*THE NUTRITIVE VALUE OF THE PROTEINS OF CORN-GLUTEN MEAL, LINSEED MEAL, AND SOYBEAN-OIL MEAL [1]

By KENNETH L. TURK, *extension animal husbandman*, F. B. MORRISON, *animal husbandman and head of department of animal husbandry*, and L. A. MAYNARD, *animal nutritionist, New York (Cornell) Agricultural Experiment Station*

INTRODUCTION

The results of previous experiments from this laboratory (*22*) [2] indicated no differences in the utilization by growing lambs of the proteins of alfalfa hay and clover hay when fed at a 10-percent level in rations which were presumably adequate in total digestible nutrients, minerals, and vitamins. Furthermore, no differences were observed between the biological value of the proteins of an alfalfa and corn ration and the proteins of a clover and corn ration when both rations were fed at a 10-percent level of protein. The biological values of the proteins of the two latter rations were approximately the same as when each of the hays formed the only source of protein, hence showing no supplementary effect due to the addition of corn protein. The average of the biological values was 81 for clover protein, 79 for alfalfa protein, 80 for the protein in the combination of clover and corn, and 77 for the protein in the combination of alfalfa and corn. These results were interpreted to indicate that alfalfa hay and clover hay are probably not deficient in quality of protein for sheep when fed in a balanced ration as regards protein and total digestible nutrients.

Since there were no significant differences in protein utilization in these experiments, the question was raised in the minds of the writers as to whether or not there are any actual differences in the nutritive value of the proteins of common feeds for sheep, when the feeds in question are fed in rations which furnish sufficient of total digestible nutrients and other known dietary essentials, and when fed at the same level of protein intake. Very few data have been presented which show any marked differences in the efficiency of protein utilization when common feedstuffs have been fed to ruminants in well-balanced rations (*5, 6, 7, 11, 19*). The common explanation given is that the ruminant has the ability to synthesize certain of the essential amino acids as a result of bacterial action in the digestive tract. This possibility has been frequently pointed out in the literature, especially with reference to the synthesis of cystine by sheep.

These experimental results (*22*) have suggested the desirability of obtaining further data on the importance of the quality of protein for ruminants and of ascertaining whether differences in the biological value of proteins can be obtained with the sheep using the nitrogen-balance type of experimentation. Therefore, experiments have been conducted to determine the nutritive values for sheep of the proteins

[1] Received for publication May 3, 1935; issued December 1935.
[2] Reference is made by number (italic) to Literature Cited, p. 411.

Journal of Agricultural Research, Washington, D. C.
Vol. 51, no. 5
Sept. 1, 1935
Key no. N. Y.(Cornell)-29

in three common protein-rich feeds which, on the basis of origin and general nutritive value, should furnish proteins differing in quality.

MATERIALS

Soybean-oil meal was selected as one of the few plant protein supplements that furnish proteins of high quality. Though some experiments have indicated that soybean proteins are rather low in cystine (*17*, *21*), they apparently supply more adequate amounts of the essential amino acids than most single seeds or seed byproducts.

In experiments with swine or rats the proteins of soybean-oil meal would probably rank above those of linseed meal and corn-gluten meal. Linseed meal is a popular protein concentrate, but some experiments have shown that its protein is not of the highest quality (*10*, *15*, *19*). Corn proteins, especially those of the endosperm, are low in two of the essential amino acids—tryptophane and lysine. Corn-gluten meal is probably even lower than the entire corn grain in tryptophane and lysine, as it commonly includes none of the germ the proteins of which are of better quality than those of the endosperm. The immediate object of this investigation, therefore, was to determine what differences, if any, would be found in the nutritive value of the proteins of soybean meal, linseed meal, and corn-gluten meal for growing lambs.

EXPERIMENTAL PROCEDURE

In experiments with swine or rats the proteins of soybean-oil meal tuted for part of the starch and sugar in a low-nitrogen ration and fed to growing wether lambs. The nitrogen balances were determined on each ration, and also the digestibility of the protein, the storage of protein, and the biological value of the proteins (*12*, *13*).

