(Reprinted from *Food Science*, January 1961, Vol. 10, No. 1, Pp. 3–6)

THE CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF BAJRA (Pennisetum typhoideum) AND BAJRA DIETS

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Bajra (Pearl millet—*Pennisetum typhoideum*) is an important food grain consumed widely by people in several countries of Asia and Africa. It is a staple food for a large number of people in several states in India. *Bajra*, considered to be a nourishing food by the consumers, is dehusked and cooked in the same way as rice. A great majority, however, powder the grain into flour and consume in the form of unleavened bread (*rotti*).

The area under cultivation in India in 1957-58 was 27 million acres and the total production was about 3.5 million tons[1]. The acreage and production of *bajra* in different states are given in Table I. *Bajra* is generally grown as a dry (rain-fed) crop, though in certain areas it is also cultivated as an irrigated crop. The crop has the advantage of being suited to regions of low rainfall and can be grown in tracts having an annual rainfall of 17-20 inches. *Bajra* under rain-fed conditions yields about 500-800 lb. while under irrigated conditions, yields of 1000-2000 lb. per acre can be obtained[2].

TABLE I. *Annual production of bajra (1957-58)*

State	Area under cultivation (1000 acres)	Production (1000 metric tons)
Andhra Pradesh ...	1,613	425
Bombay ...	8,264	1,007
Madras ...	1,368	254
Mysore ...	1,174	74
Punjab ...	2,273	279
Rajasthan ...	9,564	790
Uttar Pradesh ...	2,667	597
Madhya Pradesh ...	424	116
Other States ...	106	23
All India ...	27,453	3,565

Chemical composition of bajra

The chemical composition of different varieties of *bajra* has been determined by Rama Rao *et al.*[3] and Ranganathan *et al.*[4]. The results (Table II) show an appreciable difference in the chemical composition of the different varieties. It is seen from the Tables that *bajra* is a fair source of protein and certain B-vitamins.

Proteins: The total protein content of the six varieties analysed by Rama Rao *et al.*[3] varied from 12.5 to 14.4 per cent. According to Swaminathan[5], 6.8 per cent of the total nitrogen in *bajra* was non-protein nitrogen. Information on the physico-chemical properties of *bajra* proteins is not available in literature.

Amino acid composition: The amino acid composition of *bajra* proteins has been studied by various workers[6-9] using chemical and microbiological assay methods. The essential amino acid make up of the proteins of a few varieties of *bajra* is given in Table III, which indicates that

TABLE II. *Chemical composition of different varieties of bajra (Pennisetum typhoideum)*

No.	Strain	Moisture %	Protein (N×6.25) %	Fat %	Ash %	Carbohydrate (by diff.) %	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Thiamine (mg)
1	CO_1 ...	10.9	13.80	5.81	2.23	67.26	49.7	343	10.5	0.34
2	CO_2 ...	10.8	13.87	5.28	1.99	68.06	38.7	338	9.5	0.31
3	CO_3 ...	11.2	14.35	5.39	1.55	67.51	32.8	269	10.0	0.31
4	CO_4 ..	11 0	13.43	5.10	2.07	68.40	39.8	358	10.0	0.41
5	X_1 ...	11.0	12.50	5.58	2.22	68.70	29.0	356	9.5	0.36
6	X_2 ...	10.8	12 64	5.23	1.99	69.34	31.1	391	8.5	0.45

TABLE III. *Essential amino acid composition of different strains of bajra*

(Values expressed for 16.0 g nitrogen)

	CO_1	CO_3	CO_4
Arginine ...	7.9	8.4	6.8
Histidine ...	1.6	1.9	3.4
Isoleucine ...	5.9	5.9	4.0
Leucine ...	9.3	9.7	9.2
Methionine ...	1.9	1.7	2.4
Lysine ...	3.7	3.9	3.7
Phenylalanine ...	4.5	4.1	3.1
Threonine ...	3.5	4.1	2.8
Tryptophan ...	1.9	1.9	1.1
Valine ...	6.2	6.4	4.7

bajra proteins are good sources of all the essential amino acids except lysine[10].

