

# **Recent advances of research in antinutritional factors in legume seeds and oilseeds**



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# **$\alpha$ -Galactosides in Catalan landraces of beans (*Phaseolus vulgaris* L.) and location, candidates for protected designation of origin**

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## **Summary**

Traditional landraces of dry beans (*Phaseolus vulgaris*) are still cultivated in many places in Europe due to their organoleptic quality. These landraces, which are generally of regional interest, deserve attention from plant breeders because of their social and economic importance. Three landraces, which are still cultivated in Catalonia were assessed for raffinose and stachyose content (both accounting for flatulence) after being cultivated in three locations that are candidates for Protected Designation of Origin. The location effect was significant ( $P < 0.05$ ) for both stachyose and raffinose, while the variety effect only reached the same level of significance for raffinose. Environmental correlations were greater than genetic ones, either between stachyose and raffinose or between these two traits and other chemical compounds of the seed. From a practical point of view (flatulence production), the differences found in raffinose and stachyose content, although significant, does not seem large enough to justify the inclusion of these two compounds in the definition of Catalan Protected Designations of Origin.

**Keywords:** *Phaseolus vulgaris*, landraces,  $\alpha$ -galactosides, genetic correlations, environmental correlations

## **Introduction**

Breeding of commercial varieties of dry beans (*Phaseolus vulgaris* L.) has focused on yield and nutritive value. Little attention has been paid to organoleptic quality. In Spain, beans are a minor crop, but some traditional landraces are still cultivated due to their gastronomic prestige, sometimes associated with a typical culinary speciality. Such landraces have a poor yield performance and other agronomic traits but the high price they obtain, in local markets, makes their cultivation worthwhile.

To protect valuable landraces associated with certain regions and local dishes, the European Community promotes the Protected Designation of Origin (PDO). To contribute to this task regarding traditional beans of Catalonia, our laboratory has launched a program to ascertain the chemical basis of the gastronomic differences and to determine the effect of genotype and environment on the final product.

In addition to gastronomic traits we are also monitored some chemical compounds with undesirable side effects or antinutritional properties. Among others, we checked the  $\alpha$ -galactosides of sucrose, which are partially responsible for flatulence (Alles *et al.*, 1996). Significant differences in raffinose and stachyose content have been found among varieties (Drum *et al.*, 1990; Muzquiz *et al.*, 1999) and locations (Muzquiz *et al.*, 1999). Thus, information on these compounds might be useful for the definition of PDOs. The objectives of this experiment were i) to describe the genetic and environmental variation in raffinose and stachyose in Catalan landraces, cultivated in areas that are candidates for PDO, and ii) to evaluate whether these traits would be of use in the definition of PDOs.

## Materials and methods

Field trials included the Catalan landraces Castellfollit del Boix, Genoll de Crist, and Montcau (pure line derived from the Ganxet landrace), and the checks Canela (from Vegas Bañezanas Company, La Bañeza, Leon, Spain) and Navy (from B & W Co-Op. Inc., Brekenridge, Michigan, USA).

The experiment was conducted in Santa Pau, with a volcanic soil; Castellar del Vallès, with soil originating from limestone decomposition; and El Prat de Llobregat, with alluvial soil (Table 1). All three locations are in Catalonia (NE Spain) and have a mild Mediterranean climate. A complete randomized block design (2 blocks per location) was used, where each plot consisted of two rows of 80 competitive plants. The distance between plants in a row was 50 cm and between rows 75 cm (greater than usual in order to avoid differences in competition among varieties). Irrigation was provided when necessary in Castellar and El Prat. The Santa Pau location was not irrigated, as this is the traditional way of cultivation.

Table 1. Edaphic characteristics of the three locations.

	Santa Pau	Castellar	El Prat
Soil pH	7.6	8.1	8.2
Oxidizable organic-matter (%)	4.4	2.8	2.2
Nitric nitrogen (mg N-NO <sub>3</sub> /kg)	43	15	53
Phosphorus (Olsen) (ppm)	55	97	50
Potassium (ppm)	> 600	451	356
Magnesium (ppm)	466	332	306
Calcium carbonate equivalent (%)	< 4	18	30
Calcium (ppm)	4,703	8,454	7,325
Cation exchange capacity (Meq/100 g)	26.3	13.3	7.2
Textural class (USDA)	Sandy-loam	Clay-sandy-loam	Loam

Raffinose and stachyose content were determined simultaneously as their trimethylsilyl derivatives by gas chromatography. Verbascose was not assessed, but its content in beans, on average, is only 5 % of the total  $\alpha$ -galactosides of sucrose (Muzquiz *et al.*, 1999).

The traits were analysed using the linear equation:

$$X_{ijkl} = \mu + G_i + L_j + B_{k(j)} + GL_{ij} + \xi_{l(ijk)}$$

where,  $G_i$  = population effect;  $L_j$  = location effect;  $B_k$  = block effect within location and  $\xi_{l(ijk)}$  = the residual effect (plot within population, block and location).

