



Determination of some functional and sensory attributes and suitability of colored- and noncolored-flesh potatoes for different cooking methods

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Abstract

Twenty-two colored-flesh potatoes and three commercial noncolored-flesh varieties – which were all raw as they were microwaved (800 W, 8 min) and fried (180 °C, 5 min) – were characterized in terms of functional, sensory aspects and suitability for use. Twelve genetic samples were more suitable for frying (> 20% dry matter), four for boiling (~15-18% dry matter) and nine for preparing puree or roasting (~18 to 20% dry matter). The total polyphenol content (TPC) of the raw colored-flesh potatoes contained between 1.10 to 3.68 g of gallic acid equivalent kg⁻¹ in fresh weight (FW), which was between two- and three-fold higher than the measured values in noncolored-flesh varieties. The total antioxidant capacity (TAC) was between 1.00 to 4.71 g of Trolox equivalent kg⁻¹ FW, which was also lower in noncolored-flesh potatoes. The cooking process (frying and microwave) did not affect the TPC in most of the genetic samples analyzed, but it reduced the TAC by 40-75% (fried) and 30-90% (microwaved). According to sensory evaluation results, the genetic samples R2, R19, R3 and R5 were suitable for frying, while R16, R21, R9, R15 and R22 were suitable for microwaving. Colored-flesh potatoes are an interesting alternative for consumers due to their greater phytochemical content.

Keywords: dry matter; polyphenols; antioxidant capacity; sensory evaluation.

Practical Application: Ponder the functional quality and suitability for use of colored-flesh native potatoes.

1 Introduction

The potato (*Solanum tuberosum* L.) has a world production of approximately 388 million tons, is one of the most important food crops after corn, rice and wheat, and is the food base for a sizeable percentage of the world population (Food and Agriculture Organization, 2017). The average world potato intake is between 30-40 kg per person per year. The highest consumption occurs in Eastern Europe countries, with values of up to 100 kg, and in countries located in the Andean region (origin center), with a consumption of approximately 70-80 kg per person per year (Food and Agriculture Organization, 2017). Even though the importance of potato in the diet is due to its high carbohydrate content, potatoes are also rich in minerals (potassium, phosphorous, magnesium and iron), fiber and proteins of high biological value. Additionally, potatoes provide compounds with antioxidant activity such as vitamins (C, B6 and B3), polyphenols and carotenoids (Andre et al., 2007a, b, 2014; Ezekiel et al., 2013). Due to the amount consumed, they are considered one of the main contributors of phytochemicals in the diet. Nevertheless, their overall nutritional value is still underestimated (Blessington et al., 2010; Andre et al., 2014).

Although modern commercial potato production mainly includes materials with white and/or yellow flesh and yellow or red skin, there are many other varieties of pulp and/or colored skin with nutritional characteristics of interest. These varieties are found

mainly in the Andean region, which is considered the center of origin of the potato. The potato's genetic diversity enables finding individuals with different types of ploidy (diploids to pentaploids) that manifest in the phenotype throughout differences in tuber shape and size, pulp and/or skin color, crop cycle, productivity, storage potential, suitability for use and nutritional composition (Andre et al., 2007a; Madroñero et al., 2013).

Colored-skin and/or -flesh potatoes, which are also called Andean potatoes, constitute a genetic resource with less work done in the genetic improvement area compared to noncolored potatoes. This may be due to the large number of genetic materials – approximately 200 wild species – and their great genetic variability (Soto et al., 2013). However, their characteristics, especially nutritional ones, have aroused the interest of consumers and breeders. Their nutritional characteristics are mainly associated with their richness in phenolic compounds, which are considered secondary metabolites produced by plants that include flavonoids, phenolic acids, tannins, stilbenes, coumarins and lignins. Phenolic acids such as chlorogenic, caffeic and quinic are the most abundant phenolics in potatoes, followed by flavonoids, which include the anthocyanins which are of fundamental importance in colored potatoes (Scalbert et al., 2005).

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Phenolic compounds are also associated with the sensorial quality of fresh and processed products and the prevention of cardiovascular diseases, cancer, neurodegenerative disorders, diabetes, osteoporosis, etc. (Scalbert et al., 2005; Oliveira et al., 2014).

Even though many factors – such as the dry matter content (texture), yield (economic factor) and pest resistance—are involved in the success of releasing a new potato variety to the market, it is also important to consider the suitability for use, the nutritional value and the acceptance by consumers (Leighton et al., 2010).

Unlike most vegetable foods, potatoes are not eaten raw. They are consumed prepared in different ways like cooking, baking and/or boiling. Genetic diversity, which is responsible for characteristics such as dry matter and reducing sugar content among others, also affects the quality of the elaborated product; not all genetic varieties are suitable for different types of preparation.

On the other hand, the cooking processes affect the nutrient content to some extent, as they influence the concentration and bioavailability of bioactive compounds present in potato tubers (Navarre et al., 2010; Silveira et al., 2017a; Yang et al., 2016).

Therefore, the suitability for use of different genetic varieties, the consumer preferences, and the nutritional composition of the whole and prepared product are considered valuable tools to support genetic improvement work.

The aim of this study was: a) to determine the suitability of colored-flesh potatoes considering consumer preferences; b) to make a preliminary functional characterization; c) and to evaluate the impact of the most widespread preparation methods on the functional composition.

