A STANDARDIZED METHOD OF PREPARING COMMON BEANS (PHASEOLUS VULGARIS L.) FOR SENSORY ANALYSIS

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ABSTRACT

Methods of preparing bean samples for sensory analyses should be simple and reproducible. The method we propose, based on popular traditions (soaking and cooking beans in distilled water, forgoing blanching, and keeping simmering to a minimum), increased the number of beans that remained whole after cooking by 50% compared with the check method. No differences between the new method and the check were observed in the solids lost during the cooking process or in a panel’s evaluation of the sensory properties of the beans. Furthermore, the new method is more efficient for handling the small samples that are common in breeding programs. Its repeatability for both sensory and nutritional analyses is very high: two replicates seem sufficient for high resolution. Thus, we propose that it be adopted for sensory and nutritional analyses of cooked beans.

PRACTICAL APPLICATIONS

This article describes a new standardized method to prepare dry beans for sensory and nutritional analyses. This clear, simple, repeatable method has the additional advantages of being similar to traditional cooking methods, and is suitable for use with small samples of seeds. We propose it as a reference for sensory and nutritional research in dry beans.

INTRODUCTION

Dry beans are nutritious (Bennink 2005; Boye 2008) and complement the compounds provided by cereals (Baudoin and Maquet 1999). Domesticated in America (Evans 1976), dry beans are now consumed throughout the world and are the main ingredient in many well-established dishes in local cuisines. Their acceptance by the markets is related with sensory characteristics that can be evaluated by sensory panels composed of consumers and/or trained professionals (Antoun and Tsimidou 1997; Gervi et al. 1997; Meilgaard et al. 2007; Suwannaporn and Linnemann 2008; Tesfaye et al. 2010; Elia 2011).

Sensory traits cannot be analyzed unless beans are cooked. Moreover, the content of some nutritive and antinutritive components changes during the precooking and cooking process, so it is also more realistic to use cooked beans for analyses of nutritional value (Vidal-Valverde et al. 1998; Costa de Oliveira et al. 2001; Zia-ur et al. 2001; Pujolà et al. 2007; Balamaze et al. 2008; Shiga et al. 2009). The method of preparation needs to be standardized to allow analyses to be repeated and compared. Furthermore, the method of preparation should result in cooked beans similar to those eaten by consumers (the nutritional and sensory evaluations must yield realistic data) and be applicable to small samples because seeds from breeding programs or experimental plots are often available only in small quantities.

As there is no standard protocol for cooking dry beans for analysis, in our laboratory, we first used the Una Norma Española (UNE) 87028-1 method (UNE 1997), which was especially developed for the sensory analysis of legumes (Sanz 1997). However, this method has several drawbacks. First, the protocol does not clearly specify the composition of the cooking water. Second, the process differs in key ways from the methods consumers usually use. Third, the high proportion of broken beans resulting from the method makes it...
impossible to appreciate the full sensory potential of the product because of the negative visual impression of the samples on the judges. Objective approaches, such as that proposed by Mattson (Mattson 1946), can be useful for comparing the physical properties of beans, studying the “hard-to-cook” phenomenon or performing precise chemical analyses (Paredes-López et al. 1989; Aguilera and Rivera 1992; El-Tabey 1992; Medeiros et al. 2007); however, these approaches are too complicated and too far removed from ordinary cooking methods for our practical purposes. Another approach is to set the same cooking time for all samples (Lazou et al. 2010; Valdés et al. 2011). Although this approach can be useful for some chemical analyses, it departs from the actual conditions in which beans are consumed because few samples are at the optimal point of doneness when served.

Beans are very popular in southern Europe, and are the main ingredient in dishes like “Fabada” and “Mongetes amb Botifarra” in Spain, “Cassoulet” and “les Moquettes” in France, or “Pasta e Fagioli” and “Faggioli all’uccelletto” in Italy. Moreover, given the popularity of legumes, there are many traditions about the best way to cook them at home. Thus, we considered that the experience of professional cooks and legume vendors, heirs to the popular tradition, would be a good starting point to develop a standard method of cooking beans for analysis.

