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AGRICULTURAL EXPERIMENT STATION.
KANSAS STATE AGRICULTURAL COLLEGE.

DEPARTMENT OF ANIMAL HUSBANDRY.

Feeding Work Horses.

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Far less experimental work has been conducted with horses than with any other class of domestic animals. Less is known to-day of the influence of different feeds, and combinations of feeds upon horses than upon any other group of farm animals. Little attention has been given to study of the best methods of feeding and maintaining horses. The general feeding practices have been, and are to-day, fixed largely by tradition, custom, or arbitrary rule. Throughout the middle west the common roughage for horses has been prairie hay. Thousands of acres of native grass in Kansas have been broken up, and the prospect is that there will soon be a shortage of this class, of rough feed. Oats have been the standard grain for horses for many years, but oats of high quality are becoming more difficult to obtain each year and higher in price. Some other grain must be found to take the place of oats—in part at least—in compounding an economical and satisfactory ration for work horses. The Kansas Agricultural Experiment Station conducted an investigation in an attempt to solve some of these problems, and the results are reported in this circular.

OBJECTS OF THE EXPERIMENT.

The objects of the experiment were:

1. To make a direct comparison of the value of prairie, timothy, alfalfa, and small-grain hays for horse feeding.
2. To find, if possible, a grain or a mixture of grains for horse feeding that would give as good results as oats.
3. To make a careful study of the influence of various grains and mixtures of grain for standard horse rations.

HORSES USED.

The horses used in this experiment belonged to the United States Sixth field artillery. They averaged about 1165 pounds in weight and ranged in age from five years up, the average age being about eleven years.

NATURE OF THE WORK.

Nowhere is the work of horses so uniform as in the army. Each horse does practically the same kind and the same amount of work. The work performed during the experiment in question might properly be classed as rapid light draft. It consisted chiefly of marching and drilling, the horses being hitched to heavy wagons and guns. A considerable portion of the work was done at a trot and no small amount at a gallop, While the artillery horse performing his regular duties did not work so many hours a day as the farm horse during the busy season, yet the work done was extremely fatiguing and more severe than the average work done by the farm horse throughout the year.

WEIGHING.

The horses were weighed individually at the beginning of the experiment and at the end of each thirty-day period. Accurate records were kept of the weights.

GENERAL OBSERVATIONS.

Throughout the experiment careful observations were made of the effect of the various feeds upon the general health, spirit and condition of the horses. Special attention was given to the effect upon the respiratory and digestive organs,

SICK REPORT.

A careful sick report was kept. All horses off their feed for more than forty-eight hours, or prevented by illness or injury from performing their regular duties for a like period of time, were eliminated in calculating results.

In the total of 937 horses only fourteen cases of digestive disturbance were observed during the entire period of the experiment. Of these fourteen cases twelve were slight at-

tacks of colic. The other two were severe cases of enteritis, resulting in death.

The digestive disturbances were reported from the following lots:

Lot 1: One case of colic; mild.
Lot 2: Three cases of colic; mild.
Lot 3: One case of colic; mild.
Lot 5: One case of enteritis; fatal.
Lot 6: Two cases of colic; mild.
Lot 7: Two cases of colic; mild.
Lot 8: Three cases of colic; mild.
Lot 9: One case of enteritis; fatal.

METHOD OF FEEDING.

The horses were fed at 5:30 and 11:30 o'clock in the morning and 5:30 in the afternoon. All lots except Nos. 13, 14, 16 and 17 were fed one-third of the grain allowed at each meal and all of the hay at night. Lots 13, 14, 16 and 17 also received portions of hay at the morning and noon feedings. When a ration was of different grains they were thoroughly mixed before feeding.

COST OF VARIOUS FEEDS USED.

