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ALFALFA:

ITS GROWTH, COMPOSITION, DIGESTIBILITY, Etc.

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The Agricultural Experiment Station.

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ALFALFA.

The perennial plant known and called alfalfa by the Spanish, and by the French, lucerne, has been grown extensively and for many years in the Southwest under the name of Chilian, or California clover.

Its botanical name, *Medicago sativa*, from the Greek, *Medike*, is derived from that language, meaning fodder plant. It was known by the Greeks and Romans 2,300 years ago, and was used as a forage long before the Christian era.

Columella, Virgil and Cato speak of it in their writings. When the Roman Empire flourished it furnished food for the war horse. Grecian cattle cropped it upon the hillsides, and the Spanish cavalier fed his horse upon it. The Romans brought it from Media 470 B. C., hence its generic name.

It was introduced into Mexico in the time of the Conquest; thence into South America, and from Chili into California in 1854, where it has been grown more successfully and in greater quantities than elsewhere. It found its way into Colorado early in the sixties, having been raised for the first time in the State in the Platte valley, near Denver.

It flourishes at all altitudes below 7,000 feet, and in all soils that will produce other good crops. Sandy and clay loams are best adapted to its habits. Soils underlaid with shale, or hard pan, are not conducive to its successful growth, inasmuch as the roots of the plant must penetrate the sub-soil until they find moisture. Where surface drainage is good, and the land not too wet or too alkaline, it readily secures a stand, and the first season makes a crop of one or two tons per acre—often without an irrigation in this arid climate.

It is the most tenacious of all forage plants, enduring more harsh treatment, more dry weather, heat and cold, after making a stand, than any of the others. It is, indeed, "a child of the sun," defying the hottest suns, the driest soils and the greatest variations of temperature—in fact, it keeps fresh and green while all other plants dry up and die around it.

Its growth is exceedingly rapid. In some soils and under certain conditions it makes a growth of thirty to forty-five inches a month, and in some localities a cutting every month in the summer season. The first cutting is ready about the middle of June—just before blooming—and is considered the best for working teams, inasmuch as it contains more fattening elements, and hence is a stronger food. The second crop is cut in July, and the third in September, and if the fourth is cut, it is ready in October. The second crop, and particularly the third, is better for milch cows, and animals that do not work, inasmuch as it is more succulent, contains fewer coarse stems and is more easily masticated.

The feeding value, as seen in the tables given, is clearly demonstrated in practical stock feeding. No other clover, grass or forage plant compares with it, or contains a greater per cent. of protein substances.

Horses grow fat on it alone; cattle make fat, flesh and milk; sheep thrive and are perfectly healthy when fed on it, and even hogs, when pastured on it, need no other food.

The preparation of the soil for sowing alfalfa is about the same as for clover, turnips, or other small seeds; if quite moist, good stands are secured on the raw sod merely by harrowing, or drilling the seed. The condition of the soil is everything, in rapid and successful germination. Being a rapid grower, and very succulent, it requires a large amount of moisture to start it successfully and keep it growing until well rooted, as when once rooted it is safe.

The amount of seed per acre necessary to secure a good stand for hay, is twenty to twenty-five pounds; for seed, twelve to sixteen pounds are sufficient. As the plant bears its seeds so differently from red clover, thick seeding is detrimental to the propagation of a large yield on account of its growing not on the top like red clover, but upon the entire plant, from bottom to top. For hay, the seed on sandy soil should be sown alone; on cloddy, clayey soils, wheat, oats or barley in small quantity can be sown with it for shade. Timothy and orchard grass, when sown with alfalfa, serve to keep it from lodging, and when in sufficient quantities, they become a preventive of hoven in the feeding and pasturing of cattle and sheep. The seed should be sown with a drill, as it is much more evenly and uniformly distributed, and after drilling, a light harrowing crosswise assists in an even stand, and hastens germination. The time to sow depends very much on the soil and climate. So soon as all fear of frost is gone and the soil is moist and warm, sow—about April 20 to May 10. Even earlier sowing has proved very successful in some soils and seasons, especially where it is done in old wheat or oat stubble, without previous preparation.

CUTTING AND CURING.

Alfalfa should be cut just before blooming, somewhat earlier than red clover. At that stage of its growth the plant contains the greatest amount of valuable feeding substances.

When slightly wilted it should be raked into winrows, and then put into small cocks to be cured. If left to cure before raking, the stems become hard and dry, the leaves drop off, the color is lost, and much of the hay is rendered unfit for feed. Curing is the most important operation of all in making alfalfa hay.