2 Materials and methods

2.1 Potato cultivars

Twenty three native colored-flesh potatoes from the breeding program of the National Institute of Agricultural Research (INIA La Pampa, Unnamed Road, Purranque, X Región, Chile) and the noncolored commercial varieties Yagana, Pukará and Karú, which were enhanced and released by the same institute and already established in the market, were studied (Figure 1). All of the analyzed potatoes were cultivated in the INIA experimental field with the same edaphoclimatic conditions under a commercial production agronomic management. Potatoes were harvested in autumn (southern hemisphere).

2.2 Curing

Potatoes were harvested and transported to the Centro de Estudios Postcosecha (CEPOC) located in the Facultad de Ciencias Agronómicas of the Universidad de Chile (La Pintana, Santiago, Chile), which was approximately 960 km away. After they arrived, the tubers were subjected to curing treatment in a ventilated shed (average temperature of 15 °C, 85% RH) for 30 days.

2.3 Potato processing

After curing, tubers were selected, discarding those with physical and/or biological damage, and randomly divided in 6 groups of 10 tubers per genetic variety. Three of them were fried, and the remaining three were boiled in the microwave.

Potato chips were generated using tubers previously washed with tap water and brushed using a soft bristle brush to remove dirt adhered to the skin. Next, they were rinsed and placed on stainless steel mesh to eliminate surface water. Chips of 0.2 cm thickness were cut using a mandolin (Tescoma, Madrid, Spain) and immediately immersed in water to prevent oxidation. Prior to frying, water was drained and chips were centrifuged using a domestic centrifuge (Ilko, Santiago, Chile). Frying was done in a domestic fryer (Moulinex, Uno, Shanghai, China) in 180 °C sunflower oil (Belmont, Santiago, Chile) for 5 min. After frying, potatoes were placed on paper towels to absorb the excess oil.

To microwave boil, potatoes were peeled using a domestic peeler (Tescoma, Madrid, Spain) and manually cut into cubes (approximately 1 cm × 1 cm). As in the case of fried potatoes, cubes were immersed in tap water to prevent oxidation after peeling and cutting. Approximately 200 g of potatoes were placed in a 1 L beaker with 600 mL of water and microwaved (Daewoo KOG-8A2B, Barcelona, Spain) at 800 W for 8 min.

2.4 Dry matter determination

For dry matter determination 50 g of potato cubes were placed in glass Petri dishes and kept in an oven (T6, Heraeus Instruments, London, United Kingdom) at 105 °C. Weight was measured (Hinotek, FA/JA, Ningbo, China) every 24 hours until a constant value was reached. The results were expressed as percentage (%) of the initial weight. Determinations were done in triplicate.

2.5 Total Polyphenol Contents (TPC)

For the extraction, 0.5 g of frozen sample was collected and homogenized by an Ultraturrax T25 basic (T18 basic IKA Ultra-Turax, Chile) at 14,000 rpm for 2 min with 5 mL of methanol (Merck, Germany). After homogenization, samples were maintained for 1 h on an orbital shaker in the dark for further centrifugation (Hermle Z 326 K, Hermle Labortechnik, Wehingen, Germany) at 4 °C and 1,050 x g for 20 min. The supernatant was separated and reserved for determinations.

TPC was determined using the methodology proposed by Singleton & Rossi (1965) with modification. A volume of 19.2 µL of the extract was placed in ELISA plates (Jet Biofil, China) and mixed with 29 µL of 1 N Folin Ciocalteu reagent (Merck, Germany).

After 3 min, 192 µL of a mixture composed by 0.4% NaOH (Sigma, Germany) and 2% Na₂CO₃ (Sigma, Germany) was added. ELISA plates were incubated in the dark for 120 min (reaction time previously determined). Absorbance was measured in a microplate reader (UVM-340, Asis, United Kingdom) at 760 nm. The results were expressed as g of gallic acid equivalents per kg of fresh weight (g GAE kg⁻¹ FW). Measurements were performed in triplicate.

