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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
College Station, Brazos County, Texas

BULLETIN NO. 402 OCTOBER, 1929

DIVISION OF CHEMISTRY

Supplementary Energy-Production Coefficients of American Feeding Stuffs Fed Ruminants

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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†As of October 1, 1929. *Dean, School of Veterinary Medicine.
**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

Digestion experiments numbering 41 are given in this Bulletin, together with a compilation of other American digestion experiments published since Bulletin No. 325 was issued. Revised production coefficients are presented based on the new data. The digestion experiments reported are for alfalfa, barley, broom-corn seed, cotton burs, cottonseed hulls, cottonseed meal, flax plant by-product, guar hay, linseed meal, milo, peanut hulls, prairie hay, rice bran, rice hulls, rice polish, wheat, wheat bran, wheat gray shorts, and wheat brown shorts.

CONTENTS

BULLETIN NO. 402 OCTOBER, 1929

SUPPLEMENTARY ENERGY-PRODUCTION COEFFICIENTS OF AMERICAN FEEDING STUFFS FED RUMINANTS

G. S. FRAPS

Digestion coefficients and energy-production coefficients calculated from 1078 American digestion experiments were given in Texas Bulletin No. 325 of March 19, 1925. Since that time additional digestion experiments have been conducted at this and other Agricultural Experiment Stations and some errors have been found in the bulletin referred to. This Bulletin contains a report on 41 experiments conducted at the Texas Experiment Station, a compilation of other American digestion experiments with ruminants, and revised production coefficients based on the new data. The feeds studied include alfalfa, barley, broom-corn seed, cotton burs, cottonseed hulls, cottonseed meal, flax plant by-product, guar hay, linseed meal, milo, peanut hulls, prairie hays, rice bran, rice hulls, rice polish, wheat, wheat bran, wheat gray shorts, and wheat brown shorts. The composition, coefficients of digestibility, and production coefficients are given for the samples studied.

This is the eighth bulletin in a series presenting work the object of which is to ascertain the feeding value of Texas feeding stuffs by means of digestion experiments with ruminants. Previous bulletins in the series are Nos. 104, 147, 166, 203,, 245, 291, 315. Bulletin No. 329 contains a compilation of American experiments with ruminants.

DIGESTIBILITY OF FEEDS

The digestibility of a feeding stuff is one of the most important factors in the productive value of a feed, since only the feed which can be digested is utilized. Our knowledge of the digestibility of many feeds is not yet entirely sufficient as a basis for estimating their productive energy. The object of the digestion experiments here presented is to secure information with respect to productive values, so far as digestion experiments may aid, and to secure more complete information with respect to feeds concerning which more data are needed. The digestibility of sugar, starches, and other constituents of these feeds is being studied, with the same object in view.

The value of feeding stuffs for feeding purposes depends upon several things. These include bulk, palatability, ash, suitability to the animal, mineral constituents, vitamine content, digestible protein, and productive energy. The most important of these from the standpoint of animal nutrition are the digestible protein and the productive energy.

Digestible Protein

Protein is that group of constituents of the feed which is used to form muscle, skin, hair, and similar portions of the body, and secretions of the body which are necessary for life, and to replace and repair animal tissue. The protein is equal to nitrogen multiplied by 6.25.

The digestible protein is that which is digested and absorbed during the passage of the food through the body of the animal. The amount of digestible protein in the food represents the capacity of the food to furnish material for the production of lean meat, or for the repair or replacement of the tissues of the animal body.

Protein is made of a variety of constituents and varies in character in the different feeding stuffs. In the same feeding stuff it usually consists of several different kinds of chemical compounds. The proteins of some feeding stuffs appear to lack part of the essential constituents for the proper replacement or the repair of the animal tissues, and for this reason are not as effective as other proteins.

Productive Energy

Productive energy is a measure of the capacity of the feeding stuff to furnish animals the material for heat, for bodily energy, for work, or for the production of fat or other carbonaceous material. Protein, when digested, may be burned for the production of heat, or energy, or may be stored up as fat. The same is true of the constituents of the nitrogen-free extract and for that portion of the crude fiber which is digested.

The work of digestion consumes a certain amount of energy. Energy is also used for metabolic changes consequent on the digestion of the food. The energy remaining after these losses are deducted may be used for productive purposes. That is to say, it may be used for movements of the body, beating of the heart, breathing, other bodily actions, for the production of fat, of milk, or of work. Energy is, no doubt, consumed in the production of milk, fat, work, etc., so that the energy remaining for productive purposes does not reappear entirely in the final products, milk, fat, work, etc. There is yet no reason to believe that the available energy is utilized to the same extent for milk as it is for work, or that the same proportion may be used for maintenance as for other purposes. Thus, the net energy or productive energy as measured by one product may be quite different from that when measured by another. The utilization of the productive energy, however, is a function of the animal, and not of the feed. It is quite possible that although the relative amount of available energy utilized for different purposes is different, it may be in the same proportion for different feeds. The productive energy referred to in this Bulletin is measured by the amount stored up as fat. It is the value of a feed for the purpose of producing fat or energy after all the requirements consequent on the consumption of the food have been deducted.

