5.2 THE INFLUENCE OF SENSORY ATTRIBUTES ON THE ACCEPTABILITY OF 20 LINES OF GUATEMALAN BLACK BEANS

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In Guatemala, black beans are consumed by almost 95% of the population, losses of beans because of unacceptable characteristics for consumers have been high. When there have been efforts to introduce new high yielding varieties some with better nutritional value, their consumption has been very low because of rejection from the consumers. These facts reflect the problems that our countries are having due to lack of knowledge of the consumers criteria of acceptability. No study relating the sensory attributes of black beans with their perceived acceptability has been reported, therefore, the main purpose of this research was to predict the acceptability of 20 samples of black beans based on sensory analysis, in-house acceptability tests and physical characteristics, with the ultimate aim to predicting Guatemalan consumers acceptability of black beans.

Twenty experimental samples, a blind control and a reference were included (Table 1), they came from different locations and were from different types, and varieties. They were also stored under different storage conditions.

Samples were tested for physical characteristics (seed weight, seed coat percent, moisture percent and 4 h water absorption). The optimum cooking time for each one was obtained using the OTMS.

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Sensory evaluation was done to evaluate the acceptability of the samples and to identify their sensory characteristics.

A preliminary acceptability text was carried out at the beginning of the study to check if we had a wide range of sensory characteristics in samples collected. The results of this test confirmed that there were significant differences among the samples for appearance, texture and flavour.

Quantitative descriptive analysis test was carried out to identify, describe and quantify the characteristics of appearance, flavour and texture of the samples. A group of trained panelists was used for this test They were screened on basis of sensory acidity and willingness to participate, then they were trained. The training in the development of the vocabulary of terms to describe the characteristics, the design of the ballot, the definition of the terms used in the ballot, the use of reference standards and the evaluation of the reference sample against which the other samples were going to be compared. After the treining was completed and the panelists were consistent in their results the formal panel sessions for the final evaluation were carried out. Twenty one different samples plus the reference were evaluated at this stage, the characteristics under evaluation were darkness of color and percentage of split beans for appearance, intensity of beany flavour, beany aftertaste and butterness for flavours and particle size hardness, cohesiveness, seed coat toughness and chewiness for texture Ten trained panelists participated and a total of 14 sessions were necessary to present the samples having two replications for each case, three experimental

samples, the blind control and the reference were presented to each panelists in each session having the order of the samples randomized to avoid errors for position. The task of the panelists was first to taste the reference sample, then taste the other samples and compare each one against the reference for each characteristic.

Ballots having 15 cm unstructured line scales ranging from no presence of the attribute (value of 0) to strong presence of the attribute (value of 30) were used for the evaluation, these scales had the intensity of the reference already marked

A final in-house acceptability test was carried out to evaluate the overall acceptability of the samples; a group of 34 untrained judges from INCAP's staff or students participated in the evaluation. Nine points hedonic scales ranging from 2 = dislike extremely to 9 = like extremely were used. Eleven samples were presented in each session and a replication of the evaluation was done so a total of 4 sessions were necessary to evaluate the samples.

RESULTS

Table 2 shows the F values for the scores given by the trained panel, all those values were significant at $P \leq 0.001$.

Duncans test was carried out to see which samples were different for each characteristic. Table 3 shows the results of the comparison of mean scores for particle size of the cotyledon It can be seen the beans with biggest particle size were the old ones and those that were under

accelerated storage, being significantly different from the other samples The samples with the smallest particle size were the bush beans from Jutiapa, with the bush (E) having the lowest value.

Hardness showed similar results. According to the panelists the hardest beans were the old ones and those under accelerated storage while the softest samples were some bush samples from Jutiapa and a vine bean from Chimaltenango.

It can be observed that there is a close relationship between the above characteristics.

Cohesiveness was also measured. The most cohesive beans were two vine beans from Chimaltenango and three bush beans from Jutiapa while the least cohesive samples were the old ones and those under accelerated storage. The same samples that were rated as having higher particle size and hardness were the ones rated as being the least cohesive

When comparing mean scores for intensity of beany flavour it can be observed in Table 4 that the samples with the most intense flavour were the vine beans from Chimaltenango while the old samples, 2 bush beans from Jutiapa and the ones under accelerated storage were rated as having the least intense beany flavour.

Chewiness was also measured, the results for this characteristic shows that the most chewy beans were the old ones and those that were under accelerated storage while the least chewy were the bush beans Jutiapa having the Bush (E) the lowest score.

The results of bitterness show that the highest scores were assigned to the vine beans from Chimaltenango while the lowest scores

were for the bush beans from Jutiapa with the bush (E) having the lowest score.