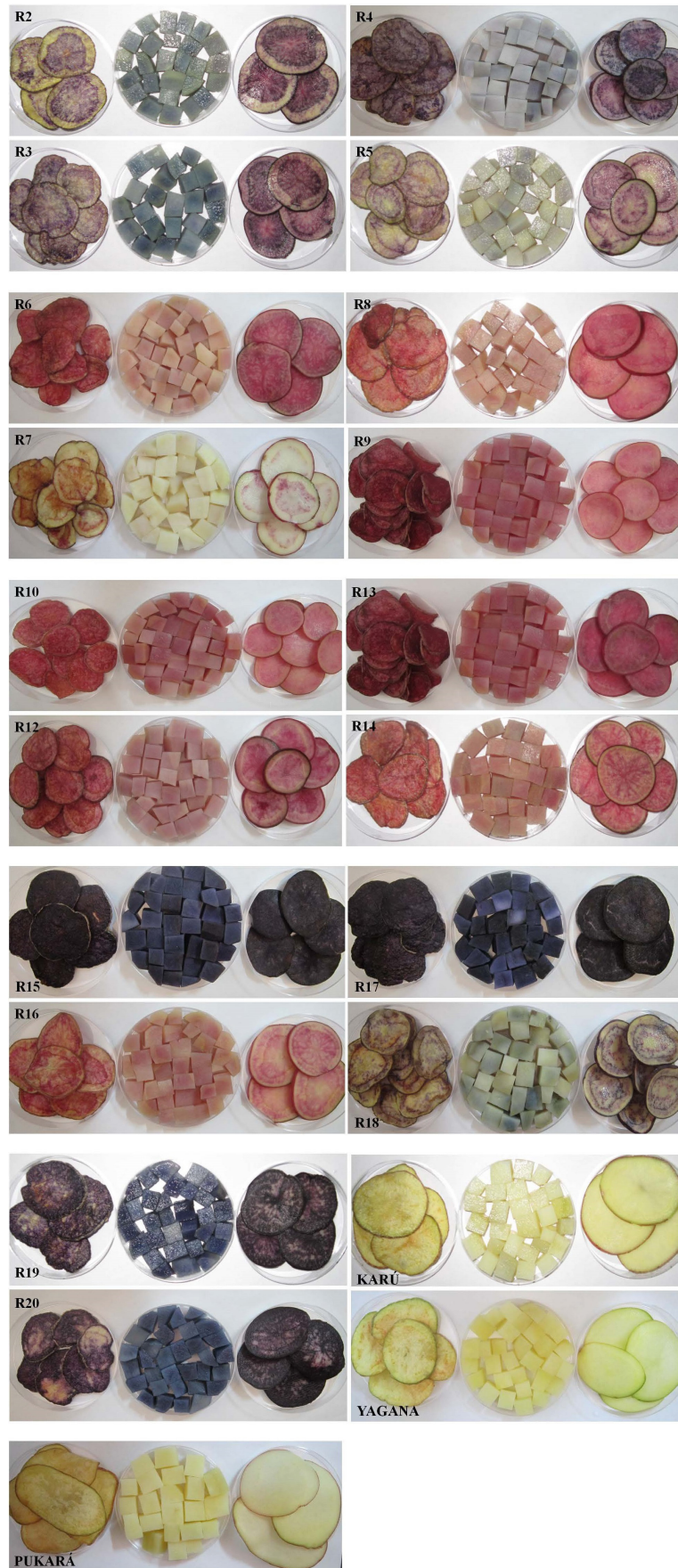


Figure 1. Fried, microwave boiled and raw genetic materials and commercial potatoes varieties.

2.6 Total Antioxidant Capacity (TAC)

Total antioxidant capacity was determined using the same extract used for TPC determination with the ferric reducing antioxidant power assay (FRAP) proposed by Benzie & Strain (1999). Determinations were made in 6 μ L of extract mixed with 198 μ L of FRAP reagent (300 mM acetate buffer pH 3.6), 10 mM of 2, 4, 6-tripyridyl-s-triazine (TPTZ) in 40 mM HCl and 20 mM ferric chloride ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) at a proportion of 10:1:1 (v/v) after an incubation period of 120 min in the dark. The wavelength used for the reading was 793 nm.

Results were expressed as g of Trolox equivalents per kg of fresh weight (g TE kg^{-1} FW). These measurements were also performed in triplicate.

2.7 Sensory evaluation

Sample preparation

Sensory evaluation was performed on 5 consecutive days at the same time (10 AM). In each instance, 5 genetic varieties were evaluated.

After frying, potato chips were placed in aluminum trays on an electric grill (Oster OS-4767, Chile) to keep them hot until the evaluation. Microwave boiled potatoes were kept in thermal boxes for the same reason.

Quality rating test

Fifteen semi-trained panelists (7 men and 8 women) between the ages of 20 and 40 participated in sensory evaluation. The sessions were conducted in insulated booths at $20 \text{ }^\circ\text{C} \pm 1 \text{ }^\circ\text{C}$. Panel members were provided with 15-20 g samples placed in white wells identified with three-digit labels and room temperature water, which served as a palate cleanser in between evaluation sessions. Samples were randomized to exclude any bias due to position effect.

Evaluation was done through a structured hedonic scale of 9 points considering different sensory attributes depending on whether the potato was fried or microwave boiled.

The descriptive attributes considered for the fried potato were: flavor (1: very bad, 5: acceptable, 9: very good), crispness (1: not very crispy, 5: acceptable; 9: very crispy); firmness (1: very soft, 5: acceptable, 9: very firm) and oiliness (1: very low, 5: acceptable, 9: very high). Sensory evaluation for microwave boiled potato considered the following descriptors: flavor (1: very bad, 5: acceptable, 9: very good), flouriness (1: cohesive or nonmealy, 5: acceptable, 9: very floury), and firmness (1: very soft; 5: acceptable; 9: very firm).

2.8 Statistical analysis

The analysis of variance (ANOVA, $p \leq 0.05$) was performed using a completely random design. All variables analyzed met the conditions of normality and homoscedasticity. Means were separated using Tukey's test. The results were reported as the mean \pm standard error of the mean. All statistical analyses were

run in Infostat version 2016 (Universidad Nacional de Córdoba, Argentina).