The stated cost of the various rations used in the experiment, except those containing small-grain hays, is based upon Kansas City prices at the time the feeds were purchased. The small-grain hays were purchased f. o. b. San Francisco, at $10 a ton; the freight from San Francisco to Fort Riley was $20 a ton, making the total cost $30 a ton. The other feeds cost as follows:

Barley	65 cents a bushel.
Corn	55 cents a bushel.
Oats	38½ cents a bushel.
Bran	$20 a ton.
Alfalfa meal	$14 a ton.
Timothy hay	$12.50 a ton.
Prairie hay	$12.50 a ton.
Alfalfa hay	$10 a ton.
Linseed oil meal	$35.50 a ton.
Brown sugar	$5 a cwt.
Wheat hay	$10 a ton.
Wild-oat hay	$10 a ton.
Barley hay	$10 a ton.

The relative values given for barley, corn, oats, bran, linseed oil meal, alfalfa hay and alfalfa meal are about the same as those usually prevailing in the vicinity of Fort Riley. Prairie hay in this vicinity usually costs about the same as alfalfa hay, while timothy hay usually averages from 25 to 40 percent higher.than prairie hay.

CORN VERSUS OATS.

Every horseman appreciates the value of oats as a feed for horses of every class and age, and especially for work horses. Usually, however, oats are from 20 to 35 percent higher in price than corn. It is often asked, therefore, Can as good results be obtained from feeding corn to work horses as from feeding oats? The following results obtained from the Fort Riley experiment throw some light on this question:

TABLE I. Corn *versus* oats.

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test	Gain or loss per horse during test	Grain daily per 1000 pounds live weight.	Hay daily per 1000 pounds live weight.	Nutritive ratio	Cost of daily ration per 1000 pounds live weight
		Years.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*		
1	76	9.35	140	1,131.2	+16.3	Oats..... 10.51	Prairie hay.. 12.25	1: 7.9	$0.2026
2	76	8.34	140	1,180.9	—29.3	Corn..... 10.27	Prairie hay.. 11.98	1:11.5	.1754
5	69	11.00	110	1,196.8	—13.3	Oats..... 3.36 Corn..... 6.72	Prairie hay.. 11.75	1:10.1	.1796

During the early part of the experiment — January and February — while the weather was cold and the work only moderate, there was apparently no difference between the corn-fed and the oats-fed horses. The horses receiving corn did their work and maintained their weight and condition just as well in every respect as the horses receiving oats. But as the weather grew warmer and the work more severe, the corn-fed horses in lot 2 gradually began to lose weight, and at the end of the experiment had lost 29.3 pounds to the horse. The oats-fed horses in lot 1 made a gain of 16.3 pounds to the horse during the same period. The horses in lot 1 were fed oats and prairie hay, receiving daily 10.51 pounds of grain and 12.26 pounds of prairie hay per thousand pounds live

weight. The horses in lot 2 were fed corn, receiving daily 10.27 pounds of grain and 11.98 pounds of prairie hay per thousand pounds live weight. That is, the horses of lot 1, receiving oats and hay, were fed daily .24 pound of grain and .27 pound of hay more per thousand pounds live weight than the horses of lot 2, receiving corn and prairie hay. While the difference is very small, it should be considered.

The results show that there is not a great difference in the feeding value of corn and oats with prairie hay for roughage for mature horses doing light work during cold weather. During hot weather, however, horses will not maintain their weight, nor stand hard work as well, when fed corn and prairie hay as when fed oats and prairie hay. Taking the ration fed in lot 1 as a standard, and comparing the digestible nutrients of this ration with the digestible nutrients of the ration fed in lot 2, as shown in the summary table, it will be noted that the ration of corn and prairie hay is deficient in digestible protein and that it would require the substitution of 1.37 pounds of corn for each pound of oats to supply an amount of digestible protein equal to that in the standard ration fed in lot 1. In so doing, an excessive amount of digestible carbohydrates and fat would be fed. Carbohydrates produce a large amount of heat in the processes of digestion, which is the reason for the common observation that a ration of corn with either prairie or timothy hay is too heating to be fed work horses in hot weather.

