

DIGESTIBILITY OF CORN SILAGE, VELVET-BEAN MEAL, AND ALFALFA HAY WHEN FED SINGLY AND IN COMBINATIONS

By P. V. EWING, *Animal Husbandman, Texas Agricultural Experiment Station*
and F. H. SMITH,¹ *Georgia Agricultural Experiment Station*

INTRODUCTION

This paper is the third in a series of investigations on the associative action of various feeds. The results with rations made up of corn silage, cottonseed meal, and starch² and those made up of corn silage and cottonseed meal³ have been published, and the present article deals with the question of the digestibility of rations made up of corn silage, velvet-bean meal, and alfalfa hay. The investigation was conducted with the view of studying the extent and causes of fluctuations in the total nutrient digestibility induced by the combinations of these feeds, and the relationship of these fluctuations to the feeding practice.

PLAN OF INVESTIGATION

The steers used were the high-grade 2-year-old north-Georgia¹ Short-horns which had been used in the nutrition work of the winter of 1915-16 (previously reported).⁴

The corn silage and alfalfa hay were both produced on the Station farm and were of average grade. The velvet-bean meal was from commercial stock and came from near the southern Georgia-Alabama line. The average analyses of these feeds are given in Table I.

TABLE I.—Average percentage composition of the feeds used

Feed.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Silage.....	26.29	0.773	7.304	1.180	0.252	15.46
Alfalfa hay.....	91.02	2.675	30.770	6.865	2.564	34.68
Velvet-bean meal.....	89.37	4.576	14.430	4.250	2.764	48.84

¹ F. H. Smith is now a lieutenant in the Aviation Branch of the United States Army. The work on which this paper is based was done while the senior and junior writers were connected with the Georgia Agricultural Experiment Station in the capacities of Animal Husbandman and Chemist, respectively.

² EWING, P. V., and WELLS, C. A. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE, COTTONSEED MEAL, AND STARCH IN STEER RATIONS. *Ga. Agr. Exp. Sta. Bul.* 115, p. 269-296, 7 diagr. 1915.

³ EWING, P. V., WELLS, C. A., and SMITH, F. H. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE AND COTTONSEED MEAL IN STEER RATIONS. pt. 2. *Ga. Agr. Exp. Sta. Bul.* 125, p. 149-164, 1 fig. 1917.

⁴ EWING, P. V., and SMITH, F. H. A STUDY OF THE RATE OF PASSAGE OF FOOD RESIDUES THROUGH THE STEER AND ITS INFLUENCE ON DIGESTION COEFFICIENTS. *In Jour. Agr. Research*, v. 10, no. 2, p. 55-63. 1917.

Nine different rations were fed, and the digestion trials were made in triplicate, different quantities of the feeds being used in each of the three trials. The first three rations contained but one feed each, the next three contained two feeds each, and the last three contained three feeds each. A feature of the rations was the variations presented as to quantities and proportions, and in each of the last three rations the quantity in one feed was varied, while the other two were kept constant. This provided means for checking the influences exerted by the specific components of the rations. The composition of the various rations and the weight of the feces excreted daily are given in Table II. The percentage composition of the feces is given in Table III.

TABLE II.—Weights of animals, feed, and feces

Ration No.	Digestion trial No.	Steer No.	Average weight.	Average daily feed.			Average weight of feces excreted daily.
				Silage.	Velvet-bean meal.	Alfalfa.	
			<i>Kgm.</i>	<i>Kgm.</i>	<i>Kgm.</i>	<i>Kgm.</i>	<i>Kgm.</i>
I.....	a.....	63	260	6			2.280
	b.....	64	284	8			4.705
	c.....	62	259	10			5.045
II.....	a.....	61	273			3.000	4.642
	b.....	66	280			4.000	6.120
	c.....	65	282			4.292	6.850
III.....	a.....	65	270		3.50		2.609
	b.....	65	288		3.50		2.368
	c.....	65	277		3.50		2.521
IV.....	a.....	66	284	2		4.000	6.651
	b.....	65	293	3		3.000	6.298
	c.....	61	278	4		2.000	4.934
V.....	a.....	64	298	4	3.50		5.072
	b.....	63	282	6	2.75		5.749
	c.....	62	271	8	2.00		6.475
VI.....	a.....	64	290		2.00	3.000	8.128
	b.....	63	274		2.80	2.800	7.745
	c.....	62	290		3.00	2.000	6.480
VII.....	a.....	62	306	8	2.00	2.000	9.950
	b.....	63	318	6	2.00	2.000	9.193
	c.....	64	335	4	2.00	2.000	8.372
VIII.....	a.....	64	335	4	2.00	2.000	8.372
	b.....	61	262	4	1.50	2.000	6.367
	c.....	66	298	4	2.50	2.000	9.217
IX.....	a.....	64	335	4	2.00	2.000	8.372
	b.....	62	318	4	2.00	2.500	7.638
	c.....	63	318	4	2.00	3.000	8.610

