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Hardness of carioca beans (*Phaseolus vulgaris* L.) as affected by cooking methods

Beatriz dos Santos Siqueira [a], Rosana Pereira Vianello [b], Kátia Flávia Fernandes [c], Priscila Zaczuk Bassinello [b,*]

[a] Faculty of Agronomy and Food Engineering, Federal University of Goiás, Goiânia, GO, Brazil
[b] Embrapa Rice and Beans, Santo Antônio de Goiás, GO, Brazil
[c] Institute of Biology Sciences, Federal University of Goiás, Goiânia, GO, Brazil

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A B S T R A C T

Instrumental texture analysis is a fast and practical tool that has been used to assess bean cooking quality. However, lack of standardization for sample preparation has resulted in quite divergent reports in literature. So, five bean cooking methods were evaluated to identify and establish the best one that differentiates hardness of fresh and aged grains. Bean hardness was highly affected by cooking time and temperature. Mattson Bean Cooker and hot air oven were not adequate, providing undercooked grains with hardness above 4 N. Hardness of grains cooked on a hotplate decreased as the cooking time increased from 30 to 60 min. Likewise, with the autoclave at milder condition (105 °C/10 min) the grains were harder (2.99 N for fresh grains and 3.40 N for aged grains), while at severe condition (115 °C/20 min) softer grains were obtained (0.77 N for fresh grains and 1.01 N for aged grains). The suitable methods to prepare cooked bean for instrumental texture analyses seem to be the hotplate cooking for 45 or 60 min and the autoclave procedure at 110 °C/15 min, once they promoted the grain softening and discriminated fresh and aged beans.

1. Introduction

Common beans (*Phaseolus vulgaris* L.) are susceptible to the hardening (hard-to-cook) phenomenon during their shelf life, which has directly affected the consumption of this food. Although bean present many nutrients that make their consumption advantageous (Cardador-Martínez, Loarca-Piña, & Oomah, 2002; Leterme, 2002; Oomah, Corbe, & Balasubramanian, 2010), they have been passed over because of less nutritious foods, or foods with faster cooking time and also precooked foods. This fact is a reflection of changing dietary habits of the population, and especially to the time required for cooking common beans (Leterme & Muñoz, 2002).

Breeding programs aim to develop new cultivars that meet consumer preference for appearance and textural characteristics, so this food of high nutritional value is not completely replaced by poor nutritional foods. In this process, hundreds of thousands of breeding lines need to be evaluated and, breeders are faced with the task of developing varieties with improved yield, tolerance to abiotic and biotic stresses in addition to improved grain quality (Yokoyama & Stone, 2000). Cooking time is one of the traits evaluated by many breeding programs, and the Mattson Bean Cooker is the recommended equipment for measuring this variable (Proctor & Watts, 1987). In a standard Mattson analysis, soaked grains are positioned in each of the saddles of the rack so that the tip of each plunger is in contact with the surface of the grain. During the cooking test the lower portion of the cooker rack is immersed in a boiling water bath. When the grain becomes sufficiently tender, the plunger penetrates the grain and drops a short distance through the hole in the saddle. The time at which a plunger drops is recorded manually (Wang & Daun, 2005).

Instrumental texture analysis has been increasingly applied to assess the hardening of beans (Nasar-Abbas et al., 2008; Saha, Singh, Mahajan, & Gupta, 2009; Yousif, Deeth, Caffin, & Lisle, 2002), due to its characteristic of fast and practical execution, which enable its use to evaluate large number of genotypes in breeding program. However, the lack of standardization of sample preparation for this type of analysis has resulted in quite divergent reports in the literature, making it difficult to compare the results.

* Corresponding author. Embrapa Rice and Beans, C. Postal 179, CEP 75375-000 Santo Antônio de Goiás, GO, Brazil. Tel.: +55 62 3533 2186.
E-mail addresses: priscila.bassinello@embrapa.br, prizac@gmail.com (P.Z. Bassinello).

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When the bean breeding program evaluates the grain resistance to cooking, it is necessary to adopt a method that is useful for distinguishing the differences in germplasm, conferring high experimental accuracy and being representative of the cooking pattern that usually is achieved by consumers (Ribeiro, Cargnelutti Filho, Poersch, & Rosa, 2007). In this sense, more efficient and cost-effective methods of preparing and evaluating beans cooking quality would encourage the adoption of grain quality improvement as a focus of breeding programs and facilitate development of common beans' cultivars with improved grain quality (Yeung et al., 2009). This work aimed to evaluate the effect of different practices for cooking fresh crop and aged dry beans on hardness and also to propose a procedure to prepare bean for instrumental texture analysis.

2. Material and methods

Carioca beans (*P. vulgaris* L., cv Pérola) were provided by Embrapa Rice and Beans (Santo Antônio de Goiás, Brazil). The material was grown in two seasons at the same location (Capivara's Farm, Santo Antônio de Goiás, Brazil). The first crop was harvested at the end of June 2011 and the second one at the beginning of October 2011. After harvest samples were naturally dried and sorted by hand to remove extremely small beans and those with defective seed coat or excessively dirty surfaces. Then each crop of carioca beans were packaged in polyethylene bags with a capacity of about 2 kg until the analysis.

