since the Chihuila Blanca variety (rare tuberous form) reached an average score of 2.55 points, on the 5-point hedonic scale, the remaining varieties, with shapes Normal students reached average grades between 1.70 and 3.5.

The Uvilla (round shape) and Macholulo (elongated elliptical) varieties were located in the last level of preference in terms of size and shape attributes.

Skin color: The most preferred varieties in this attribute were: Milagrosa (pink color) and Egg Yolk (yellow color), with average scores equal to 1.60a. A similar level of preference was reached by the varieties: Coneja Blanca (yellow), Orupiña (pink) and Violeta (pale yellow).

Among the eight varieties that the panelists liked least (highest score 3) are Coneja and Leona Negra, with dark skin colors tending to black; like the Macholulo, Huagrasinga, Tushpa varieties, with purple skin; Moronga (yellow with scattered red spots), Calvache (red skin) and Chaucha Holandesa (red skin with cream pigmented eyebrows).

In general, the panelists preferred the yellow varieties without the presence of purple or red colors in the skin

Pulp color: The panelists liked the pulp color of the cultivars: Milagrosa (yellow pulp), Ovaleña (yellow), Chaucha Amarilla

(intense yellow), with average grades between 1.2a and 1.45b, over a maximum value of five points.

The varieties that the panelists liked least were those with pale colors: light yellow in Chaucha Holandesa and cream in Sta. Rosa; with scores between 3.75 and 3.90, respectively; Tushpa's 3.85-rated deep purple varieties were equally disliked.

Flavor: The varieties: Chaucha Amarillaa, Violetab, Milagrosabc, are framed in the category "I like it a lot", with an average score of less than 2.

In general, the native varieties reached greater acceptance in flavor compared to the control.

The taste of the majority of the varieties (17) was placed in the "I like it moderately" category, with scores between 2 and 3 points. The varieties Leona Blanca, Leona Negra and the commercial control Super Chola, were framed in the category "Neither like nor dislike".

Texture: The cultivar that the panelists liked the most in the texture attribute was Chaucha Amarilla, with an average score of 1.45a. The varieties Violeta, Orupiña and Coneja Blanca followed in acceptance, with average scores between 1.80 and 2.00, on the 5-point hedonic scale; where the expected or desirable condition corresponds to <lower is better>.

The varieties Sta. Rosa and Chaucha Holandesa obtained the least acceptance, with a rating equal to 3.30g.

CHEMICAL CHARACTERIZATION

DRY MATERIAL

The varieties Moronga, Calvache, Coneja Negra, Leona Negra and Coneja Blanca, presented dry matter contents higher than 25 %; Most of the materials evaluated (Table 1), presented values between 20.80 and 24.42 %, adequate levels to obtain good yields in the production of snacks (30).

FIBER

Crude fiber values of native potatoes ranged from 1.90 % for the Quillu ecotype to 6.07 % for Chaucha Holandesa, with an average value of 3.50 %; the control Super Chola, presented a value of 2.50 %.

The maximum fiber value found in the Chaucha Holandesa variety supplies 24.28% of the daily requirement of the recommended daily dietary ration according to Gómez, 2001 (8), while the average content supplies 14% of the daily requirement. (Table 2).

FAT

Lipids represent less than 1% of the dry weight in potatoes (3) and their contribution is not considered important in relation to the daily requirement. The range of variation detected was 0.24% for the Calvache variety and 0.68% for Quillu; the control Super Chola presented an average value of 0.38%.