Feeding stuffs vary considerably in the amounts of energy lost in

the processes consequent upon digestion. For example, the digested constituents of high-grade cottonseed meal have full value for the production of fat, but one pound of the digested constituents of wheat straw has only one-fifth the value of one pound of those of cottonseed meal. Feeding stuffs high in crude fiber suffer great losses in digestion, and the productive energy is consequently lowered.

The productive energy is calculated from the results of tests with various feeds, in which the animal is first fed a measured ration sufficient to form a little fat and the quantity of fat formed is exactly determined. Then the animal is fed the same ration with the addition of the feed to be studied, and the quantity of fat produced is again measured. The additional quantity of fat produced is due to the addition of the feed to be studied and represents its fat-producing power. The productive energy may be stated in terms of matter, such as fat, or in terms of energy, such as therms. In the United States it is commonly stated in terms of therms. Productive energy may also be calculated from feeding experiments (see Texas Bulletins Nos. 306, 379).

Ash

Ash constituents of feeding stuffs are particularly important to growing animals, as they are necessary for the formation of bones, and certain portions of the ash are also required for the blood.

THE DIGESTION EXPERIMENTS

The productive coefficients and the coefficients of digestibility given in this Bulletin have been calculated from the results of digestion experiments with sheep. The method of conducting the experiments is described in Bulletins Nos. 147 and 166 of this Station. The production coefficients were calculated as described in Bulletins Nos. 185 and 375.

COEFFICIENTS OF DIGESTIBILITY

The coefficients of digestibility are used to calculate the digestible constituents of a feeding stuff, and until fifteen or twenty years ago the digestible nutrients were used exclusively for calculating rations in the feeding of animals. Developments in scientific knowledge concernng feeding stuffs have rendered the use of digestible constituents an antiquated method for calculating rations, although many people are still using them. The digestible nutrients do not show the real feeding value of the feeding stuffs, for the reason that the nutrients digested from different feeds have different values to the animal body. The use of the digestible nutrients for comparing the values of different feeds is correct only when one pound of digestible nutrient in one feed is equal in productive energy to one pound of digestible nutrient in other feeds. When these digestible nutrients are known to have different values, the use of the digestible constituents as a basis of calculation in feedin

experiments, on the assumption of the equality in value of the nutrients, is of course no longer permissible.

COMPOSITION OF FEEDS

Table 1.—Average percentage composition of feeds used in Texas experiments.

Lab. No.	Feed	D. E. No.	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Water	Ash
24154–5	Alfalfa	178	15.26	1.94	31.05	36.31	6.92	8.52
21948–49	Alfalfa	170	14.31	1.73	29.65	37.71	8.35	8.25
21948–49	Alfalfa	154	14.31	1.73	29.65	37.71	8.35	8.25
26282	Alfalfa hay (leafy)	194	20.30	1.67	21.06	39.54	7.35	10.08
26312	Alfalfa hay (stemmy)	195	15.48	1.82	29.22	38.37	8.45	6.66
21824	Alfalfa meal	153	17.45	1.69	23.52	40.06	7.79	9.49
25789	Barley	188	10.22	1.70	5.06	70.60	10.22	2.20
26152	Brazos county prairie hay	191	6.15	2.80	29.69	47.29	6.17	7.90
22924–25	Broom corn seed	169	10.17	1.91	14.17	59.73	7.00	7.02
25952	Cotton burs	189	9.80	2.19	31.23	40.00	8.89	7.89
22146–7	Cottonseed feed	158	39.63	6.64	15.74	26.38	6.49	5.13
22166–7	Cottonseed hulls	164	3.50	.43	51.33	34.15	7.97	2.62
22801–2	Cottonseed hulls	168	3.92	1.19	47.00	38.21	7.35	2.36
22131–2	Cottonseed meal	157	43.08	10.47	11.91	22.80	5.98	5.77
22187–8	Cottonseed meal	160	44.67	9.23	11.33	21.73	7.01	6.04
22719–20	Cottonseed meal	166	44.35	6.90	11.36	25.39	6.17	5.86
24872	Cottonseed meal	187	46.81	7.55	10.39	23.13	6.26	5.86
22215–16	Flax plant by-product	163	6.27	1.23	45.75	32.43	7.65	6.68
21798–9	Goose grass	152	3.24	1.03	32.98	45.75	7.86	9.15
26050	Guar hay	190	16.55	1.34	19.30	41.21	9.25	12.35
26246	Harris county prairie hay	193	4.20	2.48	31.93	48.64	6.62	6.13
24732	Linseed meal (old process)	185	32.22	6.53	9.66	36.78	7.66	7.15
22115–16	Linseed meal (old process)	161	35.62	6.78	9.14	35.35	7.91	5.22
21964	Mesquite grass	155	5.15	1.59	27.86	42.26	6.73	16.41
23160	Milo	176	11.91	2.58	1.83	71.21	10.95	1.52
24414	Milo	186	10.44	2.38	2.69	71.63	11.10	1.76
24547	Peanut hulls	182	10.41	5.01	47.33	26.02	6.53	4.70
23087–8	Rice bran	180	14.64	14.58	13.59	37.08	8.64	11.47
24303–4	Rice hulls	179	2.29	.48	44.85	27.30	6.11	18.97
23115–6	Rice polish	174	14.34	13.73	2.61	55.67	7.93	5.72
24706	Wheat	184	13.91	1.50	3.13	70.53	8.74	2.19
23183	Wheat bran	177	17.50	4.09	9.48	54.37	8.43	6.13
24671	Wheat brown shorts	183	18.32	5.08	6.48	56.74	8.83	4.50
23158–9	Wheat gray shorts	175	19.87	4.61	4.69	57.22	10.01	3.60
24383–4	Wheat gray shorts	181	19.24	5.34	5.07	57.00	8.96	4.39

