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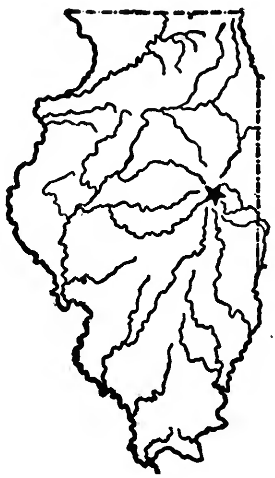
THE SUNFLOWER AS A SILAGE CROP

FEEDING VALUE FOR DAIRY COWS; COMPOSITION AND DIGESTIBILITY WHEN ENSILED AT DIFFERENT STAGES OF MATURITY

By W. B. NEVENS



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Contents of Bulletin No. 253

THE SUNFLOWER AS A SILAGE CROP

FEEDING VALUE FOR DAIRY COWS; COMPOSITION AND DIGESTIBILITY WHEN ENSILED AT DIFFERENT STAGES OF MATURITY

By W. B. NEVENS, Assistant Chief in Dairy Cattle Feeding

The sunflower is an important silage crop in sections of Illinois in which successful corn raising is uncertain owing to drouth and the ravages of chinch-bugs. Some difficulties, however, have been experienced in the use of sunflowers for silage as a substitute for corn. A good quality of silage is not always secured and as a result the normal level of milk production frequently is lowered. Also, digestive troubles sometimes occur. Since somewhat similar difficulties were encountered in the early use of corn silage and these were largely overcome by harvesting and ensiling the corn at a comparatively advanced stage of maturity, it seemed likely that a practical solution for the problems involved might be had by making a study of the feeding value for milk production of silage made from sunflowers harvested at different stages of maturity. Accordingly an experiment was undertaken with this object in view, the results of which are reported in this bulletin. Studies of the composition and digestibility of the silage were considered essential parts of the investigation.[1]

REVIEW OF PREVIOUS WORK

A review of the literature covering investigations of sunflower silage was first made in order to determine, if possible, whether the experimental work so far conducted pointed to a method of averting the undesirable features arising in the use of sunflowers for silage.

Value for Milk Production.—A considerable number of feeding trials have been conducted in which sunflower silage and corn silage have been compared with regard to their feeding value for milk production. Reports of the work indicate a wide variance in the results secured. In several cases[2, 6, 13, 19, 24, 26, 29, 30, 32, 37] it was found that sunflower silage was "equal" to corn silage, nearly equal, or at least gave "excellent results." In a number of instances,[1, 9, 10, 14, 31, 36], however, decreased production was noted as a result of feeding

[1]The results of the investigation of the composition and yield of the sunflower crop at different stages of maturity are to be published in a later bulletin.

sunflower silage. One report[23] states that cows fed sunflower silage and corn silage in alternate periods for one season maintained their milk yields, but that during the following season, when they were fed sunflower silage continuously, they dropped in milk flow. In two cases[25, 38] sunflower silage is reported as superior to corn silage for dairy cows.

Palatability.—The reports of the relative palatability of corn and of sunflower silage are also somewhat conflicting. In several cases[1, 6, 8, 29] it is stated that sunflower silage was eaten as readily as corn silage or other kinds of silage,[25] but the majority of writers [10, 14, 23, 26, 36, 39, 43, 44] mentioning this fact state that sunflower silage is less palatable than corn silage. One writer[23] notes that there was a decreased amount of sunflower silage consumed as the feeding continued, and another[27] observes that "sunflower silage varies greatly in quality and palatability." Sunflower silage at one station[10] showed "a distinct lack of palatability." Silage made from the later cuttings of sunflowers at the Wisconsin Station[45] was less palatable than that of earlier cuttings.

Physiological Effects.—In one report[1] cows fed sunflower silage are said to have appeared to be "just as healthy" as those fed corn silage, and another report[6] states that "no bad effects" were noted and that the condition of the cattle fed sunflower silage was superior to that of the cattle fed either corn or peas and oats silage. One investigator[37] states that "all cows were in splendid condition at the close of the experiment." On the other hand, it is stated by one writer[9] that "sunflower silage does not have a desirable physical effect on the cow." In one case[12] a slight tendency to scouring was observed in calves fed sunflower silage.

A pronounced tendency to diuresis (greatly increased excretion of urine) was noted in a few cases[12, 30] as a result of feeding sunflower silage.

Data are also given to show that cows receiving sunflower silage gained less in weight or suffered greater losses in weight than the cows fed the control rations.[6, 38, 44] In one case[1] no difference in loss or gains was noted between the groups of cows compared.

Digestibility.—Digestion trials with sunflower silage have been conducted at a number of experiment stations.[15, 28, 34, 41] While the reports of these trials are valuable contributions to our knowledge of the value of sunflower silage, the data in the majority of the experiments show a marked lack of uniformity in the results secured with the different animals employed in the same digestion trial, and in the coefficients secured at the different stations. Further, they contribute little or no information on the digestibility of silage from sunflowers harvested at different stages of maturity.

Effect of Stage of Maturity.—But one investigation[7] of the comparative feeding value of sunflower silage made from plants cut at different stages of maturity has come to the attention of the writer, and the results of this trial were inconclusive. More extensive study has been made, however, of the composition of the sunflower plant at different stages.[1, 11, 40] The Montana Station[11] reports sunflower silage made "from plants in practically all stages of growth has always been of a quality ranging from fairly good to excellent . . . Silage made from plants in early stages of maturity is likely to be more acid, darker in color, and of slightly inferior quality to that made from plants in the later stages." Chemical analyses made at different stations[1, 40] indicate that the plant continues to increase in dry matter until maturity and that apparently the stage of maximum food value is at the "dough" or later stages. Fitch[16] attributes the poor results following the feeding of silage made from wild sunflowers, in part at least, to the late cutting of the sunflowers. Results at the Wisconsin Station[45] led to the conclusion that sunflowers should be cut during the early blossoming stage. The "preponderance of poor silage comes from sunflowers cut when quite mature, while most of the good silage is made by ensiling during the early blossoming stage."

Effect on Composition of Milk.—Several investigators[1, 6, 7] have noted that the feeding of sunflower silage had no apparent effect upon the composition of the milk and produced no objectionable flavor. One report[26] states that the butter fat produced on sunflower silage rations had a slightly higher olein content, while another mentions a slightly increased iodin number and refractive index of the butter fat.

Summary.—The lack of uniformity in the results secured at different experiment stations would indicate that the sunflower silage used varied greatly in character and quality, possibly owing to climatic factors but probably, in part at least, to the ensiling of sunflowers at different stages of maturity. It should be pointed out further, that corn silage varies greatly in composition, being influenced by such factors as maturity of the crop at the time of ensiling, water content of the crop, proportion of ears to stalks, etc. The data secured thru analyses of a large number of corn silage samples at this Station, together with a survey of analyses reported from other stations, indicate that there is ample justification for the assumption that the corn silage fed in comparison with sunflower silage at different stations was not of exactly the same composition, and that the comparison of sunflower silage with corn silage upon a pound-for-pound basis is not a thoroly reliable method for arriving at the feeding value of sunflower silage.

GROWING AND ENSILING THE SUNFLOWERS

In beginning the experimental work at this Station, a field was planted to Mammoth Russian sunflowers on May 18, 1921. The rows were 3 feet 6 inches apart and the plants averaged about 10 inches apart in the row. Three wooden stave silos, each 10 feet by 24 feet in size, and roofed, were used for ensiling the crop.

The first cutting was made on August 13, eighty-seven days from the time of planting, and was ensiled in Silo No. 8. At that time about 23 percent of the plants were coming into bloom; that is, they plainly showed the yellow rays of the heads, and most of the rest of the plants were in the bud stage. The estimates of the proportion of the plants in bloom were made by actual count of the number of blossoms in one row of the sunflowers (about one-fourth mile in length) upon the day of filling the silo. The leaves on only the lower two or three feet of the stalks had died. The plants contained so much water that soon after they were ensiled, a large quantity of juice oozed out around the doors and at the bottom of the silo.[1] This silage was subjected to leaching by rains, a total of 1.22 inches falling before the roof of the silo had been completed.

A second cutting was made on September 1 and 2, 106 days from the time of planting, when approximately 95 percent of the plants were in bloom. At that stage nearly one-half of the leaves on the plants had been killed by rust. These plants contained a smaller percentage of water than those ensiled August 13. Only a small amount of juice was lost by leakage from the silo (Silo No. 7).

A third cutting from the same field was made on September 21 and 22, and was ensiled in Silo No. 9. At that stage of maturity, the weight of the crop per acre had decreased greatly, the plants having become very low in water content. Most of the plants had seeds in the dough or more mature stage, a small amount of them shelling out in the handling of the crop. A few of the plants were entirely dead at the time of cutting, owing largely to the effects of rust, but most of the plants had a number of green leaves near the tops of the stalks. During most of the growing season some plants were much more advanced than others.

The silage thus secured was fed to dairy cows as described in the following pages.

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[1] It is suggested that this difficulty can be avoided by allowing the plants to wilt in the field after harvesting before bringing to the silo.

PLAN OF FEEDING TRIAL

ANIMALS USED

As many cows of the pure-bred dairy herd as were available were employed. These were divided into two similar groups. The make-up of the groups remained constant thruout the feeding of sunflower silage from the first silo, but when feeding from the second and third silos was begun, it was necessary in a few cases to make substitutions of cows because of decreased milk production occasioned by advancing lactation. The groups were also increased in size as additional cows became available. However, records of production are reported for only those cows which were in milk during the two consecutive periods in which a certain cutting of sunflower silage was fed. The age, breed, and stage of lactation of the cows used are shown in Table 1.