3 Results and discussion

3.1 Dry matter contents

The values measured in the analyzed genetic varieties ranged from 14.8% to 26.1% (Figure 2). Considering dry matter limits employed to define the suitability for use, three groups were identified. The first included potatoes with higher dry matter content with values between 20.8% and 26.1% and corresponded to varieties suitable for frying. Potatoes suitable for frying should have high dry matter content ($>20\%$) to minimize oil absorption (Cacace et al., 1994). The R18 to R15 varieties corresponded to this first group. In this group, R18 differed from Pukará, R14, R10, R7 and R22.

The second group, with medium dry matter content, included potatoes with values between 18.7% and 20%, comprising the R8 to R4 genetic varieties (Figure 2). These potatoes were considered suitable for puree and roasted potatoes (Feltran et al., 2004; Kita et al., 2015). The last group included potatoes with lower dry matter values between 14.8% and 17.7% which were suitable for boiling, and this group contained the R12, R19, R20 and R1 genetic varieties.

3.2 Total Polyphenol Contents (TPC)

The genetic varieties analyzed showed great differences in TPC. The varieties with higher values presented up to twice the TPC compared to that measured in the genetic varieties with lower values, as shown on Figure 3. The values registered on raw potato were between 1.10 and 3.68 g GAE kg^{-1} FW, which is in the range of values reported in similar works (Andre et al., 2007a; Ezekiel et al., 2013; Calliope et al., 2018; Silveira et al., 2017a, b).

The commercial noncolored potatoes Karú, Yagana and Pukará presented between 80-85% less TPC compared with the genetic variety R2 that showed the highest content.

Differences between colored- and the noncolored-flesh potatoes were also previously reported. It was mentioned that colored potatoes presented at least 2- to 3-fold more TPC than the noncolored varieties (Calliope et al., 2018; Silveira et al., 2017a, b).

Differences between TPC and TAC content associated with the potato flesh color were found. In general, purple-flesh potatoes were richer in TP while red-flesh potatoes presented higher TAC values. The same pattern was reported previously by Kita et al. (2015).

For microwave boiled potatoes, three groups were identified when considering TPC (Figure 4). In the first group, measured values were approximately 4 g GAE kg^{-1} FW, and this group included the genetic varieties R15 and R17. The second group, with values of approximately 2 g GAE kg^{-1} FW, comprised most of the genetic varieties evaluated. Finally, the third group comprised the genetic varieties with TPC values ≤ 1 g GAE kg^{-1} FW. The genetic varieties with variegated flesh and the noncolored potatoes Karú, Yagana and Pukará belonged to this group.

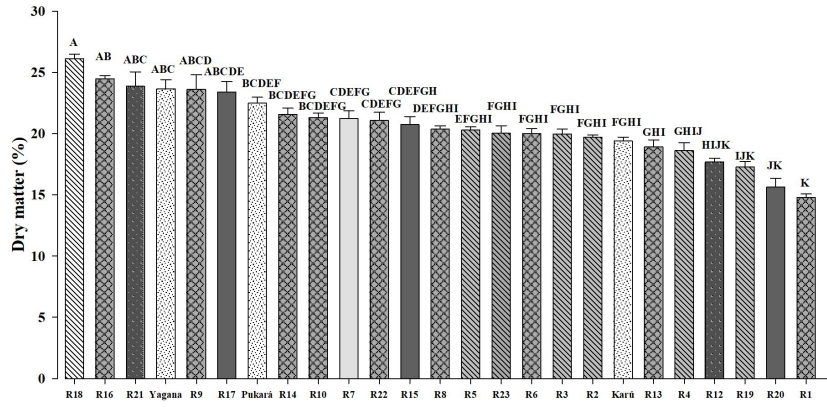


Figure 2. Dry matter (%) of raw genetic materials and commercial potatoes varieties. Means followed by different letters are statistically different according to Tukey test at $p \leq 0.05$. Vertical bars indicate the standard error of the means ($n = 3$).

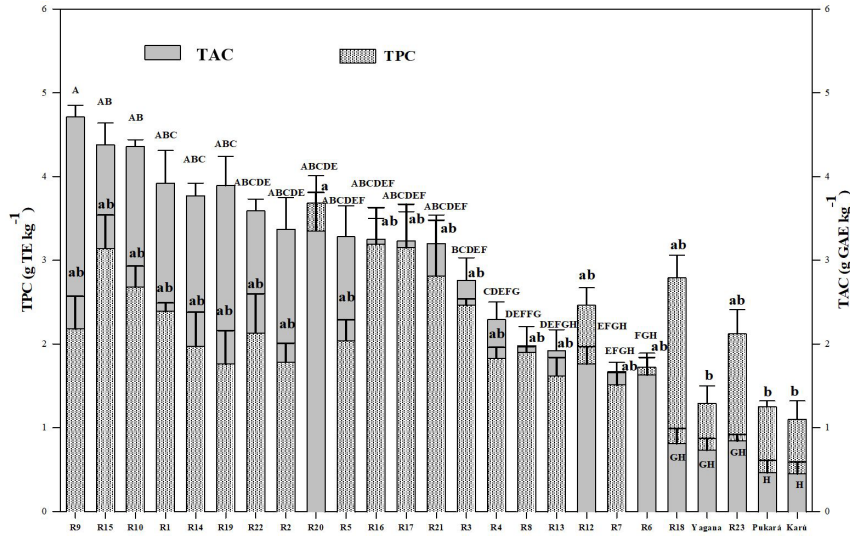


Figure 3. Total polyphenols contents (GAE g kg⁻¹) and total antioxidant capacity (TE g kg⁻¹) of raw genetics materials and commercial potatoes varieties. Means followed by different letters, uppercase (TAC) and lowercase (TPC), are statistically different according to Tukey test at $p \leq 0.05$. Vertical bars indicate the standard error of the means ($n = 3$).