The composition of feeds used in the Texas digestion experiments reported in this Bulletin are shown in Table 1.

The leafy alfalfa hay has a content of crude fiber a little higher than that in alfalfa leaf meal. The stemmy alfalfa hay has a crude fiber content lower than the average. The alfalfa meal was of very good quality, the crude fiber being low and the protein high.

The cotton burs were the ordinary mill-run burs taken from seed cotton at a cotton gin. They contained a small amount of seed.

The goose grass came from Galveston County and is the predominant grass in prairie hay in some sections of the State.

The guar was grown at substation No. 5, Temple, Bell County.

The Harris County prairie hay came from a pasture of the Loin Disease Field Laboratory of the Texas Agricultural Experiment Station in Harris county.

DIGESTION COEFFICIENTS, TEXAS EXPERIMENTS

Table 2.—Individual coefficients of digestibility, Texas experiments.

Lab. No.	Feed	D. E.	No.	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
24154–5	Alfalfa	Sheep 1	178	74.63	42.16	52.95	73.07	1134
		" 2	178	74.26	39.71	50.64	70.47	
	Average			74.45	40.94	51.80	71.77	
21948–9	Alfalfa	Sheep 3	170	69.90	23.37	49.36	67.62	1128
		" 15	170	65.15	29.67	51.08	66.96	
	Average			67.53	26.52	50.22	67.29	
21948–9	Alfalfa	Sheep 3	154	71.26	31.49	52.85	73.62	1112
		" 13	154	60.61	30.80	50.30	70.20	
	Average			65.94	31.15	51.58	71.85	
26282	Alfalfa hay (leafy)	Sheep 3	194	81.47	33.66	58.25	80.93	1149
		" 15	194	78.85	30.04	52.20	78.18	
	Average			80.16	31.85	55.23	79.56	
26312	Stemmy alfalfa hay	Sheep 13	195	71.49	31.43	42.56	66.28	1150
		" 15	195	74.31	39.22	48.03	69.90	
	Ave rage			72.90	35.33	45.30	68.09	
21824	Alfalfa meal	Sheep 13	153	66.55	23.49	40.48	69.29	1111
		" 15	153	61.07	28.52	53.03	71.99	
	Average			63.81	26.01	46.76	70.64	
25789	Barley (fed with alfalfa)	Sheep 3	188	83.76	93.19	35.65	96.51	1144
		" 15	188	72.81	80.69	81.87	89.39	
	Average			78.29	86.94	58.76	92.95	
26152	Brazos county prairie hay	Sheep 3	191	36.08	48.63	61.02	57.79	1147
		" 15	191	36.05	49.28	59.89	58.99	
	Average			36.07	48.96	60.46	58.39	
22924–5	Ground broom corn seed, fed with alfalfa	Sheep 3	169	54.52	78.84	34.84	63.99	1127
		" 15	169	50.24	82.72	37.56	62.31	
	Average			52.38	80.78	36.20	63.15	
25952	Cotton burs	Sheep 3	189	24.95	61.55	58.03	51.93	1145
		" 15	189	22.36	62.86	49.42	48.37	
	Average			23.66	62.21	53.73	50.15	
22146–7	39% cottonseed feed	Sheep 3	158	85.37	98.17	53.46	81.77	1116
		" 15	158	83.89	100.00	69.48	93.11	
	Average			84.63	99.09	61.47	87.44	
22166–7	Cottonseed hulls (fed with cottonseed meal)	Sheep 3	159	0	62.40	55.69	53.30	1117
		" 15	159	0	56.20	52.24	64.95	
	Average			0	59.30	53.97	59.13	

Table 2.—Individual coefficients of digestibility, Texas experiments.