EXPERIMENTAL PERIODS

In order to get the best possible comparisons of the feeding values for milk production of the sunflower silage obtained from plants at three different stages of maturity, it was planned to compare each

TABLE 1.—BREED, AGE, AND STAGE OF LACTATION OF COWS USED IN EXPERIMENT

Cow No.	Breed	Age, 10-7-21			Days in milk at beginning of periods		
					Period I (10-7-21)	Period III (12-16-21)	Period V (2-17-22)
		yrs.	*mos.*	*days*			
Group A							
155	Jersey	16	0	13	44	114	117
280	Jersey	2	7	4	157	227	......
235	Jersey	7	4	3	......	......	9
270	Guernsey	3	7	3	......	......	63
282	Guernsey	7	2	2	73	143	206
287	Guernsey	2	5	12	54	124	187
74	Ayrshire	15	4	21	......	62	125
134	Ayrshire	13	0	9	202	272	335
277	Ayrshire	2	10	11	......	......	8
254	Holstein	6	9	2	......	26	89
263	Holstein	3	9	26	98	168	231
Group B							
253	Holstein	6	10	15	......	21	84
255	Holstein	6	8	27	31	101	264
135	Ayrshire	12	10	21	122	192	255
224	Ayrshire	6	7	22	......	2	65
271	Guernsey	3	3	4	......	27	90
278	Guernsey	2	7	26	181	250	......
245	Guernsey	5	6	5	......	......	28
291	Guernsey	2	3	1	......	2	65
232	Jersey	12	0	10	......	67	130
279	Jersey	5	11	6	279	......	......

cutting of silage with corn silage. This plan accomplished the twofold purpose of comparing the values of the three cuttings of sunflower silage with each other and at the same time of comparing the sunflower silage with corn silage. Accordingly the feeding periods were arranged as follows:

Period	Group of cows	Silage fed
I	A	Sunflower silage, 2d cutting
	B	Corn silage
II	A	Corn silage
	B	Sunflower silage, 2d cutting
III	A	Sunflower silage, 3d cutting
	B	Corn silage
IV	A	Corn silage
	B	Sunflower silage, 3d cutting
V	A	Sunflower silage, 1st cutting
	B	Corn silage
VI	A	Corn silage
	B	Sunflower silage, 1st cutting

Each experimental feeding period was 28 days in length and was preceded by a 7-day preliminary, or transition, period. Whenever sunflower silage was to be fed during a certain period, it was gradually substituted for the corn-silage ration during the preliminary period, but whenever the ration containing corn silage replaced the sunflower silage ration, the change was made abruptly. In one instance, Period IV, the length of the period was unavoidably shortened to 21 days because the sunflower silage in the bottom of the silo was found spoiled.

Several conditions made it necessary to employ shorter experimental periods than are considered desirable in most feeding experi-

FIG. 1—HARVESTING THE FIRST CUTTING OF SUNFLOWERS

Hand cutting seemed the best way to prevent losing any of the crop in harvesting. At this cutting the stalks were from ten to fifteen feet tall and were not tangled to any extent.

ments. Since the chief object of the feeding trial was to compare the feeding value for milk production of silage made from sunflowers harvested at three different stages of maturity, it was necessary to complete the comparison within a relatively short period of time in order to finish it during one lactation period. Also it was desirable to feed the silage during the cooler months of the year in order to avoid any changes in the composition of the silage which might be induced by hot weather. It is believed, further, that the results secured in the short periods used were more favorable than might have been the case had longer periods of sunflower feeding with consequently greater decrease in milk flow been employed.

RATIONS

The two groups of cows were fed grain and hay from the same supply thruout the experiment. The grain used consisted of a mixture of 600 pounds ground corn, 600 pounds ground oats, 600 pounds wheat bran, and 250 pounds of old-process linseed oil meal. A supply was ground and mixed twice weekly. The amount of grain fed was proportional to the milk production, adjustments being made at the close of each experimental week after feed and milk records for that week had been compared.

A supply of western alfalfa hay of good, uniform quality was purchased in a quantity (about two carloads) sufficient for the entire test. It was planned to feed the hay in an amount proportional to the amount of silage consumed, but this was found impractical on account of the failure of a few cows to consume a reasonable amount of silage. It was fed, therefore, in such amounts as the cows would consume readily.

Sunflower silage was to form as large a proportion of the ration as possible in order that its influence on milk production and health might be exerted to the fullest extent. The amounts consumed, however, were much less than had been anticipated. The cows were always fed all they would consume, and in a few cases the amount of hay was limited somewhat in order to induce the cows to eat more of the silage. The corn silage was fed in such amounts as the cows would clean up readily. Forty pounds daily was found to be the maximum amount desired.

In feeding the cows, the silage was first weighed out in a large weighing scoop, the grain added, and the whole emptied into the manger. The hay was fed after the bulk of the silage and grain had been consumed. The silage, grain, and hay were each fed twice daily, and any refused feed was weighed back each day.

ANALYSIS OF FEEDS

The silage and hay were sampled at two-week intervals from the supply to be used the following two weeks.[a] A core of silage to a depth of 24 to 30 inches was taken at several points on the surface of the silage in the silo. These several portions, in total about 1.5 pounds, were united for the silage sample, immediately weighed, and dried in a drying oven at a temperature of 45° to 50° C. In most cases two silage samples, together representing a four-weeks feeding period, were composited for the chemical determinations.

At two-week intervals a few bales of hay were selected at random from the supply and a core was taken centrally lengthwise thru each

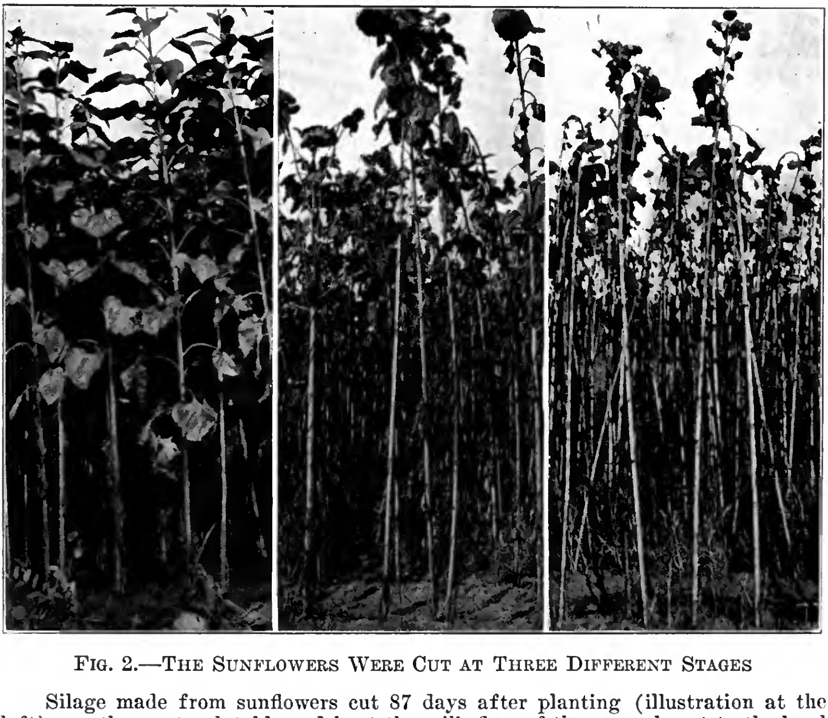

FIG. 2.—THE SUNFLOWERS WERE CUT AT THREE DIFFERENT STAGES

Silage made from sunflowers cut 87 days after planting (illustration at the left) was the most palatable and kept the milk flow of the cows closest to the level of corn silage rations. About one-fourth of the plants were coming into bloom at this cutting. Most of the upper leaves were green and succulent, altho those on the lower two or three feet of the stalks were dead.

By the time of the second cutting, close to 95 percent of the plants were in bloom and nearly half the leaves had been killed by rust.

When the third cutting was made, the leaves on all but the upper two or three feet of the plants had died and many of the plants themselves were dead. Both this cutting and the second were made too late for the best silage.

[a]A roughage sampler which has been developed in the dairy production laboratory of this Station was used for the purpose. See Jour. Indus. and Engin. Chem. 16, 386. 1924.

bale while still unbroken. The cores, about one pound in total weight, were united for the hay sample. Two samples were composited later for analysis, as in the case of the silage.

As each batch of grain was ground, samples were taken by means of a double-tube brass grain trier. Three trierfuls were mixed for the sample of each batch. Eight samples, representing the same four-weeks feeding period as for the silage, were composited for analysis.

The grain and hay samples and the dried silage samples were kept until analyzed in half-gallon glass fruit jars provided with rubber rings and tightly fitting glass covers.

The methods of analysis described in the Proceedings of the Association of Official Agricultural Chemists were followed, except where otherwise noted.

RESULTS OF FEEDING TRIAL

Milk and Fat Production

In Table 2 is presented a summary of the milk and butter-fat production of the two groups of cows while on sunflower silage and on corn silage, and their gains or losses in live weight.

One of the most striking results shown in this comparison is the greater production of the groups while receiving corn silage over their production on the sunflower silage ration, the increase ranging from 15 to 25 percent in milk yield, 10 to 13 percent in butter-fat yield, and 12 to 16 percent in fat-corrected milk production.[a]

The production of the cows when fed silage made from the first cutting of sunflowers more nearly approached their production when fed corn silage than when they were fed silage made from either the second or the third cutting of sunflowers. While the degree of superiority of the sunflower silage made from the early cut plants over that from the late cut plants, as shown in this manner, was not marked, it is indicative of the greater nutritive value of the silage from the early cut plants.

Economy of Production

The relative efficiency of the sunflower silage and the corn silage rations was studied by computing the digestible nutrients and net energy consumed, above the requirement for maintenance, per unit of production. Comparisons on these bases are given in Table 3.

The total nutrients consumed were determined by applying the results of the chemical analyses of the feed samples to the net weights of the feed consumed. The digestible nutrients of the feeds consumed,

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[a]The values for the fat-corrected milk production were determined according to the formula of Gaines and Davidson.[18]

TABLE 2.—COMPARATIVE PRODUCTION OF COWS ON SUNFLOWER SILAGE AND ON CORN SILAGE; ALSO GAINS OR LOSSES IN LIVE WEIGHT

Period	Group	Number of cows	Kind of silage	Total production during period				Gain or loss in live weight	
				Milk	Fat		F C M[1]	Entire group	Av. per cow
				lbs.	*perct.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	A	6	Sunflower, 2d cutting	3151	4.97	157	3611	−159	−27
II	B	4	Sunflower, 2d cutting	1653	4.24	70	1712	− 35	− 9
			Total	4804	4.72	227	5323	−194	−19 (Av.)
II	A	6	Corn	3367	4.79	161	3767	+180	+30
I	B	4	Corn	2454	3.88	95	2409	+ 26	+ 7
			Total	5821	4.41	256	6176	+206	+21 (Av.)
Greater production on corn silage				21%		13%	16%	400[2]	
III	A	9	Sunflower, 3d cutting	4531	4.92	223	5160	−325	−36
IV	B	8	Sunflower, 3d cutting	3387	4.21	143	3495	−287	−36
			Total	7918	4.62	366	8655	−612	−36 (Av.)
IV	A	9	Corn	3951	4.36	172	4163	− 15	− 2
III	B	8	Corn	5961	3.92	234	5892	−123	−15
			Total	9912	4.10	406	10055	−138	− 8 (Av.)
Greater production on corn silage				25%		11%	16%	474[2]	

TABLE 2.—*Concluded*

Period	Group	Number of cows	Kind of silage	Total production during period				Gain or loss in live weight	
				Milk	Fat		F C M[1]	Entire group	Av. per cow
				lbs.	*perct.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
V	A	10	Sunflower, 1st cutting	5033	4.48	225	5393	−111	−11
VI	B	8	Sunflower, 1st cutting	4485	4.25	182	4528	−150	−19
			Total	9518	4.28	407	9921	−261	−15 (Av.)
VI	A	10	Corn	5424	4.27	232	5645	+ 50	+ 5
V	B	8	Corn	5532	3.95	218	5490	+227	+28
			Total	10956	4.11	450	11135	+277	+15 (Av.)
Greater production on corn silage				15%		10%	12%	538[2]	

[1]F C M = fat-corrected milk. Correction is made by use of the formula 0.4 M + 15 F, where M is milk in pounds and F is fat in pounds (Gaines and Davidson).

