Journal of Food Composition and Analysis 22 (2009) 533–538

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Original Article

Ascorbic acid concentration of native Andean potato varieties as affected by environment, cooking and storage

G. Burgos, S. Auqui, W. Amoros, E. Salas, M. Bonierbale *

International Potato Center (CIP), P.O. Box 1558, Lima 12, Peru

ARTICLE INFO

Article history:
Received 3 September 2007
Received in revised form 30 April 2008
Accepted 5 May 2008

Keywords:
Potato
Solanum tuberosum L.
Ascorbic acid
Vitamin C
Cooking
Storage
Genotype
Andean potato varieties
Environment
Food composition

ABSTRACT

The ascorbic acid (AA) concentration of tubers was determined in 25 Andean potato varieties (*Solanum tuberosum* L.) grown in three environments, and the effect of cooking and storage time in subsets of samples was evaluated. Significant variation due to genotype, environment and genotype × environment (G × E) interaction was found. AA concentration in freshly harvested raw, peeled tubers ranged from 22.2 to 121.4 mg/100 g on a dry weight basis (DW) and from 6.5 to 36.9 mg/100 g on a fresh weight basis (FW) with the accession 704393 showing the highest levels of AA in all three locations. Differences in AA concentration were found among cooking methods and storage times; and significant non-crossover interactions with genotype were observed for both of these parameters. It was found that AA concentration of boiled tubers of the six varieties evaluated was higher than in oven and microwaved tubers and that AA concentration of tubers of the 23 varieties evaluated decreased with storage time. The variety 704393 retained 54 and 34% of its original AA concentration after boiling and storage during 26 weeks under farmer conditions. One hundred grams of fresh harvested boiled potatoes of this variety (704393) could provide adults with 17–20% of the recommended daily allowance (RDA) of AA.

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the world's most important crops, ranking fifth in terms of human consumption and fourth in worldwide production (Horton, 1987). Beyond supplying energy and good quality protein, potato is also an important source of vitamins and minerals. However, its value within the human diet—particularly as a source of vitamin C—is often underestimated or ignored, (Dale et al., 2003; Woolfe, 1987). There are two major forms of vitamin C: L-ascorbic acid (AA) and L-dehydroascorbic acid (DHAA); however, the terms vitamin C and ascorbic acid are frequently used as synonyms (Bates, 1997).

AA is an essential component of most living tissues. As an antioxidant, it plays an important role in protection against oxidative stress. AA is an important scavenger of free radical species, such as reactive oxygen species that can cause tissue damage resulting from lipid peroxidation, DNA breakage or base alterations, and may contribute to degenerative diseases such as heart disease or cancer (Bates, 1997). In addition, due to its participation in the oxidation of transition metal ions, AA also plays an important role in enhancing the bioavailability of non-haem iron (Teucher et al., 2004). The Food and Agriculture Organization (FAO/WHO, 2001) indicated that the recommended nutrient intake of vitamin C ranges from 25 to 45 mg/day, depending on age. However, based on available biochemical, clinical, and epidemiological studies, the current RDA for AA is suggested to be 100–120 mg/day for adults to achieve cellular saturation and reduce risk of heart disease, stroke and cancer in healthy individuals (Naidu, 2003).

Newly harvested potato tubers have been reported to contain up to 46 mg AA/100 g FW (Han et al., 2004; Mishra, 1985; Mullin et al., 1991; Nordbotten et al., 2000) depending primarily upon the variety, the maturity of the tubers at harvest, the sampling method, and—to almost as great an extent—the environmental conditions under which they were grown (Murphy, 1946).Several authors have described considerable reduction in the quantities of AA during cooking and storage in potatoes as well as in vegetables, with losses that vary widely according to cooking method (Augustin et al.,

* Corresponding author. Tel.: +51 1 349 6017; fax: +51 1 317 5326.
E-mail address: m.bonierbale@cgiar.org (M. Bonierbale).

0889-1575/$ – see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.jfca.2008.05.013

1978a; Lešková et al., 2006; Suárez et al., 2004) and storage time (Casañas et al., 2003; Mishra, 1985; Zee et al., 1991).

However, almost all information about the AA concentration of potato in freshly harvested and stored potatoes in raw and cooked tubers relates to improved commercial varieties and there is scant information about the nutrient concentration of potato genetic resources, including the many native cultivars still grown and consumed in the Andean center of origin and diversity of potato.

The present study sought to determine the AA concentrations of a taxonomically diverse set of native Andean potato cultivars grown in three different environments, and the effects of cooking and storage on those concentrations. This information will be very useful to recommend those varieties and preparation methods with the highest retention of AA, as well as to assess genetic diversity for use in breeding programs seeking to improve the nutritional value of potato.