Lab. No.	Feed	D. E.	No.	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
22166–7	Cottonseed hulls...	Sheep 3	164	0	51.49	46.82	50.42	1122
		" 13	164	0	50.21	50.50	60.41	
	Average.....	.....	.....	0	50.85	48.66	55.42	
22166–7	Cottonseed hulls...	Sheep 15	165	0	100.00	46.45	40.61	1123
22801–2	Cottonseed hulls...	Sheep 3	171	0	74.12	57.57	80.02	1129
		" 15	171	0	83.43	45.24	44.04	
	Average.....	.....	.....	0	78.78	51.41	62.03	
22801–2	Cottonseed hulls (fed with alfalfa)	Sheep 3	168	0	100.00	58.49	61.61	1126
		" 15	168	0	98.18	59.22	67.86	
	Average.....	.....	.....	0	99.09	58.86	64.74	
22801–2	Cottonseed hulls (fed with cotton-seed meal).....	Sheep 3	167	0	74.09	58.72	64.18	1125
		Sheep 15	167	0	88.23	54.92	57.16	
	Average.....	.....	.....	0	81.16	56.82	60.67	
22131–32	Cottonseed meal (fed with alfalfa)	Sheep 13	157	73.85	97.39	65.00	82.14	1115
		" 15	157	74.95	98.83	62.37	82.47	
	Average.....	.....	.....	74.40	98.11	63.69	82.31	
22187–8	Cottonseed meal (fed with alfalfa)	Sheep 3	160	80.63	97.12	45.67	65.61	1118
		" 13	160	78.49	96.67	42.98	79.85	
	Average.....	.....	.....	79.56	96.90	44.33	72.73	
22719–20	Cottonseed meal (fed with alfalfa)	Sheep 3	166	82.55	90.81	27.49	66.15	1124
		" 15	166	81.09	97.87	47.43	71.48	
	Average.....	.....	.....	81.82	94.34	37.46	68.82	
24872	Cottonseed meal (fed with alfalfa)	Sheep 3	187	84.95	98.26	79.67	83.01	1143
		" 15	187	82.01	96.21	57.91	74.82	
	Average.....	.....	.....	83.48	97.24	68.79	78.92	
22215–6	Flax plant by-product.....	Sheep 3	163	35.41	61.92	21.77	40.19	1121
	"	" 3	162	0	.20	0	22.85	1120
		" 15	162	9.47	50.00	10.61	31.49	
	Average.....	.....	.....	4.74	25.10	5.31	27.17	
21798–9	Goose grass.....	Sheep 13	152	0	100.00	43.69	34.09	1110
26050	Guar hay.....	Sheep 3	190	74.29	13.60	45.80	72.63	1146
		" 15	190	75.14	19.06	44.33	73.02	
	Average.....	.....	.....	74.72	16.33	45.07	72.83	
26246	Harris county prairie hay.....	Sheep 3	193	38.32	72.37	78.39	70.36	1148
		" 15	193	40.85	70.38	75.45	72.54	
	Average.....	.....	.....	39.59	71.38	76.92	71.45	

Table 2.—Individual coefficients of digestibility, Texas experiments—continued.

Lab. No	Feed	D. E.	No.	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
24732	Linseed meal (fed with alfalfa)	Sheep 3	185	88.75	73.91	45.27	80.00	1141
		" 15	185	86.16	98.48	63.41	82.25	
	Average			87.46	86.20	54.34	81.13	
22115–6	Linseed meal (fed with cottonseed hulls)	Sheep 3	161	75.93	94.29	100.00	79.71	1119
		" 15	161	74.73	97.81	99.34	97.67	
	Average			75.33	96.05	99.67	88.69	
22115–6	Linseed meal (fed with alfalfa)	Sheep 13	156	84.78	97.63	34.09	82.89	1114
		" 15	156	83.16	97.42	19.01	80.05	
	Average			83.97	97.53	26.55	81.47	
21964	Mesquite grass (fed with alfalfa)	Sheep 3	155	8.41	63.37	47.43	38.85	1113
		" 13	155	0	71.96	41.59	33.95	
	Average			4.21	67.67	44.51	36.40	
23160	Milo (fed with alfalfa)	Sheep 3	176	74.15	86.14	100.00	97.75	1132
		" 15	176	81.75	92.89	100.00	100.00	
	Average			77.95	89.52	100.00	98.88	
24414	Milo (fed with alfalfa)	Sheep 3	186	59.29	87.08	79.06	89.96	1142
		" 15	186	63.17	81.93	100.00	94.91	
	Average			61.23	84.51	89.53	92.44	
24547	Peanut hulls (fed with alfalfa)	Sheep 3	182	55.27	90.77	19.79	50.16	1138
		" 15	182	49.52	93.54	25.39	49.44	
	Average			52.40	92.16	22.59	49.80	
23087–8	Rice bran (fed with alfalfa)	Sheep 3	180	70.26	86.09	34.43	66.75	1136
		" 15	180	63.02	83.09	50.76	61.75	
	Average			66.64	84.59	42.60	64.25	
24303–4	Rice hulls (fed with alfalfa)	Sheep 3	179	0	27.72	23.31	31.26	1135
		" 15	179	0	0	0	0	
	Average			0	13.86	11.66	15.63	
23115–6	Rice polish (fed with alfalfa)	Sheep 3	174	86.21	92.92	81.06	94.81	1130
		" 15	174	79.65	87.49	60.76	93.99	
	Average			82.93	90.21	70.91	94.40	
24706	Wheat, whole (fed with alfalfa)	Sheep 3	184	83.78	60.28	86.13	93.98	1140
		" 15	184	69.17	80.07	100.00	96.73	
	Average			76.48	70.18	93.07	93.36	
23183	Wheat bran (fed with alfalfa)	Sheep 3	177	29.02	7.69	10.42	51.69	1133
		" 15	177	79.17	84.06	92.97	83.86	
	Average			54.10	45.88	51.70	67.78	