In this study, we aimed to (1) compile traditional practices for cooking dry beans and use that information to elaborate a standard method of preparing beans for sensory analyses; (2) compare the method with the UNE method; and (3) determine the repeatability of the method in a set of sensory and nutritional evaluations.

**MATERIALS AND METHODS**

**Survey of Professionals, Preliminary Experiments and Proposal of the New Method**

In Catalonia (northeast Spain), professional legume vendors have prepared legumes to be sold cooked in markets and specialized shops since the late 19th century, when the industrial revolution profoundly reorganized the social structure (Giner 1984) and women left the home to join the workforce (Dominguez 2005). A questionnaire covering all aspects about precooking, cooking and postcooking conservation of dry beans was submitted to 17 professional legume vendors from diverse towns in Catalonia with a long tradition of dry bean consumption. Furthermore, we held a seminar with 12 cooks experienced in the preparation of dry beans to analyze their procedures. These 12 cooks also completed the same questionnaire as the professional legume vendors.

We used the information obtained from the questionnaire and seminar to design a basic protocol for the preparation of cooked beans. From the basic protocol, we performed several experiments to refine some points of the procedure that were not unanimously agreed upon by the professionals. These experiments included the evaluation of the influence of the volume of water during soaking and cooking, the length of soaking time, the influence of the type of water, the effect of the quantity of beans cooked, and the effect of using a lid during cooking.

The new method was finally established as follows: 250 g beans are soaked in 750 mL distilled water for 14 h, drained and placed in a 2-L thick-bottomed stainless steel pot, with enough cold distilled water to cover the beans by 1 cm. The pot is brought to a boil, and then the heating source is lowered to the minimum that allows boiling (without blanching or changing the water). During the cooking process, the level of the water is controlled, and cold distilled water is added periodically to compensate for evaporation and keep the beans covered with water. The beans are cooked with a lid on, and 2.5 g NaCl is added shortly before the beans are done (unless nutritional analyses must be performed). The beans are considered cooked when they are soft enough to be eaten; this is determined by successive sampling by a trained person.

**Comparing the New Protocol with the UNE Method**

The trial was conducted using 250 g of beans/sample (the minimum amount to enable sensory analysis by a panel of 12 tasters) of the varieties Tolosa, White kidney, Faba, Ganzet, Genoll de Crist, Planxeta, Castelfollit del Boix and Navy (Santalla et al. 2001; Sánchez et al. 2007). These varieties represented a wide scope of genetic pools, morphologies of the seeds and gastronomic uses. With this election, we wanted to have a general value of the results.

The trial comprised the following: (1) The UNE check method (Sanz 1997): 250 g beans are soaked in 1250 mL distilled water for 12–14 h, drained and placed in a 2-L thick-bottomed stainless steel pot with 1.5 L cold low mineral-content water. The beans are blanched by bringing the pot to a boil, draining the beans and adding 1.5-L cold mineral water. The pot is then covered with a lid and is kept boiling until the beans are cooked. For sensory analysis, 2.5 g NaCl is added when the beans are done; and (2) the new method described above.

We carried out both procedures a total of four times in each variety. In each of the 64 preparations (combinations of variety and method), we recorded (1) the cooking time; (2) the percentage of beans that remained whole after cooking (100 g cooled beans are drained for 5 min, then the whole beans are separated from the broken ones and weighed to calculate the percentage of whole beans); and (3) the dry extract of the cooking water to determine whether the loss of...
solids differed between methods. Furthermore, a panel with 12 members who were previously trained over a 2-year period (Romero del Castillo et al. 2008b) used a paired-comparison test (ISO 2005) to evaluate the differences between varieties prepared using the two methods. All tasting sessions took place in individual booths meeting the standards set forth by the International Organization for Standardization (ISO 2007). The samples were maintained at 70°C until they were served to the panelists (maximum 1 h).

Repeatability of the New Method

A sensory trial including several varieties with different degrees of similarity on sensory traits according to previous experiments was carried out to test the repeatability of the new method.

