Distribution of Nutrients in the Anatomical Parts of Common Indian Pulses

SHALINI SINGH, H. D. SINGH, and **K. C. SIKKA,** Indian Agricultural Research Institute, New Delhi, India

ABSTRACT

Grains from seven common pulses grown in India were separated into seed coat, cotyledons, endosperm (in guar only), and embryo, and the proportion of each was determined. All fractions and the whole grain of each pulse were analyzed for ash, protein, ether extract, crude fiber, nitrogen-free extract, phosphorus, calcium, and iron contents. Cotyledons, being the major and fairly balanced component, account for almost the entire food value of the whole seed.

Pulses are an important source of nutrition in India. Besides providing other nutrients, they are the cheapest source of protein in the Indian diet. They are consumed in different forms, as whole seed, in split form, or after removal of certain component parts, the seed coat and embryo[1].

Concerning the chemical composition of different parts of some cereal grains, Earle *et al.* (1), Hinton (2), and Hubbard *et al.* (3) have shown that whole seed is quite inhomogeneous and different parts differ in their chemical composition. The findings of Lal *et al.* (4) on Bengal gram and distribution of nitrogen in seed parts of ripening pea (Raacke, 5) also confirm the earlier finding.

Information concerning the composition of the component parts of different pulses grown and consumed in the Indian subcontinent and other Far Eastern countries as food and feed can be of great value to plant breeders and nutritional experts.

Determinations were made of the amount of seed coat, cotyledons, embryo, and endosperm (for guar only), and these fractions were analyzed for ash, protein, ether extractives, crude fiber, nitrogen-free extract (by difference), phosphorus, iron, and calcium.

MATERIALS AND METHODS

Seven different strains of pulses were selected for this investigation. Varieties selected for analysis are those commonly consumed and include Cajan pea (*Cajanus cajan*), Pea (*Pisum sativum*), Lentil, (*Lens esculenta*), mung bean (*Phaseolus aureus*), Cowpea (*Vigna sinensis*), French bean (*Phaseolus vulgaris*), and guar (*Cyamopsis tetragonoloba* L.). Sources of the materials are given in Table I.

Separation of the seeds into three components was similar to the methods of Lal *et al.* (4) and Raacke (5) except that the seeds were kept overnight at 4°C. The components were then dried, weighed, and powdered in a

[1] Although botanically the two cotyledons in pulses are part of the whole embryo, in the present paper, wherever *embryo* has been used it should be taken to mean the rest of the embryo, i.e., the whole embryo minus the cotyledons.

Wiley mill, mesh No. 40. The embryo part, being very small, was ground in a glass mortar with pestle.

Samples of the grain and the fractions resulting from the separation were analyzed for ash, nitrogen, ether extractives, crude fiber, phosphorus, iron, calcium, and nitrogen-free extract. The methods of the Association of Official Agricultural Chemists (6) were used to determine ash, nitrogen, crude fiber, iron, and calcium. Oil was determined as in AOAC method for oil in cotton seed, except that the samples were extracted for 8 hr. with petroleum ether, b.p. 40°–60°C. Phosphorus was determined by King's (7) method, a modification of the method of Fiske and Subbarow (8). Nitrogen-free extract was obtained by difference only.

RESULTS AND DISCUSSION

All analyses are reported on moisture-free basis. The identity of the pulses and the chemical composition are shown in Table I. The physical and chemical composition of the fractions is shown in Table II. In Table III, derived from Table II by calculation, is shown the amount of each fraction expressed as the percentage of the whole pulse seeds. In Table IV is shown the amount of each constituent in the whole pulse seeds. The composition of the whole pulse grain (calculated value) was calculated from the composition of its parts as given in Table III by totaling for each constituent the percentage found in the three fractions of each sample of whole grain.