TABLE III.—Percentage composition of the feces of steers

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
I.....	a.....	20.34	0.459	4.115	2.276	0.391	11.05
	b.....	15.48	.445	3.008	1.714	.313	8.36
	c.....	15.07	.346	3.113	1.467	.300	8.27
II.....	a.....	21.76	.972	8.238	2.677	.507	6.70
	b.....	21.72	1.035	8.336	2.200	.520	6.90
	c.....	21.28	.998	8.331	2.291	.464	6.76
III.....	a.....	20.50	1.888	4.159	2.818	.983	5.49
	b.....	19.70	1.086	4.355	2.324	.841	8.68
	c.....	20.205	1.592	4.231	2.633	.931	6.665
IV.....	a.....	24.24	1.097	8.222	2.552	.541	8.99
	b.....	20.06	.920	6.635	2.221	.437	7.55
	c.....	21.53	.931	6.668	2.330	.498	8.49
V.....	a.....	19.42	.900	4.262	1.641	.628	8.69
	b.....	18.17	.691	4.373	1.577	.547	8.11
	c.....	15.60	.444	3.638	1.426	.448	7.29
VI.....	a.....	16.97	.965	6.118	1.660	.428	5.55
	b.....	19.40	.955	6.658	1.812	.565	6.44
	c.....	18.05	.799	6.218	1.929	.555	5.64
VII.....	a.....	17.83	.611	5.787	1.699	.405	7.20
	b.....	19.50	.727	6.361	1.865	.473	7.59
	c.....	17.39	.750	5.716	1.779	.455	6.30
VIII.....	a.....	17.39	.750	5.716	1.779	.455	6.30
	b.....	20.23	.800	6.126	2.319	.550	7.55
	c.....	16.37	.689	4.723	1.916	.454	6.20
IX.....	a.....	17.39	.750	5.716	1.779	.455	6.30
	b.....	19.49	.778	6.215	2.279	.502	7.08
	c.....	20.08	.811	6.444	2.293	.518	7.30

The equipment used and the general methods of weighing and sampling the feeds were similar to those previously described.¹ The digestion trials were of 12 days' duration each, with a minimum preliminary feeding period of 18 days. The quantity of feed was so gauged that there were no orts, and if a steer failed to eat its feed, the trial with that animal was discontinued.

DISCUSSION OF RESULTS

The digestion coefficients, with which we are primarily concerned, obtained for the several rations are given in Tables IV to X, being summarized and averaged in Tables VIII, IX, and X. In each instance the starting point for these studies is the result of feeding-alone experiments, probably the most accurate guide on the digestion of a specific food, especially when the metabolic products are taken into account. However, this has not been done in this study.

¹ EWING, P. V., WELLS, C. A., and SMITH, F. H. Op. cit.

