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Preliminary study of the factors that determine nutrient composition of bean-cooking broth*

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Abstract. Bean cooking broth or liquor is a food preparation that results from cooking beans under a number of circumstances. This preparation is the first bean-derived food provided by mothers to their children as young as two months of age. Because of this, bean cooking plays an important nutritional role that must be evaluated. The present study attempted to evaluate, through a number of experiments, the significance of cultivars, method of cooking – either under atmospheric or vapor pressure – cooking time, salt addition, soaking and grain size on bean broth content. This was established mainly by solid content, and also by protein, ash and tannin content in different experiments.

The results indicated that cultivars, but mainly cooking and soaking time, cooking method, and seed size were all important factors in determining brean-broth composition, mainly of total solids. Protein and ash contents were less affected. Prolonged cooking of the bean-broth resulted in a decrease in polyphenolic content. The relative nutritional importance of the above factors should be studied further.

Introduction

Bean-cooking broth is the cooking liquor that results from bean (*Phaseolus vulgaris*) preparation for consumption (Bressani, Flores and Elías, 1973; Bressani et al., 1987). Previous studies have reported this food product to be the first bean-derived food which mothers provide to their children, starting as early as when they are two months old (Bressani et al., 1987). The amounts administered with rice and lime-treated corn dough ("tortillas") vary from 28–160 g/day; therefore, its nutrient content is of particular nutritional significance. Results from a field survey demonstrated that cooking broth contained from 5.5 to 11.5 g% of total solids, with 1.2% protein and an average of 5% total free-sugars (Bressani et al., 1987). The factors

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responsible for this nutrient content are unknown; however, the composition of bean broth may be associated with bean cultivars, age of beans before cooking and locality where they were grown on the one hand, and on the process used for their preparation for consumption such as cooking time, type of cooking pot used, and the additives added during cooking, on the other. The above factors which possibly determine bean-broth composition were the subject of this investigation. Since the quality of bean-broth is associated with bean acceptability, its study may be an important factor to be considered in bean improvement programs.

Material and methods

In order to study the effect of cultivar on bean-broth yield and composition, a total of 15 selections, both black (8) and red (7), from adaptability trials were used. Studies on the effects of cooking practices were conducted with the Tamazulapa bean cultivar, grown in the lowlands of Guatemala and harvested in January 1985. Studies in this respect included the effect of cooking time, of salt addition – since this is a practice commonly carried out in rural homes – (Bressani et al., 1978), of bean soaking before cooking and of repeated boiling; the latter being a procedure where beans are boiled, allowed to cool and then boiled again. A study on the effect of seed size of the same cultivar was also carried out. Grains from the tamazulapa variety were classified into large (0.209 g/seed), medium (0.142 g/seed), and small (0.067 g/seed) size and processed as described above. These materials contained 23.4, 23.7 and 24.6% protein, respectively. Unless specifically indicated, all tests were run by processing 50 g samples in duplicate with 150 cc hot water. Cooking was done by placing beakers with its contents in crude fiber apparatus with a condenser as cover to reduce water loss. Cooking time for all trials was 90 min, at atmospheric pressure, except when the study of the effect of cooking time was performed, in which case cooking times were 70, 90, 110, 120 and 150 min. In another set of studies, red, white and black bean cultivars were used to study the effect of time and type of cooking on bean-broth composition. Cooking times were 30, 60, 90, 120 and 150 min at atmospheric pressure and 15 lb/square inch using the same 1:3 bean:water ratio with lots containing 500g of beans, and as before, all tests were done in duplicate. In these studies, however, all the bean cooking liquor collected was lyophilized and weighed.

After cooking, the contents of the beaker or container were separated into beans and cooking liquor by pouring through cheesecloth. Moisture content of the raw and cooked bean was determined by vacuum drying (AOAC, 1970). The cooked bean's weight was determined before drying. Volume of the cooking liquor was measured and aliquots of 25 cc were used for total solids by evaporation to dryness. Aliquots were also taken for nitrogen analysis by the Kjeldahl method and ash content as described by AOAC procedures. Tannins were determined as tannic acid (Burns, 1971) and as catechin equivalent (Price, Van Scoyoc and Butler, 1978). Results were subjected to standard statistical analysis.

