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COMPOSITIONAL CHANGES IN WINGED BEAN [*Psophocarpus tetragonolobus* (L) DC] SEED DURING MATURATION

S. GAJAMERAGEDERA AND G. RAVINDRAN
Department of Food Science and Technology, University of Peradeniya, Peradeniya, Sri Lanka.

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Abstract: The seeds of three varieties of winged bean were chemically analysed at six different stages of maturity. Results indicated that dry matter, crude protein, crude fat and P contents increased whereas crude fibre, carbohydrate, Ca, K and Mg contents decreased with maturity. Soluble sugars and starch contents increased up to half-way in development, but decreased thereafter; the reverse trend was observed for the non-starch polysaccharide fraction. Mature seeds did not contain starch.

1. Introduction

Winged bean, a potentially valuable and underutilised source of protein and oil, can play a significant role as soybeans since their compositions are remarkably similar.[10] The high nutritive value of winged bean seeds has been well documented.[9] However, due to difficulties in the preparation of dishes and bakery products from mature seeds, winged bean is yet to make any impact at the consumer level.

The most relished part of the winged bean plant is the tender pod. The nutritional composition of green pods compares well with other legume pods such as cowpea, kidney beans or lalab beans,[3] but the low protein content (2–3% on a fresh weight basis) reduces its potential as a protein crop.

At two weeks after flowering, the pod is tender and juicy, and the seeds are not properly formed. The pod case becomes fibrous and less edible with maturity, but the unripe seeds inside the pod case remain edible. These immature, green seeds are eaten raw or cooked in preference to the pods in some areas of Indonesia and Papua New-Guinea, and found to be similar in taste to garden peas.[5] However, the stage at which the immature seeds should be harvested for optimum nutritive value and acceptibility has hitherto not been investigated. It is reasonable to expect that the chemical composition of the seeds vary depending on the stage of maturity. Hence the present study was undertaken to determine the changes in chemical composition of winged bean seeds during development with the ultimate objective of selecting a suitable stage for 'winged bean pea' production. Included in this paper are the data on proximate, mineral and carbohydrate components.

2. Materials and Methods

2.1 Materials

The seeds of three Sri Lankan varieties, namely SLS 1, SLS 3 and SLS 6, were obtained from the International Winged Bean Institute, Pallekelle, Sri Lanka. They were planted on 31 November 1983 at the experimental unit of the Institute and grown under recommended cultural practices. The flowers were tagged individually and pod samples were collected at 30 (Stage 1), 40 (Stage II), 50 (Stage III), 60 (Stage IV), 70 (Stage V) and 80 (Stage VI) days after flowering. The seeds matured around 75–80 days.

2.2 Sample Preparation

About 500g seeds were removed from the pod, weighed, dried to a constant weight at 60^0C and ground in a Wiley Laboratory Mill to pass through a 60 – mesh sieve. The following determinations were performed on the flour samples.

2.3 Proximate Analysis

Moisture (before and after drying), crude protein (N x 6.25), crude fibre, crude fat and ash contents were determined according to the standard procedure of AOAC.[2] Carbohydrates were calculated by difference.

2.4 Mineral Analysis

Mineral components were determined on samples digested with perchloric and nitric acids using Atomic Absorption Spectrophotometer (Perkin–Elmer Model 2830). To samples used for analysis of calcium and magnesium was added 1% (w/v) lanthanum to overcome potential anionic interferences. Cesium chloride solution was added to the samples before dilution to give a final concentration of 2000 ppm cesium for sodium analysis and 1000 ppm cesium for potassium analysis. Phosphorus was determined independently using a colorimetric method.[4]

2.5 Carbohydrate Determination

2.5.1 Soluble sugars

Defatted samples (5 g) in triplicate were extracted for soluble sugars as described by Garcia and Palmer.[7] The total soluble sugar content of the extract was determined by the phenolsulphuric acid method.[6]

2.5.2 Starch

Starch was assayed by two methods *viz* the perchloric acid method[11] and the enzymatic method of Thivend *et al.*[16]

2.5.3 Non-starch polysaccharides (NSP)

Defatted samples were extracted for NSP by the procedure of Selvendran *et al.*[14] This method involved removal of intracellular compounds with sodium deoxycholate, soluble sugars with 85% ethanol, protein with phenol: acetic acid:water and starch with dimethyl sulphoxide. The resulting insoluble residue was dried and gravimetrically determined as NSP.

