NUTRITIVE VALUE OF BUFFALO GOURD SEED PROTEIN[1]

M. TU,[2] W. D. EUSTACE,[2] and C. W. DEYOE,[2] Department of Grain Science and Industry, Manhattan, KS 66506

Cereal Chem. 55(5): 766-772

ABSTRACT

Buffalo gourd (*Cucurbita foetidissima*) seeds are rich in protein and oil and could be grown for food in arid lands. Buffalo gourd seed flour (70% protein) was prepared and its nutritive value studied by rat growth, protein efficiency ratio (PER), and comparisons with soybean protein and casein. The limiting essential amino acids were studied by supplementing diets deficient in amino acids with lysine, threonine, methionine, and isoleucine. Differences between soybean meal protein and gourd seed protein were not significant ($P < 0.05$). Supplementing gourd seed protein with lysine and threonine gave highly significant growth response. PER was similar to that of casein.

Suitable vegetable protein sources have been investigated as a supplement for current dietary protein supplies (1). One such source is buffalo gourd (*Cucurbita foetidissima* HBK), a wild perennial indigenous to Western North America and Mexico as far south as Guanajuato (2), the seeds of which have been described as rich in protein and oil (3,4).

Weber et al (5) reported that the quality of protein in crude gourd meal for feeding weanling mice was lower than that of whole egg. Hensarling et al (6) found the corrected protein efficiency ratio (PER) for isolated storage globulin of buffalo gourd seeds was 1.66 compared with casein at 2.50 g of weight gain per gram of protein intake.

Little information is available concerning the nutritive value of decorticated buffalo gourd seed flour and its possible limiting amino acids. We studied the nutritive value of buffalo gourd seed flour protein by comparing growth of rats and PER of gourd flour, soybean flour, and casein. We also attempted to determine possible deficiencies of essential amino acids.

MATERIALS AND METHODS

W. D. Eustace, of the Department of Grain Science and Industry, Kansas State University, Manhattan, prepared the buffalo gourd seed flour. The method (Fig. 1) was developed to separate buffalo gourd seed hulls from the endosperm. The dry seeds were run through a roller mill set with a 0.020-in. gap, differential 3:1, corrugation 22 per inch, and grinding action dull to dull. The cracked buffalo gourd seed was sifted over a 20-W Farsberg Screener. The overs were sent to an impact machine (Forsberg Impact Huller, Model 78) operating at 4,000 rpm that separated the hulls and endosperm. The stock through 20-W screener after the impactor is combined with the stock through a 20-W screener after the roller mill and sifted over an 18- and 36-W sifter. The overs of the 20-W screener after impaction were sifted over an 8-, 10-, and 12-W sifter. The throughs of the 12-W

[1]Contribution No. 947-J, Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS 66506.

[2]Graduate research assistant, associate professor, and professor, respectively. Department of Grain Science and Industry, Kansas State University, Manhattan, KS 66506.

0009-0352/78/000087$03.00/0

sifter were ground again on the roller mill with a gap of 0.005 in. The ground material was sifted over an 18- and 36-W sifter. The flour collected from the pan was used in this nutritional study.

Soybean flour was purchased from Far-Mar-Co., Inc., Hutchinson, KS.

The composition of buffalo gourd seed flour and soybean flour as determined by AOAC methods is presented in Table I. Amino acid analyses were made by the procedure of Spackman et al (7) with a Beckman automatic amino acid analyzer (Beckman Instruments, Inc., Fullerton, CA).

Diet compositions and the amount of each amino acid added are shown in Table II. The calcium, phosphorous, potassium, and magnesium were added to adjust to National Research Council (NRC) requirements (8) for those nutrients.