Results and discussion

A. *Genetic composition*

The effect of genetic composition on the yield of cooked beans and on total solids, protein and ash content of the cooking liquor produced under standard processing conditions is shown in Table 1. All samples came from the same experimental plot and were harvested during the same year (1984); therefore differences, if they occur, are due to genetic make-up. Analysis of variance showed no statistical significant differences between cultivars of the same color or different color, in all parameters measured in the cooked beans and respective cooking broth, with the exception of the dry weight for the black bean cultivars. Average content of total solids was slightly higher in the black bean-broth (3.69 g) than in the red (3.43 g). Bean protein content averaged 0.57 g in black beans and 0.61 g in red beans. Average ash content was similar between bean colors, although values ranged from 0.58 to 0.87 in red beans and between 0.68 and 0.79 g in black beans. Protein and ash represent 35.2 and 39.3% of the weight of the solids in the broth, respectively. The correlation of total solids and protein ($r = 0.330$) was not significant; however, ash was significantly correlated to total solids ($r = 0.622$). Although no statistical significant differences were found, these data suggest that genetic make-up is an important factor in determining bean cooking liquor composition and since it is a food provided to children as indicated in previous studies (Bressani et al., 1978), the cooking liquor composition could be used as a selection parameter for bean acceptability.

B. *Cooking time*

Cooking conditions may have a significant influence on bean cooking liquor composition. Results of cooking time at atmospheric pressure are shown in Table 2. Statistical analysis of the data showed significant differences for all parameters measured for the cooked bean and the cooking broth. The data demonstrated that as cooking time increased from 70 to 150 min, wet weight of cooked beans and the hydration value increased, while the dry weight of

Table 1. Influence of bean variety on cooking liquor content of protein and ash(*)

