Food Chemistry 148 (2014) 420–426

Contents lists available at ScienceDirect

Food Chemistry

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

Characterisation of nutrient profile of quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus caudatus*), and purple corn (*Zea mays* L.) consumed in the North of Argentina: Proximates, minerals and trace elements

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A R T I C L E I N F O

Article history:
Received 15 April 2013
Received in revised form 25 September 2013
Accepted 30 September 2013
Available online 17 October 2013

Keywords:
Andean cereals
Food composition database
Data quality
EuroFIR
Quality assurance
Gluten-free

A B S T R A C T

Quinoa, amaranth and purple corn are Andean cereals largely consumed in North of Argentina. Nutrient analysis with the purpose of inclusion in the Argentinean FCDB and e-search EuroFIR has become urgent matter. In this work proximate and mineral profile of Andean cereals cultivated in the North of Argentina were determined and compared with rice. Proximate analysis showed that Andean cereals have similar profile but significantly higher ($p < 0.05$) than rice. Andean cereals are rich sources of iron, copper, manganese and zinc and better than rice. Phosphorus and magnesium quinoa content could contribute up to 55% of consumers DRI. Andean cereals and rice are poor sources of potassium. To guarantee the interchange of data among users and producers of FCDB component values were obtained in compliance with EuroFIR guidelines for compilation process. Present work provides necessary information to FCDB users who wish to have access to food reference analytical parameters.

1. Introduction

Quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus caudatus*) are known as pseudocereals and purple corn (*Zea mays* L.) is a cereal all of Andean origin cultivated in Argentina for thousands of years after domestication at 3000 B.C years ago. The Argentine people supported in their Andean culture and tradition have maintained and preserved quinoa, amaranth and purple corn as a staple food even during the Spanish conquers period when the crop of these Andean cereals was forbidden (Pedreschi & Cisneros-Zevallos, 2006; Rastogi & Shukla, 2013; Valencia, Encina, Binaghi, Greco, & Ferrer, 2010a).

Quinoa and amaranth are considered crops with large genetic variability and therefore adapted to diverse agro-climatic habitats and edaphic conditions. High yields depending on Germplasm lines and quality trials are obtained in salinity regions, at higher and lower elevations, from sea level up to Himalayas even in monsoon climate or regions with mild seasons (Bhargava, Shukla, Rajan, & Ohri, 2007; Rastogi & Shukla, 2013). Purple corn is a rare and ancient Andean cereal with large kernels. It is grown for culinary purposes, but has also recently been studied for its health benefits since it apparently has unusually high levels of antioxidants and anti-inflammatory properties, namely anthocyanin (Pedreschi & Cisneros-Zevallos, 2006; Pedreschi & Cisneros-Zevallos, 2007).

In nineties quinoa has been classified by NASA as an emerging crop with excellent nutritional properties for long term human space missions due to its high content in protein and unique amino acid composition in particular in what respects to lysine and sulfur amino-acids (Schlick & Bubenheim, 1993). Meanwhile quinoa and amaranth were introduced in several countries outside of Andean region. Quinoa is also cultivated in England, Sweden, Denmark, the Netherlands, Italy and France. Recently France has reported an area of 200 ha with yields of 1080 kg/ha and Kenya has shown high seed yields (4 t/ha). Purple Corn is also grown in Ecuador, Bolivia and Chile. The strongest interest in amaranth (investigation and production) in Europe has been in Austria, Czech Republic, Slovak Republic, Germany, Hungary, Poland, Russia, Italy and Slovenia. In Canada, United States, Japan, Australia and European Countries these Andean cereals evidence an increasing acceptance

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0308-8146/$ - see front matter
http://dx.doi.org/10.1016/j.foodchem.2013.09.155

regarding food consumer preferences (Hirose, Fujita, Ishii, & Ueno, 2010; Rastogi & Shukla, 2013; Valencia et al., 2010a).

The interest of these non-Andean countries by these cereals can be explained by their properties as functional gluten-free ingredients of bread, pasta and confectionary products. The importance of this healthy gluten-free products gain major interest since protein availability of these set of cereals was demonstrated in animal and human studies as being better than other common products gluten-free.

The successful application of Andean cereals in foods gluten-free was demonstrated in several studies and recently reviewed by Alvarez-Jubete, Arendt, and Gallagher (2010). The authors have demonstrated that a well-balanced diet in protein, fibre, calcium, iron and vitamin E could be obtained whenever these Andean cereals take part in the diet by replacing other gluten-free ingredients. Moreover, due to their rheological properties, sensory characteristics, nutrient profile and stability the gluten-free formulations based on quinoa or amaranth confers a texture similar to corn based formulations. In parallel, the taste, smell and flavor influence and reinforce consumer preferences (Giménez et al., 2012, 2013).