The presence of the hulls in oats gives them the advantage of producing a lighter and looser mass in the stomach than corn. The tendency of food to pack in the horse's stomach, because of the absence of a churning or mixing motion, is thereby lessened and the digestive juices are allowed to permeate the food mass more thoroughly. Because of its greater bulk, there is also less danger from overfeeding oats than corn.

There was apparently no difference in the endurance, wind or spirit of the horses in lots 1 and 2. Both rations were satisfactory in this respect, but at the end of the experiment the corn-fed horses did not show quite as good condition and thrift as the oats-fed horses.

A study of the results obtained in lot 5 corroborates the deductions made from the results of lots 1 and 2.

In lot 5 a grain ration of corn and oats with prairie hay was fed. By referring to Table I it will be noted that the corn and oats, mixture gave better results than corn and prairie hay. It did not give as satisfactory results as oats and prairie hay, so far as maintaining the weight was concerned. No difference could be noted in spirit, endurance or wind. On a thousand-pound-live-weight basis the combination of oats one part and corn two parts cost $0.0042 a day more than corn alone, and $0.023 a day less than oats alone.

TABLE II. Corn, bran, and linseed oil meal *versus* oats.

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test	Gain or loss per horse during test	Grain daily per 1000 pounds live weight.	Hay daily per 1000 pounds live weight.	Nutritive ratio	Cost of daily ration per 1000 pounds live weight
		Years.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*		
1	76	9.35	140	1,131.2	+16.3	Oats..... 10.51	Prairie hay...12.25	1: 7.9	$0.2026
15	22	12.00	140	1,159.3	+3.9	Corn..... 5.16 Bran..... 2.58 Lin. meal.... 0.86	Prairie hay.. 12.05	1: 8.4	.1669

In lot 15 a combination of corn, bran and lineed oil meal in the proportion of 6:3:1 was used as a substitute for oats fed in lot 1 (Table II). It will be noted that 8.6 pounds of these mixed grains was substituted for 10.51 pounds of oats per thousand pounds live weight, or 1 pound of the mixed grains for 1.2 pounds of oats. The horses receiving the corn, bran, linseed oil meal and prairie hay made an average gain of 3.9 pounds during the experiment. This ration proved to be practically as satisfactory as the ration consisting of oats and prairie hay fed to the horses in lot 1. While the horses in lot 156 did not make gains quite as great as those in lot 1, they showed a trifle better condition, and their wind, endurance and spirit were just as good. The cost of the daily ration fed to lot 15 (corn, bran, linseed oil meal and prairie hay) was $0.0257 (or practically 12 percent) cheaper per thousand pounds live weight than the ration (oats and prairie hay) fed to lot 1. The ration fed to lot 15 has been used at the Kansas State Agricultural College for a number of years and has proved very satisfactory for work horses.

TABLE III. Alfalfa hay, corn and oats *versus* oats and prairie hay.

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test	Gain or loss per horse during test	Grain daily per 1000 pounds live weight.		Hay daily per 1000 pounds live weight.		Nutritive ratio	Cost of daily ration per 1000 pounds live weight
1	76	*Years.* 9.35	140	*Lbs.* 1,131.2	*Lbs.* +16.3	Oats	*Lbs.* 10.51	Prairie hay	*Lbs.* 12.25	1: 7.9	$0.2026
12	17	12.00	140	1,163.2	+25.6	Oats Corn	1.70 6.80	Alfalfa hay	8.50	1: 5.8	.1295

Better results might be expected from the horses of lot 1 than from those of lot 12, as shown in Table III, because the former were younger and received more grain. However, the horses in lot 12, receiving the combination of corn with a very small amount of oats and alfalfa hay, did their work just as well in every respect as the horses in lot 1. They showed no signs of shortness of wind, softness, lack of endurance, bowel looseness, or excessive urination. They made a gain of 25.6 pounds per horse during the experiment. The daily feed cost was only $0.1295 per thousand pounds live weight, or 36 percent, less than the ration consisting of oats and prairie hay. The amount of grain was reduced 19 percent and the amount of hay 30 percent. It will be noticed that a very small amount of alfalfa hay was fed, wherein lies the principal secret of feeding alfalfa hay to work horses. It should be looked upon rather as a concentrate than as a roughage, and should be fed in limited amounts. This point will be discussed more in detail later.