IRRIGATION.

On the low land, where the roots have access to moisture continually, alfalfa needs little or no irigation. When water is applied, it should be done before cutting, for two two reasons—it stimulates the growth of the next crop, and in the cutting the mower does its work much better and more effectively, the stems being more pliable and easily cut.

In the experience of many farmers, alfalfa is the best renovator and the best green crop for fertilizing soils of any thus far tried. It not only kills all noxious weeds, but puts into the soil in quantities manurial elements found to be invaluable to the growth of any crop. Many experiments among farmers, but not at the Experiment Station, have proved it to be fifty per cent. better than red clover. The roots being very large and long, not only enrich, but make the soil porous and well suited, not only to its own growth, but the growth of any other plant.

Just why alfalfa has, when fed green or wet, a greater tendency to bloat cattle and sheep than other forage, has not yet been fully or satisfactorily explained. Whether it is due to the alkali of the soil absorbed by the plant, or to its very succulent growth, or to its quality, remains yet to be demonstrated. It is a fact that it is a dangerous pasture for cattle and sheep, unless the weather is very dry, or unless the stock are first fed with dry feed before being driven upon it.

ALFALFA PARASITES.

The dodder (*Cuscuta*) are annual, leafless, climbing plants that twine around the plant destined to be the foster parent, and into the structure of which they send out aerial sucker-like roots at the points of contact, and through these imbibe the sap of the host plant.

The stems of the dodder are orange or reddish colored, and consist of small, fleshy tendrils twisted around a branch. At the base of the flowers and at the joints of the stems may be found minute scales. These are rudimentary leaves; but the plant in its present stage of development has no need of green leaves, as it finds its food already prepared in the host plant.

The flowers appear in clusters around the stem, which very soon form fruit; the latter consists of four seeds, which do not split into lobes, but open and put forth a little spiral body, which is the embryo. The seeds are destitute of cotyledons, and so are dependent for their development, for a short time, on the albumen stored up in the seed. The number of flowers in each cluster ranges from ten to twenty, and the seeds are of a pale gray color, difficult to detect with the naked eye, and hence the rapid spread of the plant.

When the seed falls to the ground, it usually remains dormant until the following spring—sometimes, however, it germinates the same season, if the conditions are favorable.

With the return of spring, the embryo begins growth by sending one end into the soil, and with the other it sends up a stem turning from right to left, or contrary to the sun's apparent motion. Up to this stage its growth is like that of any ordinary plant, but its existence is brief, if no friendly stem be within reach. If it touch some living branch or stem, it seizes it by means of sucker-like roots, which it at once throws out, and then it goes on twining and fastening itself to the foster plant and to other plants in its vicinity.

It now ceases to have any connection with the soil, and is a true parasite, feeding on the juices of the plant it has seized upon.

The dodder will obtain a foothold upon any plant whose stem is not too large for it to encircle, but it is particularly injurious to clover, alfalfa and hops. They are natives of the temperate regions of both hemispheres, and the seeds possess acrid and purgative properties.

In this region, where seeds rarely perish from untoward conditions, the dodders may become an enemy to the growth of the plants mentioned.

As it is an annual, however, it can be destroyed before it has seeded, which may be done by cutting the infected portion of the crop close to the ground and then burning it.

But this would have to be done thoroughly, as, in the case of alfalfa, the dodder flowers quite close to the ground, where it cannot easily be seen, and a few seeds remaining continues the plant another year.

It is, however, much easier to prevent its introduction than to get rid of it; for, when such a plant has obtained a foothold, it has been shown to be extremely difficult to exterminate, or to keep in check.

Alfalfa seeds are about two lines long and about one and one-fourth broad, while dodder seeds are little more than half the size.

If clover and alfalfa seeds are well sifted through a seive of proper size, the dodder will be readily separated. If crops are to be free from the dodder pests, the farmer must see to it that the seed for the crop is clean.

Our native flora is said to embrace six species and one variety. The species parasitic on alfalfa in this vicinity are *Cuscuta epilinus*, the flax dodder (introduced), and *Cuscuta Gronovii*, a species abundant in wet, shady places from the Rocky Mountains to the Atlantic States, and also parasitic on *Ambrosia trifida* and other compositæ.

CHEMICAL SECTION.