Sample identity	Beans				Cooking liquor			
	Dry wt. raw (g)**	Wet wt. cooked (g)	Dry wt. cooked (g)***	Hydration value****	Volume (ml)	Dry wt. solids (g)	Protein (g)	Ash (g)
Black color								
ICTA Quetzal	43.5	107.4 ± 3.6	39.8 ± 0.09^{a}	2.46 ± 0.08	66.2 ± 5.3	3.68 ± 0.09	0.50 ± 0.01	0.78 ± 0.02
ICTA Tamazulapa	43.5	106.4 ± 2.7	39.8 ± 0.02^{a}	2.45 ± 0.06	69.2 ± 2.5	3.77 ± 0.02	0.59 ± 0.07	0.76 ± 0.06
Brunca	42.8	107.0 ± 2.8	38.4 ± 0.61^{b}	2.49 ± 0.06	67.0 ± 2.8	4.40 ± 0.62	0.63 ± 0.08	0.79 ± 0.04
Huasteco	42.8	106.9 ± 0.5	39.2 ± 0.35^{ab}	2.49 ± 0.01	70.0 ± 0.0	3.60 ± 0.35	0.55 ± 0.02	0.68 ± 0.09
Porrillo Sintético	42.6	103.2 ± 0.2	39.0 ± 0.21^{ab}	2.42 ± 0.00	71.5 ± 4.9	3.60 ± 0.21	0.56 ± 0.08	0.73 ± 0.16
Xan-112	43.4	105.7 ± 0.2	40.0 ± 0.44^{a}	2.43 ± 0.00	71.7 ± 1.1	3.45 ± 0.44	0.50 ± 0.00	0.70 ± 0.07
Bat-1636	42.9	106.3 ± 0.4	39.3 ± 0.22^{ab}	2.47 ± 0.01	70.7 ± 2.5	3.61 ± 0.22	0.64 ± 0.02	0.68 ± 0.11
Xan-87	43.3	107.0 ± 1.2	40.0 ± 0.23^{a}	2.47 ± 0.03	70.7 ± 2.5	3.38 ± 0.23	0.60 ± 0.03	0.73 ± 0.07
Ave ± S.D.	43.1 ± 0.36	106.2 ± 1.9	39.4 ± 0.58	2.46 ± 0.04	69.6 ± 3.0	3.69 ± 0.38	0.57 ± 0.06	0.73 ± 0.07
Red color								
Revolución 79	43.1	106.6 ± 1.8	39.5 ± 0.23	2.47 ± 0.04	70.5 ± 6.4	3.51 ± 0.22	0.66 ± 0.09	0.72 ± 0.08
Rojo de Seda	42.5	105.1 ± 2.7	38.8 ± 0.27	2.46 ± 0.06	70.5 ± 6.4	3.78 ± 0.27	0.70 ± 0.06	0.74 ± 0.13
Corobici	42.5	105.4 ± 3.6	38.8 ± 0.21	2.48 ± 0.08	72.0 ± 4.2	3.67 ± 0.20	0.61 ± 0.01	0.77 ± 0.08
Revolución 81	43.1	102.5 ± 5.2	39.9 ± 0.43	2.37 ± 0.12	70.5 ± 6.4	3.22 ± 0.42	0.56 ± 0.05	0.71 ± 0.06
Centa Izalco	42.7	104.4 ± 9.1	40.0 ± 1.15	2.44 ± 0.24	56.2 ± 23.0	2.75 ± 1.14	0.56 ± 0.18	0.58 ± 0.28
Acacias 4	42.9	100.7 ± 4.1	39.4 ± 0.60	2.34 ± 0.09	72.5 ± 10.6	3.57 ± 0.60	0.63 ± 0.13	0.87 ± 0.04
Bat 1449	42.8	105.9 ± 8.9	39.3 ± 0.45	2.47 ± 0.70	70.5 ± 6.4	3.50 ± 0.44	0.53 ± 0.01	0.78 ± 0.11
Ave ± S.D.	42.8 ± 0.25	104.4 ± 4.6	39.4 ± 0.12	2.43 ± 0.12	69.0 ± 9.6	3.43 ± 0.53	0.61 ± 0.09	0.74 ± 0.13

* All figures on absolute basis.
** 50 g of beans cooked in 150 cc of water for 90 min. Weights have been corrected for moisture content.
*** Different letters indicate statistical differences at 0.05 level.
**** Wet wt., cooked dry wt., raw.

Table 2. Effect of cooking time at atmospheric pressure on bean cooking liquor content of protein and ash

	Beans*,**			Cooking liquor**			
Cooking time (min)	Wet wt. cooked (g)	Dry wt. cooked (g)	Hydration value	Volumen (ml)	Dry wt. (g)	Protein (g)	Ash (g)
70	99.1 ± 1.6^{c}	41.3 ± 0.06^{a}	2.18 ± 0.03^{c}	90 ± 0.0^{a}	4.9 ± 0.13^{b}	0.81 ± 0.00^{bc}	0.79 ± 0.05^{b}
90	100.7 ± 0.6^{bc}	40.6 ± 0.12^{b}	2.21 ± 0.12^{bc}	84 ± 3.5^{a}	5.1 ± 0.06^{ab}	0.76 ± 0.03^{d}	0.79 ± 0.02^{b}
110	100.5 ± 1.0^{bc}	39.5 ± 0.06^{d}	2.21 ± 0.02^{bc}	90 ± 5.8^{a}	5.2 ± 0.24^{a}	0.85 ± 0.00^{a}	0.83 ± 0.04^{b}
130	101.8 ± 0.7^{ab}	40.3 ± 0.12^{c}	2.24 ± 0.02^{ab}	84 ± 1.2^{a}	5.2 ± 0.04^{a}	0.84 ± 0.01^{ab}	0.86 ± 0.03^{ab}
150	103.1 ± 0.6^{a}	39.8 ± 0.12^{d}	2.27 ± 0.02^{a}	85 ± 3.5^{a}	5.2 ± 0.10^{ab}	0.81 ± 0.02^{c}	0.92 ± 0.04^{a}
Statist. difference	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

* Dry wt. Raw beans: 45.5 g. Tamazulapa variety.

