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ScienceDirect
Food Chemistry 102 (2007) 1034–1041
Food Chemistry
www.elsevier.com/locate/foodchem

Protein and starch content of raw, soaked and cooked beans (*Phaseolus vulgaris* L.)

Montserrat Pujolà, Albert Farreras, Francesc Casañas *

Departament d'Enginyeria Agroalimentaria i Biotecnología, Escola Superior d'Agricultura de Barcelona, Universitat Politecnica de Catalunya, Campus Baix Llobregat, Edifici ESAB, 08860 Castelldefels, Spain

Received 1 December 2005; received in revised form 3 February 2006; accepted 22 June 2006

Abstract

Organoleptic qualities are an important factor in the market value of legumes, especially in developed countries. Unfortunately, the molecules that have the greatest influence on the texture of beans undergo important transformations during soaking and cooking. Moreover, the extent to which these changes are linear is unknown, making uncertain the use of raw beans in chemical screenings for sensory properties. Results of our experiments show that the amount of protein and amylose present in raw beans provides a good indicator of these substances in cooked beans (correlation coefficients between raw and cooked beans = 0.91, $p \leqslant 0.001$ and 0.87, $p \leqslant 0.01$, respectively). The Mg content in the raw seed coat also shows a strong correlation with that found in the cooked seed coat ($r = 0.86$, $p \leqslant 0.01$). The correlations found for the other traits are weaker, indicating that the evaluation of raw samples is not predictive of the findings in cooked beans.

Keywords: Common beans; Soaking; Cooking; Chemical changes; Texture prediction in cooked beans

1. Introduction

Dry beans have recovered prestige in the diets of developed countries. This is due, in part, to health problems related to meat consumption, as well as the discovery of the benefits of legumes in the diet and the protection they afford against colon disease (Champ, 2001; Hangen & Bennink, 2003; Lee, Prosky, & DeVries, 1992; Mathres, 2002).

Consumers in these wealthy countries seek high organoleptic qualities. Unfortunately, breeders and producers in the second half of the twentieth century disregarded the obtainment and promotion of varieties with high organoleptic qualities. Consequently, most information available about the properties of legumes in general and beans in particular refers to their production and nutrition-related chemical composition (Broughton, Hernández, Beebe, Gepts, & Vanderleyden, 2003). The lack of information about sensory characteristics makes the objective description of materials and their genetic improvement difficult from this perspective.

One of the most highly appreciated aspects of beans in gastronomy is their texture, although the main chemical components for this characteristic are uncertain for both the seed coat and the cotyledon. Uronic acids seem to play a role in the perception of the seed coat (Casañas, Pujola, Bosch, Sánchez, & Nuez, 2002; Wang, Chang, & Grafton, 1988), as does the content of Ca and Mg (Quenzer, Fuman, & Burns, 1978). The protein and starch (with its components) content must contribute to the texture, considering their quantitative importance in the seed, their properties in other foods (Champagne, Bett-Garber, McClung, & Bergman, 2004; Ong & Blanxhard, 1995; Park, Kim, & Kim, 2001; Ramesh, Bhattacharya, & Mitchell, 2000) and similar findings in beans (Pujolà et al., 2004).

At present, we need trained panelists working with cooked beans to evaluate the sensory properties of beans.

* Corresponding author. Tel.: +34 935521215; fax +34 935521121.
E-mail address: francesc.casanas@upc.edu (F. Casañas).

0308-8146/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2006.06.039

Both the method of evaluation (sensory panel) and the state of the product (cooked) place severe limits on the number of samples that can be evaluated. For this reason, it would be helpful to handle chemical or instrumental approximations, to describe materials objectively, in order to evaluate the genetic and environmental influences on sensory qualities and thus enable selection. Eliminating the need for cooking would also simplify the evaluation of these traits but the cooking process has been shown to affect chemical parameters such as fibre (Kutos, Golob, Kac, & Plestenjak, 2003; Rehman & Shah, 2004).

As mentioned above, there are some indications regarding the factors responsible for texture in beans. To estimate the sensory value of the cooked beans from the concentration of some of these components would be very valuable. Unfortunately, limited information is available on this subject (Casañas et al., 2002; De Almedia Costa, Queiroz-Monici, Pissini, & de Oliveira, 2004; Hosfield & Uebersax, 1980; Hosfield, Uebersax, & Isleib, 1984).