The percentage composition of feeds used in this experiment is shown in table 1.

TABLE 1.—*Percentage composition of feeds used*

Feed	Dry matter	Ash	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract
Corn-gluten meal	93.95	2.80	42.36	1.68	4.96	42.15
Linseed meal	93.35	5.11	39.01	5.56	7.44	36.23
Soybean-oil meal	93.05	5.66	42.60	5.73	5.72	33.34

The soybean-oil meal was an expeller-process product and had a pleasant cooked odor and nutlike taste. All the feeds were apparently of good quality and were fed as obtained from the feed manufacturer.

Each of the feeds was added to a low-nitrogen ration of ground wheat straw, cellulose, cornstarch, sugar, corn oil, and salt mixture in such amounts as to provide a protein level of about 11 percent. Of this 11 percent protein, 10 percent came from the feed in question and 1 percent from the straw and other ingredients. The same amount of straw was included in all the rations to furnish bulk, and different amounts of pure cellulose [3] were included to equalize the concentration of crude fiber. Raw cornstarch, cane sugar, and corn oil were included in order to increase and equalize the total energy

[3] Washed sylphrap.

content of the rations. The composition of the rations is given in table 2.

TABLE 2.—*Percentage composition of experimental rations*

Constituent	Low-nitrogen ration	Corn-gluten-meal ration	Linseed-meal ration	Soybean-oil-meal ration
Corn-gluten meal		23.6		
Linseed meal			25.7	
Soybean-oil meal				23.5
Straw, wheat	25.0	25.0	25.0	25.0
Cellulose, regenerated	10.5	9.7	9.0	9.5
Starch	28.0	17.4	17.2	18.0
Sugar	28.0	17.3	17.1	18.0
Corn oil	4.5	4.0	3.0	3.0
Salt mixture	4.0	3.0	3.0	3.0
Total	100	100	100	100
Protein content (N×6.25) [1]	1.15	10.99	11.0	10.96

[1] These percentages of nitrogen represent the averages of analyses on 3 mixes of the low-nitrogen ration and 6 mixes of each of the other 3 rations.

The salt mixture was similar in composition to the one designed by Woodward and McCay (*23*) which is used in this laboratory in synthetic diets for herbivorous animals. The lambs were allowed free access to common salt during all preliminary and intervening periods. A vitamin A and D concentrate was added during experiment 2. It was fed at the rate of 0.0125 g per kilogram of live weight per day. No vitamin B supplements were added because this would have involved adding nitrogen to the ration. The importance of and necessity for vitamins in short balance experiments of this type do not seem to be definitely known.

Three young growing wethers were used. They were purebred Shropshire lambs from the university flock. The details involved in carrying out the experiments and the methods of analysis used were the same as those employed in the previous experiments (*22*). The experimental periods were 10 days in length. The preliminary and intervening periods were also 10 days in length, except those preceding the low-nitrogen periods, which were generally longer.

The lambs were fed twice a day. The plan followed in feeding each lamb on the different rations is shown in table 3:

TABLE 3.—*Plan followed in feeding each lamb the different rations in experiments 1 and 2*

EXPERIMENT 1

Lamb no. 6	Lamb no. 7	Lamb no. 8
Low nitrogen	Low nitrogen	Low nitrogen.
Corn-gluten meal	Linseed meal	Soybean-oil meal.
Linseed meal	Soybean-oil meal	Corn-gluten meal.
Soybean-oil meal	Corn-gluten meal	Linseed meal.
Low nitrogen	Low nitrogen	Low nitrogen.

EXPERIMENT 2

Low nitrogen	Low nitrogen	Low nitrogen.
Soybean-oil meal	Corn-gluten meal	Linseed meal.
Linseed meal	Soybean-oil meal	Corn-gluten meal.
Corn-gluten meal	Linseed meal	Soybean-oil meal.
Low nitrogen	Low nitrogen	Low nitrogen.

