Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 106 (2008) 576–582
Food Chemistry
www.elsevier.com/locate/foodchem

Availability of essential and trace elements in frozen leguminous vegetables prepared for consumption according to the method of pre-freezing processing

Zofia Lisiewska *, Jacek Słupski, Waldemar Kmiecik, Piotr Gębczyński

Department of Raw Materials and Processing of Fruit and Vegetables, University of Krakow, 122 Balicka Street, 30-149 Krakow, Poland

Received 27 January 2006; received in revised form 18 April 2007; accepted 18 June 2007

Abstract

The content of ash and P, K, Ca, Mg, Na, Fe, Zn, Mn, Cu, Cr and Ni was determined in broad bean and pea seeds of milk-wax maturity and in French-bean pods. The investigation covered the raw material; blanched and cooked material and frozen products prepared from blanched or cooked vegetables after 12 months of storage at −30 °C. Frozen products were prepared for consumption either by cooking or by defrosting and heating in a microwave oven. The smallest general loss of constituents caused by blanching was found in broad bean seeds, while the greatest loss was in French-bean pods. Cooking the same batch of the raw material increased the loss by 0–14%, depending on the species and the analysed element. In 100 g of product, prepared for consumption using the modified method (cooking–freezing–defrosting and heating in a microwave oven), the content of ash was greater by 4–12%; of phosphorus by 2–11%; of potassium by 16–36%; of magnesium by 17–31%; of iron by 7–23%; of zinc by 4–12%; of manganese by 4–16% and of copper by 3–13% compared with products obtained using the traditional method (blanching–freezing–cooking). The recorded level of the remaining elements was not always higher: in the case of calcium the difference varied from −2% to +7%; of sodium from −11% to +24%; of chromium from −14% to +9%; and of nickel from −4% to +54%.

Keywords: Broad bean; Pea, French-bean; Freezing; Cooking; Minerals

1. Introduction

Leguminous vegetables are characterised by a high content of carbohydrate compounds, proteins and group B vitamins (Kunachowicz, Nadolna, Przygoda, & Iwanow, 2005; Souci, Fachmann, & Kraut, 2000). Hence the researchers paid special attention to the above-mentioned nutrients. Only a few previous works deal with the content of mineral compounds in these vegetables and the products obtained from them, despite the fact that they are a rich source of these compounds (Kunachowicz et al., 2005).

In the climatic conditions of central-eastern Europe, the leguminous vegetables most popularly grown and consumed are pea and broad bean, at the stage of milk-wax maturity and French-beans. Unfortunately, the consumption of these vegetables is still too low in comparison with dietary recommendations (WHO/FAO Expert Report, 2003). This may be due to incorrect dietary habits but also due to the insufficient supply of ready-to-eat products easily prepared by the consumer.

Only a small amount of the species mentioned above are consumed directly after harvest, since the period of their supply during the growing season is very short. Both broad bean and pea, as well as French-bean, are valuable raw materials for canning and freezing. In contrast to frozen products, canned food can be consumed without further culinary preparation. However, as Kmiecik, Lisiewska, and Jaworska (2000); Korus, Lisiewska, and Kmiecik (2003); Lisiewska, Kmiecik, and Gębczyński (1999) and

* Corresponding author. Tel./fax: +48 12 662 47 57.
E-mail address: rrlisiew@cyf-kr.edu.pl (Z. Lisiewska).

0308-8146/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2007.06.025

Lisiewska, Korus, and Kmiecik (2002) report, frozen products retain greater amounts of almost all chemical constituents compared with canned food, even after preparation for consumption by cooking in water.

The aim of this work was to evaluate the retention of the level of ash and 11 mineral constituents in frozen leguminous vegetables, prepared for consumption after 12 months of refrigerated storage. The investigation included seeds of pea and broad bean at the stage of milk-wax maturity and pods of French-bean. The investigated products were obtained using the traditional and the modified freezing processes, the modification being cooking to consumption consistency instead of blanching before freezing.

