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The Effect of Environmental Conditions on the Chemical Composition of Soybean Seeds: Relationship Between the Protein, Oil, Carbohydrate and Trypsin Inhibitor Content

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ABSTRACT

The effects of environmental conditions on the chemical composition of three different varieties of soybean, grown in three different localities in Egypt which differ in climatic conditions, were studied. Correlations between contents of protein, oil, carbohydrate and trypsin inhibitor were statistically analysed.

INTRODUCTION

Several investigators have shown an interest in the chemical analysis of soybean seeds. For example, Inam-Ul-Haq (1963) found that the chemical composition of soybeans was affected by growing in different localities and varied considerably according to variety. The average composition was 8·39% moisture, 5·93% ash, 34·6% protein, 19·4% fatty substances and 30·9% carbohydrates.

Taira *et al.* (1972) reported that protein, oil, carbohydrate and ash levels varied according to variety and location. Also, the protein content of seeds

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was negatively correlated with oil or carbohydrate content, but positively correlated with the ash content. Hymowitz *et al.* (1972) revealed that total sugar and oil contents in soybean seeds were positively associated and ash was negatively correlated with protein content. Sucrose and raffinose content were positively correlated with oil content, while stachyose content was positively associated with protein.

Sandulescu & Sbircen (1978) found that most soybean samples contained 9–35 trypsin inhibitor (units per milligramme extracted protein).

Silva *et al.* (1979) showed that the levels of trypsin inhibitor in 48 varieties of soybean were 15·3–107 inhibitor units (IU). Pavlova *et al.* (1982) reported that the protein content was weakly correlated to trypsin inhibiting activity, while the oil content showed a medium high correlation.

MATERIALS AND METHODS

Materials

Samples of soybean seeds (Clark, Woodworth, and Williams varieties) grown in three different localities, Giza (near Cairo), Sakha (lower Egypt, north) and Shandawill (Upper Egypt, south), were obtained from the Legumes Research Section, Agriculture Research Centre, Giza, Egypt. Milling of soybean was done on an experimental Wiley mill to pass through a 60 mesh screen.

Methods

Moisture content was determined by heating at 105°C for 3 h. Extraction of fat was carried out by petroleum ether. Total hydrolysable carbohydrate was determined after acid hydrolysis; the results were expressed as glucose using the Schaffer–Somogyi micro method. Protein was determined using the Kjeldahl procedure. Fibre was determined after digestion with acid and alkali. Ash was determined by ignition in a muffle furnace at 550°C.

Protein content was calculated as N × 6·25. Sugars were identified by paper chromatography according to Daniels (1971).

Trypsin inhibitor activity was determined by the modified method of Hamerstrand *et al.* (1981). The inhibitor content was calculated from the differential absorbance readings and reported in absolute units as milligrams of trypsin inhibitor per gram of defatted sample.

Analysis of variance and correlation coefficients were calculated according to Snedecor & Cochran (1967).

RESULTS AND DISCUSSION

In this investigation the effects of environmental conditions on the chemical composition of soybean seeds were studied. The same agricultural treatments were applied in three localities which differ in climatic condition: Shandawill (Upper Egypt), Giza (Mid. Egypt) and Sakha (Lower Egypt). Soil and plant characteristics in Giza, Sakha and Shandawill are shown in Table 1.

Table 2 shows moisture, fat, protein, total hydrolysable carbohydrate, total sugar, stachyose, raffinose, sucrose, fibre, ash and trypsin inhibitor contents of soybean seeds.

TABLE 1
Soil and Plant Characteristics

	Giza (*Mid Egypt*)	*Sakha* (*Lower Egypt*)	*Shandawill* (*Upper Egypt*)
Soil pH	8·2	8·1	8·2
Organic matter in soil	2·6%	2·0%	2·0%
Planting dates or period	15 Apr.–30 May	15 Apr.–30 May	Duration, 4 months
Average temperature during the growing season[a]	19·8–35·7°C	19·5–32·5°C	23·4–41·9°C
Rainfall (if any)	Nothing	Nothing	Nothing
Moisture in the soil	Irrigated	Irrigated	Irrigated
Type and condition of soil	Clay loam	Clay	Silty loam
Agricultural preparation	Two ploughings; Soil levelling; Ridging at 60 cm apart—seeding		
Fertilizers used	22·5 kg P_2O_5 during seed bed preparation + 75 kg N per feddan added at three equal doses, 15, 30, 45 days after sowing		
Pesticides	1-Lannate 300 g per feddan to control cotton leaf worm; 2-Tedifol 1 litre per feddan to control red spider mite		