TABLE IV.—*Digestion coefficients of the total nutrients of each ration*

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen free extract.
I.....	a.....	70.58	78.26	78.54	26.76	40.00	72.85
	b.....	65.38	66.13	75.69	13.83	25.00	68.23
	c.....	71.09	77.92	78.49	37.29	40.00	73.03
II.....	a.....	63.02	43.75	58.61	39.81	68.83	70.13
	b.....	62.67	41.12	58.57	50.91	68.93	69.60
	c.....	62.68	40.87	56.78	46.78	70.91	68.91
III.....	a.....	82.90	69.38	78.42	50.34	73.20	91.63
	b.....	85.10	83.75	79.61	63.09	79.38	90.05
	c.....	83.72	75.00	78.81	55.71	75.26	90.17
IV.....	a.....	61.31	40.16	60.28	43.14	66.67	64.76
	b.....	64.12	43.69	63.40	41.91	67.06	68.38
	c.....	63.02	45.88	63.73	37.50	59.02	68.06
V.....	a.....	76.44	75.92	72.90	57.65	70.09	81.05
	b.....	74.10	76.74	69.94	51.60	65.93	79.48
	c.....	74.04	81.17	72.97	48.60	61.33	78.68
VI.....	a.....	69.48	54.65	58.99	53.61	73.49	77.65
	b.....	70.24	63.55	59.24	54.99	70.47	78.67
	c.....	74.01	72.78	61.55	52.83	73.14	83.10
VII.....	a.....	68.93	70.67	61.29	46.52	68.25	75.38
	b.....	65.41	65.10	56.41	41.30	66.94	73.14
	c.....	68.75	64.41	59.95	44.61	67.24	76.98
VIII.....	a.....	68.75	64.41	59.95	44.61	67.24	76.98
	b.....	69.43	66.88	65.27	40.32	65.69	76.48
	c.....	70.45	67.84	65.69	38.97	67.69	77.46
IX.....	a.....	68.75	64.41	59.95	44.61	67.24	76.98
	b.....	70.89	68.95	64.82	42.76	70.54	78.03
	c.....	68.96	65.52	63.10	41.72	68.31	76.14

TABLE V.—*Digestion coefficients of corn silage by difference*^a

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
I.....	a.....	70.58	78.26	78.54	26.76	40.00	72.85
	b.....	65.38	66.13	75.69	13.83	25.00	68.23
	c.....	71.09	77.92	78.49	37.29	40.00	73.03
IV.....	a.....	49.82	26.67	79.57	43.37
	b.....	68.06	47.83	86.30	18.86	37.50	65.74
	c.....	63.12	51.61	75.68	12.77	10.00	66.35
V.....	a.....	54.18	74.19	62.33	61.70	20.00	54.69
	b.....	58.78	78.27	61.87	43.66	13.33	63.36
	c.....	65.62	88.71	70.03	41.49	20.00	60.28
VII.....	a.....	61.34	87.10	55.99	38.30	45.00	66.61
	b.....	47.24	69.57	39.27	14.08	26.67	57.43
	c.....	52.95	67.75	45.21	19.15	10.00	63.75
VIII.....	a.....	52.95	67.75	45.21	19.15	10.00	63.75
	b.....	62.17	90.32	70.21	2.13	10.00	67.48
	c.....	54.75	80.64	65.41	10.00	60.36
IX.....	a.....	52.95	67.75	45.21	19.15	10.00	63.75
	b.....	65.87	106.45	68.84	6.38	40.00	70.06
	c.....	59.03	93.55	63.70	2.13	10.00	64.40

^a The alfalfa and velvet-bean meal digestion coefficients are based on feeding-alone experiments.

TABLE VI.—*Digestion coefficients of velvet-bean meal by difference* ^a

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
III.....	a.....	82.90	69.38	78.42	50.34	73.20	91.63
	b.....	85.10	83.75	79.61	63.09	79.38	90.05
	c.....	83.72	75.00	78.81	55.71	75.26	90.17
V.....	a.....	78.33	75.63	69.70	65.77	73.20	83.97
	b.....	76.20	76.19	60.45	63.25	71.05	84.06
	c.....	77.78	83.70	61.94	67.06	69.09	85.98
VI.....	a.....	79.41	65.22	62.28	72.94	78.18	86.29
	b.....	77.66	76.56	61.88	69.75	71.43	85.16
	c.....	81.50	84.67	66.51	60.16	75.90	89.50
VII.....	a.....	72.75	82.61	33.56	63.53	78.18	72.37
	b.....	63.12	71.74	19.38	41.18	72.73	75.85
	c.....	73.42	72.83	45.33	49.41	70.91	84.75
VIII.....	a.....	73.42	72.83	45.33	49.41	70.91	84.75
	b.....	77.11	81.16	68.06	34.37	68.29	85.95
	c.....	76.32	77.28	68.42	33.02	71.01	84.21
IX.....	a.....	73.42	72.83	45.33	49.41	70.91	84.75
	b.....	81.03	85.87	69.20	42.35	76.36	88.74
	c.....	77.00	81.52	64.01	37.65	70.91	85.16

^a The corn-silage and alfalfa-hay digestion coefficients are based on feeding-alone experiments.