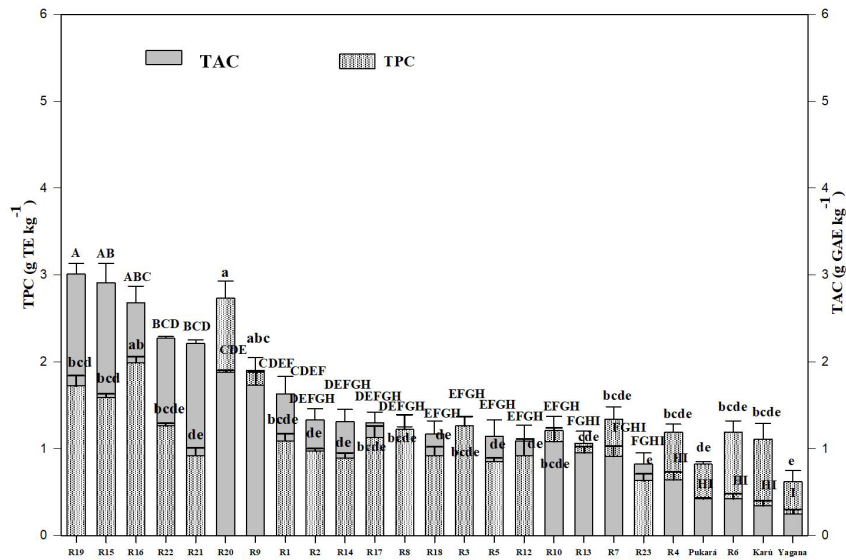


Figure 4. Total polyphenols contents (GAE g kg⁻¹) and total antioxidant capacity (TE g kg⁻¹) of microwave genetics materials and commercial potatoes varieties. Means followed by different letters, uppercase (TAC) and lowercase (TPC), are statistically different according to Tukey test at $p \leq 0.05$. Vertical bars indicate the standard error of the means ($n = 3$).

In most of the evaluated varieties, no differences were observed between the values measured in the raw potatoes and the microwave boiled ones, except for in R2 and R17 which had an increase of approximately 2% and in R16 and R18 which had a reduction of 30 and 60%, respectively (statistical comparison not shown).

For fried potatoes, TPC values were between 0.60 and 2.73 g GAE kg⁻¹ FW (Figure 5). Two groups were identified; one grouped the genetic varieties with 2 g GAE kg⁻¹ FW or more, and a second grouped the genetic varieties that showed ≤ 1 g GAE kg⁻¹ FW. However, it should be highlighted that in some genetic varieties, no differences with the raw potatoes were registered (R6, R8, R9, R19, R20, Karú, Yagana and Pukará).

In our experiment, as in similar works, we attribute the differences observed mainly to genetic variation since the edaphoclimatic conditions and the agronomic management were the same. In this sense, Yang et al. (2016) mentioned that the TPC retention after cooking would largely be a genotype-dependent characteristic.

On the other hand, the cooking process (temperature and time) determines changes in the profile of the starch, and increases in the soluble fraction and starch gelatinization are both linked to retention of compounds including TPC. This could explain the fact that microwave cooking increased TPC (Mulinacci et al., 2008; Yang et al., 2016).

For fried potatoes, the different behavior also reflects the genetic variation and is directly related to differences in polyphenol thermal stability. In general, the polyphenols present in red-flesh potatoes are more stable (Kita et al., 2015). However, in this work, not only did red-flesh potatoes maintain TPC after cooking, but purple- and noncolored-flesh potatoes also did.

It is important to consider that frying not only degrades compounds, but it also transforms them into others, many of

which are phenolic in nature and contribute to the total content (Bąkowska et al., 2003; Tian et al., 2016a). Alternatively, instead of increasing they can also decrease since phenolic compounds participate in the Maillard reaction during frying (Perla et al., 2012).

3.3 Total Antioxidant Capacity (TAC)

TAC values of raw potatoes were between 0.46 g TE kg⁻¹ FW (Karú) and 4.71 g TE kg⁻¹ FW (R9). Three groups were distinguished; one group included potatoes with TAC values higher than 3 g TE kg⁻¹ FW and contained 14 genetic varieties from R9 to R3, as shown on Figure 3. The second group had values of approximately 2 g TE kg⁻¹ FW and included potatoes with TAC values of 1 g TE kg⁻¹ FW or lower. The noncolored-flesh and variegated potatoes were in this group.

The main compounds responsible for the TAC of fruit and vegetables are phenolic, carotenoid, and anthocyanin, while vitamin C contributes less than 0.4% (Tian et al., 2016 a). Both phenolic acid and anthocyanin are plentiful in colored-flesh potatoes, which explains their higher TAC compared to noncolored and variegated ones. According to Bellumori et al. (2017), chlorogenic acid is the main contributor to TAC in yellow-flesh potatoes, while anthocyanins are the major contributors in red- and purple-flesh tubers.