	ecotypes	Humidity (%)			Dry material (%)		
		Medium			Medium		
1	bald head	74,25	±	0,14	25,75	±	0,14
2	Reed	76,04	±	0,38	23,96	±	0,38
3	Yellow Bean	75,85	±	0,49	24,15	±	0,49
4	dutch chaucha	77,52	±	0,14	22,48	±	0,14
5	Chihuila	75,58	±	1,20	24,42	±	1,20
6	white rabbit	72,68	±	0,10	27,32	±	0,10
7	black rabbit	73,42	±	0,19	26,58	±	0,19
8	huagrasinga	77,43	±	2,14	22,57	±	2,14
9	black lioness	72,78	±	0,22	27,22	±	0,22
10	miraculous	79,20	±	0,31	20,80	±	0,31
11	Moronga	74,58	±	0,90	25,42	±	0,90
12	orupina	79,11	±	0,67	20,89	±	0,67
13	oval	75,79	±	1,01	24,21	±	1,01
14	Puna	77,51	±	0,28	22,49	±	0,28
15	quillu	79,10	±	1,13	20,90	±	1,13
16	St. Rose	76,22	±	0,25	23,78	±	0,25
17	Super Chola*	75,36	±	0,49	24,64	±	0,49
18	gooseberry	76,01	±	0,45	23,99	±	0,45
19	Egg Yolks	77,42	±	0,09	22,58	±	0,09

n=3 ; * Witness

Table 1. Moisture content and dry matter in native potatoes

nutrient	recommended daily servingss*	Content in 100 g sample, dry basis**	Contribution of the nutrient
Energy (kcal)	2500	398,56	15,94%
		340,88	13,64%
Protein (g)	80	10,62	13,28%
		5,59	6,99%
Fiber (g)	25	6,07	24,28%
		1,90	7,60%
Fat	50	0,68	1,36%
		0,24	0,48%
Carbohydrates (g)	325	87,49	26,92%
		79,09	24,34%

Table 2. Contribution of nutrients of native potatoes, in relation to the recommended daily rations

* Source: Gomez., (2001) and Gallo, (1997)

**Maximum and minimum values

PROTEIN

Due to its low concentration, the potato does not constitute a notable contribution of this nutrient in the diet, however the annual per capita consumption that fluctuates between 122 kg in Quito and 50 kg in Guayaquil, raises the importance of the potato as a source of this nutrient.

The average value of protein was 7.98 %, the values fluctuated between 5.59 % for the Ovaleña variety and 10.62 % for Sta. Rosa, this last value is higher than the average found in the control variety Super Chola (8.48 %) and supplies 13.28 % of the recommended daily requirement (Table 2).

This parameter is inversely correlated with the attribute "flavor", since the Sta. Rosa, Carrizo, Chaucha Holandesa and Huagrasinga varieties, with higher protein contents, reached a lower level of acceptance in sensory tests.

AMINO ACIDS

The results of the chemical computation of the protein indicate that it is biologically incomplete, that is to say that it contains a lower quantity of essential amino acids than the reference standard. In no variety was the presence of the essential amino acid tryptophan detected.

ASH

The amount of ash is an indication of the amount of minerals present in a food product. The average value was 4.07%; the values varied between 3.34% for the Coneja Blanca variety and 4.79% for the Calvache variety, this last value exceeded the control Super Chola (4.15%).

MINERALS

Regarding the calcium content, the varieties Carrizo, Chaucha Holandesa, Coneja Blanca, Coneja Negra, Leona Negra, Milagrosa, Puña and Sta. Rosa, showed values between 3 and 42 mg/100 g. The remaining 13 varieties presented values between 10.00 and 25.67 mg/100 g and the Super Chola variety (control) presented a calcium content of 15.33 mg/100 g.

Table 3 shows that the maximum value of the calcium content (40 mg / 100 g), in the cultivar Sta. Rosa, supplies 8.40 % of the recommended daily dietary allowance of this mineral.

The magnesium content of the varieties: Chaucha Amarilla, Dolores, Chaucha Holandesa, Leona Negra, Carrizo, Calvache, Coneja Negra, Uvilla, Huagrasinga, Moronga, Puña, Macholulo and Chihuila Blanca, varied between 80.00 and 115.00 mg / 100 g., this last value corresponding to the Chaucha Amarilla variety, covers 38.33% of the recommended daily ratio.

The potassium content of the varieties: Carrizo, Chaucha Holandesa, Coneja Negra, Dolores, Leona Negra, Macholulo and Sta. Rosa, with values between 1693.00 and 2103.33 mg/100 g, exceeded the average value of the majority of fruits and vegetables (200 mg/100 g) (6). The control Super Chola registered a

potassium content equal to 1731.00 mg/100 g, while the cultivar Chaucha Holandesa with 2103.33 mg/100 g, contributes with 52.58 % of the daily requirement.

