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AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
W. B. BIZZELL, President

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DIVISION OF CHEMISTRY

DIGESTION EXPERIMENTS WITH OAT BY-PRODUCTS AND OTHER FEEDS

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**In cooperation with United States Department of Agriculture.
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SUMMARY

This bulletin contains a report of digestion experiments with 12 feeds, conducted for the purpose of securing information regarding their feeding values as shown by their productive values and digestible protein. The feeds studied are alfalfa meal, corn cobs, cottonseed hulls, kafir head stems, live-oak leaves, mesquite beans, oats, oat hull clippings, oatmeal by products, rice bran, and rice polish. The composition, coefficients of digestibility, digestive protein, productive value, and production coefficients are given for the samples studied. This is a progress report, so that detailed discussion of the feeds is left for a later bulletin.

DIGESTION EXPERIMENTS WITH OAT BY-PRODUCTS AND OTHER FEEDS

Report No. 7.

by

G. S. Fraps.

INTRODUCTION

This bulletin contains a report of digestion experiments with 12 feeds, conducted for the purpose of securing information regarding their feeding values as shown by their productive values and digestible protein. The feeds studied are alfalfa meal, corn cobs, cottonseed hulls, kafir head stems, live-oak leaves, mesquite beans, oats, oat hull clippings, oatmeal by-products, rice bran, and rice polish. The composition, coefficients of digestibility, digestive protein, productive value, and productive coefficients are given for the samples studied. This is a progress report, so that detailed discussion of the feeds is left for a later bulletin.

This is the seventh bulletin in a series whose object is to ascertain the feeding value of Texas feeding stuffs by means of digestion experiments. Previous bulletins in the series are 104, 147, 166, 203, 245, and 291.

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, though it is not the only factor. Our knowledge of the digestibility of many feeds is not yet sufficient for a basis for estimating their productive value. The object of this work 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 feed where data is needed. The digestibility of sugar, starches, and other constituents of these feeds is being studied, with the same object in view.

More extended discussions of the feeding values of the feeds reported on in this Bulletin will be presented in subsequent bulletins.

The value of feeding stuffs for feeding purposes depends upon several things. These include its bulk, its palatability, its ash content, its suitability to the animal, its vitamine con-

tent, its digestible protein, and its productive value. The most important of these from the standpoint of animal nutrition are the digestible protein and the productive value.

DEFINITION OF TERMS

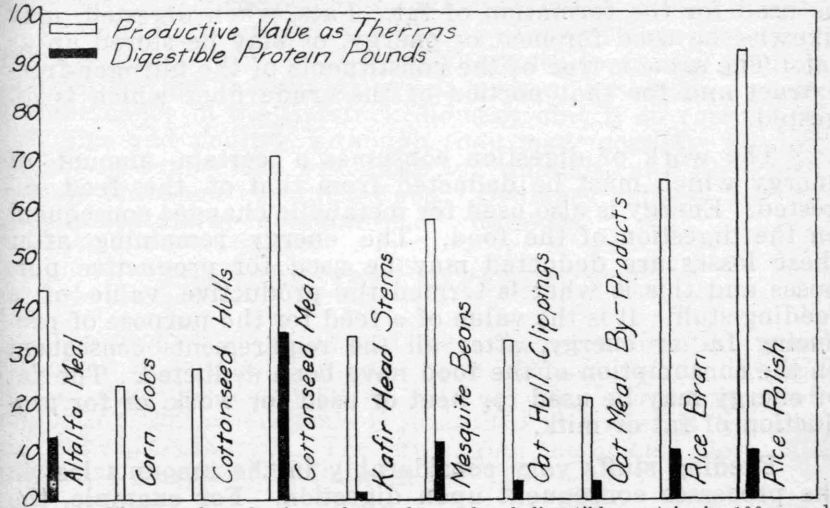

Figure 1—Therms of productive value and pounds of digestible protein in 100 pounds of the feeds studied.

Digestible Protein—Protein is the constituent 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 animal's body. The amount of digestible protein represents the capacity of the food to furnish material for the production of lean meat, or for the repair or replacement of the tissue 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 there are usually several different kinds of chemical compounds in the protein. 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 they should be. The investigations along this line are not yet definite enough to permit satisfactory statements with regard to the qualities of different protein constituents in feeding stuffs.

