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9. ABSTRACT

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Relationship between the content of oil, protein and sugar in mung bean seed

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Seed of 32 strains of mung beans (*Vigna radiata* (L.) Wilczek) were analysed for protein, oil, total sugar and individual sugar content. The ranges in values were: protein, 24·5 to 31·2; oil, 0·57 to 0·84; total sugar, 2·69 to 5·88; monosaccharides, 0·38 to 1·00; sucrose, 1·06 to 2·19; raffinose, 0·38 to 0·69; and stachyose, 0·50 to 1·50g per 100g seed. The oligosaccharides verbascose and ajugose possibly were detected, but standards were not available for confirmation. Simple correlation analysis revealed that oil and protein are negatively associated ($P < 0·01$). The correlation coefficients between total sugar and oil and total sugar and protein were positive but not significant ($P > 0·05$). Stachyose was positively associated with raffinose, monosaccharides, and total sugar content ($P < 0·01$) and protein ($P < 0·05$) but not significantly associated with sucrose or oil content.

INTRODUCTION

The mung bean (*Vigna radiata* (L.) Wilczek) (Verdcourt, 1970) is a large seeded legume that is an important source of dietary protein for many people in tropical and subtropical countries. Thus, the chemical composition of mung bean seed is an important dietary consideration. Yohe and Poehlman (1972) studied the genetic variability in mung bean seed and found that protein and methionine varied widely among 321 strains analysed. The oil content of mung bean seed has been reported to be 1·3g per 100g seed (Watt and Merrill, 1963). However, little is known about variability of oil content among mung bean strains. Certain sugars in legume seed have been implicated as flatus producers (Steggerda, 1968), but there is conflicting evidence concerning the gas-producing properties of mung bean seed. Yohe and Poehlman (1972) pointed out that the mung bean is widely regarded as non-flatulent; however, Calloway *et al.* (1971) found that the gas formation potential of mung beans was about two-thirds that of white beans (*Phaseolus vulgaris* L.). Calloway *et al.* used only one mung bean cultivar in their study, and, therefore, did not determine whether mung bean strains vary in their gas formation potential.

The purpose of this study was to measure variability of total oil, total sugar and individual sugar content in seed of selected strains and to investigate linear correlations between these components and protein content.

MATERIALS AND METHODS

Raw, mature, untreated seed of the 32 mung bean strains used in this study were multiplied in 1971 at Columbia, Missouri. Entries are listed in *Table 1.*

Table 1. Entry, place of origin, protein and oil content of mung bean seed

			Dry weight of chemical component in 100 g seed	
No.	*Entry*	*Origin*	*Protein (g)*	*Oil (g)*
1	PI 368288	India	31·2	0·60
2	PI 368297	India	29·3	0·69
3	PI 211735	Afghanistan	28·8	0·81
4	PI 374142	Hong Kong	28·6	0·57
5	PI 368292	India	28·5	0·64
6	PI 368283	India	28·3	0·61
7	PI 368301	India	27·9	0·65
8	PI 374140	Korea	27·3	0·67
9	Texas Jumbo	U.S.A.	27·3	0·70
10	PI 368266	India	27·2	0·78
11	PI 180313	India	27·1	0·70
12	PI 180315	India	26·9	0·69
13	PI 271405	India	26·7	0·75
14	PI 368278	India	26·6	0·70
15	PI 223711	India	26·6	0·78
16	PI 164889	Guatemala	26·6	0·73
17	PI 183459	India	26·6	0·75
18	PI 362322	Korea	26·6	0·72
19	PI 214334	India	26·4	0·70
20	PI 374150	Korea	26·4	0·83
21	PI 183136	India	26·1	0·78
22	PI 298915	China	26·1	0·67
23	PI 368290	India	26·0	0·77
24	PI 212907	India	26·0	0·74
25	PI 268268	India	25·9	0·74
26	PI 212908	India	25·7	0·72
27	PI 274402	India	25·6	0·78
28	PI 368330	India	25·6	0·84
29	PI 180311	India	25·4	0·75
30	PI 213015	India	25·3	0·75
31	PI 31288	India	24·6	0·74
32	PI 271401	India	24·5	0·74
Mean			26·8	0·72
Range			(24·5–31·2)	(0·57–0·84)

Seed were dried at 48°C for five days to obtain moisture contents of about three per cent before 15 g of seed were analysed for oil content by a Varian PA-7 NMR Process Analyser (COLLINS *et al.*, 1967).