The question of the composition and digestibility of alfalfa, the chief forage crop of Colorado, has, from time to time, engaged the attention of the agricultural press, and the leading farmers of this region; in addition to this, the proper time to cut alfalfa in order to secure the greatest amount of nutriment, has never been definitely settled where the plant was grown under irrigation; in order to answer these questions satisfactorily, alfalfa was cut at four different periods of *growth* and *maturity*, viz.: When,

1. Beginning to bud.
2. In full bloom.
3. When bloom was half ripened.
4. When seed was fully ripe.

The samples were cut, immediately weighed, and dried on canvas in the open air on the barn floor to a constant weight.

The amount of water lost was approximately 50 to 78 per cent. in the different periods, and the exact quantity for each is noted in the column of remarks in the table. The water named in the column headed "water," in the table, is the amount of moisture driven off when the substance was heated in an air bath to 100° C. The samples from the San Luis Station were from the farm of Mr. David Best, near Del Norte, Colorado, while those from Bent Station were from the farms of several persons near Rocky Ford, Colorado.

The analyses were made in duplicate, and the method pursued was that adopted by the Association of Official Agricultural Chemists in convention at Washington, D. C., August 9-10, 1888.

EXPLANATION OF THE ANALYSES OF FEEDING STUFFS.

Water—The amount of water in forage plants is constantly changing with the temperature and the dryness of the air to which it is exposed, and no just comparison of samples can be made unless the amount of water be known. The water is expelled by heating a weighed quantity in the air bath at 100° C. until the weight is constant—the loss is water. A refinement of this method is to dry the sample in a stream of hydrogen gas until no further loss occurs.

Ash—Ash is what is left after the combustible matters of the analysis in question are burned away, at a low red heat; there is usually a little charcoal and also some sand that has been washed or blown upon the plants; these are sometimes called accidental inpurities.

Fat, or Crude Fat—Includes everything which can be extracted from the feeding stuff by absolute ether; in this list is commonly included chlorophyll (the green coloring matter of plants) fat, wax and fat oil.

Albuminoid Nitrogen (Protein)—This includes all those nitrogenous substances which resemble white of egg, flesh, fibrin, milk casein (curd). The amount of nitrogen found is multiplied by 6.25; this number is based upon the fact that albuminoids contain about 16 per cent of pure nitrogen; this is but an approximation, but it is sufficiently accurate for practical purposes and is the number generally agreed upon; it is well known that nitrogen is found in other combinations than albuminoids, viz., in amides, alkaloids, nitrates, etc., but in these it is usually in small proportion, and does not materially influence the result.

Crude Fiber, or Cellulose—Is the essential part of the walls of vegetable cells. It is in quite a pure state in cotton fiber; it is quite insoluble, and remains as a residue when the feeding stuff has been treated with acid and alkali.

There is another constituent called carbohydrate or nitrogen free extract, and it includes such bodies as gum, starch, sugar, etc. These are extracted by water or dilute acids, but they are always indirectly determined by subtracting the sum of ash, fat, albuminoids and crude fiber from the total dry matter.

We are now prepared to consider the table containing the results of the analyses of alfalfa, clover, grass and wheat bran conducted in the Colorado Experiment Station laboratory:

TABLE OF ANALYSES.

No.	Substance.	Where Grown.	When Cut.	Water.	Ash.	Fat.	Albuminoid Nitrogen.	Crude Fiber.	Nitrogen, Free Extract.	REMARKS.
1	Alfalfa	College Farm	June 4, 1888	8.11	11.62	3.61	18.19	12.88	45.59	Beginning to bud; 77.65 per cent. of water.
2	Alfalfa	College Farm	June 20, 1888	9.37	11.68	3.34	15.22	14.65	45.74	Full bloom; 69.71 per cent. water.
3	Alfalfa	College Farm	July 13,1888	9.59	11.90	3.85	12.87	18.01	43.78	Bloom half turned; 60.89 per cent. water.
4	Alfalfa	College Farm	Sept. 11, 1888	8.56	8.43	3.92	11.67	20.23	47.18	Fully ripened seed; 49.30 per cent. water.
5	Alfalfa	College Farm	....	8.50	7.46	2.85	15.17	22.06	43.96	From bay in College barn.
6	Alfalfa	Bent Station	Third Crop	9.91	10.35	2.68	19.79	16.72	40.55	Twenty-six days from previous cutting; without irrigation.
7	Grass	Bent Station	Ripe	8.80	9.20	1.70	3.82	21.81	54.67	Bouteloua racemosa.
8	Alfalfa	Bent Station	Sept. 25, 1888	8.77	7.23	3.84	11.20	22.32	46.64	Cut for seed.
9	Alfalfa	San Luis Station	Third Crop	6.62	8.47	2.25	11.50	24.59	46.57	Very coarse.
10	Wheat Bran	Fort Collins	....	9.39	4.84	5.35	16.60	4.10	59.72	Bran and shorts, sold as bran, from Harmony Mills
11	Alfalfa	San Luis Station	July 15,1888	9.31	10.20	2.30	10.55	14.00	53.64	Irrigated one week after first cutting; in bloom; 1½ tons per acre.
12	Alfalfa	San Luis Station	June 6, 1888	8.46	9.02	2.63	12.35	19.18	48.36	Adobe land, no irrigation; yield 2½ tons per acre.
13	Alfalfa	Bent Station	July 25,1888	8.33	7.32	1.81	11.33	22.90	48.31	Irrigated June 1 and July 15, 1888; yield, 2 tons per acre.
14	Alfalfa	Bent Station	July 25,1888	9.12	7.75	2.59	10.27	21.90	48.37	Irrigated May, 1888; yield, 2 tons per acre.
15	Alfalfa	College Farm	Second Crop	9.75	7.87	2.35	11.64	19.92	48.47	From bay, College barn.
16	Red Clover	College Farm	Second Crop	8.64	7.28	3.51	10.32	18.04	52.21	From bay, College barn.