2. Materials and methods

2.1. Plant material

Twenty-five native varieties representing five taxonomic groups of cultivated potato conserved in the germplasm collection at CIP were used for this study. Samples of tubers were taken from seed plots grown in randomized complete block designs with three replications of 10 hills per plot in each of three sites of the central Peruvian Andes: Inyaya Alto (3700 m above sea level [masl]), District of Chiara, Huamanga, Ayacucho) in 2004, and La Victoria (3280 masl; District El Tambo, Huancayo; Junín) and Aymara (3800 masl; District of Pazos, Tayacaja; Huancavelica) in 2005. Well-matured tubers were harvested at 150 days after planting in La Victoria and 180 days in Inyaya and Aymara. A maximum of 75 unblemished tubers of representative size for each variety were collected from across the replicate plots at each site. 2 weeks after harvest, 15 raw, peeled tubers from each variety in each location were used to determine the AA concentrations of fresh tubers. One month after harvest, 15 tubers of each of six varieties from plots in Inyaya were boiled, baked and microwaved to evaluate the effect of the type of cooking on the AA concentration. 2 weeks after harvest, 15 tubers of all the 25 varieties from the plots in La Victoria were used to determine the AA concentration on boiled tubers. Forty-five tubers of the 23 varieties grown in La Victoria were used to assess the effect of three storage times (Fig. 1).

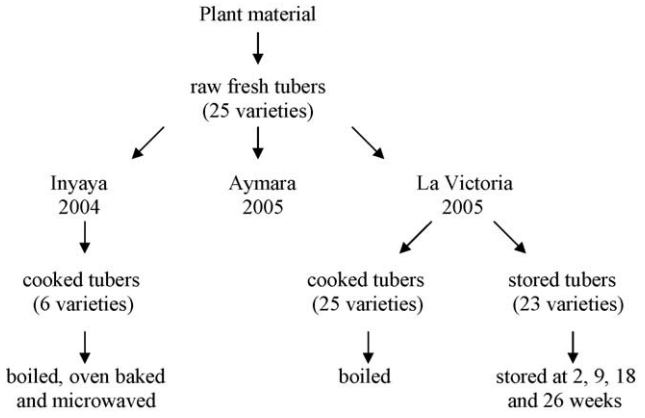

Fig. 1. Plant material distribution for analysis of raw, cooked and stored potatoes.

2.2. Sample preparation

2.2.1. Freshly harvested raw tubers

Tubers were stored at 5 °C until sample preparation. Three samples of 4–5 raw peeled tubers each were prepared for each variety 2 weeks after harvest. Tubers were washed with abundant tap water, rinsed with deionized water, dried with paper towels, peeled and cut longitudinally into four sections. One or two slices of two opposite sections of each tuber were used to prepare each of three laboratory samples. The slices were cut and mixed, and a 15 g laboratory sample was taken and placed in a stainless steel beaker and immediately analyzed as described below.

2.2.2. Cooked tubers

The effects of three cooking methods (boiling, oven baking and microwaving) on the AA concentration were tested using three laboratory samples of 4–5 tubers each per method for six of the varieties grown in Inyaya; and the AA concentrations of boiled tubers of all of the varieties grown in La Victoria were determined using three samples of 4–5 tubers each per variety. Tubers were stored at 5 °C until sample preparation.

Boiling: Each sample of each variety was placed in a stainless steel pot, covered with cool water and cooked over uniform high temperature during 25–35 min.

Microwaving: The three samples of each variety were wrapped separately with moistened paper towel and microwaved during 4–5 min.

Baking: Tubers of three samples of each variety were wrapped with aluminum foil and baked together in an oven at 160–180°C during 39–57 min.

Tubers were considered cooked when a stainless steel probe penetrated them easily. Each variety showed a different time of cooking in each cooking treatment. Cooked tubers were peeled and sampled for AA determination in the same way as raw tubers, above.

2.2.3. Stored raw tubers

Tubers of 23 varieties grown in La Victoria were stored under highland farmers' conditions: in a dark, well-ventilated room, with a mean relative humidity (RH) of 69% (58–79%) and a mean temperature of 13 °C (12–15 °C), and the AA concentrations of tubers were determined at 2, 9, 18 and 26 weeks after harvest. Three samples of 4–5 peeled tubers per variety were prepared for each storage time and the laboratory sample was obtained as explained above for freshly harvested raw tubers.

2.3. Analytical method

AA concentrations were evaluated by the spectrophotometric method of Egoville et al. (1988). The method is based on the ability of AA to reduce the dye 2,6-dichloroindophenol. Since DHAA is present in very low amount in potatoes we do not evaluate its concentration. Briefly, the 15 g laboratory sample was extracted with an oxalic acid and acetone solution (0.4 and 20%, respectively) by homogenizing in a Sorvall Omni Mixer during 5 min at 4000 rpm. The extract was filtered under vacuum through filter paper Whatman 2 and brought to 100 ml with the same extracting solution. One millilitre of the extract was reacted with 9 ml of 2,6-dichloroindophenol (1.6%) during 1 min and read at 520 nm on a spectrophotometer (SHIMADZU 160UV). The AA concentration was quantified through comparison with a standard curve of L-AA (MERCK).

2.4. Quality control

The implemented analytical method showed a good repeatability with a coefficient of variation of triplicate analyses in 10 different