Table 2.—Individual coefficients of digestibility, Texas experiments—continued.

Lab. No.	Feed	D. E.	No.	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
23158–9	Wheat gray shorts (fed with alfalfa)	Sheep 3	175	84.60	88.11	64.81	88.69	1131
		" 15	175	88.11	93.35	100.00	93.59	
	Average			86.36	90.73	82.41	91.14	
24671	Wheat gray shorts (fed with alfalfa)	Sheep 3	183	76.49	89.11	30.85	80.49	1139
		" 15	183	79.92	87.51	81.75	83.89	
	Average			78.21	88.31	56.30	82.19	
24383–4	Wheat gray shorts (fed with alfalfa)	Sheep 3	181	84.01	92.62	61.83	86.45	1137
		" 15	181	82.23	89.90	96.40	86.72	
	Average			83.12	91.26	79.12	86.59	

The digestion coefficients secured from the feeds listed in Table 1 are given in Table 2 for each of the animals used in the experiments. The concentrates were fed with the roughages as shown in Table 2 and the digestion coefficients were calculated in the usual way, using digestion experiments for the roughages from the other experiments here reported.

Table 4 contains the digestion coefficients from which the averages used in this Bulletin are derived with the exception of alfalfa hay and alfalfa meal. The number of experiments conducted with alfalfa hay is large and the coefficients have not been repeated from Bulletin No. 329.

The six digestion experiments with cottonseed hulls, fed alone, with cottonseed meal, and fed with alfalfa gave digestion coefficients which are much closer together for crude fiber and nitrogen-free extract than is the case with the digestion experiments previously reported with cottonseed hulls. The digestion coefficients for cottonseed hulls are for this reason now on a more satisfactory basis.

OTHER DIGESTION EXPERIMENTS AND CORRECTIONS

Other digestion experiments made in America are listed in Table 4 with the references at the end of this Bulletin. This table includes the Texas experiments mentioned above, experiments made at other Stations since Bulletin No. 325 was published, and some repeated from Bulletin No. 325 for the purpose of calculating the average coefficients of digestibility.

Table 4.—Digestion coefficients of American feeds, supplementary to those in Bulletin No. 329.