In addition to the determinations above noted, the ash of specimen No. 1 was analyzed, showing the following composition:

Silica ($Si O 2$)	47.33
Carbon (C)	.57
Sulphuric acid ($S O3$)	4.38
Iron oxide ($Fe2 O3$)	1.37
Chlorine ($C1$)	4.00
Magnesium oxide ($Mg O$)	4.15
Calcium oxide ($Ca O$)	16.18
Phosphoric acid ($P2 O5$)	7.15
Potassium oxide ($K2 O$)	14.25
Sodium oxide ($Na2 O$)	.25
	99.98

The proportion of ash ingredients in the plant is varible within a limited range, such variation being due to various circumstances, as the green or ripened condition of growth, the different parts of the plant taken, the soil on which the plant has been grown, the species of plant and its treatment in culture.

The question is often asked, at what period of its growth should grass be cut for hay? The albuminoids being the most desirable part of the plant, the greater the per cent. of albuminoids, other things being equal, the more nutritious the grass.

A glance at the table will show that the albuminoids *decrease* as the grass matures, but on the other hand, it will be seen that the amount of dry hay increases with the age; it will be noticed, too, that the crude fiber increases with the age of the plant. The analyses show that about the time of bloom, or a little later, is the most economical time to cut grass for hay. That alfalfa is no exception to the rule, is shown by numerous analyses of forage plants made by the Department of Agriculture, one of which has been selected by way of comparison with alfalfa:

Phleum Pratense. (Timothy.)	Ash.	Fat.	Albuminoids.	Crude Fiber.	Nitrogen, Free Extract.
Head not out	7.94	1.97	10.97	29.19	49.93
Before Bloom	7.64	2.27	7.80	29.65	52.64
In Bloom	7 05	2.18	5.52	32.26	52.99
After Bloom	6.63	2.55	5.57	31.32	53.93
Early Seed	5.95	3.74	4.84	24.70	60.77

We can now take up the comparison of alfalfa with other grasses. This part of the work is necessarily incomplete, as but few comparisons are made. A full comparison of alfalfa with other forage plants and food stuffs involves a consideration of two factors—the yield per acre and the ease with which each can be cultivated.

In the first place, alfalfa stands pre-eminent, as, with its three and often four cuttings, it is an easy task to average five or six tons per acre over large areas. Much larger yields have been realized in exceptional cases. In the second place, alfalfa is an easy plant to cultivate when once started, and even in the beginning, is not more difficult to start than other small-seeded plants, as red clover and the grasses. When a good stand has been secured, with any ordinary care, it does not kill by freezing or other hardship, provided irrigated in fall and reasonably early in the spring. This being the case, all can see what an advantage alfalfa has over other forage plants in the arid region. This does not argue for its exclusive cultivation, for other forage plants, as millets, corn, should supplement alfalfa, the main support in mixed farming.

DIGESTIBILITY.

In connection with the chemical analysis of the alfalfa, the following feeding experiment was tried to test its digestibility.