Entries and Place of Cultivation. In order to have big and small expected differences between the samples to be used to prove the reliability, we studied the following entries: (1) Croscat L, a navy-type variety (Almirall et al. 2010), cultivated in Santa Pau in shallow neutral soil (Romero del Castillo et al. 2008a); (2) Croscat D, the same variety cultivated in Santa Pau but in deep neutral soil; (3) Gra petit D, a navy-type variety cultivated in the same conditions as Croscat D (these three entries were expected to have few sensory differences, although the depth of the soil affects the availability of water during the culture); (4) Montcau, a ganxet-type variety (Bosch et al. 1998; Santalla et al. 2001), cultivated in Vallès Occidental County in deep and alkaline soil (Romero del Castillo et al. 2008a); and (5) Tolosa, a Negro-Brillante-type variety cultivated in deep and acidic soil (Santalla et al. 2001) (entries 4 and 5 were expected to differ from each other and from the other three entries from the sensory point of view).

Experimental Design and Sensory Analysis. On 4 days, the five entries were prepared using the new method and submitted to the panel following the same protocol described in the above section (comparing the new protocol with the UNE method).

Panelists evaluated a set of sensory attributes related to texture, flavor and appearance (Table 1). The intensity of each attribute was quantified on a 10 cm semistructured scale with the extremes labeled with corresponding descriptions as described by Romero del Castillo et al. (2008b).

During the preparation of samples for the sensory panel, we recorded the percentage of beans that remained whole after cooking for each sample as this was a weak point of the UNE method.

Nutritional Analysis. To determine the suitability of the method for nutritional analyses on cooked beans (important because some nutrients may change or be lost during the cooking process), samples of each entry were taken before adding the salt in each session. These samples were dried (48 h at 60°C), milled (0.4 mm with a Perten Laboratory Mill 3100, Perten Instruments, Huddinge, Sweden) and frozen at −18°C until duplicate analyses of each variety from each session were performed. Proximate composition analysis for protein (NKjeldahl × 6.25) and ash content were carried out according to the methods described by the Association of Official Analytical Chemists (AOAC 2000). Starch content was determined using the commercial kit of Total Starch (Megazyme International Ireland Limited, Bray Co. Wicklow, Ireland) using 0.1 g of cooked bean’s flour. All analysis was done in duplicate. These three parameters were considered a rough estimate of the nutritional value of the beans.

Table 1. Mean Values of the Culinary Parameters for the New Proposed Method and the Check UNE Method

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cooking time (min)</th>
<th>Percentage of whole beans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UNE method</td>
<td>New method</td>
</tr>
<tr>
<td>Tolosa</td>
<td>107.0 a</td>
<td>156.5 a</td>
</tr>
<tr>
<td>Planxeta</td>
<td>91.7 ab</td>
<td>99.3 b</td>
</tr>
<tr>
<td>Faba</td>
<td>78.0 bc</td>
<td>93.0 bc</td>
</tr>
<tr>
<td>White kidney</td>
<td>87.5 b</td>
<td>79.0 dc</td>
</tr>
<tr>
<td>Navy</td>
<td>78.0 bc</td>
<td>87.5 bc</td>
</tr>
<tr>
<td>Ganxet</td>
<td>58.5 d</td>
<td>89.0 bc</td>
</tr>
<tr>
<td>Genoll de Crist</td>
<td>61.3 cd</td>
<td>78.8 dc</td>
</tr>
<tr>
<td>Castellfollit del Boix</td>
<td>64.0 cd</td>
<td>62.3 d</td>
</tr>
<tr>
<td>Mean</td>
<td>78.3</td>
<td>93.2</td>
</tr>
</tbody>
</table>

Significance of F for method effect: <0.0001

Note: Values in the same column of the table followed by the same letter are not significantly different according to the Student-Newman–Keuls test (P ≤ 0.05).

UNE, Una Norma Española.
y_{ijk} = \mu + m_i + v_i + s_j + p_k + v_{pi} + s_{pi} + v_{pj} + s_{pj} + e_{ijk}, where \mu was the grand mean, m_i the method effect, v_i the variety effect and e_{ijk} the residual associated to each observation ijk. All effects were considered fixed.

