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PROTEIN QUALITY AND SUPPLEMENTATION

Effect of Amino Acid Supplements, Vitamin B_{12}, and Buffalo Fish on the Nutritive Value of Proteins in Sesame Seed and Meal

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A study of sesame seed and meal was undertaken, because of their importance to human nutrition and the animal feed industry. Addition of lysine, lysine and threonine, and buffalo fish benefited growth and the protein efficiency of sesame seed and meal. Sesame meal supplemented milled, white corn meal, enriched wheat flour, and white milled rice. Lysine and threonine influenced the biological value and net utilization of sesame seed. Vitamin B_{12} failed to supplement the lysine-threonine additions. Data are presented on amino acid, vitamin, and mineral content. The nutritive value of sesame seed and meal warrants their use in the enrichment of diets for certain population groups and for continued use in poultry and swine rations.

Sesame is one of the oldest staple, vegetable oil crops and a source of vegetable fats in India, China, Egypt, and Latin America. It was introduced in this country in the late 17th century in South Carolina and since 1953 has been grown on a commercial basis in Texas. Twelve million pounds a year are imported, and used for oleo, bakery products, candy, and cooking fat. The oil has the remarkable quality of remaining fresh and sweet for long periods of time. Foods, confections, oleomargarine, and bakery goods made with sesame oil remain free from rancidity up to 10 times longer than some of the better known vegetable oils. Detailed information about sesame meal, its production, trade, yields, breeding, harvesting, processing, and use are given in a recent publication by Altschul (*2*). Sesame seed is valuable to the diets of sections of the world's population and sesame meal is important as an ingredient of poultry rations (*7*).

This paper reports results of growth and metabolism experiments with young rats fed diets composed of fat-extracted sesame seed and meal with and without supplements of lysine, threonine, and vitamin B_{12}. Results are also presented of studies on the content of all members of the B-complex vitamins, amino acids (including nonessentials), calcium, phosphorus, and iron in sesame seed and meal. Included is a study of the supplementary value of the proteins of sesame seed as compared to those of milled white rice. The supplementary value of the proteins of sesame meal over those of milled white corn meal and of enriched milled wheat flour is presented, along with the supplementary value of the proteins of buffalo fish over those of sesame meal.

Experimental Procedure

Raw Material. Commercial samples of sesame seed and meal were used for the determination of vitamins, minerals, amino acids, and growth value of the proteins. The samples were fat-extracted with petroleum ether for use in rations. Growth value was determined in studies using albino rats as experimental animals fed fat-extracted sesame seed and meal rations containing 9% of protein. Fat-extracted sesame seed and meal furnished the only source of protein

Table I. Relative Efficiency of Proteins of Sesame Seed and Meal with and without Added Supplements

(Experimental period 10 weeks, 6 males and 6 females in each group. Average results per animal given. Protein in rations is 9%, except in ratio 11 it is 9.84%)

Ration	Type	Gains in Body Weight, G.	Gains in Body Weight, Increase, %	Protein Intake, G.	PER[a], G.	PER[a], Increase, %
1	Sesame seed	124	..	66.1	1.86 ± 0.05[b]	..
2	+ 0.2% L-lysine	129	4.0	69.8	1.94 ± 0.10	4.3
3	+ 0.2% L-lysine + 0.2% DL-threonine	186	50.0[c]	74.6	2.95 ± 0.12	31.7[c]
4	+ 0.2% L-lysine + 0.2% DL-threonine + 0.1 γ B_{12}	141	13.7	67.0	2.09 ± 0.08	12.3[c]
5	Sesame meal	94	..	69.3	1.35 ± 0.05	..
6	+ 0.2% L-lysine	123	30.8[c]	77.9	1.57 ± 0.05	16.3[c]
7	+ 0.2% L-lysine + 0.2% DL-threonine	156	60.0[c]	84.9	1.82 ± 0.09	34.8[c]
8	+ 0.2% L-lysine + 0.2% DL-threonine + 0.1 γ B_{12}	147	56.3[c]	83.3	1.76 ± 0.04	30.3[c]
9	Sesame meal[d]	68	..	54.9	1.24 ± 0.08	..
10	+ 1% buffalo fish	93	36.7[c]	62.1	1.50 ± 0.07	21.0[c]
11	+ 1% buffalo fish	116	70.6[c]	73.7	1.57 ± 0.06	26.6[c]

[a] Gains in body weight per gram of protein intake.
[b] Standard error.
[c] Significant for $P = 0.05$.
[d] From a new lot.