Plant characteristics	*Variety*	*Location*	
Average height of plant and yield of beans	Clark	Giza	85 cm, 1·5 ton per feddan
		Sakha	80 cm, 1·2 ton per feddan
		Shandawill	80 cm, 1·2 ton per feddan
	Woodworth	Giza	60 cm, 1·0 ton per feddan
		Sakha	55 cm, 0·8 ton per feddan
		Shandawill	55 cm, 0·7 ton per feddan
	Williams	Giza	70 cm, 1·4 ton per feddan
		Sakha	65 cm, 1·2 ton per feddan
		Shandawill	70 cm, 1·0 ton per feddan

[a] The temperature was recorded every 6 h during the growing season.

TABLE 2

Percentage of Moisture, Fat, Protein, Total Hydrolysable Carbohydrate, Total Sugar, Stachyose, Raffinose, Sucrose, Fibre, Ash and Trypsin Inhibitor (mg g^{-1}) of Defatted Sample of Soybean Varieties grown in Different Localities

Varieties	*Location*	*Moisture*	*Oil*	*Protein*	*Carbo-hydrate*	*Total sugar*	*Stachyose*	*Raffinose*	*Sucrose*	*Fibre*	*Ash*	*Trypsin Inhibitor (TI)*
Clark	Giza	8·36	21·12	40·3	12·48	2·39	0·96	0·71	1·39	4·17	5·83	102
	Sakha	8·06	24·00	32·3	14·89	3·63	1·10	0·86	1·72	4·67	6·36	118
	Shandawill	7·12	21·55	35·7	13·32	3·50	1·25	0·92	1·64	4·82	5·98	108
Woodworth	Giza	8·46	22·46	38·9	13·43	3·49	1·21	0·96	1·39	4·58	5·93	104
	Sakha	7·54	25·14	31·9	14·54	3·36	1·10	0·93	1·72	4·51	6·13	108
	Shandawill	7·35	23·90	36·0	13·80	3·60	1·14	0·76	1·76	4·65	6·19	107
Williams	Giza	8·54	21·11	39·9	13·51	3·75	1·11	0·86	1·45	4·06	5·87	86·3
	Sakha	8·36	25·60	32·2	14·95	4·13	1·13	0·87	1·63	4·70	6·31	106·5
	Shandawill	7·10	25·03	33·9	13·80	2·50	0·86	0·72	1·52	4·14	6·23	99·7

TABLE 3
Analyses of Variance Between Chemical Composition of Soybean Seeds, Varieties and Locations

Source of variance	*Degree of freedom*	*Mean square*										
		Moisture	*Oil*	*Carbo-hydrates*	*Total sugar*	*Stachyose*	*Raffinose*	*Sucrose*	*Crude protein*	*Fibre*	*Ash*	*Trypsin Inhibitor (TI)*
		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety (*V*)	2	0·056 82	2·727 25	0·215 1	0·176 511 5	0·0103 445	0·006 1	0·006 1	0·433 5	0·0716 45	0·716 45	113·691 5
		*	*	**	NS	NS	NS	*	**	NS	NS	NS
Location (*L*)	2	1·224 23	8·481 9	2·156 85	0·440 844 5	0·000 544 5	0·066 9	0·066 9	43·419	0·103 2	0·103 4	131·493
V × *L*	4	0·811 75	0·853	0·119 525	0·384 027 7	0·023 111 2	0·006 1	0·006 1	0·770 5	0·069 562 5	0·069 562 5	21·002

NS: non-significant.
*, **: significant and highly significant at 0·05 and 0·01 levels of probability, respectively.

Statistical analysis was applied to study the relationship between the chemical composition of soybean seeds and the varieties and locations (Table 3).

The moisture content significantly varied according to localities. These values agree with those of Jamieson *et al.* (1933) who found a value ranging from 4·40% to 8·39% according to varieties and localities.

