THESIS

A STUDY OF THE FEEDING VALUE OF THE DRY MATTER IN WET BEET PULP, DRIED BEET PULP AND DRIED MOLASSES BEET PULP, WHEN FED WITH CORN AND ALFALFA IN A FATTENING RATION TO LAMBS

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GENERAL DATA SHEET.

LAMB FEEDING PROJECT. YEAR 1925 - 1926.

Based on Market Weights. 130 Day Feeding Period.

Lot	I	VI	VII	VIII	IX	X
Ration	Corn Alf	Corn D P C S M Alf	Corn D P L O M Alf	Corn W P Alf	Corn D M P Alf	Corn D P Alf
Lambs in Lot	24	24	25	24	25	24
Lamb Days per Lot	2629	2575	2643	2388	2588	2629
Total Initial Wt.	1646.34	1635.33	1720.80	1633.00	1718.17	1639.13
Total Final Wt.	2360.00	2340.00	2440.00	2370.00	2450.00	2340.00
Initial Wt. per Lamb	68.60	68.14	68.83	68.04	68.73	68.30
Final Wt. per Lamb	98.33	97.50	97.60	98.75	98.00	97.50
Total Gain per Lot	713.66	704.67	719.20	737.00	731.83	700.87
Ave. Gain per Lamb	29.73	29.36	28.77	30.71	29.27	29.20
Ave. Daily Gain	2.71	2.74	2.72	3.09	2.83	2.67
Ave Daily Feed. per Lamb						
Corn	1.03	.52	.52	.98	.52	.52
D P		.52	.52			.52
D M P					.52	
W P				3.64		
L O M			.15			
C S M		.15				
Alf	2.56	2.35	2.32	1.77	2.61	2.43
Total Feed Consumed by All Lambs						
Corn	2713.87	1328.05	1378.30	2335.19	1349.70	1376.54
D P		1327.07	1377.50			1376.54
D M P					1348.90	
W P				8686.57		
L O M			400.60			
C S M		394.00				
Alf	6739.17	6061.36	5870.00	4219.58	6745.00	6378.33
Feed Required For 100 Pounds Gain.						
Corn	380.27	188.46	191.64	316.85	184.43	196.40
D P		188.33	191.53			196.40
D M P					184.32	
W P				1178.64		
L O M			55.70			
C S M		55.91				
Alf	944.31	860.17	816.18	572.53	921.66	910.06
Feed Cost per Cwt Gain	10.99	11.27	11.50	8.76	10.51	10.67
Final Wt at Market	2360.00	2340.00	2440.00	2370.00	2450.00	2340.00
Ave Final Wt. *	98.33	97.50	97.60	98.75	98.00	97.50
Shipping Shrink Lbs.	129.43	139.17	142.34	158.91	144.67	134.01
Shipping Shrink %	5. 20	5.61	5.51	6.25	5.58	5.42
Dressed Wt. Total	1227.27	1201.00	1233.00	1216.00	1222.00	1175.00
Dressed Wt. Ave.	51.33	50.04	51.38	50.67	48.88	48.96
Dressing Percent	51.99	51.32	50.53	51.31	49.88	50.21
Cost Per Lamb	9.26	9.20	9.29	9.19	9.28	9.22
At feedlot @ $13.50						
Feed Cost per Lamb	3.27	3.31	3.31	2.69	3.08	3.12
Expense per Lamb	.58	.58	.59	.57	.58	.58
Interest at 8 % four months.	Shipping and selling expense at car lot rates.					
Total Cost per Lamb	13.36	13.34	13.44	12.70	13.19	13.17
At market.						
Return per Lamb	11.80	11.70	11.71	11.86	11.80	11.70
At $12.00						
Loss per Lamb	1.56	1.67	1.73	.84	1.39	1.47

HISTORY OF BEET SUGAR MANUFACTURE

The history of sugar beets goes back to antiquity. Herodotus mentions this plant as one that nourished the builders of the pyramids of Egypt (1), and it is said (2) that the Romans introduced the crop into Gaul.