[2]Pounds difference.

except the sunflower silage, were then calculated by applying the average coefficients of digestibility as given by Henry and Morrison[22] to the total nutrients consumed. The coefficients of digestibility of the sunflower silage were determined by conducting a digestion trial in which the sole ration was sunflower silage from the same lots of silage as those used in the feeding trial. From the digestible nutrients consumed was subtracted an estimate of the nutrients required for maintenance based on the standard established by Haecker. The net energy values were calculated by the use of values given by Armsby and Fries.[5] From these were subtracted the net energy required for maintenance as estimated from Armsby's Standard.[3] In Tables 1 to 4 of the Appendix are presented the total and digestible nutrients consumed and the analyses of the feeds employed, together with the coefficients of digestibility and net energy values used in calculation.

A study of the digestible nutrients consumed per hundred pounds of milk, per pound of butter fat, or per hundred pounds of fat-corrected milk, above that required for maintenance, shows apparently no very wide difference in efficiency between the sunflower silage and corn silage rations (Table 3). In all cases a somewhat smaller amount of nutrients of corn silage was consumed per unit of production than of sunflower silage. This apparent similarity in efficiency of the two rations, however, is doubtless largely apparent and not real, since in all cases the losses in weight were greater on the sunflower silage rations (Table 2). The body tissue thus lost presumably contributed some nutrients toward the production of milk. It may be noted, also, that with the exception of two periods, both groups of cows made considerable gains in weight while being fed corn silage. A part of the feed consumed must have been used for the body increase, thus reducing the apparent efficiency of the corn silage ration as shown in milk yield.

When a comparison of the sunflower silage and corn silage rations is made upon the basis of net energy intake, rather than upon the basis of digestible nutrients, it is found that corrections for changes in live weight are necessary in order to account for the utilization of the net energy in the two rations (Table 3, column 8). It is self-evident, however, that in any logical method of comparing the efficiency of different rations for milk production there must be taken into consideration the gains or losses in live weight which are incurred.

Corrections for the gains and losses in live weight were made by employing Armsby's[4] requirements for fattening in the early stages with no considerable growth, this requirement being 2.5 therms of net energy per pound of increase in live weight, in addition to the maintenance requirement.[a] This value was applied to the number of

[a]Such a correction factor is undoubtedly of value in cases of increase in weight due to fattening, but it is of questionable value when applied to losses in weight by cows in ordinary flesh.

TABLE 3.—RELATIVE EFFICIENCY OF THE SUNFLOWER SILAGE AND THE CORN SILAGE RATION AS BASED ON THE DIGESTIBLE NUTRIENTS AND NET ENERGY CONSUMED ABOVE MAINTENANCE REQUIREMENT, PER UNIT OF PRODUCTION

Period	Group	Number of cows	Kind of silage	Digestible nutrient intake above maintenance per—			Net energy intake above maintenance per cwt. of fat-corrected milk	
				Cwt. of milk	Lb. of butterfat	Cwt. of fat-corrected milk	Uncorrected for gain or loss in live wt.	Corrected for gain or loss in live wt.
				lbs.	*lbs.*	*lbs.*	*therms*	*therms*
I	A	6	Sunflower, 2d cutting	41	8	36	13	24
II	B	4	Sunflower, 2d cutting	50	12	48	12	17
II	A	6	Corn	37	8	33	34	22
I	B	4	Corn	33	9	34	33	30
III	A	9	Sunflower, 3d cutting	42	9	37	8	23
IV	B	8	Sunflower, 3d cutting	37	9	36	4	24
IV	A	9	Corn	35	8	34	28	29
III	B	8	Corn	29	7	29	23	28
V	A	10	Sunflower, 1st cutting	41	9	38	14	20
VI	B	8	Sunflower, 1st cutting	43	11	42	15	23
VI	A	10	Corn	38	9	36	31	28
V	B	8	Corn	35	9	35	27	16
Average of six sunflower silage periods								22
Average of six corn silage periods								25

pounds of gain or loss and the correction made by adding the result to the net energy consumed by the groups suffering a loss in weight, and by deducting the result from the net energy intake of the groups gaining in weight. After making such corrections, there is not a wide discrepancy between sunflower silage and corn silage rations in the calculated amounts of net energy for milk production, as may be noted from the last column of Table 3. However, the degree of variability between the groups receiving the same ration is so wide that no great importance can be attached to this particular comparison. It seems likely from these results either that the factor used for the net energy value of the sunflower silage underestimates the value of this feed for milk production, or that the factor used in the calculation of the energy value of the losses in weight are too small.[1]

PALATABILITY

Palatability is an important factor in determining the value of any feed, in that consumption so largely depends on it. The sunflower silage used had a slightly bitter taste and was not eaten so readily as the corn silage. Of the three cuttings of sunflower silage, that made from the first cutting was the most palatable, while that made from the third cutting was decidedly the least palatable, as may be judged from the consumption shown in Table 4. The difference in consumption of silage of the first cutting and of the second was slight. The silage from the third cutting seemed very distasteful, possibly because of the effects of rust which late in the summer had attacked the plants severely, and also perhaps because of the presence of resins which develop as the plant matures. The small percentage of moisture present and the woodiness of the stalks at the time of cutting were undoubtedly important factors contributing to the unpalatability of the third cutting. This silage tended to spoil more quickly than that made from either the first or the second cutting. The consumption of the second and third cuttings of sunflower silage decreased slightly from week to week as the feeding trial progressed. The consumption of the first cutting of sunflower silage and of the corn silage was practically the same week by week.

The pronounced difference in the palatability of the silages of the various cuttings caused the proportion which they formed of the total feed intake to vary widely (Table 5). The percentages were approximately 24, 18, and 13 for the first, second, and third cuttings, respectively. Corn silage, on the other hand, furnished an average

[1] The discussion of the results of the feeding trial from the standpoint of net energy has been included as a matter of interest, altho the deductions made from the results so calculated should not be unduly emphasized. The method of calculation as applied to sunflower silage is subject to revision on account of comparatively low digestibility of the total dry matter of sunflower silage as compared with the feeds used in the original experiments by Armsby and Fries.

of about 40 percent of the total digestible nutrients of the ration. Considered on the basis of net energy, the sunflower silage contributed an even smaller proportion of the total net energy intake. As pointed out above, this may have been due to some extent to the underrating of the net energy content of the sunflower silage.

TABLE 4.—DAILY CONSUMPTION OF SILAGE

Period	Group	Number of cows	Kind of silage	Average silage consumed per cow	
				Fresh weight	Dry matter
				lbs.	*lbs.*
I	A	6	Sunflower, 2d cutting.......	27.3	6.2
II	B	4	Sunflower, 2d cutting.......	22.8	5.2
II	A	6	Corn	30.9	10.0
I	B	4	Corn	31.2	9.6
III	A	9	Sunflower, 3d cutting	12.3	3.8
IV	B	8	Sunflower, 3d cutting	10.2	3.2
IV	A	9	Corn	29.7	9.2
III	B	8	Corn	29.7	9.2
V	A	10	Sunflower, 1st cutting......	28.4	6.0
VI	B	8	Sunflower, 1st cutting......	27.3	5.8
VI	A	10	Corn	31.3	9.7
V	B	8	Corn	32.2	9.9

PHYSIOLOGICAL EFFECTS

All group totals for loss or gain in live weight show a loss with the sunflower silage ration, altho a few individual cows gained in weight during some of these periods. The totals for the groups fed corn silage show losses in two instances, but most of the period totals show substantial gains. As with sunflower silage, there were individual exceptions to the group gains or losses. The gains and losses in live weight by groups and periods are reported in Table 2.

The sunflower silage proved to be less laxative than the corn silage. This was particularly noticeable in the digestion trial, in which sunflower silage composed the entire ration. Under these conditions the sunflower silage seemed to exert a constipating effect, the dry-matter content of the feces ranging from approximately 24 to 29 percent, while at the same time a cow on a mixed ration containing corn silage produced feces having a dry-matter content ranging from 16.9 to 17.4 percent.

The average dry-matter content of the feces of steers while receiving a ration of ground corn and clover hay is reported by Grindley et al.[20] to have ranged from 14.59 percent to 19.13 percent, and while receiving a ration of ground corn, linseed meal, and clover hay to have ranged from 17.61 percent to 19.06 percent.

Several reports have appeared in experiment station literature and in the popular press to the effect that the feeding of sunflower silage causes an excessive excretion of urine. In the experiments reported in this bulletin no such effect was noted. On the contrary, during the course of the digestion trial, in which sunflower silage was fed exclusively, there was even less urine excreted than was the case on a mixed ration (see Appendix, Table 5).

The condition of the hair and the general appearance of the animals was not quite so good during the sunflower silage periods as during the corn silage periods.

No digestive disturbances were noted during the course of the feeding trial. It was necessary, however, to drop a fifteen-year old cow from the experiment on account of her persistent refusal to eat the sunflower silage.

GENERAL DISCUSSION

When the cows were fed sunflower silage from the first cutting, their yield of milk and butter fat more nearly approached the yield with corn silage than it did when they were fed sunflower silage of either the second or the third cutting. From this it may be inferred that the silage produced from the first cutting of sunflowers was superior in feeding value to that produced from the other two cuttings. Inquiry into the causes of these apparently better results from the first cutting brings to light the facts that a larger amount of this silage was consumed daily (Table 4) than was consumed of the second or the third cutting, and that at the same time it contained a larger amount of total digestible nutrients per pound (Table 11). A comparison of the requirements for milk production as expressed in the Haecker standard[21] with the amount of nutrients supplied by the sunflower silage and the corn silage rations shows clearly that the sunflower silage rations were theoretically insufficient to maintain the normal level of milk production (Table 6). The experimental data show that the greater the difference between the actual consumption and the theoretical requirement, the more rapid the decrease in milk yield.