Table II. Influence on Growth and Protein Utilization of Addition of Sesame Meal with and without Supplements

(Average results per animals for a 10-week period; 6 males and 6 females in each group)

Ration	Type	Grain and Sesame in Ration, %	Gains in Body Weight, G.	Gains in Body Weight, Increase, %	Protein Intake, G.	Protein in Rations, %	PER[a], G.	PER[a], Increase, %
12	Milled white corn meal	88	19	..	26.0	6.86	0.60 ± 0.05[b]	..
13	Sesame meal	58.6 4.5	24	26.0	34.6	6.86	0.72 ± 0.06	12.0
14	Sesame meal + 0.1% L-lysine	58.6 4.5	91	379.0[c]	55.1	6.86	1.65 ± 0.06	175.0[c]
15	Sesame meal	44 6.7	36	89.4[c]	40.0	6.86	0.90 ± 0.07	50.0[c]
16	+ 0.1% L-lysine Sesame meal	44 6.7	112	489.4[c]	61.7	6.86	1.81 ± 0.03	201.6[c]
17	Enriched milled wheat flour	88	66	..	61.6	9.03	1.08 ± 0.04	..
18	Sesame meal	58.7 5.9	69	4.6	58.7	9.03	1.17 ± 0.06	8.3
19	Polished rice	87	71	..	35.4	5.42	2.01 ± 0.07	..
20	Sesame seed	62.3 3.0	92	29.6[c]	46.0	5.42	2.02 ± 0.04	0.5
21	Sesame meal	10.6	90	26.7[c]	41.7	5.42	2.17 ± 0.07	8.0

[a] Gains in body weight per gram of protein intake.
[b] Standard error.
[c] Significant for $P = 0.05$.

Protein in rations 13, 14: $^2/_3$ from corn meal, $^1/_3$ from sesame meal.
Protein in rations 15, 16: $^1/_2$ from corn meal, $^1/_2$ from sesame meal.
Protein in ration 18: $^2/_3$ from wheat flour, $^1/_3$ from sesame meal.

in these rations and were fed at levels to incorporate the necessary protein. They were fed with and without 0.2% of L-lysine, 0.2% of DL-threonine, and 0.1 γ of vitamin B_{12} daily. The sesame seed used in this investigation is of the Palmetto variety, grown in South Carolina.

Sesame Seed Processing. The variety of sesame seed that has been used to prepare the samples of sesame meal is a K-10 type. It is also known as Margo (Texas A and M College selections) and Renner I (Texas Research Foundation selections). The seed is obtained by a wet process using alkali in the bath to remove the hulls. The hulled seed is dried before crushing in an expeller. The seeds are cooked at low temperature not over 210° F. before pressing. There is very little additional heat created during extracting, only from friction. The temperature of the cake that comes from the press is not over 200° F.

Buffalo Fish Preparation. Dried, fat-extracted buffalo fish was used in the ration for the supplementary study. This fish meal was obtained by cutting frozen buffalo fish in small pieces, grinding it in a meat chopper, drying it at room temperature with the aid of fans, and extracting the fat with petroleum ether. The protein content of fat-free sesame seed was 43.3% (nitrogen × 6.25), of fat-free sesame meal 51.3% (nitrogen × 6.25), of milled white (polished) rice 6.24% (nitrogen × 5.95), and of fat-free buffalo fish 79.1%.