Andrew Margraf, a chemist of the Berechte Der Berliner Akademie, first discovered the saccharine quality of the beet, in 1747. (3) The first sugar factory was built in Germany in 1799 (4) by Karl Frantz Achard, a pupil of Margraf. In 1811, Napoleon started the industry in France with a grant of land of nearly 80,000 acres and the establishment of six experiment stations. (3)

Three unsuccessful attempts to start sugar factories in the United States stand out in our early history. The first was by a Philadelphia company, John Vaughn, president, in 1830. In 1838, the Northampton Sugar Company was organized in Massachusetts with David Lee Child as president. Brigham Young made an unsuccessful attempt to establish the industry in Utah in the early fifties. The U. S. Department of Agriculture yearbook of 1863 speaks of the crop as a source of stock food only. (3)

In 1866, a factory was started in Fon-du-Lac, Wisconsin, by two experts from Germany, Otto and Bonesteel. This was moved to Alvarado, California, in 1870 and was the first successful factory in this country. It has been in operation to the present time except for one year. In 1888, Claus Spreckles, the "Hawaiian Sugar King", erected a factory at Watsonville, California, which was replaced in 1898 by the largest factory in

the world. (3) In 1890 the first factory in the Plains region was erected at Grand Island, Nebraska, by Oxnard Bros. and Cutting. The first factory in Colorado was built in 1899 at Grand Junction.

The Watsonville factory, for a number of years, dumped the pulp residue into the ocean and the Grand Island factory allowed it to accumulate in a huge dump, which, in 1899, showed many years' stratification as evidence of non use. About 1897, feeders of cattle and sheep began to use wet pulp in their rations and we have record (6) of large numbers of sheep being fed on wet beet pulp at Eddy, New Mexico, in 1898 and at Ames, Nebraska, in 1900.

In 1900, a factory at Alma, Michigan, began drying beet pulp. It was then mixed with refuse molasses for stock feed. Later, the molasses was dried with the pulp and the product called dried molasses pulp.

By the time the sugar beet industry was introduced into Colorado, there was a demand for pulp from stock feeders, so that livestock feeding was coincident with the erection of the first factories. In 1917, the factory at Brighton, Colorado, began drying pulp and selling it to feeders. (7)

HISTORY OF LAMB FEEDING IN COLORADO

Sheep feeding began in Colorado in 1885, when a band of 500 yearling wethers, being trailed from the Laramie Plains in Wyoming to Nebraska, were stopped by a snow storm in Weld County. They were fed on the Farr Bros. ranch and there began

an industry of great future importance to the state.

In 1889, 3000 head of fat lambs were marketed from Larimer County. The next three years show a growth of the industry to 3,500, 6,000 and 30,000 head. In 1895, there were 80,000 lambs fed in the state and, by 1901, the feeding of sheep was an established business with 400,000 head on feed. (8)

At the present time, there are annually fed in Colorado about a million and a half sheep, mostly lambs. The following figures, from the report of the U. S. Department of Agriculture, show the sheep on feed, in transit, each year on January 1st. (9)

TABLE I.

SHEEP ON FEED IN TRANSIT IN COLORADO

ON JAN. 1ST. OF EACH YEAR SINCE 1914

Year	Number	Year	Number	Year	Number
1914	1,300,000	1918	1,135,000	1922	1,040,000
1915	1,116,000	1919	940,000	1923	1,500,000
1916	1,150,000	1920	950,000	1924	1,400,000
1917	1,250,000	1921	1,283,000	1925	1,600,000

Wet pulp and dried molasses pulp are today used extensively along with grain and alfalfa in fattening these lambs.