From a practical standpoint, palatability proved the most decisive factor in determining the value of the silages from the different cuttings. Whether this would hold true under different climatic and seasonal conditions was not determined. Under the existing conditions it seemed evident that had the consumption of the sunflower silage been sufficiently large, the production of the cows would have been nearly or fully as great as when corn silage was fed. The basis for this assumption is that a few cows consumed almost as much of the first- and the second-cutting silage as they consumed of corn silage and produced nearly as well as when fed corn silage. It is reasonable to assume, therefore, that had the sunflower silage been more palatable, the cows might have eaten a sufficient amount to provide enough digestible nutrients to maintain a normal, or nearly normal, milk yield.

Doubtless much of the loss in live weight occasioned by the sunflower silage feeding could have been prevented by liberal grain feeding. In that event, however, the sunflower silage would have formed but a minor part of the ration and any important physiological effects or influences on production might have failed to materialize. Since it was the object of the investigation to study such effects or influences, it was thought advisable to carry out the experiment as planned and to feed the grain in proportion to the milk yield. It would have been much more satisfactory to have eliminated the variable factor of gain or loss in weight by feeding both groups so that the gains or losses would have been uniform than to make corrections for these gains or losses, since such corrections can, at best, be but approximations.

TABLE 5.—PROPORTION OF THE TOTAL FEED CONSUMED FURNISHED BY SILAGE

Period	Group	Kind of silage	Proportion of total feed intake furnished by silage: Total digestible nutrients	Proportion of total feed intake furnished by silage: Net energy
			perct.	*perct.*
I	A	Sunflower, 2d cutting	16.9	1.4
II	B	Sunflower, 2d cutting	18.8	2.5
II	A	Corn	42.3	40.2
I	B	Corn	40.7	38.3
III	A	Sunflower, 3d cutting	13.8	1.5
IV	B	Sunflower, 3d cutting	12.9	3.9
IV	A	Corn	43.2	40.6
III	B	Corn	37.9	36.5
V	A	Sunflower, 1st cutting	24.6	15.3
VI	B	Sunflower, 1st cutting	23.9	14.5
VI	A	Corn	44.3	42.1
V	B	Corn	40.8	41.3

The lack of condition in the hair and the change in appearance of the cows while being fed sunflower silage may have been caused by the lack of sufficient digestible matter to maintain their live weight and possibly by the effect upon the system of compounds contained in the silage, altho evidence of the latter was not established.

TABLE 6.—COMPARISON OF NUTRIENT INTAKE WITH REQUIREMENTS OF HAECKER'S STANDARD

Period	Group	Number of cows	Week ending	Ration	Av. milk daily per cow	Av. live wt. per cow
					lbs.	*lbs.*
III	A	9	12–23–21	Sunflower silage....	18.6	975.7
IV	A	9	1–27–22	Corn silage........	20.7	937.1

COMPARISON OF SUNFLOWER SILAGE RATION WITH STANDARD REQUIREMENTS

Digestible Nutrients Required Daily—Period III

	Crude protein lbs.	*Carbo-hydrates lbs.*	*Fat lbs.*
For maintenance of a 975.7 lb. cow............	0.682	6.83	.0975
For 18.6 lbs. of 4.8 percent milk...............	1.130	5.02	.4660
Total..................................	1.812	11.85	.5635
(Nutritive ratio 1:7)			

Digestible Nutrients Consumed Daily—Period III

	Crude protein lbs.	*Carbo-hydrates lbs.*	*Fat lbs.*
13.6 lbs. sunflower silage......................	.055	1.218	.131
6.4 lbs. grain..............................	.813	3.233	.183
9.0 lbs. hay...............................	.937	3.500	.077
Total..................................	1.805	7.951	.391
(Nutritive ratio 1:4.6)			
Variation from requirements..................	–0.007	–3.90	–0.1725

COMPARISON OF CORN SILAGE RATION WITH STANDARD REQUIREMENTS

Digestible Nutrients Required Daily—Period IV

	Crude protein lbs.	*Carbo-hydrates lbs.*	*Fat lbs.*
For maintenance of a 937.1 lb. cow............	.656	6.559	.0937
For 20.7 lbs. of 4.7 percent milk...............	1.221	5.589	.4968
Total..................................	1.877	12.148	.5905
(Nutritive ratio 1:7)			

Digestible Nutrients Consumed Daily—Period IV

	Crude protein lbs.	*Carbo-hydrates lbs.*	*Fat lbs.*
30.4 lbs. corn silage.........................	.460	5.529	.292
6.0 lbs. grain..............................	.764	3.051	.237
8.7 lbs. hay...............................	.973	3.373	.087
Total..................................	2.197	11.953	.616
(Nutritive ratio 1:6)			
Variation from requirements..................	+0.320	–0.195	+0.025

COMPOSITION OF SUNFLOWER SILAGE

Large composite samples of sunflower silage and of corn silage were taken as the finely cut material was placed in the silo. At the close of the working day or at the time the filling was stopped, the sample was subsampled and the subsample dried. Other composite samples were taken during the course of the feeding and digestion trials, as described on page 192. Average analyses of these samples, calculated on the fresh basis, are presented in Table 7; the individual analyses, calculated on the water-free basis, are given in Tables 8 and 9.

Composition of Fresh Matter

The sunflower plants ensiled at the more advanced stages of maturity produced silage higher in every constituent, other than water, than was the silage from the comparatively immature first cutting. It was considerably higher in dry matter, crude fiber, and ether extract. The variation in the amounts of some of these constituents is evidently not due simply to differences in the water content of the silages, but is doubtless a result of physiological changes in the plant. For example, the increase in dry matter of the third cutting over that of the first was 46 percent, while the crude fiber increased 77 percent and the ether extract 90 percent.

Sunflower silage has a higher moisture content than has corn silage. Even the silage from the third cutting of sunflowers had a slightly higher content than the corn silage fed, yet it evidently was too low in water content, or in sugar and starch content, to allow the normal fermentation processes to take place. As a result, this silage did not keep well, as noted above, while the corn silage was of excellent quality. This leads to the conclusion that if sunflowers are to produce a good grade of silage they must have a higher moisture content at the time of ensiling than corn.

The crude-protein content of sunflower silage of all three cuttings was found to be less than that of well-matured corn silage but was about the same as that of immature corn silage. The true, or albuminoid, protein forms a larger proportion of the crude protein in sunflower silage than in corn silage, in the first, second, and third cuttings forming 68, 76, and 82 percent, respectively, of the crude-protein content, while in corn silage it formed only 53 percent. It is likely that the differences in true-protein content of the silage made from sunflowers at the different stages of growth were due to a transformation of the soluble nitrogen compounds into protein as the plants approached maturity.

Composition of Dry Matter

When the analyses of the different silages used in these experiments are expressed in terms of the percentage composition of dry matter

TABLE 7.—COMPARATIVE COMPOSITION OF SUNFLOWER SILAGE AND CORN SILAGE
Expressed in percentage of the fresh substance

Description of sample	Dry matter	Crude protein	True protein	Crude fiber	N-free extract	Ether extract	Ash
Sunflower silage, 1st cutting, av. of 5 samples	21.14	1.88	1.28[1]	7.56	8.72	0.81	2.18
Sunflower silage, 2d cutting, av. of 4 samples	22.70	1.63	1.24[1]	9.15	8.56	1.13	2.23
Sunflower silage, 3d cutting, av. of 2 samples	30.90	2.09	1.72	13.41	11.01	1.54	2.85
Corn silage, av. of 6 samples	32.30	2.85	1.51	7.04	19.46	0.95	2.01
Corn silage, immature[2]	21.00	1.90	....	5.80	11.30	0.60	1.40
Corn silage, well matured[2]	26.30	2.10	....	6.30	15.40	0.80	1.70

[1]Average of two samples.
[2]Henry and Morrison, *Feeds and Feeding*, Appendix Table I.

TABLE 8.—COMPARATIVE COMPOSITION OF THE DRY MATTER OF SUNFLOWER SILAGE AT TIME OF FILLING SILO AND WHEN REMOVED

Date	Sample No.	Description of of sample	Dry matter in fresh substance	Composition of the dry matter (expressed in percentage)						
			perct.	Dry matter	Crude protein	True protein	Crude fiber	N-free extract	Ether extract	Ash
			First Cutting							
Aug. 13, 1921	5	As ensiled in Silo 8	14.87	100	9.56	....	26.27	49.43	2.67	12.06
Feb. 18-Mar. 17, 1922	117	As removed from Silo 8	20.51	100	8.32	5.85	37.35	40.02	3.91	10.39
Mar. 25–Apr. 21, 1922	121	" " " " "	22.53	100	7.97	5.99	37.30	41.41	3.81	9.47
May 10–14, 1922	169	" " " " "	21.44	100	9.16	....	33.71	42.47	3.84	10.79
May 15–19, 1922	170	" " " " "	20.73	100	9.26	....	34.30	41.15	3.99	11.28
June 4–8, 1922	183	" " " " "	20.47	100	9.70	....	36.66	40.96	3.49	9.67
			Second Cutting							
Sept. 1, 1921	10	As ensiled in Silo 7[1]	16.74	100	8.98	....	35.45	41.58	2.22	11.78
Sept. 2, 1921	11	" " " " "[1]	20.08	100	7.45	....	34.86	43.89	4.11	9.69
Oct. 8–Nov. 4, 1921	103	As removed from Silo 7	22.64	100	7.10	5.75	41.24	36.54	5.05	10.05
Nov. 5–Dec. 9, 1921	105	" " " " "	22.64	100	7.15	5.12	41.83	35.94	5.02	9.93
May 22–26, 1922	171	" " " " "	22.64	100	7.63	....	38.11	39.48	4.94	9.83
May 27–31, 1922	172	" " " " "	22.89	100	6.82	....	39.96	38.86	4.91	9.44
			Third Cutting							
Sept. 21–22, 1921	25	As ensiled in Silo 9	31.22	100	8.03	....	42.12	36.75	3.85	9.25
Dec. 17, '21–Jan. 13, 1922	111	As removed from Silo 9	30.17	100	6.67	6.03	44.68	34.64	4.96	9.03
Jan. 21, '21–Feb. 10, 1922	114	" " " " "	31.62	100	6.83	5.11	42.19	36.59	4.98	9.39

[1]Sample No. 10 represents approximately the lowest third of the silage placed in Silo 7, while Sample No. 11 represents the remainder. Probably Samples Nos. 103, 105, 171, and 172 came from the latter portion.