Corn and alfalfa are digested readily. The fact that they do not require an excessive amount of energy for digestion is one reason for the good results obtained in lot 12, where the nutritive ratio was comparatively narrow.

Prairie and timothy hay are often allowed to become too mature before cutting. The digestible nutrients become so strongly encased in cellulose that an excessive amount of energy is required to digest these hays. This makes necessary a large proportion of energy-producing elements, hence a wider nutritive ratio. The ease with which the feeds of a ration are digested has considerable influence upon the nutritive ratio required. For instance, one pound of alfalfa hay contains

.463 pound of digestible nutrients and requires .219 pound of digestible nutrients for mastication and digestion, leaving .234 pound of available digestible nutrients. One pound of average wheat straw contains .181 pound of digestible nutrients and requires .297 pound of digestible nutrients for digestion and mastication, thus using .116 pound more digestible nutrients for digestion than the straw provides.

TABLE IV. Alfalfa hay *versus* prairie hay. (A)

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test	Gain or loss per horse during test	Grain daily per 1000 pounds live weight.	Hay daily per 1000 pounds live weight.	Nutritive ratio	Cost of daily ration per 1000 pounds live weight
		Years.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*		
12	17	12	140	1,163.2	+25.6	Oats..... 1.07 Corn..... 6.08	Alfalfa hay.. 8.05	1: 5.8	$0.1295
2	76	8.34	140	1,180.9	—29.3	Corn..... 10.27	Prairie hay.. 11.98	1:11.5	.1754

The horses in lot 12 did their work very satisfactorily and showed better condition than the horses in lot 2. In lot 12 a gain of 26.6 pounds per horse was made, while in lot 2, 29.3 pounds per horse was lost during the test. In lot 12 the grain fed daily per thousand pounds live-weight was reduced 17.23 percent, the hay 29.1 percent, and the cost of the daily ration, 26.2 percent.

TABLE V. Alfalfa hay *versus* prairie hay. (B)

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test	Gain or loss per horse during test	Grain daily per 1000 pounds live weight.	Hay daily per 1000 pounds live weight.	Nutritive ratio	Cost of daily ration per 1000 pounds live weight
		Years.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*		
12	17	12	140	1,163.2	+25.6	Oats..... 1.70 Corn..... 6.80	Alfalfa hay.. 8.50	1: 5.8	$0.1295
5	69	11	110	1,196.8	—13.3	Oats..... 3.36 Corn..... 6.72	Prairie hay.. 11.75	1:10.1	.1796

The horses in lots 6 and 12 received daily practically the same amounts of corn per thousand pounds live weight. In addition to the corn, the horses in lot 5 received daily 3.36 pounds of oats per thousand pounds live weight, while the horses in lot 12 received daily, in addition to the corn, only

1.7 pounds of oats per thousand pounds live weight. Thus the horses in lot 5 received daily 10.08 pounds of grain, while those in lot 1.2 received daily 8.5 pounds of grain,per thousand pounds live weight. The horses in lot 5, receiving 10.08 pounds of grain, were fed daily 11.75 pounds of prairie hay per thousand pounds live weight, while the horses in lot 12, receiving 8.5 pounds of grain, were fed daily only 8.5 pounds of alfalfa hay per thousand pounds live weight. The horses in lot 12, receiving the smaller amounts of both grain and hay, showed better thrift and condition than those in lot 5, did their work just as well in every respect, and made a gain of 25.6 pounds per horse. Those in lot 5 showed a loss of 13.3 pounds per horse. The ration used in lot 12 resulted in a-reduction of 15.67 percent in the grain portion of the daily ration, and 27.7 percent in the hay. In the lots compared in Table V, the substitution of alfalfa hay reduced the amount of hay required almost 30 percent, at the same time reducing the amount of grain, on an average, about 16 percent. While these results do not give a direct comparison in the value of alfalfa and prairie hay, yet the conclusion that in a properly balanced ration 1 pound of alfalfa hay is probably worth 2 pounds of prairie or timothy hay appears justified.