Two steers were selected. No. 1 was a seven-eighths Shorthorn, and was 30 months old, and weighed 1,050 pounds. No. 2 was one-half Devon, and was 23 months old, and weighed 1,075 pounds. The animals were healthy and in good condition; they were fed two weeks on the alfalfa before the experiment was begun, the object being to clear the digestive canal of previous food. During the experiment they were kept in stalls in the basement of the barn, and were taken out once a day to be weighed; they were watered and fed alfalfa three times a day, eight pounds at each feed. One day the feed of alfalfa was increased to nine pounds, but, as the animals showed signs of bloating, it was reduced to eight pounds. The dung and urine for twenty-four hours were weighed at noon each day, also the steers before they were watered or fed. A harness was provided for the animals, to which rubber bags were attached to collect the dung and urine; the animals were watched day and night to see that all the excrements were saved as soon as voided, and placed in suitable vessels to receive them. An accident occurred with No. 1, causing two days' results to be rejected.

The refuse hay was carefully collected after each feed, and each day's refuse kept by itself. The dung, urine, refuse hay and water were weighed to a half ounce; the animals to a pound. One-tenth part of all the dung and urine was saved in large salt-mouth, glass-stoppered bottles that were air tight; one-tenth part of this was carefully sampled and analyzed, by the method before described for alfalfa. Kjeldahl's method was used for the urine, in the manner recommended by the nitrogen committee, Bulletin No. 19, for the determination of nitrogen; a comparison was also made by the Knop Hufner method.

The following table of ingesta and excreta by days, shows the general course of the experiment, with daily results:

TABLE.

Day.	NO. 1.				NO. 2.			
	Water.	Urine.	Dung.	Loss.	Water.	Urine.	Dung.	Loss.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
1	75 12	23 8½	54 9½	35 14½	65 ..	27 ..	41 13	24 15½
2	95 8	24 ..	51 1½	34 ½	69 8	22 6	58 8	22 3
3	93 12	23 15½	54 2	19 6	90 8	22 6	50 8½	11 6
4	73 ..	25 7	58 2	28 ..	69 4	26 9	48 6½	22 13½
5	99 ..	27 4½	58 5½	21 15	92 12	25 3½	49 11½	36 9½
6	91 8	24 9	44 6½	40 15½	73 12	27 3½	48 1	22 5
7	accid'nt	accid'nt	accid'nt	accid'nt	95 8	28 15	48 12	33 8½
8	94 8	27 1	53 10½	32 8½	86 ..	24 14½	50 ..	24 15½
9	106 4	28 4½	51 2½	35 7	69 4	25 3	53 4½	29 10½
10	79 4	28 ½	58 6½	31 8½	81 ..	27 7	46 8½	15 14½
11	99 12	27 12	60 10	25 2½	81 8	29 12	46 12½	28 14
12	90 12	29 9	56 14½	33 ½	82 4	27 4	47 1½	21 13
13	accid'nt	accid'nt	accid'nt	accid'nt	82 4	25 15½	45 14	34 2½
14	95 4	30 5	57 15½	25 13½	92 12	29 3½	49 1½	28 4
15	95 12	26 1	51 8	37 ½	70 8	27 ..	45 13½	36 6½
AV	91 9	26 9	54 10	30 13	80 2	26 10	49 5	26 15

The original weight, ...	1,050 lbs.
Ate hay in 24 hours, ...	24 lbs.
Drank water, 24 hours, . .	75 lbs., 12 oz.
Total, ...	1,149 lbs., 12 oz.
Refuse hay for that day, . .	11½ oz.
Total, ...	1,149 lbs., ½ oz.

The dung weighed, ...	54 lbs., 9½ oz.
The urine weighed, ...	23 lbs., 8½ oz.
The animal weighed, ...	1,035 lbs.
Total, ...	1,135 lbs., 2 oz.

The animal, food and water weighed, ...	1,149 lbs.,	½ oz.
The animal and excrements weighed	1,113 lbs.,	2 oz.
Loss, ...	35 lbs.,	14½ oz.

Prof. Carpenter kindly furnished me with the relative humidity of the atmosphere during the experiment, and his table shows that there is no connection between this loss and the humidity of the atmosphere; so this loss must have passed off through the skin and lungs. I have not been able to obtain any information of this loss in the ox. In the human subject there are recorded many instances. Flint's Human Physiology, 1876, page 153. Valentin's Experiment gives one and one-fifth pounds as a daily exhalation from the lungs. Valentin found that the pulmonary transpiration was more than doubled in a man immediately after drinking a large quantity of water. Landois and Sterling, Human Physiology, 1885, Vol. 1., page 255. "The expired air is saturated with watery vapor," page 264. "A healthy man loses by the skin in twenty-four hours, one sixty-seventh of his body weight (Seguin), which is greater than the loss by the lungs in the ratio of three to two." (Valentin, 1843).