TABLE 9.—COMPARATIVE COMPOSITION OF THE DRY MATTER OF CORN SILAGE AT TIME OF FILLING SILO AND WHEN REMOVED

Date	Sample No.	Description of sample	Dry matter in fresh substance *perct.*	Composition of the dry matter (expressed in percentage)						
				Dry matter	Crude protein	True protein	Crude fiber	N-free extract	Ether extract	Ash
Aug. 25, 1921	12	As ensiled in Silo 5	30.77	100	8.82	....	21.52	59.28	2.11	5.88
Aug. 26, 1921	13	" " " " "	31.63	100	9.11	....	21.59	61.18	2.46	5.63
Aug. 27, 1921	14	" " " " "	27.61	100	9.05	....	22.32	60.21	2.40	6.00
Aug. 29, 1921	15	" " " " "	35.61	100	8.87	....	22.46	59.91	2.58	6.16
Aug. 29, 1921	16	" " " " "	31.31	100	8.80	....	20.53	62.04	2.40	6.19
Oct. 23–Dec. 9, 1921	106	As removed from Silo 5	35.12	100	8.62	5.42	22.90	59.86	2.85	5.75
Dec. 17, 1921–Jan. 13, 1922	110	" " " " "	28.49	100	9.55	4.90	21.19	60.38	2.70	6.17
Jan. 21 '22–Feb. 10, 1922	113	" " " " "	32.23	100	9.28	3.91	20.88	60.22	3.64	5.96
Feb. 18–Mar. 17, 1922	118	" " " " "	32.37	100	8.60	3.92	20.89	61.80	2.90	5.79
Mar. 25–Apr. 21, 1922	122	" " " " "	32.88	100	8.39	4.23	23.18	59.28	2.71	6.40
Aug. 30, 1921	17	As ensiled in Silo 6	32.60	100	8.80	....	20.82	61.67	2.68	6.00
Oct. 8–23, 1921	104	As removed from Silo 6	32.68	100	8.61	5.55	21.54	59.72	2.89	7.21

(see Tables 8 and 9), comparison of the composition is facilitated. The data show that both the crude-protein content and the nitrogen-free-extract content of the sunflower plants decreased as the plants matured. These results are in accord with those of Shaw and Wright,[40] who found that both the total protein and the albuminoid protein, and both the reducing and the non-reducing sugars, formed decreasing percentages of the dry matter as sunflower plants advanced in maturity. These investigators also reported decreased starch contents as the seeds ripened. They found that while the corn plant, like the sunflower, showed with maturity lowered percentages of both crude and albuminoid protein and reducing sugars, there was, unlike the case with the sunflower plant, a rapid storage of starch as the corn plants approached maturity.

The ensiling process apparently caused a small loss or transformation of crude protein and nitrogen-free extract in the sunflower silage. The apparent loss of nitrogen-free extract, however, was not necessarily a loss of material from the silo, but may have been a conversion of the sugars and readily fermentable carbohydrates into organic acids thru the fermentation processes. The simultaneous development of acid (Table 10) and the disappearance of a part of the nitrogen-free extract leads to the belief that the sugars are converted into organic acid.

Some nitrogenous compounds and ash were lost by seepage of juices from the silo. These juices were rich in solids, the juice from the first cutting containing 4.07 percent total solids, while that from the second cutting contained 5.71 percent. The ash content of the juices was 93 percent and 1.56 percent, respectively, and the crude-protein content .31 percent and .54 percent.

The increase in ether-extract content may have been due to the development of new ether soluble compounds as a result of the fermentation processes. Since the organic acids usually present in silage—namely, lactic, acetic, and propionic—are soluble in ether, it seems likely that the presence of the organic acids explains the increase in the amount of ether extract. Determinations of the total acidity of fresh sunflower silage were made and the results were calculated in terms of lactic acid in the fresh silage and in the dry matter of the silage. These calculations are shown in Table 10.

The percentage of crude fiber in the sunflower plants of the three cuttings was found to be very different, being distinctly greater with the more mature plants. This same difference held true of the silage made from the three cuttings. The content in the silage was found to be greatly increased over that of the plants as ensiled, an increase for which the change in percentage of the other constituents seems barely sufficient to account.

TABLE 10.—TOTAL ACIDITY OF SUNFLOWER SILAGE CALCULATED AS LACTIC ACID

Description of sample	Date	Lactic acid per 100 grams of—	
		Fresh silage	Dry matter in silage[1]
		grams	*grams*
First cutting, Silo 8	2–25–22	1.490	7.05
Second cutting, Silo 7	11–23–21	0.920	4.05
Third cutting, Silo 9	1– 4–22	1.453	4.70
Third cutting, Silo 9	1–10–22	1.380	4.47

[1]Using average dry matter content given in Table 7.

Corn silage, in contrast to sunflower silage, shows practically no change in composition from the time of being ensiled until fed, with the exception of the ether-extract content. On the water-free basis the ether-extract content of the corn silage of Silo No. 5 increased more than 16 percent after filling, judging from the average of five samples taken from the material as ensiled, and from the four best agreeing samples of the silage as removed for feeding.

The crude-protein content of corn silage is practically the same as that of sunflower silage when compared on the basis of dry matter, the percentage in the corn being slightly higher than that in the sunflower silage made from the more mature plants. The content of nitrogen-free extract is much higher, as would be expected. The crude-fiber content of corn silage is approximately one-half that in silage made from mature sunflowers. It may be noted further that the crude-fiber content of the first, second, and third cuttings of sunflower silage was approximately 36 percent, 40 percent, and 43 percent, respectively, computed on the water-free basis, as compared with about 22 percent in corn silage. It seems probable that the superiority of one kind of silage over another may be due in large part to the difference in crude-fiber content. In the feeding trial, a somewhat direct relation was found between palatability and crude-fiber content, the relation being an inverse ratio.

The ether-extract and ash contents of corn silage are much less than those of sunflower silage.

It was somewhat surprising to find that the silage produced from the first-harvested sunflowers contained a larger proportion of digestible nutrients per pound than the silage from the second and third cuttings. This conclusion was arrived at by applying the coefficients of digestibility obtained in the digestion trial to the average analyses of the silage as removed for feeding. The results of these computations are shown in Table 11. These data would indicate that the third-cutting silage was higher in digestible nutrients than the second-cutting. However, since the digestion coefficients found for the second-cutting silage were applied to the third-cutting silage as well

TABLE 11.—DIGESTIBLE NUTRIENTS IN SUNFLOWER SILAGE AND IN CORN SILAGE
Expressed in percentage of the fresh substance

Kind of silage	Dry matter	Crude protein	Corrected crude protein	Crude fiber	N-free extract	Total carbo.	Ether extract	Total diges. nutr.
Sunflower, 1st cutting[1]	9.76	0.63	1.17	3.70	4.82	8.52	0.50	10.28
Sunflower, 2d cutting[1]	7.87	0.32	1.01	3.25	3.43	6.68	0.73	8.64
Sunflower, 3d cutting[1]	10.72	0.34	1.29	4.77	2.41	7.18	1.00	9.77
Corn, immature[2]	21.00	1.00	....	....	....	11.40	0.40	13.30
Corn, well matured[2]	26.30	1.10	....	....	....	15.00	0.70	17.68

[1]Calculated from data in Table 7 and Appendix Table 4. The digestion coefficients found for the second cutting of silage were applied to the third cutting. It is probable, however, that the third cutting of silage was less digestible, and therefore that the values are too high.

[2]Henry and Morrison, *Feeds and Feeding*, Appendix Table 3.

as to the second,[1] it is probable that some advantage was given to the silage from the most mature plants and that actually the content of total digestible nutrients of the third-cutting silage was less than that of the second cutting.

Corn silage from immature corn has a slightly higher content of total digestible nutrients than sunflower silage from any of the cuttings, while corn silage from well-matured corn has a still higher content of total digestible nutrients.

ACRE YIELD OF DIGESTIBLE NUTRIENTS

The digestible nutrients yielded per acre by sunflowers were calculated by applying to the data secured in a study of the composition of the growing crop the coefficients of digestibility secured in the digestion trial. The samples from the field investigation were taken upon dates nearly coincident with the dates of ensiling the sunflowers used in the feeding trial. The values thus obtained are shown in Table 12.

TABLE 12.—YIELD OF DIGESTIBLE NUTRIENTS OF SUNFLOWERS PER ACRE
Expressed in pounds

Date of harvest	Dry matter	Crude protein	Crude fiber	N-free extract	Carbohydrates	Ether extract	Total diges. nutr.
8-12-21.......	2732	177	891	1504	2395	96	2788
9- 1-21.......	2610	111	925	1272	2197	205	2769
9-22-21.......	2660	104	1110	1043	2153	348	3040

Apparently there is no advantage in allowing the sunflower crop to become fully mature before ensiling it, since there was no increase in digestible dry matter per acre during the forty days between the first and the third cutting. Both the crude-protein and the nitrogen-free-extract contents decreased with advancing maturity. The decrease in nitrogen-free extract was accompanied by a corresponding increase in ether-extract content, and while this larger proportion of ether extract, for which the seeds were chiefly responsible, served to bring the yield of total digestible nutrients of the crop at that stage above that at either the first or the second harvest dates, the well-ripened plants contained a high proportion of crude fiber, which greatly lessened the palatability. The increase in crude fiber during the forty days between the first cutting and the third was found to be approximately 25 percent.

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[1]This was owing to the fact that the portion of the silage which it was planned to use molded so badly that it had to be discarded.

DIGESTIBILITY OF SUNFLOWER SILAGE

A digestion trial was carried out with dairy cows in an attempt to determine the digestibility of the sunflower silage made from the different cuttings. Unfortunately, the portion of the third-cutting silage which was planned for use in the digestion trial did not keep, so that it was possible to make digestibility determinations of the first- and the second-cutting silage only.

The cows employed were two Jerseys (Nos. 155 and 234) and one Guernsey (No. 217), all dry and farrow. Cow 155 went off feed about two weeks after the beginning of the trial and was replaced by Cow 217. Sunflower silage formed the entire ration, with the exception of a small quantity of common salt, which was sprinkled upon the silage at the time of feeding. The cows were kept in specially constructed digestion stalls, except during the preliminary and intermediate feeding periods. The stalls were provided with tilting, galvanized iron mangers. As soon as the cows finished eating, the mangers were tilted forward to prevent the cows from throwing out any of the refused feed. Excelsior mattresses covered with heavy canvas were placed on the floors of the stalls, while the rear parts of the stall floors and partitions were lined with galvanized iron. Large galvanized iron catch pans were placed on the lower level at the rear of the stalls.