The same low-nitrogen period was used for the last period of experiment 1 and for the first period of experiment 2. The second experiment was, therefore, a repetition of experiment 1 with the reversed order of feeding the different rations to each lamb.

DISCUSSION OF RESULTS

The complete results of the metabolism experiments are presented in tables 4 and 5. For convenience of study, the final values are summarized in table 6.

Considerable variations in individual values are noted in a few cases, but they are no greater than commonly occur in experiments of this type. The average results for each of the two trials agreed quite closely in almost all respects. Further repetition of this work and experiments with other species would be desirable.

There was little difference in the average digestibility of the proteins of the corn-gluten-meal and the soybean-oil-meal rations. The proteins of both these rations, however, were slightly more digestible than the proteins of the linseed-meal ration.

There were some differences in the amounts of nitrogen retained or stored on the different rations. The storage from the soybean-oil-meal ration was significantly higher than from either of the other two rations. The average storage of nitrogen was 33.8 percent for the soybean-meal ration, 26.7 percent for the linseed-meal ration, and 26.5 percent for the corn-gluten-meal ration. The odds (*9*) are 302 to 1 against the difference in protein storage between soybean-oil meal and linseed meal being due to chance alone. For the other comparison, the odds were 32 to 1 in favor of soybean-oil meal as compared with corn-gluten meal. There were similar differences in the percentages of digested nitrogen stored. The average percentages of digested nitrogen stored were 51 for soybean-oil meal, 39.8 for corn-gluten meal, and 41.5 for linseed meal. These results clearly show a superiority of the proteins furnished by soybean-oil meal.

The biological values of the protein in the soybean-oil-meal ration were slightly higher than those for either corn-gluten meal or linseed meal. The average was 72.8 percent for soybean-oil-meal proteins, 65.7 for the corn-gluten meal, and 67.7 percent for linseed-meal proteins. The difference between the biological values of soybean meal and of linseed meal is significant as shown by odds of 87 to 1 against this difference being due to chance. A tendency toward statistical significance is also shown in comparing the soybean-oil-meal ration with the corn-gluten-meal ration. The odds in this case are 20 to 1 in favor of the soybean-oil-meal ration.

The proteins of linseed meal were less digestible than corn-gluten-meal proteins but they were utilized a little more efficiently on the average. Soybean proteins were digested at approximately the same rate as the corn-gluten-meal proteins, but were more efficiently utilized as indicated by the storage and biological values of the proteins. These results, as a whole, indicate that soybean-oil meal furnishes a more efficient combination of amino acids than does either linseed meal or corn-gluten meal.

The data on digested protein (nitrogen) stored show greater differences in favor of the soybean-oil-meal proteins than do the biological values. When the metabolic and endogenous nitrogen losses are considered, and the biological values of the protein computed, the differences in the average values between the soybean-oil-meal ration, and the other two rations becomes less. Since the two methods of evaluating the proteins differ only in the respect that metabolic and endogenous nitrogen are considered in the calculation of biological values, these data may question the accuracy of estimating these nitrogen losses. The writers recognize that the low-nitrogen ration used is not entirely satisfactory for sheep and for most other species. With prolonged feeding of the low-nitrogen ration there is a diminished appetite and falling off in food consumption. The data from the low-nitrogen feeding periods show that as the feed consumption decreases the rate of metabolic nitrogen excreted per unit of feed intake will increase, thus producing an error in the calculation of the biological values. This error, however, may not be very great.

Reduced feed consumption during a period of low-nitrogen feeding will leave an animal in an abnormal condition and may possibly alter the reliability of the results in the following experimental periods. These experiments were conducted in such a manner that each ration was fed to two lambs just following a low-nitrogen period and then again just preceding a low-nitrogen period. Without a single exception, the data show that higher biological values for each feed were obtained immediately following the periods of low-nitrogen feeding. These observations are not in agreement with those of Mitchell (*14*) who believes that a period of low-nitrogen feeding will exert no appreciable effects on the utilization of protein in subsequent experimental periods. There is the possibility, however, that the preliminary period of protein feeding was not of sufficient length before the collection periods were started in these experiments. In no case, however, was there a preliminary period of less than 10 days in length.