To study the repeatability of the new method with respect to the sensory attributes, we performed an ANOVA according to the linear model:

y_{ijk} = \mu + v_i + s_j + e_{ijk}, where \mu was the grand mean, v_i was the entry effect, s_j the session effect and e_{ijk} the residual associated to each observation ijk. All effects were considered fixed.

To study the repeatability of the new method with respect to the nutritional components, we performed an ANOVA according to the linear model:

y_{ijk} = \mu + v_i + s_j + e_{ijk}, where \mu was the grand mean, v_i was the entry effect and s_j the session effect. All effects were considered fixed.

Means were compared using the Student-Newman–Keuls method with a level of significance \( P \leq 0.05 \).

To check for bias in the conclusions, when we considered less than four replications of the experiment, we performed ANOVAs with all possible combinations of two and three sessions. A normalized principal components analysis (PCA) was performed using the results from the four sessions and using every possible combination of two or three sessions. The 95% confidence ellipses around each entry in the results of the four sessions make it possible to evaluate the reliability of the method if we decrease the number of sessions for the sensory or nutritional approach. This type of analysis aims to determine whether the entries behave differently if the number of sessions and their combinations vary (lie outside the confidence ellipse), and whether the distances between samples are maintained.

All statistical calculations were performed with the R program version 2.13.0 (http://www.r-project.org) using the packages: ellipse (Murdoch and Chow 2007) and agricolae (Mendiburu 2010).

RESULTS AND DISCUSSION

Comparing the Protocols

The new method proposed increases the proportion of whole beans in the cooked samples by 50% (Table 1), a considerable improvement on one of the UNE check method’s weak points. It is likely that several factors contribute to this improvement: eliminating blanching, cooking with a lower proportion of water (only covering the beans) and keeping the beans as immobile as possible (simmering). In the preliminary experiments, following the indications of the cooks and specialists in cooking beans, we tested the effects of cooking different quantities of beans. We found that cooking a large amount of beans always yielded a higher percentage of whole seeds and that breakage only became a problem when a smaller quantity of beans was cooked, e.g., cooking 250 g instead of 2500 g resulted in a mean drop in the number of beans remaining whole after cooking of 10%. Cooking large quantities of beans at once reduces thermal differences in the cooking pots that result in streams in the water and cause beans to move, collide with one another and break. Professionals normally recommend simmering large quantities of beans in little water over long periods of time (up to 3 h or even more) and adding small amounts of cold water to compensate for evaporation when necessary. We tried to reach a compromise solution for using small samples (to reflect the reality of most trials and consumers necessities) and trying to avoid very long cooking times. On the other hand, the use of distilled water for soaking and cooking makes the method universally accessible.

Cooking time is apparently longer in the new method (Table 1) because the UNE check method calls for blanching the beans and calculates cooking time from the second time that the pot is brought to a boil. However, when the precooking required by the UNE method is taken into account, the new method actually shortens the total preparation time and simplifies the process.

No significant differences between methods were found both for dry extract from the cooking water and sensory-paired comparisons of the beans.

As in other trials, we found considerable differences among varieties for all the traits studied (Table 1). The lack of a significant interaction between the variety effect and the method effect (not significant at \( P \leq 0.05 \)) reinforces the general value of our proposal.

Repeatability of the method

Sensory Analysis. Considering the four sessions, no significant differences (\( P \leq 0.05 \)) among sessions were observed (Table 2). Significant differences between entries were found for all traits, and the interaction session \( \times \) entry was significant only for seed-coat perception (Table 2). Thus, the results suggest that the method is highly repeatable for sensory analyses.

As expected, the three commercial classes (Ganxet–Montcau, Tolosa and Navy) were clearly differentiated for differences in flavor, brightness or percentage of whole seeds after cooking among the entries in the navy class (Table 3). The environmental effects seem very important for the expression of the sensory traits: we found significant differences in seed-coat roughness, seed-coat perception, aroma and mealinness between Croscat beans cultivated in different locations (Table 3). As stated in the material and methods section, the only difference between these locations was the
depth of the soil; however, as beans grown in Santa Pau are not irrigated, the availability of water seems to have an important effect on the sensory traits of the seeds.

