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Influence of blanching, freezing and frozen storage on physicochemical properties of broad beans (*Vicia faba* L)

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ABSTRACT

We evaluated the effects of blanching, freezing and frozen storage (5 months at −18 °C) on the physicochemical properties of broad beans at milk maturity stage. Times for minimal blanching (120 s) and over-blanching (180 s) were determined in a preliminary experiment. Frozen storage for five months caused 31% and 34% total chlorophyll degradation in minimally blanched and overblanched beans, respectively. Color differed greatly between fresh and blanched then frozen beans. Blanched then frozen samples showed increased firmness compared with fresh beans and decreased firmness following frozen storage, regardless of the blanching time. In sensory evaluation of cooked beans, a significant reduction in texture was found in overblanched beans compared with unblanched beans. These findings demonstrate that blanching adversely affects this vegetable and that deterioration reactions do not cease during frozen storage.

Influence du blanchiment, de la congélation et de léntreposage frigorifique sur les propriétés physicochimiques des fèves (*Vicia faba* L)

Mots clés : Fève ; Blanchiment ; Congélation ; Propriétés physico-chimiques

1. Introduction

Regarded as being of high nutritive and biological value (Lisiewska et al., 2007), broad beans are ranked among the world's most competitive grains legume crops, nutritionally equivalent to soybean products (Arogundade et al., 2006). In Chile like in Europe, broad beans are usually consumed before the seeds attain physiological maturity, that is, at the so-called milk maturity stage, corresponding to dry matter content near of 23% (Schmidt-Hebbel et al., 1992). With this

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content of dry matter the seed are perishable and their consumption can by only prolonged by canning or freezing (Kmiecik et al., 1999; Lisiewska et al., 1999).

Freezing of foods is an efficient process of food preservation because in frozen state, water is immobilized as ice and the rates of deterioration are much slower than at higher temperatures. However, this technology that stands on two basic prerequisites to deliver high quality products (1) Rapid freezing rates; and (2) Frozen storage at low and constant subfreezing temperature (Petzold and Aguilera, 2009). During frozen storage, the properties of vegetables are greatly influenced by storage conditions, especially temperature and time, even at low temperatures, suffering important quality attributes modification as a result of the action of biochemical activity, chemical and physical phenomena (Giannakourou and Taoukis, 2003). Therefore, any elevation in temperature above the designed storage temperature (normally −18 °C) tends to reduce the quality of frozen foods, and fluctuations in storage temperature tend to be even more detrimental to product quality (Singh and Heldman, 2001). In this way, the effect of conditions during frozen storage on the quality of vegetables as potato (Alvarez and Canet, 2000), strawberry and broccoli (Gormley et al., 2002) and green beans (Martins and Silva, 2002, 2003) has been documented.

A critical step prior to freezing vegetables is the blanching process, thermal treatment commonly applied in a variety of vegetable preservation treatments and is particularly important in freezing because of its very considerable influence on quality. The primary objective is to inactivate enzymes responsible for alterations in sensory quality attributes (off-flavors and odors) and in nutritional value (loss of vitamins) during storage (Canet and Alvarez, 2006). However, the severity of the thermal process should be limited in order to maintain color, texture, flavor and nutritional quality (Barrett et al., 2000).

The objective of this study was to evaluate the effects of blanching, freezing, and frozen storage (5 months) on chlorophyll, CIE Lab color, firmness and sensory evaluation of broad beans (*Vicia faba* L).

2. Materials and methods

2.1. Sample preparation

Broad beans (*Vicia faba* L) var. major (Aguadulce cv.) at the milk maturity stage weighing approximately 1.6 kg (1000 seeds) and seeds have an attractive pale green color. In Chile, this cultivar is mostly used for consumption as fresh or frozen vegetable (ODEPA, 2012).

Fresh broad beans were purchased from a local supplier (fruit and vegetable terminal, Chillán, Chile). Broad beans were kept in refrigeration (5 °C) for 12 h in pods until processing.

Broad beans were removed from their pods (grains of approximately 2.5 cm length), unhulled (discarding the very small grains, *i. e.*, length minors of 1.5 cm), washed with cold water, drained and blanched at 100 °C with steam (exhauster MSM®, model 3000/1/INX, Santiago, Chile) in relation 1:3 (sample: boiling water) for 60, 90, 120 and 180 s.

This procedure was done with three replications at a first stage to determine the blanching minimal time for peroxidase inactivation. In a second stage, samples were blanched at two time of blanching: minimal time for peroxidase inactivation and the next time of blanching (over blanching).

After the broad beans were blanched, they were cooled in cold water for 3 min, drained, and frozen on metal trays in a blast freezer (Friosur, Chillán, Chile) with an average air temperature of −35 °C, with an air velocity of 0.6 m s^{-1}, until the temperature of −18 °C was recorded with a needle-type thermocouples (Ellab A/S, Rodovre, Denmark) type T (copper-constantan) placed in the center of a broad bean test sample. Approximately 500 g of frozen broad beans were immediately put into polyethylene bags and thermally sealed. Packed broad beans were stored at −18 °C in a freezer (Friosur, Chillán, Chile). The samples were analyzed after being thawed at 5 °C for 1 h (also characterized the fresh material and cooked samples for sensorial evaluation) at time zero and 5th month of frozen storage, and were sampled from random locations inside the freezer.

2.2. Peroxidase activity

2.2.1. Extraction procedure

Ten gram of sample and 1 g of PVPP (polyvinylpyrolidone) were homogenized with 20 ml of cold (4 °C) 0.2 M sodium phosphate buffer (pH 6.5). After blending for 1 min, the homogenate was filtered through 2 layers of cheesecloth; and then the solution was centrifuged (4 °C) at 14.000 rpm for 30 min. The supernatant was filtered through Whatman #1 paper and kept on ice until analyzed. Two independent extractions per treatment were performed in triplicate.

2.2.2. Enzymatic assay

Preparation of the substrate solution required mixing 0.05 M guaiacol, 0.2 M H_2O_2, 0.2 M sodium phosphate buffer (pH 6.5) and distiller water in a ratio of 1:1:1:7 v/v/v/v. Three mL of this substrate solution were added to 25 μL of enzyme extract. The reaction was monitored for 3 min at 420 nm in triplicate. Equipment used for the assay was a multicell spectrophotometer (UV–VIS spectrophotometer, model Genesis 2PC, Spectronic, Japan) and a 1-cm path length quartz cuvette. The enzyme activity was obtained by the slope of the resulting absorbance (420 nm) v s time ($\Delta A\ min^{-1}$) and expressed in units of peroxidase per ml of sample (U ml^{-1}).

2.3. Analysis of physicochemical properties

Broad bean color was evaluated using a Minolta Chroma Meter CR–200 (Minolta Corp., Osaka, Japan). The instrument was calibrated with a standard white plate ($L = 97.59$, $a = -0.07$, $b = 1.59$). CIE Lab coordinates used D_{65} illuminant, with a 2° observer as reference system. A glass Petri dish containing a sample was placed above a white plate, and the L (lightness, black = 0, white = 100), a (redness > 0, greenness < 0), and b (yellowness, b* > 0, blue < 0) were recorded. Ten replicates were performed for each treatment and then mean values were reported. Hue angle (h^*_{ab}, hue angle, red = 0°, yellow = 90°, 180° = green, 270° = blue), chroma (C^*_{ab}, 0 at the center of the color sphere) and total color change (ΔE^*) were also calculated