The biological values obtained in these experiments for linseed-meal proteins compare favorably with those reported by Mitchell and Hamilton (*15*). Working with swine, these investigators obtained values averaging 61 when the proteins were fed at a 9-percent level. Braman (*2*), working with rats, obtained much higher values, averaging 78 at an 8-percent protein level. Bethke and his associates (*1*) reported average values of 71 for linseed-meal proteins fed to rats at a 10-percent level. There is possibly a slight species difference in in the utilization of proteins which may account for some of the differences obtained, but they can be attributed in part to the difference in level of protein intake.

It should also be pointed out that some dried yeast was provided in the rations used in these investigations (*1, 2, 15*) which undoubtedly furnishes protein of high quality. This protein might supplement that from the feeds in question.

For soybean-oil-meal proteins fed with corn silage and corn to lactating cows, Holdaway, Ellett, and Harris (*8*) reported utilization values of 77 percent. Mitchell and Villegas (*18*) reported average biological values of 64 for the proteins in soybeans fed to rats at a 10-percent level. These values, however, are not directly comparable to those obtained in the experiments reported in this paper. Many practical feeding experiments have been conducted, however, which show the high value of soybean-oil meal as a protein-rich supplement.

TABLE 4.—*Nitrogen metabolism data showing the digestibility and biological value of proteins in the first experiment* [1]

Wether no.	Body weight: Initial	Body weight: Final	Body weight: Average	Food intake	Dry-matter intake	Nitrogen intake	Fecal nitrogen	Estimated metabolic nitrogen	Food nitrogen in feces	Absorbed nitrogen	Nitrogen in urine	Endogenous nitrogen in urine	Food nitrogen in urine	Food nitrogen utilized	Digestion coefficient	Total nitrogen stored	Digestible nitrogen stored	Biological value
	Kilogram	*Kilogram*	*Kilogram*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*
LOW-NITROGEN RATION																		
6	19.40	20.37	19.89	3,678	3,561.9	6.31	19.78	[2] 0.555			8.30	[3] 0.417						
7	19.60	17.30	18.45	3,573	3,458.6	6.45	23.78	[2] .688			8.60	[3] .466						
8	16.20	14.87	15.54	2,000	1,938.0	3.39	12.47	[2] .643			9.17	[3] .590						
CORN-GLUTEN-MEAL RATION																		
6	22.87	23.90	23.39	6,997	6,655.5	123.01	41.19	36.67	4.52	118.49	40.35	9.01	31.34	87.15	67	34	51	74
7	28.47	29.03	28.75	8,000	7,582.4	142.40	51.47	41.85	9.62	132.78	54.26	9.06	45.20	87.58	64	26	40	66
8	22.43	23.33	22.88	8,000	7,706.4	139.68	41.84	47.63	[4] .00	139.68	64.53	10.75	53.78	85.90	70	24	34	61
LINSEED-MEAL RATION																		
6	23.90	24.37	24.14	7,000	6,664.7	122.64	50.97	36.46	14.51	108.13	47.56	8.62	38.94	69.19	58	20	34	64
7	23.10	23.77	23.44	8,000	7,603.2	141.12	54.54	48.13	6.41	134.71	46.24	9.49	36.75	97.96	61	29	47	73
8	24.27	25.43	24.85	8,000	7,596.0	142.16	46.01	46.03	[4] .00	142.16	53.84	10.19	43.65	98.51	68	30	44	69
SOYBEAN-OIL-MEAL RATION																		
6	26.33	26.80	26.57	7,000	6,606.6	122.22	40.38	35.94	4.44	117.78	40.11	8.74	31.37	86.41	67	34	51	73
7	26.10	27.00	26.55	8,000	7,660.8	140.40	49.06	45.35	3.71	136.69	43.74	9.56	34.18	102.51	65	34	52	75
8	19.87	20.77	20.32	8,000	7,622.4	141.68	40.95	48.10	[4] .00	141.68	45.17	10.77	34.40	107.28	71	39	55	76

LOW-NITROGEN RATION

6	25.83	23.57	24.70	3,511	3,313.2	7.69	17.88	[2] 0.540			7.39	[3] 0.299						
7	29.23	27.83	28.53	4,630	4,369.7	10.31	22.26	[2] .509			7.66	[3] .268						
8	25.30	24.00	24.65	4,000	3,778.8	8.74	22.42	[2] .593			8.54	[3] .346						

[1] Totals are for 10-day experimental periods.