The comparison of mean scores for darkness of color showed that the darkest beans were the old ones and a sample that were under accelerated storage while the lightest samples were the bush beans from Jutiapa and Suchitepequez

A relationship among some characteristics can be seen from the above results. Factor analysis was carried out to examine underlying factors responsible for intersample variation, Table 5 shows that three factors responsible for 90% of the variation were identify, they were the cotyledon textural factor that included particle size, hardness, cohesiveness and splits. The second factor was the flavour factor and it included the characteristics of aftertaste and intensity of beany flavour. The third factor identified was the seed coat and it included chewiness, seed coat toughness, bitterness and color.

The results of overall acceptability are showed in Table 6 Comparison of the means scores shows that the most acceptable beans were the bush beans with the highest scores for the bush (E) from Jutiapa and the bush (K) from Chimaltenango. The least acceptable beans were the ones that were under accelerated storage and the old samples. The lowest scored sample was the bush (M) from Peten) The samples that were outstanding for flavour were just rated as having intermediate acceptability.

Table 7 shows us the correlation matrix among all characteristics and between hedonic scores and acceptability, this shows us a strong

positive correlation existed between the hedonic value and cohesiveness while a strong negative correlation existed between hedonic and particle size and hedonic and hardness and between hedonic and chewiness

The scores of overall acceptability are shown in Table 6. These results show that the most acceptable samples were the bush beans. The highest scores were for the sample bush (E) from Jutiapa and bush (K) from Chimaltenango. The samples with the lowest scores for acceptability were the ones that were under accelerated storage and the old samples. The least acceptable sample was the bush (M) from Peten. The samples that were outstanding for flavour were just rated as having intermediate acceptability.

Table 7 shows the correlation matrix among all characteristics and between hedonic scores and acceptability. A strong positive correlation (0.91) existed between hedonic score and cohesiveness, a strong negative correlation (-0.93) existed between hedonic and particle size between hedonic and hardness (-0.88) and between hedonic and chewiness (-0.8). Most of the correlations were significant at $p < 0.01$.

Multiple regression analysis was carried out to identify the characteristics that were most important to the acceptability scores, and to obtain the equation to predict the acceptability. Table 8 shows the analysis using max R^2 for prediction of hedonic ratings on the 22 lines of beans studied. The combination of the two variables particle size and chewiness was the best model chosen with an R^2 of 0 914 The equation derived from these combination was $ACC = 10\,69 - (0\,17)X_1 - (0\,21)X_2$

Table 9 shows the residual values obtained between the actual hedonic

value and the predicted value using the above equation, as it can be seen these values are very low (between 0.02 and 0.8) which means that the equation worked was in predicting the acceptability of those samples

Regression analysis was also applied to predict the acceptability of fresh beans (17 samples), the combination of 3 variables. chewiness, cohesiveness and seed coat toughness was the one that best fit the model with an R^2 of 0,76 The equation ACC = 7.01 - (0.17) X_1 + (0.16) X_2 - (0.08) X_3.

Residuals were obtained to compare the actual and the predicted value, they were very low meaning that this equation also predicted acceptability.

GENERAL CONCLUSIONS

1. A well trained sensory panel is able to distinguish the sensory characteristics among different samples of beans.

2. It was possible to predict the acceptability of the 22 samples of Guatemalan black beans using a trained laboratory panel.

3. Using the prediction equations we can predict acceptability using fewer characteristics. Those were used in the original testing.

TABLE 1

DESCRIPTION OF SAMPLES BY SOURCE AND STORAGE CONDITIONS

Growing Location	Sample Identification Type/Seed Origin	Common Name	Harvest Date Month/Year	Storage Conditions Temperature	Moisture %
Jutiapa	Bush (A) Criollo	Cuarenteno	Jan/87	4°C	12.0
	Bush (B) Criollo	Rabia de gato	Aug/86	4°C	11.6
	Bush (C) Criollo	Sesenteno	Dec/86	4°C	12.0
	Bush (D) Criollo	Vaina morada	Nov/86	4°C	13.7
	Bush (E) ICTA	Tamazulapa	Nov/86	4°C	12.9
	Bush (F) ICTA	Quetzal	Sept/86	4°C	11.4
	Bush (G) ICTA	Suchitan	Sept/86	4°C	12.9
	Bush (H) ICTA	Quetzal	Nov/86	4°C	11.0
	Bush (I) Criollo	Pata de zope	Nov/86	4°C	11.4
	Bush (J) ICTA	Ostua	Dec/86	4°C	12.5
	Bush (J) ICTA HT	Ostua	Dec/86	37°C	12.0
Chimaltenango	Vine (A) Criollo	Itzapa	Jan/87	4°C	13.5
	Vine (B) Criollo	Parramos	Jan/87	4°C	14.3
	Vine (C) Criollo	Itzapa	Jan/87	4°C	12.3
	Vine (B) Criollo HT	Parramos	Jan/87	37°C	15.3
	Bush (K) Criollo	Itzapa	Jan/87	4°C	11.0
	Bush (L) Criollo (Ref)	Parramos	Dec/86	4°C	11.7
Peten	Bush (M) Criollo HT	Pinteno	Feb/87	37°C	14.8
Jalapa	Bush (N) Criollo	Sn. Pedro Pinula	Dec/86	4°C	
Suchitepequez	Bush (O)ICTA	Tamazulapa	Nov/86	AS**	11.4
Not known	Bush (P) GS*	Nacional	1981	AS	11.0
	Bush (Q) GS	Tamazulapa	1981	AS	11.6