A significant difference was found in the oil content according to the localities within the same variety. It is clear that the oil content varied by about ±4% in the same variety according to the locality. This may be partially due to the variability in weather conditions especially temperature and humidity which affects the metabolic processes involved in the biosynthesis of lipids. The available mineral in the soil may also affect the oil content by affecting the enzyme system responsible for the biosynthesis of oil.

Marquard & Schuster (1980) reported that considerable differences were observed in fat content depending on variety, location and annual climatic conditions.

The crude protein content varied according to localities. The highest value was recorded in the Giza locality for all the tested varieties and the lowest value was recorded at Sakha. A high significant variation in crude protein

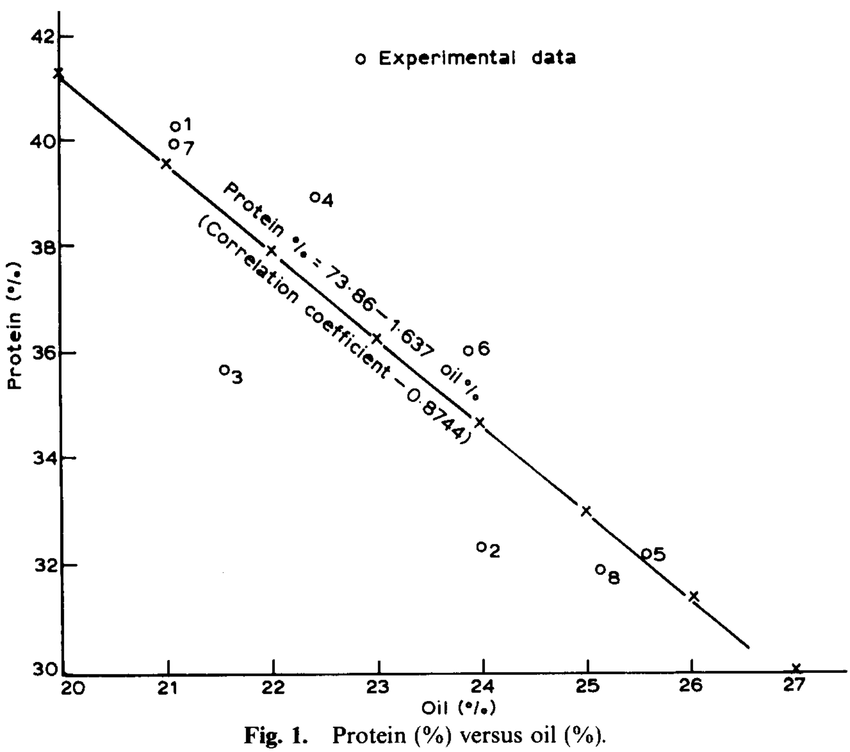

Fig. 1. Protein (%) versus oil (%).

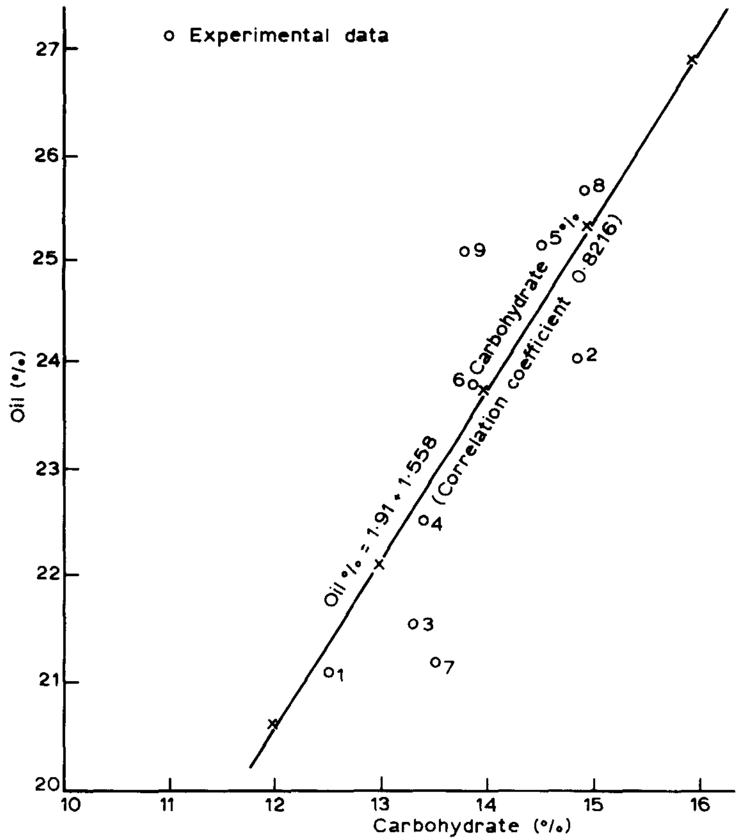

Fig. 2. Oil (%) versus carbohydrate (%).

