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Nutritional contents of advanced breeding clones of *Solanum tuberosum* group Phureja

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ABSTRACT

Nutritional contents of seven advanced breeding clones (AC) of potato (*Solanum tuberosum* group Phureja) and two commercial cultivars, Criolla Colombia and Criolla Galeras, of *S. tuberosum* group Phureja as control were evaluated. Fat, protein, ash, dietary fibre, and mineral contents were determined in whole boiled tubers. The AC-04 had the highest levels of protein (9.7 g/100 g dried weight, DW) and magnesium (107.0 mg/100 g DW) as compared to Criolla Colombia (4.0 g of protein/100 g DW and 99.5 mg of magnesium/100 g DW) and Criolla Galeras (3.1 g of protein/100 g DW and 95.0 mg of magnesium/100 g DW). The highest contents of fat (0.7 g/100 g DW), soluble dietary fibre (4.9 g/100 g DW), and manganese (0.8 mg/100 g DW) were found in AC-09, values that represented 3.9, 1.7, and 1.2 fold increase as compared to Criolla Colombia, respectively, and 3.9, 1.8, and 1.1 fold increase as compared to Criolla Galeras. The AC-51 had the highest content of insoluble dietary fibre (13.8 g/100 g DW). Among all genotypes the AC-52 had the highest contents of iron (1.3 fold increase), zinc (1.2 fold increase), and calcium (1.3 fold increase) as compared to Criolla Colombia.

1. Introduction

Potato is an Andean ancestral food and it is one of the most consumed food crop worldwide (Mosquera et al., 2013; Visser et al., 2009). It is estimated that more than 5000 varieties of potato are consumed around the world (Hawkes, 1990) and the most diverse wild cultivars are located in the Andes. This diversity suggests a considerable variability in their nutritional composition (André et al., 2009). Among Andean potatoes, the clones belonging to the *Solanum tuberosum* group Phureja have the best ability to cross with other potato genotypes because of their wild nature and accordingly they have been used extensively in potato breeding programs (Juyó, Gerena, & Mosquera, 2011). The Phureja group is diploid (2n = 24) and is geographically distributed from north Bolivia to south-west Colombia (Estrada, 1996). Tubers of *S. tuberosum* group Phureja have high variability in shape ranging from spherical to ovoid, and colour ranging from yellow to purple, both in pulp and skin (Bonierbale et al., 2004).

Potato tubers are considered to be a good source of iron and zinc. For instance, native cooked Andean potato tubers have concentrations of iron ranging from 1.0 to 2.2 mg/100 g dry weight (DW) and concentrations of zinc ranging from 0.9 to 1.6 mg/100 g DW (Burgos, Amoros, Morote, Stangoulis, & Bonierbale, 2007). In Colombia the frequency of consumption of potato is 54.5%, fourth place after rice, oil, and sugar, with an average daily consumption of 231 g (ENSIN, 2005). Protein, iron, zinc, and calcium deficiency was reported to be 36.0, 14.9, 62.3, and 85.8%, respectively, in Colombian population (ENSIN, 2005). Consumption of potato tubers with high nutritional content might be a good alternative to contribute to fulfil the recommended nutrient intake.

The Colombian advanced clones of *S. tuberosum* group Phureja were evaluated for their nutritional contents to select the best for production by communities in Colombia. This is the first study in Colombia that reports nutritional quality on the above-mentioned advanced breeding clones (AC). These nutritionally rich potato genotypes can strengthen the agriculture-nutrition link. The objective of this study was to perform the proximate analysis and determine the mineral content of seven AC of *S. tuberosum* group Phureja and rank them relative to two commercial cultivars.

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2. Methods and materials

2.1. Plant material

Hybridization was performed in the initial phase of the breeding program of *S. tuberosum* group Phureja of Universidad Nacional de Colombia to develop the new potato cultivars with high yield and resistance to both *Phythoptora infestans* and *Potato yellow vein virus* – PYVV. Simple hybrids were obtained. From different crosses around 2300 simple hybrids were derived in 2008. These hybrids were multiplied using cloning of tubers which allows to fix the phenotypic characteristics. A total of 100 genotypes were selected during 2009, designated as AC, and coded as AC-01 to AC-100. In a second selection, considering yield and resistance to late blight, 30 genotypes from different trials in different locations and crop cycles in 2010, were chosen. From these 30 genotypes, seven clones were chosen (Table 1) and further evaluated for nutritional composition. These clones were grown in Obonuco, Nariño, Colombia (01°11′N with 77°18′W and 2871 m above sea level). The experiment was conducted as a randomized complete block with nine potato genotypes, including seven AC and two commercial cultivars, Criolla Colombia and Criolla Galeras as control. Experiments had three biological replicates. Each experimental unit consisted of three tubers sown in one line. The plants were cultivated according to the local recommendations of potato cultural practices. The tubers were harvested at maturity and stored at 4 °C for less than a day.