The PCA delimited four clearly differentiated groups of entries (Fig. 1): Tòlosa, Montcau, Croscat L and Croscat D. The entry Gra Petit D overlaps with the Croscat entries from the two locations. This multivariate focus confirms that the environmental effect is very important because Croscat L and Croscat D do not overlap, although they are genetically identical.

Practically all the combinations of sessions lie within the 95% confidence ellipses centered in the variety positions obtained when the four sessions together are considered (Fig. 1). This is an indication that the method is very repeatable and that we can use a low number of repetitions for practical purposes.

**Nutritional Analysis.** As in the sensory analysis, in the nutritional analysis, the session effect was not significant ($P > 0.05$) and the entry effect was highly significant ($P < 0.0001$). It was not possible to calculate the interaction session × entry because we do not have repetitions within sessions (only duplicates of the chemical analyses).

Fewer significant differences among entries were found in the chemical components related to the nutritional value of the beans than in the sensory value (Table 4). It is also more difficult to interpret the differences because the genetic and environmental factors overlap.

This difficulty in separating the groups is also evident in the PCA for nutritional traits, where only three separate groups appear: Tòlosa, Croscat D and a third group in which Montcau slightly overlaps with Gra Petit, and these two entries overlap with Croscat L (Fig. 2). Like in the sensory analyses, the environment had strong effects in the chemical composition of the beans, as is evidenced by the clear separation between Croscat D and Croscat L in the PCA (Fig. 2).

Considering all the possible combinations of sessions, we found that there would be no differences in the conclusions reached if the number of sessions were reduced to three or two. As in the PCA of the sensory traits, although some sessions lie outside the 95% confidence ellipse generated around the mean of the four sessions, they are not distant outliers and remain outside the confidence ellipses of the other entries. Thus, in all cases, we can differentiate three groups of samples: Tòlosa, Croscat D, and a group containing Croscat L, Gra Petit D and Montcau.

**CONCLUSIONS**

Compiling traditional cooking practices and fine-tuning them through several tests has yielded a new standard method for cooking beans for sensory and/or nutritional analysis. For preparing a 250 g sample of dry beans, enough for many chemical analyses and the minimum quantity needed for sensory analysis by a 12-person panel, (1) soak the beans in 750 mL distilled water for 14 h, drain, place in a thick-bottomed 2-L stainless-steel pot and cover with cold distilled water (1 cm above the level reached by the beans); (2) bring the pot to a boil and then lower the heat source to the minimum (without blanching or changing the water); (3) during the cooking process, control the level of the water and add cold distilled water to compensate for evaporation, but be sure to maintain simmering. Keep the beans covered with water at all times; (4) cook the beans with a lid on (but be sure to allow steam to escape), and when they are done (this point is determined by the morphology, color and texture of

**TABLE 2. SIGNIFICANCE OF ANOVA FOR ALL SENSORY ATTRIBUTES RECORDED AND CONSIDERING THE FOUR SESSIONS (REPETITIONS)**

<table>
<thead>
<tr>
<th>Session</th>
<th>Seed-coat roughness</th>
<th>Flavor</th>
<th>Seed-coat perception</th>
<th>Aroma</th>
<th>Brightness</th>
<th>Mealiness</th>
<th>Whole seeds (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.0001</td>
<td>0.0667</td>
<td>0.4271</td>
<td>0.0127</td>
<td></td>
<td>0.6148</td>
<td>0.7141</td>
<td>0.0875</td>
</tr>
<tr>
<td>Entry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session</td>
<td>0.9045</td>
<td>0.1369</td>
<td>0.1060</td>
<td>0.2583</td>
<td>0.2266</td>
<td>0.4335</td>
<td>0.4534</td>
</tr>
</tbody>
</table>

ANOVA, analysis of variance.

