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Nicotinic Acid, Lysine and Tryptophan as Supplements to Low-Protein Corn

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ABSTRACT

The sample of corn contained approximately 7% of protein. This corn made up from 93.3 to 94.5% of the experimental diets. The other components were minerals and vitamins, but nicotinic acid was omitted.

The diets contained added nicotinic acid, lysine and tryptophan, singly and in various combinations. There were nine experimental diets, with 6 rats on each. Special feeders were constructed, to reduce waste to a minimum and obtain accurate records of food consumption. All of the experimental animals were analyzed at the end of a 4-week experimental period. Control animals were analyzed at the beginning of the experimental period, and it was possible to make a number of calculations. These included the amount and composition of the gains, in protein, fat, ash, water and calories. The efficiency of the gains in weight, protein and calories was also calculated.

The imbalance of amino acids in low-protein corn is relatively mild. The sample investigated contained 2.3 mg. % of nicotinic acid, and there was no positive response when this vitamin was added to the basal diet. When the experimental diet contained added lysine or tryptophan or both at once, there was some evidence of a positive response when 5 mg. % of nicotinic acid was also included.

When lysine alone was added to the basal diet there was no increase in the amount of food consumed, but there was some slight evidence of increased efficiency of utilization. When lysine was added to an experimental diet that contained added nicotinic acid there was a significant positive response. When added to an experimental diet that already contained added tryptophan there was a tremendous positive response by all criteria.

When tryptophan alone was added to the basal diet there was no indication of any improvement. The effect was about the same as when nicotinic acid alone was added. In each case if there was any effect it was harmful. Tryptophan was the second limiting amino acid.

It was estimated that low-protein corn contained about 40% of the optimum amount of lysine, and 50% of the optimum amount of tryptophan.

As a source of nitrogen, casein is vastly superior to the mixture of proteins in low-protein corn, even though the latter is supplemented with lysine and tryptophan.

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This bulletin reports on Department
of Agricultural Chemistry research
project 212, Food Conservation

Nicotinic Acid, Lysine and Tryptophan as Supplements to Low-Protein Corn

The nutritional properties of corn, *Zea Mays,* have been studied by a number of investigators and a review of some of the more pertinent literature was included in an earlier publication (1). The object of this investigation was to learn more about the nutritional effects of deficiencies of nicotinic acid, lysine and tryptophan in corn that is low in protein, and about the interrelation among these nutrients.

METHODS

Animals

The experimental animals were male albino rats, of the Sprague-Dawley strain. They were weaned at 19 to 23 days, at weights of 32 to 37 grams. They were deprived of food for the 24 hours just preceding the experimental period, though water was available, in the hope that this procedure would reduce initial variability. Six control animals were likewise deprived of food for 24 hours, and then slaughtered for analysis. It was assumed when the investigation started that the experimental animals had the same percentage of empty weight, and constituent parts, as did these controls. There were two feeding trials, with three rats per trial on each experimental diet. Each animal was in an individual cage, on a floor of wide mesh hardware cloth. The experimental periods were 28 days in length. The data presented are averages of the six animals in each set.

Carcass Analyses

The animals were chloroformed when the investigation closed. Contents of the alimentary tract were removed and the carcass was weighed again to obtain the empty weight. Weight of the intestinal contents was determined by difference. During this procedure the carcass and alimentary tract were left in an evaporating dish covered with a damp filter paper to reduce the loss of water by evaporation. The carcass was then quickly frozen at -12° C and stored in the frozen state until prepared for analysis. The control animals slaughtered as representative initial carcasses were treated in the same manner as the experimental animals.

Gains in weight were the differences between initial and final empty weights. All carcasses were ground to prepare them for the analyst. The analyses included water, protein (N x 6.25) ether extract and ash. Details of sample preparation and analytical methods will be omitted except to say we followed conventional procedures.