[2] Fecal nitrogen per 100 g dry matter in feed. These values were used in estimating the metabolic nitrogen in the feces in the experimental periods. The change in the ratio of metabolic nitrogen to dry matter consumed from the first to the last periods was assumed to occur in a linear fashion.

[3] Urinary nitrogen per kilogram of body weight. These values were used in estimating the endogenous nitrogen in the urine in the experimental periods, the same assumption of a linear variation being made as in the case of metabolic nitrogen in the feces.

[4] Estimated metabolic nitrogen greater than fecal nitrogen, therefore it was assumed that no food nitrogen was present in the feces.

TABLE 5.—*Nitrogen metabolism data showing the digestibility and biological value of proteins in the second experiment* [1]

Wether no.	Body weight			Food intake	Dry-matter intake	Nitrogen intake	Fecal nitrogen	Estimated metabolic nitrogen	Food nitrogen in feces	Absorbed nitrogen	Nitrogen in urine	Endogenous nitrogen in urine	Food nitrogen in urine	Food nitrogen utilized	Digestion coefficient	Total nitrogen stored	Digestible nitrogen stored	Biological value
	Initial	Final	Average															
	Kilograms	*Kilograms*	*Kilograms*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*	*Percent*	*Percent*
LOW-NITROGEN RATION																		
6	25.83	23.57	24.70	3,511	3,313.2	7.69	17.88	[2] 0.540			7.39	[3] 0.299						
7	29.23	27.83	28.53	4,630	4,369.7	10.31	22.26	[2] .509			7.66	[3] .268						
8	25.30	24.00	24.65	4,000	3,778.8	8.74	22.42	[2] .593			8.54	[3] .346						
CORN-GLUTEN-MEAL RATION																		
6	33.80	34.90	34.35	8,000	7,426.4	138.88	44.66	37.43	7.23	131.65	61.38	10.72	50.66	80.99	68	24	35	62
7	31.93	33.47	32.70	8,184	7,774.3	144.70	50.44	39.73	10.71	133.99	48.72	7.78	40.94	93.05	65	31	48	69
8	29.00	30.77	29.89	9,000	8,487.0	158.76	57.38	58.22	[4] .00	158.76	69.91	9.59	60.32	98.44	64	20	31	62
LINSEED-MEAL RATION																		
6	31.03	32.10	31.57	8,000	7,432.8	142.64	47.12	38.13	8.99	133.65	48.44	9.76	38.68	94.97	67	33	49	71
7	37.43	37.70	37.57	8,200	7,651.4	140.63	49.02	39.25	9.77	130.86	62.78	7.78	55.00	75.86	65	21	31	58
8	27.87	28.83	28.35	9,000	8,567.1	158.76	62.39	56.03	6.36	152.40	54.13	9.33	44.80	107.60	61	27	44	71
SOYBEAN-OIL-MEAL RATION																		
6	28.33	30.27	29.30	8,000	7,596.0	141.20	51.38	39.65	11.73	129.47	35.59	8.97	26.62	102.85	64	38	60	79
7	34.87	35.93	35.40	8,200	7,662.9	143.91	45.79	39.23	6.56	137.35	57.27	7.89	49.38	87.97	68	28	42	64
8	31.43	32.67	32.05	9,000	8,458.2	155.43	51.92	60.65	[4] .00	155.43	56.28	10.00	46.28	109.15	67	30	46	70

LOW-NITROGEN RATION

6	34.53	31.97	33.25	4,000	3,827.6	6.61	18.92	[2] 0.494			10.52	[3] 0.316						
7	38.70	37.63	38.17	4,750	4,545.3	7.85	23.35	[2] .514			7.31	[3] .192						
8	28.17	29.13	28.65	3,850	3,684.1	6.36	27.82	[2] .755			8.65	[3] .302						

[1] Totals are for 10-day experimental periods.

