Ohio Agricultural Experiment Station.

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FEEDING FOR BEEF.

EXPERIMENTS IN FEEDING FOR BEEF.

THE CHEMISTRY OF CATTLE FEEDING.

COMPARATIVE VALUE OF FEEDING STUFFS.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 60. August, 1895.

EXPERIMENTS IN FEEDING FOR BEEF.

BY C. E. THORNE AND J. FREMONT HICKMAN.

FIRST TEST.

In June, 1893, 32 three-year-old steers were purchased of farmers in the neighborhood of the Station. They were grades of mixed breeding, Shorthorn blood predominating, but there were several which showed an admixture of Holstein, Hereford and Jersey blood.

The steers were grazed on the Station farm during the summer and fall, and in January they were divided into nine lots, seven of four steers each and two of two steers each, the breeding and weight of the steers composing the different lots being shown in Table I, the attempt being made to make the seven larger lots as uniform as possible in the quality of the cattle composing them.

TABLE I.—BREEDING AND INITIAL WEIGHTS.

Lot.	No.	Breeding.	Initial weights.
			Pounds.
A	1	Grade Holstein	1,106
	2	" "	1,055
	3	" Shorthorn	982
	4	" "	932
		Average	1,019
B	5	Grade Holstein	1,072
	6	" "	1,069
	7	" Shorthorn	949
	8	" "	830
		Average	980

TABLE I—Concluded.

Lot.	No.	Breeding.	Initial weights.
			Pounds.
C	9	Grade Hereford	1,061
	10	" Holstein	1,075
	11	" Shorthorn	885
	12	" Jersey	904
		Average	981
D	13	Grade Shorthorn	991
	14	" "	1,082
	15	" "	910
	16	" "	881
		Average	966
E	17	Grade Shorthorn	1,004
	18	" "	915
	*19	" "	946
	20	" Jersey	890
		Average	939
F	21	Grade Shorthorn	1,137
	22	" "	952
	23	" "	852
	24	" "	898
		Average	960
G	25	Grade Shorthorn	1,099
	26	" "	1,032
	27	" "	960
	28	" "	889
		Average	995
H	29	Grade Shorthorn	931
	30	" "	832
		Average	881
I	31	Grade Shorthorn	776
	32	" "	830
		Average	803
		Average of H and I	842
		Average of all	960

* Steer No. 19 met with an accident during the test, making it necessary to withdraw him from the experiment.

The "initial weight" as given in the above table is the average of three weighings, made on the 9th, 10th and 11th of January, and all live weights subsequently quoted, except the final weights in the stock yards, are likewise the average of three weighings.

To each of the three lots was apportioned a ration, composed as follows:

Lot A.—Wheat bran, corn meal, gluten meal, clover hay.
Lot B.—Wheat bran, corn meal, gluten meal, clover hay, corn silage.
Lot C.—Wheat bran, corn meal, oil meal, clover hay.
Lot D.—Wheat bran, corn meal, oil meal, clover hay, corn silage.
Lot E.—Wheat bran, wheat meal, gluten meal, clover hay, corn silage.
Lot F.—Wheat bran, wheat meal, oil meal, clover hay, corn silage.
Lot G.—Wheat bran, corn meal, clover hay, corn silage.
Lot H.—Wheat bran, corn meal, timothy hay, corn silage, fed in barn.
Lot I.—Wheat bran, corn meal, timothy hay, corn silage, fed in shed.

To lots A, B, C and D—16 steers in all—was given a basal ration consisting of equal weights of corn meal and wheat bran, with as much clover hay as they would eat; a ration of hay, containing a few pounds more than they would eat, being weighed out to them morning and evening, and the mangers cleaned out and the residue weighed next morning.

Lots E and F, eight steers, received wheat meal in equal weights with bran, instead of corn meal, with the same ration of clover hay.

In addition to this basal ration, all the cattle, except lots A and C, received corn silage, fed at the rate of 20 to 34 pounds per day, according to the appetite of the animal, some of the steers consuming the larger quantity regularly, while others always left more or less uneaten.

To three lots, A, B and E. gluten meal was fed, and old process linseed oil meal to lots C, D and F, beginning in each case with one pound per steer per day and increasing gradually until the gluten or oil meal constituted one-fourth of the entire grain ration.

Lots G, H and I received corn meal and bran alone, without either gluten or oil meal, but with hay and silage as fed to the other lots; the hay being timothy instead of clover for the two small lots, H and I, and the corn meal constituting 64 per cent. of the meal ration. As our barn held but 30 cattle, four of the smaller ones were divided into two small lots, H and I, lot H being fed in the barn and lot I in an open shed in the barnyard.

After the cattle had eaten their morning feed they were weighed, the weighing beginning at ten o'clock; they were then allowed to drink from a tub standing on scales in the barn, the amount of water drunk being determined, after which, in fair weather, when the thermometer was not below 20°, they were turned into an open barnyard until afternoon, when they were stabled again, earlier or later, according to the weather.

While in this barnyard the cattle had access to a stack of wheat straw and some straw was eaten. The quantity, however, was very small, as they were given all the grain and hay they could be induced to eat, and no attempt has been made to account for the straw in the following calculations.

The experiment would have been more satisfactory, from the scientific standpoint, had the consumption of straw been determined; but on the ordinary Ohio farm straw is valued only as bedding and as an absorbent of manure, and therefore the practical feeder takes no account of it as a part of his rations. For his purpose, therefore, the determination of the amount of straw consumed would have added nothing to the value of the experiment, since all the cattle were given all the meals, silage and hay they could be induced to eat.

We did not attempt to feed the wheat unground, because we believed that if fed in that condition much of it would pass through undigested. This might have been partly obviated by soaking, but soaking is hardly practicable in winter weather. We have for years followed the practice of feeding corn meal and wheat bran in equal weight, in the belief that both the physical condition and nutritive effect of both foods is improved by the mixture, and we believed that a similar result would follow the mixing of ground wheat with its weight in bran; we therefore decided to make bran the basis of all the meal rations, adding to it corn meal, wheat meal, etc., according to the object in view.

It is possible that we might have fed the wheat meal more successfully by sprinkling it on moist, cut hay and silage; but under this method of feeding we could not have determined the exact amount eaten, which was a necessary part of the experiment.

The meals, especially the gluten and oil meals, were fed in small quantity at first, the ration being gradually increased until the cattle showed signs of surfeit, when it would be reduced until they were eating freely again. During the latter half of the test the cattle receiving mixtures containing corn meal and bran as the basis consumed 15 to 16 pounds of meal per steer per day. In the case of the wheat meal mixtures greater difficulty in feeding was experienced, and the ration was not raised above 12 pounds per head per day.

COST OF INCREASE.

The experiment was begun January 11 and continued without change of plan for 120 days. The average results for this period are summarized in Table II, which gives for each steer the total feed consumed, both in ordinary and chemically dry condition, the initial weight and the total gain, and the average quantity of dry substance consumed and the **cost of** the same, to produce a pound of increase in live weight.

By dry substance is meant the absolutely dry material, after all **the** water has been driven off at a temperature of 212° Fahrenheit. This **dry** substance is made the basis of comparison because repeated **experiments** have demonstrated that the water contained in such watery foods **as** silage, for instance, has no more nutritive value than water drawn from **a** spring or well. Such water may add to the palatability of a food, but **it** does not add to its nutritive effect.

TABLE II.—FEED CONSUMED AND TOTAL GAIN, 1894.

Lot.	No	Weight at beginning of test.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed.	
			Meals.	Hay.	Silage.	Total.	Per pound of gain.		Total.	Per pound of gain.
		Pounds.	*Pounds.*	*Pounds*	*Pounds.*	*Pounds.*	*Pounds.*	*Pnds.*	$.......	*Cents.*
A	1	1,106	1,802	1,297	....	2,775	9.84	282	20.00	**7.09**
	2	1,055	1,802	1,905	....	3,325	9.53	349	22 44	**6.43**
	3	982	1,802	1,061	....	2,561	10.58	242	19.06	**7.87**
	4	932	1,726	764	....	2,203	9.07	243	17.13	**7.05**
Average.		1,019	1,783	1,249	....	2,716	9.73	279	19.66	**7.05**
B.	5	1,072	1,721	495	4,010	2,950	10 07	293	21.15	**7.22**
	6	1,069	1,675	514	3,577	2,820	11.70	241	20.30	**8.42**
	7	949	1,698	470	2,902	2,638	9.13	289	19.47	**6 74**
	8	830	1,414	393	2,262	2,071	9.95	208	15.61	**7.51**
Average.		980	1,627	443	3,188	2,620	10.16	258	19.13	**7.42**
C.	9	1,061	1,793	1,346	....	2,811	14 06	200	21.71	**10.86**
	10	1,075	1,802	1,034	....	2,537	11.38	223	20.55	**9.20**
	11	885	1,766	1,002	....	2,476	13 91	178	20.49	**11.29**
	12	904	1,772	1,018	....	2,495	10.66	234	20.29	**8.63**
Average.		981	1,783	1,100	....	2,580	12.36	209	20.63	**9.88**
D.	13	991	1,148	335	3,681	2,215	12.24	181	16.38	**9.05**
	14	1,082	1,723	584	4,015	3 028	10.40	291	23.06	**7.92**
	15	910	1,654	216	2 855	2,353	8.62	273	19.49	**7.14**
	16	881	1,593	323	2,946	2,419	11.41	212	19.48	**9.19**
Average.		966	1,529	365	3,374	2,504	10.47	239	19.00	**8.20**
E.	17	1,004	1,375	507	2,868	2,382	10 40	229	17.99	**7.85**
	18	915	999	423	2,932	1,986	14 39	138	14.35	**10.40**
	19	....	....	....	....	....	....	....	....	**.........**
	20	890	1,304	431	2,778	2,227	8.34	267	16.93	**6.34**
Average.		936	1,226	453	2,859	2,198	10.40	212	16.42	**7.77**

TABLE II.—Concluded.

Lot.	No.	Weight at beginning of test.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed.	
			Meals.	Hay.	Silage.	Total.	Per pound of gain.		Total.	Per pound of gain.
		Pounds	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pnds.*	$.......	*Cents.*
F.	21	1,137	1,378	344	4,018	2,510	11.05	227	19.06	8.40
	22	952	1,381	348	4,017	2,516	9.05	278	20.11	7.23
	23	852	1,328	644	2,857	2,456	9.00	273	19.32	7.08
	24	898	1,348	686	2,898	2,522	10 29	245	19.71	8.05
Average.		960	1,358	505	3,447	2,501	9.78	255	19.80	7.74
G.	25	1,099	1,641	527	3,595	2,795	9.88	283	19.73	6.97
	26	1,032	1,626	296	3,204	2,479	12 21	203	18.20	8.96
	27	960	1,626	219	2,857	2,320	10.04	230	17.50	7.59
	28	889	1,619	267	2,932	2,377	11.37	209	17.68	8.46
Average.		995	1,628	327	3,397	2,493	10.78	231	18 27	7.90
H-1	29	931	1,642	313	1,727	2,142	10.65	201	16.54	8.23
	30	832	1,637	398	2,322	2,363	8 32	284	17.59	6 19
	31	776	1,638	194	2,904	2,321	8.35	278	17 51	6.30
	32	830	1,638	365	2,713	2,434	11.27	216	17.97	8.32
Average.		842	1,639	317	2,416	2,315	9.46	245	17.40	7.11
Av. of all		960	1,583	599	2,285	2,500	10.33	242	18.94	7.82

SECOND TEST.

After the sale of the 32 steers used in the test just described a second lot of 16 steers, of similar age and breeding, was purchased and grazed through the summer and fall. Like the previous lot, these steers were prepared by preliminary feeding in the fall, and on January 11 were put under systematic experiment, being divided for this purpose into five lots as shown in Table III:

TABLE III.—BREEDING AND INITIAL WEIGHTS.

Lot.	No.	Breeding.	Initial weight.
A	1	Grade Shorthorn	1,100
	2	" "	1,047
	3	Shorthorn Jersey	882
	4	Grade Holstein	986
		Average	1,003
B	5	Grade Shorthorn	1,060
	6	Shorthorn Jersey	1,046
	7	Grade Shorthorn	1,016
	8	Shorthorn Devon	914
		Average	1,009
C	9	Grade Shorthorn	1,022
	10	" "	1,014
	11	Shorthorn Jersey	871
	12	Grade Shorthorn	911
		Average	954
D	13	Grade Shorthorn	1,188
	14	" "	889
		Average	1,029
E	15	Native	968
	16	Grade Shorthorn	931
		Average	949
		Average of D. and E.	994
		Average of all	990

As in the previous test, the weights given in this experiment are the averages of three weighings, made on consecutive days.

The following rations were apportioned to these lots:

Lot A.—Wheat bran, wheat meal, gluten meal, hay and silage.
Lot B.—Wheat bran, wheat meal, gluten meal, hay and stover.
Lot C.—Wheat bran, corn meal, gluten meal, hay and silage.
Lot D.—Wheat bran, corn meal, hay and silage, fed in barn.
Lot E.—Wheat bran, corn meal, hay and silage, fed in shed.

The main objective points in this test were a repetition of the comparison between wheat meal and corn meal and a comparison between corn silage and the ordinary field-cured corn fodder of Ohio (called "stover" in the East.)

The cattle were handled as in the previous experiment, except that the meal ration was kept at a lower point, so that there were very few cases of surfeit during the test, and these occurred after the animals had been feeding for a week or more upon an unchanged ration.

