Nutritive Value of Proteins in Buckwheat and Their Role as Supplements to Proteins in Cereal Grains

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The proteins in buckwheat at an 8% level of protein intake are best known source of high biological value proteins in the plant kingdom, having 92.3% of the value of dried nonfat milk solids, and 81.4% of dried whole eggs. The proteins in buckwheat also have tremendous supplementary value to the cereal grains. Buckwheat in general is an exceptionally good crop for poor soils and can be grown where wheat or even rye cannot be grown with profit. The results of this study indicate the desirability of much further expansion of buckwheat cultivation in the Orient, Latin American countries, and Africa where a marked protein deficiency exists associated with a low resistance to infections and a low life expectancy.

A THOROUGH REVIEW of the literature disclosed that no quantitative data are obtainable on the efficiency of the proteins of buckwheat either by the nitrogen retention method of Mitchell of determining biological values (*9*) or by the Osborne and Mendel technique of determining protein efficiency ratios (*11–13*).

In 1923, Matsuyama (*8*) reported satisfactory growth in rats when buckwheat was fed at a 10% protein level. The results of Chen and Wang (*4*) on growth experiments with rats indicate that the proteins of buckwheat and corn supplement each other. Using a modified depletion and repletion method of Cannon and coworkers (*2*), Bukin and Vodolazskaya (*1*) found buckwheat, wheat, and oats to have the highest quality proteins for rats.

Occasionally, buckwheat grain and also the green fodder or straw cause peculiar eruptions and intense itching of the skin (*10*) because of photosensitization caused by a fluorescent dye (*7*). This affects only white or light-colored portions of the hide, and animals are thus injured only when exposed to light.

In connection with cooperative work with Institute of Central America and Panama in Guatemala, this department was requested to investigate the protein value of whole buckwheat from El Salvador. The growth of albino rats on a 7% protein level from that buckwheat was so phenomenal that investigation was made on the protein efficiency of a United States variety, which was obtained from Wisconsin as whole buckwheat and buckwheat flour.

Experimental Procedure and Materials

For this study 24 albino rats, sexes equally divided, were used for each group. The animals were about 28 days old, when the experiments were started and weighed 50 to 54 grams each. The whole buckwheat or buckwheat flour furnished the only source of proteins in the rations. The protein content of the El Salvador and Wisconsin whole buckwheat was 9.2% and that of Wisconsin buckwheat flour, 10.2%. Sufficient El Salvador whole buckwheat was supplied for feeding at only 7 and 5% levels of intake. The Wisconsin whole and buckwheat flour were fed at 8, 7, and 5% planes of protein intake. The duration of the experiments was 10 weeks. The rations contained 4% of Sure's salt mixture No. 1 (*15*); 7% of hydrogenated vegetable shortening; 2% of cod liver oil; 1% of wheat germ

Table I. Nutritive Value of the Proteins in Buckwheat

(24 animals in each group. Average results per animal for 10-week period)

Type of Ration	% in Ration	Protein in Ration, %	Gains in Body Wt., G.	Total Food Intake, G.	Protein Intake, G.	PER[a]
El Salvador whole buckwheat	78.7	7.0	111.3 ± 9.7[b]	772.7	54.1	2.09 ± 0.06[c]
	56.2	5.0	58.3 ± 5.6	564.5	28.2	2.06 ± 0.08
Wisconsin whole buckwheat	87.1	8.0	131.5 ± 10.5	808.3	64.7	2.03 ± 0.05
	76.1	7.0	98.5 ± 9.4	692.7	48.5	2.03 ± 0.06
	54.4	5.0	67.7 ± 8.3	632.4	31.6	2.11 ± 0.07
Wisconsin buckwheat flour	78.5	8.0	131.3 ± 11.6	796.1	63.7	2.06 ± 0.19
	68.6	7.0	87.3 ± 7.8	707.0	49.5	1.76 ± 0.08
	49.1	5.0	44.5 ± 4.3	524.7	26.2	1.70 ± 0.12

[a] Protein efficiency ratio, expressed as gains in body weight per gram of protein intake.
[b] Standard deviation.
[c] Standard deviation of the means.