ALFALFA HAY AS A HORSE FEED.

The results obtained from the use of alfalfa hay in this experiment are probably the most valuable part of the whole study, because of the general prejudice against feeding alfalfa to work horses, and because of the cheapness and abundance of alfalfa hay in most parts of Kansas. If alfalfa hay *is properly fed,* it may be fed to any kind of horses. This applies just as much to work horses as to growing horses. However, it must be cut at the proper time for horse-feeding purposes and must be fed as a concentrate rather than as a roughage.

The method practiced by a majority of those who have been feeding alfalfa to work horses has been to fill the manger morning, noon and night, allowing the horse to eat all he wishes. Prairie hay has been fed in this way without any serious results, but not so in the case of alfalfa hay. Alfalfa hay is very palatable and horses eat very large amounts. Excessive urination and soft, “windy” horses that are puffed in

the hocks, stocked on the legs and unable to endure hard work result. This has been the experience of hundreds of horsemen. The trouble is with the method of feeding, not with alfalfa hay.

It is commonly believed that the proper time to begin cutting alfalfa hay is when the field is about one-tenth in bloom. Cutting at such a time makes very good hay for cattle, but such hay is too "washy" for horses at hard work. To make hay suitable for horses at hard work, alfalfa must be allowed to become rather mature before cutting; in fact, the field should be in full bloom before the mower is started. The hay should be thoroughly cured and stacked. Special care must be taken to prevent spoiling or molding, as moldy, musty or dusty hay of any kind is injurious to horses.

Probably the chief cause of so much trouble in feeding alfalfa hay is overfeeding. One pound of alfalfa hay contains, on the average, 35 per cent more digestible protein than one pound of shelled corn; and is fairly rich in carbohydrates and fat. No one would think of feeding a 1200-pound work horse a bushel (56 pounds) of shelled corn in a day, yet by giving the same horse all the alfalfa hay he will eat, as large or a larger amount of digestible protein will be fed daily than is contained in a bushel of shelled corn. This excessive amount of highly nitrogenous material not only overworks the kidneys, but also causes irritation which may result in a pronounced chronic inflammatory condition of the kidneys. Another effect of overfeeding with alfalfa is a cloying of the whole system, resulting in impaired nutrition, filling of the legs and hocks, softness, excessive sweating, and impaired respiration. A part of the trouble with the wind comes from the fact that the overloaded digestive tract interferes with the proper functioning of the lungs. Heaves may develop, most cases of heaves resulting from indigestion. This disease is at first a functional disturbance, but later becomes structural in character and incurable.

To summarize, the points to remember in feeding alfalfa hay to work horses are: first, the hay must not be cut until quite mature; second, it, must be free from dust, mold, or smut; third, it must be fed in limited quantities. As to the amount to be fed, experience seems to indicate that 1.2 pounds per hundred pounds live weight is about the maximum amount for work horses.

Because of its high proportion of digestible protein, alfalfa balances very well with corn.and these two feeds make the most economical ration the Kansas farmer who grows alfalfa can feed, since he can control the time of cutting and the manner of curing and caring for the hay.