Nitrogen content of seed was determined by the standard Kjeldahl procedure at the University of Missouri Agricultural Experiment Station laboratories. Percentage N was converted to percentage protein by multiplying by the factor 6·25.

Total sugar and individual sugar content were determined by the gas-liquid chromatographic method of HYMOWITZ *et al.* (1972a).

Simple correlations were determined according to procedures described by STEEL and TORRIE (1960).

RESULTS AND DISCUSSION

As shown in *Table 1*, protein content ranged from 24·5 to 31·2g per 100g seed with a mean protein value of 26·8g per 100g seed. The 32 lines represent virtually the entire range of protein content expected in mung bean seed. Oil content ranged from 0·57 to 0·84g per 100g seed with a mean oil value of 0·72g per 100g seed. There was a significant ($P<0·01$) negative correlation of −0·58 between oil and protein content (*Table 2*).

Table 2. Correlations between chemical components in mung bean seed

	Oil	*Total sugar*	*Mono-saccharides*	*Sucrose*	*Raffinose*	*Stachyose*
Protein	−0·58**	0·26	0·56**	−0·08	0·21	0·42*
Oil		0·02	−0·38*	0·37*	0·11	−0·24
Total sugar			0·74**	0·74**	0·72**	0·82**
Monosaccharides				0·27	0·40*	0·72**
Sucrose					0·56**	0·27
Raffinose						0·57**
Stachyose						—

* and ** denote $P<0·05$ and $P<0·01$ respectively

Total sugar content ranged from 2·69 to 5·88g per 100g seed with a mean total sugar content of 3·72g per 100g seed (*Table 3*). The correlation coefficients between total sugar and oil and total sugar and protein were positive but not significant ($P>0·05$) (*Table 3*). For comparison, in soya beans total sugar was positively correlated with oil content ($P<0·01$) but negatively and not significantly correlated with protein content (HYMOWITZ *et al.*, 1972a).

The interaction of intestinal flora with the oligosaccharides, especially raffinose and stachyose, is believed to be the primary flatulence factor for intestinal distress often experienced by humans after consuming products containing legume seed or meal. The low molecular weight sugars such as glucose are normally ingested along the lining of the small intestine, whereas the oligosaccharides pass into the large intestine where they are anaerobically fermented to produce gas.

The monosaccharide (glucose and fructose) content ranged from 0·38 to 1·00g per 100g seed with a mean monosaccharide value of 0·67g per 100g seed (*Table 2*). Simple correlation analysis revealed that monosaccharide content was positively associated ($P<0·01$) with total sugar and protein content, but negatively associated ($P<0·05$) with oil content (*Table 3*).

The sucrose content ranged from 1·06 to 2·19g per 100g seed with a mean sucrose value of 1·60g per 100g seed. The correlation coefficients between sucrose and monosaccharides and sucrose and protein were not significant ($P>0·05$). However, the positive correlations between sucrose and total