Experimental Rations. The composition of the rest of the rations was 4% of salt mixture No. 1 (*14*), 4% of hydrogenated vegetable shortening, 2% of cellu flour, 2% of cod liver oil, and 1% of wheat germ oil as sources of vitamins A, D, and E, and the rest as glucose (cerelose). Lysine and threonine were added at the expense of glucose in the ration. The following crystalline components of the vitamin B complex were administered daily to each animal, separately from the ration: 25 γ each of thiamine, riboflavin, pyridoxine, and niacin; 150 γ of calcium pantothenate, 3 mg. of *p*-aminobenzoic acid, 6 mg. of choline chloride, and 1 mg. of inositol. The animals—six males and six females in each group—were fed *ad libitum* for 70 days in the growth experiments. Each animal was weighed weekly and accurate weekly records of food consumption were kept. From the gains in body weight per gram of protein intake the protein efficiency ratios were calculated. In the study of the supplementary value of the proteins of buffalo fish over those of sesame meal, an equivalent amount of the proteins of sesame meal was replaced by the protein of 1% of buffalo fish, leaving the protein level at 9%. In another experiment, 1% of buffalo fish was added, which increased the protein level to 9.84% (Table I, rations 10 and 11). In the study of the supplementary value of the proteins of sesame meal over those of milled white corn meal (Table II), the protein content of the rations was 6.86%. In rations 13 and 14 (Table II), two thirds of the protein was from corn meal and one third from sesame meal. In rations 15 and 16, one half of the protein was from corn meal and one half from sesame meal. In ration 18, two thirds of the protein was from wheat flour and one third was from sesame meal. The protein content of corn meal was 7.8% (nitrogen × 6.25), of enriched milled wheat flour 10.26% (nitrogen × 5.70). The protein content of the ration was 9.03% in the supplementary study of sesame meal proteins for those of enriched milled wheat flour. In the study of the supplementary value of the proteins of sesame seed over those of milled white rice, the proteins of 3% sesame seed replaced an equivalent amount of proteins in polished rice leaving the protein level of the rations at 5.42% by varying the rice content (ration 20).

A complete description of the experimental procedure for the testing of amino acids, vitamins, and minerals, and for the determination of the biological values of the proteins is presented (*8*).

Results

Results of growth and supplementary experiments are given in Tables I and II and those of metabolism experiments in Table III.

Effect of Amino Acid Addition. The results, expressed as average gain per animal (Table I), indicate that the proteins of sesame seed and meal can be improved by supplementation with lysine and threonine and that addition of vitamin B_{12} is without beneficial effect. Addition of 0.2% of L-lysine produced an average gain of 129 grams and a protein efficiency ratio (PER) of 1.94 grams in rations containing 9% of sesame seed proteins. This is a 4% increase in gain and a 4.3% increase in PER. Further addition of 0.2% of DL-threonine produced increases in gain of 50% and in PER of 31.7%, as compared to performance in ration 1. This is the combined effect of the two amino acids. It shows the beneficial effect of the threonine addition, when compared to ration 2. Daily addition of 0.1 γ of vitamin B_{12} (ration 4) produced diminished growth when compared to ration 3; vitamin B_{12} failed to supplement the lysine-threonine addition (Table I, rations 1, 2, 3, and 4). Animals fed sesame meal at the 9% level showed increased gain of 30.8% and 16.3% in PER upon supplementation of the ration with 0.2% of L-lysine. Further supplementation with 0.2% of DL-threonine produced increases in gain up to 60% and 34.8% in PER. Daily supplementation with 0.1 γ of B_{12} did not produce further increases (Table I, rations 5, 6, 7, and 8).

Effect of Buffalo Fish. Table I also indicates that when 1% of buffalo fish replaced an equivalent amount of sesame meal protein, an increase in body weight of 36.7% and in PER of 21% was obtained in animals fed sesame meal–buffalo fish rations at a 9% protein level. Addition of 1% of buffalo fish to a ration containing 9% of sesame meal further increased the gain to 70.6% and the PER to 26.6% and the protein content of the ration to 9.84%. The addition of buffalo fish in small amounts to sesame meal was accompanied by large increases in body weight and PER (Table I, rations 9, 10, and 11).