**Average of four samples per cooking time. Different letters indicate significant differences (0.05 level).

the cooked beans decreased. Total solids also increased from 4.9 g at 70 min to 5.2 g at 110 min and remained constant at 130 and 150 min. Protein and particularly ash content also increased; however, together they represented 32.6 and 33.3% of the weight of total solids. The effects of cooking time at atmospheric pressure and under pressure are also observed in the results obtained in the second study, which are presented in Tables 3 and 4, respectively.

The wet weight as well as the dry weight of all cooked beans (black, red, white) was affected by cooking time and method of procesing. Likewise, significant interactions were found between process and bean color, process and time, and time and bean color. However, the method of processing had a greater influence than cooking time. With respect to the cooking broth, its volume was influenced by method of processing, time of processing and bean color. The greater effect was due to method of process, followed by cooking time and grain color. Significant interactions were found with respect to process and color, process and time, and process, time and color. Bean cooking liquor solids content was influenced by the process and cooking time, but grain color had no effect. No interactions were detected. With respect to tannins in the cooked beans, all 3 factors had significant effects. The greater effect was due to process, followed by color and cooking time. The only significant interaction was process by color. Color played an important role due to the low levels present in white beans (Bressani and Elias, 1978). Tannins in the cooking liquor were also influenced by process, cooking time and color. The greater effect was due to grain color, followed by the process and lastly, by cooking time. The data also show that cooking for all colors, causes a transfer of the polyphenolic compounds from the beans to the cooking liquor. It is also of interest to indicate that cooking time decreases polyphenolic content in the broth and to a very much smaller extent in the beans.

Although tannins decreased with respect to cooking time in cooking liquor by the two processes, catechin behavior was not similar among the three bean colors, and was different with respect to process. No explanation can be offered at this point for these results.

Correlation coefficients between cooking time and the other variables were estimated. Wet weight of cooked beans and solid weight in the cooking broth gave a significant positive correlation ($P < 0.01$) with cooking time. On the other hand, broth volume and cooked dry bean weight showed a significant negative correlation ($P < 0.05$) with respect to cooking time. Tannin content in the cooked bean showed a negative relationship with respect to cooking time, although it was not statistically significant. However, tannin content in the broth gave a significant negative association

Table 3. Changes in tannin and catechin content and of broth solids of black, red and white beans during atmospheric cooking with respect to time

Beans

	Black				Red				White			
Cooking time (min)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)
30	108.0 ± 7.0	40.0 ± 0.0	1.31 ± 0.00	0.148	95 ± 3	40.5 ± 0.7	1.30 ± 0.03	0.134	95 ± 0.7	40.2 ± 0.4	0.417 ± 0.01	0.083
60	112.0 ± 20.0	40.4 ± 4.4	1.25 ± 0.01	0.139	97 ± 0	40.0 ± 0.0	1.13 ± 0.03	0.079	99 ± 0.7	40.0 ± 0.0	0.410 ± 0.00	0.083
90	112.0 ± 0.0	39.2 ± 0.4	1.19 ± 0.00	0.130	102 ± 6	38.8 ± 0.4	1.06 ± 0.02	0.074	112 ± 2.0	39.5 ± 0.0	0.324 ± 0.01	0.083
120	115.0 ± 1.0	37.5 ± 0.7	0.99 ± 0.01	0.111	121 ± 3	37.7 ± 0.4	1.04 ± 0.00	0.046	118 ± 14.0	38.2 ± 0.4	0.256 ± 0.01	0.065
150	112.5 ± 0.7	38.0 ± 0.0	1.04 ± 0.03	0.037	120 ± 0	38.5 ± 0.7	0.97 ± 0.01	0.046	117 ± 0.7	39.0 ± 0.0	0.231 ± 0.00	0.065