2. Materials and methods

2.1. Material

The investigated material consisted of three species of leguminous vegetables, namely broad bean – *Vicia faba* var. major (Windsor Biały cv.), pea – *Pisum sativum* – (Konsul cv.) and French-bean – *Phaseolus vulgaris* – (Delfina cv.). The seeds of broad bean and pea were at the stage of milk-wax maturity. The content of ash, P, K, Ca, Mg, Na, Fe, Zn, Mn, Cu, Cr and Ni was determined in fresh vegetables (A), after blanching (B), after cooking in 2% brine to consumption consistency (C); and in frozen products from samples B and C, after 12 months of storage at −30 °C and then prepared for consumption. Frozen products from sample B were cooked in brine, this yielding sample D and frozen products from sample C were defrosted and heated in a microwave oven, yielding sample E.

The raw material was obtained from the experimental field of the department carrying out the technological and analytical investigations. During the cultivation, all agrotechnological recommendations regarding soil preparation, fertilisation, sprinkling and plant protection against diseases and pests were taken into consideration.

2.2. Preparation of frozen products

Two variants of the pre-freezing treatment of the raw material were used. In variant I, which followed the traditional technology, the raw material was blanched and frozen and after refrigerated storage the product was cooked to consumption consistency. In variant II the raw material was cooked to consumption consistency before freezing and the subsequently frozen product was defrosted and heated to consumption consistency, in a microwave oven.

In variant I the raw material was blanched in water, in a stainless steel vessel at 95–98 °C, the proportion of the raw material to water being 1:5. The blanching time for the broad bean was 3 min 15 s, for French-bean −3 min and pea −2 min 30 s. The applied parameters of blanching brought about a decrease in the activity of catalase and peroxidase, to a level below 5% of the initial value. After blanching, the material was immediately cooled in cold water and left on sieves for 30 min to drain.

In variant II the vegetables were cooked in a stainless steel vessel in water, with 2% table salt, the proportion of the raw material to water being 1:1. The vegetables were put into boiling water. The time of cooking from the moment when the water came to the boil again was 12 min, 9 min and 8 min for broad bean, French-bean, and pea, respectively. After cooking to consumption consistency the material was placed on sieves and cooled in a stream of cold air.

The material from the blanched and cooked samples was placed on trays and frozen at −40 °C in a Feutron 3626-51 blast freezer. The time taken for the inside of the frozen products to reach the storage temperature of −30 °C was 120 min. The frozen products were packed in 500 g polyethylene bags and stored for 12 months.

2.3. Preparation of frozen products for evaluation

Samples blanched before freezing (B) were cooked in 2% brine, the proportion of brine to frozen product being 1:1. As in the case of cooking the raw material, frozen products were put into boiling water. The cooking time was measured from the moment the water came to the boil again. The cooking time was 8 min for broad beans and 6 min for French-beans and peas. After cooking, the water was immediately drained and the product was cooled to 20 °C (sample D being obtained) and analysed. Samples of the vegetables cooked before freezing were put into a covered heat-resistant vessel, defrosted and heated in a type NN-F 621 Panasonic microwave oven (sample E being obtained). The time taken to defrost and heat the product to 75 °C (Codex Alimentarius, 1993) was 8 min 15 s for all samples.

Whenever table salt was added, it was from the same batch.

2.4. Chemical analyses

The level of moisture was determined using the method given in AOAC (1984, 32.064). The content of ash was determined by incineration in a Nabertherm model L 9/S 27 furnace oven at 460 °C. In order to determine the level of individual mineral elements, the material was mineralised in a 3:1 mixture of nitric and perchloric acids. A 50 g portion of the material and 30 cm^3 of the acid mixture were placed into 250 cm^3 test tubes of the Tecator Kjeltec Auto Plus II mineralisation set. The treated samples were left until the next day, when complete mineralisation was carried out. The mineralised samples were diluted with ultra-pure water to a volume of 100 cm^3 and filtered into dry flasks. There was no residue left after filtration. The content of the individual elements in the solution was determined using an inductively coupled argon plasma