TABLE VII.—*Digestion coefficients of alfalfa hay by difference* ^a

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
II.....	a.....	63.02	43.75	58.61	39.81	68.83	70.13
	b.....	62.67	41.12	58.57	50.91	68.93	69.60
	c.....	62.68	40.87	56.78	46.78	70.91	68.91
IV.....	a.....	64.91	34.58	58.08	44.00	67.96	63.69
	b.....	62.13	33.75	59.80	43.69	70.12	66.18
	c.....	58.51	27.77	56.74	39.41	62.74	63.69
VI.....	a.....	60.01	30.00	52.76	52.42	71.42	65.51
	b.....	56.85	42.66	50.00	54.16	65.27	61.77
	c.....	59.39	64.81	49.26	49.63	68.62	67.29
VII.....	a.....	51.92	53.70	36.74	50.36	70.58	58.50
	b.....	42.52	35.18	30.07	36.49	64.70	48.67
	c.....	52.63	37.03	42.27	41.60	62.74	61.38
VIII.....	a.....	52.63	37.03	42.27	41.60	62.74	61.38
	b.....	57.96	50.00	54.14	35.77	62.74	64.69
	c.....	53.68	44.44	51.87	27.73	62.74	58.40
IX.....	a.....	52.63	37.03	42.27	41.60	62.74	61.38
	b.....	60.58	55.23	54.35	38.95	70.31	67.12
	c.....	58.44	48.75	53.30	37.86	66.23	64.45

^a The corn-silage and velvet-bean meal digestion coefficients are based on feeding-alone experiments.

TABLE VIII.—*Average corn-silage digestion coefficients when velvet-bean meal and alfalfa-hay coefficients are based on feeding-alone experiments*

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone.....	69.02	74.10	77.57	25.96	35.00	71.37
With alfalfa hay.....	60.33	42.04	80.52	15.82	23.75	58.49
With velvet-bean meal.....	59.53	80.39	64.74	48.95	17.78	62.44
With alfalfa hay and velvet-bean meal.....	56.58	81.21	55.45	15.06	19.07	64.18
Average.....	61.37	69.43	69.57	26.45	23.90	64.12

TABLE IX.—Average velvet-bean meal digestion coefficients by difference when alfalfa-hay and corn-silage coefficients are based on feeding-alone experiments

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone.	83.91	76.04	78.95	56.36	75.95	90.62
With corn silage.	77.42	78.51	64.03	65.36	71.11	84.67
With alfalfa hay.	79.52	75.48	63.03	67.46	75.17	86.98
With corn silage and alfalfa hay.	74.17	77.63	50.96	44.48	72.25	82.95
Average.	78.76	76.92	64.38	58.42	73.62	86.31

TABLE X.—Average alfalfa-hay digestion coefficients by difference when velvet-bean meal and corn-silage coefficients are based on feeding-alone experiments

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone.	62.79	41.91	57.99	45.83	69.56	69.55
With corn silage.	61.85	32.03	58.21	42.37	66.94	64.52
With velvet-bean meal.	58.75	45.82	50.67	52.07	68.44	64.86
With corn silage and velvet-bean meal.	53.67	33.26	45.25	39.11	65.06	60.66
Average.	59.27	38.26	53.03	44.85	67.50	64.90

Reference to the tables show that, as a general proposition, the digestibility of a feed is greatest when fed alone, next greatest when fed in combination with one other feed, and least when fed in combination with the two other feeds. In this connection, however, the apparent loss in digestibility is not necessarily all attributable to the combination, for the total dry matter consumed in the rations containing two feeds was greater than in the rations containing one feed, and the total dry matter of the rations made up of three feeds was greater than the rations containing two feeds. Thus, the quantity of the feed in the larger rations probably had a depressing effect on digestibility. Kellner¹ cites his own experiments with steers fed mixed rations which show an apparent decrease in digestibility with an increasing quantity of feed, and Armsby and Fries² state that their results seem to—

indicate clearly a real, although slight, effect of increasing quantity in diminishing the percentage digestibility.