Feed	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
Alfalfa hay, below 30% crude fiber	67.3	19.0	26.3	71.0	1080
"	78.0	51.0	48.0	76.0	1104
"	65.9	31.2	51.6	71.9	1112
"	67.5	26.5	50.2	67.3	1218
"	72.9	35.3	45.3	68.6	1150
Average (40)	74.3	39.8	43.0	72.4	
Alfalfa hay, 30–33% crude fiber	74.5	40.9	51.8	71.8	1134
Average (16)	71.1	31.0	44.9	70.6	
Alfalfa hay, over 33% crude fiber	66.0	0	45.0	65.0	1085
"	66.0	0	48.0	66.0	1086
"	56.0	0	42.0	64.0	1086 A
Average (23)	68.4	28.1	46.2	68.3	
Alfalfa hay, leafy, 21% crude fiber	80.2	31.9	55.2	79.6	1149
Alfalfa meal, 24% crude fiber	63.8	26.0	46.8	70.6	1111
Apple pomace, fresh	0	43.4	67.3	84.3	552
"	0	47.2	61.6	84.5	543
"	3.6	31.9	45.9	74.0	1088
"	0	32.3	55.8	77.7	1087
"	37.2	31.5	54.1	80.1	1089
Average (5)	8.2	37.3	56.9	80.1	
Barley, grain	88.1	86.3	70.4	93.0	561
"	76.3	87.5	47.3	92.3	808
"	73.6	68.3	52.3	89.7	809
"	79.9	70.7	69.3	92.2	810
"	83.9	80.0	54.3	90.9	807
"	78.3	86.9	58.8	93.0	1144
Average (6)	80.0	80.0	58.7	91.9	
Broom corn seed	33.7	91.9	33.3	69.2	733
"	52.4	80.8	36.2	63.2	1127
Average (2)	43.1	86.3	34.8	66.2	
Corn-stover silage	38.5	55.8	65.0	53.5	1098
Cotton burs	27.9	65.7	23.6	68.6	929
"	23.7	62.2	53.7	50.2	1145
Average (2)	25.8	64.0	38.7	59.4	
39% protein cottonseed feed (15.7% fiber)	84.6	99.1	61.5	87.4	1116
Cottonseed hulls, fed alone	5.7	78.1	52.1	30.4	366
"	6.8	87.8	45.9	36.9	273
"	24.6	80.6	24.6	40.3	264
"	0	50.9	48.7	55.4	1122
"	0	78.8	51.4	63.0	1129
Average (5)	7.4	75.2	44.5	45.0	
Cottonseed hulls, fed with alfalfa	0	61.8	61.9	63.3	864
"	0	93.5	52.5	71.0	1051
"	0	100.00	46.5	40.6	1123
"	0	99.1	58.9	64.7	1126
Average (4)	0	88.6	55.0	59.9	

Table 4.—Digestion coefficients of American feeds, supplementary to those in Bulletin No. 325.

Feed	Protein	Ether extract	Crude fiber	Nirto-gen-free extract	Refer-ence No.
Cottonseed hulls fed with cottonseed meal...	0	79.4	46.5	51.2	284
"	0	72.8	47.1	48.4	286
"	43.5	78.4	46.2	51.8	293
"	50.0	79.7	45.2	53.5	295
"	0	59.3	54.0	59.1	1117
"	0	81.2	56.8	60.7	1125
Average (6).....	15.6	75.1	49.3	54.1	
Cottonseed hulls, all (15).....	8.7	78.8	49.2	52.7	
Cottonseed meal, below 12% crude fiber.....	88.7	100.00	0	67.8	376
"	87.7	100.00	55.3	34.1	927
"	85.1	98.8	11.9	71.9	867
"	83.3	100.00	0	95.9	482
"	92.1	92.0	73.4	67.4	282
"	83.5	90.1	19.5	60.5	283
"	85.5	92.0	0	55.1	280
"	80.7	100.0	38.3	73.2	1050
"	73.3	94.7	53.5	53.3	1052
"	74.4	98.1	63.7	82.3	1115
"	79.6	96.9	44.3	72.7	1118
"	81.8	94.3	37.5	68.8	1124
"	83.5	97.2	68.8	78.9	1143
Average (13).....	83.0	96.5	35.9	67.8	
Goose grass.....	0	100.0	43.7	34.1	1110
Guar hay.....	74.7	16.3	45.1	72.8	1146
Hay, Harris county prairie.....	39.6	71.4	76.9	71.5	1148
Hay, Brazos county prairie.....	36.1	49.0	60.5	58.4	1147
Hay, native (New Hampshire).....	42.0	49.0	53.0	58.0	1079
Lemon pulp.....	46.2	27.4	60.3	92.0	1094
Linseed meal (old process).....	88.8	88.6	57.1	77.6	159
"	87.5	86.2	54.3	81.1	1141
"	75.3	96.1	99.7	88.7	1119
"	84.0	97.5	26.6	81.5	1114
Average (4).....	83.9	92.1	59.4	82.2	
Mesquite grass hay.....	4.21	67.7	44.5	36.4	1113
Milo, grain.....	87.9	88.2	72.3	95.6	963
"	65.9	90.2	0	84.5	829
"	78.0	89.5	100.0	98.9	1132
"	61.2	84.5	89.5	92.4	1142
Average (4).....	73.3	88.1	65.5	92.9	
Oat straw.....	23.0	54.0	50.8	54.2	997
"	28.5	45.9	57.5	60.2	998
"	13.7	31.1	71.6	51.7	812
"	0	38.3	57.6	53.2	59
"	14.3	23.3	57.3	45.1	1101
Average (5).....	15.9	38.5	59.0	52.9	
Olive pulp.....	0	86.0	0	20.3	1096
Orange pulp.....	78.5	48.9	83.7	95.4	1091
Peanut hulls or shells (commercial).....	70.6	89.7	11.7	49.1	176
"	62.2	95.9	16.4	57.6	885
"	43.4	82.0	7.7	57.6	925
"	13.2	60.7	34.4	88.0	941
"	68.5	84.1	4.7	42.5	1077
"	52.4	92.2	22.6	49.8	1138
Average (6).....	51.7	84.1	16.3	57.4	

Table 4.—Digestion coefficients of American feeds, supplementary to those in Bulletin No. 329—continued.