[2] Fecal nitrogen per 100 g dry matter in feed. These values were used in estimating the metabolic nitrogen in the feces in the experimental periods. The change in the ratio of metabolic nitrogen to dry matter consumed from the first to the last periods was assumed to occur in a linear fashion.

[3] Urinary nitrogen per kilogram of body weight. These values were used in estimating the endogenous nitrogen in the urine in the experimental periods, the same assumption of a linear variation being made as in the case of metabolic nitrogen in the feces.

[4] Estimated metabolic nitrogen greater than fecal nitrogen, therefore it was assumed that no food nitrogen was present in the feces.

TABLE 6.—*The digestibility and biological value of the proteins of corn-gluten meal, linseed meal, and soybean-oil meal when fed to lambs*

Item	Percentage digestibility and biological value when fed to lamb no. —						Average
	6 in experiment—		7 in experiment—		8 in experiment—		
	1	2	1	2	1	2	
Corn-gluten meal:							
Apparent digestibility	67	68	64	65	70	64	66.3±0.67
Percentage nitrogen intake stored	34	24	26	31	24	20	26.5±1.41
Percentage digested nitrogen stored	51	35	40	48	34	31	39.8±2.23
Biological value	74	62	66	69	61	62	65.7±1.40
Linseed meal:							
Apparent digestibility	58	67	61	65	68	61	63.3±1.08
Percentage nitrogen intake stored	20	33	29	21	30	27	26.7±1.42
Percentage digested nitrogen stored	34	49	47	31	44	44	41.5±2.01
Biological value	64	71	73	58	69	71	67.7±1.55
Soybean-oil meal:							
Apparent digestibility	67	64	65	68	71	67	67.0± .67
Percentage nitrogen intake stored	34	38	34	28	39	30	33.8±1.19
Percentage digested nitrogen stored	51	60	52	42	55	46	51.0±1.76
Biological value	73	79	75	64	76	70	72.8±1.45

The values for corn-gluten meal may, in a general way, be compared with those reported for corn grain since the gluten is largely zein, which comprises about 60 percent of the protein of corn grain. Mitchell and Kick (*16*) reported an average biological value of 54 for corn protein when fed to pigs at a protein level of approximately 8 to 9 percent. Later experiments with pigs by Mitchell and Hamilton (*15*) gave corn proteins an average biological value of 61 when fed at a protein level of 8.66 percent.

It should be pointed out that there is a possibility that the small amounts of wheat-straw nitrogen may have supplemented any amino acid deficiencies which any of the three feeds used in this investigation may have. As determined, however, the average values for soybean-oil meal are fairly high. There are no indications of marked amino acid deficiencies in this feed for sheep. These values are of special interest, since sheep have a high requirement for cystine and soybeans have been reported as deficient in this amino acid. However, Csonka and Jones (*3*, *4*) have presented analytical data which do not support the idea of a quantitative deficiency of cystine in soybeans. They do admit however, the possibility of a deficiency in quality of protein, due to low availability of amino acids when the raw meal is fed. Osborne and Mendel (*20*) had earlier found the nitrogen of commercial soybean cake and of soybean meal cooked in water was utilized somewhat better than was the case with the raw and dry-heated meals. These writers believed the utilization of protein was increased by making the amino acids more available for assimilation. Perhaps expeller-process soybean meal would not show the cystine deficiencies which raw soybeans have apparently shown in nutrition experiments (*17*, *21*).

Some observations on the fleeces of the lambs are of interest. The lambs were shorn at the beginning and again at the end of the experimental work. An examination of the wool fibers of all three fleeces showed "breaks" and distinct weakened places which corresponded exactly with the periods of low-nitrogen feeding. The breaking strength and diameter of the wool fibers was greatly reduced during the periods of low-nitrogen feeding. The portions of the wool fibers grown during the periods of protein feeding were strong. The wool had a beautiful luster and the fibers were apparently of normal length.