Diets

The sample of corn was U. S. 13, yellow, grown in central Missouri. It contained 2.3 mg. % of nicotinic acid and 7.3% of protein. This constituent was a mixture of 1.8% of zein and 5.5% of other proteins. Table 1 gives dietary constituents that were included in constant amounts in all food mixtures.

The diets of the various groups were modified in one or more respects and the modifications are described in the tables that show the results observed. The crude protein content of the nine diets used was relatively constant. It varied from 6.97% in the basal diet, to 7.95% in a positive control diet K. This comparison diet contained no corn, but this constituent was replaced by 8.6 gm. of casein, 0.2 gm. DL-methionine, 85.7 gm. of corn starch, and 5 mg. of nicotinic acid.

The other constituents were the same as shown in Table 1. Diets were hand-mixed in amounts to last approximately two weeks and stored in a cool room. Food containers were designed to reduce wastage to a minimum; food and water were always available. The amino acid supplements replaced an equal weight of corn. An estimate was made of the amount of food that would be consumed during the first day; this was weighed out to within 100 mg. At the end of the first day a second supply of feed was weighed out and after 48 hours all unconsumed food in the food container and on a filter paper under the cage floor was collected and weighed to determine how much of the diet was actually consumed. Animals then received another weighed amount of food and the procedure was continued until the end of the experimental period.

TABLE 1--CONSTITUENTS PRESENT IN ALL EXPERIMENTAL DIETS

	%		%
Corn	to make 100	Calcium Carbonate	1.0
Salts (5)[1]	4	Soybean Oil	0.5
	Vitamins per 100 gm. diet.		
Vitamin A[2]	2000 I.U.	Pyridoxine HCl	1.0 mg.
Vitamin D[3]	433 I.U.	Ca-pantothenate	3.0 mg.
Vitamin E	2.5 mg.	Choline Cl	100.0 mg.
Vitamin K	2.5 mg.	Biotin	20.0 mcg.
Thiamine HCl	1.0 mg.	Folic Acid[4]	500.0 mcg.
Riboflavin	1.0 mg.	Vitamin B_{12}	2.0 mcg.

[1] Richardson and Hogan (3).

[2] A concentrate, purchased from Distillation Products Industries, Rochester, N.Y.

[3] Delsterol, purchased from the E. I. du Pont de Nemours and Co., New Brunswick, N.J.

[4] Courtesy of T. H. Jukes, Lederle Laboratories, Pearl River, N. Y. All other vitamins courtesy of Merck and Company, Rahway, N. J.

RESULTS

Some of the basic data collected during the investigation are summarized in the Appendix, Tables 7, 8 and 9. These include the average weights of the animals and the average analytical results. For the sake of convenience, the data on feed consumption and the calculated data are interspersed in the text. There is considerable repetition in the text tables, as the text data were rearranged to facilitate comparisons. The significance of the data obtained was tested by an analysis of variance. At times this method did not show as high a degree of significance as the "t" test; in these instances, the higher values replaced the lower.

Nicotinic acid

Our data on nicotinic acid are shown in Table 2.

The effects of adding nicotinic acid to the basal diet, A, or some of its modifications, were small as a rule. Usually, even when the differences were significant they had no unequivocal explanation. Thus when nicotinic acid was added to Ration A there was a small reduction in food intake, with a corresponding reduction in response by the animal. One would conclude that the addition of nicotinic acid was not helpful, and it may have been detrimental.

The control ration in comparison 2 contained added tryptophan and in comparison 3 it contained added lysine. When either of these was supplemented with nicotinic acid there was a small increase in the retention of nitrogen, and a small decrease in the retention of fats. The fall in the ratio of fat to protein retention was mathematically significant.