Chemistry of Common Life, Johnston, 1880, page 501: "The quantity of water which is thrown out into the air from the lungs of a healthy man is very variable. It is modified by season and climate, by individual constitution and state of health, by the amount of exercise taken, by the quality of the food, by the quantity of liquid consumed, and by a variety of other circumstances. Generally speaking, however, the quantity given off by the lungs and skin together, is equal to about one-third of the weight of the whole food, solid and liquid, which is taken into the stomach. Now, the skin alone of a full-grown man exhales in twenty-four hours, in ordinary circumstances, from one and one-half to two pounds of water in the state of insensible perspiration. The difference between the weight and that of one-third of the whole food, solid and liquid, represents the quantity of water daily discharged from the lungs.' It is not far from the truth to say that for every one and one-half pounds discharged from the skin, about one pound is given off from the lungs." Those desirous of pursuing the subject further, can consult Ziemssen on Skin Diseases, page 67; Pepper, Practice of Medicine, Vol. 4, page 436; Tidy's Legal Medicine, Vol. 2, page 197; Storer's Agriculture, Vol. 1, pages 481-489; Armsby's Manual of Cattle Feeding, pages 198, 206, 234, 239; Foster's Physiology, page 606.

While we cannot compare the human subject with the domestic animals, it is reasonable to infer that the causes that influence one will influence the other. Selecting the average, it will be seen that the loss is about one-third of the water drank; that the amount of urine voided was practically the same, while the dung of No. 1 was 54 pounds, 10 ounces, it contained 82.9 per cent. of moisture, or 17.1 per cent. of dry matter; while the dung of No. 2 was 49 pounds, 5 ounces, it contained 81.7 per cent. of moisture, or 18.3 per cent. of dry matter.

The dry dung of No 1 was 43.2 per cent. of the hay eaten, while the dry dung of No. 2 was 41.8 per cent. of the hay eaten. The increased gain of 15 pounds of No. 2 over No. 1 was due, as shown by the above figures, to No. 2 being a better feeder, he having digested 1.4 per cent. more of the dry substance of the alfalfa and assimilated it. The refuse hay, which amounted to but a few ounces a day, was taken into account in the above calculation. The urine when analyzed was slightly alkaline in both cases, and had the same specific gravity, 1040.

URINE ANALYSIS.

	No. 1.	No 2.
Water,	923	926
Solids,	77	74
Ash,	25	27
Organic matter,	52	47
Alkalies,	17.2	15.05
Calcium and Magnesium,	2	2
Sulphuric acid,	2	1.9
Silica,	Traces	Traces.

There was no phosphoric acid in the urine. The nitrogen in the urine of both animals was the same, 8.6 parts in 1,000, equal to 1.85 per cent. of urea.

The total solids of dry dung was 4½ times as much as the solids of the urine.

The amount of water drank was, in the case of No. 1, 3.81 times the hay eaten; in the case of No. 2, 3.33 times.

The live weight includes the food eaten, the dung, urine, etc.

When the stomach alone will hold 100 to 150 pounds of water, and the excretion of the dung and urine is more or less irregular, we may expect a variation of from twenty to fifty pounds a day. In the experiment this was obviated, as much as possible, by weighing the dung and urine at noon and the animals at the same time, before they were fed or watered.

The following table gives the live weight and refuse hay each day:

Day.	NO. 1.		NO. 2.	
	Live Weight. Lbs.	Refuse Hay. Ozs.	Live Weight. Lbs.	Refuse Hay. Ozs.
1	1,035	11½	1,070	3½
2	1,045	6	1,060	6½
3	1,065	4½	1,090	3½
4	1,050	7	1,085	7
5	1,065	7	1,090	3½
6	1,070	9	1,090	2½
7	Accident		1,100	4½
8	1,065	4	1,105	3
9	1,080	6	1,090	2
10	1,065	4½	1,105	2
11	1,075	3½	1,105	1½
12	1,070	4	1,115	1½
13	Accident		1,115	4
14	1,065	2	1,125	3
15	1,070	2½	1,110	4
	Original Weight, 1,050 lbs.		Original Weight, 1,075 lbs.	

It will be noticed that it was the third day before the animals came back to, or exceeded, the original weight; this may be due to the animals taking some little time to get accustomed to the rubber bags and harness attachment to hold them in place, and to the excitement it would naturally cause. The average refuse hay of No. 1 was 5 6-13 ounces a day, and was about 1-77 of the hay fed. The average refuse hay of No. 2 was 3 7-15 ounces a day, and was about 1-128 of the hay fed. The ether extract of dung of No. 1 was colorless, containing no chlorophyll, while the ether extract of No. 2 was distinctly green.