2.2. Analysis of macronutrient contents

Tubers were washed and classified according to the size based on equatorial diameter measured using a gauge. Unpeeled potato tubers are typically consumed in Colombia after boiling (ENSIN, 2005). Accordingly, the whole unpeeled tubers were boiled at 92 °C with different volumes of potable water according to their equatorial diameter: 3.0–3.9 cm boiled for 20 min in tuber weight:water (g:mL) ratio of 1:3, 4.0–5.9 cm boiled for 25 min in a ratio of 1:4, and greater than 6.0 cm boiled for 30 min in a ratio of 1:3. Tubers were then cooled in an ice bath for 5 min and allowed to dry at room temperature. A sample was taken to determine water content and the remaining material was cut into slices, frozen in liquid nitrogen, and stored at −80 °C. The frozen material was freeze-dried, ground using a domestic blender to less than 0.2 mm particle diameter, enclosed in sealed polyethylene bags, and stored in a desiccator at room temperature until use.

The nutritional components were analysed according to the methods recommended by the Association of Analytical Chemists (AOAC, 1995). Water content was determined with a vacuum oven at 70 °C (AOAC 931.04). Fat content was measured based on the Goldfish method with petroleum ether as extraction solvent (AOAC 963.15). Protein content was evaluated based on the Kjeldahl method (AOAC 970.22), using a conversion factor of 6.25, and ash content was determined based on the calcination method at 550 °C (AOAC 972.15). Soluble and insoluble dietary fibres were estimated by the enzymatic-gravimetric method (AOAC 985.29). The carbohydrate content was calculated by subtracting the sum of percent ash, fat, protein, and soluble and insoluble dietary fibre contents from 100. Energy (E, kcal/100 g DW) was calculated by the formula: $E = [(g\ Fat/100\ g\ DW) \times (9\ kcal/g)] + [(g\ Protein/100\ g\ DW) \times (4\ kcal/g)] + [(g\ Carbohydrate/100\ g\ DW) \times (4\ kcal/g)]$. All contents were expressed as g/100 g of boiled potato, in both fresh weight (FW) and DW basis, except the water content and the dry matter content which were expressed only in FW basis.

2.3. Analysis of macromineral and trace mineral contents

The whole potato tubers were washed in distilled water and, different to the "analysis of macronutrient contents" procedure, dipped in a 0.25 mol/L HCl aqueous solution for 10 min to eliminate soil impurities. Then the tubers were boiled in de-ionized water as described above. Boiled tubers were sliced, frozen in liquid nitrogen, and stored at −80 °C. The frozen boiled tubers were freeze-dried and milled and a sample of 0.6 g was digested in a mixture of $HClO_4$:HNO_3 (10:1, mL:mL) in pyrex tubes (Wheal, Fowles, & Palmer, 2011). Once digestion was completed the clear solution was taken to a 25.0 mL volumetric flask and topped up with de-ionized water. Mineral contents were measured in the solutions using the inductively coupled plasma optical emission spectroscopy (ICP-OES) (Spectro Analytical Instruments, Kleve, Germany). Mineral contents were expressed as mg/100 g of boiled potato, both on FW and DW basis (Wheal et al., 2011).

2.4. Statistical analysis

A one-way analysis of variance was performed. Comparisons among means were performed by the Fischer test. Pearson's correlation among variables was evaluated considering $p < 0.05$. Statistical analyses were performed using Statgraphics Centurion version XVI (STATGRAPHICS® Centurion XVI, 2010). The data included the amount of different nutritional components measured in three biological samples and averaged per replicate. The results were expressed as means with their standard deviation.

3. Results and discussion

3.1. Macronutrient contents

Water, protein, fat, ash, soluble and insoluble dietary fibre contents significantly varied among genotypes (Fig. 1). Water content ranged from 76.1 to 81.0 g/100 g FW. The highest value of

Table 1
Characteristics of the analysed potato cultivars.

Genotypes	Genealogy	Yield (kg/h)	Level of resistance to *P. infestans*
Advanced clones			
04	Criolla Guaneña × Criolla Galeras	37,100	High
09	Criolla Guaneña × Criolla Galeras	33,100	High
50	Criolla Latina × Criolla Colombia	34,600	Medium
51	Criolla Latina × Criolla Colombia	34,400	Medium
52	Criolla Latina × Criolla Colombia	36,100	Low
59	Criolla Latina × Criolla Colombia	37,400	Medium
64	Criolla Galeras × Criolla Guaneña	32,800	High
Commercial cultivars			
Criolla Colombia	Clonal selection of yellow round genotypes (yolk egg)	33,500	Low
Criolla Galeras	Criolla Colombia × Yellow variety Tumbay (*Solanum goniocalyx*)	33,400	Medium