These differences were tested statistically and found to be significant for $P = 0.05$, except for the increases in ration 2 and the 13.7% increase in ration 4.

Table III. Biological Value of Sesame Seed with and without Supplements Determined by Nitrogen–Retention Method

(*Ad libitum* feeding. 12 animals on rations. Protein in rations 9%. Average result per animal given)

Ration	Type	Biological Value[a]	True Digestibility[b]	Net Utilization[c]
1	Sesame seed	83.9 ± 0.66[d]	87.0 ± 0.20	73.0 ± 0.74
3	Sesame seed + 0.2% L-lysine + 0.2% DL-threonine	88.3 ± 0.87	85.9 ± 0.46	75.8 ± 1.15
4	Sesame seed + 0.2% L-lysine + 0.2% DL-threonine + 0.1 γ vitamin B_{12}	84.1 ± 0.77	83.4 ± 0.33	70.1 ± 0.92

[a] Per cent absorbed nitrogen retained in animal body.
[b] True coefficient of digestibility obtained by subtracting nitrogen lost in feces from total nitrogen intake and dividing by 100.
[c] Obtained by multiplying true coefficient of digestibility by biological value and dividing by 100.
[d] Standard error.

The results of these experiments indicate that the proteins of commercial sesame seed and meal can be further improved by supplementation with lysine, threonine, and buffalo fish.

The response to lysine addition is in agreement with reports by Grau and Almquist (*4*) who found optimal chicken growth when 0.5% of L-lysine was added to an all-sesame protein diet. They also reported a mutual supplementation effect of the proteins of soybean and sesame meals in which the ratio of sesame-soybean protein approached 7 to 13 at a total protein level of 20%. The supplementary effect of perch to milled rice has been reported by Kik (*9*) and the influence on growth and protein efficiency of the addition of small amounts of defatted fish flour to several grains has been demonstrated by Sure (*15*).

Supplements to Milled White Corn Meal and Enriched Milled Wheat Flour. Table II indicates that when milled white corn meal was supplemented by sesame meal, the animals showed an increase of 26% in gain and of 12% in PER, in rations containing 6.86% protein, two thirds of which were derived from corn meal and one third from sesame meal (Table II, rations 12 and 13). Further addition of 0.1% of L-lysine produced increases of 379% in gain and 175% in PER. Similar results were obtained in rations 15 and 16, where the rations also contained 6.86% of protein; however, one half of the protein was derived from corn meal and one half from sesame meal. The increased gain was 89.4% and the increased PER was 50%. Addition of 0.1% of L-lysine further increased the gain to 489.4% and the PER to 201.6%. When enriched milled wheat flour (Gold Medal flour) was supplemented by sesame meal, the animals showed an increase of 4.6% in gain and 8.3% in PER, in rations containing 9.03% protein, two thirds of which were derived from wheat flour and one third from sesame meal (Table II, ration 18). This indicates that sesame meal can partially replace milled wheat flour without any change in protein value.

Results of some of these experiments are in agreement with those reported by Jaffé (*5–7*) who has reported that sesame and corn proteins favorably complement each other and found good growth with a mixture of 90 parts of corn, 8 parts of sesame, and 2 parts of peanuts. He prepared local corn bread by adding sesame meal.

Supplement to Milled White Polished Rice. The proteins of sesame seed at a 3% replacement level have a supplementary effect for those of milled white (polished) rice. This is shown in Table II, rations 19 and 20. The protein content of the rations is 5.42%. An equivalent amount of the proteins of polished rice was replaced by the proteins from 3% of sesame seed, leaving the protein level at 5.42%, with an increase in gain of 29.6% and in PER of 0.5%. An increase of 26.7% in growth and 8% in PER was found in animals fed ration 21, containing 5.42% of protein derived from sesame meal alone, indicating that sesame meal had better nutritive value than milled rice at that level of protein intake.

