Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 106 (2008) 310–314
Food Chemistry
www.elsevier.com/locate/foodchem

Effect of canning process on texture of Faba beans (*Vicia Faba*)

I. Revilla *, A.M. Vivar-Quintana

Food Technology Area, University of Salamanca, E.P.S of Zamora, Avda. Requejo 33, 49022 Zamora, Spain

Received 16 May 2005; accepted 26 February 2007

Abstract

The effects of different treatments such as traditional cooking, sterilizing at different time–temperature combinations and the addition of different brines on instrumental texture were evaluated. Previously, a comparison of different texture-measuring devices and optimisation of instrumental texture analysis were carried out. The results showed that all the texture-measuring devices used differentiated perfectly among the different products tested. Regarding heat treatments assayed, different sterilization treatments affected skin texture but had no significant effect when whole grain was considered. Finally, the addition of chelation agents to the brine did not affect the textural parameters but the commercial quality related to the production of Faba beans under a "Geographical Indication" had an important effect on the firmness of both the pericarp and whole seed and on pectin content.

Keywords: Texture analysis; Sensory analysis; Canning process; Brine; Pectin; Quality

1. Introduction

Texture is an important quality aspect of vegetable food products. Both the control and the modification of texture are major objectives in modern food technology. To achieve these objectives it is necessary to have available precise, repetitive and reproducible tools to study and monitor the changes along the different technological processes employed. Instrumental texture analyses have been applied to measure firmness in legumes using different devices as shear cell (Stolle-Smits, Beekhuizen, Recourt, Voragen, & van Dijk, 2000; Stolle-Smits, Donkers, van Dijk, Derksen, & Sassen, 1998), wedge-type blade (Abu-Ghannam, 1998), compressed with a flat platen or penetrated with cylindrical probes (Bay, Bourne, & Taylor, 1996; Taiwo, Akanbi, & Ajibola, 1997). However, the commonest technique used is to evaluate the texture by sensory evaluation (El-Moniem, 1999; El-Moniem, Honke, & Bednarska, 2000; Wang, Chang, & Grafton, 1988). Nevertheless, no comparisons among the different devices have been carried out and there is a lack of information concerning the differences when textural analysis is referred to the pericarp, albumen or whole grain. In a search of the literature, no references were found comparing sensory and instrumental analyses of Faba beans, the legume considered here.

Dry bean processing usually requires an initial hydration stage in order to facilitate faster cooking and to reduce anti-nutritional factors (Frias, Vidal-Valverde, Sotomayor, Diaz-Pollan, & Urbano, 2000; Quast & da Silva, 1977; Vidal-Valverde et al., 2002). The hydration step elicits substantial reduction in the hardness of the beans due to the increase in moisture content, but changes in hardness reach a stage of equilibrium once specific moisture content has been attained (Abu-Ghannam, 1998).

When legumes are processed thermally, first turgor is destroyed, leading to a loss of crisp succulence. Blanching, cooking and sterilization affect the tissues of vegetables, leading to a decrease in firmness that is mainly due to changes in cell-wall pectins during heating, in turn leading to the formation of soluble pectins by β-eliminative degradation of methylated pectins (Reeve, 1970; Sajjaanantakul, Van Buren, & Downing, 1989; Van Buren, 1986). A strong

* Corresponding author. Tel.: +34 980 545000; fax: +34 980 545002.
E-mail address: irevilla@usal.es (I. Revilla).

0308-8146/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2007.02.046

correlation between firmness and soluble pectin has been found in several bean cultivars (Wang et al., 1988).

Differences in the thermal treatments employed may affect the final texture of legumes. Previous works have shown that increasing cooking time results in a softening of cowpea texture that can be attributed to the gelatinisation and hydrolysis of starch (Sefa-Dedeh, Stanley, & Woisey, 1978; Taiwo et al., 1997). However, in other cases sensory panels have indicated the absence of significant differences between Mung beans cooked for different times (El-Moniem, 1999). Regarding the sterilization process reaching the same F value, lower temperatures and higher times afford beans with lower firmness (Wang et al., 1988).