Feed	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
Wheat bran	86.0	77.2	42.7	74.6	945
"	82.6	84.1	44.1	80.3	947
"	77.7	80.4	12.4	75.2	972
"	70.2	72.1	16.1	67.2	34
"	78.5	60.5	56.3	70.4	163
"	82.3	54.7	25.1	74.6	139
"	79.6	75.6	23.6	70.4	162
"	78.2	66.7	14.3	71.9	179
"	73.7	82.6	0	67.5	86
"	82.1	54.0	36.2	64.1	102
"	73.7	78.1	25.9	76.8	455
"	75.6	41.9	68.5	73.5	449
"	54.1	45.9	51.7	67.8	1133
Average (13)	76.5	67.2	32.1	71.9	
Wheat brown shorts	89.3	83.6	20.7	83.4	952
"	78.9	85.1	0	82.6	85
"	78.2	88.3	56.3	82.2	1139
Average (3)	82.1	85.7	25.7	82.7	
Wheat flour middlings and gray shorts	90.8	85.7	0	87.7	451
"	82.6	95.5	0	89.5	948
"	88.9	82.7	51.9	90.6	946
"	72.7	0	0	98.6	450
"	84.8	84.9	36.3	87.8	164
"	86.4	90.7	82.4	91.1	1131
"	83.1	91.3	79.1	86.6	1137
Average (7)	84.2	88.5	35.7	90.3	

As pointed out by Hamilton, Mitchell and Kammlade in Bulletin No. 303, Illinois Experiment Station, two errors were made in the digestion coefficients given for soy bean meal in Bulletin No. 329. Number 13 and number 14 in Bulletin No. 329 are coefficients for soy bean meal with hay and not soy bean oil-meal alone. These are accordingly omitted from the revision here given.

REVISED PRODUCTION COEFFICIENTS

Table 3.—Revised production coefficients for ruminants.

Name of feed	Factor	Protein	Ether extract	Crude fiber	Nitrogen-free extract
Alfalfa hay (below 30% crude fiber)	CM	.755	.812	—.152	.776
Alfalfa hay (30–33% crude fiber)	CM	.722	.633	—.136	.756
Alfalfa hay (over 33% crude fiber)	CM	.695	.574	—.122	.732
Alfalfa hay, leafy (21% crude fiber)	CM	.814	.650	—.025	.852
Alfalfa meal (24% fiber)	CN	.648	.531	.193	.757
Apple pomace	CN	.083	.848	.291	.858
Barley, grain	BM	.813	1.82	.011	.984
Broom corn seed	AN	.438	1.963	.0	.709
Corn stover silage	CM	.391	1.139	.079	.573
Cotton burs	CM	.262	1.305	—.203	.636
39% protein cottonseed feed (15.7% fiber)	CM	.860	2.563	.041	.937
Cottonseed hulls, all	CM	.088	1.608	—.080	.564
Cottonseed meal (below 12% crude fiber)	AN	.843	2.496	.066	.726

Table 4.—Digestion coefficients of American feeds, supplementary to those in Bulletin No. 325—continued.

Feed	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Reference No.
Pineapple pulp	20.7	Neg.	69.6	79.7	1093
Pinto bean culls	53.6	41.0	Neg.	84.0	1081
Pinto bean straw	67.4	29.8	51.5	66.9	1084
Pinto bean straw and roots	35.6	22.7	44.5	63.8	1082
Raisin pulp	24.1	90.2	18.5	52.1	1090
Rice bran, below 12% fiber	67.8	89.0	33.7	79.4	859
"	74.8	92.7	4.2	74.1	921
"	64.7	54.8	13.3	78.1	425
"	62.9	88.6	29.2	78.2	749
"	76.2	89.0	32.3	68.3	1047
"	66.6	84.6	42.6	64.3	1136
Average (6)	68.8	83.1	25.9	73.7	
Rice hulls	0	0	12.0	5.0	1022
"	8.6	29.3	.4	30.8	919
"	0	13.9	11.7	15.6	1135
Average (3)	2.9	14.4	8.0	17.1	
Rice polish	69.0	90.6	29.4	89.6	858
"	65.6	73.5	22.1	92.7	426
"	61.9	91.1	0	92.3	186
"	75.0	88.2	8.2	94.3	1048
"	82.9	90.2	70.9	94.4	1130
Average (5)	70.9	86.7	26.1	92.7	
Soy bean hay	74.9	59.3	52.6	59.8	657
"	71.1	29.2	60.8	68.8	274
"	70.0	54.0	58.0	82.0	241
"	69.0	61.9	34.7	64.1	1099
Average (4)	71.3	51.1	51.5	68.7	
Soy bean meal and whole soy beans	91.1	85.7	71.2	76.3	177
"	89.8	98.5	0	68.3	423
"	91.5	93.1	100.0	82.2	556
"	91.1	93.5	100.0	91.2	548
"	90.1	84.1	0	44.7	1102
"	88.0	94.0	19.0	82.0	1106
Average (6)	90.3	91.5	48.4	74.1	
Soy bean oil meal	88.0	94.8	100.0	111.8	1103
"	90.0	74.0	55.0	82.0	1105
"	80.0	64.0	100.0	81.0	1107
"	79.0	82.0	0	86.0	1108
"	80.0	96.0	86.0	88.0	1109
Average (5)	83.4	82.2	68.6	89.8	
Soy bean straw	14.5	14.6	31.8	53.8	1100
Wheat	90.3	86.5	88.2	96.2	951
"	92.2	91.0	90.1	96.0	950
"	67.1	80.0	20.0	92.5	583
"	81.8	64.4	38.2	93.5	584
"	78.1	65.0	39.8	92.0	793
"	76.5	70.2	93.1	93.4	1140
Average (6)	81.0	76.2	61.6	93.9	