Results in Table I on the distribution of different nutrients for the deter-

TABLE I
COMPOSITION OF WHOLE SEED[a]

Sample	Variety and Strain	Source		Ash	Protein (N×6.25)	Ether Extract	Crude Fiber	Nitrogen-Free Extract	Phosphorus	Calcium	Iron
				%	%	%	%	%	*mg./100 g.*	*mg./100 g.*	*mg./100 g.*
Cajan pea		IARI	D	4.15	22.9	3.8	5.0	64.15	366	296	6.7
(Pusa best)			C	4.09	21.8	3.9	5.3	64.9	369	294	6.7
Pea (N.P. 29)		B.S.S	D	2.84	27.9	3.2	5.9	60.1	286	259	5.2
		(Pusa)	C	2.82	27.8	3.1	5.8	60.5	289	257	5.3
Lentil (M.P.		B.S.S	D	2.40	29.6	3.1	3.2	61.7	363	140	7.3
hybrid)		(Pusa)	C	2.44	29.6	2.9	3.3	61.8	368	158	7.2
Mung bean		B.S.S	D	3.00	25.6	3.0	3.5	64.9	313	199	7.5
(T_1)		(Pusa)	C	3.07	25.5	3.1	3.5	64.8	314	206	7.4
Cowpea (E.C.		IARI	D	3.20	25.0	2.1	3.1	66.7	459	243	6.9
13060)			C	3.18	25.3	2.3	3.0	66.2	459	243	6.9
French bean		Market	D	3.66	32.5	2.1	2.9	58.8	398	175	6.9
		variety	C	3.68	32.1	2.2	2.6	59.4	396	174	6.9
Guar		IARI	D	3.60	34.4	3.9	5.2	52.9	339	349	9.6
(Sadabahar)			C	3.58	33.9	3.9	5.4	53.2	333	343	9.9

[a] All values on moisture-free basis. D indicates values determined; C, calculated.

TABLE II

COMPOSITION OF PULSE FRACTIONS

SAMPLE	VARIETY AND STRAIN	PROPORTION OF WHOLE GRAIN	ASH	PROTEIN (N×6.25)	ETHER EXTRACT	CRUDE FIBER	NITROGEN-FREE EXTRACT	PHOSPHORUS	CALCIUM	IRON
		%	%	%	%	%	%	*mg./100 g.*	*mg./100 g.*	*mg./100 g.*
SEED COAT										
Cajan pea (Pusa best)		15.50	3.50	5.6	0.3	31.9	58.7	30.5	917	9.5
Pea (N.P. 29)		10.00	2.42	3.1	0.4	46.9	47.2	14	900	6.1
Lentil (M.P. hybrid)		8.05	1.94	14.3	0.6	29.4	53.7	152	723	12.8
Mung bean (T_1)		12.09	3.00	10.6	0.6	25.6	60.2	36	812	16.7
Cowpea (E.C. 13060)		10.64	3.17	10.7	0.9	25.8	59.4	89	853	11.6
French bean		8.64	3.98	8.2	0.6	26.6	60.6	79	808	11.6
Guar (Sadabahar)		17.11	4.00	9.9	0.7	28.4	57.0	50	781	13.3
ENDOSPERM										
Guar (Sadabahar)		38.50	1.57	8.3	1.7	0.8	88.6	29	160	8.4
COTYLEDONS										
Cajan pea (Pusa best)		83.00	4.17	24.3	4.4	0.4	66.7	423	176	6.1
Pea (N.P. 29)		89.28	2.83	30.1	3.3	1.2	62.6	311	181	4.9
Lentil (M.P. hybrid)		89.97	2.45	30.1	3.0	1.0	63.4	374	103	6.4
Mung bean (T_1)		85.61	3.05	26.9	3.3	0.5	66.3	341	115	6.1
Cowpea (E.C. 13060)		87.23	3.15	26.7	2.3	0.3	67.6	496	165	6.1
French bean		90.37	3.64	34.0	2.3	0.3	59.8	421	115	6.4
Guar (Sadabahar)		42.78	5.20	65.6	6.9	0.5	21.8	702	328	9.5
EMBRYO										
Cajan pea (Pusa best)		1.50	5.98	48.1	13.5	1.4	31.0	890	400	13.0
Pea (N.P. 29)		1.26	4.03	47.9	10.2	2.6	35.3	814	461	19.2
Lentil (M.P. hybrid)		1.98	3.94	71.1	8.2	2.4	14.4	952	355	19.2
Mung bean (T_1)		2.30	4.36	52.5	9.4	1.4	32.3	756	492	22.9
Cowpea (E.C. 13060)		2.12	4.38	44.1	9.8	1.6	40.1	829	368	20.7
French bean		0.99	4.52	68.3	7.7	1.8	17.7	897	438	18.5
Guar (Sadabahar)		1.61	4.12	62.1	12.0	1.6	20.2	832	498	18.4