Table IV gives for this test the data given in Table II for the previous test; these data covering the period of 110 days from January 11 to April 30, inclusive:

TABLE IV.—FEED CONSUMED AND TOTAL GAIN, 1895.

Lot.	No.	Initial weight.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed per pound of gain.
			Meals.	Hay.	Silage or stover.*	Total.	Per pound of gain.		
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds*	*Pounds.*	*Cents.*
A	1	1,100	1,281	838	2,570	2,471	13 14	188	9.62
	2	1,047	1,281	699	2 570	2,340	12.00	195	9.00
	3	882	1,114	309	2,543	1,817	9 93	182	7.93
	4	986	1,165	540	2,548	2,187	11.95	183	9.22
Average.......		1,003	1,210	596	2,558	2,264	11.78	187	8.95
B	5	1,060	1,281	938	511*	2,524	12.25	206	8.16
	6	1,046	1,278	996	376*	2,449	16 55	148	11.14
	7	1,016	1,216	961	381*	2,364	14.41	164	9.72
	8	914	1,242	907	310*	2,297	12.35	186	8.60
Average.......		1,009	1,262	943	394*	2,401	13.64	176	8.93
C	9	1,022	1,279	723	2,384	2,323	10.61	219	7.50
	10	1,014	1,281	660	2,570	2,596	9.17	283	6.26
	11	871	1,087	445	2,018	1,815	12.26	148	9.02
	12	911	1,281	556	2,030	2,098	8.74	240	6.43
Average.......		954	1,232	671	2,250	2,208	9.90	222	7.01
D&E	13	1,188	1,291	1,097	2,570	2,723	12.16	224	8.00
	14	889	1,291	742	2,613	2,401	9.68	248	6.68
	15	968	1,265	884	2,492	2,483	10 10	238	6 63
	16	931	1,292	762	2,546	2,405	12 40	194	8 06
Average.......		994	1,256	871	2,555	2,503	11.07	226	7.40
Av'ge of all...		990	1,247	770	2,483	2,335	11.93	203	8.10

* Stover.

The cost of food, as given in Tables II and IV, is based upon the market price of the feeding stuffs at the Station at the time the first experiment was made, with respect to the meals and hay, and upon an estimated relative value of $2.50 per ton for corn silage. Following are the prices:

Corn meal	$16 00	per ton.
Wheat meal	20.00	"
Gluten meal	18.00	"
Oil meal	26 00	"
Wheat bran	16.00	"
Clover hay	8 00	"
Corn silage	2.50	"

These values of corn meal and wheat meal correspond to a fraction over 39 cents per bushel for corn and to about 52½ cents per bushel for wheat, one-eighth being allowed for grinding.

Tables II and IV show a wide range of productiveness in the different steers, the variations due to individuality being so great that conclusions must be drawn with caution, even when lots of ten or twelve animals are compared. It must therefore be understood that the conclusions which follow are tentative only, and are subject to revision or reversal when our knowledge shall be increased by more extended investigation.

CORN MEAL *vs.* WHEAT MEAL.

The results of this comparison are summarized in Table V:

TABLE V.—COMPARISON OF CORN AND WHEAT MEALS.

Year.	Test food.	Lots compared.	No. of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of feed per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Corn meal	B. D.	8	2.07	10.31	7.79
	Wheat meal	E. F.	7	1.98	10.02	7.75
1895	Corn meal	C.	4	2.02	9.90	7.01
	Wheat meal	A.	4	1 70	11.78	8 95

These results, as will be seen, are contradictory, the wheat meal showing the better result in 1894, and the corn meal in 1895.

OIL MEAL *VS.* GLUTEN MEAL.

Table VI shows the results of the comparison of oil meal and gluten meal, the oil meal being the ordinary, old process meal and the gluten meal being the product of the American Glucose Company, of Buffalo, N. Y. and Peoria, Ills., the two meals containing the following proportions of dry substance and protein as determined in our laboratory:

	Dry substance.	Protein.
Oil meal	90.25	37.81
Gluten meal, 1894	91.94	27.71
Gluten meal, 1895	91.81	22.81

TABLE VI.—COMPARISON OF OIL MEAL AND GLUTEN MEAL.

Year.	Test food.	Lots compared.	Number of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Oil meal	C. D. F.	12	1.96	10.78	8.52
	Gluten meal	A. B. E.	11	2.11	10.05	7.31
	Mixed meals with Gluten meal.	B.	4	2.15	10.31	7.42
	" " without " "	G. H. I.	8	1.98	10.10	7.49
1895	" " with " "	C.	4	2.02	9.90	7.01
	" " without " "	D. E.	4	2.05	11.07	7.40

The test of 1894 seemed to show clearly that, at the relative cost of the two feeding stuffs ($26.00 per ton for oil meal and $18.00 per ton for gluten meal), the gluten meal was much the cheaper food, and therefore the oil meal was not used again in 1895. In both tests, however, a ration of corn meal, bran and gluten meal was compared with a similar ration containing no gluten meal, the results being again in favor of the gluten meal.

CORN SILAGE AS PART OF A RATION.

In 1894, lots A and C received no silage, while lots B and D had the same meal and hay rations with silage in addition. The results are given in Table VII, together with the comparison in 1895 of silage with stover:

TABLE VII.—CORN SILAGE AS PART OF A RATION.

Year.	Test food.	Lots compared.	Number of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Ration with silage..................	B. D.	8	2.07	10.31	7.79
	Ration without silage...............	A. C.	8	2.03	10.86	8.26
1895	Silage................................	A.	4	1.70	11.78	8.95
	Stover................................	B.	4	1.60	13.64	8.93

The silage in 1894 contained about eight per cent. of grain, as shown by frequent determinations, the quantity being considerably larger near the top of the silo. Up to February 20 the average was 17 per cent., after that date, 5 per cent. In 1894 the proportion of grain did not exceed one-half of one per cent., and ran quite uniformly near this quantity In 1894 the grain contained in the silage was a material addition to the ration, amounting to an average of a pound and a half per steer per day; but in 1895 the quantity was less than an ounce and a half per steer per day—probably not more than was found in the stover fed in comparison.

CORN SILAGE VS. CORN STOVER.

Our silage corn, planted late and on thin land, had failed to ear because of the drouth, so that it seemed practicable to make a direct comparison between corn fodder cured as silage and corn fodder field cured in the ordinary way. The fall was favorable for field curing, and the stover was put into the barn, after husking, in unusually good condition. It was cut before feeding, and was fed to the cattle at the rate of eight pounds per steer per day, while the silage was fed at the rate of 24 pounds per head per day; these quantities being adopted on the supposition that the dried fodder would contain about 75 per cent. dry substance and the silage about 25 per cent., thus making the two rations uniform in quantity of dry substance contained. It turned out, however, that the stover contained more dry substance and the silage less than was anticipated, the former averaging 93 per cent. and the latter only 20 per cent. of dry substance.

In computing the relative cost of the rations containing stover and silage the stover is valued at $3.00 per ton, which is about its market value here, while the silage is valued at $2.50, as in the previous test, though this is a high valuation for silage containing no grain. At these valuations, the cost of the increase made on the two rations was the same (see Table VII), but the silage-fed cattle made their gain on considerably less dry substance than those fed on stover, and, more than this, the silage-fed cattle consumed a much larger proportion of the silage than the stover-fed lot did of their ration. Up to April 30, 3,504 pounds of stover, or more than half the quantity fed, was left in the mangers. During the same period 29,794 pounds of silage were given to the other 12 steers, only 390 pounds of which were refused, or about one and one-third per cent.

But in previous experiments cows, when fed a large ration of silage (40 pounds per day) rejected a very considerable portion,[1] while it is probable that if these steers had not had plenty of good hay to fall back upon they would have consumed a larger proportion of the stover.

The experiment indicates, therefore, that our silage was more palatable to the cattle than the stover, though that was of better than average quality; while the cattle fed on stover consumed more dry substance in producing a pound of increase than those fed on silage.

Numerous experiments in the comparative feeding of corn silage and field-cured corn fodder (that is, stalks and ears) have been made by other Stations. Following is a brief summary of their results:

In 1883 the New Jersey Station found that the digestible portions of the silage and field-cured fodder were of equal value for milk production, but more digestible food was secured per acre, and that at less cost of harvesting and preserving, in the case of field-cured corn than in that of silage.[2]

At the Massachusetts Station the results of five years' experiments led to the conclusion that fodder corn, corn stover and corn silage, when fed pound for pound of dry matter, in place of English hay, compared well, as far as the quality and quantity of the milk and of the cream obtained were concerned.[3]

The Iowa Station made an experiment in 1889, from which the following conclusions were drawn:

"In this instance it did not pay to put any corn fodder in the silos. The weather was so dry that the corn fodder was not injured in the field; it cost so much less than the silage when prepared for feeding, there was so much less waste by spoiling, the fodder was relished so much better by all kinds of stock, and produced so much better results in fattening and in milk, that there was no room for choice between it and the ensilage in our silos. When fed in moderate quantities with other coarse fodder, our ensilage was well relished, being cleaned up as well as other coarse fodders, or better."[4]

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[1] See Bulletin of this Station for June, 1889, p. 91.

[2] N. J. Exp. Sta., Ann. Rpt. 1883, pp. 127-144.

[3] Mass. State Exp. Sta., Sixth Ann. Rpt., p. 19.

[4] Iowa Exp. Sta., Bulletin for August, 1889.

The Pennsylvania Station compared the digestibility of silage and field-cured corn fodder, and found the field-cured corn fodder more digestible by steers than the silage.[5]

The Maine Station found silage not superior to fodder in digestibility when fed to sheep.[6]

In an experiment made by the Michigan Station, "silage, though nearly a quarter had spoiled, lasted longer, gave more flesh, and cost less in preparation than the corn fodder."[7]

At the Missouri Station dry fodder for cows proved more effective than silage.[8]

At the Illinois Station, heifers fed on dry fodder made practically the same gain per pound of dry substance consumed as when fed on silage.[9]

At the Wisconsin Station several experiments have been made, which are summarized as follows in the Seventh Annual Report of the Station for 1890:

> "Corn silage with us has proved sometimes superior to dry fodder corn in nutritive value, sometimes inferior. Considering all trials conducted at this Station, the conclusion will be that properly cured corn fodder corn and corn silage of similar variety and maturity are of equal value for milk and butter production."[10]

At the Utah Station the results obtained from silage fed to steers and sheep were inferior to those obtained from dry fodder corn.[11]

At the Vermont Station, cows gave about nine per cent. more milk while fed on silage, but the milk was of better quality when the cows were fed on dry corn fodder; but in a subsequent test the silage showed better results.[12]

The logical conclusion of all this work is that the process of ensilage adds nothing to the nutritive value of a feeding stuff. It does add to its palatability, however, when the method has been properly employed, and in consequence, a larger proportion of the fodder will be consumed. In regard to the cost of this method, we do not consider it any greater than that of the ordinary method of cutting and husking and stacking the stover, and not so great as cutting, husking and stacking and grinding the grain, and certainly all this must be done if the food materials are to be as thoroughly preserved and made as completely available as they are in well cured silage.

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5 Penna. Exp. Sta., Ann. Rpt. for 1889, pp. 123–133.
6 Maine Exp. Sta., Ann. Rpt. for 1889, pp. 49–57.
7 Mich. Exp. Sta., Bulletin 47, April, 1889.
8 Missouri Exp. Sta., Bulletin No. 8, 1889.
9 Ill. Exp. Sta., Bulletin No. 9, May, 1890, pp. 302–314.
10 Wis. Exp. Sta., Ann. Rpt 1891, pp. 80–97.
11 Utah Exp. Sta., Bulletin No. 8, 1891, Bulletin 19, 1892, and Ann. Rpt. 1893, pp. 11–20.
12 Vt. Exp. Sta., Ann. Rpt. 1891, pp. 75–86, and 1892, pp. 154–165.

CONCLUSIONS RESPECTING DIFFERENT RATIONS.

It will be observed that the effects of the different rations employed are in no case sufficiently marked to justify positive conclusions, except in the comparison of gluten meal and oil meals, which seems safely to warrant the statement that, for the fattening of cattle, these feeding stuffs are approximately of equal value, pound for pound, and that the one which can be bought for least money is the one to use.

The comparison of silage with stover would be equally decisive in favor of silage, but for the well known fact that cattle will eat corn stover much more freely than they did in this experiment when they have no other coarse food to take its place.

While the experiments need repetition in order to eliminate the factor of individuality, which is so liable to obscure results when small numbers of animals are dealt with, they nevertheless exhibit some very interesting points when taken collectively. Some of these are discussed in the following pages.

HEAVY *vs.* LIGHTER FEEDING.

It will be observed that the cattle fed in 1895 fattened more slowly and with a greater consumption of food per pound of increase than those fed the previous season. The treatment of the two lots differed in this respect: In 1894 we aimed to feed the cattle all the meals they would eat, beginning with a small ration, but increasing it as rapidly as they would take it until they began to reject it, then lowering the ration until it was eaten freely, when it would be increased again. Our object was to ascertain the highest limit at which grain might be safely fed, as a guide in future work. The result was that we had frequent cases of temporary surfeit, during which the live weight would remain stationary or retrograde for a week or more, but in most cases the interruptions to growth were but temporary, and were followed by a rapid increase in weight. In 1895 the meal rations were kept one or two pounds below the limit indicated in the previous test; there were very few cases of surfeit, and yet the gain was not so good. Apparently too large a proportion of the food was required to keep the vital machinery running.

EFFECT OF TEMPERATURE ON FATTENING CATTLE.