Ration D in comparison 4 contained both tryptophan and lysine. When this combination was supplemented with nicotinic acid the results were somewhat erratic. There was a reduction in the amount of food and protein consumed by animals on this diet, without much change in the storage of either protein or fat. However, because of the reduced food intake, there were mathematically significant increases in gains in weight per unit of protein or total food consumed. The increase in protein retained per unit of protein consumed was also significant. Inspection of comparisons 2, 3, and 4 indicates that under some circumstances the low-protein corn diets were improved by supplying additional nicotinic acid.

It is our view that in investigations of this type it is desirable to analyze the experimental animals to obtain a higher degree of precision. In comparison 4, for example, there was a significant difference in cost of gains in weight and in protein. The differences in cost of gains in calories, however, failed to reach statistical significance.

Lysine

The effect of adding lysine to low-protein corn is shown in Table 3.

TABLE 2--CORN AS A SOURCE OF NICOTINIC ACID

Comparison	1		2		3		4	
Ration	A	E	B	F	C	G	D	H
Corn, %	94.5	94.5	94.3	94.3	93.5	93.5	93.3	93.3
DL-Tryptophan[1], %	----	----	0.2	0.2	----	----	0.2	0.2
DL-Lysine HCl[2], %	----	----	----	----	1.0	1.0	1.0	1.0
Nicotinic acid, mg. %	----	5.0	----	5.0	----	5.0	----	5.0
Observations on the animals.								
Food consumed, gm.	148	138	134	141	145	155	173	154
Protein consumed, gm.	10.3	9.6	9.6	10.1	10.8	11.6	13.3	11.8
Gain in weight, gm.	19.2	16.3	16.1	16.2	22.8	23.1	36.7	36.2
Gain in water, gm.	10.1	8.6	7.5	8.2	12.0	13.1	19.9	19.0
Gain in protein, gm.	2.7	2.3	2.1	2.4	3.3	3.6	5.5	5.9
Gain in fat, gm.	5.3	4.1	5.6	4.6	6.2	4.9	9.4	9.3
Gain in ash, gm.	0.89	0.76	0.74	0.92	1.0	1.25	1.3	1.59
Gain in calories	66	53	65	57	77	67	121	122
Gain in weight/gm. food consumed, gm.	0.13	0.12	0.12	0.11	0.16	0.15	0.21 *	0.24
Gain in weight/gm. protein consumed, gm.	1.9	1.7	1.7	1.6	2.1	2.0	2.7 *	3.1
Gain in protein/gm. protein consumed, gm.	0.26	0.24	0.21	0.23	0.30	0.31	0.41 *	0.50
Gain in calories/gm. food consumed	0.44	0.38	0.48	0.40	0.53	0.44	0.68	0.79
Gain in calories/gm. protein consumed	6.4	5.4	6.7	5.6	7.0	5.8	8.9	10.3
Fat gained ÷ protein gained	2.0	1.8	2.9 **	.9	2.0 *	1.4	1.7	1.6

[1] Courtesy of the Dow Chemical Co., Midland, Michigan.

[2] Courtesy of Dr. J. Waddell, E. I. Du Pont de Nemours and Co., New Brunswick, N. J.