TABLE III

DISTRIBUTION OF THE CHEMICAL CONSTITUENTS IN PULSES[a]

SAMPLE VARIETY	ASH	PROTEIN N×6.25	ETHER EXTRACT	CRUDE FIBER	NITROGEN-FREE EXTRACT	PHOSPHORUS	CALCIUM	IRON
	%	%	%	%	%	mg./100 g.	mg./100 g.	mg./100 g.
SEED COAT								
Cajan pea (Pusa best)	0.54	0.9	0.05	4.9	9.1	4.7	142	1.47
Pea (N.P. 29)	0.24	0.3	0.04	4.7	4.7	1.4	90	0.95
Lentil (M.P. hybrid)	0.15	1.1	0.05	2.4	4.3	12.3	58	1.03
Mung bean (T_1)	0.36	1.3	0.07	3.1	7.3	4.3	98	2.0
Cowpea (E.C. 13060)	0.34	1.1	0.1	2.7	6.3	9.5	91	1.24
French bean	0.34	0.7	0.5	2.3	5.9	6.6	75	1.0
Guar (Sadabahar)	0.68	1.7	0.1	4.9	9.7	8.6	134	2.3
ENDOSPERM								
Guar (Sadabahar)	0.60	3.2	0.7	0.3	34	11.2	61	3.22
COTYLEDONS								
Cajan pea (Pusa best)	3.44	20.2	3.6	0.3	55	351	146	5.05
Pea (N.P. 29)	2.53	26.9	2.9	1.0	56	278	161	4.4
Lentil (M.P. hybrid)	2.20	27.1	2.7	0.9	57	336	93	5.76
Mung bean (T_1)	2.61	23.0	2.8	0.4	57	292	99	5.2
Cowpea (E.C. 13060)	2.75	23.3	2.0	0.3	59	433	144	5.3
French bean	3.29	30.7	2.0	0.3	54	380	104	5.8
Guar (Sadabahar)	2.22	28.1	3.0	0.2	9.3	300	140	4.1
EMBRYO								
Cajan pea (Pusa best)	0.09	0.7	0.2	0.02	0.5	13.4	6.0	0.19
Pea (N.P. 29)	0.05	0.6	0.1	0.03	0.4	10.3	5.8	0.24
Lentil (M.P. hybrid)	0.08	1.4	0.2	0.05	0.3	18.8	7.0	0.38
Mung bean (T_1)	0.1	1.2	0.2	0.03	0.7	17.4	11.3	0.53
Cowpea (E.C. 13060)	0.09	0.9	0.2	0.03	0.9	17.6	7.8	0.44
French bean	0.04	0.7	0.1	0.02	0.2	8.9	4.3	0.18
Guar (Sadabahar)	0.07	1.0	0.2	0.03	0.3	13.4	5.3	0.29

[a] Data derived from Tables I and II. Proportion of whole grain existing as indicating constituents in specified fraction.

mined and calculated values agree remarkably. Among the pulses, guar and French bean contain maximum amounts of protein; lentil and pea come next. Besides protein, pulses in general are a good source of calcium, phosphorus, and iron, except lentil and French bean, which are comparatively low in calcium (Table I); all others contain about 200 to 350 mg./100 g. of calcium. For total protein, calcium, and phosphorus the results obtained for mung T_1, lentil, pea, and arhar agree to a greater extent with those of Dhingra and

Das (9). But the values obtained for ether extract, nitrogen-free extract, and particularly iron are higher than those obtained by Dhingra and Das (9). The results also agree very well with those published by Aykroyd and Doughty (10) and with those in "Composition of foods used in Far Eastern countries" (11), in all major constituents except calcium and ether extract. The difference in chemical composition may be attributed to the effects of soil, climate, strain of seed, and fertilizer treatment (12,13). The protein content in pea agrees remarkably with that obtained by Raacke (5) in ripening pea.