**TABLE 3. MEAN VALUES OF THE SENSORY TRAITS FOR THE FIVE ENTRIES CONSIDERING THE FOUR SESSIONS**

<table>
<thead>
<tr>
<th>Entry</th>
<th>Seed-coat roughness</th>
<th>Flavor</th>
<th>Seed-coat perception</th>
<th>Aroma</th>
<th>Brightness</th>
<th>Mealiness</th>
<th>Whole seeds (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montcau</td>
<td>8.63 a</td>
<td>2.56 c</td>
<td>2.17 c</td>
<td>4.22 b</td>
<td>7.84 a</td>
<td>2.60 d</td>
<td>39.80 a</td>
</tr>
<tr>
<td>Croscat D</td>
<td>7.90 b</td>
<td>3.66 b</td>
<td>2.13 c</td>
<td>2.04 d</td>
<td>6.70 b</td>
<td>3.29 c</td>
<td>18.34 b</td>
</tr>
<tr>
<td>Croscat L</td>
<td>5.67 c</td>
<td>3.46 b</td>
<td>4.97 a</td>
<td>3.18 c</td>
<td>6.79 b</td>
<td>4.08 b</td>
<td>20.58 b</td>
</tr>
<tr>
<td>Gra Petit D</td>
<td>6.26 c</td>
<td>4.04 b</td>
<td>1.91 c</td>
<td>2.93 c</td>
<td>6.13 b</td>
<td>2.70 d</td>
<td>18.86 b</td>
</tr>
<tr>
<td>Tòlosa</td>
<td>4.07 d</td>
<td>6.76 a</td>
<td>4.33 b</td>
<td>5.67 a</td>
<td>4.02 c</td>
<td>6.38 a</td>
<td>12.31 b</td>
</tr>
</tbody>
</table>

Note: Values in the same column of the table followed by the same letter are not significantly different according to the Student-Newman–Keuls test ($P = 0.05$).
each variety, and must be decided by a trained person), add 2.5 g NaCl before draining if submitted to a sensory panel; and (5) for sensory analysis, the cooked beans can be maintained at 70°C for up to 2 h until the test is performed, and for nutritional analysis, the cooked beans must be drained immediately and pretreated according to the analysis to be performed.

The method is better than the UNE method of preparing legumes because it increased the number of beans that remained whole after cooking by 50%, specifies the type of water to use and simplifies the process by eliminating blanching. Moreover, the new method is based on traditional methods of cooking beans, so it is more realistic.

**FIG. 1. PRINCIPAL COMPONENTS ANALYSIS OF SENSORY TRAITS**

**TABLE 4. MEAN VALUES OF THE NUTRITIONAL PARAMETERS FOR FIVE GENOTYPES TESTED IN FOUR SESSIONS**

<table>
<thead>
<tr>
<th>Entry</th>
<th>Ash g/kg dry matter</th>
<th>Protein g/kg dry matter</th>
<th>Starch g/kg dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montcau</td>
<td>34.9 b</td>
<td>263.4 a</td>
<td>335.3 b</td>
</tr>
<tr>
<td>Croscat D</td>
<td>40.4 a</td>
<td>261.5 a</td>
<td>407.2 a</td>
</tr>
<tr>
<td>Croscat L</td>
<td>40.5 a</td>
<td>257.4 a</td>
<td>337.3 b</td>
</tr>
<tr>
<td>Gra Petit D</td>
<td>42.8 a</td>
<td>274.1 a</td>
<td>338.0 b</td>
</tr>
<tr>
<td>Tolosa</td>
<td>35.0 b</td>
<td>216.0 b</td>
<td>327.2 b</td>
</tr>
</tbody>
</table>

Note: Values in the same column of the table followed by the same letter are not significantly different according to the Student-Newman–Keuls test ($P \leq 0.05$).
The proposed method is highly repeatable, and the results suggest that few repetitions would provide great discriminatory power for both sensory and chemical analyses, even among highly similar materials. We recommend that the new method be established as the standard for sensory and/or nutritional analyses.

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