MANUFACTURE AND UTILIZATION OF SUGAR BEET PULP

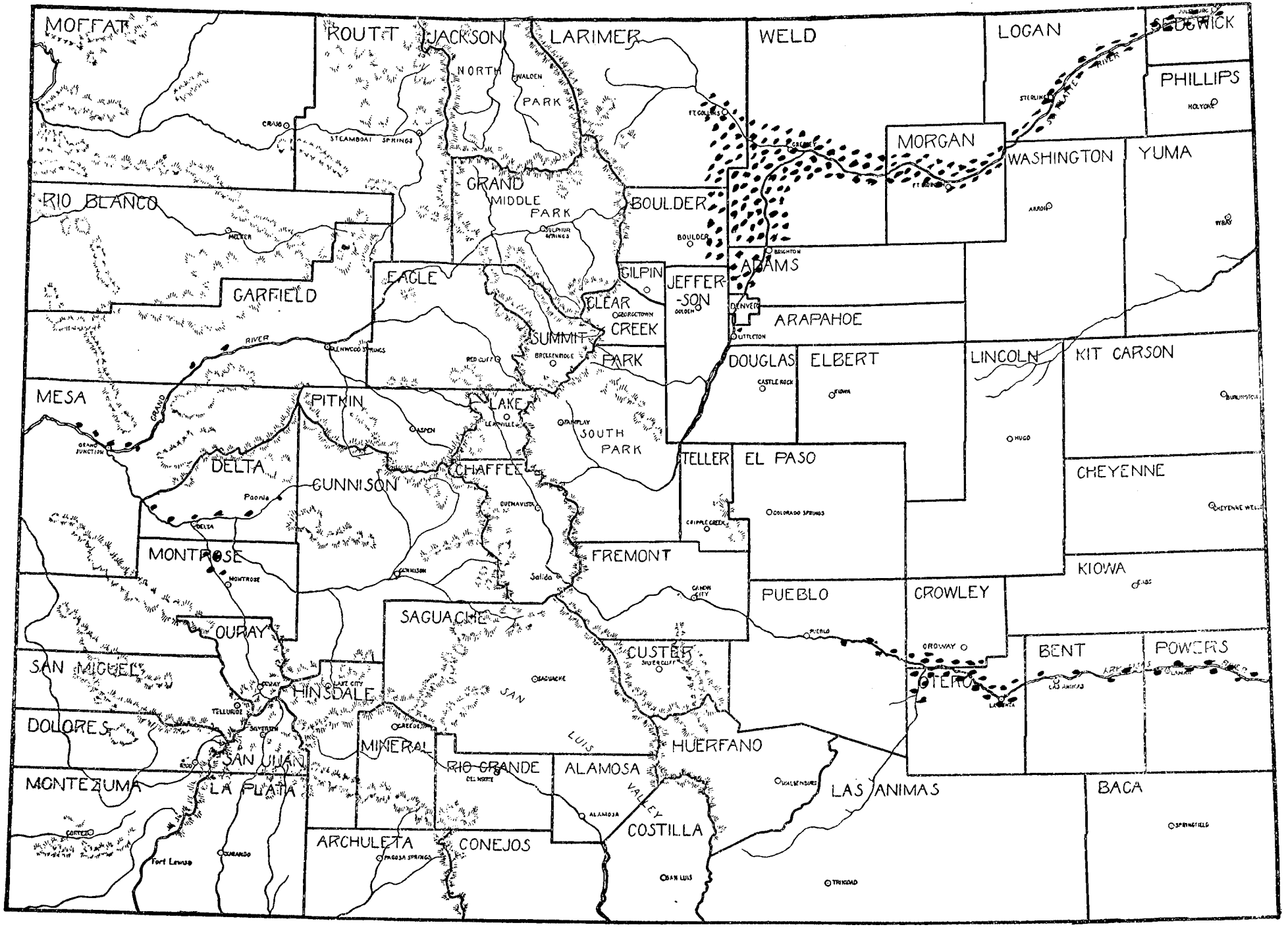
Palmer (10) states that, in 1924, there were 41 sugar companies, in the United States, operating 104 factories with

a daily slicing capacity, during campaign, of 107,775 tons of beets. He is also authority for the statement that, during the same year, 657,000 acres of beets, with an average yield of 10.66 tons to the acre, produced 7,006,000 tons of beets. From these figures, we may estimate, at .25 tons of pulp to the ton of beets, (7) a production of 1,751,500 tons of wet pulp available for stock feeding in the United States in 1924. Townsend (12) estimates that this country will not make all its own sugar until 400 factories are in operation. At present the competition of cane sugar, imported and domestic, prevents such an expansion.

The Colorado Yearbook (13) gives the following facts for this state, in 1924. It ranks first in production of sugar beets, with an acreage of 229,000 acres and a total yield of 2,548,000 tons of beets, which would yield about 637,000 tons of wet pulp available for stock feeding in the state. As this acreage is, largely, concentrated in the irrigated land near the factories, this production is nearly all from seventeen counties, the greatest production being from 77,200 acres, in Weld County, and the greatest concentration being in Larimer County, where about 20% of the cultivated acreage is in sugar beets. The average production in the state in 1924 was 11.15 tons per acre.

The map on page 12 shows graphically the distribution, by counties, of the sugar beet acreage. Each dot represents 1,000 acres of beets. There has been no attempt to locate exact fields, but the acreage for each county has been concentrated in that part of the county given to beet culture. Counties having

less than 1,000 acres have been ignored.



Acreage of Sugar Beets by Counties. Each Dot Represents 1,000 Acres of Beets.

SUGAR FACTORIES
IN COLORADO AND ADJOINING TERRITORY

Freed (14) gives the locations of the beet sugar factories in and adjacent to Colorado as follows:

Colorado: Eaton, Greeley, Windsor, Fort Collins, Loveland, Longmont, Brighton, Fort Lupton, Brush, Fort Morgan, Sterling, Ovid, Johnstown, Delta, Grand Junction, Swink, Rocky Ford and Sugar City.

Nebraska: Grand Island, Scottsbluff, Gering, Bayard, Mitchell and Minatare.

Wyoming: Lovell, Worland, Sheridan and Torrington.

