

Screening Common Bean Germplasm for Raffinose-Family Oligosaccharide Content

K.E. McPhee and J.R. Myers

University of Idaho, Research and Extension Center, Kimberly, ID 83843

The raffinose-family oligosaccharides (RFOs) (including raffinose, stachyose, and verbascose) are thought to affect nutritional and agronomic aspects of common bean. Recent studies (1) suggest that these sugars may help stabilize cell membranes, preventing damage to seed as they imbibe. Secondly, RFOs have been implicated as an anti-nutritional factor which causes flatulence when the beans are consumed (2). To study these aspects of RFOs, we evaluated 79 accessions for oligosaccharide content. These data are published to document the range of RFOs found in germplasm of greater genetic diversity than those previously examined. Lines were chosen on the basis of folk reputation, of being sweet, having greater digestibility, or spoiling more easily. No verbascose was observed in this screen. Eight accessions were further analyzed in a diallel to investigate genetic control, the results of which are reported elsewhere (3).

Five to ten seeds of each accession were ground to a fine powder and were extracted in hot ethanol. Derivatized soluble sugars were quantitated using gas-liquid chromatography. Details of the procedure can be found in (3).

The results from this analysis are presented in Table 1. The mean for fructose, sucrose, raffinose, and stachyose was 3.64, 19.73, 1.12, and 21.11 mg/gm, respectively and the range for each sugar was 1.86 to 7.03, 11.97 to 31.20, 0.21 to 5.04, 13.42 to 27.83, respectively. With one exception, previous studies (4) have generally examined germplasm of North American descent, which lacks genetic variability compared to global genetic resources. As a result, previously published values are more homogeneous than those presented here. Ortega's (5) research is an exception in that Mexican landrace material was studied. Our analysis of some of the same accessions as used in (5) corroborate the earlier study.

References

1. Bernallugo, I., and A.C. Leopold. 1995. Seed stability during storage: Raffinose content and seed glassy state. *Seed Sci. Res.* 5:75-80.
2. Fleming, S.E. 1981. A study of relationships between flatus potential and carbohydrate distribution in legume seeds. *J. Food Chem.* 46:794-798.
3. McPhee, K. 1995. Determination of environmental and genetic effects controlling raffinose-family oligosaccharide accumulation in common bean (*Phaseolus vulgaris* L.) seeds. Ph.D. Thesis, University of Idaho.
4. Sathe, S.K., S.S. Deshpande, and D.K. Salunkhe. 1984. Dry beans of *Phaseolus*. A review. Part 2. Chemical composition: Carbohydrates, fiber, minerals, vitamins, and lipids. IV. Carbohydrates. *Crit. Rev. Food Sci. Nutr.* 21:41-93.
5. Ortega Delgado, M.L., and C. Rodriguez Coquiez. 1979. Estudio de azúcares solubles en semillas de frijol. *Agrociencia* 37:17-24.

Table 1. Fructose (Fru), Sucrose (Suc), Raffinose (Raff), and Stachyose (Stach) content of 79 accessions screened to obtain an estimate of the variation for the raffinose-family oligosaccharides in common bean. Accessions in boxes were used in an eight parent diallel for genetic analysis of raffinose-family oligosaccharides.