Cooking broth

	Black				Red				White			
	Broth volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)	Broth volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)	Total volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)
30	81 ± 3	2.8 ± 0.4	11.20 ± 0.33	0.269	86 ± 0	3.8 ± 1.4	13.87 ± 0.34	0.575	90 ± 4	2.2 ± 0.4	1.16 ± 0.02	0.074
60	56 ± 11	3.0 ± 0.0	9.03 ± 0.07	0.250	66 ± 2	2.5 ± 0.7	11.78 ± 0.06	0.464	67 ± 3	3.5 ± 0.7	1.11 ± 0.00	0.074
90	50 ± 3	4.0 ± 2.8	7.24 ± 0.07	0.260	56 ± 6	3.0 ± 0.0	6.64 ± 0.09	0.289	54 ± 8	3.2 ± 11.0	1.10 ± 0.00	0.074
120	72 ± 1	4.5 ± 0.7	6.78 ± 0.08	0.232	64 ± 3	4.0 ± 14.0	3.28 ± 0.04	0.213	68 ± 2	3.5 ± 0.7	1.11 ± 0.00	0.074
150	72 ± 1	4.3 ± 0.4	6.26 ± 0.12	0.031	65 ± 2	4.2 ± 0.4	2.81 ± 0.07	0.213	66 ± 2	4.0 ± 1.4	1.11 ± 0.00	0.074

* Absolute basis.

Table 4. Changes in tannin and catechin content and of broth solids of black, red and white beans during pressure cooking with respect to time

Beans	Black				Red				White			
Cooking time (min)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)	Wet wt. cooked (g)	Dry wt. cooked (g)	Tannins (%)	Catechins (%)
30	116 ± 0.0	38.7 ± 0.35	0.88 ± 0.04	0.065	124.0 ± 1.4	38.7 ± 0.35	1.09 ± 0	0.093	114 ± 1.4	38.7 ± 0.35	0.294 ± 0	0.083
60	120 ± 1.4	38.0 ± 0.71	0.83 ± 0.00	0.088	115.0 ± 11.3	34.5 ± 4.90	1.08 ± 0	0.097	125 ± 0.7	38.0 ± 0.00	0.301 ± 0	0.083
90	120 ± 0.0	37.5 ± 0.00	0.82 ± 0.01	0.102	132.5 ± 3.5	38.7 ± 1.10	0.94 ± 0	0.102	129 ± 0.7	37.0 ± 0.00	0.301 ± 0	0.083
120	126 ± 0.0	37.0 ± 1.40	0.82 ± 0.01	0.111	122.0 ± 42.0	31.7 ± 1.10	0.84 ± 0	0.093	121 ± 1.4	31.0 ± 0.00	0.301 ± 0	0.083
150	117 + 1.4	37.2 ± 1.10	0.81 ± 0.00	0.093	125.5 + 2.1	38.0 ± 0.00	0.60 ± 0	0.083	123 ± 0.7	37.5 ± 0.71	0.301 ± 0	0.083

Bean broths	Black				Red				White			
	Broth volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)	Broth volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)	Broth volume (ml)	Total solids* (g)	Tannins (%)	Catechins (%)
30	66 ± 3	3.0 + 0.7	8.17 ± 0.14	0.325	56 ± 1	3.0 ± 1.4	4.16 ± 0.02	0.306	70.0 ± 7.0	25.0 ± 0.7	1.09 ± 0.00	0.056
60	56 ± 2	5.0 ± 0.0	6.64 ± 0.16	0.278	64 ± 8	4.0 ± 0.0	4.08 ± 0.07	0.324	67.5 ± 0.7	40.0 ± 1.4	1.08 ± 0.00	0.037
90	52 ± 2	5.5 ± 0.7	5.27 ± 0.00	0.343	57 ± 4	3.0 ± 0.0	3.48 ± 0.03	0.167	61.0 ± 1.0	5.5 ± 2.1	0.94 ± 0.00	0.037
120	54 ± 6	5.5 ± 0.7	4.00 ± 0.00	0.371	59 ± 1	6.0 ± 0.6	2.70 ± 0.05	0.121	70.0 ± 0.0	4.0 ± 1.4	0.84 ± 0.02	0.037
150	53 ± 7	4.0 + 1.4	3.47 ± 0.00	0.343	48 ± 2	4.5 + 0.7	1.90 ± 0.04	0.093	64.0 ± 6.0	4.5 ± 0.7	0.60 ± 0.02	0.037

* Absolute basis.