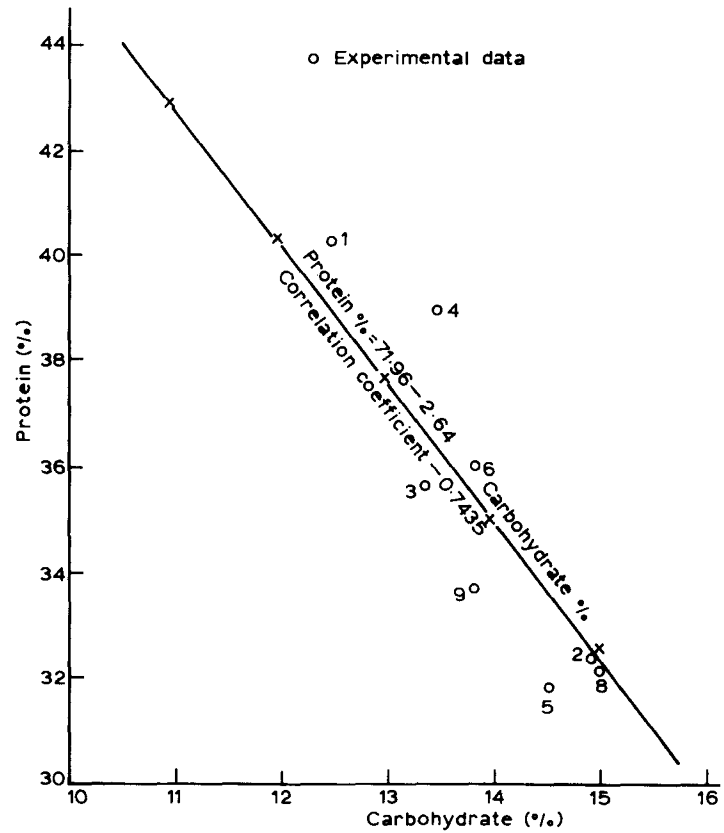

Fig. 3. Protein (%) versus carbohydrate (%).

was found according to locality. These results are in agreement with those reported by Arvind Mishra *et al.* (1978).

Regarding the fibre contents, there are no significant differences between the varieties grown in the same or in different localities. Heller (1934) found that crude fibre ranged from 3·48% to 4·67%.

The ash content of the studied varieties showed a narrow range. There are no significant differences between varieties. However, the differences due to location are significant. It has been reported (Anon., 1944) that the ash content ranged from 3·5 to 6%.

The variation in total hydrolysable carbohydrates due to location was highly significant. Sakha locality showed the highest value in total hydrolysable carbohydrates. A highly significant linear relation was found between protein and oil and total hydrolysable carbohydrate content in the seeds (Figs 1, 2, 3). It seems that the soil composition and temperature highly affect the biosynthesis of the carbohydrate.

There was no change, due to variety of the soybean, in reducing sugar or non-reducing sugar contents. The varieties grown at Sakha locality had the highest content of non-reducing sugars.