The man who buys alfalfa hay on the market usually chooses the hay showing the brighest green color. This is often the poorest for work horses, because it has been cut too green and is very "washy." If, however, the purchaser will select average, well-cured, clean alfalfa hay he will be able to reduce the cost of feed very materially by substituting alfalfa hay for a part of the prairie or timothy hay. He may substitute 1 pound of alfalfa hay for 1½ to 2 pounds of prairie or timothy hay, until from one-third to one-half or more of the prairie or timothy hay has been replaced by alfalfa hay, the amount used depending upon the quality of the alfalfa substituted for the other hays. The grain ration, too, may be cut down, as shown by the results obtained in lots 2, 5 and 12.

TABLE VI. SUMMARY

Lot No.	Number of horses	Average age of horses	Number of days fed	Average weight of horses at beginning of test, January 15, 1911	Average weight of horses at end of test	Gain or loss of horses during the test	Daily ration per horse.	Grain daily per 1000 pounds live weight.
		Years.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	76	9.35	140	1,131.2	1,147.5	+16.3	Oats 12 Prairie hay 14	Oats 10.51
2	76	8.34	140	1,130.9	1,151.6	—29.3	Corn 12 Prairie hay 14	Corn 10.27
3	74	10.44	140	1,185.0	1,172.1	—12.9	Oats 8 Corn 4 Prairie hay 14	Oats 6.78 Corn 3.39
4	76	11.00	140	1,159.3	1,151.6	— 7.7	Oats 8 Corn 4 Timothy hay 14	Oats 6.90 Corn 3.45
5	69	11.00	110	1,196.8	1,183.5	—13.3	Oats 4 Corn 8 Prairie hay 14	Oats 3.36 Corn 6.72
6	73	11.30	110	1,177.7	1,169.4	— 8.3	Oats 4 Corn 6 Alfalfa meal 4 Prairie hay 12	Oats 3.41 Corn 5.11 Alfalfa meal 3.41
7	79	11.00	110	1,153.0	1,156.0	+ 3.0	Oats 4 Corn 6 Alfalfa meal 4 Timothy hay 12	Oats 3.44 Corn 5.16 Alfalfa meal 3.44
8	75	11.86	110	1,170.5	1,163.8	— 6.7	Oats 4 Corn 6 Bran 4 Prairie hay 12	Oats 3.39 Corn 5.10 Bran 3.39
9	76	10.40	110	1,167.4	1,173.5	+ 6.1	Oats 4 Corn 6 Bran 4 Timothy hay 12	Oats 3.39 Corn 5.09 Bran 3.39
10	77	10.00	110	1,170.0	1,167.5	— 2.5	Oats 4 Corn 6 Linseed meal 1 Prairie hay 12	Oats 3.41 Corn 5.11 Linseed meal .85
11	18	14.00	140	1,181.6	1,163.3	—18.3	Oats 12 Prairie hay 14	Oats 10.26
11A	3	9.00	140	1,100.0	1,108.3	+ 8.3	Barley 12 Prairie hay 14	Barley 10.86
12	17	12.00	140	1,163.2	1,188.8	+25.6	Corn 8 Oats 2 Alfalfa hay 10	Corn 6.80 Oats 1.70
15	22	12.00	140	1,159.3	1,163.2	+ 3.9	Corn 6 Bran 3 Linseed meal 1 Prairie hay 14	Corn 5.16 Bran 2.58 Linseed meal .86
18	18	12.50	75	1,197.7	1,180.0	—17.7	Oats 10 Brown sugar 5 Prairie hay 14	Oats 8.32 Brown sugar .42

OF EXPERIMENTS.