($P < 0.01$) with respect to cooking time. These observations are of interest since they suggest differences in composition and probably in nutritive value of the cooking broth due to the type of cooking procedure used. As for using cooking liquor composition as a selection parameter for acceptability purposes, the best cooking time for maximum differences should be established, since it is to be expected that differences between cultivars will disappear as cooking time increases. Observations on the loss of tannins, particularly under atmospheric pressure, are of interest since previous studies have indicated that these substances reduce weight gain in experimental animals (Elías, Fernández and Bressani, 1979; Braham and Bressani, 1985) and decrease protein utilization.

C. *Cooking practices*

Although soaking is not a common preparation practice, based on a survey conducted in Guatemala (Bressani et al., 1987), its influence on cooking liquor composition is of interest as shown in Table 5. Soaking influenced cooking liquor composition, since total solids and protein as percentage increased as soaking time increased. Housewives usually cook beans twice. This method of bean preparation was tested and as shown, it increased total solids. This effect is similar in nature to soaking beans, although it is stronger in its effects because the structure of the beans is significantly altered due to the cooking process. Cooking practices often include addition of small amounts of salt during cooking (Bressani et al., 1987). The effects of this practice on the cooking liquor composition is shown in Table 6. Percent total solids increased as well as percentage protein and ash content. The increase is probably due to the addition of salt rather than to a

Table 5. Effect of soaking time on bean cooking liquor composition

Soaking time (h)	Wet wt. cooked beans (g)	Dry wt. cooked beans (g)	Hydration value*	Cooking liquor vol (ml)	Cooking liquor	
					Total solids (%)	Protein (%)
0	110.7 ± 2.3	38.5 ± 0.3	2.56	84	4.39 ± 0.04	0.90 ± 0.00
4	104.4 ± 1.6	38.6 ± 0.1	2.42	82	4.97 ± 0.26	1.05 ± 0.07
8	110.9 ± 2.0	37.7 ± 1.4	2.57	78	5.80 ± 0.32	1.15 ± 0.07
Double cook**	106.8 ± 1.0	38.7 ± 0.1	2.47	86	6.10 ± 0.57	1.00 ± 0.00

50 g raw Tamazulapa beans, with 13.7% moisture. All values are average of two determinations.
* Wet wt. cooked Dry wt. raw × 100.
**Cooked for 90 minutes, allowed to cool, cooked again.

Table 6. Effect of salt addition on bean cooking liquor content of protein and ash

Seed wt. (g/seed)	Beans*,**			Cooking liquor**			
	Wet wt. cooked (g)	Dry wt. cooked (g)	Hydration value	Volume (ml)	Dry wt. solids (g)***	Protein (g%)	Ash (g%)
0.0	100.5 ± 2.53	39.4 ± 0.35	2.33 ± 0.06	81.5 ± 2.1	4.16 ± 0.02	0.95 ± 0.01	1.10 ± 0.01
0.5	104.9 ± 0.75	40.7 ± 0.10	2.43 ± 0.01	77.0 ± 0.0	3.56 ± 0.05	0.98 ± 0.02	1.20 ± 0.01
1.0	105.1 ± 0.73	40.8 ± 0.28	2.44 ± 0.01	77.0 ± 1.0	3.20 ± 0.11	0.99 ± 0.00	1.45 ± 0.00

* Tamazulapa variety, 43.13 dry weight.
** Average of two samples.
*** Dry wt. in solids corrected for salt addition.