The sunflower silage for the day's feeding was obtained fresh from the silo each morning. It was thoroly mixed and an 800-gram sample was taken as the two feeds for each cow were weighed out. One feed of silage was given at once and the other was placed in a galvanized iron can for the afternoon feeding. The sample was weighed immediately and as soon as possible was placed in a drying oven at a temperature of 45° to 50° C. After drying for two to three days, the sample was weighed and placed in a half-gallon glass jar provided with a tightly fitting cover. The dried samples representing one experimental period were ground together and analyzed.

The orts were carefully collected and weighed each morning before feeding time. In some cases the entire quantity was dried and kept for analysis, while in others an aliquot was taken each day. The samples of the orts were dried in the same oven and treated in the same manner as the silage samples.

Both the feces and the urine were collected directly by a man in constant attendance and placed in galvanized iron cans fitted with tight covers. The cans had previously been treated with a solution of 10-percent thymol in alcohol. After each collection of feces, a small quantity of powdered thymol was sifted on from a shaker-top can. These thymol cans were weighed daily and corrections made for the weight of the thymol which had been added from them. At the end of the experimental day the collections of excreta were weighed and sampled. The feces were mixed thoroly in a large, specially constructed galvanized iron pan and a large aliquot was taken. The sample was placed in a one-gallon friction-top pail, two grams of powdered thymol were added, and the pail was placed in a refrigerator held at a temperature of about 5° C. At the end of each experimental period the aliquot samples representing that period were mixed thoroly and composited.

Analyses were made of the fresh excreta, determinations being made in the same manner and for the same constituents as in the case of the feeds. Instead of determining the true protein, however, as was done with the feeds, the metabolic nitrogen was determined, the method described by Forbes, Mangels, and Morgan[17] being employed. An estimation of the metabolic nitrogen was considered essential to a correct interpretation of the results, because in the digestion of a ration of the kind fed, which was less than normal in quantity but above normal in the proportion of indigestible crude fiber, there would presumably be a larger proportion of unabsorbed digestive juices, epithelial cells, mucus, etc., per unit of dry matter in the feces than with a normal ration. The amount of protein ingested was much below normal, Cow 217 having an intake of only 147 grams daily.

TABLE 13.—SUMMARY OF RESULTS OF DIGESTION TRIAL WITH SUNFLOWER SILAGE

Kind of silage	Coefficients of digestibility						
	Cow No.	Dry matter	Crude protein	Corrected crude protein	Crude fiber	N-free extract	Ether extract
First cutting...	234	47	38	64	50	60	68
" " ...	234	43	40	63	39	54	61
" " ...	234	42	46	70	34	49	60
" " ...	155	48	26	59	56	60	60
Second cutting.	234	36	27	68	35	43	66
" " .	234	37	29	61	35	40	68
" " .	217	33	11	58	36	39	63

A summary of the results obtained in the digestion trial is shown in Table 13; the detailed data are presented in Appendix Table 6. These results are not wholly in agreement, there being some variability in the coefficients secured with different animals. The greatest range of variability occurs in the determinations of protein and crude fiber. The corrected crude-protein coefficients, which were calculated in the usual manner after first deducting the metabolic nitrogen from the total nitrogen of the feces, show a much closer agreement than the ordinary crude-protein coefficients. The lack of agreement in results secured with different cows is probably due to irregular consumption and excretion. These two factors were particularly noticeable with Cow 217. Lack of palatability of the sunflower silage was evidently the cause of the variation in appetite from day to day, and the lack of exercise together with the high content of dry matter in the feces were no doubt the principal factors responsible for the irregular excretion. The absence of close agreement between some of the coefficients accords with the results secured by other investigators in determinations of the digestibility of sunflower silage.

There is, on the whole, a distinct difference in the digestibility of the sunflower silage from the early cutting and that from the more mature plants, in spite of some lack of uniformity of the coefficients secured. The early cut silage proved to be the more digestible, as evidenced especially by the coefficients of digestibility of the dry matter, nitrogen-free extract, and crude fiber. The coefficients of digestibility of the dry matter of the early cut silage were approximately 33⅓ percent greater than those found for the silage from the second cutting. In the case of the ether-extract content the order of digestibility seems to be reversed. This apparent discrepancy may be accounted for by the fact that the first-cutting silage contained practically no developed seeds, while the second-cutting silage had a somewhat larger proportion. The ether extract of the seeds consists largely of oil, which is more highly digestible than the crude-ether-extract content of a roughage high in fiber. A similar relationship holds in the case of corn silage from mature and from immature corn, the ether-extract content of the mature corn being the more highly digestible.[22]

It is possible that the coefficients of digestibility, particularly of crude protein, would have been higher had not a considerable quantity of silage juice, containing a large amount of solid matter in solution or in suspension, been lost from the silos by seepage.

EFFECT OF SUNFLOWER SILAGE UPON COMPOSITION OF MILK

Composite samples of milk of seven of the experimental cows were taken every fifth week during the course of the feeding trial, beginning with Period III. The composites consisted of aliquot portions of each milking during three consecutive days. These samples were analyzed for fat, crude protein, sugar, total ash, specific gravity, and total solids. The analyses indicated very slight changes in the composition of the milk during the feeding of the sunflower silage. Such changes as were noted were in the direction of slightly increased fat, protein, sugar, and total solids. There is no proof that these increases were due to the physiological effects upon the milk-secreting system of compounds contained in the sunflower silage. It is most likely that the lessened volume of milk shown to have been produced during the sunflower silage periods, primarily as a result of a lower nutrient intake, was the factor responsible for the very minor increases noted in the percentage of the solid constituents.

No exact tests were made to determine whether or not the feeding of sunflower silage affects the flavor of the milk. However, no differences in this respect were noticed when the ration was changed from corn silage to sunflower silage or vice versa.

SUMMARY

The object of this investigation was to determine the stage of development at which the sunflower crop should be ensiled for highest milk production. The investigation included a study of feeding value of the silage and the yield of digestible nutrients per acre.

Sunflowers Harvested at Three Dates.—Mammoth Russian sunflowers planted on May 18, 1921, were harvested at three different dates: on August 13, when approximately 23 percent of the plants were coming into bloom; on September 1 and 2, when approximately 95 percent of the plants were in bloom and nearly half the leaves had been killed by rust; and on September 21 and 22, when most of the plants had seeds in the dough stage and all but a few leaves at the tops of the canes had died.

Earliest Cutting Gave Highest Milk Yield.—The silage from the first cutting of sunflowers kept the milk flow nearer to the level maintained on corn silage rations than did that from either the second or the third cutting. Not only did it contain a somewhat larger amount of digestible nutrients per pound but the cows ate it more readily. Also the loss in live weight was less when the cows were fed the first-cutting silage than when fed silage of the later cuttings.

Earliest Cutting the Most Palatable.—The sunflower silage was less palatable, on the whole, than the corn silage. Of the three cuttings of sunflower silage, the first was slightly more palatable than the second, while the third was by far the least palatable. From a practical standpoint, palatability proved to be the most decisive factor in determining the value of the different silages. It seems evident that had the consumption of the sunflower silage been sufficiently large, the production of milk would have been nearly or fully as great as when the cows were fed corn silage.

No Physical Disturbances Were Apparent.—Sunflower silage was much less laxative than corn silage. No diuretic effects were noted, nor were any digestive disturbances apparent.

So far as could be determined, the feeding of sunflower silage did not affect the composition of the milk, and no changes in flavor were noticed.

Sunflower Silage Lower in Nutrients Than Corn Silage.—Sunflower silage made from the mature plants was higher in every constituent, other than water, than silage from the less mature plants, and contained a much higher proportion of crude fiber and ether extract. As compared with corn silage, the sunflower silage was lower in dry matter, crude protein, and nitrogen-free extract, but higher in crude fiber, ether extract, and ash. The true protein content of the sunflower silage formed a larger proportion of the crude protein than it did in the case of the corn silage. Sunflowers apparently must be in a relatively less mature stage than corn at the time they are ensiled, or at least have a higher moisture content, in order to insure their preservation as silage.

Changes in Composition Followed Ensiling.—The ensiling of the sunflowers caused a small loss or transformation of crude protein and nitrogen-free extract. The contents of ether extract and organic acids were increased.

Early Cut Silage More Highly Digestible.—The results of a digestion trial with non-lactating cows showed the silage from the early cut sunflower plants to be more highly digestible than the silage from the second cutting, the dry matter being 33⅓ percent more digestible.

Early Cutting Recommended.—There was no advantage in allowing the crop to mature fully before ensiling it. The yield of digestible dry matter per acre decreased slightly during the forty-day period between the first and the third cuttings. While an increase of about 9 percent in yield of total digestible nutrients may be assumed in the silage from the third cutting as compared with the first cutting, this was more than offset by the decrease in palatability resulting from the higher content of crude fiber.