The nutritional properties of quinoa and amaranth seeds cultivated in Andean region and in Europe were compared by several authors and differences were observed in nutrient content, as well as in flavonoid contents. Quinoa and amaranth are a good source of flavonoids and other bioactive compounds with putative health effects (Rastogi & Shukla, 2013; Valencia, Hellstrom, Pihlava, & Mattila, 2010b). In crops cultivated in Japan a higher content in bioactive compounds was observed when compared to those cultivated in South America (Hirose et al., 2010). Schoenlechner, Wendner, Siebenhandl-Ehn, and Berghofer (2010) have analysed quinoa and amaranth folate profile in bread, noodles and pasta and postulated that quinoa could be an alternative for folate source in normal subjects. Studies performed on animals have recently reported a gastro protective activity of quinoa seeds (Schoenlechner et al., 2010; Stikic et al., 2012). These effects are mainly attributed to Arabinose and arabinose-rich pectic polysaccharides that compose the dietary fibre of quinoa. Studies on genetic variability of 27 lines of quinoa grown on the same climatic conditions have demonstrated a high correlation with nutritional quality. These studies indicated that an accurate estimation of dietary intake should be calculated through local crops.

Recognising the importance of quinoa "in providing food security and nutrition and in the eradication of poverty" the General Assembly of United Nations has designated, in its resolution A/RES/66/221, the year 2013 as being the International Year of quinoa.

In the last decade the consumption of quinoa and amaranth has growth substantially across the world (Giménez et al., 2013). In spite of their nutritional importance only a few Food Composition Databanks (FCDB) include quinoa and amaranth as part of their food composition data (EUROFIR, 2013). This information is available in USA and Canada Databanks, both from the same analytical data source (EuroFIR, 2013). Information on purple corn composition is even more deficient. Therefore and as far as the authors are aware, no analytical work that involves quinoa, amaranth and purple corn was reported with the purpose of inclusion in a FCDB.

The aim of this work was to characterise proximate and mineral profile of quinoa, amaranth and purple corn consumed in the north of Argentina and originated from Jujuy Province crops. The study was framed by accepted EuroFIR quality criteria with the purpose of guaranteeing data results reliability and future inclusion in Argentinean Food Composition Data and throught other national food composition databases be included in EuroFIR e-search. A second objective was to compare nutrient profile of these Andean cereals with rice as gluten-free ingredients of cereals based foods.

2. Materials and methods

2.1. Samples and sample preparation

Samples of quinoa, amaranth and purple corn complete seeds were obtained from a Cooperative of Producers (CAUQUEVA-Tilcara, Jujuy, Argentina). White polished rice was obtained from local factories in Portugal (Ribatejo). Primary samples were taken according to a selective sampling plan. In this phase five samples of each material were collected just once for purple corn and amaranths. Quinoa and rice samples were collected in two consecutive years.

The samples were immediately prepared after receipt in the laboratory. Quinoa was washed for 20 min with tap water with the aim to eliminate bitter taste and toxic saponins. Washed grains were dried at 45 °C for 12 h. Dried seeds were packed in vacuum bags and stored at room temperature until they used in analysis and processing. Amaranth, purple corn and white rice samples seeds were homogenised and milled using a high speed grinder, a knife mill GRINDOMIX GM 200 equipped with titanium knives to prevent contamination. The prepared samples were stored in vacuum bags at room temperature until processing. The food products were analysed raw.

2.2. Reagents and chemical standards

All reagents were of high analytical grade. Deionised water of level I, as EN ISO 3696, was used for the preparation of all solutions. The nitric acid (65%) and hydrogen peroxide solutions used were of ultrapure grade, and nitric acid (65%) was first distilled, in acid distillation system (Milestone SubPUR).

A 2% concentration solution of nitric acid was used to prepare working standard solutions, to dilute samples and to prepare blanks. A nitric acid solution with a 2–4% concentration was used to wash up the ICP-OES and ICP-MS sample introduction system.

Working multi-element standard solutions were prepared from mono-element high purity ICP stock standards containing 1000 mg/L of each element (Copper, Manganese, Iron, Zinc, Magnesium, Calcium, Phosphorus, Sodium and Potassium).

Working multi-element standard solutions of Nickel, Molybdenum, Strontium, Vanadium, Lithium, Cobalt, Selenium were prepared from multi-element solution XVI (21 elements diluted in acid nitric), high purity ICP stock standard 100 mg/L.

2.3. Analysis

2.3.1. Proximate

2.3.1.1. Moisture and ash contents. Moisture content was determined by gravimetric method, using a dry air oven from Heraeus Instruments, Hanau, Germany, at 102 °C ± 2 °C during 2 h, using 5 g of sample, until constant weight (AOAC 952.08, 2000); EuroFIR Method indicator ME1103. Total ash analysis was carried out in a muffle furnace M110 (Heraeus Instruments , Hanau, Germany) at 525 °C ± 25 °C for 20 h, using 5 g of sample, until constant weight, according to AOAC 923.03 (2000); EuroFIR Method indicator MI 1018.

2.3.1.2. Extraction and quantification of total fat. Total fat determination was performed with an acid hydrolysis method (AOAC 948.15, 2000) – EuroFIR Method indicator MI 1202 – followed by extraction using a Soxhlet apparatus (Soxtec™ 2050) for 1 h 30 min with petroleum ether (40–60 °C), as the extraction solvent. The residue obtained was dried for 1 h 30 min at 102 °C ± 2 °C, until constant weight.