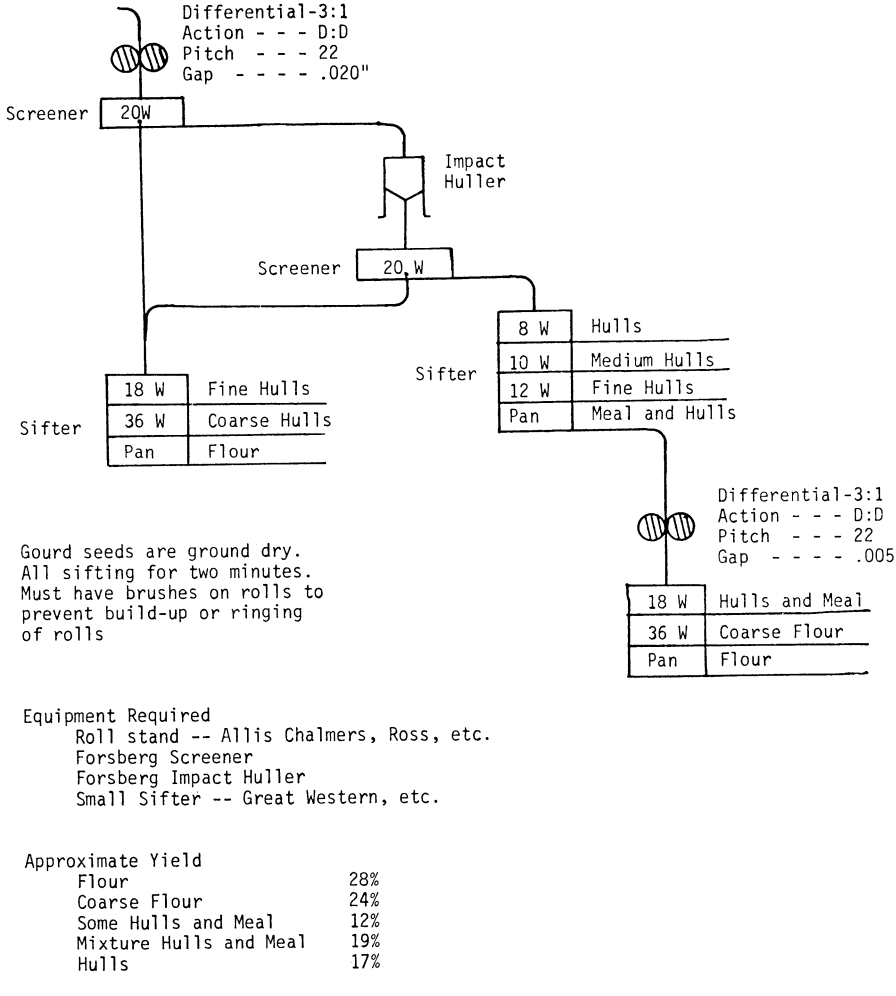

Fig. 1. Flow chart for processing buffalo gourd seed.

Buffalo gourd seed flour, soybean flour, and casein were used to supply 10% protein in the diet.

Sixty 22-day-old male weanling rats of the Sprague-Dawley strain were used. Five were randomly assigned to each diet. They were placed in wire-bottom cages

TABLE I
Composition of Buffalo Gourd Seed Flour and Soybean Flour

Ingredients	Buffalo Gourd Seed Flour (%)	Soybean Flour (%)
Protein (N × 6.25)	70.2	52.1
Fat	0.3	1.5
Moisture	7.6	4.6
Ash	8.8	6.2
Fiber	4.0	2.2

TABLE II
Composition of Diets Fed to Weanling Rats

Ingredients	Diet Composition (g/100 g)		
	Groups		
	1–10	11	12
Casein			12.5
Soybean flour		18.8	
Buffalo gourd seed flour and one or more essential amino acids to total[a]	14.2		
Cottonseed oil	3.95	3.67	4.0
Cellulose (nonnutritive)	...	...	...
Vitamin mix[b]	0.25	0.25	0.25
Trace mineral mix[c]	0.025	0.025	0.025
Dicalcium phosphate	1.9	1.9	1.9
Calcium carbonate	0.76	0.5	0.5
Potassium sulfate	0.2	...	0.45
Sodium chloride	0.3	0.2	0.3
Magnesium carbonate	0.15	...	0.15
Corn starch/glucose (4:1)	78.3	74.6	74.9

