Food Chemistry 238 (2018) 42–50

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Biodiversity of Andean potatoes: Morphological, nutritional and functional characterization

Sonia Rosario Calliope, Manuel Oscar Lobo, Norma Cristina Sammán *

Centro de Investigación y Transferencia Jujuy, CONICET, Facultad de Ingeniería, Universidad Nacional de Jujuy, Ítalo Palanca 10, Jujuy, Argentina

ARTICLE INFO

Article history:
Received 5 April 2016
Received in revised form 6 December 2016
Accepted 20 December 2016
Available online 22 December 2016

Keywords:
Andean potatoes
Biodiversity
Morphology
Composition
Bioactive compounds

ABSTRACT

Andean potatoes (*Solanum tuberosum andigenum*) are a staple food for Andean population; there is great biodiversity but only few varieties are cultivated nowadays. In order to contribute to biodiversity conservation of Andean potatoes, information about their morphological, nutritional and functional characteristics was generated. In gene bank (INTA-Balcarce), varieties collected from regional producers were preserved. Forty-four genotypes were multiplied and characterized. Morphological characteristics; proximate composition and functional compounds were analyzed. Cluster analysis separated them into 3 groups according to distinguishing characteristics, which define industrial or nutritional applications. Group 2 was characterized by higher content of macronutrients and Group 3 with the highest antioxidant activity, both would be advisable for direct consumption. Genotype CS 1418 had big size and oval form so it could be destined to potato chips industry. Knowledge on nutritional and functional properties of genotypes contributes to promoting the cultivation depending on properties and also to preserve biodiversity.

1. Introduction

Biodiversity loss of organisms, species and populations is a highly topical subject. In the world, species are becoming extinct rapidly and most of the reasons are related to human activity (Chapin et al., 2000). Modern crops contain less than 1% of the genetic diversity available in wild species.

The biodiversity of wild species and subspecies could play a key role in global nutrition and food security because different varieties of the same species can provide different amounts of nutrients and functional compounds. Therefore, it is extremely important to generate this information (Toledo & Burlingame, 2006).

Burlingame, Mouillé, and Charrondiére (2009) in a review about the potato nutritional composition found differences in nutritional profile due to its great biodiversity. It shows that nutritional content should be one of the criteria for the promotion of cultivars and that nutrient analysis and its disclosure should be conducted systematically.

Other researchers emphasize the need of studies about the characterization of local varieties and promote the conservation and recovery of regional biodiversity (Rodríguez Galdón et al., 2012). Potatoes are one of the crops with the greatest genetic diversity, which is displayed in their ability to grow in very different environments (Navarre, Goyer, & Shakya, 2009).

Andean potatoes (*Solanum tuberosum andigenum*) are native of South America; Peru and Bolivia contain the greatest genetic biodiversity of this crop, therefore, these countries are considered the center of origin and domestication of these species (Navarre et al., 2009). Andean potatoes are also found in north of Argentina, Ecuador, Colombia and South of Venezuela (Spooner, 2013). The geographical area of origin of Andean potatoes in Argentina is confined to Quebrada de Humahuaca, Puna and high valleys in Jujuy and Salta provinces. These environments are characterized by abrupt changes in altitude and precipitation patterns. Andean potato is a food staple of the Andean population.

These tubers represent a valuable genetic resource since Andean farmers have historically selected those varieties with appropriate nutritional characteristics and resistant to diseases and pests. Even though there is a high diversity, only few varieties are grown and there is risk of many of them are becoming extinct (Tapia & Fries, 2007).

The potato provides energy due to its high carbohydrate content; also, contains minerals, fiber, proteins and antioxidant compounds such as polyphenols and carotenoids, vitamins E and C, which contribute to nutrition and wellness of consumers. These properties are often underestimated or ignored (Burgos, Auqui, Amoros, Salas, & Bonierbale, 2009). The Food and Agriculture

* Corresponding author.
E-mail addresses: soniroscal@gmail.com (S.R. Calliope), mlobo@fi.unju.edu.ar (M.O. Lobo), nsamman@arnet.com.ar, nsamman@fi.unju.edu.ar (N.C. Sammán).

http://dx.doi.org/10.1016/j.foodchem.2016.12.074
0308-8146/

Organization of the United Nations (FAO) pointed out that if the analysis of nutrients of diversity in different food species and intra-species were made systematically and these data were disseminated, the national information systems for food and agriculture would be strengthened and this could be useful to build the basis for setting priorities and national policy (FAO, 2008).

The morphological characterization of tubers can be used as a source of information to identify genotypes in gene banks. Madroñero, Rosero, Rodríguez, Navia, and Benavides (2013) determined that the best qualitative variables to discriminate an Andean potatoes collection were primary and secondary skin color and secondary color of tuber pulp. Also this characterization allows the identification of "elite germplasm" to be used as parents in future breeding programs.

Potatoes have a high diversity of phenolic compounds. The quantity and quality present in the tuber depend on its genotype characteristics and may be affected by climatic and agri-management factors (André et al., 2009). Genetic biodiversity loss may not only result in food with lower content of functional compounds but it may also induce the loss of knowledge referred to the biosynthetic pathways of the tubers (Albishi, John, Al-Khalifa, & Shahidi, 2013; Fernández Orozco, Gallardo Guerrero, & Hornero Méndez, 2013).