Microwave boiled potatoes showed TAC values between 0.43 and 4.71 g TE kg⁻¹ FW (Figure 4). In this case, the genetics varieties can also be divided in three groups with the same range of values as in raw potatoes. The groupings are not necessarily coincident with those of raw potatoes, since a potato may belong to a group when raw and a different one when microwave boiled.

Microwave boiling did not affect the TAC of 15 evaluated genetic varieties since no statistical differences were observed.

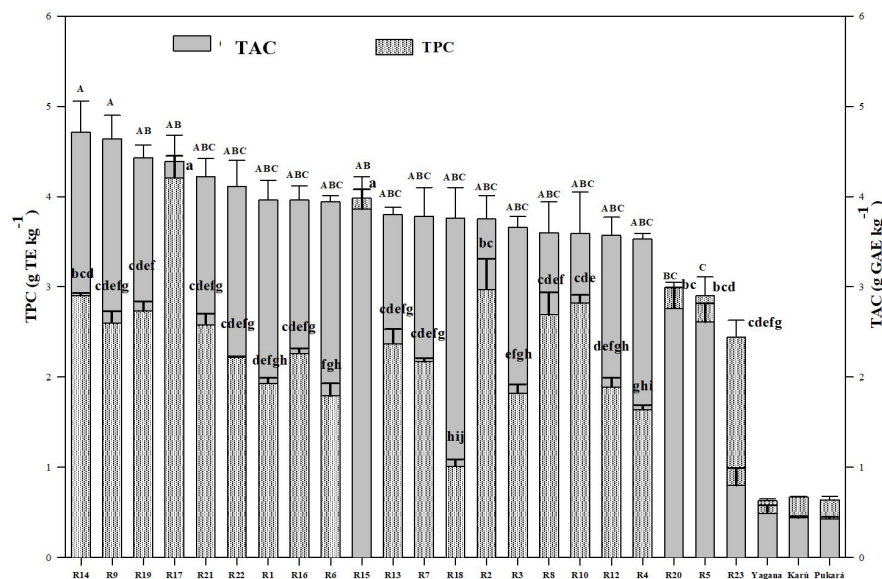


Figure 5. Total polyphenols contents (GAE g kg⁻¹) and total antioxidant capacity (TE g kg⁻¹) of fried genetics materials and commercial potatoes varieties. Means followed by different letters, uppercase (TAC) and lowercase (TPC), are statistically different according to Tukey test at $p \leq 0.05$. Vertical bars indicate the standard error of the means ($n = 3$).

On the other hand, the remaining 10 genetic varieties were affected by the cooking method and recorded between one and two times more TAC than raw potatoes (statistical comparison not shown).

Burgos et al. (2013) also reported an increase of approximately 10% in TAC in boiled purple-flesh potatoes. In a previous work, we also observed an increase of approximately 1- to 2-fold in TAC as in TP of the microwave boiled potatoes (Silveira et al., 2017a).

In contrast, some researchers reported a reduction in potato TAC after different cooking methods, including microwave boiling even though the reductions observed of approximately 14% were considered lower than those observed after other cooking methods (Tian et al., 2016b).

The measured TAC values in fried potatoes were between 0.25 and 3.0 g TE kg⁻¹ FW (Figure 5). In the group with the highest content, the varieties had approximately 3 g TE kg⁻¹ FW, and this group included genetic varieties between R19 and R1. A second group with values close to 1 g TE kg⁻¹ FW and including varieties from R2 to R23 was determined. Finally, there was a group comprised of genetics varieties with values less than 0.5 g TE kg⁻¹ FW (R4, Pukará, R6, Karú and Yagana). In all cases, TAC values measured in fried potatoes were between 40 and 75% lower than those measured in raw potatoes and between 30 and 90% lower than the values of microwave boiled potatoes (statistical comparison not shown).

It should be noted that fried noncolored-flesh potatoes did not differ from raw material in terms of TAC or TP. This also happened with the microwave boiled noncolored-flesh potatoes.

Within the cooking methods evaluated and reported in the literature, frying is considered the most detrimental in terms of phytochemical content maintenance (Brown et al., 2008; Kita et al., 2015).

The main compounds affected by frying conditions (temperature and time) are anthocyanins and carotenoids (Kita et al., 2013).

According to Tian et al. (2016b), anthocyanin content was reduced between 60 and 80%, while carotenoids were reduced between 66 and 76% after frying, air-frying and stir-frying, with the last method being most detrimental. In a previous work, we found a TAC reduction of approximately 58% in colored-flesh potatoes after frying (Silveira et al., 2017a).

3.4 Sensory evaluation

Sensory evaluation results of fried potato are presented in Table 1. Flavor did not show differences between genetic varieties, and the values were above 5 on the scale used. The main differences in crispness were registered for R15, R16 and R21, with values of approximately 8. They were crunchier than R2, R3, R5, R19 and Yagana, which had values between 4 and 6.

Table 1. Mean values for the sensory acceptability scores of fried potatoes based on a 9 point hedonic scale (1 = very bad/not very crispy/soft/low, 5 = acceptable; 9 = very good/crispy/firm/high).