For phosphorus, the Carrizo variety presented a higher content (265.00 mg/100 g) than the control variety Super Chola (251.00 mg/100 g); following in quantitative importance the Dolores variety with 230.00 mg/100 g. The phosphorus contribution of the Carrizo variety supplies 38.33% of the recommended daily ration of this mineral.

minerals	Recommended daily requirement*	Content in 100 g dry base sample**	Contribution of the mineral per 100 g of potato
Calcium (e)	500	42,00	8,40%
		10,00	2,00%
Magnesium(e)	300	115,00	38,33%
		60,00	20,00%
Potassium (mg)	4000	2103,33	52,58%
		1516,67	37,92%
Phosphorus (mg)	800	265,00	33,13%
		110,33	13,79%
Sodium (mg)	2500	59,33	2,37%
		10,00	0,40%
Copper (mg)	1,7	0,80	47,06%
		0,16	9,41%
Iron (mg)	10	16,47	164,70%
		2,63	26,30%
Manganese (mg)	1875	2,00	0,11%
		0,34	0,02%
Zinc (mg)	15	5,10	34,00%
		0,84	5,60%

Table 3. Contribution of minerals of native potatoes in relation to the recommended daily requirements

* Source: Gomez., (2001) and Gallo, (1997)

**Maximum and minimum values

The amount of iron present in the potato is notable, especially in the black rabbit variety (16.47 mg/100 g), which covers the entire iron requirement of the human organism.

STARCH GRANULE SIZE AND MICROSCOPIC APPEARANCE.

Starch appears under the microscope, composed of tiny individual structures called "granules", whose size and shape are characteristic of each species (8).

The starch granules of the Puña variety and the Super Chola control are larger (50.42 and 50.64 um) than the granules of the other 10 native potato varieties. Some fundamental properties of starches, such as their higher water absorption index and water solubility index, are related to the larger size of their granules (11) (Table 4).

	Ecotype	MAJOR DIAMETER (µm)				MINOR DIAMETER (µm)		
		Medium			DMS Range	Medium		
1	dutch chaucha	26,34	±	4,64	d	18,23	±	2,27
2	Reed	31,19	±	8,83	cd	20,03	±	3,84
3	black lioness	33,21	±	5,52	c	23,22	±	3,54
4	white rabbit	35,58	±	2,96	c	23,48	±	2,13
5	Yolk	36,00	±	7,09	c	22,17	±	2,98
6	black rabbit	38,20	±	7,35	c	23,91	±	3,60
7	Puna	44,36	±	7,63	b	25,36	±	5,12
8	Super Chola (Witness)	44,62	±	5,44	b	25,75	±	2,95
9	Coneja Negra	46,67	±	6,95	ab	24,70	±	3,24
10	Puña	50,42	±	6,71	a	30,37	±	4,80
11	Super Chola (Testigo)	50,64	±	12,60	a	31,70	±	7,57

n=10

Table 4. Size and shape of starch granules

The starch granules of the native potato ecotypes and the control presented oval shapes.

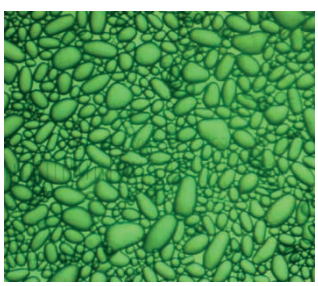

Photo Nº 1. Microscopic appearance of the starch of the native potato variety "Coneja Negra"

AMYLOGRAPHIC BEHAVIOR

In the viscosity curves obtained with the Brabender amylograph in a 5% starch suspension (Figure 1), differences are observed in the gelatinization temperatures and maximum viscosity of the starches. The Coneja Blanca, Sta. Rosa, Coneja Negra,

Carrizo, Chaucha Holandesa and Uvilla varieties show gelatinization temperatures of 63°C to 68°C, with a maximum viscosity (Vm) below 1570 UB, which indicates that the grade of association of its molecules is greater than that of the starch of other ecotypes (18), likewise they have less ease of cooking (between 11 and 19 minutes).