Table 7. Effect of seed size on bean cooking liquor content of protein and ash

Seed wt. (g/seed)	Beans*,**				Cooking liquor*			
	Dry wt. raw (g)	Wet wt. cooked (g)	Dry wt. cooked (g)	Hydration value	Volume (ml)	Dry wt. solids (g)	Protein (%)	Ash (%)
0.209	43.1	111.5 ± 4.7^{b}	40.6 ± 0.8^{b}	2.59 ± 0.11	51.2 ± 11	3.46 ± 0.48	1.29 ± 0.12^{b}	1.42 ± 0.11^{b}
0.142	44.7	119.8 ± 9.4^{ab}	41.7 ± 0.8^{b}	2.57 ± 0.08	38.7 ± 9	3.01 ± 0.44	1.61 ± 0.21^{ab}	1.56 ± 0.22^{ab}
0.066	47.3	125.8 ± 0.9^{a}	44.4 ± 1.3^{a}	2.66 ± 0.02	32.2 ± 7	3.08 ± 0.35	1.91 ± 0.18^{a}	1.81 ± 0.15^{a}

* Tamazulapa variety.
**Average of two samples.
Different letters indicate significant differences at 0.05 level.

solubilization effect caused by the addition of salt; however, only a small change was observed in protein content.

D. *Seed size*

Table 7 shows the importance of seed size on wet and dry weight of cooked beans and on bean broth composition. Statistical analysis showed significant effects with respect to wet and dry cooked bean weight, and protein and ash content. As results show, there was a significant effect caused by seed size, with smaller seeds giving a higher level of percentage ash, and protein content. These results were interpreted in that for a given weight, more seeds with smaller weight will be present as compared to the number of seeds with higher weight, thus resulting in higher percent solids in the cooking liquor. Likewise, more protein and ash were detected in the cooking liquor of the smaller seeds than that from the heavier seeds.

The data presented suggest that cultivars (genetic make-up, grain size, grain color), and cooking practices influence bean cooking liquor composition. Likewise, atmospheric cooking has a different effect as compared to pressure cooking. This is of particular importance when conducting biological assays with processed beans, since atmospheric cooking may give a different result as compared to pressure cooking, the latter being the method more often used at laboratory level. More detailed studies are thus recommended due to the broth's nutritional significance with respect to child feeding, particularly during the weaning process.

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References

1. AOAC (1970) Official Methods of Analysis, 11th edn. Washington DC: Association of Official Analytical Chemists
2. Braham JE, Bressani R (1985) Effect of bean broth on the nutritive value and digestibility of beans. J Sci Food Agric 36: 1028
3. Bressani R, Elias LG (1980) The nutritional role of polyphenol in beans. In: Hulse JH (ed.) Polyphenols in Cereals and Legumes. Proc. Symp. 36th Annual Meeting, Institute of Food Technologists, St. Louis, MO, June 10–13, 1979, Canada, International Development Research Center, IFT, pp. 61–68

Different letters indicate significant differences at 0.05 level.

4. Bressani R, Flores M, Elias LG (1973) Acceptability and value of food legumes in the human diet. In: Wall D (ed.) Potentials of Field Beans and Other Food Legumes in Latin America. Cali, Colombia, pp. 17–48 (CIAT Series Seminars No. 2E)
5. Bressani R, Navarrete DA, García Soto A, Elías LG (1987) Culinary practices and consumption characteristics of common beans at the rural home level. Arch Latinoamer Nutr (in press)
6. Burns RE (1971) Method for estimation of tannin in grain sorghum. Agron J 63: 511
7. Elías LG (1982) Conocimientos actuales sobre el proceso de endurecimiento del frijol. Arch Latinoamer Nutr 32: 233
8. Moscoso W (1982) Efecto del almacenamiento a temperatura y humedad altas sobre algunas caracteristicas físicas y químicas del frijol. Arch Latinoamer Nutr 32: 342
9. Price ML, Van Scoyoc S, Butler LG (1978) A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. J Agr Food Chem 26: 1214