Other sources of textural variability are the presence of different additives in the brine and the selected cultivar. The addition of $CaCl_2$ or EDTA improves the firmness of canned beans (Wang et al., 1988), and the different cultivars show different characteristics of tenderness and cooking quality (Escribano, Santalla, & de Ron, 1997; Stolle-Smits et al., 1998)

The Faba bean, of the Major variety, which has large white seeds, is a crop of significant importance in northwest of Spain. This type of bean is produced on small farms following traditional methods, and indeed recently they have aroused considerable interest owing to their good seed quality and high price. They are mainly sold in the dry state although for further commercialisation they are also sold canned. However, commercialisation of the product in this form has received little attention in the past and hence an optimisation of the canning process became necessary (Revilla & Vivar-Quintana, 2004). The following step necessary is to study the effect of variables related to the canning process on the properties of Faba beans, especially on their final texture.

2. Materials and methods

2.1. Samples

The samples used in this study were obtained from a local market of Zamora (Spain). Two types of dry Faba beans (var. Major) were selected: *Habón de Sanabria* (HS), Faba beans of extra quality, cultivated on small farms with traditional methods in the Sanabria region, north-western Spain, and only available in markets of artisan products; and Reference (R), Faba beans of good quality and broadly commercialized without Geographical Indication. Both of them have large white seeds of similar appearance but the second one are cheaper. The mean weight of the beans selected was 2 g per seed.

The samples were soaked in water with low Ca^{2+} content (80 mg Ca^{2+}/L) at 12 °C for 12 h. Following this they were strained to remove the water and the increase in weight was recorded. After soaking and draining different cooking and autoclaving process were implemented.

Cooking procedure: 200 g of the samples under consideration were cooked in water with 2% of NaCl at atmospheric pressure for the following periods: 30, 60 and 90 min. The cooking water was drained off and the seeds were analysed.

Autoclaving procedure: 150 g of sample were placed in glass cans, filled with brine containing 2% of NaCl, closed and processed thermally in an autoclave (Selecta, Barcelona, Spain) at 110 °C for 40 min or at 115 °C for 20 min, giving a sterilization value of $F = 3$.

For the last trial two different brines were used containing (a) 2% of NaCl and (b) 2% of NaCl and 0.2% of E.D.T.A.

2.2. Texture analysis

The texture of the samples was determined using a Texture Analyser (Model XT2i; Stable Micro Systems, England). The analysis employed was the return-to-start (RTS) method, measuring force under compression with a Warner–Bratzler shear cell, a 10 mm cylindrical probe (P10) and a 2 mm cylindrical probe (P2), recording the peak of maximum force. Whole bean or cotyledon sections (8 replicates) were prepared and each section was axially compressed to 75% of its original height for penetration probes and to accomplish sample cutting with the Warner–Bratzler probe. Force-time curves were recorded at a speed 1 mm/s for cylindrical probes and 2 mm/s for Warner–Bratzler shear cell. The results were expressed in grams.

2.3. Pectin analysis

Total pectin was measured in wine alcohol insoluble residues after their acid hydrolysis (Proctor & Peng, 1989). The Robertson method (1979) was used to quantify the total pectin content which was expressed as mg/L of galacturonic acid.

2.4. Sensory analysis

Descriptive analyses were carried out by twelve trained testers on the canned samples (50 g), which were heated up to 70 °C and presented to the panel without brine. Selected parameters were albumen hardness, pericarp hardness, grain integrity, flouriness, creaminess and granulosity (Table 1) which were evaluated on a structured scale of six

Table 1
Definition of descriptors for the sensory profiling

Descriptors	Definitions
Albumen hardness	Resistance of the albumen to chewing
Pericarp hardness	Resistance of the skin to chewing
Grain integrity	Presence or not of missing or broken parts on the bean
Flouriness	Floury sensation in the mouth
Creaminess	Sensation of gentle, soft contact lining the mouth
Granulosity	Sensation of small hard granules in the mouth

points, ranging from 0 to 5, where the 0 value corresponded to the lowest intensity of attribute and 5 to the highest intensity of attribute.

