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Evaluation of bush and vine black beans for physical, chemical and nutritional characteristics*

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SUMMARY. The present study was undertaken to learn if there are physical, chemical and nutritonal differences between vine and bush type of beans. Four samples of black color beans (*Phaseolus vulgaris*) of the vine type, and four of the bush type were collected from farmers in the same growing area. The samples were analyzed for some physical properties including, 100 seed weight, size distribution, percent seed coat, water absorption, cooking time, and of solids on cooking waters. Vine type beans had larger 100-seed weights, larger sized beans, thicker seed coats, and lower of solids in the cooking water than bush type beans. Rate of water absorption was different. The chemical characterization included proximate analysis and fiber fractionation. Vine type beans had, on the average, less ether extract and protein than bush types. No differences were found in fiber fractions, although there was a higher variability in the vine types. Protein quality and protein digestibility when fed as the single protein source, were similar on the average, with more variability in the vine types. Both types, efficiently supplemented maize proteins and the protein digestibility was higher than when fed alone. In general there were no large differences, except in some physical measurements, between vine and bush type beans, with the former showing greater nutritional variability which could be useful in selection programs, if such variability is confirmed.
Keywords: Vine vs. bush type of beans; Physical, chemical, nutritional characteristics.

RESUMEN. Estudio comparativo del crecimiento vegetativo de los frijoles de enredo y rastrero. Algunas características físicas, químicas y nutricionales. El presente estudio se llevó a cabo para conocer si existen diferencias en algunas características físicas, químicas y nutricionales entre frijoles de tipo arbustivo y de tipo de enredadera. Un total de 4 muestras de frijol negro (*P. vulgaris*) de cada tipo fueron recolectadas de agricultores en la misma región agrícola. Las muestras fueron analizadas para algunas características físicas que incluyeron el peso de 100 granos, la distribución por tamaño, el porcentaje de cáscara, la absorción de agua, el tiempo de cocción y por los sólidos en las aguas de cocción. Los frijoles del tipo de enredo tenían mayor peso por 100 granos, mayor tamaño, mayor contenido de cáscara y menor contenido de sólidos en el agua de cocción, que los frijoles de tipo arbustivo. La caracterización química incluyó el análisis proximal y el fraccionamiento de la fibra. Los frijoles tipo enredo tenían en promedio menos extracto etéreo y proteína que los frijoles tipo arbustivo. No se encontraron diferencias en las fracciones de la fibra, a pesar de que se encontró una mayor variabilidad en los de tipo enredadera. La calidad de la proteína y su digestibilidad cuando se evaluaron como única fuente de proteína en la dieta, fueron similares en promedio, con mayor variabilidad en los frijoles tipo enredadera. Los dos tipos de frijoles, suplementaron eficientemente las proteínas del maíz y la digestibilidad de la proteína en la mezcla fue mayor que cuando se evaluaron solos. La calidad de la proteína cuando se evaluaron solos, se reflejó cuando se evaluaron en mezclas con maíz. En general no se encontraron diferencias, excepto en algunas características físicas entre los dos tipos de frijoles. Los frijoles de tipo arbustivo mostraron, sin embargo, mayor variabilidad nutricional, la cual podría ser útil en programas de selección.

INTRODUCTION

There are two important types of common beans produced and consumed in Guatemala in terms of their growth behaviour. Type I has a determined growth and in general has from 5 to 7 nodes, with erect plants and grows as a bush. It is grown in

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monoculture. Type IV has an undetermined growth and in general it may have up to 39 nodes. The plants are of the climbing vine type and are grown in association with maize. The guide shoot may vary in length from 154 to 326 cm (1). Type IV grows and produces well in the highlands of Guatemala, in average yearly temperatures varying from 16 to 18°C. According to Masaya (2) the production of vine-type beans in the highlands, represents around 22.5% of the total production of beans in the country. Vine beans (type IV) are often cultivated by small farmers, in association with corn, resulting in an efficient food crop production system, providing two basic foods from the same area of land. This production system presents potential to improve the nutritional status of the population by making more food available from limited space. Results from a number of feeding tests show that a diet of 10-30% beans and 70-90% corn, or other cereal grain, results in a significantly improved diet, as compared to the protein quality of the individual foods (3,4).