Nonetheless, the variety of tubers and, therefore, biodiversity is lost because the agronomic and commercial selection of some varieties. Other factors that contribute to the loss of the crop genetic diversity are the replacement of local varieties for high-yielding species, the abandonment of the traditional lifestyle, phytosanitary problems, the lack of policies for primary production and development of post-harvest processes, changes of dietary patterns oriented towards cereals such as rice and wheat and their by-products consumption and the low demand in the markets. All of the above mentioned leads to the production of a limited number of varieties of regional tubers (FAO, 2013).

Consequently, it is of the utmost importance to work in the recovery and study of Andean crops (Jiménez, Rossi, & Sammán, 2007) to allow diversification of their production (Lutaladio & Castaldi, 2009). These actions would also support to inhabitants of the region, who still keep their manners respecting their ancestral knowledge. By working together with regional producers, science can achieve strategies for the preservation of agro-biodiversity (Burgos et al., 2013; Toledo & Burlingame, 2006). Greater awareness of the nutritional and functional properties of the different varieties of Andean potatoes will contribute to the preservation of the biodiversity, which is part of the Argentine regional heritage and will allow reintroducing these healthy foods in the population diet (Jiménez, Rossi, & Samman, 2009).

The aim of this work is to contribute to biodiversity conservation of Andean potatoes by generating information about the morphological, nutritional and functional characteristics of different genotypes in order to increase their production and application in food industry and nutrition.

2. Material and methods

2.1. Materials

Forty-four genotypes of Andean potatoes stored in the Germplasm Bank of the National Agricultural Technology Institute (INTA Balcarce, Buenos Aires, Argentina) were used.

In practice, many of these varieties are not grown since many years, and therefore they were reintroduced in the Andean region for this study. Potatoes were sown in Hornillos, Jujuy (Argentina), all in the same place, planting date and agronomic conditions; the soil type in this region is sandy loam and gravel in all the topsoil.

2.2. Morphological characterization of potato tubers

Characterization was done according to the guide proposed by the International Potato Center (CIP). Nine descriptors were used: Skin predominant color, Intensity of the predominant color of the skin, Skin secondary color, Secondary color distribution of the skin, General and Secondary form, Pulp predominant color, Pulp secondary color, Pulp secondary color distribution and Eyes Profundity, following the codification listed in Table 1.

Weights of tubers were registered. Ten tubers from each genotype were weighted using an electronic scale. Sizes were rated according to established characteristics by the National Institute for Agricultural Research (INIAP) of Ecuador: small potatoes (20–40 g), medium (41–60 g), big (61–90 g) and very big (over 90 g) (Monteros, Yumisaca, Andrade-Piedra, & Reinoso, 2011).

Tubers without damage, stains, cuts or with presence of worms were selected. All of them were characterized in the first week after harvest.

2.3. Chemical composition

All the analytical determinations were performed according to AOAC methods (AOAC, 1998). Moisture was determined in oven at 135 °C (AOAC 930.15). Total protein content was analyzed by Kjeldahl method (Buchi Digestion Unit K-435) with a nitrogen-to-protein conversion factor of 6.25 (AOAC 979.09). Total dietary fiber was assessed using the enzymatic-gravimetric method (AOAC 985.19). For ash analysis a carbonization at 550 °C (Mufle furnace Indef, M/07C2) was performed (AOAC 923.03).

Usable total carbohydrate was determined by the Clegg method (Clegg, 1956). Dried potato (1 g) was digested with perchloric acid, and then anthrone solution was added. The hydrolyzed starches and soluble sugars were determined together colorimetrically at 630 nm. Results were expressed in g glucose/100 g. Standard glucose solutions (Sigma Aldrich) were used, for the layout of calibration curve.

2.4. Total phenolic (TP) determination

2.4.1. Sample preparation

The samples were weighed, washed and cut into slices (unpeeled) of 1 cm thick then were freeze-dried using a Lyovac GT 2 (Leybold Heraeus – Germany). After lyophilisation and stabilization in desiccators, they were ground in a laboratory mill and stored in zip-lock bags and kept refrigerated at 4 °C until use.

2.4.2. TP quantification

TP content was determined according to Lachman, Hamouz, Orsak, Pivec, and Dvorak (2008) using the Folin-Ciocalteau reagent. TP extraction was performed from the lyophilized sample (2 g) with methanol solution (80%) for 24 h. Initially samples were sonicated for 15 min and stirred for 1 h in a bath at room temperature. Sample was filtered and completed to 100 mL. Then, 5 mL Folin Ciocalteau reagent were added to 5 mL of sample, after agitation followed by addition of 7.5 mL of 20% sodium carbonate solution. After 2 h at room temperature, absorbance was measured in a spectrophotometer (Mapada, model UV6300PC) at 765 nm against a blank. The results were expressed as gallic acid equivalents (GAE) (Sigma Aldrich, Switzerland) per kg of dry matter.