2.5. Statistical analysis

Data were analysed by one-way analysis of variance (ANOVA). The statistical significance of each factor considered was calculated at the $\alpha = 0.05$ level using the F-test. The LSD Fisher-test was employed to test for statistically significant differences between samples. All statistical analyses were carried out using the Statgraphic Plus for Windows Computer Package (1995 Manugistics, Inc.).

3. Results and discussion

3.1. Comparison of texture-measuring devices

In order to choose the most appropriate probe to analyse the texture of Faba beans, different devices -cylindrical probes and shear cell probe, used in other research works to evaluate legumes- were assayed (Stolle-Smits et al., 2000; Stolle-Smits et al., 1998; Taiwo et al., 1997).

Optimisation of the texture measuring method was carried out using Faba beans that had been soaked (maximum water absorption of 106%) and cooked at atmospheric pressure for three different periods (30, 60 and 90 min). These samples were previously assessed on the basis of their sensory characteristics as being of hard pericarp and albumen and very high grain integrity for Sample 1; soft pericarp and albumen and high grain integrity for Sample 2, and very soft pericarp and albumen but low grain integrity for Sample 3.

The first method used was a penetration test using two different probes, a 10 mm cylindrical probe and a 2 mm cylindrical probe, in both cases with an assay speed of 1 mm/s and a compression distance of 3 mm. Faba beans were divide into two halves and both pericarp and albumen zones were analysed with the two probes.

The second method used a shear cell, the Warner–Bratzler probe, with an assay speed of 2 mm/s and 30 mm of distance, necessary to completely cut the Faba grains. Whole Faba beans were used in this test.

The results obtained (Table 2) point to the existence of statistically significant differences between the samples as regards all the probes assayed, together with a positive correlation between the sensory and instrumental results. In principle, this indicates the appropriateness of all types of probes used for Faba bean textural analysis.

These results are consistent with those reported in previous works, which reported that increased cooking time results in a softening of texture (Sefa-Dedeh et al., 1978; Silva, Bates, & Deng, 1981; Taiwo et al., 1997) both of skin and albumen, and consequently of the whole seed. As expected, on comparing P2 and P10 probes, the maximum force increased with the contact area.

Because all the probes differentiated perfectly between the samples and preparation for the Warner–Bratzler probe was easier, this probe was selected for the following assays, together with the P2 probe for skin only. The reason for choosing this later assay is that in some cases the albumen is soft but the sample has a hard skin. Due to its small area, the P2 probe affects only the skin and could help to differentiate these samples.

3.2. Effect of canning treatment

Heat treatment is particularly important in the preparation of legumes for consumption from the point of view of acceptability. In order to optimise the autoclaving treatment for Faba beans, two temperature/time combinations (110 °C/40 min; 115 °C/20 min), were compared with the cooking treatment determined previously as optimal by the members of the sensory panel: (Sample 2, 60 min at atmospheric pressure).

The results of the instrumental texture analysis with Warner–Bratzler probe showed that the values for the autoclaved samples were slightly lower than for the cooked ones (Fig. 1), although there were no statistically significant differences in the texture of whole seeds among the three methods used. According to these results, both sterilizing methods would be appropriate.

Notwithstanding, there were differences in skin hardness among all the samples. Regarding the two sterilization methods used, the higher temperature used (115 °C) improved pericarp firmness and this is in agreement with

Table 2
Comparison between texture-measuring devices

	P2 probe		P10 probe		Warner–Bratzler
	Pericarp	Albumen	Pericarp	Albumen	Whole seed
Sample 1	414.58[c]	293.67[c]	2338.97[c]	3601.65[c]	1109.94[c]
Sample 2	100.71[b]	126.69[b]	759.93[b]	512.18[b]	632.24[b]
Sample 3	80.34[a]	33.86[a]	408.19[a]	334.95[a]	333.75[a]

[a–c]Different letter means differences statistically significant at $\alpha = 0.05$.