Genetic material	Flavor	Crispness	Firmness	Oiliness
R1	5.67 ± 0.43 ns	6.40 ± 0.47 abcde	5.60 ± 0.42 cde	4.80 ± 0.49 ab
R2	6.33 ± 0.57	5.07 ± 0.85 de	5.13 ± 0.75 e	5.67 ± 0.53 a
R3	6.47 ± 0.39	6.27 ± 0.42 bcde	5.80 ± 0.46 bcde	4.73 ± 0.49 ab
R4	6.60 ± 0.39	7.53 ± 0.38 abc	6.73 ± 0.4 abcde	2.40 ± 0.24 b
R5	6.13 ± 0.36	4.40 ± 0.4 e	5.33 ± 0.66 de	4.93 ± 0.43 ab
R6	5.73 ± 0.51	7.00 ± 0.44 abcd	6.40 ± 0.46 abcde	4.20 ± 0.55 ab
R7	6.87 ± 0.43	8.20 ± 0.24 abc	7.87 ± 0.24 abc	3.80 ± 0.47 ab
R8	7.13 ± 0.38	6.47 ± 0.52 bcde	6.20 ± 0.48 abcde	4.33 ± 0.6 ab
R9	6.67 ± 0.53	8.33 ± 0.25 ab	8.20 ± 0.26 a	2.40 ± 0.4 b
R10	6.4 ± 0.57	7.27 ± 0.56 abc	7.27 ± 0.45 abcde	4.40 ± 0.49 ab
R12	6.07 ± 0.4	7.73 ± 0.33 abc	7.47 ± 0.38 abcd	4.27 ± 0.52 ab
R13	7.07 ± 0.28	8.33 ± 0.21 ab	7.93 ± 0.33 ab	3.87 ± 0.42 ab
R14	6.13 ± 0.62	7.80 ± 0.31 abc	7.73 ± 0.3 abc	3.67 ± 0.48 ab
R15	6.47 ± 0.6	8.40 ± 0.21 a	7.20 ± 0.55 abcde	2.67 ± 0.33 ab
R16	6.53 ± 0.55	8.47 ± 0.22 a	8.33 ± 0.29 a	2.67 ± 0.33 ab
R17	7.20 ± 0.4	8.33 ± 0.41ab	7.53 ± 0.36 abcd	4.53 ± 0.74 ab
R18	6.27 ± 0.47	7.07 ± 0.41 abcd	6.80 ± 0.48 abcde	3.20 ± 0.43 ab
R19	6.40 ± 0.42	6.20 ± 0.62 cde	5.67 ± 0.41 bcde	4.33 ± 0.43 ab
R20	5.80 ± 0.49	7.73 ± 0.41 abc	7.33 ± 0.36 abcde	3.13 ± 0.43 ab
R21	7.53 ± 0.54	8.47 ± 0.24 a	8.27 ± 0.21 a	2.40 ± 0.38 b
R22	6.07 ± 0.66	8.27 ± 0.23 abc	8.20 ± 0.24 a	3.40 ± 0.51 ab
R23	6.33 ± 0.45	8.07 ± 0.28 abc	7.07 ± 0.59 abcde	4.33 ± 0.57 ab
Karú	7.33 ± 0.5	7.33 ± 0.62 abc	7.47 ± 0.43 abcd	3.87 ± 0.57 ab
Yagana	6.73 ± 0.37	6.47 ± 0.59 bcde	6.07 ± 0.65 abcde	4.40 ± 0.55 ab
Pukará	6.47 ± 0.68	8.33 ± 0.25 ab	7.87 ± 0.36 abc	3.60 ± 0.58 ab

Values are means ± standard error of the means (n = 15). Means followed by different letters in the same column are statistically different according to Tukey test at p ≤ 0.05. ns = not significant.

One of the most relevant parameters apart from color, odor and flavor in potato chip quality, relative to consumer perception, is crunchy texture. This parameter is closely linked to the characteristics of the raw material, especially the dry matter content, and it is also affected by the temperature and exposure time during the elaboration process (Kita, 2002).

The genetic varieties that exhibited higher firmness values were R9, R16, R21, and R22 (approximately 8) compared to the varieties identified as R1, R2, R3, R5 and R19, which had values of approximately 5. Most of the analyzed varieties were categorized as acceptable to low oiliness (values less than 5), except variety R2, which presented a value greater than 5. This genetic material showed significant differences with R4, R9 and R21, which all had low oiliness.

Although it is known that fried potatoes have between 35-45 g of oil 100 g⁻¹ (fresh weight) which gives them their characteristic and appreciated taste, it is also true that consumers increasingly prefer low-fat oiliness fried potatoes (Mellema, 2003; Pedreschi & Moyano, 2005).

According to consumer opinion, the R2 variety would be the least suitable for frying followed by R19, R3 and R5. At the other extreme, the most suitable ones would be R16 and R21 followed by R9, R15 and R22.

The sensory evaluation results were related to the dry matter content since the best evaluated fried genetic varieties – R16, R21, R9, R15 and R22 – were within the group with the highest dry matter content and were considered suitable for frying (24.48; 23.87; 23.62; 21.5 and 21.06, respectively). According to Kita (2002), potatoes with dry matter values higher than 25% can exhibit hard textures, while potatoes with low dry matter contain much oil and are characterized by greasy and sticky textures.