The starches whose gelatinization temperatures fluctuated between 61º and 64º C, require less heat to reach their gelatinization, a condition in which the hydrogen bonds of the intermolecular zones of the amorphous zones are broken and the absorption of a greater quantity continues. water (11).

The ease of cooking of the starch of the Puña variety (9 min.) allows us to recommend its use in the preparation of formulations where the development of a rapid viscosity is required. Depending on the ease of cooking the Puña variety, followed by the Chaucha Holandesa (11 min.), Calvache (13 min.), Coneja Negra (13 min.) and Leona Negra (11 min.) varieties, with values close to of the control Super Chola (9 min.), and lower than the starch of the ecotypes Sta. Rosa (20 min.), Egg Yolk (19 min.), Reed (14 min.) and White Rabbit (19 min.).

Contrast the stability of the gel of the Sta. Rosa variety (30 UB) with theinstability of the gels of the other ecotypes under study and even of the control Super Chola (1340 BU), being the Puña ecotype (1350 BU) the most unstable among them. Also noteworthy is the high gelling index of the starches from Sta. Rosa (430 UB) and Carrizo (340 UB); in contrast to the lower gelling index of the Uvilla (180 UB) and Coneja Blanca (180 UB) starches.

Figure 1 shows that the starches from Puña and the control Super Chola have higher maximum viscosity. When starches are cooked in water

its granules swell enormously, thus a high peak is observed on the amylogram, followed by rapid and further weakening during firing. The starch behavior of these varieties is correlated with their larger granule size (50.42 um).

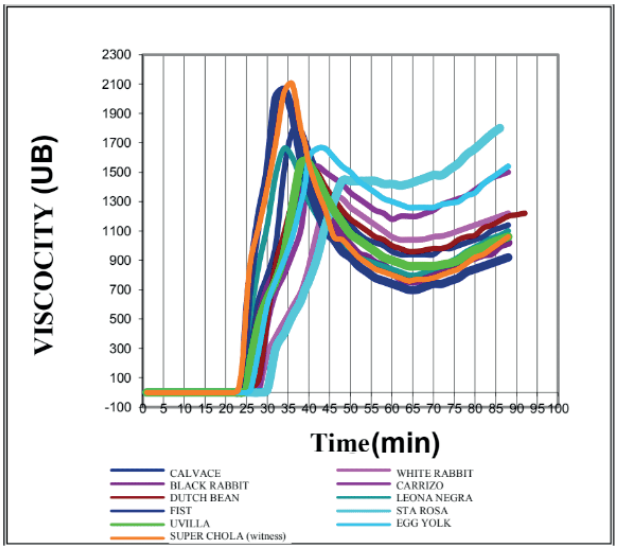

Figure 1.Amylographic behavior of native potato starches

The starches of the remaining varieties showed a moderate swelling power, for which the paste peak is lower and the weakening during cooling is less, since their granules do not swell excessively to reach brittleness.

The Leona Negra, Yema de Huevo, Calvache and Puña varieties showed gelatinization temperatures between 63°C and 68°C, with a maximum viscosity (Vm.) below 2070 UB. At 89°C, the starches of Super Chola, Calvache, Leona Negra and Puña present a similar behavior; when they are stirred for 20 minutes, they considerably lose their stability, decreasing their viscosity, which indicates that all of them are weak starches to mechanical agitation when they are at high temperatures.

After cooling the paste to 55°C, no apparent variation in the viscosity of the suspension is observed for the starches of the different varieties, with the exception of Sta. Rosa, Carrizo and Egg Yolk, whose viscosity tends to rise after cooling. cooling.

In general, it was observed that the starches with the highest maximum viscosity have higher amylose contents, with the exception of the Puña variety, whose amylographic behavior may be influenced by the higher protein content and lower starch content in relation to the control Super Chola.