Statistical significance *$P < 0.05$ **$P < 0.01$

TABLE 3--CORN PROTEINS AS A SOURCE OF LYSINE

Comparison	1			2			3			4		
Ration	A		C	E		G	B		D	F		H
Corn, %	94.5		93.5	94.5		93.5	94.3		93.3	94.3		93.3
DL-Tryptophan[1], %	----		----	----		----	0.2		0.2	0.2		0.2
Nicotinic acid, mg. %	----		----	5		5	----		----	5		5
DL-Lysine HCl, %	----		1.0	----		1.0	----		1.0	----		1.0
Observations on the animals.												
Food consumed, gm.	148		145	138		155	134	*	173	141		154
Protein consumed, gm.	10.3		10.8	9.6		11.6	9.6	*	13.3	10.1		11.8
Gain in weight, gm.	19.2		22.8	16.3		23.1	16.1	**	36.7	16.2	**	36.2
Gain in water, gm.	10.1		12.0	8.6	*	13.1	7.5	**	19.9	8.2	**	19.0
Gain in protein, gm.	2.7		3.3	2.3	*	3.6	2.1	**	5.5	2.4	**	5.9
Gain in fat, gm.	5.3		6.2	4.1		4.9	5.6	**	9.4	4.6	**	9.3
Gain in ash, gm.	0.89		1.0	0.76	*	1.25	0.74	**	1.3	0.92	**	1.59
Gain in calories	66		77	53		67	65		121	57		122
Gain in weight/gm. food consumed, gm.	0.13	*	0.16	0.12	*	0.15	0.12	**	0.21	0.11	**	0.24
Gain in weight/gm. protein consumed, gm.	1.9		2.1	1.7		2.0	1.7	**	2.7	1.6	**	3.1
Gain in protein/gm. protein consumed, gm.	0.26		0.30	0.24	*	0.31	0.21	*	0.41	0.23	**	0.50
Gain in calories/gm. food consumed	0.44		0.53	0.38		0.44	0.48	**	0.68	0.40	**	0.79
Gain in calories/gm. protein consumed	6.4.		7.0	5.4		5.8	6.7	**	8.9	5.6	**	10.3
Fat gained ÷ protein gained	2.0		2.0	1.8		1.4	2.9	**	1.7	1.9		1.6

Statistical Significance $*P < 0.05$ $**P < 0.01$

When lysine was added to the basal diet, comparison 1, there was some indication of improvement in response. The amount of food consumed did not increase, but there was a slight increase in the gain in weight and in the retention of protein. The only increase that reached statistical significance was in the gain in weight per unit of food consumed. Presumably the statistical evidence of improvement would have been more impressive if there had been a larger number of experimental animals.

In comparison 2, lysine was included in a diet that contained added nicotinic acid, and the effect was much more marked. By five criteria of improvement the differences reached statistical significance and barely failed to be significant by two others. One would conclude that lysine was the first limiting amino acid in the basal diet. Nicotinic acid also was a limiting factor, because of the limited supply of tryptophan.

In comparison 3 both diets contained added tryptophan, and when additional lysine was also supplied as in Diet D, there was unmistakable improvement. As one would expect, the differences were significant in all 14 criteria.

In comparison 4, both diets contained added nicotinic acid as well as added tryptophan. Again, as would be expected, the response to added lysine was impressive.

Tryptophan

The effect of adding tryptophan to low-protein corn is shown in Table 4.

An unexpected detrimental effect was encountered when tryptophan was added to the basal diet (as in Diet B). Though the differences lacked mathematical significance, the amount of protein stored was diminished and the amount of fat stored was increased. The difference in the ratios of fat stored to protein stored was statistically significant. One could explain this apparently deleterious effect by assuming that the addition of tryptophan had accentuated the imbalance between this amino acid and lysine. A comparison with Table 2 indicates that nicotinic acid and tryptophan may have the same effect, when either one alone is added to the basal diet.

Additional data on this point are found in comparison 2. When tryptophan was added to a diet that already contained nicotinic acid the effect was insignificant. One could suppose that the imbalance between tryptophan and lysine is not injurious, if the supply of nicotinic acid is adequate.

In comparison 3 both diets contained lysine, and in comparison 4 both diets contained lysine and nicotinic acid. In each case there was a marked response when tryptophan was supplied in addition.

Miscellaneous Results

Our data permit a few comparisons not yet mentioned that deserve emphasis. These are brought together in Table 5.