The chemical composition and nutritive value of the common bean has been studied extensively (5,6,7). In general, the variability reported in major nutrients is not very large. However, specific studies on the chemical composition and nutritional value between type of beans based on their growth behavior are not readily available. Guatemalan highland farmers often indicate that vine type beans are larger, softer, easier to cook, more palatable after cooking and produce a thicker cooking broth, as compared with bush beans. Consumer acceptability criteria for bean in Guatemala includes black color, softness of the grain, cooking time and thickness of the cooking liquor (8). Farmers also claim that vine type beans do not become as hard to cook after storage as bush type. It is well known that most food legumes develop a hard-to-cook condition, particularly if they have been stored at high temperatures and high relative humidity (9,10). Even though much knowledge on the chemical composition and nutritive value of black beans is available, a comparative study between vine (Type IV) and bush (Type I) beans was worth conducting, particularly in view of the fact that many farmers produce and consume Type IV, and since they claim vine beans are better than bush beans in certain postharvest technology traits. Therefore, the present study was undertaken to determine if vine beans are different or similar in physical, chemical and nutritional characteristics than bush beans, in samples of both types of beans cultivated by farmers in the same growing area.

MATERIALS AND METHODS

Sample description: Four samples each, of vine and bush type beans, were collected from 5 growing areas in the highlands of Guatemala. The localities for bean collection were chosen on the basis of the presence in the field of both types of beans and which had to be as close to each other as possible, to minimize possible effects of soil and of other environmental factors. The samples were identified with the name of the four localities, since they were not known varieties: Chuarrancho, Pachalí, Parramos and Santiago Sacatepéquez. All samples were common black beans (*Phaseolus vulgaris*). A 15-Kg sample of each variety was obtained directly from the farmers, to guarantee they were produced in the same harvest season (August) and in the same locality. The bean samples were stored at 6°C until their chemical and biological analysis was performed.

Sub-samples were taken to measure weight and size of the seeds, percentage of seed coat, cooking time, water absorption and content of solids in cooking broth. Bean weight was obtained by weighing 100 seeds, in triplicate. Bean size distribution was measured by screening 100 seeds in sieves of 3 sizes, with a longitudinal aperture of 10mm by 3.18, 5.56 and 7.90 mm for small, medium and large size grain, respectively. The number of seeds passing each screen was expressed as percentage of the total. The percentage of seed coat was obtained by separating manually the seed coat on two samles of 25 seeds each. The seed coat, cotyledon and seed coat plus cotyledons were weighed, and the seed coat and cotyledon, expressed as percentage of the whole seed. Cooking time was estimated by placing 100 seeds into 400 ml of boiling water, (94°C). The volume of water was kept constant through the cooking process. Cooking time was estimated by removing 10 seeds at 20 min intervals and then pressed between the fingers. Cooking time was recorded when the seeds did not give a sensation of graininess upon pressing between the fingers. Water absorption was obtained from 25 seeds per sample, which were placed in 25ml of tap water. Weight changes were measured every hour during a total of four hours. Cooking broth solids were measured by cooking 100 seeds in 400 ml of water during the cooking time study indicated previously. The liquid was then separated from the seeds by screening through a 40 mesh sive. The cooking liquor was dried with air at 60°C and the dried solids weighed.

All samples were chemically analyzed by the AOAC procedures (11). The beans samples were also analyzed for fiber components. A 0.60g samples of finelly ground bean was first treated with Thermamyl, using a phosphate buffer at pH 6.0 (Asp et al, 1983) (12). The pH was adjusted to 7.0 with 1N NaOH and the analysis was continued by the method of Goering and Van Soest (1970) (13) and AOAC (11).