Table II. Relative Efficiency of the Proteins

(Fed at 8% protein level for 10 weeks)

Food	Protein Efficiency Ratio (PER)[a]	PER in % of Dried Nonfat Milk Solids	PER in % of Dried Whole Eggs
Wisconsin whole buckheat	2.03 ± 0.05[b]	91.0	80.2
Wisconsin buckwheat flour	2.06 ± 0.19	92.3	81.4
Soybean meal	1.01 ± 0.09	45.3	40.0
Peanut meal	1.28 ± 0.04	52.9	50.6
Cottonseed meal	1.11 ± 0.10	49.8	43.9
Dried nonfat milk Solids (low heat)	2.23 ± 0.08		88.1
Dried whole eggs	2.53 ± 0.08		

[a] Expressed as gains in body weight per gram of protein intake.
[b] Standard deviation of the mean.

oil; and the rest, percentagewise, glucose (Cerelose). The fat-soluble vitamins A, D, and E were furnished by the cold liver oil and wheat germ oils in the rations. All rations were supplemented separately from the ration with a liberal supply of the B vitamins (*14*). The animals were weighed once weekly and accurate records were kept of food consumption. The protein efficiency ratios were determined from the calculated protein intake, expressed as gains in body weight per gram of protein intake. The results are summarized in Tables I, II, and III.

Interpretation of Results

In Table I, the protein efficiency ratios in El Salvador and Wisconsin whole buckwheats are very high and of the same values at 7 and 5% planes of intake; also at 7% level of intake, no notable difference was observed in protein efficiency between the Wisconsin whole buckwheat and the Wisconsin buckwheat flour. The surprising observation, however, is that at 7 and 5% planes of intake the Wisconsin whole buckwheat has a higher protein efficiency ratio than the buckwheat flour. From this study the hulls appear to have supplied some supplementary amino acids at the 7 and 5% levels of intake. This phase of the study needs further investigation. Nevertheless, the proteins in buckwheat flour at an 8% plane of intake are the best source of high biological value proteins in the plant kingdom, having 92.3% of the value of dried nonfat milk solids and 81.4% of that of dried whole eggs (Table II). In other words, the proteins in buckwheat flour, without any amino acid additions, approximate the nutritive efficiency of

Table III. Supplementary Relationship between Proteins in Buckwheat Flour, Milled Cereal Grains, and Sorghum

(24 animals in each group. Growth of 10 weeks. Average results per animal)

Type of Ration	% in Ration	Protein in Ration, %	Gains in Body Weight, G.	%	Mortality, %	Total Food Intake, G.	Protein Intake, G.	PER[a]	Increase, %
Milled wheat flour	88.3	9.0	37.6 ± 6.5[b]			509.7	45.9	0.82 ± 0.04[c]	
Milled wheat flour	44.2	4.5							
Buckwheat flour	44.1	4.5	139.2 ± 11.2	270.2		823.4	74.1	1.88 ± 0.04	129.3
Milled wheat flour	58.9	6.0							
Buckwheat flour	29.4	3.0	110.8 ± 9.4	194.7		798.3	71.8	1.54 ± 0.03	87.8
Milled wheat flour	70.7	7.2							
Buckwheat flour	17.6	1.8	81.7 ± 7.9	117.3	8.3	690.6	62.2	1.31 ± 0.07	59.7
Milled white corn meal	76.9	6.0	5.5 ± 2.1		50.0	400.9	24.0	0.23 ± 0.04	
Milled white corn meal	38.5	3.0							
Buckwheat flour	29.4	3.0	78.3 ± 8.1	1323.6		720.5	43.2	1.81 ± 0.05	687.0
Milled white corn meal	51.3	4.0							
Buckwheat flour	19.6	2.0	49.2 ± 7.3	794.5		656.5	39.4	1.22 ± 0.06	430.4
Milled white corn meal	61.5	4.8							
Buckwheat flour	11.8	1.2	19.2 ± 4.2	249.1	16.6	442.8	29.5	0.65 ± 0.04	182.6
Ark. grain sorghum	78.4	8.0	13.6 ± 3.5			382.0	30.6	0.44 ± 0.05	
Ark. grain sorghum	39.2	4.0							
Buckwheat flour	39.2	4.0	81.7 ± 8.3	500.7		588.8	47.1	1.73 ± 0.08	293.2
Ark. grain sorghum	58.8	6.0							
Buckwheat flour	19.6	2.0	29.5 ± 4.5	116.9		385.1	30.8	0.96 ± 0.07	118.2
Milled rye flour	80.0	6.0	19.1 ± 4.6			389.0	23.3	0.82 ± 0.05	
Milled rye flour	40.0	3.0							
Buckwheat flour	29.9	3.0	72.4 ± 7.8	279.1		600.4	36.0	2.01 ± 0.05	145.1
Milled rye flour	53.4	4.0							
Buckwheat flour	19.6	2.0	55.6 ± 7.1	191.5		552.4	33.1	1.68 ± 0.04	104.9
Milled rye flour	64.0	4.8							
Buckwheat flour	11.8	1.2	38.0 ± 6.3	98.9		443.3	26.6	1.43 ± 0.06	74.4