TABLE 4--CORN PROTEINS AS A SOURCE OF TRYPTOPHAN

Comparison	1		2		3		4	
Ration	A	B	E	F	C	D	G	H
Corn, %	94.5	94.3	94.5	94.3	93.5	93.3	93.5	93.3
Niacin, mg. %	----	----	5	5	----	----	5	5
DL-Lysine HCl %	----	----	----	----	1	1	1	1
DL-Tryptophan %	----	0.2	----	0.2	----	0.2	----	0.2
Observations on the animals.								
Food consumed, gm.	148	134	138	141	145	173	155	154
Protein consumed, gm.	10.3	9.6	9.6	10.1	10.8	13.3	11.6	11.8
Gain in weight, gm.	19.2	16.1	16.3	16.2	22.8 **	36.7	23.1 **	36.2
Gain in water, gm.	10.1	7.5	8.6	8.2	12.0 **	19.9	13.1 **	19.0
Gain in protein, gm.	2.7	2.1	2.3	2.4	3.3 **	5.5	3.6 **	5.9
Gain in fat, gm.	5.3	5.6	4.1	4.6	6.2 *	9.4	4.9 **	9.3
Gain in ash, gm.	0.89	0.74	0.76	0.92	1.00 *	1.30	1.25 *	1.59
Gain in calories	66	65	53	57	77 **	121	67 **	122
Gain in weight/gm. food consumed, gm.	0.13	0.12	0.12	0.11	0.16 **	0.21	0.15 **	0.24
Gain in weight/gm. protein consumed, gm.	1.9	1.7	1.7	1.6	2.1 **	2.7	2.0 **	3.1
Gain in protein/gm. protein consumed, gm.	0.26	0.21	0.24	0.23	0.30 **	0.41	0.31 **	0.50
Gain in calories/gm. food consumed	0.44	0.48	0.38	0.40	0.53 *	0.68	0.44 **	0.79
Gain in calories/gm. protein consumed	6.4	6.7	5.4	5.6	7.0 *	8.9	5.8 **	10.3
Fat gained ÷ protein gained	2.0 **	2.9	1.8	1.9	2.0	1.7	1.4	1.6

Statistical Significance *P < 0.05 **P < 0.01

TABLE 5--MISCELLANEOUS COMPARISONS

Comparison	1			2			3				
Ration	C		B	C		E	G		D		K
Casein, %	----		----	----		----	----		----		8.6
DL-Methionine[1], %	----		----	----		----	----		----		0.2
Corn Starch, %	----		----	----		----	----		----		85.7
Corn, %	93.5		94.3	93.5		94.5	93.3		93.5		----
DL-Lysine HCl, %	1.0		----	1.0		----	1.0		1.0		----
DL-Tryptophan, %	----		0.2	----		----	----		0.2		----
Nicotinic acid, mg. %	----		----	----		5	5		----		----
Observations on the animals.											
Food consumed, gm.	145		134	145		138	155		173	**	283
Protein consumed, gm.	10.8		9.6	10.8		9.6	11.6		13.3	**	22.5
Gain in weight, gm.	22.8		16.1	22.8		16.3	23.1	**	36.7	**	91.3
Gain in water, gm.	12.0	*	7.5	12.0		8.6	13.1	**	19.9	**	52.2
Gain in protein, gm.	3.3	*	2.1	3.3		2.3	3.6	**	5.5	**	16.1
Gain in fat, gm.	6.2		5.6	6.2		4.1	4.9	**	9.4	**	19.4
Gain in ash, gm.	1.0		0.74	1.0		0.76	1.25		1.30	**	2.34
Gain in calories	77		65	77		53	67	**	121	**	276
Gain in weight/gm. food consumed, gm.	0.16	**	0.12	0.16	**	0.12	0.15	**	0.21	**	0.32
Gain in weight/gm. protein consumed, gm.	2.1	*	1.7	2.1	*	1.7	2.0	**	2.7	**	4.1
Gain in protein/gm. protein consumed, gm.	0.3	**	0.21	0.30	*	0.24	0.31	**	0.41	**	0.72
Gain in calories/gm. food consumed	0.53		0.49	0.53	*	0.38	0.44	**	0.68		0.97
Gain in calories/gm. protein consumed	7.0		6.7	7.0	*	5.4	5.8	**	8.9	**	12.3
Fat gained ÷ protein gained	2.0	**	2.9	2.0		1.8	1.4		1.7		1.2