Against this background, our aim is to determine to what extent the chemical composition of raw or soaked beans is a reliable indicator of their chemical composition after cooking, and thereby determine whether the chemical composition of raw and/or soaked beans would be useful in the evaluation of their texture after cooking.

2. Material and methods

2.1. Genetic material

The Spanish landraces (traditional varieties) Planchada, Tolosa, Faba, Genoll de Crist, Castellfollit del Boix and Ganxet, and the American variety Midland (Navy market class (Santalla, De Ron, & Voysest, 2001)) were used. Planchada is white and flat, has a 57 g/100 seed weight, and belongs to the Large Great Northern market class (Santalla et al., 2001), Tolosa is dark and rounded, has a 40 g/100 seed weight, and belongs to the Negro Brillante market class (Santalla et al., 2001), Faba is white and elongated, has a 93 g/100 seed weight and belongs to the Faba market class (Santalla et al., 2001), Genoll de Crist is white, with a brown spot around the hilum, and rounded, has a 39 g/100 seed weight, and belongs to the Rounded Caparron market class (Santalla et al., 2001), Castellfollit del Boix is white and flat, has a 44 g/100 seed weight, and belongs to the Great Northern market class (Santalla et al., 2001), and Ganxet is white, flat and kidney shaped, has a 52 g/100 seed weight (Bosch, Casañas, Sánchez, Pujolà, & Nuez, 1998), and belongs to the Hook market class (Santalla et al., 2001).

All varieties had been shown to be clearly different from a sensory perspective (Casañas et al., 2004; Pujolà et al., 2004) and enjoy great prestige in gastronomic and/or industrial uses. Each variety was cultivated in Spain in the region where it most fully develops its organoleptic traits. For the Ganxet variety, samples from three different locations within the most favourable growing area for this bean were used (Ganxet 10, Ganxet 11 and Ganxet 53). Previous experiments (Casañas et al., 2004; Pujolà et al., 2004) have shown that these varieties exhibit a wide range of variation for the texture of the seed coat and cotyledon, as well as for their chemical composition.

2.2. Chemical analyses

On the basis of previous experiments (Pujolà et al., 2004), as well as those of other authors with beans or different grains (Champagne et al., 2004; Ong & Blanxhard, 1995; Park et al., 2001; Ramesh et al., 2000) the most important molecules involved in texture are taken to be protein, starch (amylose, amylopectine), and seed coat Ca and Mg. Resistant starch was also analyzed because it is considered to be a fermentable component (together with the raffinose group) and therefore related to the protective capacity attributed to beans on the colonic mucosa.

2.2.1. Samples and sample preparation

The nine samples were analyzed in the following states: raw (full seed), soaked (full seed and seed coat) and cooked (full seed and seed coat). Raw seeds of each type were dried to constant weight and ground to pass through the 0.5 mm screen of a mill (Laboratory Mill 3100, Perten).

Another fraction of each sample was soaked for 24 h at 20 °C (2500 ml of tap mineral water were added to 500 g of bean seed). After soaking, the seed coats (episperm) of randomly chosen seeds were separated from the rest of the seed (endosperm plus embryo) and were dried to constant weight allowing calculation of the ratio of the seed coat weight to the total weight (seed coat proportion, as a percentage). Both seed coat and a sample of soaked full seed were then separately milled.

A fraction of the soaked seeds was cooked in low mineralized water until the optimum state for consumption was reached. Cooked beans were processed like soaked beans, to obtain milled samples of seed coat and full seed.

The moisture content of all fractions was determined by gravimetric heating (65 °C, 48 h) in a convection oven.

2.2.2. Crude protein was determined using the Kjeldahl method

(AOAC, 1990), quantifying the amount of nitrogen by selective ammonium electrode. Crude protein content was then calculated as $\%N \times 6.25$.

2.2.3. Starch content was determined using the Official AOAC (1997)

Glucose was determined by HPLC chromatography. The total starch was calculated as glucose $\times 0.9$.

2.2.4. Amylose and amylopectin

Amylose content was analyzed using the methodology proposed by Juliano et al. (1981). The complex coloration amylase/iodide was determined using a UV/Visible spectrophotometer ($\lambda = 620$ nm). The amylopectin content