Carbohydrates: Bajra coutaius 67 to 72 per cent carbohydrates of which starch is the maiu constituent. Kurien *et al.*[24] have reported that *bajra* contains 60.7 per cent of starch and 1.2 per cent of reducing sugars, the roughage content (cellulose and hemicelluloses) being 9 per cent of the whole grain. No information is available regarding the nature of hemicelluloses present iu *bajra.*

Minerals: Rama Rao *et al.*[3] reported that the mineral content of *bajra* ranged from 1.6 to 2.2 per cent. The calcium content of *bajra* is low ranging from 29-50 mg. per cent and comparable to that of *jowar* and wheat. The phosphorus content of the grain is comparable to those of other cereals and ranges from 270 to 380 mg. per 100 g. Sundararajan[11] and Giri[12] reported that 50 to 75 per cent of the phosphorus in the grain was present as phytin phosphorus. The iron content of *bajra* varied from 8.5 to 10.5 mg. per 100 g.

Vitamins: The thiamine content of different varieties of *bajra*, according to Rama Rao *et al.*[3] varied from 309 to 445 μg/100 g. Chitre *et al.*[13] studied the thiamine, riboflavin and nicotinic acid contents of two varieties of *bajra* and reported that they contained about 390 μg of thiamine, 188 μg of riboflavin and 4.43 mg. of nicotinic acid per 100 g. of the grain.

Distribution of protein, calcium and phosphorus between the husk and endosperm of bajra

Kurien *et al.*[14] studied the distribution of protein, calcium and phosphorus between the husk and eudosperm of *bajra.* The whole grain was soaked in water for 24 hours and grouud to a fine paste in the mortar. The husk was separated from the endosperm by sieving through a 100 mesh sieve. The endosperm was separated on the centrifuge aud dried in an air oven at 50-60°C. The husk accounted for 11.8 per cent of the whole grain. The protein, calcium and phosphorus contents of the husk, endosperm and the dried solids from the superuatant liquid are given in Table IV. The results show that the husk contains 11.5, 36.1 and 14.6 per cent of the total proteiu, calcium and phosphorus respectively of the whole grain.

Digestibility and biological value of the proteins of bajra

Digestibility and biological value of the proteins of *bajra* have been studied by various workers[15-18]. Swaminathan[15] reported values of 83

TABLE IV. *Protein, calcium and phosphorus contents of the husk and endosperm of bajra*

(All values are given on moisture free basis)

Component	Component as % of whole grain	Protein (N×6.25)		Calcium		Phosphorus	
		%	as % of protein in the whole grain	mg %	as % of calcium in whole grain	mg %	as % of phosphorus in whole grain
Whole grain ...	...	12.87	...	55	...	358	...
Husk ...	11.8	12.45	11.5	168	36.1	442	14.6
Endosperm ...	83.6	2.43	15.8	17	25.4	240	56.1
Dried solids from the supernatant liquid ...	3.8	24.4	72.0	534	36.9	3404	28.7

per cent and 89 per cent for the biological value and the digestibility co-efficient respectively of the proteins of *bajra* when fed to rats at 5 per cent level of protein intake. The protein efficiency ratio of *bajra* proteins at 5 per cent level was 1.2 and higher than that of *ragi* or *jowar* proteins[16]. Rama Rao *et al.*[17] and Phansalkar *et al.*[18] found that the protein efficiency ratios of *bajra* proteins at 10 per cent level of protein intake were 1.4 and 1.8 respectively. The proteins of pulses like red gram, black gram, green gram and Bengal gram supplemented those of *bajra* to a significant extent[18]. Rama Rao *et al.*[17] also found that the proteins of groundnut and Bengal gram possessed a significant supplementary value to those of *bajra*.

Availability of calcium and phosphorus from bajra

The calcium content of *bajra* is of the same order as that of *jowar* but much less than that of *ragi*. Sundararajan[11] and Giri[12] reported that 50-75 per cent of phosphorus in *bajra* was present as phytate phosphorus which is not readily available for nutrition. Giri[19] found that about 90 per cent of the ingested calcium and 74 per cent of the ingested phosphorus were retained by rats, while retentions of 49.5 per cent and 54.1 per cent respectively were reported by Ranganathan[20]. Giri[19] also found that the availability of calcium and phosphorus to rats from *bajra* was comparable to that of other millets like *ragi* and *jowar* when fed at the same levels of calcium and phosphorus.