Name	Accession Number	Source	Market Class/ Description	Origin	-----mg/gm-----			
					Fru	Suc	Raff	Stach
	AFR 569	CIAT ¹	Calima	Colombia	3.65	12.49	0.90	17.80
	AFR 574	CIAT ¹	Calima	Colombia	5.18	23.51	1.11	14.34
	AFR 612	CIAT ¹	Calima	Colombia	4.45	21.60	0.88	18.30
	AFR 613	CIAT ¹	Calima	Colombia	4.47	22.13	0.98	16.24
Alleman	PI 282003	USDA	Coscorron	Chile	3.42	23.51	0.39	20.38
Alto Jahuel	PI 282118	USDA	Coscorron	Chile	2.58	19.82	0.64	24.47
Anasazi		AM ²	Anasazi	USA	3.70	27.42	2.56	18.93
Blanco	PI 282025	USDA	Coscorron	Chile	3.77	15.92	2.79	27.83
Blanco								
el Llano	PI 282104	USDA	Coscorron	Chile	3.21	22.41	1.94	17.13
Burros		Edwards ³		Chile	3.39	26.37	0.95	15.44
	Chis. 2-A-3	Ortega ⁴	Black	Mexico	3.43	16.93	2.39	22.80
	Chis. 115	Ortega ⁴	White	Mexico	3.68	18.97	2.58	18.81
	Chis. 146-A	Ortega ⁴	L. Black	Mexico	2.87	19.58	1.73	21.26
	Chis. 152	Ortega ⁴	White	Mexico	3.79	19.75	5.04	19.28
	Chis. 253	Ortega ⁴	Black	Mexico	3.45	15.73	2.19	25.40
		Edwards ³	Coscorron	Chile	2.87	15.03	2.97	14.88
Narayate	D13	Kelly ⁵	Sugar	Malawi	4.05	17.24	0.41	23.61
Narayate	D14	Kelly ⁵	Sugar	Malawi	4.08	16.95	0.57	22.64
Yarada	D27	Kelly ⁵	Sugar	Malawi	3.09	16.44	2.11	21.56
Mazunga	D42	Kelly ⁵	Sugar	Malawi	3.31	15.20	0.29	17.34
Kanzama	D60	Kelly ⁵	Sugar	Malawi	3.34	17.41	0.92	19.27
	D104	Kelly ⁵	Sugar	Malawi	3.86	15.14	1.07	17.30
Nanyati	D106	Kelly ⁵	Sugar	Malawi	3.68	18.14	0.81	23.79
Nanyati	D108	Kelly ⁵	Sugar	Malawi	4.00	19.13	0.59	17.87
Nanyati	D109	Kelly ⁵	Sugar	Malawi	6.10	18.30	1.88	13.42
Nanyati	D112	Kelly ⁵	Sugar	Malawi	3.17	17.74	0.62	20.40
Nanyati wofiira	D140	Kelly ⁵	Sugar	Malawi	3.19	25.39	0.69	23.14
	D172	Kelly ⁵	Sugar	Malawi	3.36	11.97	0.45	13.55
Sugar			Purple					
Elizabeth	PI 414830	USDA	Cranberry	Hungry	3.72	19.12	0.25	17.76
Blanco	G 1080 ⁶	CIAT	Coscorron	Chile	4.36	24.27	2.79	19.97
Blanco								
el Llano	G 1106 ⁶	CIAT	Coscorron	Chile	3.11	25.91	2.04	22.56
Alto Jahuel	G 1113 ⁶	CIAT	Coscorron	Chile	3.43	20.76	0.52	18.94
Cacahute 72	G 5481	CIAT	Cacahute	Mexico	3.49	14.32	0.56	27.66
Mendez	G 5844	CIAT	Coscorron	Chile	4.11	24.14	0.64	21.83
	G 13775	CIAT	Sugar	Zambia	3.43	22.25	0.44	20.08
	G 13790	CIAT	Sugar	Zambia	3.04	15.26	0.53	17.50
	G 13799	CIAT	Sugar	Zambia	3.22	23.92	0.47	26.54
	G 13812	CIAT	Sugar	Zambia	2.83	16.97	0.55	17.66
	G 13817	CIAT	Sugar	Zambia	2.55	31.20	0.40	17.08
M80434	G 13872	CIAT	Cacahute	Mexico	2.51	20.46	0.41	21.15
Misamfu								
Speckled	G 14470	CIAT	Sugar	Zambia	3.28	19.91	0.64	26.49

Table 1. (continued)