The ash of the dung was as follows:

	No. 1.	No. 2.
Sand and Silica (Si O2)	14.70	15.40
Carbon (C)	1.28	.83
Iron and Alumina oxides	6.48	6.01
Lime (Ca O)	34.75	36.00
Magnesia (Mg O)	7.04	7.03
Sulphuric acid (S O3)	6.99	6.38
Chlorine (C1)	9.44	9.54
Phosphoric acid (P 205)	6.77	6.38
Alkalies	12.50	12.46
	99.95	100.03

The analysis of the dung was as follows:

DUNG ANALYSIS.

	Water.	Dry Matter.	Ash.	Ether Extract.	Crude Fiber.	Albuminoid Nitrogen.	Nitrogen Free Extract.
No. 1	82.9	17.1	12.4	.99	22.47	7.05	57.09
No. 2	81.7	18.3	12.23	1.04	21.95	7.31	57.49

The ash of the moist dung of No. 1 was 2.11 per cent.; of No. 2, was 2.23 per cent. of the whole.

The analysis of the refuse hay was as follows:

REFUSE HAY ANALYSIS.

	Water.	Dry Matter.	Ash.	Ether Extract.	Crude Fiber.	Albuminoid Nitrogen.	Nitrogen Free Extract.
No. 1.......	7.37	92.63	6.54	1.71	23.6	8.13	60.02
No. 2.......	7.14	92.86	6.85	1.77	28.6	8.52	54.26

The ash of the dung is about double that of the refuse hay. The alfalfa fed was the second crop, and the chemical analysis shows that it was too ripe when cut; alfalfa cut earlier would show better results as to its feeding qualities. It took, in the case of No. 1, 18 pounds of hay to make one pound of increase of live weight; in the case of No. 2, it took 10⅓ pounds, or an average of both animals of 14 pounds.

By way of illustration, the digestibility of the crude fiber is worked out for No. 1 for the 13 days:

No. 1 ate 312 pounds of hay; it contained 9.75 per cent. of moisture; equals 281.58 pounds of dry hay; this hay contained 19.92 per cent. of crude fiber=56.09 pounds of crude fiber. The refuse hay was 5 6-13 ounces a day=4.43 pounds. This refuse hay contained 23.6 per cent. of crude fiber=1.04 pounds. Subtracting this from 50.09 pounds, leaves 49.05 pounds of crude fiber the animal ate. The dung averaged 54.625 pounds a day, or 710.125 pounds; it contained 17.1 per cent. of dry dung =121.43 pounds; this contained 22.47 per cent. of crude fiber=27.28 pounds of crude fiber; subtracting this from the amount of crude fiber in the hay, leaves (49.05–27.28) =21.77 pounds digested by the animal, or, expressed in per cent., equals 44.3 per cent.

In a similar way, all the other ingredients were worked out.

A few words might be said as to the chemical changes that take place in the digestive tract of the animal.

The digestion takes place in the alimentary canal, consisting of the mouth, gullet, stomach, small and large intestines. The mouth secretes saliva and a ferment known as ptyalin, which changes the starch to some form of sugar. The stomach of ruminants consists of four compartments; the partially chewed mass passes into the largest division, called the paunch, and partly into the second stomach, or recticulum; here the food remains for a time, acted upon by the fluids of the stomach; the dissolved portion passes through the other divisions of the stomach; when swallowed the second time, it goes into the first and second stomach, and into the third stomach, omasum, or manifolds. From the third stomach it passes to the fourth stomach, abomasum, or rennet, there to undergo the ordinary process of digestion. The gastric juice and pepsin change the albuminoids into a soluble form called peptones, and the mass into chyme, which can be absorbed more or less into the circulation. We have traced it into the intestines, which in the ox is nearly 20 times as long as the body. The chief digestive fluids are the bile, which acts upon the fat; and the pancreatic juice, which has three ferments—diastase, which converts the starch into sugar; trypsin, which acts upon the albuminoids, and a ferment which separates fats into glycerin and fatty acids. By the action of these various digestive fluids, the chyme is converted into chyle, or, in plainer language, the process of digestion is essentially a process of solution, the soluble portion being assimilated by the animal, and the waste portion excreted as dung. It is rarely possible to have a complete digestion of all the nutrients of the food, portions nearly always escaping digestion, especially when a rich food is given, or when we strive for large or rapid production of organic substances, such as milk. This has given rise to the old adage, "the richer the food, the better the manure." Some have thought that the fat, fiber and nitrogen free extract, act as the fuel acts to the steam engine; that the albuminoids, acting as the materials of construction and repair, can be easily made over by the animal into its own substance. The fiber, from its very composition, cannot restore the waste of the animal It has been found that there is a certain relation between the albuminoids, fat, fiber and nitrogen free extract, which is the best and most economical; this is known as the nutrient ratio.