The weather during January and February, 1895, was much colder than during the same period of 1894, the average temperature at 7 A. M., for the three weeks beginning January 26, being near the zero point. During the first two weeks of this period the cattle showed no diminution in gain, but from February 9 to March 5 the average live weight of the herd was stationary, though the cattle were eating well.

We supposed, at that time, that this check in growth was due to the extreme cold; but in April a similar check occurred, this time beginning during a period of abnormally high temperature. Apparently, the effect of weather conditions upon fattening cattle is a matter for further study.

Diagrams I and II show the average rate of increase in weight of the two herds, and also the temperature at 7 A. M. each morning, the upper temperature line indicating the temperature inside the stable, the lower line the outside temperature.

FINISHING BEEVES ON GRASS.

On the 10th of May, 1894, half the steers were turned on grass, taking the alternate, odd numbers throughout the list, the cattle of even numbers being kept at the barn and treated as they had been through the winter. The cattle turned on grass were brought to the barn every evening, stabled through the night and fed night and morning. They continued to eat nearly as much meal and more than half as much hay and silage as the cattle which had no grass, but during the next thirty days they made an average gain of but 32 pounds per head, while the remainder of the cattle gained over 59 pounds each. The weather through May was cold and wet.

In 1895 this test was repeated on the same plan, and with similar results. In this case, the May weather was very dry, but variable in temperature, being abnormally warm during the first half of the month, followed by ten days of frosty nights. The cattle this year were turned out a week earlier, and were kept a week later before marketing, being shipped June 15, so that they had 45 days of grazing instead of 30. The result of this test is graphically shown in Diagrams I and II. In these diagrams the straight diagonal line indicates the average rate of increase of each lot from beginning to end of test, the zig-zag line running along this diagonal shows the daily variations in the average total weight of the herd, this line being divided into two at the point where the grazing experiment begins. It happened in both cases that the odd numbered steers, which were turned out, were heavier in the average than those kept in. In the second test, as in the first, the steers turned out gained less during the first 30 days than those kept in, but during the last 15 days of the second test it will be observed that the pastured steers made apparently a more rapid gain than those kept in, but in both tests the gain cost more in case of the pastured steers than in that of those kept in the barn.

DIAGRAM I.—AVERAGE RATE OF INCREASE AND TEMPERATURES, 1894.

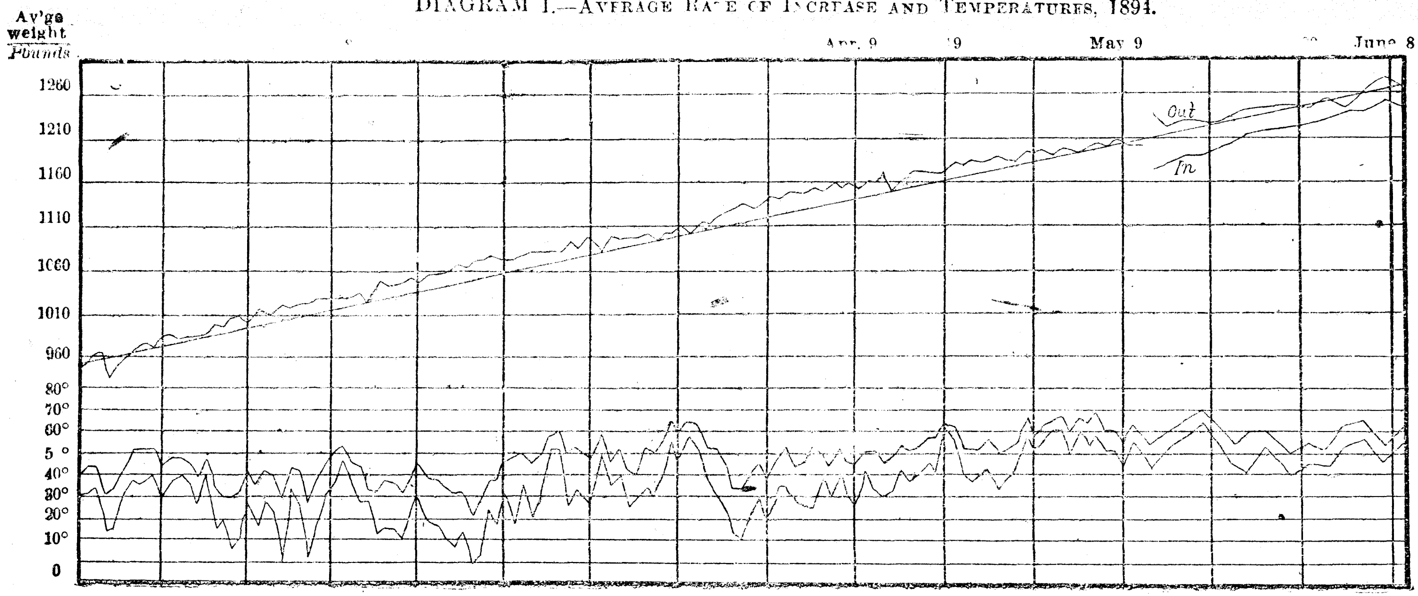
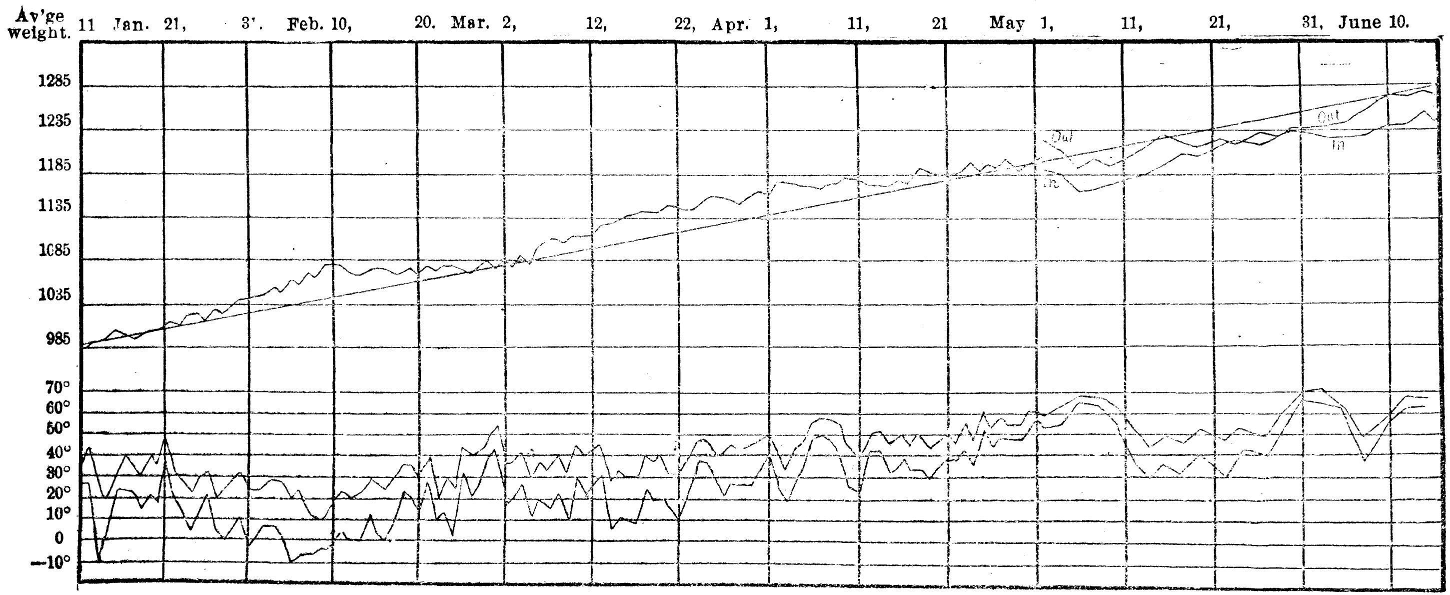


DIAGRAM II.—AVERAGE RATE OF INCREASE AND TEMPERATURES, 1895.



Both lots of steers were shipped to Pittsburg on Saturday, yarded over Sunday and sold on Monday, and in both cases the total weight on Monday at Pittsburg exceeded the final weight at home on Saturday, due to the fact that this final weight was taken before watering. In 1894 the pastured steers apparently lost least in shipment, while in 1895 the reverse was the case, but as the weight of water drank on the day of shipment was not taken we cannot give the relative shrinkage in shipment.

The data for this experiment are given in Table VIII:

TABLE VIII.—FINISHING BEEVES ON GRASS.

Year.	Treatment.	Number of cattle.	Days on pasture.	Dry substance consumed per steer per day.	Daily cost of food per steer.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Cents.*	*Pounds.*	*Pounds.*	*Cents.*
1894	Kept in barn	16	....	20.16	15 33	2.00	10.00	7.66
	Pastured.....	15	30	15.39	12 93	1 42	10.84	9.10
1895	Kept in barn	8	....	20 99	16 09	1.76	11.95	9.15
	Pastured.....	8	45	15.21	12 55	1.37	10.68	9.14

This table shows that in 1894 the cost of food per pound of gain was greater in the case of the pastured steers than in that of those kept in the barn, and in 1895 it was practically the same, no allowance being made for the grass consumed in either case.

WARM BARN *vs.* OPEN SHED.

The barn in which these tests were conducted was a remodeled "Pennsylvania" barn, the overshoot having been inclosed with barn boards, the cracks well battened and several glazed windows added. The cattle stood in two rows of box stalls on a plank floor, with their heads toward a middle passage, and were tied with chains. They very soon became entirely reconciled to their quarters, and were handled without difficulty. In each experiment, two steers were fed in an open yard on the west side of the barn, the steers having a shed, closed to the north and east but open to the south and west, into which they could go at will and in which they were fed. Following is the average outcome of this comparison for the two tests:

Treatment.	Initial weight.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
Fed in barn	960	1.99	10.20	7.27
Fed in shed	876	1.93	10.53	7.38

The differences here indicated are not sufficient to justify the assertion that either method of caring for the cattle was better than the other, so far as the utilization of food by the cattle is concerned.

INCREASE AT DIFFERENT PERIODS OF FATTENING.

In Table IX the data concerning food consumption and increase are arranged in three periods, the first including the 60 days from January 11 to March 11, in both cases; the second including the 60 days from March 12 to May 10 in 1894, and the 50 days from March 12 to April 30 in 1895, and the third, the month ending June 9 in 1894, and 45 days ending June 14, 1895.

TABLE IX.—INCREASE AT DIFFERENT PERIODS OF FATTENING.

Year.	Period.	Season.	Dry substance consumed per steer per day.	Daily cost of food per steer.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
			Pounds.	*Cents.*	*Pounds.*	*Pounds.*	*Cents.*
1894	I	January and Febru'y.	20.81	15.11	2.21	9.40	6.83
	II	March and April	20.85	16.44	1.82	11.16	9.04
	III	May and June	20.16	15.33	2.00	10.00	7.66
1895	I	January and Febru'y.	20.98	13.85	2.19	9.57	6 32
	II	March and April	23.22	16 25	1.43	16.29	11.39
	III	May and June	20.99	16.09	1.76	11.95	9.15

In this table the data for May and June are for the steers kept in the barn. It will be observed that both lots of cattle show a better increase, both in rate and cost of gain, during May and June than during March and April, while both agree in showing a still better gain during the first period of feeding. The month of April, in both tests, was the period of slowest gain and greatest cost.

SOME POSSIBILITIES IN CATTLE FEEDING.

As was stated at the outset, the cattle fed in this experiment were a mixed lot. They included not only several grades of the dairy breeds, but several of those of purest shorthorn blood were not the best type of feeding cattle. But our object was to ascertain what might be done with the average Ohio steer, under the management of the average Ohio farmer. We believed that such an experiment would be useful in not only showing what might be expected of such a lot of steers as might be picked up in any county of Ohio, but that it would have a greater value if it showed the contrast between cattle of different feeding capacity than if it showed only the highest possible achievement.

Tables II and IV show that there was a wide difference in the utilization of their food by the different cattle. To show this point more clearly we have summarized the results in four groups below, arranging the groups according to the cost of feed required to produce a pound of increase:

TABLE X.—SUMMARY OF TABLES II AND IV.

Group.	Number of cattle.	Initial weight.	Total gain.	Dry substance consumed per pound of gain.	Cost of feed per pound of gain.
I.	11	950	277	9.32	6.52
II	12	979	246	9.85	7.47
III	13	983	213	11.62	8.41
IV.................	11	990	180	13.20	9.84

It appears from the above summary that the cost of the increase was 50 per cent. greater in the case of the eleven worst steers than in that of the eleven best ones.

THE AVERAGE OUTCOME.

The total weight, at the beginning of the experiment, of the 31 steers which were fed throughout the first test, was 29,781 pounds (average 960), and the total weight of the same steers at the end of 120 days was 37,283 pounds, a gain of 7,502 pounds, or a small fraction over two pounds per steer per day. To produce this gain, the cattle consumed 49,071 pounds of mixed meals, 18,585 pounds of hay and 70,867 pounds of silage, the whole containing 77,500 pounds of dry substance. The daily consumption per steer was 13¼ pounds of meals, 5 pounds of hay and 19 pounds of silage, a total of 20 4-5 pounds of dry substance, no allowance being made for straw consumed nor for feed rejected.

The total cost of the feed consumed, at the prices given, was $587.04, or $7.82 per hundred pounds of gain.

The steers were finally sold in Pittsburg at $4.70 per hundred pounds, a price which netted $4 50 per hundred pounds at the station, making their value, at the end of the 120 days under review, $1,677.64. Deducting from this the cost of feed, $587.00, gives $1,090 64, which would be $3.66 per hundred pounds on their weight at the beginning of the experiment.