Sensory evaluation of microwave boiled potatoes determined no differences in flavor for those with scores between 3 and 6 (Table 2).

For the mealiness descriptor, R1 and R4 were scored as nonmealy, while R18 showed the highest value of mealiness but was still within the limit of acceptance. For the firmness, the panelists observed that R22, R23 and Yagana were categorized as very soft and unable to maintain structure after preparation, especially when compared to R15.

Therefore, R1 and R4 were within the group of potatoes with the greatest suitability for preparation by microwaving while R15, R18, R22, R23 and Yagana were in the group with less suitability. Additionally, a strong correlation with dry matter content was observed since the best rated (R1 and R4) varieties were in the group with lower dry matter content (14 and 17, respectively).

Smith et al. (2009) reported that lack of mealiness is a desirable attribute in boiled potatoes. These authors mentioned that boiled potatoes should retain their shape, be moist and have low mealiness and starch content as their main attributes. Additionally, Seefeldt et al. (2011) reported that potatoes suitable for boiling are characterized by being 'moist', 'creamy', 'pleasant sweet', and tasting of potato and butter while the least appropriate are characterized by a higher intensity of attributes such as 'bitter', 'discoloration', 'reflection', 'mealy' and 'adhesive' and have a high dry matter content.

Table 2. Mean values for the sensory acceptability scores of microwaved potatoes based on a 9 point hedonic scale (1 = very bad/cohesive or non mealy/soft; 5 = acceptable; 9 = very good/floury/firm).

Genetic material	Flavor	Mealiness	Firmness
R1	4.07 ± 0.42 ns	2.33 ± 0.32 b	4.53 ± 0.56 ab
R2	4.93 ± 0.21	3.87 ± 0.41 ab	4.07 ± 0.63 ab
R3	6.20 ± 0.57	2.80 ± 0.31 ab	5.47 ± 0.54 ab
R4	4.87 ± 0.52	2.33 ± 0.51 b	3.87 ± 0.62 ab
R5	4.80 ± 0.54	3.80 ± 0.44 ab	3.47 ± 0.5 ab
R6	4.73 ± 0.55	3.33 ± 0.42 ab	4.40 ± 0.62 ab
R7	5.33 ± 0.53	4.67 ± 0.56 ab	3.87 ± 0.64 ab
R8	4.73 ± 0.45	3.87 ± 0.56 ab	4.47 ± 0.54 ab
R9	5.00 ± 0.53	4.40 ± 0.58 ab	4.07 ± 0.64 ab
R10	4.60 ± 0.38	4.73 ± 0.51 ab	3.60 ± 0.59 ab
R12	4.53 ± 0.45	2.87 ± 0.39 ab	4.87 ± 0.61 ab
R13	5.13 ± 0.36	3.40 ± 0.43 ab	4.93 ± 0.61 ab
R14	5.60 ± 0.62	3.60 ± 0.54 ab	5.07 ± 0.61 ab
R15	3.93 ± 0.43	2.80 ± 0.34 ab	6.53 ± 0.58 a
R16	4.00 ± 0.55	3.07 ± 0.51 ab	5.13 ± 0.68 ab
R17	4.46 ± 0.58	3.07 ± 0.45 ab	5.47 ± 0.65 ab
R18	5.00 ± 0.53	5.20 ± 0.51 a	4.00 ± 0.62 ab
R19	4.80 ± 0.47	4.47 ± 0.45 ab	3.87 ± 0.47 ab
R20	3.33 ± 0.56	3.47 ± 0.54 ab	5.27 ± 0.69 ab
R21	5.20 ± 0.54	4.27 ± 0.53 ab	4.33 ± 0.71 ab
R22	4.33 ± 0.56	4.40 ± 0.28 ab	2.87 ± 0.58 b
R23	5.40 ± 0.52	4.67 ± 0.29 ab	3.07 ± 0.43 b
Karú	4.80 ± 0.46	2.93 ± 0.29 ab	4.53 ± 0.43 ab
Yagana	4.80 ± 0.58	4.13 ± 0.26 ab	3.27 ± 0.51 b
Pukará	5.13 ± 0.67	3.40 ± 0.31 ab	3.80 ± 0.51 ab

Values are means ± standard error of the means (n = 15). Means followed by different letters in the same column are statistically different according to Tukey test at p ≤ 0.05. ns = not significant.

Based on the sensory evaluation in both fried and microwave boiled potatoes, it was observed that the attributes related to texture differed between the evaluated varieties. This is similar to a previous work on sweet potatoes genetic variety characterization, in which Leighton et al. (2010) reported that sensory evaluation determined different components of the texture with greatest variability to be determinants in consumer acceptance. The authors recommended its utilization in new emerging cultivar studies in both sweet potatoes and potatoes.

4 Conclusions

A great variability in composition of the analyzed genetic varieties was found, where the colored-flesh materials outperformed the noncolored ones in terms of functional compounds.

The differences found in dry matter percentage and in sensorial evaluation allow for identification of colored-flesh varieties with different suitability for use.

The evaluated cooking methods (frying and microwaving) did not determine substantial variations in TPC. However, some of the microwave boiled potatoes presented higher TAC than the raw ones.

Colored-flesh potatoes constitute a very promising resource that could be exploited for the development of novel and attractive products that are especially rich in functional compounds.

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