Productive Value—Productive value means the ability of the feeding stuff to furnish animals the material for heat, for bodily energy, for work, or for the production of fat. Protein, when digested, may be burned for the production of heat, or energy, or its nitrogen may be split off and the residue be used for the formation of fat. Fats, when digested, may likewise be used for 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 which must be deducted from that of the feed digested. 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 and this is what is termed the productive value of a feeding stuff. 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. The fat or energy may be used for heat or used for work, or for production of fat or milk.

Feeding stuffs vary considerably in the amounts 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 a great loss in digestion, and the productive value is consequently lowered.

The productive value 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 additions of the feed to be studied and represents its fat-producing power. The productive value may be stated in terms of matter, such as fat, or in terms of energy, such as therms. It is commonly stated in terms of therms.

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

Vitamines—Vitamines are substances which are essential to the life of the animal. It is believed that there are several

different groups. One group is chiefly present in seeds, and another chiefly in the leaves of plants, while milk contains three or more.

Seed products highly milled for human use have their vitamines largely removed. For example, in the milling of rice, the vitamines are left in the bran and removed almost entirely from the grain. The relation of vitamines to animal feeding requires further investigations; at present vitamines appear of significance in the livestock industry chiefly in connection with pigs and poultry, although they may possibly be important in connection with breeding animals, and also with animals fed upon certain rations. Ordinary rations fed to animals contain an abundance of vitamines.

THE DIGESTION EXPERIMENTS

The productive value and the values for digestible protein 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 No. 147 and 166 of this Station. The production coefficients were calculated as described in Bulletin No. 185.

COEFFICIENTS OF DIGESTIBILITY

The coefficients of digestibility are used to calculate the digestible constituents of a feeding stuff, and until ten or fifteen years ago the digestible nutrients were used exclusively for calculating rations in the feeding of animals. Developments in scientific knowledge concerning 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 are of different value 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 value to one pound 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 feeding experiments, on the assumption of the equality in value of the nutrients, is of course no longer permissible.

RESULTS OF THE EXPERIMENTS

Table 1—Composition, productive value and digestible protein in 100 pounds feed used.

Laboratory Number		Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract	Water	Ash	Productive Value Therms	Digestible Protein Pounds
20715–6	Alfalfa meal, D.E. 144	17.19	1.84	22.76	41.00	7.82	9.39	43.04	12.88
19421–2	Alfalfa meal, D.E. 134	10.98	1.67	35.06	38.82	6.85	6.62	35.55	7.81
19920–1	Corn cobs, D.E. 139	3.25	.33	34.93	53.31	6.41	1.77	23.55	0
20190–	Corn cobs, D.E. 141	2.90	.30	34.26	52.71	8.30	1.53	27.87	0
21086–7	Cottonseed hulls, D.E. 146	3.42	.68	48.60	36.16	8.78	2.36	26.97	0
21035–6	Cottonseed meal fed with alfalfa D.E. 145	42.97	6.62	11.52	26.37	6.33	6.19	70.77	34.68
21035–6	Cottonseed meal fed with hulls, D.E. 147	42.97	6.62	11.52	26.37	6.33	6.19	62.94	31.50
19861–2	Kafir head stems, D.E. 138	6.73	.99	19.61	56.72	8.02	7.93	33.15	1.36
21176–7	Mesquite beans, D.E. 148	12.89	1.92	27.49	47.52	5.39	4.79	57.79	11.65
19464–5	Oats, low grade, D.E. 135	11.14	4.61	16.92	54.96	8.53	3.84	66.77	7.91
20101–	Oat hull clippings, D.E. 140	8.75	2.34	24.39	46.27	8.05	10.20	32.30	3.46
19833–4	Oat hull clippings, D.E. 137	8.70	2.46	24.66	46.74	7.40	10.04	38.30	3.26
21206–7	Oak leaves, live oak, D.E. 149	9.28	2.66	29.93	45.30	6.23	6.60	0	0
19821–2	Oat meal by-products, D.E. 136	6.46	1.89	28.89	50.87	6.08	5.81	20.89	3.29
20565–6	Rice bran, D.E. 142	13.21	13.86	15.91	37.64	7.60	11.78	65.65	10.07
20827–8	Rice polish, D.E. 143	13.42	9.42	2.73	59.92	8.66	5.85	92.24	10.07

The composition of the feeds used is shown in Table 1, together with the digestible protein and productive values of the feeds expressed as therms.