In other words, an advance in price of 84 cents per hundred pounds paid the cost of the food consumed during the test (excepting the straw), estimating it at its full market value, but making no allowance for the straw consumed, for the labor of caring for the cattle, nor for interest on the capital invested.

The initial weight of the 16 steers used in the second test was 15,846 pounds; their weight at the end of 110 days was 19,091 pounds, a gain of 3,245 pounds, or 1.84 pound per steer per day. These steers consumed in the four months 20,076 pounds of mixed meals, 29,407 pounds of silage, 1,578 pounds of stover and 12,881 pounds of hay, all containing 38,724 pounds of dry substance; the daily consumption per steer being 11.4 pounds of meals, 16.7 pounds of silage, 7.3 pounds of hay and .9 pound of stover, a total of 22 pounds of dry substance.*

The total cost of food consumed was $262.92, or $8.10 per hundred pounds of gain. The steers were sold in June in Pittsburg at $5 00 per hundred pounds, netting $4.77 per hundred at the station, or a total value of $910 64 at the end of the 110 days. Deducting from this the cost of feed, as before, we have a net value of $647.72 at the beginning of the test, or $4.09 per hundred on the initial weight. In this case, therefore, an advance in price of 68 cents per hundred pounds paid the cost of food consumed during the test, with the exceptions already noted. As an offset against these items we have the manure produced:

VALUE OF MANURE.

Table XV (see appendix) gives the average per centages of moisture, ash, nitrogen, phosphoric acid and potash found in the common feeding stuffs, as compiled by W. H. Beal, of the Office of Experiment Stations, U. S. Department of Agriculture, and published in the Hand Book of

*These steers were bedded with straw, but they did not have access to straw pile in the yard, as did those in the previous test.

Experiment Station Work. The analyses given are the averages of American analyses, unless otherwise noted:

On the basis of these analyses, the feeding stuffs used in the first experiment under review would have contained approximately the quantity of fertilizing constituents shown in Table XI:

TABLE XI.—FERTILIZING CONSTITUENTS IN FEEDING STUFFS.

Feeding stuff.	Quantity fed.	Fertilizing constituents.		
		Nitrogen.	Phos. acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Bran	19,106	510	552	307
Corn meal*	19,121	348	134	76
Wheat meal	3,644	86	32	22
Gluten meal	3,464	174	11	2
Oil meal	3,736	203	62	51
Clover hay	16,008	331	61	352
Timothy hay	2,577	32	14	23
Corn silage	70,867	198	78	262
Totals	....	1,882	944	1,095

*Estimated on the basis of corn kernels, the meal being unbolted.

The 7,500 pounds increase in live weight was chiefly water and fat. Experiments made on a large scale by Sir John B. Lawes indicate that such increase, in the case of cattle, would contain about 1.23 per cent. of nitrogen and 1.47 per cent. of ash. This ash would contain a small quantity of phosphoric acid and potash, but it is safe to assume that, after making full allowance for the fertilizing constituents carried away in this 7,500 pounds of increase, there would still be left not less than 1,8 0 pounds of nitrogen (equivalent to 2,200 pounds of "ammonia"), 900 pounds of phosphoric acid and 1,000 pounds of potash, to be returned to the soil, if all of the manure were carefully saved.

In the case under consideration the cattle were fed on a cemented floor, from which lines of sewer pipe, laid in cement, led to a cemented cistern, which collected all the liquid not caught by absorbents, and the solid excrement, with its straw, was carried into an open, saucer-shaped barnyard, where it was further mixed with straw from the stack already referred to. Undoubtedly part of the valuable constituents of the manure was lost by this treatment; but where such manure can be drawn directly to the field and immediately spread, the necessary loss is small. A covered barnyard would prevent loss from leaching, but would involve greater loss from heating unless great care was exercised.

In the Official Report of the Ohio State Board of Agriculture on Commercial Fertilizers for the year 1894, ammonia is valued at 17 cents per pound, soluble and reverted phosphoric acid at 6½ cents and potash at 6½ cents, these valuations being based on the average price of the ingredients in Ohio, as sold that year, in commercial fertilizers.

On the basis of these valuations the nitrogen, phosphoric acid and potash in the manure produced in the test of 1894 would be worth $497; $374 for the nitrogen, $58 for the phosphoric acid and $65 for the potash.

It is true that it would be practically impossible to save all the fertility thus produced and return it to the soil, especially the nitrogen. It is true, moreover, that it is possible to purchase nitrogen and phosphoric acid in forms in which they will give a quicker return than in stable manure; but it is also true that much of the nitrogen and phosphoric acid of ordinary commercial fertilizers are little if any more effective than those of manure, and in some cases they are undoubtedly less so—as when raw bone, or horn, hoof and leather shavings are used as the source of these constituents.

It is further true that these essential constituents of fertility may be purchased in forms at once more effective and less expensive than the ordinary, mixed fertilizers of commerce—that is to say, in nitrate of soda, basic slag or superphosphate, and muriate of potash; but it is also true that few farmers buy these materials.

It is further true that it costs more to apply fertility to the field in the form of stable manure than in that of the convenient "phosphate;" but it is also true that this extra cost is a very small item when the manure is simply hauled from the stable to the field on the ordinary farm.

It would seem, therefore, that after making full allowance for unavoidable losses of nitrogen, for slower availability and for greater expense in application, there would still remain value enough in the manure left by cattle fed under careful management to give a handsome profit on the feeding, provided the cost of the feed itself be recovered in the increased value of the cattle. The difference in price, however, which has been shown to be necessary to recover this cost is far below the difference which farmers expect to receive as a rule, and which a comparison of market quotations will show to be the rule, so that there is reasonable ground to expect a direct profit on the feed consumed, in addition to the indirect profit to be found in the manure.*

The cattle used in these tests were simply lots of ordinary, three-year-old steers, such as may be picked up in any county of Ohio, and certainly not above the average quality of the cattle of the State; in fact, an expert feeder, accustomed to the high-grade Shorthorns of the grazing regions of Ohio, Kentucky, Illinois and Iowa would have pronounced them unpromising lots of cattle for feeding.

The experiment (for both tests may be included as one) had for its prime object a general study of the conditions affecting beef production, a study designed to supplement the similar study of the production of milk, which has been carried on at this Station during previous years. It was made under such conditions as prevail on the ordinary, well managed farm, and its outcome, so far at least as rapidity of growth is concerned, has been excelled by many farmers. It was our purpose to arrive at an average basis in feeding, and we believe that our results, in regard to food required in fattening, may be accepted as safely within the limits of ordinary work.

In Table XII, republished from Bulletin 50 of this Station, we have compiled the results of such recent experiments in steer feeding by other Stations as contain the data necessary for comparison, from which it will be seen that our results were quite moderate.

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*The following table, compiled from statistics published by the Cincinnati Price Current, gives the average monthly range of prices in Chicago for good to choice steers, weighing 1,200 to 1,500 pounds, for the seven years, 1888 to 1894, inclusive:

PRICES OF CATTLE IN CHICAGO.

January	$3.15 @ $5.55
February	3.30 @ 5.35
March	3.60 @ 5.35
April	3.80 @ 5.30
May	3.90 @ 5.30
June	3.90 @ 5.60
July	3.55 @ 5.50
August	3.20 @ 5.65
September	3.15 @ 5.70
October	3.00 @ 5.85
November	3.00 @ 6.00

This table indicates that the average price of the lower grades of cattle is highest in May and June, and that of the higher grades in October and November. There is, of course, an advance in grade as cattle are fattened.

TABLE XII.—PRODUCTIVITY OF FOOD IN STEER FEEDING.

	Number of steers in test.	Age at end of test.	Gain in live weight.		Reference.
			Per day.	Per 100 lbs. dry substance consumed.	
		Years.	*Pounds.*	*Pounds.*	
Massachusetts........	7	1	1.36	9.24	Ann. Rpts. 1891 and 1892.
"	7	2	1.45	7.65	" " "
New York State.....	5	1½	1.27	11.29	" 1890.
Virginia...............	12	3	2.17	9.26	Bulletin 10.
Ontario................	6	2	1.48	11.13	Exp. Farms Rpt. 1891.
Kansas................	8	3	2.50	10.00	Bulletins 34 and 39.*
Maryland..	4	3	2.78	11.60	Bulletin 22.
Iowa...........	18	1	2.48	11.35	" 20.†
"	18	2	3.03	9.55	" 20.
Ohio	47	3	1.91	9.24	....
Average	....	....	....	9.77	....

* Dry matter estimated from Jenkins and Winton's tables, and comparison made with lots fed on balanced rations only.

† Dry matter estimated from Jenkins and Winton's tables. These steers and five of the Massachusetts steers were fed through two successive winters.

THE CHEMISTRY OF CATTLE FEEDING.

From 40 to 60 per cent. of the animal body consists of water, the quantity being smaller as the fatness of the animal increases.

Mineral substances (left as ash in burning) compose two to five per cent. of the entire body, varying from about 67 per cent. of the bones to a mere trace in the softer tissues and fluids. No part of the system is entirely destitute of minerals.

From 6 to 30 per cent. of the body consists of fat, the quantity varying with the condition of the animal. Pure fat is a chemical union of three elementary substances, carbon, oxygen and hydrogen. The same three substances, combined in different proportions, constitute the woody fibre and the starches, sugars and fats of plants. In the process of digestion and assimilation the fibre, starches and sugars (collectively called carbhydrates) serve first as fuel, for the support of the vital heat and for the production of motion or work; when more is consumed than is required for these purposes it is stored in the form of fat, this fat serving as a reservoir of fuel which may be drawn upon in case of deficiency of food. The fat of the food also serves the same purpose as the carbhydrates, for which it is estimated to be about two and one-fourth times as valuable, pound for pound. There seems to be a close parallelism between the nutritive values of fat and starchy matters and their fuel values, when burned for the production of heat.

A fourth important class of nutritive substances contains nitrogen and sulphur in addition to the three elements found in the carbhydrates and fat. These are the so-called protein compounds, also known as albuminoids. They contain about 16 per cent. of nitrogen and their office is that of growth and repair. In every cell of the vegetable or animal organism, which is charged with living functions, protein is found. It is consumed in relatively large quantities in the growth of young animals, and in the production of milk.

All feeding stuffs contain more or less water. In hays, grains, etc., the water content usually ranges between 10 and 15 per cent.; in silage it amounts to 70 or 80 per cent., and in roots, grass and green fodders it may reach 85 to 95 per cent.—a turnip or mangel may contain more water than would be found in the same weight of milk—but while the water of the food may add to its palatability, such water has no more nutritive value than water drawn from a spring or well. This point has been fully demonstrated.

Of the several mineral elements which appear to be essential to animal life the two most abundant are phosphoric acid and lime, these two constituting about four-fifths of the total ash; but if any one of the necessary mineral elements be absolutely withheld from the system life will soon cease.

In ordinary farm practice there is seldom any lack of mineral substances in food, especially in case of animals fed on the coarser feeding stuffs, but in exclusive grain feeding there is a possibility of reducing these constituents below the point needed for the most perfect growth. Thus Director Henry, of the Wisconsin Experiment Station, in summarizing the results of several experiments in pig feeding, says: "It appears plain to us that the excessive feeding of corn, with its deficiency in ash, tends to repress the natural development of the muscles, reduces the blood and some of the internal organs of the body and gives weak bones."*

*Seventh Annual Report, Agricultural Experiment Station of the University of Wisconsin, page 32.

There is ground for the suspicion that the ash constituents are more liable to be deficient in human than in animal foods.

The protein supply is more liable to be deficient than that of minerals, especially where corn and timothy hay are the feeder's chief dependence, since these are both relatively deficient in this constituent. Our present knowledge of the laws governing nutrition justifies the statement that a certain amount of both minerals and protein is absolutely essential to assimilation, and that only so much of the carbhydrates and fat will be utilized as are required to balance the protein and minerals available. Protein, like the starches, etc., may be converted into heat and fat; but protein cannot be formed from starch or fat, since these are destitute of nitrogen.