[1] Courtesy of the Dow Chemical Co., Midland, Michigan

Statistical Significance $^*P < 0.05$ $^{**}P < 0.01$

There has been some discussion as to whether lysine or tryptophan is the first limiting amino acid in the proteins of corn, and our pertinent data on this point are shown in comparison 1. The added supplements are tryptophan in Ration B and lysine in Ration C. The differences in the results obtained on these two rations are statistically significant by about half the criteria. Some of the others barely fail to reach significance at the 5% level. The differences were largely due to the fact that when lysine was included in the diet there was a marked increase in the storage of protein and water. There were corresponding increases in the efficiency of gains, in protein and in total weight.

The effects of supplying lysine and nicotinic acid are illustrated in comparison 2. As shown in Table 4, both nicotinic acid and tryptophan were probably harmful when added alone, rather than helpful. As one would expect, Ration E, with added nicotinic acid, is much inferior to Ration C, which contains added lysine. The data in comparisons 1 and 2, then, are closely parallel.

The combination of lysine and tryptophan, shown in comparison 3, is superior to the combination of lysine and nicotinic acid by practically every criterion, as would be expected. Tables 2 and 4 show that when lysine is included in the diet it is improved markedly by the further additions of tryptophan, and only slightly by the further addition of nicotinic acid. Lysine was the first limiting amino acid in this sample of corn, but the degree of the deficiency was not much more severe than the deficiency of tryptophan.

Biological value of Supplemented Corn Proteins

Diet D was one of the better low-protein corn rations. In comparison 3 it is contrasted with Ration K, which contains the same amount of protein, but in the form of casein. This source of nitrogen was vastly superior to the proteins of corn, even when the corn was supplemented with lysine and tryptophan. The animals which consumed casein ate more, gained more, and the gains were more economical. The data in Table 6 lead one to expect this result. When lysine and tryptophan are added to the corn ration, some other amino acid becomes a limiting factor, presumably isoleucine (4).

A few additional data on the degree of deficiency of lysine and tryptophan are shown in Table 6.

TABLE 6--LYSINE AND TRYPTOPHAN IN CORN PROTEINS AND IN COMPARISON PROTEINS

Source of Protein[5]	Lysine	Tryptophan
	%	%
Corn (7% protein)	3.0	0.8
Casein	8.5	1.3
Whole Egg	7.0	1.5

[5] Corn protein, assayed by Laura M. Flynn.
Casein and whole egg protein reported by Block and Bolling (3).

It is commonly assumed that the essential amino acids are supplied in optimum proportions by the proteins of whole egg. If this assumption is correct, the mixture of corn proteins contains 53% of the optimum amount of tryptophan, and 43% of the optimum amount of lysine. This investigation indicated that lysine was the first limiting amino acid in this sample of corn. The difference was small, but real.

SUMMARY

Lysine was the first limiting factor in this sample of low-protein corn and tryptophan was the second.

If there was any response at all when nicotinic acid was added to the basal diet, it was negative. There was a slight reduction in the amount of food consumed, in the gains in weight and in the various body constituents. There was some slight evidence of improvement when nicotinic acid was added to a diet that also contained either lysine, or tryptophan. The effect, if any, was to increase the storage of nitrogen and reduce the storage of fat.

When lysine was added to the basal diet there was a slight response, but it was not statistically significant. The maximum response on low-protein corn was obtained when lysine and tryptophan were added simultaneously.

If there was any response at all when tryptophan was added to the basal diet it was negative.

As a source of protein, a mixture of low-protein corn, lysine and tryptophan is vastly inferior to casein.

Analyses of the experimental animals are often highly important in an investigation of the utilization of nutrients.