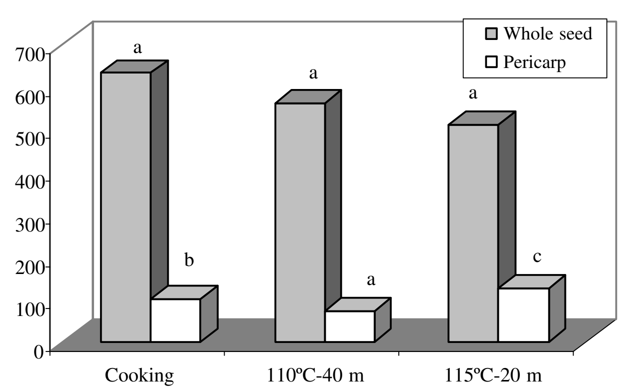

Fig. 1. Effect of different heating treatments on instrumental texture. ([a–c]Different letter means differences statistically significant within the series at $\alpha = 0.05$.)

the results of previous works (Wang et al., 1988). The softest skin corresponded to the 110 °C at 40 min combination, but the product showed lower grain integrity. These results also showed the usefulness of the P2 probe for differentiating similar samples on the basis of the hardness of their skin.

Another source of variability in texture was the presence of different additives in the brine. In order to study this issue, Faba beans cans were elaborated using two brines that differed in the presence or not of EDTA in brine. This chelator agent should decrease the hardness of the product (Revilla, Vivar-Quintana, & Fuentes-Cuervo, 2004). For this trial the samples were autoclaved at 115 °C for 20 min. This process had previously been seen to produce the best textural characteristics.

The results showed that there were no significant differences in instrumental texture either in skin or in whole seed hardness due to the presence of EDTA in the brine (Fig. 2). Regarding the total pectin content of the brine, there were no statistically significant differences between brines, in agreement with the results of both sensory and instrumental firmness.

The sensory parameters did not show statistically significant differences for any of the parameters considered (Fig. 3). Thus, the addition of chelating agents to the brine did not modify the textural characteristics of the product, probably due to the low content in calcium of the water used in the trial. The results for instrumental texture differ from those reported previously for beans, describing greater hardness when EDTA and $CaCl_2$ were added (Wang et al., 1988).

The last variable considered was the Faba bean commercial quality. Cans of two different dry Faba bean qualities were elaborated; one of them was of extra quality produced only in a small area of Spain under traditional methods and is called *Habon de Sanabria*. This Faba bean is very popular and is expensive due to its high quality. It has very soft skin and albumen, and these organoleptic properties determined objectively, could be an efficient way to measure any differences with other

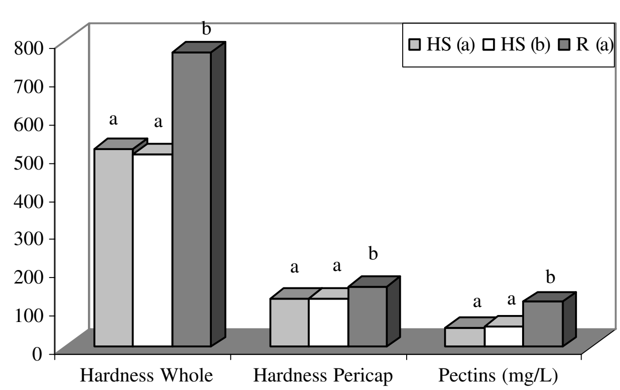

Fig. 2. Effect of brine and variety on instrumental texture and pectin content of brine. ([a–c]Different letter means differences statistically significant between treatments at $\alpha = 0.05$.)