Name	Accession Number	Source	Market Class/ Description	Origin	-----mg/gm-----			
					Fru	Suc	Raff	Stach
Large Speckled Speckled Small Round	G 14536	CIAT	Sugar	Malawi	3.68	20.25	0.39	20.32
	G 14537	CIAT	Sugar	Zambia	3.89	23.01	0.62	22.07
	G 15306A	CIAT	Sugar	Zambia	3.40	21.14	0.32	23.65
Granado	G 17679	CIAT	Coscorron	Chile	3.28	21.21	0.53	25.09
No. 1	G 17699	CIAT	Coscorron	Chile	1.86	16.19	0.35	18.25
Americano	G 18174	CIAT	Coscorron	Chile	2.76	18.57	0.39	18.56
Largo	G 18270	CIAT	Cacahute	Mexico	4.26	13.12	0.35	24.23
Francisca	G 18354	CIAT	Coscorron	Chile	2.45	12.65	0.21	16.91
298	G 18355	CIAT	Coscorron	Chile	4.13	21.23	0.26	20.60
No. 4	G 18372	CIAT	Coscorron	Chile	3.27	16.48	0.42	21.57
Criollo	G 22013	CIAT	Cacahute	Mexico	4.45	15.51	0.91	17.88
Line 040	G 22880	CIAT	Sugar	Malawi	3.70	22.79	0.84	26.78
Line 050	G 22890	CIAT	Sugar	Malawi	3.20	14.86	0.35	18.23
Line 060	G 22900	CIAT	Sugar	Malawi	3.28	14.35	0.69	20.53
Line 070	G 22910	CIAT	Sugar	Malawi	3.77	18.18	0.55	23.72
Line 210	G 23046	CIAT	Sugar	Malawi	3.49	20.72	0.44	21.97
Jacob's Cattle		UI	Heirloom	USA	3.33	17.43	0.79	27.82
Manteca		Edwards ⁷	Manteca	Chile	3.39	25.81	1.12	22.33
Gasless								
Jacob's Cattle	NSL 98059	USDA	Heirloom	USA	3.44	15.40	1.02	24.49
Gasless Bush ⁸	NSL 194077	USDA	Heirloom	USA	2.98	18.98	0.62	24.53
	PR 14	Beaver ⁹	Cranberry	Puerto Rico	2.85	22.05	0.38	18.36
	PR 30	Beaver ⁹	Cranberry	Puerto Rico	3.01	14.43	0.54	19.25
	PR 40	Beaver ⁹	Small Red	Puerto Rico	7.03	12.38	1.69	23.46
	PR 63	Beaver ⁹	Small Red	Puerto Rico	3.38	16.27	1.79	27.07
	Puc. 40	Ortega ⁴	Black	Mexico	3.54	23.95	2.84	17.48
Sweetbean	PI 273193	USDA	Sugar	S. Africa	2.76	16.13	0.30	21.50
	Sug 85	CIAT ¹	Cranberry	Colombia	3.21	13.35	1.15	22.02
	Sug 86	CIAT ¹	Cranberry	Colombia	3.99	17.75	0.68	13.59
	Sug 87	CIAT ¹	Cranberry	Colombia	3.75	20.27	1.86	22.66
	Sug 88	CIAT ¹	Cranberry	Colombia	4.79	25.87	1.73	18.77
Taylor		UI	Cranberry	USA	3.18	20.85	0.77	21.71
UI 50		UI	Cranberry	USA	3.10	24.03	1.52	22.04
UI 686		UI	Cranberry	USA	3.73	30.81	1.58	24.55
	Ver. 6-1	Ortega ⁴	L. White	Mexico	4.27	25.64	2.44	18.73
	Ver 105	Ortega ⁴	Black	Mexico	6.31	12.76	2.03	25.91
Viva		UI	Pink	USA	2.80	21.22	1.62	21.52
	02882	CIAT	Sugar	Colombia	4.27	19.68	1.78	23.38
	13769	CIAT	Sugar	Colombia	4.32	27.55	1.70	19.45
43-314	PI 282049	USDA	Coscorron	Chile	2.85	16.85	0.42	24.24

¹Rodriguez, M.A., H.F. Ramirez, M.C. Valencia, O. Voysest, and J.W. White. 1995. Catalog of advanced bean lines from CIAT. Centro Internacional de Agricultura Tropical. Cali, Colombia, 2nd Edition. ²Adobe Milling Co., Dove Creek, CO USA. ³Collected in Santiago, Chile by Dr. Marlin Edwards, Northrup King Co., Northfield, MN USA. ⁴Provided by Dr. M.L. Ortega Delgado, Rama de Botánica, Colegio de Postgraduados, Chapingo, México. ⁵Provided by Dr. Jim Kelly, Michigan State University, East Lansing, MI USA from collections made in the Dedza area of Malawi. ⁶G 1080, G1106, and G 1113 correspond to PI 282025, PI 282104, and PI 282118, respectively. ⁷Collected in Temuco, Chile by Dr. Marlin Edwards, Northrup King Co., Northfield, MN USA. ⁸Gasless Bush is probably the same as Gasless Jacob's Cattle. ⁹Breeding Lines provided by Dr. Jim Beaver, University of Puerto Rico, Mayaguez, PR.