The physicochemical characteristics of native starches are largely responsible for the physical and chemical modifications experienced by these polymers subjected to various process conditions.

The water absorption capacity and the gelatinization temperature are specific characteristics of each starch and depend on various factors such as the size of the granules, the amylose/amylopectin ratio, intra and intermolecular forces, among others (45).

Starches with maximum viscosity can be used for processes to obtain expanded products, while those with less resistance to temperature increase can be used to make tortillas or products that do not require extensible dough.

Amylose –amylopectin: The varieties with the highest amylose content were Chaucha Amarilla, Carrizo and Chihuila Blanca, whose average values (36.81; 36.79; 35.68%) were located in ranges a and b, the remaining varieties presented lower values. to 34.49%.

Some particular properties of the starch of the Sta. Rosa and Egg Yolk varieties, such as its higher amylose content and viscosity, can be used for various processes such as extrusion.

CHARACTERIZATION FUNCTIONAL

Ascorbic acid: The value found for the Uvilla variety (26.22 mg/100 g) is higher than that reported for the potato (18 mg/100 g) by Verdú (2005). This value is similar to the value reported by Sañaicela, (2007), for the purple tree tomato (28 mg / 100 g) (39).

The average value found in Puña exceeds the control Super Chola (19.62 mg / 100 g). However, in other materials such as Carrizo, Chaucha Holandesa and Calvache, the average values were 9.60; 9.37 and 7.67 mg/100 g, respectively.

According to the recommended daily dietary allowance of vitamin C (50 mg / 100 g) (14), native potatoes could contribute to the daily requirement of this vitamin from 15 % (7.67 mg / 100 g, Calvache) up to 50% (26.22 mg/100 g, Uvilla); however, the loss of it due to cooking processes must be considered, which can vary between 30% in frying to 45% in open pot cooking. Also during storage, the loss of vitamin C can reach between 50 and 60% from the third month (9,27).

Total Carotenes: The highest values corresponded to the Chaucha Amarilla variety (11.38 ug/g of sample), with deep yellow pulp, followed by the Quillu variety (10.03 ug/g of sample). The varieties analyzed presented lower carotene contents, including the control Super Chola (5.40 ug / g of sample).

The concentration of carotenes in native potatoes is ten times lower than that reported for vegetables such as yellow carrots, which have a content of 100 ug/g of edible portion, Will, 1998.

Anthocyanins: According to the Minimum Significant Difference test at 5%, in the first statistical range (a), the Tushpa variety (0.42 nm) was located, with a purple pulp. Followed by the varieties: Dolores (0.37 nm) with red skin; Puña (0.36 nm), Machululo (0.29 nm) and Huagrasinga (0.24 nm) with purple skin; Red-skinned Calvache (0.20 nm), Black Rabbit, purple-skinned (0.18 nm), Reddish-skinned Miraculous (0.18 nm), Reed, purple-skinned (0.14 nm), and Super Chola, reddish-skinned (0.14 nm)

The lower values corresponded to the varieties that presented red or purple

pigmentation as a secondary color; among these it is mentioned a: Dutch chaucha with reddish skin and cream pigmented eyebrows. The maximum value of anthocyanins determined in the native cultivar Tushpa (0.42 nm) is similar to that reported by Calderón, 2002 (40), for commercial cocoa from Chone (0.52 nm) and 31 % lower than that reported for commercial cocoa. from the town of Ventanas (1.35 nm),

Polyphenols: The Tushpa, Dolores and Macholulo varieties presented the highest values of polyphenols (646.33 - 516.25 - 518.59 mg gallic acid/100 g) (Table 5), the same ones that correlate with the highest concentration of anthocyanins.

The following varieties, Orupiña, Chaucha Holandesa, Moronga, Milagrosa, Coneja Negra, Carrizo, Ovaleña, Calvache, Puña and Huagrasinga, presented values between 144.12 and 326.02 mg gallic acid / 100 g (dry basis). The variety taken as control (Super Chola) presented the lowest value of polyphenols (71.72 mg gallic acid / 100 g).