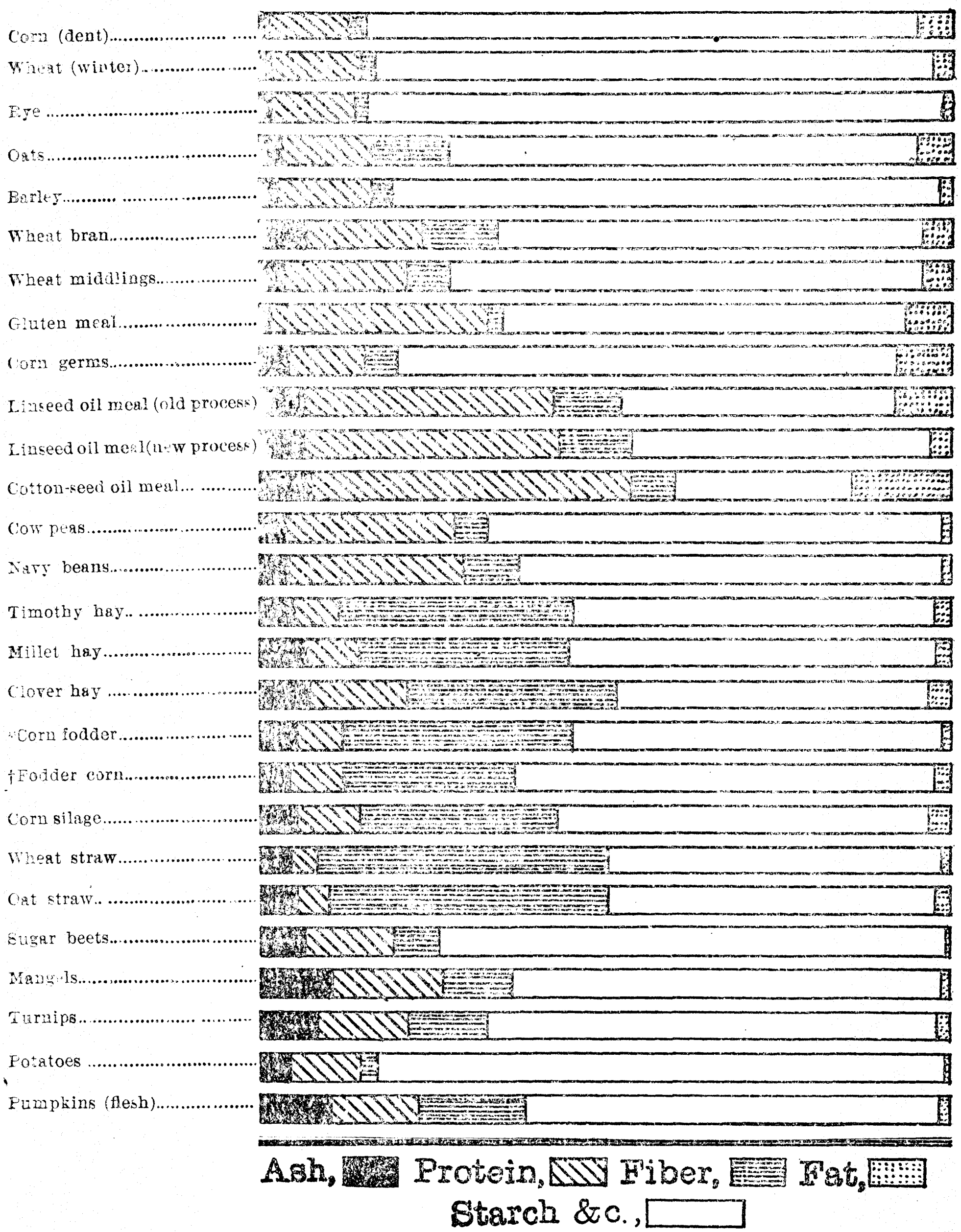
Diagram III shows the relative proportion of ash, protein, fiber, fat and starchy matters in 100 parts of the dry substances of a few of the more common feeding stuffs. This diagram illustrates the large proportion of protein in the various by-products—bran, middlings, gluten meal, etc.; the preponderance of fiber in the hays and straws, and the very interesting fact that, when divested of water, the most conspicuous difference between the grains and roots is the larger proportion of ash in the roots and of fat in the grains, the per centage of protein being nearly the same.

THE NUTRITIVE RATIO.

All substances used in animal nutrition are found, when subjected to chemical analysis, to be composed of two or more elementary substances, chemically combined. Water, for instance, is a combination of the two gasses, oxygen and hydrogen, united in the proportion of one volume of oxygen with two volumes of hydrogen. The starches, fats, etc., are composed of the elements of water, united with carbon, the three elements being always found united in certain fixed proportions. The protein compounds contain these three elements, united with nitrogen and sulphur, the proportions again being fixed and definite.

It seems highly probable that a similar law controls the assimilation of food in the animal body, and that the greatest effect will be produced from a given food when the constituents of that food bear to each other a certain ratio. What this ratio is we do not yet know; probably it varies within certain limits, according as the energy of the food is directed towards growth, the production of milk or wool, or the accumulation of fat etc., somewhat as the same two gases which, when simply mixed together, give to us the air which is the breath of life, may form, when chemically combined in one proportion, the corrosive nitric acid, or in another proportion, the so-called "laughing gas." Chemical combination, it will be observed, is a very different thing from simple mixture.

DIAGRAM III.—RELATIVE COMPOSITION OF DRY SUBSTANCE IN FEEDING STUFFS.



* Without grain—"stover." Entire plant.

This probable parallelism has suggested the attempt to discover the laws governing assimilation, and we have heard much, in recent years, about the "nutritive ratio," by which is meant the proportion between the nitrogenous, or protein constituents of the food and the non-nitrogenous constituents—the carbhydrates and fats; the theory being that for some purposes—as growth and milk production—there should be a larger proportion of protein than is required for the maintenance of heat, for work or for fattening.

DIGESTIBILITY OF FOODS.

It is evident that such a law as that indicated can only apply to the digestible portions of the food; for in all foods there is a larger or smaller portion which is never dissolved by the digestive fluids, but passes through the body unchanged. Experiments made within recent years, in which both food and excreta were subjected to analysis, indicate that there is a wide difference in the digestibility of the different classes of foods and between the different constituents in the same class; thus a much larger proportion of the grains is digestible than of the straws and hays; the fats are more fully digestible than protein, etc.; and further than this, the combinations in which foods are used affect their digestibility.

The experiments upon which our present knowledge respecting the digestibility of foods is based have been made on comparatively few animals, and by methods which are confessedly crude, so that the most that can be said of this knowledge is that it is an advance beyond the absolute lack of exact information which formerly prevailed, and that calculations based upon the results of these experiments will be closer approximation to the actual truth than those which deal only with the total substance contained in the foods, as shown by chemical analysis. To illustrate: 100 pounds of the dry substance of wheat straw is found by experiment to contain on the average about 43 pounds of digestible matter, while the same quantity of the dry substance of the wheat grain contains about 84 pounds of digestible matter. In other words, there is about half as much digestible matter in wheat straw, as in an equal weight of wheat grain,—the percentage of water being nearly the same in both. Further than this, the digestion experiment shows that the two most valuable food constituents—protein and fat—are not only relatively deficient in the straw but are less digestible than the similar constituents of the grain; and thus, while of total digestible substance the grain contains only twice as much as the straw, yet of digestible protein it contains 12 times as much, and of digestible fat about four times as much.

In Table XIII, compiled by E. W. Allen, of the Office of Experiment Stations, U. S. Department of Agriculture, is given the average percentage of digestible constituents in 100 pounds of feeding stuffs, deduced as far as possible from American analyses and American digestion experiments:

TABLE XIII.—DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFFS.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates	Fat.	Fuel value.
Green fodder:	*Pounds.*	*Pounds*	*Pounds*	*Pounds.*	*Calories.*
Corn fodder[1] (average of all varieties)	20.7	1.10	12.08	0.37	26,076
Rye fodder	23.4	2.05	14.11	0.44	31,914
Oat fodder	37.8	2.69	22.66	1.04	51,624
Redtop, in bloom	34.7	2.06	21.24	0.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	0.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	0.42	34,755
Timothy,[2] at different stages	38.4	2.28	23.71	0.77	51,591
Kentucky blue grass	34.9	3.01	19.83	0.83	45,985
Hungarian grass	28.9	1.92	15.63	0.36	34,162
Red clover, at different stages	29.2	3.07	14.82	0.69	36,187
Crimson clover	19.3	2.16	9.31	0.44	23,191
Alfalfa,[3] at different stages	28.2	3.89	11.20	0.41	29,798
Cowpea	16.4	1.68	8.08	0.25	19,209
Soja bean	28.5	2.79	11.82	0.63	29,833
Corn silage	20.9	0.86	11.79	0.65	25,714
Corn fodder,[1] field cured	57.8	2.48	33.38	1.15	71,554
Corn stover, field cured	59.5	1.98	33.16	0.57	67,766
Hay from—					
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	0.95	100,078
Timothy[2] (all analyses)	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.33	1.95	86,516
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	6.58	35.35	1.66	84,995
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa[3]	91.6	10.58	37.33	1.38	94,936

[1]Corn fodder is entire plant, usually sown thick. [2]Herd's grass of New England and New York [3]Lucern.

TABLE XIII—Continued.

Feeding stuff.	Dry matter.	Protein.	Carbo-hydrates.	Fat.	Fuel value.
Hay from—Concluded:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Cowpea	89.3	10.79	38.40	1.51	97,865
Soja bean	88.7	10.78	38.72	1.54	98,569
Wheat straw	90.4	0.80	37.94	0.46	73,997
Rye straw	92.9	0.74	42.71	0.35	82,294
Oat straw	90.8	1.58	41.63	0.74	83,494
Soja bean straw	89.9	2.30	39.98	1.03	82,988
Roots and tubers:					
Potatoes	21.1	1.27	15.59	......	31,360
Beets	13.0	1.21	8.84	0.05	18,904
Mangel-wurzels	9.1	1.03	5.65	0.11	12,889
Turnips	9.5	0.81	6.46	0.11	13,986
Ruta-bagas	11.4	0.88	7.74	0.11	16,497
Carrots	11.4	0.81	7.83	0.22	16,998
Grains and other seeds:					
Corn (average of dent and flint)	89.1	7.92	66.69	4.28	156,836
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat (all varieties)	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	7.01	65.20	3.25	148,026
Corn and cob meal	84.9	6.46	56.28	2.87	128,807
Oatmeal	92.1	11.53	52.06	5.93	143,302
Barley meal	88.1	7.35	62.88	1.96	138,818
Ground corn and oats, equal parts	88.1	7.39	61.20	3.72	143,275
Pea meal	89.5	16.77	51.78	0.65	130,246
Waste products:					
Gluten feed	92.2	20.40	43.75	8.59	155,569
Gluten meal	91.2	25.49	42.32	10.38	169,931
Hominy chops	88.9	7.45	55.24	6.81	145,341
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4.00	9.37	1.38	30,692
Brewers' grains (dried)	91.1	14.73	36.60	4.32	115,814
Rye bran	88.4	11.45	50.28	1.96	123,089
Wheat bran, all analyses	88.5	12.01	41.23	2.87	111,188
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat middlings	86.8	17.34	26.58	4.54	100,850

TABLE XIII—Concluded.

Feeding stuff.	Dry matter.	Protein.	Carbo-hydrates.	Fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds*	*Calories.*
Waste products—Concluded:					
Cotton-seed meal	91.8	37.01	16.52	12.58	152,653
Cotton-seed hulls	88.9	0.42	30.95	1.69	65,480
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	89.8	27.89	36.36	2.73	131,026
Peanut meal	89.3	42.94	22.82	6.86	151,268
Milk and its by-products:					
Whole milk	12.8	3.48	4.77	3.70	30,866
Skim milk—cream raised by setting	9.6	3.13	4.69	0.83	18,048
cream raised by separator	9.4	2.94	5.24	0.29	16,439
Buttermilk	9.9	3.87	4.00	1.06	37,685
Whey	6.6	0.84	4.74	0.31	11,68[illegible]

The last column in the above table, headed "fuel value," indicates the heat and energy power of the food. It will be remembered that one of the primary functions of the food is to produce heat for the body and energy for work. The value of food for this purpose is measured in "heat units" or "calories,"[1] and is calculated from the nutrients digested. Thus the fuel value of one pound of digestible fat is estimated to be 4,220 calories, and of one pound of digestible protein or carbohydrates about 1,860 calories. The total fuel value of a feeding stuff is found by using these factors.

The meaning of the figures in the above table is that in 100 pounds of green corn fodder containing an average amount of dry matter (20.7 pounds) there are contained approximately 1.10 pounds of digestible protein (materials containing nitrogen), 12.08 pounds of digestible carbohydrates (starch, sugar, fiber, etc.), and 0.37 pound of digestible fat; and that these materials when burned in the body will yield 26,076 calories of heat, furnishing energy for work and maintaining the temperature of the body.

THE CALCULATION OF RATIONS.

With such a table before us as the one just given, it is possible to so adjust a ration that it may contain any desirable proportion of the different nutritive constituents.

To illustrate: The average daily ration consumed by the four steers of lot A in our first experiment consisted of 14.86 pounds of mixed meals and 10.41 pounds of clover hay. About 22 per cent. of the meal ration was gluten meal, the remainder being bran and corn meal in equal parts. Such a ration would contain the following quantities of digestible nutrients as calculated from Table XII:

[1] A calorie of heat is the amount required to raise the temperature of a pound of water about 4° Fahrenheit.

DIGESTIBLE NUTRIENTS IN RATION.

Food.	Protein.	Carbhy-drates.	Fat.
	Pounds.	*Pounds.*	*Pounds.*
3.28 lbs. gluten meal	0.83	1.39	0.34
5.79 lbs. wheat bran	0.70	2.39	0.17
5.79 lbs. corn meal	0.46	3.86	0.24
10.41 lbs. clover hay	0.68	3.68	0.17
Totals	2.67	11.32	0.92

Multiplying the total fat by two and one-fourth and adding the product to the carbhydrates we have a total sum of 13.37, which is approximately five times the amount of the protein, hence we say that the nutritive ratio is one to five.

After this manner the rations fed to the different lots of cattle in the two experiments have been calculated, the results being given in Table XIV:

TABLE XIV.—DIGESTIBLE NUTRIENTS CONSUMED.