*GS = Government storage
**AS = Ambient storage

TABLE 2

ANOVA F VALUES FOR TRAINED PANEL SCORES FOR SENSORY CHARACTERISTICS OF 21 BLACK BEAN SAMPLES

Characteristics	F Value
Particle Size	27.38
Hardness	17.69
Cohesiveness	16.13
Split	54.59
Aftertaste	5.34
Intensity	6.65
Chewiness	5.58
Seed Coat Toughness	6.34
Bitterness	2.71
Color	50.36

[1]F values were all significant at ($P \leq 0.001$)

TABLE 3

COMPARISON OF MEAN SCORES FOR PARTICLE SIZE GIVEN BY TRAINED PANEL

Name	Mean Score	Means with same bar are not significantly different
Bush (P) GS	22.9	
Bush (Q) GS	21.1	
Bush (M) Peten (Cr) HT	19.0	
Bush (J) Jutiapa (I) HT	16.6	
Vine (B) Chimalt (Cr) HT	14.6	
Bush (O) Such (I)	11.3	
Bush (F) Jutiapa (I)	8.8	
Bush (N) Jalapa (Cr)	8.4	
Bush (G) Jutiapa (I)	8.3	
Bush (I) Jutiapa (Cr)	7.5	
Bush (C) Jutiapa (Cr)	6.6	
Bush (B) Jutiapa (Cr)	6.3	
Viné (C) Chimalt (Cr)	6.0	
Vine (B) Chimalt (Cr)	5.8	
Bush (D) Jutiapa (Cr)	5.5	
Vine (A) Chimalt (Cr)	5.2	
Bush (K) Chimalt (Cr)	5.1	
Bush (J) Jutiapa (I)	5.0	
Bush (H) Jutiapa (I)	4.9	
Bush (E) Jutiapa (I)	4.4	

TABLE 4

COMPARISON OF MEAN SCORES FOR INTENSITY OF BEAN FLAVOUR

Name	Mean Score	Means with same bar are not significantly different
Vine (A) Chimalt (Cr)	22.5	
Vine (B) Chimalt (Cr)	21.9	
Vine (C) Chimalt (Cr)	21.6	
Bush (K) Chimalt (Cr)	20.2	
Bush (F) Jutiapa (I)	20.1	
Bush (H) Jutiapa (I)	20.1	
Bush (J) Jutiapa (I)	20.0	
Bush (C) Jutiapa (Cr)	19.6	
Bush (G) Jutiapa (I)	18.9	
Bush (I) Jutiapa (Cr)	18.8	
Bush (N) Jalapa (Cr)	18.7	
Bush (D) Jutiapa (Cr)	18.5	
Bush (J) Jutiapa (I) HT	18.4	
Vine (B) Chimalt (Cr) HT	17.7	
Bush (E) Jutiapa (I)	17.4	
Bush (O) Such (I)	16.7	
Bush (B) Jutiapa (Cr)	16.6	
Bush (Q) GS	15.0	
Bush (M) Peten (Cr) HT	14.9	
Bush (P) GS	13.9	

TABLE 5

FACTOR ANALYSIS FOR SENSORY CHARACTERISTICS OF BLACK BEANS SCORED BY TRAINED PANEL

Characteristic	Factor 1	Factor 2	Factor 3
Particle Size	0.835	0.000	0.000
Hardness	0.805	0.000	0.000
Cohesiveness	-0.771	0.000	0.000
Split	-0.676	0.000	0.000
Aftertaste	0.000	0.941	0.000
Intensity	0.000	0.912	0.000
Chewiness	0.000	0.000	0.778
Seed Coat Toughness	0.000	0.000	0.710
Bitterness	0.000	0.000	0.579
Color	0.473	0.000	0.428
Variance Explained by each Factor	2.718	1.912	1.676