Biological Values. Table III shows the biological values, true digestibilities, and net utilization values of sesame seed supplemented with and without additions of L-lysine, DL-threonine, and vitamin B_{12}, as determined by the nitrogen retention method of Mitchell (*12, 13*). The net utilization values are obtained by multiplying the true coefficient of digestibility by biological values and dividing by 100. The resulting values are somewhat higher for the proteins of sesame seed supplemented by amino acids and addition of vitamin B_{12} decreased the utilization. The small differences in net protein utilization be-

Table IV. Determination of Amino Acids

	In Fat-Free Sesame Seed, %, 43.3% Protein		In Fat-Free Sesame Meal, %, 51.3% Protein	
	In dry matter	In protein	In dry matter	In protein
Alanine	1.30	3.00	1.35	3.63
Arginine[a]	5.00	11.55	5.20	10.40
Aspartic acid	3.33	7.69	3.99	7.78
Cystine	0.52	1.15	0.60	1.17
Glutamic acid	4.21	9.72	3.80	8.20
Glycine	3.49	8.06	3.96	7.72
Histidine[a]	0.90	2.08	1.10	2.14
Isoleucine[a]	2.00	4.62	2.30	4.48
Leucine[a]	3.00	6.93	3.60	7.02
Lysine[a]	1.20	2.77	1.41	2.75
Methionine[a]	1.23	2.84	1.40	2.73
Phenylalanine[a]	2.52	5.82	2.71	5.28
Proline	1.60	3.69	1.92	3.74
Serine	1.42	3.28	1.80	3.51
Threonine[a]	1.60	3.70	1.71	3.33
Tryptophan[a]	0.75	1.73	0.70	1.37
Tyrosine	2.00	4.62	1.90	3.71
Valine[a]	2.70	6.23	2.65	5.16

[a] Nutritionally essential.

Table V. Vitamins and Other Constituents in Fat-Free Sesame Seed and Sesame Meal

Constituent	Seed, γ/G.	Meal, γ/G.
Thiamine	2.4	2.7
Riboflavin	2.5	2.0
Nicotinic acid	80	82.5
Pantothenic acid		
Total	9.5	12.0
Free	3.4	3.8
Biotin	0.06	0.07
Folic acid		
Total	0.20	0.23
Free	0.10	0.13
Pyridoxine	2.33	2.32
Inositol	740	830
Choline	1320	1590
p-Aminobenzoic acid	0.65	0.80
	%	%
Calcium	1.65	1.10
Phosphorus	1.60	1.25
Iron	0.0044	0.0037
Nitrogen	6.93	8.21
Protein, nitrogen × 6.25	43.3	51.3
Fat, in the original	39.3	34.5
Moisture	4.5	4.5
Ash	5.5	5.2
Fiber	6.3	5.7

tween rations 1 and 3, 1 and 4, and 3 and 4 were statistically significant.

The results of the metabolism experiments can explain the differences in growth-promoting values of the sesame proteins found in the growth experiments. The amino acid supplemented proteins were more efficiently utilized and promoted better growth as a result of the smaller losses of nitrogen during metabolism.

Amino Acid Content. Table IV shows the results of the amino acid determination in fat-free samples of sesame seed and meal expressed as percentages calculated on the basis of air-dried samples, and also expressed as the percentage in the crude proteins (N × 6.25). The content of the amino acids (essential) agrees well with that reported (*3, 11*). The experimental results indicate that sesame meal is nutritionally inferior to sesame seed, which is not reflected in the amino acid composition data. However, the sesame meal used in these experiments is not produced from the same sesame seed. They belong to different varieties. Possibly, the sesame meal might have been slightly damaged in processing during the crushing operation. Heat promotes chemical linkage of lysine to other amino acids leading to reduced availability to the animals. Heat also produces a reaction of some amino acids with carbohydrates to combinations which prevent complete regeneration of these amino acids in the digestive tract (*2*).

Vitamins and Other Nutrients. A number of vitamins were determined by other methods (*8*). The results of these tests are given in Table V, which also contains data on calcium, phosphorus, iron, and other constituents. The values found for niacin are lower and for riboflavin are higher than those reported by Lease (*10*), while the calcium values are lower than those reported (*2*).

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