A 5kg sub-sample of each cultivar stored at 4°C was cooked in the autoclave at 15 lbs pressure, during 40 minutes, with 15 kg of water. The cooked samples were dried in hot air at 60°C and then ground. Two biological trials were performed. One in which beans provided all the protein in the diet, (fixed at 10%), and the second one in which mixtures of 11% beans and 89% corn were prepared and utilized in a basal diet to provide 10% protein. The basal diet contained bean or bean/maize flour to provide 10% protein, 4% mineral mixture (14), 5% cottonseed oil, 1% cod liver oil and 5ml of a complete B-vitamin mixture (15). Each diet was fed to Wistar weanling rats, 22-23 day-old, which were placed in all-wire individual cages with raised bottoms and diets provided *ad libitum*. Water was available at all times. Room temperature was 23°C with a 12 hour light cycle. Weight changes and diet intake were measured every 7 days. During the last 5 days of the 28 day Protein Efficiency Ratio (PER) study, faecal samples were collected to calculate Apparent Protein Digestibility.

RESULTS AND DISCUSSION

The physical characteristics of the two bean types are shown in Table 1. The weight of 100 seeds of the vine beans was greater than the 100 seeds weight of the bush beans. The difference was statistically significant ($P<0.05$). Seed size distribution was also different beettween bean types, particularly in large and medium size seeds. The vine type had a higher percentage of large beans, while the bush type had a higher percentage of medium size beans. Both types showed a similar amount of small beans. Seed coat percentage was statisticaly different ($P>0.05$), with 8.77 and 9.85% for the bush and vine beans, respectively.

TABLE 1
SOME PHYSICAL CHARACTERISTICS OF BUSH AND VINE BEAN (*P. VULGARIS*) CULTIVARS

Location	Weight 100 seeds g	Size distribution % Large (10x7.90 mm)	Medium (10x5.56 mm)	Small (10x3.18 mm)	Seed coat %	Water Absor -ption %
			Bush type			
Chuarrancho	21.31	15	60	25	9.32	65
Pachalí	23.39	24	54	22	8.37	70
Santiago, Sac	23.19	11	65	24	8.95	66
Parramos	23.33	5	64	31	9.24	42
Average ±S.D	22.81±0.87	13.7±6.9	61±4.3	25±3.4	8.97±0.37	
			Vine type			
Chuarrancho	27.19	30	52	18	9.62	87
Pachalí	28.33	28	44	28	9.94	85
Santiago, Sac	25.94	28	53	19	9.87	6
Parramos	25.76	34	48	18	9.98	5
Average ±S.D	26.81±0.04	30±2.4	49±3.6	21±4.2	9.85±0.14	

Water absorption values, measured at the end of 4 hrs ranged from 42 to 70% for the bush type, and from 5 to 87% for the vine type. Two samples of the vine beans having a shiny seed coat, absorbed only small amounts of water after four hours of soaking, while the water absorption of the four bush bean samples was highter. In this respect, the route that water inhibition follows is controversial. In dry beans (*Phaseolus vulgaris)* three structures have been suggested as possible sites of water entry: the hilum, the micropyle and the raphe. The latter two structures are above and below the hilum, whieh has a larger surface area. However, al three structures may be functional to a different degree probably associated to genetic factors and growing conditions (16, 17).

Other data are shown in Table 2. Cooking time was similar for samples from each group of beans, however, the amount of solids in cooking broth was higher on the average ($P>0.05$) for the bush type (9.00%) as compared to the vine type (7.90%). The results are similar to those reported previously (18).

TABLE 2
COOKING TIME AND PERCENT OF SOLIDS IN COOKING WATERS OF BUSH AND VINE TYPE BEAN CULTIVARS

Location	Cooking time min	Solids in cooking waters %
	Bush type	
Chuarrancho	150	9.82
Pachalí	120	8.89
Santiago, Sac	120	7.90
Parramos	150	9.40
Mean ± S.D.	135 ± 15	9.00 ± 0.72
	Vine type	
Chuarrancho	120	8.14
Pachalí	150	7.69
Santiago, Sac	150	7.95
Parramos	150	7.83
Mean ± S.D.	142.5 ± 13	7.90 ± 0.16
Significance	NS	S

The chemical compositon of the raw samples is shown in Table 3. Ether extract averaged 5.44% for bush beans, and 4.47% for vine beans. Two samples in the latter group showed the lowest ether extract content of all. These beans are those which did not show water absorption (Table 1). The average difference in ether extract, however, is not significant. Protein was 24.4% for the bush beans, and 22.3% for the vine beans, on the average, but the differences were not statistically significant. Crude fiber content was found higher in the vine type, which also showed a larger seed coat percentage.