No significant correlation was found between raffinose or stachyose and

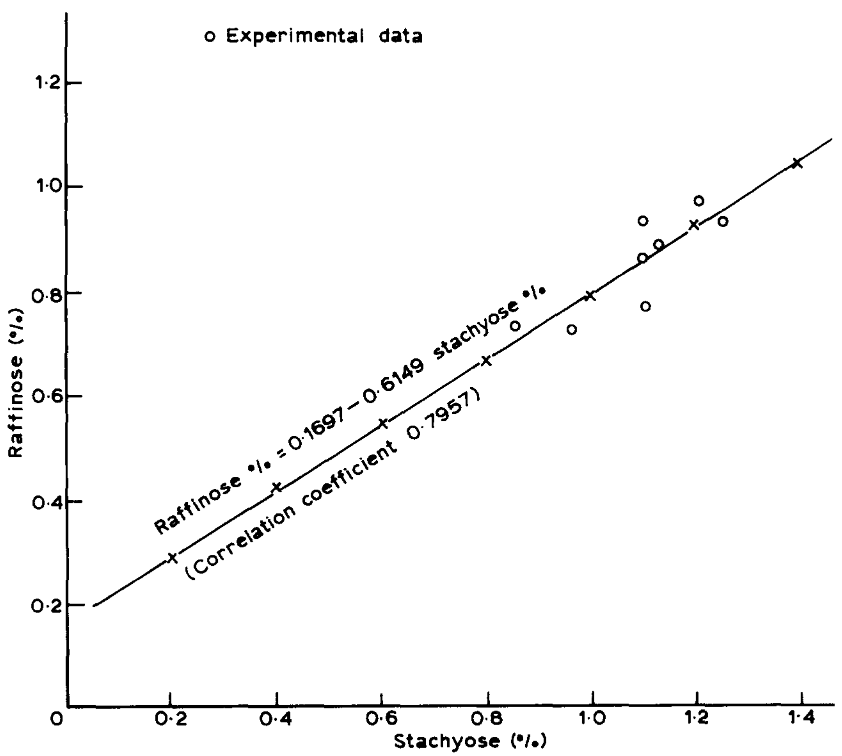

Fig. 4. Raffinose (%) versus stachyose (%).

oil or protein. But a significant linear relation was found between raffinose and stachyose (Fig. 4). Hymowitz *et al.* (1972) reported wider ranges for sucrose (2·5–8·2%), raffinose (0·1–0·9%) and stachyose (1·4–4·1%).

Trypsin inhibitor content of different soybean varieties grown at different localities ranged from 86·3 to 118 mg per gram defatted sample. The varieties grown at Sakha had the highest trypsin inhibitor content while those grown at Giza had the lowest values but these differences were non-significant.