Hay daily per 1000 pounds live weight.	Digestible nutrients per day per 1000 pounds live weight.			Total digestible nutrients per day per 1000 pounds live weight.	Nutritive ratio.	Cost of grain per day per 1000 pounds live weight.	Cost of hay per day per 1000 pounds live weight.	Total cost per day per 1,000 pounds of live weight.	Lot No.
	Protein.	Carbohydrates.	Fat.						
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*					
Prairie hay..... 12.25	1.492	10.542	.595	12.629	1: 7.9	$0.1261	$0.0765	$0.2026	1
Prairie hay..... 11.98	1.160	11.990	.633	13.792	1:11.5	.1006	.0748	.1754	2
Prairie hay..... 11.86	1.345	10.762	.593	12.700	1: 8.9	.1145	.0741	.1886	3
Timothy hay..... 12.08	1.345	10.897	.567	12.809	1: 9.0	.1166	.0755	.1921	4
Prairie hay..... 11.75	1.236	11.219	.604	13.059	1:10.1	.1062	.0734	.1796	5
Prairie hay..... 10.22	1.448	10.846	.533	12.827	1: 8.3	.1148	.0639	.1787	6
Timothy hay..... 10.34	1.441	10.906	.517	12.864	1: 8.3	.1159	.0646	.1805	7
Prairie hay..... 10.12	1.467	10.877	.594	12.938	1: 8.3	.1245	.0632	.1877	8
Timothy hay..... 10.17	1.449	10.847	.565	12.861	1: 8.3	.1245	.0635	.1880	9
Prairie hay..... 10.23	1.327	9.789	.571	11.687	1: 8.3	.0161	.0639	.1700	10
Prairie hay..... 11.98	1.457	10.300	.581	12.338	1: 7.9	.1231	.0749	.1980	11
Prairie hay..... 12.68	1.292	12.531	.376	14.199	1:10.3	.1466	.0792	.2258	11 A
Alfalfa hay..... 8.50	1.655	8.721	.408	10.784	1: 5.8	.0870	.0425	.1295	12
Prairie hay..... 12.05	1.330	9.975	.538	11.843	1: 8.4	.0916	.0753	.1669	15
Prairie hay..... 11.65	1.239	9.455	.502	11.196	1: 8.5	.1208	.0728	.1936	18

SOME FUNDAMENTAL PRINCIPLES OF FEEDING.

Feeds supply materials for growth, fat, the repair of waste and are the source of heat and energy. Only the digestible portions of the food are available for these purposes. The nutrients necessary are protein, carbohydrates, fat and ash. A definite amount of each of these nutrients is required to insure the maintenance and upbuilding of the animal body, a shortage or an excess of anyone resulting in an unbalanced ration and waste, both actual and potential. Too often the wrong concentrate is used, because its composition is not known, or the functions of the nutrients it contains are not clearly understood. It is well, therefore, to note carefully just what part each of these nutrients plays.

1. Protein substances are those which contain the element nitrogen. Carbohydrates and fat contain no nitrogen and are spoken of as non-nitrogenous nutrients. Protein substances are flesh-builders. They nourish the muscles and enter largely into the composition of the skin, tendons, blood, nervous system, hair, internal organs, and fetus. Protein may also furnish muscular energy when occasion requires, and some material for the production of heat. It is held by many to be a stimulant to muscular and functional activities in general, and may form body fat. It is also an appetizer. As no substance that does not contain nitrogen can be substituted for or converted into protein, the absolute necessity for a certain amount of protein-furnishing material in a horse's ration is evident. Such feeds as cottonseed meal, linseed oil meal, peas, bran, shorts, and alfalfa, clover, and cowpea hay contain comparatively high proportions of digestible protein.

2. Carbohydrates furnish much of the energy for the production of heat and work by an animal, and are obtained from the various feeds in the form of starch, sugar, and cellulose (fiber). They are converted principally into glycogen, a carbohydrate resembling starch, which is stored in the liver and muscular tissues of the animal. When this glycogen is needed it is converted into a glucose, which is soluble, and passes into the blood. Some of the carbohydrates may be converted into fat and some may be burned to supply heat or muscular energy. Corn, barley, oats, wheat, kafir and the various hays and fodders contain high proportions of digestible carbohydrates,

3. Fat is found in the various feeds in smaller amounts than either protein or carbohydrates. It is either stored up in the body as fat or burned to furnish heat and energy. Cottonseed meal and linseed oil meal are rich in fat, the former containing about three times as much digestible fat as corn.