Year.	Lot.	Digestible nutrients consumed.				Calories consumed per pound of gain.	Nutritive ratio.
		Per head per day.			Total per pound of gain.		
		Protein.	Carbhy-drates.	Fat.			
1894	A	2.67	11.32	0.92	6.41	12,875	1 : 5
	B	2.29	12.39	0.67	7.25	14,520	1 : 6.3
	C	2.70	10.57	0.80	8.09	16,121	1 : 4.6
	D	2.24	10.66	0.85	6.89	13,825	1 : 5.6
	E	1.93	9.48	0.70	6.87	13,586	1 : 5.7
	F	2.21	10.43	0.63	6.23	12,293	1 : 5.3
	G	1.58	12.09	0.72	7.46	14,775	1 : 8.7
	H I	1.53	11.39	0.68	6.67	13,195	1 : 8.4
1895	A	2.19	10.44	0.77	7.88	15,726	1 : 5.6
	B	2.28	10.42	0.73	8.40	16,702	1 : 5.3
	C	2.14	10.12	0.85	6.62	13,299	1 : 5.7
	D E	1.79	12.57	0.71	7.33	14,453	1 : 7.9

It would seem, from these results, that there are other factors governing the productivity of a ration which are of more importance in the fattening of cattle than the mere ratio of its nutritive constituents, and this is in accord with our general knowledge of the functions of the different materials.

When coal is burned under the boiler of an engine a chemical combination takes place between the carbon of the fuel and the oxygen of the atmosphere, attended with evolution of heat, which heat is converted into work through the expansive force of steam. When food is taken into the stomach the digestive processes set up there a chemical action in which the carbon of the food is recombined, this process likewise being attended with heat as manifested in the constant maintenance of the high temperature of the body. If more food is taken than is required for heat maintenance the surplus may be stored in the form of fat, or it may be expended in work, while if the food be less in quantity than that required for heat maintenance, the heat will still be kept up by drawing upon the stored up fat of the body.

For the production of heat under artificial methods the protein constituents of the food are found to be equal, but not superior to the carbhydrates, the nitrogen of the protein compounds being simply inert so far as heat production is concerned, and this appears to be equally true in the production of heat, or its reciprocals, fat storage and work, in the animal mechanism; but when the resultant of the food energy is growth, then something more than the elements of heat are required; for this process involves the production of living tissue, and no such tissue can be formed in the absence of nitrogen and certain minerals. Even the storage of fat in mature animals is attended with some destruction of old tissues and their renewal, so that some protein is required in a ration for any purpose; but the quantity necessary for this purpose will evidently be less than that required for the growth of young animals.

FEEDING STANDARDS.

The following tables give the feeding standards compiled by Emil Wolff, of Germany, and which are generally accepted as approximately the proportions in which the different food constituents may be used with best effect for the various purposes named, the "nutritive ratio" being calculated by multiplying the digestible fat by two and one-half, adding this to the carbhydrates and dividing by the protein. The factor two and one-half was used by Wolff but later investigators prefer two and one-fourth, as probably more nearly correct.

TABLE XV.—WOLFF'S FEEDING STANDARDS.

A.—*Per Day and Per 1,000 Pounds Live Weight.*

	Total organic matter.	Digestible food materials.			Nutritive ratio.	Fuel value.
		Protein.	Carbhydrates.	Fat.		
	Pounds	*Pounds.*	*Pounds.*	*Pounds.*		*Calories.*
Oxen at rest in stall	17.5	0.7	8.0	0.15	1 : 12.0	16,815
Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	1 : 9.0	22,235
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	1 : 8.0	25,050
Oxen moderately worked	24.0	1.6	11.3	0.30	1 : 7.5	24,260
Oxen heavily worked	26 0	2.4	13.2	0.50	1 : 6.0	31,126
Horses moderately worked	22.5	1.8	11.2	0.60	1 : 7.0	26,712
Horses heavily worked	25.5	2.8	13.4	0.80	1 : 5.5	33,508
Milch cows	24.0	2.5	12.5	0.40	1 : 5.4	29,590
Fattening steers:						
First period	27.0	2.5	15.0	0.50	1 : 6.5	34.660
Second period	26.0	3.0	14.8	0.70	1 : 5.5	36,062
Third period	25.0	2.7	14.8	0.60	1 : 6.0	35,082
Fattening sheep:						
First period	26.0	3.0	15.2	0.50	1 : 5.5	35,962
Second period	25.0	3.5	14.4	0.60	1 : 4.5	35,826
Fattening swine:						
First period	36.0	5.0	27.5		1 : 5.5	60,450
Second period	31.0	4.0	24.0		1 : 6.0	52,080
Third period	23.5	2.7	17.5		1 : 6.5	37,570

B.—*Per Day and Per Head.*

	Average live weight per head.	Total organic matter.	Digestible food materials.			Nutritive ratio.	Fuel value.
			Protein.	Carbohydrates.	Fat.		
Growing cattle:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds*	*Pounds.*		*Calories.*
Age—							
2 to 3 months	150	3.3	0.6	2.1	0.80	1 : 4.7	5,116
3 to 6 months	300	7.0	1.0	4.1	0.30	1 : 5.0	10,750
6 to 12 months	500	12.0	1.3	6.8	0.30	1 : 6.0	16,332
12 to 18 months	700	16.8	1.4	9.1	0.23	1 : 7.0	20,712
18 to 24 months	850	20.4	1.4	10.3	0.26	1 : 8.0	22,859
Growing sheep:							
Age—							
5 to 6 months	56	1.6	0.18	0.87	0.045	1 : 5.5	2,143
6 to 8 months	67	1.7	0.17	0.85	0.040	1 : 5.5	2,066
8 to 11 months	75	1.7	0.16	0.85	0.037	1 : 6.0	2,035
11 to 15 months	82	1.8	0.14	0.89	0.032	1 : 7.0	2,051
15 to 20 months	85	1.9	0.12	0.88	0.025	1 : 8.0	1,966
Growing fat swine:							
Age—							
2 to 3 months	50	2.1	0.38	1.50		1 : 4.0	3,496
3 to 5 months	100	3.4	0.50	2.50		1 : 5.0	5,580
5 to 6 months	125	3.9	0.54	2.96		1 : 5.5	6,510
6 to 8 months	170	4.6	0.58	3.47		1 : 6.0	7,532
8 to 12 months	250	5.2	0.62	4.05		1 : 6.5	8,686

The digestible nutrients consumed per day by the average steer in our feeding experiment were as follows:

Total dry substance	21.2	pounds.
Protein	2.13	"
Carbhydrates	11.00	"
Fat	0.75	"
Nutritive ratio	1 : 6	
Calories	27,568	

As the average weight of our steers was considerably over 1,000 pounds, it will be seen that their recorded daily consumption of food was much less than that estimated in the German calculations, and it is not at all probable that enough straw was eaten to make up the difference.

COMPARATIVE VALUE OF FEEDING STUFFS.

1.—NUTRITIVE VALUE.

Of all feeding stuffs used in Ohio it is probable that the price of none is governed so exclusively by its intrinsic value as a food for animals as is that of corn. The soil and climate of this State give to this plant its most perfect development, and long experience has demonstrated its value as a food for all kinds of animals. It is used to a comparatively limited extent as a source of human food, or in the production of liquors, and its value is fixed, not by the price in Liverpool, as in the case of wheat, but by the local supply and demand. Its annual product in Ohio exceeds in weight of grain that of all other grain crops, and its cured stalks and leaves nearly equal in weight the annual hay crop of the State.

The average price of corn in Chicago, since 1880, has averaged about 45 cents per bushel. It is worth about as much at the average shipping points in Ohio as in Chicago, and it can be taken from the farm to this average shipping point for less than five cents per bushel. 40.8 bushels of corn will make a ton of unbolted meal, deducting one-eighth for grinding. It seems, therefore, that $16.00 per ton may be assumed as a fair average price for corn meal on the Ohio farm, the expense of hauling to and from the mill not greatly exceeding that of hauling to the shipping point, and being partly compensated by lower tolls in some sections and by home grinding on many farms.

Of the feeding stuffs which are relatively rich in protein, wheat bran is undoubtedly the one most used on Ohio farms. Made at many hundreds of mills, scattered over the State, it is within easy reach of every farmer. Its average cost on the farm is probably not far from $15 per ton.*

On the basis of these valuations we make the following comparison of the relative cost of digestible protein on the one hand and of digestible carbhydrates and fat on the other in these standard feeding stuffs, the fat being reduced to its starch equivalent by multiplying by two and one-quarter:

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*The average prices of No. 2 yellow corn and wheat bran in the Pittsburg market for the year 1894 were 49 cents per bushel, and $14.88 per ton. Deducting freight, the value of corn would be about 44 cents at the average shipping point. The wholesale price of bran in Pittsburg is probably not far from the retail cost to the farmer, by the time it reaches his farm.

Feed.	Digestible constituents.		Cost per cental.
	Protein	Carbhydrates.	
	Per cent.	*Per cent.*	*Cents.*
Corn	7.92	76.32	80
Wheat bran	12.01	47.69	75

It appears from this comparison that 100 pounds of bran contain about 62½ per cent. of the carbhydrates and equivalent fat found in corn. We may therefore reduce both feeds to the same carbhydrate basis by multiplying the corn constituents and price by .625, as follows:

100 pounds bran, costing 75 cents, contains 12.01 pounds protein and 47.69 pounds carbhydrates.

62½ pounds corn, costing 50 cents, contains 4.95 pounds protein and 47.69 pounds carbhydrates.

Difference in protein, 7.06 pounds, costing 25 cents.

From which we find that, on the basis of this comparison, the protein in these feeds costs 3.55 cents per pound. By the same method we find the cost of the carbhydrates to be about 0.68 cent per pound.

2.—MANURIAL VALUE.

In addition to these nutritive values, our animal feeding stuffs have an incidental, but by no means unimportant value as sources of fertility; and indeed some of them, as cotton-seed and linseed oil meals and wheat bran, may sometimes be used directly for this purpose, in competition with the ordinary fertilizers of commerce: For instance, the Connecticut Experiment Station, which was the first fertilizer control station in America and has given most careful study to this question, says, in its eighth annual report:

"Attention is again called to the merits of Cotton Seed Meal as a fertilizer. It is the cheapest supply of available organic nitrogen now in the market. Experience demonstrates that it is very prompt to act and quite odorless. Its use as a fertilizer seems to be mostly confined to tobacco, but it is equally valuable for other crops, and at present rates deserves to be used extensively, to replace the higher priced nitrogen of dried blood, tankage and ground bone."

Analyses made by the Connecticut Station show that nitrogen may be purchased in cotton-seed meal at about 15 cents per pound (equivalent to 12¼ cents for ammonia), making due allowance for the phosphoric acid and potash contained in the meal, these being valued at five cents and four and one-half cents per pound respectivley.

On the basis of these valuations, we have compiled from Table XIII and Table XVI which follows, a table showing the fertilizing constituents contained in one ton of some of the more common feeding stuffs; the manurial value of the e fertilizing constituents; the feeding value, calculated as has been shown, and the average market value in 1894, as nearly as can be estimated from data at hand:

TABLE XV.—COMPARATIVE VALUES OF FEEDING STUFFS PER TON OF 2,000 POUNDS.

Feeding stuff.	Fertilizing constituents per ton.			Manurial value per ton.	Feeding value per ton.	Market value per ton.
	Nitrogen.	Phosphoric acid.	Potash.			
Green fodder:	*Pounds.*	*Pounds.*	*Pounds.*			
Corn fodder [1] (average all varieties)	8.2	3.0	6 6	$1.66	$2.54	....
Timothy grass, at different stages...	8.6	3.2	15.2	2.34	5.08	....
Hungarian grass	9.6	5.2	15.2	2.09	3 59	....
Red clover	10 6	2 6	9.2	2.11	4.40	....
Cowpeas	5.4	2.0	6.2	1.17	2.36	....
Corn silage...............	5.6	2.2	7.4	1.27	2.42	....
Corn silage, more mature	....	....	....	....	3.25	....
Hay, and dry, coarse fodder:						
Corn fodder,[1] field cured...............	35.2	10.8	17.8	$6.57	$6.82	....
Corn stover[2]	29.8	5.8	28.0	4.60	6.17	....
Hay from timothy (all analyses) ...	25.2	10.6	18.0	5.09	8.43	[3]$8.46
Hay from Hungarian grass..	24.0	7.0	26.0	5.05	10.64	....
Hay from red clover...............	41.4	7.6	44 0	8.46	10.00	....
Hay from cowpeas...............	....	....	....	....	13.25	....
Wheat straw	11.8	2.4	10 2	2.32	5 47	....
Rye straw...............	9.2	5.6	15.8	2.33	6.44	....
Oat straw	12.4	4 0	24.8	3.11	7.00	....
Roots and tubers:						
Potatoes	4 2	1 4	5 8	$1.00	$3.02	....
Beets (red)...............	4 8	1.8	8.8	1.18	2.08	....
Mangel-wurzels...............	3.8	1.8	7.6	.98	1.41	....
Turnips...............	3.6	2.0	7.8	.97	1.49	....
Grains:						
Corn (ave'ge of dent & flint) ground	36.4	14.0	8.0	$6.50	$16.00	$16.00
Oats, ground...............	41.2	16.4	12.4	7.52	14.42	[4]21.41

[1]Entire plant. [2]Fodder, without grain. [3]Average farm price of hay in Ohio, December 1, 1894, as reported by U. S. Department of Agriculture. [4]Average price in Chicago, 30c per bushel

TABLE XV—Concluded.