[a]Supplemented amino acids in: diet 2, L-threonine (0.19%); diet 3, L-lysine (0.37%); diet 4, L-isoleucine (0.14%); diet 5, L-threonine (0.19%) and L-lysine (0.37%); diet 6, L-threonine (0.19%) and D,L-methionine (0.13%); diet 7, L-lysine (0.37%), L-threonine (0.19%), and D,L-methionine (0.13%); diet 8, L-threonine (0.19%), D,L-methionine (0.13%), and L-isoleucine (0.14%); diet 9, L-lysine (0.37%), L-threonine (0.19%), D,L-methionine (0.13%), and L-isoleucine (0.14%).

[b]Vitamins were added at NRC requirements for growth (8) plus 20 iu of Vitamin D_3/100 g, d-biotin 150 μg/100 gm, and ascorbic acid 1.25 g/100 g.

[c]Trace mineral mix contained Mn, 10%; Fe, 10%; Ca, 14%; Cu, 1%; Zn, 5%; I, 0.3%; and Co, 1%.

in a room maintained at 26–28°C for four weeks. Feed and water were provided ad libitum. Records were kept to determine weight gain and feed consumption, which were used to calculate the PER.

RESULTS

The essential amino acid contents of the soybean and buffalo gourd seed flours used are shown in Tables III and IV, respectively. Compared with the NRC growth requirement for the rat (8), buffalo gourd seed flour was deficient in methionine, threonine, lysine, and isoleucine; soybean flour was deficient in methionine.

TABLE III
Essential Amino Acids in Soybean Flour Compared With Minimums for Rat Growth

Amino Acids	g Amino Acids/ 100-g Sample	Requirements[a] for Growth (% of diet)	Supplied by 18.8% Soybean Flour (% of diet)	Deviations From Growth Requirements (%)
Lysine	6.41	0.75	1.20	+60
Isoleucine	1.73	0.46	0.33	−28
Leucine	3.05	0.62	0.57	− 8
Methionine	0.11	0.33	0.02	−94
Phenylalanine	1.86	0.33	0.34	+ 3
Threonine	1.44	0.41	0.27	−34
Valine	1.76	0.49	0.33	−33
Tryptophan	1.60	0.12	0.30	+66

[a]NRC requirements for rats (8).

TABLE IV
Essential Amino Acids of Buffalo Gourd Seed Flour Compared With Minimums for Rat Growth

Amino Acids	g Amino Acids/ 100-g Sample	Requirements[a] for Growth (% of diet)	Supplied by 14.2% Buffalo Gourd Seed Flour (% of diet)	Deviations From Growth Requirements (%)
Lysine	2.70	0.75	0.38	−49
Isoleucine	2.27	0.46	0.32	−30
Leucine	4.31	0.62	0.61	− 2
Methionine	1.39	0.33	0.20	−39
Phenylalanine	2.84	0.33	0.40	+39
Threonine	1.55	0.41	0.22	−46
Valine	2.66	0.49	0.38	−22
Tryptophan	0.62	0.12	0.09	−25

[a]NRC requirement for rats (8).

Supplementing the buffalo gourd seed flour diet with lysine (Diet 3) resulted in an insignificant growth response compared with that from Diet 1 (Table V). When the other deficient amino acids, threonine (Diet 2) and isoleucine (Diet 4), were added individually to buffalo gourd seed flour, growth responses were still insignificant (Table V). Adding threonine, the second most limiting amino acid, plus methionine (Diet 6) or methionine and isoleucine (Diet 8) did not

TABLE V
Average Net Weight Gained and Protein Efficiency Ratios (PER) From Weanling Rat Diets