Nutritive value of poor bajra diets

The nutritive value of poor vegetarian diets based on *bajra* has been studied by Rama Rao *et al.*[21] by the rat growth method. The results showed that the growth promoting value of a diet based on *bajra* was comparable to that of a similar diet based on wheat, the average weekly increase in body weight of rats being 12.7 g. on the poor *bajra* diet and 9.4 g. on the poor wheat diet. Kurien *et al.*[22] studied the effect of partial or complete replacement of rice in a poor Indian diet by *bajra* on the growth and composition of the body, blood and livers of rats. The results (Table V) showed that replacement of rice by *bajra* either partially or completely led to a slight

TABLE V. *Effect of partial or complete replacement of rice by bajra in poor vegetarian diets on the growth and haemoglobin content of rats*

(Duration of experiment—8 weeks)

Percentage of rice and bajra in the diet		Average weekly gain in body weight (g)	Haemoglobin g/100 ml.
Rice	78.5 ...	5.9	14.79
Rice Bajra	58.9 19.6 ...	7.5	15.37
Rice Bajra	39.2 39.3 ...	7.2	14.83
Bajra	78.5 ...	7.3	15.23

improvement in the overall nutritive value of the diet as judged by the growth of rats. There was, however, no significant difference in the haemoglobin, red blood cell count and the total serum proteins of the blood or in the protein, fat and moisture contents of the carcass and livers of the different groups of rats.

Human metabolism studies

Kurien *et al.*[23] studied the metabolism of nitrogen, calcium and phosphorus in children fed on a poor diet based on *bajra* . All the subjects were in positive nitrogen, calcium and phosphorus balances. The apparent digestibility of the proteins was 52.9 per cent. The same workers reported that the partial or complete replacement of rice by *bajra* in a poor Indian diet caused a decrease in the retention of nitrogen and calcium and an increase in the retention of phosphorus in children[24]. The results are given in Table VI.

Use of bajra for the production of malt

Bajra can be used for the preparation of malt. The optimum conditions for the preparation of *bajra* malt have been studied by Chandrasekhara *et al.*[25]. The method recommended by the authors consisted in steeping the grain in running water for 24 hours and in couching the grain for germination for 72 hours at room temperature (23°-27°C). The germinated grain was dried

TABLE VI. *Mean daily intake and balance of nitrogen, calcium and phosphorus in children on rice-bajra diets*

Diet No.	Quantity of rice and bajra in the diet (g)	Nitrogen			Calcium		Phosphorus	
		Intake (g)	Balance (g)	Apparent digestibility %	Intake (mg)	Balance (mg)	Intake (mg)	Balance (mg)
A	Rice 360 ...	6.92	2.02	75.3	352	119	726	162
B	Rice 270 / Bajra 90 ...	7.26	1.87	73.2	378	117	867	224
C	Rice 180 / Bajra 180 ...	7.83	1.49	64.3	418	113	1029	297
D	Bajra 360 ...	8.67	1.11	52.9	479	92	1346	356
	Standard error of the mean ...		±0.09	± 1.40		± 6.8		±12.9

in the sun or in a current of hot air at 45°-55°C and the vegetative portion was removed by rubbing. The resulting malted grain was powdered.

Bajra malt can be used in the preparation of balanced malt foods by blending with specially prepared low fat groundnut flour, puffed Bengal gram flour and skim milk powder and fortifying with essential minerals and vitamins.

Enzymes of bajra and bajra malt

Chandrasekhara and Swaminathan[25] studied the amylases of *bajra* and *bajra* malt. *Bajra* in the ungerminated condition contained negligible amylase activity. Germination of the grain led to a marked increase in the α-amylase activity but only a slight increase in the β-amylase activity. The diastase activity of *bajra* malt was, however, less than that of *ragi* malt.

Conclusions

It is evident from the above account that *bajra*, like *jowar* (*Sorghum vulgare*) and *ragi* (*Eleusine coracana*) has a high nutritive value as a food grain, comparing well in this respect with whole wheat. Studies conducted on children have shown that 25 per cent of rice in a poor vegetarian diet, can be replaced by *bajra* without affecting the retention of nitrogen, calcium and phosphorus. *Bajra*, like other millets, has the advantage that it can be cultivated in regions of low rain fall and its yield can be easily increased by adopting irrigation. The increased production and consumption of *bajra* and other millets will no doubt help overcome the shortage of cereals in the country.

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PRINTED IN INDIA AT THE WESLEY PRESS, MYSORE