Table 3. Total sugar and individual sugar contents of mung bean entries

	Dry weight of chemical component in 100g seed						
*No.**	*Total sugar* (g)	*Mono-saccharide* (g)	*Sucrose* (g)	*Raffinose* (g)	*Stachyose* (g)	*Verbascose?* (g)	*Ajugose?* (g)
1	4·19	0·87	1·19	0·63	1·50	+**	+†
2	3·00	0·63	1·12	0·44	0·81	+	–
3	5·19	0·94	2·19	0·69	1·38	+	+
4	4·32	0·88	1·38	0·56	1·38	+	+
5	3·75	0·88	1·12	0·50	1·25	+	+
6	3·63	0·88	1·19	0·44	1·13	··	–
7	5·00	1·00	2·19	0·56	1·25	+	+
8	2·69	0·56	1·25	0·38	0·50	+	–
9	3·50	0·63	1·38	0·56	0·94	+	+
10	3·50	0·63	1·63	0·44	0·81	+	+
11	4·19	0·63	1·94	0·56	1·06	+	+
12	3·50	0·69	1·44	0·38	1·00	+	+
13	3·63	0·63	1·44	0·50	1·06	+	+
14	2·94	0·69	1·06	0·44	0·75	+	+
15	3·50	0·63	1·31	0·50	1·00	+	+
16	3·94	0·63	1·69	0·56	1·00	+	+
17	4·50	0·69	2·19	0·63	1·00	+	–
18	3·13	0·56	1·38	0·44	0·75	+	–
19	4·06	0·81	1·63	0·56	1·06	+	+
20	4·25	0·56	1·88	0·56	1·19	+	+
21	3·69	0·75	1·31	0·56	1·00	+	+
22	3·13	0·50	1·25	0·38	1·00	+	+
23	3·13	0·38	1·69	0·56	0·50	+	–
24	3·75	0·63	1·50	0·56	1·06	+	+
25	3·06	0·31	1·25	0·50	1·00	+	–
26	3·32	0·56	1·25	0·56	0·94	+	+
27	5·06	0·88	1·75	0·50	1·44	+	+
28	3·25	0·56	1·44	0·44	0·81	+	–
29	3·31	0·63	1·56	0·44	0·69	–	–
30	4·19	0·75	1·56	0·63	1·19	+	+
31	3·94	0·63	1·69	0·56	1·06	+	+
32	2·63	0·38	1·19	0·38	0·69	+	+
Mean	3·72	0·67	1·50	0·51	1·01		
Range	(2·69–5·88)	(0·38–1·00)	(1·06–2·19)	(0·38–0·69)	(0·50–1·50)		

* Numbers correspond to entries listed in *Table 1*
** Trace amounts of a C30 sugar detected
† Trace amounts of a C36 sugar detected

sugar and sucrose and oil were significant at $P=0{\cdot}01$ and $P=0{\cdot}05$, respectively.

Raffinose content ranged from 0·38 to 0·69g per 100g seed with a mean value of 0·51g per 100g seed, but this was not significantly ($P>0{\cdot}05$) correlated with oil or protein content. However, raffinose was positively associated with sucrose and total sugar content ($P<0{\cdot}01$) and fructose ($P<0{\cdot}05$).

Stachyose content ranged from 0·50 to 1·50g per 100g seed with a mean stachyose value of 1·01g per 100g seed. In general, the stachyose content in mung bean seed was much lower than in soya beans (4·1g per 100g seed), cowpeas (3·2g per 100g seed), and common beans (2·7g per 100g seed), but slightly higher than groundnuts (~0·2g per 100g seed) (WALKER and HYMOWITZ, 1972; HYMOWITZ *et al.*, 1972b). Simple correlation analysis revealed that stachyose was not significantly associated with either sucrose or oil content in mung bean seed. However, stachyose was positively associated with raffinose, monosaccharides, and total sugar content ($P<0{\cdot}01$) and protein ($P<0{\cdot}05$). The high positive correlation value of 0·82 between stachyose and total sugar content suggests that total sugar content may be utilized as a predictor of stachyose content in mung bean seed.

In seed of many of the mung bean entries analysed we found two additional peaks on the chromatogram beyond the stachyose peaks. We suspect the first peak to be the pentasaccharide, verbascose, and the second peak to be the hexasaccharide, ajugose. The presence of verbascose in the mung bean has been reported by TAKEUCHI *et al.* (1961), but no mention of ajugose in mung beans has been reported. Since verbascose or ajugose standards were not available, only presence (+) or absence (−) of the suspected sugars are reported in *Table 3*.

The great variability in total sugar and individual sugar content in the 32 mung bean entries analysed suggests that strains such as PI 374140 (No. 8) may be non-flatulent, while other strains have the potential to be gas producers. Such information may be useful to breeders in developing mung bean cultivars with a non-flatulent characteristic in the seed.

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