Diet Group	Composition (g/100 g)	Weight Gained (g) (Mean ± SD)[a]	PER	
			Actual (Mean ± SD)[a]	Adjusted
1	Buffalo gourd seed flour	57.0 ± 2.4 C	1.94 ± 0.08 C	1.72
2	Buffalo gourd seed flour Threonine (0.19%)	67.2 ± 2.1 C	2.02 ± 0.08 BC	1.79
3	Buffalo gourd seed flour Lysine (0.37%)	63.4 ± 2.6 C	2.18 ± 0.09 B	1.93
4	Buffalo gourd seed flour Isoleucine (0.14%)	64.4 ± 2.7 C	1.95 ± 0.12 C	1.73
5	Buffalo gourd seed flour Threonine (0.19%) Lysine (0.37%)	92.2 ± 5.9 B	2.82 ± 0.05A	2.50
6	Buffalo gourd seed flour Threonine (0.19%) Methionine (0.13%)	64.8 ± 5.1 C	1.97 ± 0.05 BC	1.75
7	Buffalo gourd seed flour Lysine (0.37%) Threonine (0.19%) Methionine (0.13%)	97.6 ± 3.4 B	3.00 ± 0.16A	2.66
8	Buffalo gourd seed flour Threonine (0.19%) Methionine (0.13%) Isoleucine (0.14%)	59.8 ± 2.7 C	1.96 ± 0.11 C	1.74
9	Buffalo gourd seed flour Threonine (0.19%) Lysine (0.37%) Methionine (0.13%) Isoleucine (0.14%)	117.8 ± 9.1A	2.98 ± 0.18A	2.64
10	Autoclaved gourd seed flour	66.1 ± 6.8 C	2.08 ± 0.09 BC	1.84
11	Soybean flour	65.5 ± 4.0 C	2.02 ± 0.12 BC	1.79
12	Casein	89.5 ± 9.2 B	2.82 ± 0.22A	2.50

[a]Duncan's multiple range test (11). Means without letter in common differ significantly ($P < 0.05$).

significantly improve the buffalo gourd seed flour diet. Buffalo gourd seed flour diet supplemented with lysine and threonine (Diet 5) or further supplemented with methionine in Diet 7, however, gave a significantly improved growth response (Table V) that was comparable to casein (Diet 12). When all four deficient amino acids were added to buffalo gourd seed flour (Diet 9), the growth response was significantly better than was the casein diet (Diet 12).

The autoclaved buffalo gourd seed flour diet (Diet 10) was only slightly better than the nonautoclaved one (Diet 1), and not statistically different. This may indicate lack of growth inhibitor in buffalo gourd seed flour. The low methionine content in soybean flour (Diet 11) yielded insignificant improvement compared with growth response of buffalo gourd seed flour diet (Diet 1).

The PER value for buffalo gourd seed flour was 1.72 compared with caseins standardized at 2.50. The nutritive value of buffalo gourd seed flour protein was greatly improved by supplementing with the combination of lysine and threonine (Diet 5), with a PER value (2.50) similar to casein (Diet 12). The PER value of Diet 5 was further improved by adding methionine (Diet 7) to give a PER value of 2.66, or by supplementing with all other deficient amino acids (Diet 9) to give a PER value of 2.64.

To assess buffalo gourd seed protein for potential human food uses, the amino acid composition (Table VI) was evaluated according to FAO/WHO

TABLE VI
Amino Acid Composition and A:E Ratio[a] of Buffalo Gourd Seed Flour

Amino Acids	Buffalo Gourd Seed Flour		FAO Pattern[b]	
	Content (g amino acid/ 16 g N)	A:E ratio	Content (g amino acid/ 16 g N)	A:E ratio
Lysine	3.85	124	5.5	152
Isoleucine	3.23	104	4.0	111
Leucine	6.14	197	7.0	194
Methionine	1.99	64	3.5[c]	97[c]
Phenylalanine	4.05	131	6.0[d]	166[d]
Threonine	2.21	71	4.0	111
Valine	3.79	122	5.0	138
Tryptophan	0.89	29	1.0	27
Tyrosine	2.93	106	...	...
Cystein	1.95	63	...	...
Histidine	2.35	...	...	...
Arginine	15.73	...	...	...
Glutamic acid	20.65	...	...	...
Aspartic acid	8.93	...	...	...
Proline	3.19	...	...	...