TABLE 3
PROXIMATE CHEMICAL COMPOSITION OF BUSH AND VINE BEAN CULTIVARS*
(%)

Location	Moisture	Ether extract	Crude fiber	Protein	Ash
		Bush type			
Chuarrancho	10.16	5.32	4.56	25.9	4.94
Pachalí	9.98	5.23	4.17	25.1	5.15
Santiago, Sac	11.16	5.84	4.53	20.8	5.48
Parramos	9.84	5.39	4.45	25.9	5.21
Average ±S.D	10.28±0.52	5.44±0.23	4.43±0.15	24.2±2.1	5.19±0.19
		Vine type			
Chuarrancho	9.67	5.06	4.39	25.2	5.35
Pachalí	11.02	5.91	5.12	23.0	5.58
Santiago, Sac	9.30	3.49	4.76	19.9	5.41
Parramos	10.16	3.41	4.78	21.2	5.13
Average ±S.D	10.04±0.64	4.47±1.06	4.76±0.26	22.3±2.0	5.37±0.16
Significance	NS	NS	NS	NS	NS

* Raw

The results of fiber fractionation are shown in Table 4. Although Total Dietary Fiber is the accepted way to establish the concentration of these chemical compounds in foodstuffs, the method used in feed analysis was applied in order to have a general view of the distribution of various chemical components which make up dietary fiber. Neutral detergent fiber (NDF) average percentage was similar for the bush and vine type beans, however, variablity between samples within the vine type was higher. The average of acid detergent fiber (ADF) was similar between bush and vine type beans, as well as cellulose and lignin content. However, average hemicellulose content was higher for the bush type, and the variability between bean samples within the vine type was also high. None of the differencees were thus, statistically significant. The average values are similar to those published before (7).

TABLE 4
FIBER FRACTIONATION OF BEANS
(%)

Bean sample	Dry matter	NDF	ADF	Hemice-llulose	Cellulose	Lignin
			Vine type			
Parramos	87.7	12.1	6.6	5.5	6.0	0.6
Pachalí	88.2	15.0	7.0	7.9	6.4	0.8
Santiago, Sac	88.3	8.0	7.4	0.7	6.5	0.6
Chuarrancho	89.3	14.5	6.9	7.6	6.2	0.7
Average±S.D.	88.4±0.58	12.4±2.70	7.0±0.28	5.4±2.88	6.3±0.19	0.7±12
			Bush type			
Parramos	88.6	15.0	6.0	9.0	5.4	0.6
Pachalí	89.2	16.4	6.7	9.8	6.1	0.5
Santiago, Sac	88.4	16.5	7.6	8.9	6.8	0.7
Chuarrancho	89.4	12.9	6.4	6.5	6.0	0.6
Average±S.D.	88.9±0.41	15.2±1.45	6.7±1.23	8.5±1.23	6.1±0.50	0.6±0.07
Significance	NS	NS	NS	NS	NS	NS

As percent dry matter

The protein quality of both types of beans when they provide the only source of dietary protein is shown in Table 5. There were no statistical significant differences in weight gain, feed intake, PER and protein digestiblity on the average between the bean types. The bush type showed a slightly higher protein digestibility than the vine type. All bush types shower greater variation. In one vine sample (Pachalí) PER was the lowest (0.64), as compared with the others with values that ranged from 1.20 to 1.51. Bean samples of the two types with the lowest PER also showed the lowest apparent protein digestibility, which in any case was low for all samples. The protein quality of this group of samples is similar to those reported previously (7).

