Journal of Food Composition and Analysis 22 (2009) 556–562

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Original Article

Tuber quality and nutritional components of "early" potato subjected to chemical haulm desiccation

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ARTICLE INFO

Article history:
Received 13 October 2008
Received in revised form 15 December 2008
Accepted 9 January 2009

Keywords:
Early potato
Tuber
Solanum tuberosum L.
Nutritional value
Vitamin C
Antioxidant
Resistant starch
Low-carb potato
Glycemic index in potato
Haulm desiccation
Gluphosinate ammonium
Agriculture and nutrition
Food analysis
Food composition

ABSTRACT

"Early" potato is a typical crop grown in most of the Mediterranean countries, and it is one of the most important horticultural crops exported towards the Northern European markets. In order to improve market value of early potatoes, growers are more and more involved in choosing new potato varieties and constantly looking for methods to improve the commercial quality of tubers. One of the most increasingly used agro-techniques is chemical haulm desiccation, which aims to simplify harvesting and can help to manipulate tuber size distribution and tuber skin-set. Its effect on yield and quality aspects of early potato remains to be better evaluated. This paper resumes results of trials and analysis conducted during 2007 concerning the effect of the application of a chemical desiccant (gluphosinate ammonium) on some relevant nutritional parameters of three early potato varieties (Spunta, Ditta, and Krone) grown in Southern Italy. Tubers from the trials were analyzed for tuber size distribution, flesh and skin colour, dry matter, nitrate, soluble carbohydrates, total and resistant starch, vitamin C, phenol content, and total antioxidant activity. Results indicate that chemical desiccation does not affect the levels of vitamin C and those of other molecules with antioxidant properties as well as those of total soluble carbohydrates. On the other hand, it induces a significant decrease in starch storage and an increase in the percentage of resistant starch (a component of dietary fibre).

1. Introduction

The importance of the potato (*Solanum tuberosum* L.) as one of the world's major staple crops is increasingly being recognised because it produces more dry matter and protein per hectare than the major cereal crops. The nutritional value of potato tubers is the key driver for this growth, along with the economic benefits that potato cultivation can bring to developing economies. The increasing sophistication in the market for fresh potatoes as well as the increasing consumption of processed potato products (including chips, French fries, and a wide range of frozen and chilled products) strongly contribute to maintaining the interest for innovation and yield improvement in potatoes growing in developed countries as well (Van Gijessel, 2005; Mc Gregor, 2007).

The potato tuber has much to offer to health-conscious consumers, as it is virtually free from fat and cholesterol, and is rich in vitamins and potassium. Moreover, it provides significant amounts of protein and dietary fibre, and is relatively low in calories. In spite of genotype and agronomic or pedo-climatic conditions determining noticeable differences in nutritional value, potato tubers are also one of the richest sources of antioxidants in the human diet. These include ascorbic acid (8–54 mg/100 g), polyphenols (123–441 mg/100 g), carotenoids (up to 0.4 mg/100 g) and tocopherols (up to 0.3 mg/100 g) (Buckenhuskes, 2005; Storey, 2007; Leo et al., 2008; Delaplance et al., 2008).

On the other hand, potato tubers are generally considered to have one of the highest glycemic index (GI) of any food, since carbohydrates constitute about 75% of the total tuber dry matter. However, GI values differ between varieties, and "early" (or "new") potatoes seem to have a lower GI than those harvested at full

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doi:10.1016/j.jfca.2009.01.001

maturation because of a different starch structure (Storey, 2007). Recently, there have been several attempts to promote ''low-carb'' potato varieties with health benefits, claimed to have a relatively lower percentage of calories and carbohydrates than the average variety (see, for example, University of Florida, 2004, or http://sunfreshofflorida.com/). These ''low-carb'' potatoes are the consequence of the reduction in the synthesis and/or translocation of sugars in the tubers, or of the increase in the percentage of dietary fibre or other less caloric metabolites. ''Early'' potatoes seem to be good candidates for this purpose, since they have significant low levels of carbohydrate, in particular starch, than main-crop potato (http://www.inran.it/).

''Early'' potato is a typical crop grown in most Mediterranean countries. Its main peculiarity is an earlier harvest in comparison with main-crop potato, as it is harvested and traded from March to June. From a commercial standpoint, early potatoes are traditionally defined as ''potatoes harvested before they are completely mature, marketed immediately after their harvesting, and whose skin can be easily removed without peeling'' (UNECE of Geneva, Standard FFV-52/2006).

Today, consumers' requirements are often associated with visual characteristics of fresh market potatoes such as shape, size and appearance. The characteristics of potatoes after harvesting and cooking are of interest for the consumers (Angós et al., 2008). Potato growers are also more and more involved in choosing new potato varieties, and they are constantly looking for methods to improve the commercial characters of the tubers, such as haulm (leaf and stalk) destruction before harvest. This agro-technique is normally used in order to: (1) reduce tuber skinning at harvest and minimize shrinkage in storage; (2) optimize tuber size distribution; (3) slow the development of diseases such as potato late blight (*Phytophtora infestans*); (4) reduce bruising and mechanical injury during harvest and handling; (5) increase harvest efficiency by reducing vine biomass and weakening stolon attachment (Ronald, 2005). However, haulm destruction before harvest could also affect the storage of molecules of nutritional value in the tubers, including even the carbohydrates.