Table 2 contains the coefficients of digestibility

PRODUCTION COEFFIENTS

The productive coefficients of the feeds studied calculated according to the method described in Bulletin 185 are given in Table 3. The productive value of the feeds can be calculated by multiplying the composition by the production coefficient and adding the products, with due regard to the positive or negative value of crude fiber.

DESCRIPTION OF FEEDS USED

Alfalfa Meal—Two samples of alfalfa meal were used, one low in fiber, the other high in fiber. Alfalfa meal was fed with all the feeds used in the experiments here discussed, excepting in Experiment 147 cottonseed hulls were fed with cottonseed meal.

Corn Cobs—Ground corn cobs were used. Corn cobs have a low feeding value.

Table 2—Digestion Coefficients found in the experiments.

Laboratory Number		Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
20715–6	Alfalfa meal 22.8% fiber, D.E. 144	74.9	20.1	43.1	73.7
19421–2	Alfalfa meal 35.1% fiber, D.E. 134	71.1	50.5	49.5	68.2
19920–1	Corn cobs, D.E. 139	0	1.4	52.4	43.6
20190–	Corn cobs, D.E. 141	0	59.1	56.4	48.7
21086–7	Cottonseed hulls, D.E. 146	0	92.9	52.50	71.02
21035–6	Cottonseed meal, D.E. 145	80.65	100.0	38.32	73.15
	Cottonseed meal, fed with hulls, D.E. 147	73.3	94.7	53.5	53.3
19861–2	Kafir head stems, "pummies," D.E. 138	20.18	52.90	33.11	58.40
21176–7	Mesquite beans, D.E. 148	90.41	95.3	58.9	81.29
19464–5	Oats, low grade, D.E. 135	71.0	92.4	60.5	82.0
20101–	Oat hull clippings, D.E. 140	39.51	76.35	55.8	57.59
19833–4	Oat hull clippings, D.E. 137	37.53	77.40	55.9	61.26
21206–7	Oak leaves, live oak, D.E. 150	0	29.70	10.42	26.9
19821–2	Oat meal by-products, D.E. 136	50.98	82.75	29.63	40.64
20565–6	Rice bran, D.E. 142	76.20	89.04	32.31	68.32
20827–8	Rice polish, D.E. 143	75.00	88.21	8.2	94.32

Cottonseed Hulls—Cottonseed hulls were fed with alfalfa. The digestibility was not as high as in a previous experiment, but higher than some other experiments secured.

Cottonseed Meal—The protein of cottonseed meal was digested about ten per cent. less when it was fed with cottonseed hulls (D. E. 147) than when fed with alfalfa. The fiber was digested to a greater extent when fed with the hulls than with the alfalfa, and the nitrogen-free extract less.

Kafir Head Stems—Kafir head stems are a waste product from threshing kafir heads, and are sometimes called "pummies." They have a digestibility near to that of ordinary hay, and a corresponding value. The digestible protein is low.

Live Oak Leaves—These live oak leaves came from Midland and were collected in February 1923. They were dry when fed. An attempt to feed 100 grams with 100 grams alfalfa was not successful. When 50 grams were fed with 150 grams alfalfa, one animal ate them, the other refused to eat. No digestible protein and no productive value was found in the experiment made. Additional experiments are needed, for range goats eat live oak leaves freely at certain periods of the year, and we would expect them to have some feeding value.

Mesquite Beans—The mesquite beans came from Spur. They have a high digestibility and a productive value about 50 per cent. higher than alfalfa.

Table 3—Production Coefficients as found in the experiments.