[a] Protein efficiency ratio, expressed as gains in body weight per gram of protein intake.
[b] Standard deviation.
[c] Standard deviation of the means.

proteins of animal origin of high biological value.

Supplementary Relationships between Proteins in Buckwheat Flour, Milled Cereal Grains, and Grain Sorghum. Table III shows that the replacement of one half, one third, and one fourth of the proteins in milled wheat flour with equivalent amounts of proteins in buckwheat flour was accompanied with 270.2, 194.7, and 117.3% increased growth; and 129.3, 87.8, and 59.7% increase in protein efficiency ratios, respectively. Similar percentagewise replacements of the proteins in milled white corn meal with equivalent amounts of proteins in buckwheat flour resulted in 1323.6, 794.5, and 249.1% increased growth; and 687.0, 430.4, and 182.6% increase in protein efficiency, respectively. Replacement of one half and one third of the proteins in Arkansas grain sorghum with equivalent amounts of proteins in buckwheat flour was followed by 500.7 and 116.9% increased growth and 293.2 and 118.2% increase in protein efficiency.

Rye has considerable amounts of bran which is removed in milling leaving a flour of low protein content. The milled rye flour obtained from General Mills contained only 7.5% protein (N $\times$ 5.7) (*6*). It was, therefore, possible to introduce a maximum of only 6.0% protein in the ration. Replacement of one half, one third, and one fourth of the proteins in milled rye by equivalent amounts of proteins in buckwheat flour resulted in 279.1, 191.5, and 98.9% gains in body weight; and 145.1, 104.9, and 74.4% increase in protein efficiency, respectively.

The results of this study indicate the necessity of large expansion of the cultivation of buckwheat in various sections of the world, particularly in the Orient, Latin American countries, and Africa where there exists a marked protein deficiency associated with a low resistance to infections and low life expectancy (*2*, *5*).

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FEED FROM SEWAGE

Sewage Sludge as a Feed Ingredient for Swine and Poultry

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Dry activated sludge can be included in the diet of the baby pig up to a level of 5% without adverse effects on growth. Levels of 2 and 10% in the diet of the chick produced a growth response in excess of 8% over a control group.

Microbiological assays have indicated (*2*, *3*) that dry activated sewage sludge is a potential source of vitamin B_{12}. Schendel and others (*5*) have shown that a level of 2% sludge in the diet of the baby pig will satisfy the B_{12} requirement for growth without adverse effects. It seemed desirable to investigate higher levels of sludge as a possible source of other growth factors or toxic substances.

Crossbred baby pigs 2 to 3 days old were obtained from a commercial hatchery for use in these experiments. The pigs were kept together for 2 days to facilitate their learning to drink from bowls and then were housed individually in wire-bottomed metal cages. They were fed approximately every 8 hours an alpha-protein synthetic milk, the composition of which is given in Table I, in amounts estimated to be 100 to 200 ml. more than they would consume before the next feeding. Sewage sludge and vitamins were added at the time of feeding; control animals received 0.8 γ of vitamin B_{12} per kg. of body weight per day by weekly intramuscular injection (*4*). Microbiological assay with *Ochromonas malhamensis* indicated 4.0 γ of B_{12} activity per gram of sludge and with *E. coli* mutant 7.5 γ of B_{12} activity per gram of sludge.

The first experiment compared a basal group with a group receiving the basal diet plus dry activated sewage sludge at the rate of 10% of the dry matter of the diet. After 3 weeks it became apparent (Table II) that the 10% level was inhibiting growth and decreasing feed efficiency. At this point the sludge was lowered to a level of 5% and the experiment continued for 3 more weeks, during which the gains paralleled those of the basal and the feed efficiency improved markedly.