SUMMARY

Metabolism studies were conducted with three growing wether lambs to determine the digestibility, storage, and biological value of the proteins of soybean-oil, corn-gluten, and linseed meals. The experiment was repeated, thus giving six determinations for each feed. Each of the feeds in question was added to a low-nitrogen ration in such amounts as to furnish a protein level of 10 percent, with approximately 1 percent additional being furnished by the other ingredients of the ration. All rations were equalized in energy content.

The average coefficients of apparent digestibility for protein were 67.0 percent for soybean-oil meal, 66.3 for corn-gluten meal, and 63.3 percent for linseed meal.

The lambs were more efficient in storing protein from the soybean-oil-meal ration than from either of the other rations. The average percentage of protein intake stored was 33.8 for soybean-oil-meal, 26.5 for corn-gluten meal, and 26.7 for linseed meal.

Slightly but significantly higher biological values were obtained for the soybean-oil-meal ration. The average of the biological values was 72.8 for soybean-oil-meal proteins, 65.7 for corn-gluten-meal proteins, and 67.7 for linseed meal proteins.

These data show the superiority of the proteins of soybean-oil meal over those furnished by linseed meal and corn-gluten meal. Furthermore, they indicate that it is possible to measure differences in quality of protein using sheep and the nitrogen-balance type of experimentation.

LITERATURE CITED

(1) Bethke, R. M., Bohstedt, G., Sassaman, H. L., Kennard, D. C., and Edington, B. H.
1928. THE COMPARATIVE NUTRITIVE VALUE OF THE PROTEINS OF LINSEED MEAL AND COTTONSEED MEAL FOR DIFFERENT ANIMALS. Jour. Agr. Research 36: 855–871, illus.

(2) Braman, W. W.
1931. THE RELATIVE VALUES OF THE PROTEINS OF LINSEED MEAL AND COTTONSEED MEAL IN THE NUTRITION OF GROWING RATS. Jour. Nutrition 4: 249–259.

(3) Csonka, F. A., and Jones, D. B.
1933. DIFFERENCES IN THE AMINO ACID CONTENT OF THE CHIEF PROTEIN (GLYCININ) FROM SEEDS OF SEVERAL VARIETIES OF SOYBEAN. Jour. Agr. Research 46: 51–55.

(4) ——— and Jones, D. B.
1934. THE CYSTINE, TRYTOPHANE, AND TYROSINE CONTENT OF THE SOYBEAN. Jour. Agr. Research 49: 279–282.

(5) Hart, E. B., and Humphrey, G. C.
1915. THE RELATION OF THE QUALITY OF PROTEINS TO MILK PRODUCTION. Jour. Biol. Chem. 21: 239–253, illus.

(6) ——— and Humphrey, G. C., with the cooperation of Schaal, A. A.
1916. FURTHER STUDIES ON THE RELATION OF THE QUALITY OF PROTEINS TO MILK PRODUCTION. Jour. Biol. Chem. 26: 457–471, illus.

(7) ——— and Humphrey, G. C., with the cooperation of Sure, B.
1917. THE RELATION OF THE QUALITY OF PROTEINS TO MILK PRODUCTION. Jour. Biol. Chem. 31: 445–460, illus.

(8) HOLDAWAY, C. W., ELLETT, W. B., and HARRIS, W. G.
1925. THE COMPARATIVE VALUE OF PEANUT MEAL, COTTONSEED MEAL, AND SOYBEAN MEAL AS SOURCES OF PROTEIN FOR MILK PRODUCTION. Va. Agr. Expt. Sta. Tech. Bull. 28, 54 pp., illus.

(9) LOVE, H. H.
1924. A MODIFICATION OF STUDENT'S TABLE FOR USE IN INTERPRETING EXPERIMENTAL RESULTS. Jour. Amer. Soc. Agron. 16: 68–73.