Data were recorded on a per plot basis. Calculations used the GLM procedure of the SAS statistical package (SAS Institute, 1985). Genetic and environmental correlations of raffinose and stachyose with other traits (Casañas *et al.*, 2003) were calculated using the mean value of variety and trait, and the mean value of location and trait, respectively.

## Results and discussion

The location effect was significant for stachyose ( $P < 0.02$ ) (Table 2). The Santa Pau trial had the lowest value at 10 % lower ( $P < 0.05$ ) than El Prat (the highest value). There was no significant difference in this trait for variety (Table 2) or for the variety  $\times$  location interaction.

Raffinose, which accounted for less than 10 % of the total  $\alpha$ -galactosides in our analysis (Table 2), had highly significant differences ( $P < 0.001$ ) for location, variety, and the location  $\times$  variety interaction. The ranking for raffinose content (significant,  $P < 0.05$ ) was Santa Pau  $>$  Castellar  $\approx$  El Prat, for location and Castellfolit del Boix  $\approx$  Navy  $>$  Montcau  $>$  Genoll de Crist  $\approx$  Canela, for variety.

Stachyose plus raffinose content (Table 2) was not significant for any effect (location, variety, or location  $\times$  variety) because, in general, the higher the value was for stachyose, the lower it was for raffinose; thus, the two compensated for each other.

Table 2. Variety and location means (g/kg) and least significant difference (LSD) ( $P < 0.05$ ) of raffinose (Raf) and stachyose (Sta) and their total (Raf + Sta).

Variety	Raf	Sta	Raf + Sta	Location	Raf	Sta	Raf + Sta
Genoll de Crist	0.84	23.41	24.25	Santa Pau	1.88	22.33	24.21
Montcau	1.81	22.70	24.51	Castellar	1.60	23.65	25.25
Castellfolit del Boix	2.39	23.30	25.69	El Prat	1.52	24.92	26.44
Canela	0.81	25.62	26.43	LSD	0.23	2.57	ns
Navy	2.48	23.17	25.63				
LSD	0.30	ns	ns				

The environmental correlation between stachyose and raffinose was  $-0.96$  ( $P < 0.19$ ). The corresponding genetic correlation was lower ( $-0.61$ ) (Table 3). Similarly, stachyose and raffinose contents were more environmentally than genetically correlated with other chemical seed traits. Genetic correlations were only significant between stachyose and glucose, while environmental correlations of stachyose were significant with protein, glucose and citric acid (Table 3). Generally, the higher the correlation of a given trait with stachyose was, the lower was the corresponding one with raffinose. While this was true for the genetic correlations, it was especially evident for the environmental ones. The correlations of total  $\alpha$ -galactosides (raffinose + stachyose) with other seed compounds were similar to the ones for stachyose, because of its predominant proportion of the total.

Cation exchange capacity was strongly correlated with  $\alpha$ -galactosides, positively with raffinose and negatively with stachyose. As a high soil cation exchange capacity generally means less plant stress and  $\alpha$ -galactosides are considered to have an anti-stress effect, this correlation makes sense. Other correlations with soil characteristics are more difficult to explain from a physiological point of view. A random association between cation exchange capacity and some chemical elements could account for these values.

Although the results show significant differences in some effects and traits, the magnitude of the differences does not seem enough to justify the use of these data (as the difference of flatulence induced) in the definition of Catalan PDOs.

Table 3. Genotypic and environmental correlations of raffinose and stachyose, with seed traits and soil characteristics of locations.

	Raffinose		Stachyose		Raffi + Stachy	
	Genetic	Environ.	Genetic	Environ.	Genetic	Environ.
Seed trait						
Stachyose	-0.61	-0.96	-	-	-	-
Malic acid	-0.72	-0.80	-0.05	0.94	-0.70	0.96
Citric acid	-0.33	-0.88	0.08	0.98*	-0.19	0.99**
Glucose	0.57	-0.92	-0.92***	0.99**	-0.65	1.00***
Lactose	-0.34	0.62	0.65	-0.36	0.53	-0.32
Sucrose	-0.78	-0.91	0.01	0.75	-0.68	0.72
Protein	0.41	0.98*	-0.37	-0.99**	-0.10	-0.99**
Soil characteristics						
Phosphorus		-0.21		-0.09		-0.14
Potassium		0.98*		-0.99**		-0.99**
Magnesium		1.00***		-0.94		-0.92
Calcium carbonate		-0.96		1.00***		1.00***
Calcium		-0.87		0.69		0.65
Cation exchange capacity		0.99**		-0.98*		-0.97

Probabilities used. \*P = 0.15; \*\*P = 0.10; \*\*\*P = 0.05.

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