TABLE 6

COMPARISON OF MEAN SCORES OF OVERALL ACCEPTABILITY GIVEN BY UNTRAINED PANELISTS

Name	Mean Score	Means with same bar are not significantly different
Bush (E) Jutiapa (I)	6.8	
Bush (K) Chimalt (Cr)	6.8	
Bush (D) Jutiapa (Cr)	6.7	
Bush (L) Chimalt (Cr)	6.5	
Bush (J) Jutiapa (I)	6.4	
Bush (H) Jutiapa (I)	6.4	
Bush (C) Jutiapa (Cr)	6.3	
Vine (C) Chimalt (Cr)	6.2	
Bush (A) Jutiapa (Cr)	6.1	
Bush (G) Jutiapa (I)	6.1	
Bush (I) Jutiapa (Cr)	5.9	
Vine (B) Chimalt (Cr)	5.7	
Bush (F) Jutiapa (I)	5.7	
Bush (N) Jalapa (Cr)	5.5	
Vine (A) Chimalt (Cr)	5.3	
Bush (B) Jutiapa (Cr)	5.0	
Bush (O) Such (I)	5.0	
Bush (J) Jutiapa (I) HT	3.5	
Vine (B) Chimalt (Cr) HT	3.4	
Bush (Q) GS	3.0	
Bush (P) GS	2.9	
Bush (M) Peten (Cr) HT	2.5	

TABLE 7

PEARSON CORRELATION MATRIX OF SENSORY AND HEDONIC MEAN SCORES

	intens.	aftert.	hard.	p.size	cohes	scoatt	chew	bitt.	col.	split	Hedon
Intensity	1.00	0.96[a]	-0.80[a]	-0.77	0.80[a]	-0.26	-0.48	0.39	-0.20	0.69	0.6
Aftertaste		1.00	-0.72[a]	-0.66	0.72	-0.21	-0.37	0.43	-0.11	0.65	0.5
Hardness			1.00	0.94[a]	-0.95[a]	0.55	0.76[a]	0.00	0.57[a]	-0.79[a]	-0.8
Particle size	1.00		-0.98[a]	0.54	0.76[a]	0.06	0.52		-0.76[a]	-0.9	
Cohesiveness			1.00	-0.51	-0.75	-0.00	-0.44		0.77[a]	0.9	
S.coat toughness				1.00	0.78[a]	0.45[c]	0.51		-0.44	-0.6	
Chewiness					1.00	0.35	0.61[b]		-0.48	-0.8	
Bitterness						1.00	0.45		0.04	-0.1	
Color							1.00		-0.20	-0.5	
Split									1.00	0.6	
										1.0	

[a]significant at $p<0.001$
[b]significant at $p<0.01$
[c]significant at $p<0.05$

TABLE 9

RESIDUAL BETWEEN ACTUAL AND PREDICTED
HEDONIC VALUES OF 22 LINES OF BEANS

ACTUAL HEDONIC VALUE	PREDICTED HEDONIC VALUE*	RESIDUAL
6.15	5.83	0.32
5.38	5.77	-0.39
5.03	5.75	-0.72
6.36	5.79	0.57
5.03	4.93	0.10
6.75	6.49	0.26
6.85	6.37	0.48
5.54	5.71	-0.17
5.77	5.70	0.07
6.85	6.87	-0.02
6.24	5.99	0.25
5.71	5.69	0.02
6.13	5.89	0.24
6.45	6.53	-0.08
5.92	5.99	-0.07
6.47	6.36	0.11
6.53	6.80	-0.27
2.91	2.11	0.80
3.50	4.11	-0.61
3.04	2.78	0.26
2.59	3.15	-0.56

*Calculated from the equation
$Acc = 10.69 - (0.17)X_1 - 0.21(X_2)$

TABLE 8

MULTIPLE REGRESSION ANALYSIS USING MAX R^2 FOR PREDICTION OF HEDONIC RATINGS ON 22 LINES OF BLACK BEANS

VARIABLE DESCRIPTION	Beta Value 1 var	2 var*	4 var	6 var	6 var
Y Intercept	7.50	10.69	10.86	11.58	9.07
X1 Particle Size	-0.22	-0.17	-0.20	-0.22	-0.16
X2 Chewiness		-0.21	-0.11	-0.11	-0.14
X3 Seed Coat Toughness			-0.079	-0.08	-0.07
X4 Split			-0.017	-0.021	
X5 Color				0.022	0.01
X6 Aftertaste				-0.029	-0.25
X7 Intensity					0.29
X8 Hardness					
X9 Cohesiveness					
X10 Bitterness					
R^2	0.881	0.914	0.921	0.926	0.931

*In the stepwise regression procedure no other variables met the 0.1500 significance level for entr into the model