2.6 Statistical Analysis

The best fitted regression lines were obtained to study the correlation between the changes in proximate components and age of the seeds, using the methods described by Steel and Torrie.[15]

3. Results and Discussion

3.1 Proximate Composition

The proximate composition of the winged bean varieties during different stages of seed maturation is presented in Table 1. At stage I, the seeds were just forming and the endosperm contained 80.7—82.4% moisture, but a rapid accumulation of dry matter was seen with maturity of seeds. The percent crude protein increased rapidly from stage I to VI. A positive correlation between the protein content and the age of the seeds was observed in all three varieties. Variety SLS 6 had the highest protein content at all developmental stages. The general trend with crude fat was a gradual increase upto maturity. Varieties SLS 1, SLS 3 and SLS 6 had 16.9, 17.2 and 15.3% fat, respectively, at maturity. The ash contents of the three varieties showed variable trends with maturity. In the case of SLS 1, the total mineral showed a gradual increase from stage I to stage VI, but the reverse was true for variety SLS 6. Although crude fibre is not a good estimate of the fibre fraction, it is the most commonly used method to determine fibre. The crude fibre values for the three varieties ranged from 6.7 in SLS 3 to 8.8 in SLS 6 at stage I, but showed a general decrease with maturity. The carbohydrate contents also showed a decline in all three varieties. The reason for this declining trend in fibre contents is unclear, since most food plants are known to become fibrous with maturity. It is possible that seeds behave in a different manner. Authors are unaware of any previous work where the fibre contents were studied in relation to seed maturity.

Table 1. Changes in proximate components of winged bean varieties during seed maturation.[1]

			% Dry weight basis				
Variety	Stage of maturity	Dry matter	Crude protein	Crude fat	Ash	Crude fibre	Carbohydrate
	I	17.5	31.8	15.6	4.6	8.1	39.9
	II	31.5	32.9	15.9	4.4	7.5	39.3
SLS 1	III	39.9	36.9	16.1	4.5	6.5	36.0
	IV	59.9	37.2	16.4	4.8	6.7	34.9
	V	73.9	37.4	16.8	4.9	6.5	34.3
	VI	84.8	37.8	16.9	5.0	6.8	33.5
	I	19.2	32.6	15.5	4.3	6.4	41.2
	II	31.0	33.2	16.5	4.1	6.4	39.8
SLS 3	III	40.7	36.4	16.4	4.3	6.1	36.8
	IV	67.4	38.8	16.8	4.2	5.8	34.4
	V	75.8	39.1	16.8	3.9	5.8	34.4
	VI	86.3	39.4	17.2	4.0	5.9	33.6
	I	18.9	33.9	13.3	5.9	8.8	38.1
	II	26.7	36.5	14.5	5.8	7.6	35.6
SLS 6	III	42.6	38.9	15.1	5.2	7.4	33.4
	IV	68.3	41.9	15.2	5.1	6.6	31.2
	V	77.8	42.3	15.4	5.1	6.9	30.3
	VI	86.4	42.6	15.3	5.0	6.6	30.5

[1] Each value is a mean of three determinations.

3.2 Mineral Composition

Winged bean seeds contained significant amounts of all the minerals during all developmental stages (Table 2). These values, with the exception of Mg and P, fall within the ranges reported elsewhere for winged bean seeds.[9] The Mg and P contents of our samples were slightly higher. The total phosphorus was found to increase with seed maturity. Other major elements analysed *viz*, calcium, magnesium and potassium, showed a decrease with maturity in all the three varieties. No marked differences were observed with regard to the trace minerals.

3.3 Carbohydrate Composition

Information on carbohydrates of other legumes has contributed towards defining their nutritional role and understanding of cooking and processing qualities. The limited reports available on carbohydrates of winged beans[7,8,12,13] agree that winged bean seeds have a high content of carbohydrates, but disagree sharply on composition especially with regard to its starch content. Sajjan and Wankhede[13] reported a high level of starch, whereas the others[7,8,12] found little or no starch. Garcia and Palmer[7] have suggested that WB seeds, like soybeans, may contain starch during the early stages of development. This prompted us to study the carbohydrate composition during seed development.

Changes in soluble sugars, starch and NSP during seed development are given in Table 3. The soluble sugar content increased from stage I to stage II (for SLS 3) or III (for SLS 1 & 6), but decreased thereafter. The values for soluble sugars of mature seeds fall within the range reported by Garcia and Palmer,[7] for five other varieties of winged bean.