TABLE IV

DISTRIBUTION OF THE CHEMICAL CONSTITUENTS IN PULSES[a]

SAMPLE VARIETY	ASH	PROTEIN N×6.25	ETHER EXTRACT	CRUDE FIBER	NITROGEN-FREE EXTRACT	PHOSPHORUS	CALCIUM	IRON
	%	%	%	%	%	*mg./100 g.*	*mg./100 g.*	*mg./100 g.*
SEED COAT								
Cajan pea (Pusa best)	13.0	4.0	1.0	98.0	14	1.3	48	21.9
Pea (N.P. 29)	9.0	1.0	1.0	80.0	8	0.5	35	18.2
Lentil (M.P. hybrid)	6.2	4.0	2	75	7	3.3	38	13
Mung bean (T_1)	12.9	5	2	88	11	1.4	49	23
Cowpea (E.C. 13060)	10.6	4	5	87	9	2.0	33	18
French bean	9.2	2	2	73	10	1.6	43	14.5
Guar (Sadabahar)	19.0	5	3	94	18	2.5	38	24
ENDOSPERM								
Guar	16.6	9	17	6	64	3.3	18	33.3
COTYLEDONS								
Cajan pea (Pusa best)	83.3	90	95	6	86	95.8	49	75.5
Pea (N.P. 29)	89.1	96	90	17	92	97.1	62	84.3
Lentil (M.P. hybrid)	91.6	91	90	28	92	92.7	60	79.1
Mung bean (T_1)	81.3	90	93	11	87	94.9	50	70
Cowpea (E.C. 13060)	87.0	93	95	14	88	94.2	59	76.7
French bean	90.0	94	95	14	91	95.6	59	84
Guar (Sadabahar)	61.6	81	77	5	17	88.5	40	42.7
EMBRYO								
Cajan pea (Pusa best)	2.1	3	5	0.4	0.7	3.9	2	2.8
Pea (N.P. 29)	1.7	2	3	0.5	0.6	3.5	2.2	4.6
Lentil (M.P. hybrid)	3.1	5	6	1.5	0.4	5.1	4.5	5.2
Mung bean (T_1)	3.3	5	7	0.8	1.1	5.5	5.6	7.0
Cowpea (E.C. 13060)	2.8	3	10	1.0	1.2	3.8	3.2	6.3
French bean	1.0	2	4	0.6	0.3	2.2	2.4	2.6
Guar (Sadabahar)	1.9	3	5	0.6	0.6	4.0	1.5	3.0

[a] Data derived from Tables I, II, and III. Proportion of total of indicated constituents existing in the specified fraction.

The distribution of nutrients in different seed fractions, calculated as percentage of whole seed, shows that the major portion of ash, protein, ether extract, nitrogen-free extract, phosphorus, and iron is present in the cotyledons (Table IV). Whereas 80 to 93% of crude fiber and 32 to 50% of calcium are present in the seed coat, the embryo contains very little, about 2 to 3% of these constituents (Table IV).

It may be seen from Table II that, although the embryo is the richest part of the whole seed, being smallest in proportion, it accounts for an insignificant part of the total food value of the whole seed (Table IV). The seed coat, however, being larger in proportion than the embryo, is low in all of the constituents except crude fiber and calcium; therefore, it also contributes very little to the food value.

Cotyledons, being the major and fairly balanced component, account for almost the entire food value of the seed. Our results agree remarkably with the findings of Lal *et al.* (4) on the distribution of nutrients in seed parts of Bengal gram.

In view of the above findings, removal of the seed coat and embryo during milling would not apparently affect the food value of all the pulses.

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