Potato haulm can be destroyed before tuber harvest by mechanical destruction, chemical desiccation or a combination of both. Chemical desiccants are widely used as they are a quick and effective method of killing potato haulms. Vines are desiccated 10–21 days before intended harvest. During this time interval, tuber skin-set increases, vines decrease in mass, and tubers loosen from stolons. Cultivar, plant maturity at the time of vine desiccation, product type and application rate, as well as environmental conditions can influence the desiccation rate of the haulm (Ivany and Sanderson, 2001). The drawbacks to this agro-technique include reduced tuber yield and size and lower specific gravity. Although photosynthesis stops soon after application of the desiccant, the tubers continue to absorb water. Therefore, in wet years an appreciable increase in tuber size can occur. This water uptake can also reduce tuber dry matter which may affect the suitability of the tubers for processing (Harris, 1992).

While the effects of chemical desiccation on yield and some qualitative parameters (dry matter, stem-end discolouration, skin-set) of main-crop potatoes have been well studied (Ronald, 2005), the effect of desiccation on yield and quality of early potatoes needs to be further investigated. Up to 2007, gluphosinate ammonium (GA) was the only active ingredient admitted in Italy for chemical haulm desiccation of potato crop. The objective of our research was to evaluate the effect of GA on different varieties suitable for early potato production, with special regard to some important qualitative parameters related to the nutritional traits of tubers.

2. Material and methods

2.1. Plant material and growth conditions

The experiment was conducted in 2007 in Apulia Region (Southern Italy), within a variety field trial realised in collaboration with a local potato growers' association. Field soil texture was clay (30.9% sand, 23.3% silt and 45.8% clay), and soil pH and organic matter were 7.9% and 1.9%, respectively. The climate of the region is a typical maritime-Mediterranean.

Within the variety trial, three varieties were chosen: Krone, Ditta, and Spunta. Spunta is the most common variety grown in Mediterranean countries, while Ditta and Krone have been recently introduced at a local level by seed potato companies as promising varieties for early potato production. These varieties are all considered to be suitable for the fresh market, with a comparable ''medium to medium-early'' maturing cycle. Planting date was on 1 February. Potato seed pieces were machine-planted at a distance of 0.20 m in-row and 0.80 m between rows. At planting, fertilizers were applied banded with a total of 150 kg ha^{-1} of nitrogen, 150 kg ha^{-1} phosphorous (as P_2O_5) and 200 kg ha^{-1} of potassium (as K_2O).

A split-plot design with three replications was used, with cultivars set up into the plots and desiccant treatment compared with the control into the sub-plots. Each experimental sub-plot corresponded to 40 m^2 (4 rows 12.5 m long). On 5 June, chemical desiccant (gluphosinate ammonium, Basta®) was applied at first signs of haulm maturity and basal foliage yellowing at 0.48 kg ha^{-1} of active ingredient, according to the technical guidelines defined by the chemical company for the registered formulation (Basta®), by means of a small-plot sprayer which dispersed a volume of 300 L ha^{-1} at a pressure of 275 kPa. The two central rows of each four-row plot were mechanically harvested fourteen days after treatment, on 19 June. Tubers were graded into the following categories: undersized (<35 mm diameter), marketable (35–70 mm), and oversized (>70 mm), then they were counted and weighed. Undersized, green or spoiled tubers were considered as rejects. The tubers derived from the three replications were separately subjected to the analyses.

2.2. Dry weight and nitrate content

In order to measure dry weigh, tuber pulp was maintained in a forced-draft oven at 65 °C until constant weight was reached. The dehydrated tubers were finely milled using an MF 10.1 cutting-grinding head, 25 mm sieve (IKA® Werke GmbH, Staufen, Germany) and used for ion-exchange chromatography analysis of nitrate as reported in Santamaria et al. (1999). Nitrate (NO_3) content was expressed on a tuber fresh weight basis (FW).

2.3. Colour

Five tubers were selected for colour reflectance measurements by a Minolta Chroma Meter CR-200 (Minolta Camera Co. Ltd., Osaka 541, Japan). The external and internal colour was measured on the intact skin and on the freshly cut tuber, respectively. The tri-stimulus values obtained were used to calculate the CIELAB chromatic coordinates: L* refers to lightness and ranges from black (L* = 0) to white (L* = 100) while a* (+a* = red; −a* = green) and b* (+b* = yellow; −b = blue) represent coordinates for hue. From these values, chroma (C*) and hue angles (h°) were calculated based on C* = (a*2 + b*2)0.5 and h° = arctangent b*/a*. While H° (where 0° = red-violet; 90° = yellow; 180° = blue-green; 270° = blue) is useful to quantify the hue expressed by an object, C* is somewhat analogous to colour saturation (McGuire, 1992).