(10) MCCOLLUM, E. V.
1914. THE VALUES OF THE PROTEINS OF THE CEREAL GRAINS AND OF MILK FOR GROWTH IN THE PIG, AND THE INFLUENCE OF THE PLANE OF PROTEIN INTAKE ON GROWTH. Jour. Biol. Chem. 19: 323–333.

(11) MAYNARD, L. A., MILLER, R. C., and KRAUSS, W. E.
1928. STUDIES OF PROTEIN METABOLISM, MINERAL METABOLISM, AND DIGESTIBILITY, WITH CLOVER AND TIMOTHY RATIONS. N. Y. (Cornell) Agr. Expt. Sta. Mem. 113, 33 pp.

(12) MITCHELL, H. H.
1924. A METHOD OF DETERMINING THE BIOLOGICAL VALUE OF PROTEIN. Jour. Biol. Chem. 58: 873–903.

(13) ———
1924. THE BIOLOGICAL VALUE OF PROTEINS AT DIFFERENT LEVELS OF INTAKE. Jour. Biol. Chem. 58: 905–922.

(14) ———
1928. A NOTE ON QUANTITATIVE METHODS OF MEASURING THE NUTRITIVE VALUE OF PROTEINS. Biochem. Jour. 22: [1323]–1326.

(15) ——— and HAMILTON, T. S.
1931. THE NUTRITIVE VALUE FOR GROWING SWINE OF THE PROTEINS OF LINSEED MEAL AND OF COTTONSEED MEAL, BOTH ALONE AND IN COMBINATION WITH THE PROTEINS OF CORN. Jour. Agr. Research 43: 743–748.

(16) ——— and KICK, C. H.
1927. THE SUPPLEMENTARY RELATION BETWEEN THE PROTEINS OF CORN AND OF TANKAGE DETERMINED BY METABOLISM EXPERIMENTS ON SWINE. Jour. Agr. Research 35: 857–864.

(17) ——— and SMUTS, D. B.
1932. THE AMINO ACID DEFICIENCIES OF BEEF, WHEAT, CORN, OATS, AND SOYBEANS FOR GROWTH IN THE WHITE RAT. Jour. Biol. Chem. 95: 263–281, illus.

(18) ——— and VILLEGAS, V.
1923. THE NUTRITIVE VALUE OF THE PROTEINS OF COCONUT MEAL, SOYBEANS, RICE BRAN, AND CORN. Jour. Dairy Sci. 6: 222–236.

(19) MORRIS, S., and WRIGHT, N. C.
1933. THE NUTRITIVE VALUE OF THE PROTEINS FOR MILK PRODUCTION. II. A COMPARISON OF THE PROTEINS OF BLOOD MEAL, PEA MEAL, DECORTICATED EARTH-NUT CAKE, AND A MIXTURE OF DECORTICATED EARTH-NUT CAKE AND FLAKED MAIZE. Jour. Dairy Research 5: 1–14, illus.

(20) OSBORNE, T. B., and MENDEL, L. B., with the cooperation of FERRY, E. L., and WAKEMAN, A. J.
1917. THE USE OF SOYBEAN AS FOOD. Jour. Biol. Chem. 32: 369–387, illus.

(21) SHREWSBURY, C. L., and BRATZLER, J. W.
1933. CYSTINE DEFICIENCY OF SOYBEAN PROTEIN AT VARIOUS LEVELS, IN A PURIFIED RATION AND AS A SUPPLEMENT TO CORN. Jour. Agr. Research 47: 889–895.

(22) TURK, K. L., MORRISON, F. B., and MAYNARD, L. A.
1934. THE NUTRITIVE VALUE OF THE PROTEINS OF ALFALFA HAY AND CLOVER HAY WHEN FED ALONE AND IN COMBINATION WITH THE PROTEINS OF CORN. Jour. Agr. Research 48: 555–570.

(23) WOODWARD, J. C., and MCCAY, C. M.
1932. SYNTHETIC DIETS FOR HERBIVORA. Soc. Expt. Biol. and Med. Proc. 30: 241–242.