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APPENDIX

TABLE 1.—TOTAL NUTRIENTS CONSUMED

Period	Group	Feed	Amount fed	Dry matter	Protein	Crude fiber	N-free extract	Ether extract
			lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	A	Sunflower silage	4579.0	1036.69	73.72	427.67	378.68	52.66
		Grain.........	1260.5	1127.51	197.26	98.94	732.85	43.48
		Hay..........	1789.1	1659.53	283.70	577.23	563.21	44.17
	B	Corn silage....	3491.8	1141.12	98.47	245.82	681.58	33.17
		Grain.........	828.0	740.64	129.58	64.99	481.39	28.56
		Hay..........	1050.8	974.74	167.58	338.98	330.92	25.86
II	A	Corn silage....	5200.0	1826.24	157.56	418.08	1093.04	52.00
		Grain.........	1204.0	1086.00	198.41	87.41	703.13	37.32
		Hay..........	1611.6	1509.90	232.87	505.55	601.61	30.94
	B	Sunflower silage	2557.0	579.42	41.42	242.92	208.40	29.15
		Grain.........	584.0	526.76	96.24	42.39	341.00	18.10
		Hay..........	932.5	873.66	134.74	292.53	348.10	17.90
III	A	Sunflower silage	3122.5	942.06	62.76	420.91	326.30	46.84
		Grain.........	1527.5	1369.86	249.13	111.20	888.47	52.69
		Hay..........	2331.5	2176.68	342.24	751.90	808.33	52.69
	B	Corn silage....	6647.5	1893.87	180.81	401.51	1123.43	51.18
		Grain.........	1691.0	1516.47	275.80	123.10	981.79	58.33
		Hay..........	1892.5	1766.83	277.81	610.33	656.12	42.77
IV	A	Corn silage....	5824.0	1877.08	174.14	391.96	1130.44	68.14
		Grain.........	1148.0	1031.24	186.89	72.66	675.15	54.30
		Hay..........	1618.0	1516.22	254.99	477.47	585.55	42.71
	B	Sunflower silage	1721.0	544.18	37.17	229.58	199.12	27.19
		Grain.........	1156.0	1038.43	188.19	73.17	679.84	54.67
		Hay..........	1434.0	1343.80	225.99	423.17	518.96	37.85
V	A	Sunflower silage	7942.0	1628.90	135.81	608.36	652.04	63.54
		Grain.........	1621.0	1499.10	226.45	123.03	994.32	97.26
		Hay..........	2386.0	2278.15	364.81	701.72	919.56	63.47
	B	Corn silage....	7219.5	2336.95	201.41	488.04	1444.62	67.86
		Grain.........	1691.0	1563.83	261.09	128.34	981.62	101.46
		Hay..........	1926.5	1839.42	294.56	566.58	742.47	51.24
VI	A	Corn silage....	8764.0	2881.60	241.88	667.81	1708.10	78.00
		Grain.........	1651.0	1480.12	266.63	121.34	957.08	67.36
		Hay..........	2325.0	2198.52	385.02	626.12	887.45	60.91
	B	Sunflower silage	6125.5	1380.08	110.26	515.15	571.51	52.68
		Grain.........	1596.0	1430.81	257.75	117.30	925.20	65.11
		Hay..........	1960.0	1853.37	324.58	527.82	748.13	51.25

TABLE 2.—DIGESTIBLE NUTRIENTS AND NET ENERGY CONSUMED

Period	Group	Feed	Dry matter	Crude protein	Crude fiber	N-free extract	Ether extract	Total digestible nutrients	Net energy
			lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*therms*
I	A	Sunflower silage	359.52	14.43	152.04	151.62	34.09	394.79	14.57
		Grain	851.27	154.25	42.54	599.47	36.26	877.85	884.96
		Hay	995.71	201.42	248.20	405.51	16.78	892.89	504.54
		Total	2206.50	370.10	442.78	1156.60	87.13	2131.43	1404.07
	B	Corn silage	753.14	50.22	159.78	483.93	27.20	755.13	545.61
		Grain	559.18	101.33	27.94	393.77	23.81	576.61	581.27
		Hay	584.84	118.98	145.76	238.26	9.83	525.12	297.47
		Total	1897.16	270.53	333.48	1115.96	60.84	1856.86	1424.35
II	A	Corn silage	1205.32	80.36	280.75	776.06	42.64	1233.11	914.03
		Grain	819.93	155.15	37.58	575.16	31.12	837.91	847.20
		Hay	905.94	165.33	217.38	433.15	11.75	842.30	513.54
		Total	2931.19	400.84	535.71	1784.37	85.51	2913.32	2274.77
	B	Sunflower silage	200.94	8.11	86.36	83.44	18.87	220.37	17.79
		Grain	397.90	75.26	18.22	278.93	15.10	406.39	410.85
		Hay	524.20	95.66	125.79	250.63	6.80	487.36	297.16
		Total	1123.04	179.03	230.37	613.00	40.77	1100.67	725.80
III	A	Sunflower silage	326.71	12.29	149.63	130.65	30.32	360.79	27.79
		Grain	1034.24	194.82	47.81	726.76	43.94	1069.26	1078.54
		Hay	1306.00	242.99	323.31	581.99	20.02	1193.34	700.99
		Total	2666.95	450.10	520.75	1439.40	94.28	2623.39	1807.32
	B	Corn silage	1249.95	92.21	260.98	797.64	41.97	1245.26	899.13
		Grain	1144.93	215.68	52.93	697.07	48.64	1075.12	999.69
		Hay	1060.09	197.25	262.44	472.41	16.25	968.66	569.03
		Total	3454.97	505.14	576.35	1967.12	106.86	3289.04	2467.85

TABLE 2.—DIGESTIBLE NUTRIENTS AND NET ENERGY CONSUMED—*Concluded*

Period	Group	Feed	Dry matter	Crude protein	Crude fiber	N-free extract	Ether extract	Total digestible nutrients	Net energy
			lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*therms*
IV	A	Corn silage	1238.87	88.81	254.77	802.61	55.87	1271.90	922.65
		Grain	778.58	146.14	31.24	552.27	45.28	831.53	833.78
		Hay	909.73	181.04	205.31	421.59	16.23	844.46	504.73
		Total	3027.18	415.99	491.22	1776.47	117.38	2947.89	2271.16
	B	Sunflower silage	188.72	34.10	81.62	79.73	17.60	235.05	52.41
		Grain	784.01	147.16	31.46	556.10	45.59	837.30	839.56
		Hay	806.28	160.45	181.96	373.65	14.38	748.42	447.32
		Total	1779.01	341.71	295.04	1009.48	77.57	1820.77	1339.29
V	A	Sunflower silage	751.90	45.31	297.73	359.64	39.02	790.47	322.00
		Grain	1131.82	177.08	52.90	705.97	81.11	1118.45	1014.19
		Hay	1366.89	259.01	301.74	662.08	24.10	1308.07	772.02
		Total	3250.61	481.40	652.37	1727.69	144.23	3216.99	2108.21
	B	Corn silage	1542.39	102.72	317.23	1025.68	55.65	1570.84	1156.20
		Grain	1180.69	204.17	55.19	802.96	84.61	1252.69	1213.39
		Hay	1103.65	209.14	243.58	534.57	19.47	1031.10	432.85
		Total	3826.73	516.03	616.00	2363.41	159.73	3854.63	2802.44
VI	A	Corn silage	1901.86	123.36	434.08	1212.75	63.96	1914.10	1398.64
		Grain	1117.44	208.50	52.17	782.89	56.17	1169.94	1174.10
		Hay	1319.11	273.36	269.23	638.96	23.14	1233.62	747.20
		Total	4337.41	605.22	755.48	2634.60	143.27	4317.66	3319.94
	B	Sunflower silage	637.04	36.78	252.11	316.10	32.35	677.78	287.01
		Grain	1080.26	201.56	50.43	756.81	54.30	1130.97	1089.23
		Hay	1112.02	230.45	226.96	538.65	19.48	1039.89	593.14
		Total	2829.32	468.79	529.50	1611.56	106.13	2848.64	1969.38

TABLE 3.—COMPOSITION OF FEEDS EMPLOYED IN FEEDING TRIAL
(Expressed in percentage of the fresh substance)

Sample No.	Description	Feeding period	Dry matter	Crude protein	True protein	Crude fiber	N-free extract	Ether extract	Ash
101	Grain mixture	Oct. 1–Nov. 4	89.45	15.65	14.07	7.85	58.14	3.45	4.36
102	Alfalfa hay	Oct. 1–28	92.44	16.34	13.97	32.57	29.48	2.65	11.40
103	Sunflower silage, Silo 7	Oct 8–Nov.4	22.64	1.61	1.31	9.34	8.27	1.15	2.28
104	Corn silage, Silo 6	Oct 8–23	32.68	2 82	1.81	7.04	19.52	0.95	2.36
105	Sunflower silage, Silo 7	Nov. 5–Dec. 9	22.66	1.62	1.16	9.50	8.15	1.14	2.25
106	Corn silage, Silo 5	Oct. 23–Dec. 9	35.12	3.03	1.91	8.04	21.02	1.00	2.02
107	Alfalfa hay	Oct 29–Dec. 9	93.69	14.45	12.06	31.37	37.33	1.92	8.62
108	Grain mixture	Nov. 5–Dec. 9	90.20	16.48	14.19	7.26	58.40	3.10	4.96
109	Alfalfa hay	Dec. 17–Jan 13	93.36	14.68	11.35	32.25	34.67	2.26	9.50
110	Corn silage, Silo 5	" "	28.49	2.72	1.40	6.04	17.20	0.77	1.76
111	Sunflower silage, Silo 9	" "	30.17	2.01	1.82	13.48	10.45	1.50	2.73
112	Grain mixture	" "	89.68	16.31	14.47	7.28	58.06	3.45	4.58
113	Corn silage, Silo 5	Jan. 21–Feb. 10	32.23	2.99	1.26	6.73	19.41	1.17	1.92
114	Sunflower silage, Silo 9	" "	31.62	2.16	1.62	13.34	11.57	1.58	2.97
115	Grain mixture	" "	89 83	16.28	14.64	6.33	58.81	4.73	3.68
116	Alfalfa hay	" "	93.71	15.76	12.98	29.51	36.19	2.64	9.61
117	Sunflower silage, Silo 8	Feb. 18–Mar. 17	20.51	1.71	1.20	7.66	8.21	0.80	2.13
118	Corn silage, Silo 5	" "	32.37	2.79	1.27	6.76	20.01	0.94	1.88
119	Alfalfa hay	" "	95.48	15.29	1.68	29.41	38.54	2.66	9.58
120	Grain mixture	" "	92.48	15.44	13.97	7.59	61.34	6.00	4.11
121	Sunflower silage, Silo 8	Mar. 25–Apr. 21	22.53	1.80	1.35	8.41	9.33	0.86	2.13
122	Corn silage, Silo 5	" "	32.88	2.76	1.39	7.62	19.49	0.89	2.11
123	Alfalfa hay	" "	94.56	16.56	14.33	26.93	38.17	2.62	10.28
124	Grain mixture	" "	89.65	16.15	14.04	7.35	57.97	4.08	4.09

TABLE 4.—COEFFICIENTS OF DIGESTIBILITY AND NET ENERGY VALUES USED IN CALCULATION OF DIGESTIBLE NUTRIENTS AND THERMS OF ENERGY IN FEEDS CONSUMED

	Coefficients of digestion					
	Dry substance	Crude protein	Corrected crude protein	Crude fiber	N-free extract	Ether extract
Sunflower silage, Silo 8, 1st cutting[1]	46.16	33.36	62.46	48.94	55.31	61.41
Sunflower silage, Silo 7, 2d cutting[2]	34.68	19.58	61.71	35.55	40.04	64.74
Sunflower silage, Silo 9, 3d cutting[3]	34.68	19.58	61.71	35.55	40.04	64.74
Corn silage[4]	66.00	51.0	.....	65.00	71.00	82.00
Alfalfa hay[4]	60.00	71.0	.....	43.00	72.00	38.00
Grain mixture[5]	75.50	78.2	.....	43.00	81.80	83.40

[1] From Appendix Table 6, average of Cows 234 and 155.
[2] From Appendix Table 6, average of Cows 234 and 217.
[3] Assumed same as 2d cutting.
[4] From Henry and Morrison, *Feeds and Feeding*, Appendix Table II.
[5] Compiled from Henry and Morrison. Weighted average of coefficients for grains composing the mixture.