In general, it was found that the more intense the red or purple color of the skin or pulp turns out to be, the varieties have a higher polyphenol content. However, the values found are lower in relation to those reported for cocoa 8362 mg gallic acid/100 g by Calderón, 2002.

	Variety	mg gallic acid / 100 g sample, dry basis			
		Medium			DMS Range
1	tushpa	646,33	±	10,55	a
2	pains	516,25	±	4,69	b
3	macholulo	518,593	±	9,38	b
4	huagrasinga	326,02	±	6,64	c
5	Puna	310,00	±	3,91	d
6	bald head	265,47	±	5,47	e
7	oval	273,283	±	3,91	e
8	Reed	254,143	±	2,74	f
9	black rabbit	228,36	±	5,86	g
10	miraculous	212,343	±	0,79	h
11	Moronga	180,313	±	2,35	i
12	dutch chaucha	170,157	±	7,82	j
13	orupina	144,117	±	5,54	k
14	Super Chola (Witness)	71,72	±	3,13	l

Table 5. Polyphenol content in native potato varieties

CONCLUSIONS

- Most of the native varieties under study presented round shapes (10); eyes with medium depth (14); yellow skin without secondary color (8) and light yellow flesh (9).

- The round-shaped varieties, and appropriate for the elaboration of chips are: Ovaleña and Orupiña; while the varieties of oblong and elongated shapes:Dutch Chaucha, Chivolulo, White Rabbit, Reed, Black Lion, Calvache, Yellow Chaucha, Sta. Rosa and MacholuloThey are suitable for the preparation of sticks.

- The specific gravity for the varieties under study varied between 1.11 (Chaucha Amarilla and Calvache) to 1.07 (Puña, Orupiña and Macholulo).

- In the raw state, most varieties presented internal texture values between 7 and 10.00 kgf; however, the ones that were hardest were Chihuila Blanca and Macholulo (11.00 and 12.23 kgf respectively).

- In general, the tubers, which presented texture values greater than 10 kgf, and a weight greater than 90 g, required cooking times greater than 40 min. The tubers with an average weight between 20 and 80 g, and texture values between 7 and 9 kgf, required cooking times of less than 30 min. to achieve the right texture for consumption.

- The Chaucha Amarilla, Chaucha Holandesa, Yema de Huevo and Sta. Rosa varieties begin the sprouting process after the first week of storage, while the Chivolulo, Moronga and Tushpa varieties begin their sprouting after the ninth week.

- From the sensory analysis, it can be

seen that the varieties that the panelists liked the most were those with yellow skin and pulp colors. The starch content also influenced the level of acceptability, since the varieties with a higher level, such as Chaucha Amarilla, obtained better levels of acceptability.

- Regarding mineral content, native varieties are generally rich in iron (average value: 6 mg / 100 g) and potassium (average value: 1741.00 mg / 100 g).

- The reducing sugar content of the native varieties did not exceed 0.33%, being suitable for frying processes, except the Coneja Blanca variety with 0.37%.

- According to the amylographic analysis, the starch of the Puña variety presents a high viscosity (2070 UB) and aptitude to be used in expansion processes. While the starches of the varieties that are not very resistant to temperature increases are suitable for making tortillas or products that do not require great extensibility of the dough, especially the Sta. Rosa variety.

- The Tushpa and Macholulo varieties, purple in color and less acceptable by the panelists, had the highest polyphenol content, 145.11 and 130.32 mg ac. gallic / 100 g sample, respectively.

- According to the recommended daily dietary allowance of vitamin C (50 mg / 100 g) (14), native potatoes could contribute from 15% (7.67 mg / 100 g, Calvache) to 50% (26.22 mg / 100 g, Uvilla); however, the loss in cooking processes must be considered.

- For carotene content, the highest values correspond to the Chaucha Amarilla variety (11.38 ug/g sample), followed by the Quillu variety (10.03 ug/g sample).

- The Tushpa, Dolores and Macholulo varieties presented the highest values of polyphenols (646.33 - 516.25 - 518.59 mg gallic acid / 100 g), the same ones that correlate with the highest concentration of anthocyanins.

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