It is seen, therefore that heat and muscular energy may be produced from carbohydrates, fats, and to a limited extent from protein substances. One pound of digestible fat is worth about 2.24 times as much as 1 pound of digestible protein or 1 pound of digestible carbohydrates in the production of heat and muscular energy. Fat in the body is produced from the fat and the carbohydrates of the food eaten, and to a certain extent from the protein.

4. Ash is also a necessary constituent of a satisfactory ration. It is the residue after the combustible portion of feedstuffs has been burned in the body. It consists chiefly of lime, phosphorus, iron, potash, magnesia, soda, sulphur, etc., and is found principally in the bones, though in small quantities in other tissues of the body. A considerable supply of ash is found in all coarse feedstuffs; hence this constituent does not cause so much concern as do protein, carbohydrates, and fat. In a ration consisting principally of grain it may be necessary to give attention to insuring a supply of ash.

TABLE VII. Digestible nutrient values used in figuring results.

	Total dry matter.	Total ash.	Digestible crude protein.	Digestible carbohydrates.	Digestible fat.
Corn (Dent)	89.4%	1.5%	7.8%	66.8%	4.3%
Oats	89.6	3.2	10.7	50.3	3.8
Barley	89.2	2.5	8.4	65.3	1.6
Bran	88.1	5.8	11.9	42	2.5
Alfalfa meal or hay	93.2	10.6	11.1	39.1	.6
Linseed oil meal (O. P.)	90.2	5.5	30.2	32	6.9
Prairie hay	90.8	7.8	3	42.9	1.6
Timothy hay	86.8	4.4	2.8	42.4	1.3
Barley hay	85	4.2	5.7	43.6	1
Wild-oat hay	85.7	3.8	2.9	48.7	1.7
Oat hay	86	5.7	4.7	36.7	1.7
Wheat hay (Club)	91.2		3.6	46.1	1.1

Table VII shows that linseed oil meal, alfalfa and oats are rich in protein; corn, barley, oats and bran in carbohydrates; linseed oil meal, corn, oats and bran in fat; and that prairie, timothy and small-grain hays are relatively richer in carbohydrates than in protein or fats.

TABLE VIII. Average equivalents in quarts of one pound of each of the more common grains.

One pound of corn equals	0.6 quarts (approximately).
One pound of oats equals	1 quart (approximately).
One pound of barley equals	0.7 quart (approximately).
One pound of bran equals	2 quarts (approximately).
One pound of alfalfa meal equals	2 quarts (approximately).
One pound of linseed oil meal equals	0.5 quarts (approximately).

CONCLUSIONS.

1. Corn is a satisfactory substitute for oats for work horses during the winter months; but is not a satisfactory substitute during the winter months when both are fed with prairie or timothy hay.

2. Corn is a satisfactory substitute for oats for work horses both winter and summer when fed with alfalfa hay.

3. A mixture of corn, bran and linseed oil meal in the proportion of 6:3:1 by weight is a satisfactory substitute for oats for work horses when both are fed with timothy or prairie hay. This mixture is also cheaper than oats.

4. Ten pounds of alfalfa hay a day for each thousand pounds of live weight is approximately the proper amount for work horses.

5. Alfalfa hay is a satisfactory substitute for prairie hay for work horses when fed in limited amounts, and cheapens the ration.

6. A nutritive ratio of about 1:8 is most satisfactory when the roughage consists of timothy or prairie hay. A nutritive ratio of 1:6 is quite satisfactory when the roughage consists mostly of alfalfa, hay.

7. No digestive disturbances could be attributed to any ration fed in this experiment.

8. The horses fed bran, linseed oil meal and alfalfa hay showed the greatest thrift and best coats of hair.

9. The horses fed oats did not show any more spirit than those receiving corn.