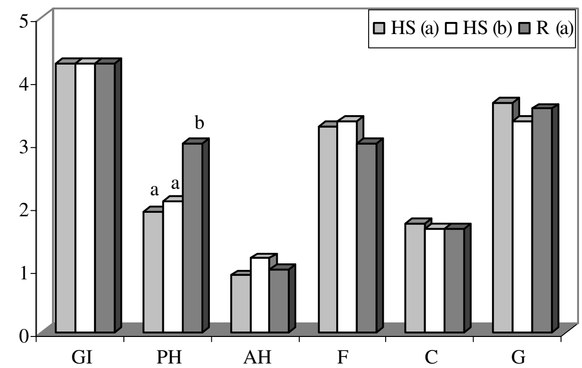

Fig. 3. Effect of brine and variety on sensory analysis. (G: grain integrity; PH: pericarp hardness, AH: albumen hardness, F: flouriness; C: creaminess; G: granulosity). ([a–c]Different letter means differences statistically significant between treatments at $\alpha = 0.05$.)

similar products in order to establish a "Protected Geographical Indication". In order to test this, samples of *Habon de Sanabria* Faba beans (HS) were compared with another commercial Faba bean used as reference (R). This latter seed is very similar in colour and size, but its price is lower and is considered harder by consumers (Revilla & Vivar-Quintana, 2004). Previous results had shown there were no differences due to the brine composition, and hence the final trials were elaborated with brine (a) without E.D.T.A.

The results revealed statistically significant differences as regards the instrumental texture between the two kinds of seeds (*Habón de Sanabria* and Reference), hardness (skin and whole seed) being lower for the *Habón de Sanabria* beans (Fig. 2). These results point to the usefulness of textural analysis to discriminate between two products very similar in appearance but with different textures.

Analysis of soluble pectins in the brine showed statistically significant differences between the two types of Faba beans. The Reference Faba beans had higher values of soluble pectins than the *Habón de Sanabria* type. These results and those observed previously when the effects of two brine types were compared were in agreement with previously reported findings describing a high correlation between firmness and the amount and type of pectin (Stolle-Smits et al., 2000; Wang et al., 1988). In this study, the higher the content of total pectin in the brine the greater the firmness of the canned Faba beans. This is probably due to the higher content of pectins in the pericarp of harder beans and the greater dissolution into the brine during the heating process.

Regarding the sensory parameters (Fig. 3), no statistically significant differences were detected in the majority of these, except for pericarp hardness, which showed a higher value for the Reference than for the *Habón de Sanabria* Faba beans. This result is in agreement with the values found in instrumental texture analysis and show that the significant differences in canned Faba beans are mainly found in pericarp.

4. Conclusions

The results of the present study point to the usefulness of instrumental textural analysis in establishing the effects of different variables on the quality of canned Faba beans, a higher correlation with the sensory analysis and greater accuracy and sensitivity being observed in some cases.

It is suggested that for Faba beans, heat treatment and quality related to the production under a "Geographical Indication", but not the addition of chelating agents to the brine, have a significant effect on their textural properties.

Acknowledgements

Authors want to thanks the realisation of sensory analysis of the samples to the Institute of Agricultural Research and Technology (ITACyL) (Zamadueñas, Spain).

References

Abu-Ghannam, N. (1998). Modelling textural changes during the hydration process of red beans. *Journal of Food Engineering, 38*, 341–352.

Bay, A. P. M., Bourne, M. C., & Taylor, A. G. (1996). Effect of moisture content on compressive strength of whole snap bean (*Phaseolus vulgaris* L.) seeds and separate cotyledons. *Journal of Food Engeneering, 31*(4), 327–331.

El-Moniem, G. M. A. (1999). Sensory evaluation and in vitro protein digestibility of mung bean as afected by cooking time. *Journal of the Science of Food and Agriculture, 79*(14), 2025–2028.