LITERATURE CITED

1. Hogan, A. G., G. T. Gillespie, Osman Kocturk, B. L. O'Dell and Laura M. Flynn. The percentage of protein in corn and its nutritional properties. J. Nutrition 57:225-239 (1955)
2. Richardson, L. R. and A. G. Hogan. Diet of mother and hydrocephalus in infant rats. J. Nutrition 32:459-466 (1946)
3. Block, R. J. and Diana Bolling. The amino acid composition of proteins and foods. 1951. C. C. Thomas, Publisher, Springfield, Ill., U. S. A.
4. Benton, D. A., A. E. Harper and C. A. Elvehjem, Effect of isoleucine supplementation on the growth of rats fed zein or corn diets. Arch. Biochem. Biophys., 57:13-19 (1955)

APPENDIX

TABLE 7--WEIGHTS OF ANIMALS

Supplements Added to Basal Diet	Weights of Animals			
	Live		Carcass[1]	
	Initial	Final	Initial	Final
	gm.	gm.	gm.	gm.
A None	37.1	55.7	33.0	52.2
B, Tr.[2] 0.2	36.8	52.4	33.2	49.3
C, L[3] 1.0	36.7	59.4	33.1	55.9
D, Tr. 0.2, L 1.0	39.3	73.2	32.6	69.3
E, N[4]	35.2	49.1	29.7	46.0
F, Tr. 0.2, N	36.9	50.8	31.8	48.0
G, L 1.0, N	39.3	59.4	33.4	56.5
H, Tr. 0.2, L 1.0, N	39.0	73.4	33.2	69.4
K, M[5] 0.2, N	37.8	126.6	32.2	123.5
Initial Controls	36.9		31.9	

[1] The initial fasted live weights were 0.8 gm. more than the initial carcass weights.
[2] Tr. = DL-tryptophan, %
[3] L = DL-lysine monohydrochloride %
[4] N = Nicotinic acid, 5 mg. %
[5] M = DL-methionine, %

TABLE 8--AVERAGE COMPOSITION OF ANIMALS, INITIAL

Group	Water	Protein	Fat	Ash
A, gm.	24.3	6.09	1.44	1.10
B, gm.	24.4	6.11	1.44	1.10
C, gm.	24.4	6.10	1.44	1.10
D, gm.	24.0	6.01	1.42	1.08
E, gm.	21.9	5.47	1.29	0.99
F, gm.	23.4	5.87	1.38	1.06
G, gm.	24.6	6.16	1.45	1.11
H, gm.	25.5	6.13	1.45	1.11
K, gm.	23.7	5.94	1.40	1.07
Initial Controls, %	73.70	18.45	4.36	3.33

TABLE 9--AVERAGE COMPOSITION OF ANIMALS, FINAL

Group	Water	Protein	Fat	Ash	Total
A, %	66.09	16.84	12.85	3.82	99.6
gm.	34.5	8.79	6.72	1.99	52.0
B, %	64.71	16.62	14.15	3.76	99.24
gm.	31.9	8.16	7.07	1.85	48.98
C, %	65.12	16.82	13.43	3.76	99.13
gm.	36.4	9.38	7.59	2.10	55.47
D, %	63.35	16.71	15.28	3.45	98.79
gm.	43.9	11.53	10.83	2.38	68.64
E, %	66.09	17.04	11.51	3.87	98.51
gm.	30.4	7.80	5.43	1.75	45.38
F, %	65.83	17.22	12.29	4.13	99.47
gm.	31.6	8.26	5.96	1.98	47.80
G, %	66.73	17.20	11.23	4.24	99.40
gm.	37.7	9.70	6.40	2.36	56.16
H, %	62.68	17.26	15.30	3.88	99.12
gm.	43.5	12.00	10.76	2.69	68.95
K, %	61.54	17.84	16.83	2.77	98.98
gm.	76.0	22.01	20.75	3.41	122.17