Feeding stuff.	Fertilizing constituents per ton.			Manurial value per ton.	Feeding value per ton.	Market value per ton.
	Nitrogen	Phos-phoric acid.	Potash.			
Grains—Concluded:	*Pounds.*	*Pounds.*	*Pounds.*			
Wheat (all varieties) ground	47 2	16.0	11.4	$8.36	$17.19	$[5]20.00
Rye, ground	35.2	16.4	10.8	6.55	16.37	18.45
By-products, etc.:						
Corn and cob meal	28.2	11.4	9.4	$5.20	$13.12	$13.04
Gluten meal	100.6	6.6	0.1	15 43	27.03	18.00
Wheat bran (all analyses)	53.4	57.8	32.2	12.27	15.12	15.00
Wheat middlings	52.6	19 0	12.6	9.37	17.36	16.70
Wheat flour	....	....	....	....	16.77	[6]22.34
Hominy feed	32.6	19.6	9 8	6.28	14.88	....
Cotton-seed meal	147.0	51.8	36.0	26 26	32.37	26.20
Linseed oil meal, old process	108.6	33.2	27.4	19.11	27.04	[7]26.79
Linseed oil meal, new process	115 6	36 6	27.8	20.35	25.58	18.00

[5] Equivalent to 52½c. per bushel. [6] Average price of low grade flour at Pittsburg for 1894.
[7] Average price at mills for domestic sales for year ending July 31, 1894

The manurial value, as given in Table XV, is based upon prices much lower than those at which commercial fertilizers are ordinarily sold at retail, though it is possible to purchase nitrogen, phosphoric acid and potash in their cheapest forms at these rates. A similar valuation would rate barnyard manure at about two dollars per ton, whereas its value, as compared with the average prices of mixed fertilizers in Ohio, is nearly three dollars per ton.

It should be understood that neither the manurial nor feeding values are given as absolute values. What they mean is that, at the average market prices of standard fertilizers and feeding materials, the various feeding stuffs are worth the prices given, as compared with each other, no allowance being made for relative convenience in handling nor for adaptability to special purposes.

It will be observed that in many cases there is a very close agreement between the calculated feeding value and the market value. Corn silage has no market value, not being a material suitable for handling, but its calculated value corresponds very closely to the estimated value, deduced from the results of our first feeding experiment, the silage used in that test being a little better, perhaps, than the first sample quoted in the table, but not equal to the second.

The market value of clover hay is considerably lower than that of timothy; but its actual feeding value is undoubtedly higher. This is because of the prejudice against clover hay as a feed for horses. Those who have fed perfectly cured clover hay know that this prejudice is due to the great difficulty in curing clover hay in our climate, and not to any defect in the clover itself. When properly cured it is as valuable a feed for horses as for any other animals.

The values given to the straws in this comparison may seem high; but it must be remembered that all these valuations are based upon the effect of rations made up of different foods, bearing to each other the proportions best adapted to complete digestion. If straw were fed alone it would show no such value as that given, but when fed in small quantities and in connection with other foods giving the proper balance to the ration it is probably worth the price indicated, in comparison with other foods, and this is as true of all the other feeding stuffs as of the straw.

The values given to roots and potatoes will probably seem low; but these values are in harmony with the results of extensive feeding experiments, made at this Station. Attention is called again to the fact that turnips and mangels contain a larger percentage of water than does milk, while the relative proportion of protein is much smaller than in milk. They may have a hygienic value, similar to that of fruits and vegetables in human diet, but this has not been demonstrated by experiment.

The market value of oats is much higher than the theoretical value; but the price of oats is governed by the reputation it has made as a food for horses, by its comparatively large use in human food, and by its relative cost of production. While the average price of corn in Chicago has averaged 45 cents per bushel, or 80 cents per cental of shelled grain, that of oats has averaged 30 cents per bushel, or 94 cents per cental. But the average yield of corn in Ohio is about 32 bushels, or 1,792 pounds of shelled grain per acre; that of oats for the 10 years, 1883–92, was 27.73 bushels, or 887 pounds of grain per acre; the actual weight of grain per acre being therefore less than half as much in the case of oats as in that of corn. The average acre of oats in Ohio has therefore been worth, at Chicago prices, $8.32, while that of corn has been worth $14.40, omitting the straw and fodder from the calculation. It is true that the acre of oats may be produced more cheaply than the acre of corn; but the difference in market value here indicated is certainly greater than the difference in cost of production, and oats would hardly be raised, in most parts of Ohio, except for its usefulness in a general system of crop rotation.

Among the by-products, the market price of gluten meal and new process linseed oil meal is seen to be very much below their theoretical value, which may be explained by the fact that these are comparatively new feeding stuffs, and farmers have not learned to use them generally. In our feeding experiment, as has been already stated, we found no ground for rating gluten meal lower than old process linseed oil meal. We have not made a thorough comparison of the two kinds of linseed meal, nor of cotton-seed meal.

Finally, it will be observed that this table is simply an attempt to compare animal foods on the basis of their average nutritive constituents, valuing these according to the best data at present attainable; data which it is hoped may be greatly improved upon in the near future. No attempt is made to estimate those factors of final value which are due to relative cost of handling (as between corn fodder and hay), to adaptability to special purposes, or to established prejudices. These factors, as well as the further point that a feeding stuff can only produce its full effect when fed in a ration adjusted to the physiological requirements of the animal, must be kept in mind in the use of the table.

APPENDIX.

The average composition of the principal materials used in feeding animals is shown in Tables XVI and XVII. Table XVI is compiled from tables originally prepared by Professors Jenkins and Winton, of the Connecticut Experiment Station, and revised by Dr. E. W. Allen, of the Office of Experiment Stations, U. S. Department of Agriculture, and Table XVII is given as compiled by Mr. W. H. Beal, of the Office of Experiment Stations. Both tables are intended to show the average composition, as derived from the most trustworthy analyses, American analyses being used wherever practicable.

TABLE XVI.—AVERAGE COMPOSITION OF FEEDING STUFFS.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
GREEN FODDER.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	
Corn fodder: [1]							
Flint varieties	79.8	1.1	2.0	4.3	12.1	0.7	40
Flint var. cut after kernels had glazed	77.1	1.1	2.1	4 3	14.6	0.8	10
Dent varieties	79 0	1.2	1.7	5.6	12.0	0.5	63
Dent var. cut after kernels had glazed	73.4	1.5	2.0	6.7	15.5	0.9	7

[1] Corn fodder is the entire plant, usually a thickly planted crop. Corn stover is what is left after the ears are harvested.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber	Nitrogen free extract.	Fat.	Number of analyses.
GREEN FODDER—Concluded.	Per ct	Per ct.	Per ct	Per ct	Per ct.	Per ct	
Corn fodder—Concluded:							
Sweet varieties	79.1	1.3	1.9	4.4	12.8	0.5	21
All varieties	79.3	1.2	1.8	5.0	12.2	0.5	126
Leaves and husks, cut green	66.2	2.9	2.1	8.7	19.0	1.1	4
Stripped stalks, cut green	76.1	0.7	0.5	7.3	14.9	0.5	4
Rye fodder	76.6	1.8	2.6	11.6	6.8	0.6	7
Oat fodder	62.2	2.5	3.4	11.2	19.3	1.4	6
Redtop,[1] in bloom	65.3	2.3	2.8	11.0	17.7	0.9	5
Tall oat grass,[2] in bloom	69.5	2.0	2.4	9.4	15.8	0.9	3
Orchard grass, in bloom	73.0	2.0	2.6	8.2	13.3	0.9	4
Meadow fescue, in bloom	69.9	1.8	2.4	10.8	14.3	0.8	4
Italian rye grass, coming into bloom	73.2	2.5	3.1	6.8	13.3	1.3	24
Timothy,[3] at different stages	61.6	2.1	3.1	11.8	20.2	1.2	56
Kentucky blue grass,[4] at different stages	65.1	2.8	4.1	9.1	17.6	1.3	18
Hungarian grass	71.1	1.7	3.1	9.2	14.2	0.7	14
Red clover, at different stages	70.8	2.1	4.4	8.1	13.5	1.1	43
Alsike clover,[5] in bloom	74.8	2.0	3.9	7.4	11.0	0.9	4
Crimson clover	80.9	1.7	3.1	5.2	8.4	0.7	3
Alfalfa,[6] at different stages	71.8	2.7	4.8	7.4	12.3	1.0	23
Serradella, at different stages	79.5	3.2	2.7	5.4	8.6	0.7	9
Cowpea	83.6	1.7	2.4	4.8	7.1	0.4	10
Soja bean	75.1	2.6	4.0	6.7	10.6	1.0	27
Horse bean	84.2	1.2	2.8	4.9	6.5	0.4	2
Flat pea (*Lathyrus sylvestris*)	66.7	2.9	8.7	7.9	12.2	1.6	2
Rape	84.5	2.0	2.3	2.6	8.4	0.5	2
SILAGE.							
Corn silage	79.1	1.4	1.7	6.0	11.0	0.8	99
Sorghum silage	76.1	1.1	0.8	6.4	15.3	0.3	6
Red clover silage	72.0	2.6	4.2	8.4	11.6	1.2	5
Soja bean silage	74.2	2.8	4.1	9.7	6.9	2.2	1
Cowpea vine silage	79.3	2.9	2.7	6.0	7.6	1.5	2
Fieldpea vine silage	50.1	3.5	5.9	13.0	26.0	1.6	1
Silage of mixture of cowpea vines and soja bean vines	69.8	4.5	3.8	9.5	11.1	1.3	1

[1]Herd's grass of Pennsylvania. [2]Meadow oat grass. [3]Herd's grass of New England and New York [4]June grass. [5]Swedish clover. [6]Lucern.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER.	*Per ct.*	*Per ct.*	*Per ct*	*Per ct*	*Per ct.*	*Per ct*	
Corn fodder,[1] field cured	42.2	2.7	4.5	14.3	34.7	1.6	35
Corn leaves, field cured	30.0	5.5	6.0	21.4	35.7	1.4	17
Corn husks, field cured	50.9	1.8	2.5	15.8	28.3	0.7	16
Corn stalks, field cured	68.4	1.2	1.9	11.0	17.0	0.5	15
Corn stover,[2] field cured	40.5	3.4	3.8	19.7	31.5	1.1	60
Hay from:							
Redtop,[3] cut at different stages	8.9	5.2	7.9	28.6	47.5	1.9	9
Redtop, cut in bloom	8.7	4.9	8.0	29.9	46.4	2.1	3
Orchard grass	9.9	6.0	8.1	32.4	41.0	2.6	10
Timothy,[4] all analyses	13.2	4.4	5.9	29.0	45.0	2.5	68
Timothy, cut in full bloom	15.0	4.5	6.0	29.6	41.9	3.0	12
Timothy, cut soon after bloom	14.2	4.4	5.7	28.1	44.6	3.0	11
Timothy, cut when nearly ripe	11.1	3.9	5.0	31.1	46.7	2.2	12
Kentucky blue grass	21.2	6.3	7.8	23.0	37.8	3.9	10
Cut when seed was in milk	24.4	7.0	6.3	24.5	34.2	3.6	4
Cut when seed was ripe	27.8	6.4	5.8	23.8	33.2	3.0	4
Hungarian grass	7.7	6.0	7.5	27.7	49.0	2.1	13
Meadow fescue	20.0	6.8	7.0	25.9	38.4	2.7	9
Italian rye grass	8.5	6.9	7.5	30.5	45.0	1.7	4
Mixed grasses	15.3	5.5	7.4	27.2	42.1	2.5	126
Rowen (mixed)[5]	16.6	6.8	11.6	22.5	39.4	3.1	23
Mixed grasses and clovers	12.9	5.5	10.1	27.6	41.3	2.6	17
Swamp hay	11.6	6.7	7.2	26.6	45.9	2.0	8
Salt marsh	10.4	7.7	5.5	30.0	41.1	2.4	10
Red clover	15.3	6.2	12.3	24.8	38.1	3.3	38
Red clover in bloom	20.8	6.6	12.4	21.9	33.8	4.5	6
Alsike clover	9.7	8.3	12.8	25.6	40.7	2.9	9
White clover	9.7	8.3	15.7	24.1	39.3	2.9	7
Crimson clover	9.6	8.6	15.2	27.2	36.6	2.8	7
Japan clover	11.0	8.5	13.8	24.0	39.0	3.7	2
Vetch	11.3	7.9	17.0	25.4	36.1	2.3	5
Serradella	9.2	7.2	15.2	21.6	44.2	2.6	3
Alfalfa[6]	8.4	7.4	14.3	25.0	42.7	2.2	21
Cowpea	10.7	7.5	16.6	20.1	42.2	2.2	8
Soja bean	11.3	7.2	15.4	22.3	38.6	5.2	6

[1]Entire plant. [2]What is left after the ears are harvested. [3]Herd's grass of Pennsylvania. [4]Herd's grass of New England and New York. [5]Second cut. [6]Lucern.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber	Nitrogen free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Concluded.	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	
Hay from—Concluded:							
Flat pea (*Lathyrus sylvestris*)	8.4	7.9	22.9	26.2	31.4	3.2	5
Peanut vines (without nuts)	7.6	10.8	10.7	23.6	42.7	4.6	6
Soja-bean straw	10.1	5.8	4.6	40.4	37.4	1.7	4
Horse-bean straw	9.2	8.7	8.8	37.6	34.3	1.4	1
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3	7
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2	7
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3	12
Buckwheat straw	9.9	5.5	5.2	43.0	35.1	1.3	3
ROOTS AND TUBERS.							
Potatoes	78.9	1.0	2.1	0.6	17.3	0.1	12
Sweet potatoes	71.1	1.0	1.5	1.3	24.7	0.4	6
Red beets	88.5	1.0	1.5	0.9	8.0	0.1	9
Sugar beets	86.5	0.9	1.8	0.9	9.8	0.1	19
Mangel-wurzels	90.9	1.1	1.4	0.9	5.5	0.2	9
Turnips	90.5	0.8	1.1	1.2	6.2	0.2	3
Ruta-bagas	88.6	1.2	1.2	1.3	7.5	0.2	4
Carrots	88.6	1.0	1.1	1.3	7.6	0.4	8
Artichokes	79.5	1.0	2.6	0.8	15.9	0.2	2
GRAINS AND OTHER SEEDS.							
Corn kernel:							
Dent, all analyses	10.6	1.5	10.3	2.2	70.4	5.0	86
Flint, all analyses	11.3	1.4	10.5	1.7	70.1	5.0	68
Sweet, all analyses	8.8	1.9	11.6	2.8	63.8	8.1	26
Pop varieties	10.7	1.5	11.2	1.8	69.6	5.2	4
Soft varieties	9.3	1.6	11.4	2.0	70.2	5.5	5
All varieties and analyses	10.9	1.5	10.5	2.1	69.6	5.4	208
Sorghum seed	12.8	2.1	9.1	2.6	69.8	3.6	10
Barley	10.9	2.4	12.4	2.7	69.8	1.8	10
Oats	11.0	3.0	11.8	9.5	59.7	5.0	30
Rye	11.6	1.9	10.6	1.7	72.5	1.7	6
Wheat, spring varieties	10.4	1.9	12.5	1.8	71.2	2.2	13
Wheat, winter varieties, all analyses	10.5	1.8	11.8	1.8	72.0	2.1	262
Wheat, all varieties	10.5	1.8	11.9	1.8	71.9	2.1	310
Rice	12.4	0.4	7.4	0.2	79.2	0.4	10

TABLE XVI—Continued.