NET ENERGY VALUES[1]

Net energy value of silage equals 1.588 therms per pound of digestible organic matter minus 52.54 therms per cwt. of total dry matter.

Net energy value of alfalfa hay equals 1.588 therms per pound of digestible organic matter minus 53.03 therms per cwt. of total dry matter.

Net energy value of grain mixture equals 1.808 therms per pound of digestible organic matter minus 55.01 therms per cwt. of total dry matter.

[1] Calculated from values given by Armsby and Fries, Pa. Agr. Exp. Sta., Bul. 142, 1916.

TABLE 5.—URINE EXCRETION OF COWS FED SUNFLOWER SILAGE ONLY AND OF ONE FED A MIXED RATION CONTAINING CORN SILAGE

Cow No.	Ration	Volume daily	Specific gravity	Total nitrogen in urine
		gms.		*percent*
234	Sunflower silage, 1st cutting	8583	1.0159	0.40
234	Sunflower silage, 1st cutting	9030	1.0145	0.34
234	Sunflower silage, 1st cutting	10793	1.0148	0.37
155	Sunflower silage, 1st cutting	8176	1.0153	0.40
155	Sunflower silage, 1st cutting	5380	1.0187	0.51
234	Sunflower silage, 2d cutting	11231	1.0149	0.28
234	Sunflower silage, 2d cutting	11783	1.0156	0.27
217	Sunflower silage, 2d cutting	9397	1.0124	0.37
217	Sunflower silage, 2d cutting	9014	1.0108	0.31
274	Mixed ration, ad lib	14089	1.0288	0.70
274	Mixed ration, ad lib	14775	1.0295	0.73
274	Mixed ration	9245	1.0285	0.80
274	Mixed ration	11516	1.0271	0.66

TABLE 6.—DETAILED RESULTS OF DIGESTION TRIALS

		Dry substance	Total nitrogen	Metabolic nitrogen	Crude protein	Crude fiber	N-free extract	Ether extract	Ash
Cow 234 Period I, May 10–14, 1922									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[2]	51 000	21.44	0.31	......	1.94	7.24	9.11	.83	2.31
Orts	1 951	29.40	0.18	......	1.12	15.03	10.50	.33	2.43
Feces	20 736	26.73	0.47	0.205	2.94	8.21	8.52	.64	6.42
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		10 934.4	158.1	......	999.6	3 692.4	4 646.1	423.3	1 178.1
Nutrients in orts		573.6	3.5	......	21.9	293.3	204.9	6.4	47.4
Nutrients consumed		10 360.8	154.6	......	977.7	3 399.1	4 441.2	416.9	1 130.7
Nutrients in feces		5 542.7	97.5	42.5	609.6	1 702.4	1 766.7	132.7	1 331.3
Nutrients digested		4 818.1	......	......	368.1	1 696.7	2 674.5	284.2	......
Coef. of digestibility		46.50	......	64.42[1]	37.69	49.91	60.22	68.17	......
Cow 234 Period II, May 15–19									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[2]	75 000	20.74	0.31	......	1.94	7.11	8.54	.83	2.34
Orts	5 337	25.97	0.17	......	1.08	13.68	9.08	.23	1.91
Feces	30 285	26.43	0.44	0.168	2.75	9.34	8.97	.79	4.58
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		15 555.0	232.5	......	1 440.0	5 332.5	6 405.0	622.5	1 755.0
Nutrients in orts		1 391.2	9.1	......	57.9	732.8	486.4	12.3	102.3
Nutrients consumed		14 163.8	223.4	......	1 382.1	4 599.7	5 918.6	610.2	1 652.7
Nutrients in feces		8 004.3	133.3	50.9	832.8	2 828.6	2 716.7	239.3	1 387.1
Nutrients digested		6 159.5	......	......	549.3	1 771.1	3 201.9	370.9	......
Coef. of digestibility		43.48	......	63.11[1]	39.75	38.54	54.10	60.78	......

TABLE 6.—*Continued*

		Dry substance	Total nitrogen	Metabolic nitrogen	Crude protein	Crude fiber	N-free extract	Ether extract	Ash
Cow 234 Period III, May 22–26									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[3]	75 000	22.64	0.27	......	1.73	8.63	8.94	1.12	2.23
Orts	3 019	26.39	0.16	......	1.04	13.70	9.01	0.52	2.11
Feces	39 991	25.82	0.37	0.21	2.31	9.85	9.19	0.70	3.77
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		16 980.0	202.5	......	1 297.5	6 472.5	6 705.0	840.0	1 672.5
Nutrients in orts		796.7	4.8	......	31.4	413.6	272.0	15.7	63.7
Nutrients consumed		16 183.3	197.7	......	1 266.1	6 058.9	6 433.0	824.3	1 608.8
Nutrients in feces		10 325.6	148.0	84.0	923.8	3 939.1	3 675.2	279.9	1 504.4
Nutrients digested		5 867.7	......	......	342.3	2 119.8	2 758.8	544.4	......
Coef. of digestibility		36.26	......	67.62[1]	27.03	34.98	42.88	66.04	......
Cow 234 Period IV, May 27–31									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[3]	75 000	22.89	0.25	......	1.56	9.15	8.90	1.12	2.16
Orts	5 466	28.36	0.19	......	1.19	13.51	10.09	0.81	2.76
Feces	39 023	25.09	0.32	0.145	2.00	10.23	9.42	0.66	2.78
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		17 167.5	187.5	......	1 170.0	6 862.5	6 675.0	840.0	1 620.0
Nutrients in orts		1 550.2	10.4	......	65.1	738.5	551.5	44.3	150.9
Nutrients consumed		15 617.3	177.1	......	1 104.9	6 124.0	6 123.5	795.1	1 469.1
Nutrients in feces		9 790.0	124.9	56.7	780.5	3 992.1	3 674.0	257.6	1 084.8
Nutrients digested		5 826.4	......	......	324.4	2 131.9	2 449.5	538.1	......
Coef. of digestibility		37.37	......	61.48[1]	29.36	34.81	40.00	67.62	......

[1]Corrected protein coefficient, after deduction of metabolic nitrogen of feces.
[2]Sunflower silage, Silo 8, first cutting. [3]Sunflower silage, Silo 7, second cutting.

TABLE 6.—*Continued*

Cow 234—Period V, June 4-8

		Dry substance	Total nitrogen	Metabolic nitrogen	Crude protein	Crude fiber	N-free extract	Ether extract	Ash
		Composition							
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[2]	75 000	20.47	0.31	......	1.99	7.40	8.39	0.72	1.98
Orts	3 488	28.22	0.20	......	1.25	14.22	10.44	0.29	2.02
Feces	33 868	24.70	0.37	0.14	2.31	9.83	8.89	0.63	3.04
		Calculation of digestibility							
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		15 352.5	232.5	......	1 492.5	5 550.0	6 292.5	540.0	1 485.0
Nutrients in orts		984.3	7.0	......	43.6	496.0	364.1	10.1	70.5
Nutrients consumed		14 368.2	225.5	......	1 448.9	5.054.0	5 928.4	529.9	1 414.5
Nutrients in feces		8 365.4	125.3	47.4	782.4	3 320.2	3 010.9	213.4	1 029.6
Nutrients digested		6 002.8	......	......	666.5	1 724.8	2 917.5	316.5	......
Coef. of digestibility		41.77	......	69.88[1]	46.00	34.12	49.21	59.72	......

Summary for Cow 234

	Dry substance	Crude protein	Corrected crude protein	Crude fiber	N-free extract	Ether extract
Av. coefficients for Periods I, II, and V	43.92	41.15	65.80	40.86	54.51	62.89
Av. for Periods III and IV	36.82	38.20	64.55	34.90	41.44	66.83

[1]Corrected protein coefficient, after deduction of metabolic nitrogen of feces
[2]Sunflower silage, Silo 8, first cutting.

TABLE 6.—*Concluded*

		Dry substance	Total nitrogen	Metabolic nitrogen	Crude protein	Crude fiber	N-free extract	Ether extract	Ash
Cow 217—May 22–31, 1922									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[3]	100 000	22.77	0.26	......	1.65	8.89	8.92	1.12	2.20
Orts	13 870	27.04	0.21	......	1.21	12.26	9.42	0.97	3.11
Feces	45 221	28.37	0.46	0.163	2.89	10.14	10.33	0.81	4.20
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		22 765.0	260.0	......	1 645.0	8 890.0	8 920.0	1 120.0	2 195.0
Nutrients in orts		3 750.2	28.7	......	178.9	1 700.5	1 306.5	133.8	431.2
Nutrients consumed		19 014.8	231.3	......	1 466.1	7 189.5	7 613.5	986.2	1 763.8
Nutrients in feces		12 829.6	208.9	73.9	1 305.4	4 586.0	4 671.8	368.3	1 897.9
Nutrients digested		6 185.2	......	......	160.7	2 603.5	2 941.7	617.9	......
Coef. of digestibility		32.53	......	58.37[1]	10.96	36.21	38.64	62.65	......
Cow 155—May 10–19, 1922									
Composition									
	gms.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Silage fed[3]	101 465	21.08	0.31	......	1.94	7.17	8.82	0.83	2.32
Orts	15 364	22.03	0.22	......	1.45	9.37	8.61	0.47	2.18
Feces	42 048	22.09	0.49	0.22	3.08	5.96	7.28	0.73	4.87
Calculation of digestibility									
		gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Nutrients in silage fed		21 390.3	309.4	......	1 967.9	7 278.5	8 947.3	842.2	2 359.5
Nutrients in orts		3 385.6	34.9	......	223.4	1 430.7	1 323.7	71.9	335.0
Nutrients consumed		18 004.7	274.5	......	1 744.5	5 847.8	7 623.6	770.3	2 024.5
Nutrients in feces		9 291.4	207.7	95.5	1 298.3	2 566.5	3 065.7	308.7	2 051.9
Nutrients digested		8 713.3	......	......	446.2	3 281.3	4.557.9	461.6	......
Coef. of digestibility		48.39	......	59.12[1]	25.57	56.11	59.77	59.92	......

[1]Corrected protein coefficient, after deduction of metabolic nitrogen of feces.
[2]Sunflower silage, Silo 8, first cutting.
[3]Sunflower silage, Silo 7, second cutting.