Our results have shown the same slight decline, but it is not probable that the total decline in digestion coefficients obtained with three feeds compared with two, and with two feeds compared with one, is accounted

¹ KELLNER, OSKAR. DIE ERNÄHRUNG DER LANDWIRTSCHAFTLICHEN NUTZTIERE. Aufl. 6, p. 48. Berlin, 1912.

² ARMSBY, H. P., and FRIES, J. A. THE INFLUENCE OF TYPE AND OF AGE UPON THE UTILIZATION OF FEED BY CATTLE. U. S. Dept. Agr. Bur. Anim. Indus. Bul. 128, p. 28. 1911.

for by the increased quantity of feed. We must therefore conclude that in general, so far as the feeds we are studying are concerned, the combination with other feeds has a depressing effect on digestion. This does not necessarily follow for all the individual nutrients.

It is evident from a study of the tables that, so far as the average apparent digestion coefficients of silage are concerned, nothing is especially abnormal or noteworthy. It is true that the nitrogen (crude protein) digestion presents some irregularities when fed in combination with other feeds, but when fed alone these irregularities are not out of the ordinary. The amount of nitrogen in corn silage is so small that variations are likely to occur. Ash digestion also not only shows considerable irregularity at times but frequently shows a negative coefficient. This same condition has been noted in previous digestion experiments.

The apparent coefficients obtained for velvet-bean meal are of special interest on account of the relatively few digestion trials that have been made with this comparatively important feed. From our results it is seen that, as a whole, this feed is rather highly digestible; and when fed alone approximately 84 per cent of the dry matter is digested. The apparent digestibility of none of the nutrients averaged less than 58 per cent.

The apparent digestion coefficients for alfalfa hay present no marked irregularities. They do show the same general decline as a result of combination and quantity of feed. This decline amounts to over 10 per cent from feeding alone to the combining of all three feeds in Ration VII, where the total quantity of dry matter consumed was greater than in any other ration.

Thus, these results show no great variations from what might have been expected. While it is true that from an economic standpoint we are interested in that combination of feeds which will give the greatest digestibility for all the nutrients of the rations, these results do show no marked decline as a result of food combinations. If marked declines existed, their presence would be magnified by the determination of digestion coefficients by difference, but here we have no marked variations from the normal and can therefore conclude that the combining of these feeds has resulted in no marked increase or decrease in apparent digestion coefficients.

When rations that contain silage, velvet-bean meal, and alfalfa hay are fed, the tendency seems to be to lower the digestibility of the whole slightly below the calculated digestion coefficients. There are indications also that slightly better use is made of the feeds fed when the ration is made up of silage and one of the protein feeds than when both the protein feeds are fed, and that the most complete digestion takes place with silage and alfalfa rather than with the silage and velvet-bean meal, although the difference is small.

We appreciate the effect of individual variation in digestion and the slight variations which are likely to occur as a result of making the digestion trials at different times. The trials were made in triplicate, and the time factor was minimized by the method of planning the experiment. The slight variations noted are so general that it is hardly conceivable that they could in any way be accounted for by the possible errors mentioned.

CONCLUSIONS

Aside from the actual digestion coefficients obtained by the feeding of these feeds alone and under the different combinations, a review of the coefficients seems to justify the following conclusions:

(1) The combining of these feeds in general tends toward lowering the digestibility of the several nutrients of the rations.

(2) The digestion of corn silage, alfalfa hay, and velvet-bean meal is apparently fairly constant under the different combinations.

(3) More accurate digestion coefficients are obtained by feeding-alone experiments, where such are possible, rather than by the usual difference method.

(4) Greater variations are presented in the apparent digestibility of nitrogen and ash than in other nutrients.

(5) Compared with similar feeds, velvet-bean meal is apparently well digested.