It is found that only a certain per cent. of the fat, crude fiber, albuminoids, etc., is assimilated by the animals, the rest passing off as dung. The per cent. assimilated is called the digestion coefficient. I have selected from various sources the digestibility of some grasses, etc., by way of comparison with the alfalfa.

DIGESTIBILITY OF FEEDING STUFFS. (DIGESTION COEFFICIENT).

	Albuminoids.	Crude Fat.	Fiber.	Nitrogen Free Extract.
Alfalfa (experiment),	.77	.54	.49	.64
Wheat Bran,	.78	.69	.33	.77
Clover hay (good),	.62	.60	.47	.70
Clover hay (medium),	.55	.51	.45	.65
Pasture clover (very young),	.78	.64	.67	.78
Alfalfa, before blossoming, and in flower,	.74	.39	.43	.67
Potatoes,	.65		.55	.93
Oats,	.77	.82	.17	.74
Corn,	.79	.85	.62	.91

The table can be best illustrated by means of an example. Suppose you wish to know how much digestible food is contained in a ton of wheat bran. By referring to the table (No. 10), wheat bran contains:

Dry matter, ...	90.61
Albuminoids, ...	16.60
Fat, ...	5.35
Nitrogen free extract, ...	59.72
Fiber, ...	4.10
Ash, ...	4.84

And from the table of digestibility of feeding stuffs, we find in wheat bran, that

78 per cent. of albuminoids,
69 per cent. of fat,
33 per cent. of fiber,
77 per cent. of nitrogen free extract,

are digestible by oxen. Multiplying the amounts of the different constituents by the digestion coefficients, gives the actual amounts of digestible matter.

Digestible fiber, ...	4.10x.33= 1.353 lbs.
Digestible nitrogen free extract, .	59.72x.77=45.984 lbs.
Digestible albuminoids, ...	16.60x.78=12.948 lbs.
Digestible fat, ...	5.35x.69= 3.691 lbs.

If it is desired to estimate the amount per ton (2,000 lbs.), we have simply to multiply these numbers by 20.

To determine the nutritive ratio in any feeding stuff, add together the amounts of digestible fiber and nitrogen free extract and the amount of digestible fat multiplied by $2\frac{1}{2}$, and divide the sum by the amount of digestible albuminoids. This can be illustrated by the nutritive value of the wheat bran in question:

Digestible fiber, ...	1.35
Digestible fat (3.69x$2\frac{1}{2}$), ...	9.22
Digestible nitrogen free extract, . . .	45.98
	56.55

56.55 divided by 12.94 (digestible albuminoid)=4.37.

Or, the nutritive value of wheat bran is 1 : 4.37. The nutritive ratio of the alfalfa in the feeding experiment is 1 : 4.90.

After all, the vital question to the farmer is, "Does it pay?"

This experiment shows that the nutritive ratio of alfalfa is quite good, and that average animals, like those fed in the experiment, will gain seven pounds weight for every 100 pounds of hay consumed, or a gain of 140 pounds weight for each ton of alfalfa. In determining final results, there are three important factors brought in question—the price of alfalfa, the cost of transportation, and the price obtained for the beef when placed on the market. Whether it will pay, or not, is a problem which can be solved only by the farmer or stockman, each in his own locality, after a knowledge of the preceding data.

To conclude, we believe alfalfa to be the best forage plant for Colorado, and the whole arid region, for the following reasons:

1. It is easy to raise and secure a fine stand of plants, if the soil be put in proper condition.

2. Its staying qualities are good, as the oldest fields show no diminution in growth or yield; neither does it kill by winter exposure, if given the least care and irrigation at the proper time.

3. The quantity produced by the many cuttings make it much more valuable than the other clovers or grasses.

4. It is as digestible as clover hay, constituent by constituent.

5. Its chemical composition shows that it is a rich, strong food, when properly cured.

6. Its feeding qualities are excellent, being relished by all farm animals.

It is also an excellent flesh and milk producer. In general, it will do to say that it has about all the good qualities of a forage plant, with very few poor ones. It has shown a tendency to split up, or diverge into several well marked varieties, under careful cultivation.

In a future bulletin, these, together with the rooting proclivities, with and without irrigation, will engage our attention.