El-Moniem, G. M. A., Honke, J., & Bednarska, A. (2000). Effect of frying various legumes under optimun condicions of amino acids, in vitro digestibility and oligosaccharides. *Journal of the Science of Food and Agriculture, 80*(1), 57–62.

Escribano, M. R., Santalla, M., & de Ron, A. M. (1997). Genetic diversity in pod and seed quality traits of common bean populations from northwestern Spain. *Euphytica, 93*, 71–81.

Frias, J., Vidal-Valverde, C., Sotomayor, C., Diaz-Pollan, C., & Urbano, G. (2000). Influence of processing on available carbohydrate content and antinutritional factors of chickpeas. *European Food Research and Technology, 210*, 340–345.

Proctor, A., & Peng, L. C. (1989). Pectin transitions during blueberry fruit development and ripening. *Journal of Food Science, 54*(2), 385–387.

Quast, D. G., & da Silva, S. D. (1977). Temperatura dependence of hydraion rate and effect of hydration on the cooking rateo f dry legumes. *Journal of Food Science, 42*, 1299–1303.

Reeve, R. M. (1970). Relationships of histological structure to texture of fresh and processed fruits and vegetables. *Journal of Texture Studies, 1*, 247–284.

Revilla, I., & Vivar-Quintana, A. M. (2004). Establecimiento y optimización de parámetros determinantes en el proceso de elaboración de conservas de habones. *Alimentación, Equipos y Tecnología, 196*, 33–36.

Revilla, I., Vivar-Quintana, A. M., & Fuentes-Cuervo, O. (2004). Effect of processing on texture in canned artichokes. *Acta Horticulturae, 660*, 551–556.

Robertson, G. L. (1979). The fraction extraction and quantitative determination of pectic substances in grapes and musts. *American Journal of Enology and Viticulture, 30*(3), 182–186.

Sajjaanantakul, T., Van Buren, J. P., & Downing, D. L. (1989). Effects of methyl ester content on heat degradation of chelator soluble carrot pectin. *Journal of Food Science, 54*, 1273–1277.

Sefa-Dedeh, S., Stanley, D. W., & Woisey, P. W. (1978). Effects of soaking time and cooking conditions on texture and microstructure of cowpeas (*Vigna unguiculata*). *Journal of Food Science, 43*(5), 1833–1839.

Silva, C. A. B., Bates, R. P., & Deng, J. C. (1981). Influence of pre-soaking on black bean cooking kinetics. *Journal of Food Science, 46*(3), 716–720.

Stolle-Smits, T., Beekhuizen, J. G., Recourt, K., Voragen, Z. G. J., & van Dijk, C. (2000). Preheating effects on the textural strength of canned green beans. 1. Cell wall chemistry. *Journal of Agricultural and Food Chemistry, 48*(11), 5269–5277.

Stolle-Smits, T., Donkers, J., van Dijk, C., Derksen, J., & Sassen, M. M. (1998). An electron microscopy study on the texture of fresh, blanched and sterilized green bean pods (*Phaseolus vulgaris* L). *Lebensmittel-Wissenschaft und-Technologie, 31*, 237–244.

Taiwo, K. A., Akanbi, C., & Ajibola, O. O. (1997). The effects of soaking and cooking time on the cooking properties of two cowpea varieties. *Journal of Food Engineering, 33*, 337–343.

Van Buren, J. P. (1986). Snap bean texture softening and pectin solubilization caused by the presence of salt during cooking. *Journal of Food Science, 51*, 131–135.

Vidal-Valverde, C., Sierra, I., Frias, J., Prodanov, M., Sotomayor, C., Hendley, C., et al. (2002). Nutritional evaluation of lentil flours obtained after short-time soaking processes. *European Food Research and Technology, 215*, 138–144.

Wang, C. R., Chang, K. C., & Grafton, K. (1988). Canning quality evaluation of pint and navy beans. *Food Technology – Chicago, 53*(3), 772–776.