Laboratory Number		Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
20715–6	Alfalfa, D.E. 144	.761	.410	−.138	.789
19421–2	Alfalfa meal, D.E. 134	.732	1.031	−.070	.730
19920–1	Corn cobs, D.E. 139	0	.029	−.039	.467
20190–	Corn cobs, D.E. 141	0	1.207	0	.522
21086–7	Cottonseed hulls, D.E. 146	0	1.908	−.038	.761
21035–6	Cottonseed meal, D.E. 145	.819	2.586	−.190	.783
21035–6	Cottonseed meal, D.E. 147	.744	2.448	−.027	.571
19861–2	Kafir head stems, D.E. 138	.205	1.080	−.245	.626
21176–7	Mesquite beans, D.E. 148	.919	1.945	.030	.871
21206–7	Oak leaves, live oak, D.E. 149	0	.542	−.488	.288
19464–5	Oats, low grade, D.E. 135	.721	2.100	.048	.878
20101–	Oat hull clippings, D.E. 140	.401	1.558	−.140	.617
19833–4	Oat hull clippings, D.E. 137	.381	1.759	0	.656
19821–2	Oat meal by-products, D.E. 136	.518	1.881	−.282	.435
20565–6	Rice bran, D.E. 142	.774	2.303	−.254	.732
20827–8	Rice polish, D.E. 143	.762	2.281	0	1.010

Oats—The oats used were low grade, and contained nearly 17 per cent. crude fiber.

Oat Hull Clippings—Oat hull clippings are the clippings from oats when they are cut for the purpose of reducing their weight to the bushel. Their productive value appears to be usually about the same as ordinary hay, and sometimes a little more.

Oat Meal By-Products—Oat meal mill by-products consist of a mixture of oat hulls, with a small amount of fine oat groats, and are obtained in the manufacture of rolled oats for human consumption. The digestibility of this material was much lower this year than last year, and the resulting productive value is little over half that of ordinary hay. This product consists chiefly of oat hulls, and oat hulls have a low digestibility and a low feeding value.

Rice Bran and Rice Polish—Rice bran and rice polish are by-products secured in the process of rice milling. The productive value of the rice polish was 50 per cent. more than that of rice bran, while the digestible protein was nearly the same.

ACKNOWLEDGMENT

Laboratory and other work involved in this Bulletin was taken part in by S. E. Asbury, W. H. Walker, J. B. Smith, Mrs. Velma Graham, and other members of the staff.

Table 4—Digestion Coefficients obtained with each sheep.

Laboratory Number		Sheep	Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
20715–6	Alfalfa meal, D.E. 144	A	73.13	20.62	37.62	72.28
		B	76.65	19.58	48.62	75.10
19421–2	Alfalfa meal, D.E. 134	A	71.12	50.50	49.53	68.18
19920–1	Corn cobs, fed with alfalfa, D.E. 139	A	0	0	57.96	43.46
		B	0	2.87	46.85	43.81
	Corn cobs, fed with alfalfa, D.E. 141	A	0	35.21	59.13	48.58
		B	0	83.04	53.65	48.79
21086–7	Cottonseed hulls, fed with alfalfa, D.E. 146	A	0	100.00	49.55	67.70
		B	0	87.00	55.45	74.33
21035–6	Cottonseed meal, fed with alfalfa, D.E. 145	A	79.11	100.00	42.75	72.59
		B	82.19	100.00	33.88	73.71
	Cottonseed meal, fed with C/S hulls, D.E. 147	A	72.50	94.86	61.09	53.59
		B	74.00	94.49	45.88	53.04
19861–2	Kafir head stems, fed with alfalfa, D.E. 138	A	30.13	60.20	48.12	62.70
		B	10.23	45.60	18.10	54.09
21176–7	Oak leaves, live oak, fed with alfalfa, D.E. 149	A	0	26.53	10.42	26.87
21206–7	Mesquite beans, fed with alfalfa, D.E. 148	A	85.40	97.70	58.80	80.42
		B	95.42	92.80	58.89	82.15
19464–5	Oats, low grade, fed with alfalfa, D.E. 135	A	71.00	92.40	60.50	82.01
20101–	Oat hull clippings, fed with alfalfa, D.E. 140	A	44.18	73.60	45.36	59.22
		B	34.84	79.10	40.61	55.95
19833–4	Oat hull clippings, fed with alfalfa, D.E. 137	A	41.05	81.00	64.90	64.88
		B	34.01	73.80	47.04	57.63
19821–2	Oat meal by-products, fed with alfalfa, D.E. 136	A	50.49	83.60	30.45	38.05
		B	51.46	81.90	28.90	43.23
20565–6	Rice bran, fed with alfalfa, D.E. 142	A	75.92	90.14	28.93	67.50
		B	76.40	87.93	35.68	69.13
20827–8	Rice polish, fed with alfalfa, D.E. 143	A	68.60	87.61	0	91.80
		B	81.35	88.81	16.39	96.84