Table 3.—Revised production coefficients for ruminants—continued.

Name of feed	Factor	Protein	Ether extract	Crude fiber	Nitrogen-free extract
Flax plant by-product	CM	.204	.888	—.472	.361
Goose grass	CM	0	2.041	—.150	.365
Guar hay	CM	.759	.333	—.134	.780
Hay, Harris county prairie	CM	.402	1.457	.117	.765
Hay, Brazos county prairie	CM	.367	.999	.030	.625
Hay, native (New Hampshire)	CM	.427	1.000	—.050	.621
Lemon pulp	CM	.469	.624	.029	.985
Linseed meal (old process)	AM	.852	2.382	.019	.880
Mesquite grass hay	CM	.043	1.381	—.150	.390
Milo, grain	CM	.745	2.000	.085	.995
Oat straw	CM	.162	.786	.025	.567
Olive pulp	CM	0	2.22	—.617	.217
Orange pulp	CM	.798	1.111	.280	1.022
Peanut hulls or shells (commercial)	CM	.525	1.717	—.442	.615
Pineapple pulp	CM	.211	0	.129	.854
Pinto bean culls	B	.545	.931	0	.900
Pinto bean straw	CM	.685	.607	—.066	.717
Pinto bean straw and roots	CM	.362	.463	—.150	.683
Raisin pulp	BN	.245	2.33	—.110	.557
Rice bran (below 12% fiber)	AN	.699	2.149	—.040	.789
Rice hulls	CN	.029	.294	—.232	.183
Rice polish	AN	.720	2.243	—.038	.993
Soy bean hay	CM	.724	1.043	—.065	.736
Soy bean meal and whole soy beans	A	.917	2.367	0	.794
Soy bean oil meal	AM	.847	2,126	.117	.962
Soy bean straw	CM	.147	.298	—.276	.576
Wheat	BM	.823	1.732	.043	1.066
Wheat bran	B.77	59.84	117.62	26.47	59.29
Wheat brown shorts	B.85	70.90	165.58	23.39	75.28
Wheat flour middlings and gray shorts	B.93	79.56	187.08	35.55	89.94

Revised energy-production coefficients are given in Table 3. The additional experiments made little change in these coefficients for some of the feeds. With other feeds where few experiments had previously been made, the changes are larger. It should be pointed out that the basis for making the calculations of production coefficients for lemon pulp, orange pulp, and pineapple is unsatisfactory and additional data are needed.

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REFERENCES TO DIGESTION EXPERIMENTS

Numbers	
1-1078	See Texas Bulletin 329.
1079	New Hampshire Bulletin 152.
1080	Illinois Bulletin 283.
1081-1084	New Mexico Bulletin 143.
1085-1086A	Washington Station, Jour. Agr. Res. 35, p. 4.
1087-1089	Virginia Technical Bulletin 32.
1090-1096	California Bulletin 409.

Numbers	
1097-1103	Illinois Bulletin 291.
1104-1109	Illinois Bulletin 303.
1110-1150	Texas, this Bulletin.

SUMMARY AND CONCLUSIONS

1. Digestion experiments numbering 41 are reported and include tests on alfalfa, barley, broom-corn seed, cotton burs, cottonseed hulls, cottonseed meal, flax plant by-product, guar hay, linseed meal, milo, peanut hulls, prairie hay, rice bran, rice hulls, rice polish, wheat, wheat bran, wheat gray shorts, and wheat brown shorts.
2. The composition, coefficients of digestibility, and production coefficients are given for the samples studied.
3. Digestion experiments made at other American Experiment Stations are referred to, and corrections made in some figures previously published, especially for soy-bean products.
4. Production coefficients are given supplementing those in Bulletin No. 329, based on the new data published in this Bulletin.