[a]A:E ratio values are milligrams of amino acid per gram of total essential amino acids.
[b]From FAO-WHO (9).
[c]Level for methionine plus cystine.
[d]Level for phenylalanine plus tyrosine.

requirements (9). Table VI indicates that lysine and threonine are low, and isoleucine and valine are borderline.

Amino acid composition data of buffalo gourd seed flour protein indicate arginine, aspartic acid, and glutamic acid are the most plentiful, which agrees with reported data (3,5,10).

CONCLUSIONS

Buffalo gourd seed flour yielded growth in rats similar to that with soybean flour. The nutritional value of buffalo gourd seed protein yielded a PER value similar to casein when two deficient essential amino acids, lysine and threonine, were added. There was no significant difference ($P < 0.05$), however, between the PER value of buffalo gourd seed flour with lysine and threonine (Diet 5, PER 2.50) and that of buffalo gourd seed flour with lysine, threonine, and methionine (Diet 7, PER 2.66) or that of buffalo gourd seed flour plus all deficient amino acids (Diet 9, PER 2.64). This suggested that lysine and threonine are the most limiting essential amino acids in buffalo gourd seed flour for rat growth.

Acknowledgment

We wish to acknowledge D. B. Parrish, Department of Biochemistry, Kansas State University, for providing facilities for this study.

Literature Cited

1. SQUIBB, R. L., WYLD, M. K., SCRIMSHAW, N. S., and BRESSANI, R. J. All vegetable protein mixture for human feeding. J. Nutr. 69: 343 (1959).
2. BOLLEY, D. S., MacCORMACK, R. H., and CURTIS, L. C. Utilization of the seeds of the wild perennial gourds. J. Am. Oil Chem. Soc. 27: 571 (1950).
3. JACKS, T. J., HENSARLING, T. P., and YATSU, L. Y. Cucurbit seeds. I. Characterization and uses of oils and proteins. A review. Econ. Bot. 26: 135 (1972).
4. TU, M. The partial characterization of *Cucurbita foetidissima,* master's thesis, Kansas State University, Manhattan, KS (1973).
5. WEBER, C. W., BEMIS, W. P., BERRY, J. W., DEUTSCHMAN, A. J., and REID, B. L. Protein evaluation of two species of Cucurbita seeds. Proc. Soc. Exp. Biol. Med. 130: 761 (1969).
6. HENSARLING, T. P., JACKS, T. J., and BOOTH, A. V. Cucurbit seeds. II. Nutritive value of storage protein isolated from *Cucurbita foetidissima* (Buffalo gourd). J. Agric. Food Chem. 21: 986 (1973).
7. SPACKMAN, D. H., STEIN, W. H., and MOORE, S. Automatic recording apparatus for use with chromatography of amino acids. Anal. Chem. 30: 1190 (1958).
8. NATIONAL RESEARCH COUNCIL, Committee on Animal Nutrition. Nutrient requirements of domestic animals. National Academy of Science-National Research Council, Washington, DC (1972).
9. FOOD AGRICULTURAL ORGANIZATION/WORLD HEALTH ORGANIZATION. Energy and Protein Requirements. FAO Meet. Rep. Ser. 52: 63 (1973).
10. LYMAN, C. M., KUIKEN, K. A., and HALE, A. Amino acids in feedstuffs. Essential amino acid content of farm feeds. J. Agric. Food Chem. 4: 1008 (1956).
11. DUNCAN, D. B. Multiple range and multiple F tests. Biometrics 11: 1 (1955).

[Received March 17, 1977. Accepted February 9, 1978]