Beans from the first crop were analyzed after aging for 7 months (aged grains − AG) at a room with natural incidence of light from the rising sun and environmental conditions, where the mean temperature during this period was 23.5 °C and the relative humidity average was 54.2%. The samples were placed randomly and underwent rotation position in the storage tray. Moisture content of AG at the end of the storage time was 8.75 ± 0.21%. The other group of seeds (beans from the second crop) corresponded to the freshly harvested grains (FG), thus they were stored at −18 °C in the dark until the performance of the analyses. Moisture content of these grains was 8.66 ± 0.05%.

To each test performed, 50 seeds of both FG and AG (average bean seed weight of 0.28 ± 0.02 g) were previously soaked in 100 mL of distilled water for 18 h at 25 °C (Plhak, Caldwell, & Stanley, 1989). The soaking water was discarded and the seeds were submitted to different methods of cooking, using a Mattson Bean Cooker (MBC), a hotplate, an autoclave, a boiling water bath and a hot air oven. All the methods used 200 mL of distilled water to cook the samples (water-bean ratio 1:4), except those conducted at the MBC, which tested 25 seeds with 1 L of distilled water (water-bean ratio 1:40). After cooking, the cooking water was discarded and the beans were left to cool to room temperature (25 ± 2 °C). The hardness of the cooking grains was assessed through the instrumental texture analysis.

2.1. Cooking methods

2.1.1. Cooking on a Mattson Bean Cooker

A Mattson Bean Cooker was used to record the mean cooking time (CT) of the FG and the AG. It consists of 25 plungers and a cooking rack with 25 reservoir-like perforated saddles, each of which holds a grain and a plunger calibrated to a specific weights. Each plunger weighs 90 g and terminates in a stainless steel probe of 1.0 mm in diameter (Wang & Daun, 2005). The cooking proceeded by immersing MBC in a beaker with boiling water (98 °C) over a hotplate. The 50% cooked point, indicated by plungers dropping and penetrating 13 of the individual beans, corresponds to the sensory preferred degree of cooking, according to methodology adapted from Proctor and Watts (1987).

After reaching the mean CT the remaining grains were collected (Test 1) and submitted to the hardness analysis.

2.1.2. Cooking on a hotplate

Soaked beans were cooked for different times in a glass beaker with boiling distilled water (98 °C) on a hotplate. The primary condition tested corresponded to the cooking of beans adopting the CT previously determined at MCB, with the beaker covered with watch glass (Test 2) and uncovered (Test 3). An additional test was conducted on the hotplate (Test 4), using the CT of plungers dropping and penetrating 100% of the individual beans at the MCB.

Further tests were also performed on the hotplate. It consisted of cooking 50 grains in a beaker, covered with watch glass, during 30, 45 and 60 min (Test 5, Test 6, Test 7, respectively).

2.1.3. Cooking on an autoclave

The procedure of cooking in an autoclave followed the method described by Revilla and Vivar-Quintana (2008), with modifications. Fifty soaked grains were placed in glass beaker, filled with 200 mL of distilled water, covered with watch glass, and cooked under the conditions of 105 °C/10 min (Test 8), 110 °C/15 min (Test 9) and 115 °C/20 min (Test 10).

2.1.4. Cooking on a boiling water bath

Fifty soaked grains were put in a beaker with 200 mL of boiling distilled water (98 °C), covered with watch glass, and then the beaker was placed in a boiling water bath. The cooking times were 30, 45 and 60 min for Test 11, 12 and 13, respectively.

2.1.5. Cooking in a hot air oven

The last test (Test 14) was the cooking of beans in a hot air oven, as described by Nasar-Abbas et al. (2008) with modifications. Fifty soaked grains were placed in a glass beaker, filled with 200 mL of distilled water and covered with aluminum foil. The cooking conditions used in this methodology were 2 h at 105 °C.

2.2. Hardness measurement

A TA-XTplus texture analyser (Stable Micro Systems Ltd, Surrey, UK) was used for the textural analyses of drained cooked beans. The analysis employed was the return-to-start method, measuring force under compression with a 2 mm cylindrical probe (P2), recording the peak of maximum force. P2 is the probe most indicated for assessing bean hardness because its small area affects the tegument and could help to differentiate similar samples, even when they present soft cotyledon but hard tegument (Revilla & Vivar-Quintana, 2008). Whole beans were axially compressed to 90% of its original height. Force-time curves were recorded at a speed of 1 mm/s and the results corresponded to the average of about 30 measurements of individual cooked grains expressed in Newtons (N).

2.3. Cooking quality classification

After cooking by different methods, the grains were classified for cooking quality according to the 1–5 scale scores (Table 1) established by Yeung et al. (2009).

2.4. Statistical analysis

All experiments were conducted at least three repetitions and mean values were reported. Statistica 6.0 (StatSoft Inc., Tulsa, Okla, U.S.A.) was used to perform ANOVA followed by the Tukey test to compare means at 95% significance.