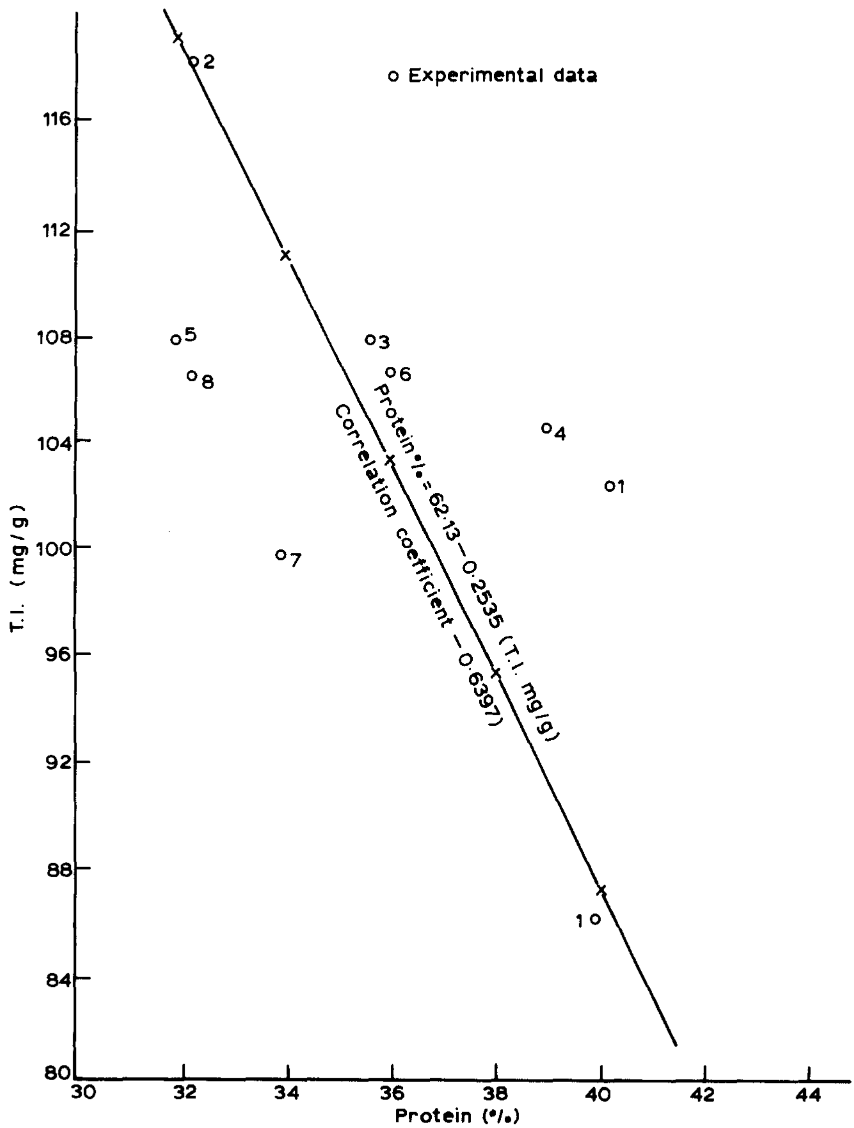

Fig. 5. TI ($mg\,g^{-1}$) versus protein (%).

TABLE 4
Regression Equations for Composition of Soybeans

Relation	*Regression equation*
Protein % versus oil %	Protein % = 73·86 − 1·637 oil % with correlation coefficient −0·8744
Oil % versus carbohydrate %	Oil % = 1·91 + 1·558 carbohydrate (correlation coefficient 0·821 6)
Protein % versus carbohydrate %	Protein % = 71·96 − 2·64 carbohydrate % (correlation coefficient −0·743 5)
Raffinose % versus stachyose %	Raffinose % = 0·169 7 + 0·614 9 stachyose % (correlation coefficient 0·795 7)
TI ($mg\,g^{-1}$) versus protein %	Protein % = 62·13 − 0·253 5 (TI $mg\,g^{-1}$) (correlation coefficient −0·639 7)

Silva *et al.* (1979) reported that the level of trypsin inhibitor was 15·3–107 units.

The correlations between trypsin inhibitor (TI) and protein, oil and carbohydrate contents in soybean seeds was calculated and were found to be:

Relation	*Correlation coefficient*
TI $mg\,g^{-1}$ versus oil %	0·20377
TI $mg\,g^{-1}$ versus carbohydrates %	0·23210
TI $mg\,g^{-1}$ versus protein	−0·63970

(see Fig. 5).

Pavlova *et al.* (1982) found that the protein content was weakly correlated to trypsin inhibiting activity, while the oil content showed a medium high correlation.

The regression equations are shown in Table 4.

REFERENCES

AOAC, Association of Official Analytical Chemists (1970). Washington. (11th Edn).

Anon., Northern Regional Research Lab. (1944). AIC-45, 8 pp. *Chem. Abst.*, 1944, 38, 6581.

Arvind Mishra, Gupta, A. K. & Mehta, S. K. (1978). *Food Forming Agric.*, **9**(8), 235–37.

Daniels, D. G. H. (1971). *J. Sci. Food Agr.*, 22–136.

Hamerstrand, G. E., Black, L. T. & Glover, J. O. (1981). *Cereal Chem.*, **58**(1), 42–5.

Heller, H. (1934). *Fettchem Umchan,*, **41**, 86; *Chem. Abst.* (1934), **28**, 4800.

Hymowitz, T., Collins, F. I., Panczner, J. & Walker, W. M. (1972). *Agron. J.*, **64**(2), 613–16.

Inam, Ul-Haq (1963). *Pakistan J. Sci. Res.*, **15**(4), 123–7.
Jamieson, G. S., Baughman, W. F. & Mckinney, R. S. (1933). *J. Agri. Research*, **46**, 87–8.
Marquard, R. & Schuster, W. (1980). *Fette, Seifen Anstrichn*, **82**(4), 137–42.
Pavlova, L. S., Sayanova, V. V., Shirokova, E. P. & Drozdov, V. V. (1982). *Biokhim, Genet. Sel Bobovykh Zlakovykhn Ku't*, 34–41.
Sandulescu, C. & Sbircen C. (1978). *Ind. Chim. Aliment.*, **13**, 227–36.
Silva, A. D., Barbosa, C. F. & Portela, F. (1979). *Cientifica*, **7**(2), 317–20.
Snedecor, G. W. & Cochran, W. G. (1967). *Statistical methods*. The Iowa State University Press, Ames, Iowa, USA, 543.
Taira, Harue & Taira Hirokadzn (1973). *Nippon Sakumotsu Gakkai Kiji*, **42**(2), 185–96.