TABLE 5
PROTEIN QUALITY AND PROTEIN DIGESTIBILITY OF BUSH AND VINE TYPE BEAN CULTIVARS AS A SOLE PROTEIN SOURCE IN DIET

Location	Average weight gain g	Average diet intake g	PER	APD %
		Bush type		
Chuarrancho	35±9.6	241±35.1	1.16±0.18	67.2±2.6
Pachalí	39±5.7	281±39.2	1.12±0.07	69.7±3.9
Santiago, Sac	28±6.1	264±24.1	1.00±0.23	62.4±1.9
Parramos	32±7.7	255±48.1	1.08±0.06	67.9±2.0
Average±S.D.	33±4.1	260±4.5	1.08±0.06	66.8±2.7
		Vine type		
Chuarrancho	52±6.9	300±40.5	1.51±0.13	64.4±5.0
Pachalí	17±4.7	229±26.7	0.64±0.12	62.4±2.6
Santiago, Sac	35±6.1	248±28.4	1.20±0.13	66.9±1.6
Parramos	34±7.3	269±38.5	1.30±0.21	64.0±8.3
Average±S.D.	34±12.4	261±26.3	1.16±0.82	64.4±1.6
Casein	125±10.4	390±26.4	2.94±0.19	93.1±11.8
Significance	NS	NS	NS	NS

Table 6 summarizes results in which the bean samples were fed with corn in a weight ratios of 11:89 g, bean: corn. There were no difference between the two bean types with respect to average weight gain, diet intake, PER, and protein digestibility. Beans of either type which resulted of low quality when fed alone, resulted also low when they were tested in combination with corn. This is probably a reflection of the extent of methionine deficiency in bean protein. All parameters were, however, higher when the beans were fed in combination with maize, as described before (3,4), due to the supplementary effect beans have on maize, since it provides a supplementary protein rich in lysine, which is an amino acid deficient in maize (19).

TABLE 6
PROTEIN QUALITY AND PROTEIN DIGESTIBILITY OF BUSH AND VINE TYPE BEANS IN A 89: 11, MAIZE: BEAN DIET

Location	Average weight gain g	Average diet intake g	PER	APD %
		Bush type		
Chuarrancho	93±7.9	418±28.7	2.23±0.08	80.1±1.4
Pachalí	92±6.9	92±22.2	2.19±0.10	83.3±0.7
Santiago, Sac	70±9.3	367±35.3	2.03±0.14	80.0±1.6
Parramos	82±10.7	417±34.1	2.04±0.13	78.3±2.3
Average±S.D.	84±9.3	408±24.0	2.12±0.09	80.4±1.8
		Vine type		
Chuarrancho	95±4.2	439±41.7	2.16±0.30	80.9±1.6
Pachalí	69±9.5	380±26.4	1.96±0.17	79.3±2.1
Santiago, Sac	84±8.9	406±36.4	2.14±0.14	80.4±1.33
Parramos	78±7.3	403±113.6	2.01±0.11	80.4±0.4
Average±S.D.	81±9.5	402±23.3	2.07±0.07	80.2±0.6
Casein	125±10.4	390±26.4	2.94±0.19	93.1±11.8
Significance	NS	NS	NS	NS

The improvement in protein quality in the maize diets varied from 48.0 to 51.2% with the bush type, however, for the vine type the increment was higher, 67.3% in one sample, 43.9% for another one, and only 35.3 and 30.1 for the other two. The main nutritional effect of beans at the level tested with maize would be due to the lysine provided by 11% of beans. Based on the results, it may be suggested that the bush type of beans to contain similar lysine levels, while one vine sample possibly contained more lysine, and the other three, less lysine than the bush type. However, the content of methionine, the first limiting amino acid in bean protein, could also be involved in the response observed.

The results indicate that aside from the differences in weight and size, vine type beans are on the average, similar to bush type, in terms of chemical composition, fiber fractions, and nutritive value, however, there is a higher variability within samples, a finding that could be useful in terms of selection of better quality cultivars. Furthermore, the production potential of vine type beans should be improved, and their cultivation should be encouraged in agricultural production systems, since both maize and beans and possibly other crops, such as pumpkins, would become available from the same area of land in intensive polyculture systems (20).

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