Table 2. Mineral composition of winged bean varieties at different stages of seed maturity (mg/100 g flour)[1]

Variety	Stage of maturity	Calcium	Magnesium	Potassium	Phosphorus	Manganese	Iron	Copper	Zinc
	I	486.0	246.0	1039.0	424.5	1.9	9.8	5.0	5.1
	II	492.0	244.4	991.0	435.0	2.1	9.8	4.9	4.7
SLS 1	III	436.0	235.0	905.0	452.0	2.3	9.5	4.8	5.2
	IV	436.0	235.4	897.0	504.0	2.5	8.4	4.4	6.0
	V	376.0	213.6	800.0	479.0	2.7	7.2	4.3	6.6
	VI	370.0	210.1	804.0	490.2	2.7	7.1	4.6	6.8
	I	494.0	226.8	1042.0	414.5	3.0	10.0	4.9	4.9
	II	423.0	248.0	960.0	466.0	3.0	9.6	4.7	4.7
SLS 3	III	420.0	237.7	944.0	504.0	3.1	9.9	4.9	4.5
	IV	402.0	204.4	936.0	475.5	3.1	9.8	5.2	4.6
	V	370.0	195.0	874.0	517.5	3.1	9.2	5.4	4.0
	VI	383.0	198.3	881.0	520.3	3.1	9.5	5.2	4.4
	I	554.0	245.1	1055.0	477.0	3.3	11.8	5.0	4.9
	II	474.0	241.4	960.0	483.0	3.2	11.2	4.8	4.8
SLS 6	III	452.0	239.2	849.0	487.0	3.1	9.6	4.9	4.9
	IV	318.0	237.7	849.0	518.0	3.1	9.5	4.9	5.0
	V	421.0	232.9	820.0	525.0	3.1	9.3	4.8	4.5
	VI	418.0	232.1	818.0	527.0	3.1	9.8	4.8	4.8

[1] Each value is a mean of three determinations.

Table 3. Changes in soluble sugar, starch and non-starch polysaccharides defatted winged bean flour during seed maturation (% dry weight basis)[1]

Variety	Stages of maturity	Soluble sugar	Starch			non-starch polysaccharides	Total Carbohydrates[2] (i)+(ii)+(iii)	
		(i)	Perchloric acid method	Enzymatic method	Average (ii)	(iii)	a	b
SLS 1	I	10.2	6.0	6.4	6.2	33.1	49.5	41.9
	II	16.0	7.2	7.7	7.5	30.7	54.2	45.6
	III	14.2	3.5	3.5	3.5	32.4	50.1	42.0
	IV	13.6	1.7	2.9	2.3	33.3	49.2	41.3
	V	12.6	0.0	0.8	0.4	36.2	49.2	40.9
	VI	11.8	0.0	0.7	0.3	36.9	49.0	40.7
SLS 3	I	11.3	5.3	5.8	5.6	31.6	48.5	41.1
	II	17.4	6.2	6.6	6.4	28.0	51.8	43.2
	III	13.8	3.3	4.7	4.0	29.0	46.8	39.1
	IV	13.1	1.3	2.7	2.0	32.2	47.3	39.3
	V	12.4	0.0	0.9	0.5	35.4	48.3	40.2
	VI	12.2	0.0	0.7	0.3	36.3	48.8	40.4
SLS 6	I	9.4	3.9	4.8	4.3	35.8	49.5	42.9
	II	12.8	5.5	5.6	5.5	31.4	49.7	42.6
	III	13.3	2.6	3.7	3.1	31.4	47.8	40.6
	IV	11.2	1.3	2.4	1.8	31.6	44.6	37.8
	V	11.3	0.0	0.8	0.4	33.3	45.0	38.0
	VI	10.5	0.0	0.4	0.2	34.2	44.9	38.0

[1] Each value is a mean of three determinations.

[2] Columns a and b represent the total carbohydrate contents of defatted and full fat flour, respectively.

Changes in starch during seed maturation followed similar pattern as sugars, but decreased to zero starch in the mature seeds. These results confirm that the conflicting reports with regard to the starch content of WB seeds[7,8,12,13] are, in fact, due to differences in the maturity of the samples. Adam *et al.*[1] have reported similar pattern of changes in starch and sugars in developing soybean seeds. They suggested that these components are utilized for the synthesis of proteins and lipids towards later stages of seed maturation.

Non—starch polysaccharides constitute the main fraction of the carbohydrate of WB seeds during all developmental stages (Table 3). This fraction, which represents the material that is resistant to hydrolysis by the enzymes of the mammalian digestive tract, have currently been popularised in the broader nutritional context as dietary fibre. The components of NSP include structural polysaccharides such as cellulose, hemi-cellulose and some pectins, structural non-polysaccharides such as lignin and non-structural polysaccharides such as gums and mucilages.

In all three varieties, NSP decreased up to stage II (40 days) and then gradually increased. This trend is to be expected since structural polysaccharides in plant materials are known to increase with maturity.

The NSP values when added to their corresponding starch and soluble sugar contents, yielded total carbohydrates. These values, for all varieties, compare closely to the calculated total carbohydrate (carbohydrate by difference + fibre) values obtained from the proximate analysis (Table 2). The general pattern in varieties SLS 1 and 3 is an increase up to stage II and a decline thereafter. Variety SLS 6 showed a gradual decrease with maturity.

Further studies are in progress on the changes in anti-nutritional factors, protein digestibility and sensory characteristics with winged bean seed maturity.

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