	Water.	Ash.	Pro-tein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
GRAINS AND OTHER SEEDS—Concluded.	Per ct	Per ct.	Per ct.	Per ct	Per ct.	Per ct	
Buckwheat	12.6	2.0	10.0	8 7	61.5	2.2	8
Sunflower seed (whole)	8.6	2.6	16.3	29.9	21.4	21.2	2
Cotton seed, whole (with hulls)	10.3	3.5	18 4	23 2	24.7	19.9	5
Cotton-seed kernels (without hulls)	6.2	4.7	31.2	3.7	17 6	36.6	2
Cotton seed, whole, roasted	6 1	5 5	16.8	20 4	23.5	27.7	2
Peanut kernel (without hulls)	7 5	2.4	27 9	7.0	15.6	39.6	7
Horse bean	11.3	3.8	26.6	7.2	50.1	1.0	1
Soja bean	10.8	4.7	34.0	4.8	28.8	16.9	8
Cowpea	14.8	3.2	20.8	4.1	55 7	1.4	5
MILL PRODUCTS.							
Corn meal	15.0	1.4	9.2	1.9	68.7	3.8	77
Corn and cob meal	15.1	1.5	8.5	6.6	64.8	3.5	7
Oatmeal	7.9	2.0	14.7	0.9	67.4	7.1	6
Barley meal	11.9	2.6	10.5	6.5	66.3	2.2	3
Rye flour	13.1	0.7	6.7	0.4	78.3	0.8	4
Wheat flour, all analyses	12.4	0.5	10.8	0.2	75.0	1.1	20
Buckwheat flour	14.6	1.0	6.9	0 3	75.8	1 4	4
Ground linseed	8.1	4.7	21 6	7.3	27.9	30.4	2
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2	2
Soja-bean meal	10 8	4.5	36.7	4.5	27.3	16.2	1
Ground corn and oats, equal parts	11.9	2.2	9.6	....	[1] 72.0	4 4	6
WASTE PRODUCTS.							
Corncob	10.7	1.4	2.4	30 1	54.9	0.5	18
Hominy chops	11.1	2 5	9.8	3.8	64.5	8.3	12
Corn germ	10.7	4.0	9.8	4.1	64.0	7.4	3
Corn-germ meal	8.1	1 3	11.1	9.9	62 5	7.1	6
Gluten meal	8.8	0.8	29 7	2.2	49.8	8.7	54
Recent analyses	8.2	0.9	29 3	3.3	46 5	11 8	20
Chicago[2]	10 1	1.1	30 1	1.6	48.7	8.4	6
Buffalo[2]	8.2	0 8	23.3	6.1	50.4	11.2	5
Cream gluten	8.1	0.7	36.1	1.3	39 0	14.8	3
Gluten feed	7 8	1.1	24 0	5 3	51.2	10 6	11
Buffalo[2]	7.7	1.1	25.0	5.3	49.3	11 6	5
Pope's	14.0	0 6	33 3	1.6	36.5	14.1	1
Peoria[2]	7.5	0.8	19 8	8.2	51.1	12.6	1

[1] Including fiber

[2] Included in above average.

TABLE XVI—Concluded.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses
WASTE PRODUCTS—Concluded.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	
Chicago maize feed	9.1	0.9	22.8	7.6	52.7	6.9	3
Glucose feed and glucose refuse	6.5	1.1	20.7	4.5	56.8	10.4	2
Dried starch feed and sugar feed	10.9	0.9	19 7	4.7	54.8	9.0	4
Starch feed, wet	65.4	0.3	6.1	3.1	22.0	3.1	12
Oat feed	7.7	3.7	16.0	6.1	59.4	7.1	4
Barley screenings	12.2	3.6	12.3	7.3	61.8	2.8	2
Malt sprouts	10.2	5.7	23.2	10.7	48.5	1.7	4
Brewers' grains, wet	75.7	1.0	5.4	3.8	12.5	1.6	15
Brewers' grains, dried	8.2	3.6	19.9	11.0	51.7	5.6	3
Grano gluten	5.8	2.8	31.1	12.0	33.4	14.9	1
Rye bran	11.6	3.6	14.7	3.5	63.8	2.8	7
Wheat bran from spring wheat	11.5	5.4	16.1	8.0	54.5	4.5	10
Wheat bran from winter wheat	12.3	5.9	16.0	8.1	53.7	4.0	7
Wheat bran, all analyses	11.9	5.8	15.4	9.0	53.9	4.0	88
Wheat middlings	12.1	3.3	15.6	4.6	60.4	4.0	32
Wheat shorts	11.8	4.6	14.9	7.4	56.8	4.5	12
Wheat screenings	11.6	2.9	12.5	4.9	65.1	3.0	10
Rice bran	9.7	10.0	12.1	9.5	49.9	8.8	5
Rice hulls	8.2	13.2	3.6	35.7	38.6	0.7	3
Rice polish	10.0	6.7	11.7	6.3	58.0	7.3	4
Buckwheat middlings	13.2	4.8	28.9	4.1	41.9	7.1	3
Cotton-seed meal	8.2	7.2	42.3	5.6	23.6	13.1	35
Cotton-seed hulls	11.1	2.8	4.2	46.3	33.4	2.2	20
Linseed meal, old process	9.2	5.7	32.9	8.9	35.4	7.9	21
Linseed meal, new process	10.1	5.8	33.2	9.5	38.4	3.0	14
Peanut meal[1]	10.7	4.9	47.6	5.1	23.7	8.0	2,480
Peanut hulls	9.0	3.4	6.6	64.3	15.1	1.6	5
MILK AND ITS BY-PRODUCTS.							
Whole milk	87 2	0.7	3.6	....	4.9	3.7	793
Skim milk cream raised by setting	90.4	0.7	3.3	....	4.7	0.9	96
Skim milk, cream raised by separator	90.6	0.7	3.1	....	5.3	0.3	7
Buttermilk	90.1	0.7	4.0	....	4.0	1.1	85
Whey	93.8	0.4	0.6	....	5.1	0.1	46

[1] Mostly European analyses.

TABLE XVII.—FERTILIZING CONSTITUENTS OF AMERICAN FEEDING STUFFS.

	Moisture	Ash.	Nitrogen	Phos-phoric acids.	Potash.
GREEN FODDERS.					
Corn fodder	73.51	4.84	0.41	0.15	0.33
Common millet	62.58	....	0.61	0.19	0.41
Hungarian grass (*German millet*)	74.81	....	0.39	0.16	0.55
Orchard grass (*Dactylis glomerata*)	73.14	2.09	0.43	0.16	0.76
Timothy grass (*Phleum pratense*)	66.90	2.15	0.48	0.26	0.76
Mixed pasture grasses	63.12	3.27	0.91	0.23	0.75
Red clover (*Trifolium pratense*)	80.00	....	0.53	0.13	0.46
White clover (*Trifolium repens*)	81.00	....	0.56	0 20	0.24
Alsike clover (*Trifolium hybridum*)	81.80	1.47	0.44	0.11	0.20
Scarlet clover (*Trifolium incarnatum*)	82.50	....	0.43	0.13	0.49
Alfalfa (*Medicago sativa*)	75.30	2.25	0.72	0.13	0.56
Cowpea	78.81	1.47	0.27	0.10	0.31
Soja bean (*Glycine soja*)	73.20	....	0.29	0 15	0.53
Corn silage	77.95	....	0.28	0.11	0.37
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears)	7 85	4.91	1.76	0.54	0.89
Corn stover (without ears)	9.12	3.74	1.04	0.29	1.40
Common millet	9.75	....	1.28	0.49	1.69
Hungarian grass	7.69	6.18	1.20	0.35	1.30
Hay of mixed grasses	11.99	6.34	1.41	0.27	1.55
Redtop (*Agrostis vulgaris*)	7.71	4.59	1.15	0.36	1.02
Timothy	7 52	4.93	1.26	0.53	0.90
Orchard grass	8.84	6.42	1.31	0.41	1.88
Kentucky blue grass (*Poa pratensis*)	10 35	4.16	1.19	0.40	1.57
Meadow fescue (*Festuca pratensis*)	8.89	8.08	0.99	0.40	2.10
Red clover	11.33	6.93	2.07	0.38	2.20
Mammoth red clover (*Trifolium medium*)	11.41	8.72	2.23	0.55	1.22
White clover	....	....	2.75	0.52	1.81
Scarlet clover	18.30	7.70	2.05	0.40	1.31
Alsike clover	9.94	11.11	2.34	0.67	2.23
Alfalfa	6.55	7.07	2.19	0.51	1.68
Bokhara clover (*Melilotus alba*)	7.43	7.70	1.93	0.56	1.83
Soja bean (whole plant)	6.39	6.47	2.32	0.67	1.08
Soja bean (straw)	13.00	....	1.75	0.40	1.32
Cowpea (whole plant)	10.95	8.40	1.95	0.52	1.47
Barley straw	11.44	5.30	1.31	0 30	2.09
Barley chaff	13.08	....	1.01	0.27	0.99
Wheat straw	12.56	3.81	0.59	0.12	0.51

TABLE XVII—Continued.

	Moisture	Ash.	Nitrogen	Phosphoric acid.	Potash.
HAY AND DRY COARSE FODDERS—Concluded.					
Wheat chaff	8.05	7.18	0.79	0.70	0.42
Rye straw	7.61	3.25	0.46	0.28	0.79
Oat straw	9.09	4.76	0.62	0.20	1.24
ROOTS, BULBS, TUBERS, ETC.					
Potatoes	79.75	0.99	0.21	0.07	0.29
Red beets	87.73	1.13	0.24	0.09	0.44
Sugar beets	86.95	1.04	0.22	0.10	0.48
Mangel-wurzels	87.29	1.22	0.19	0.09	0.38
Turnips	89.49	1.01	0.18	0.10	0.39
Ruta-bagas	89.13	1.06	0.19	0.12	0.49
Carrots	89.79	9.22	0.15	0.09	0.51
GRAINS AND OTHER SEEDS.					
Corn kernels	10.88	1.53	1.82	0.70	0.40
Sorghum seed	14.00	....	1.48	0.81	0.42
Barley	14.30	2.48	1.51	0.79	0.48
Oats	18.17	2.98	2.06	0.82	0.62
Wheat (spring)	14.35	1.57	2.36	0.70	0.39
Wheat (winter)	14.75	....	2.36	0.89	0.61
Rye	14.90	....	1.76	0.82	0.54
Common millet	12.68	....	2.04	0.85	0.36
Soja beans	18.33	4.99	5.30	1.87	1.99
MILL PRODUCTS.					
Corn meal	12.95	1.41	1.58	0.63	0.40
Corn and cob meal	8.96	....	1.41	0.57	0.47
Ground oats	11.17	3.37	1.86	0.77	0.59
Ground barley	13.43	2.06	1.55	0.66	0.34
Rye flour	14.20	....	1.68	0.85	0.65
Wheat flour	9.83	1.22	2.21	0.57	0.54
Pea meal	8.85	2.68	3.08	0.82	0.99
BY-PRODUCTS AND WASTE MATERIALS.					
Corn cobs	12.09	0.82	0.50	0.06	0.60
Hominy feed	8.93	2.21	1.63	0.98	0.49
Gluten meal	8.59	0.73	5.03	0.33	0.05
Starch feed (glucose refuse)	8.10	....	2.62	0.29	0.15
Malt sprouts	10.38	12.48	3.55	1.43	1.63
Brewers' grains (dry)	6.98	6.15	3.05	1.26	1.55
Brewers' grains (wet)	75.01	....	0.89	0.31	0.05
Rye bran	12.50	4.60	2.32	2.28	1.40

TABLE XVII—Concluded.

	Moisture	Ash.	Nitrogen	Phosphoric acid.	Potash.
BY-PRODUCTS AND WASTE MATERIALS—Concluded.					
Rye middlings	12.54	3.52	1.84	1.26	0.81
Wheat bran	11.74	6.25	2.67	2.89	1.61
Wheat middlings	9.18	2.30	2.63	0.95	0.63
Cotton-seed meal	9.90	6.82	6.64	2.68	1.79
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Apple pomace	80.50	0.27	0.23	0.02	0.13