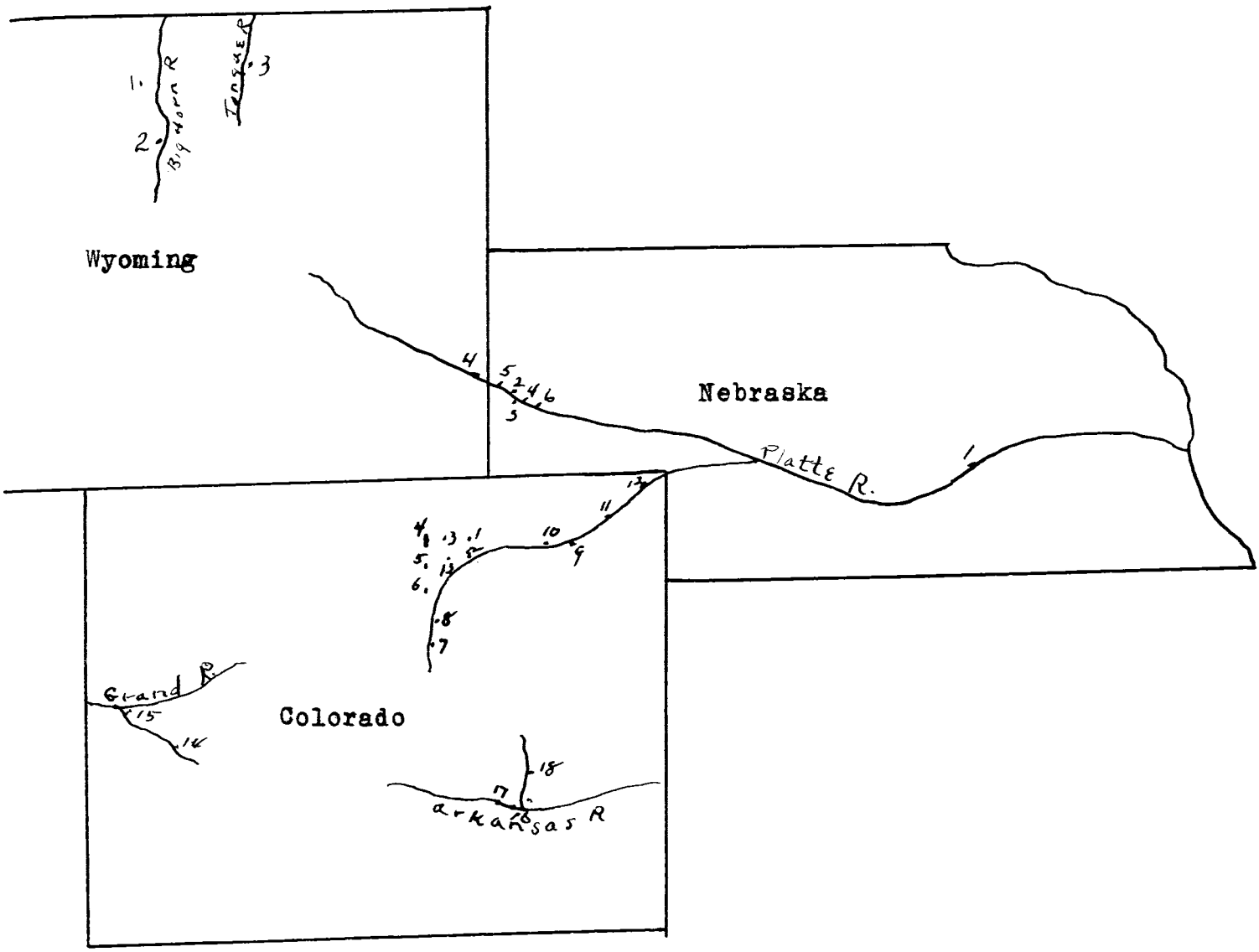
The Johnstown factory of the Great Western Sugar Company is a molasses refinery and not a beet slicing plant. It is under construction to be ready for operation on the product of the 1926 crop.

The map on page 14 shows the location of these factories. There are 21 slicing factories in Colorado, 7 in Nebraska and 4 in Wyoming, or a total of 32 in Colorado and the two adjoining states.

There are pulp driers in the factories at Brighton and Ovid, in Colorado, at Gering and Minatare in Nebraska and at Torrington in Wyoming. The Brighton factory will produce all of the dried molasses pulp of the Great Western Sugar Company after the Johnstown refinery is in operation.

PRODUCTION OF BEET PULP (15) (7)

The manufacture of sugar from beets results in the



COLORADO, WYOMING AND NEBRASKA, SHOWING LOCATION OF SUGAR FACTORIES

Wyoming
1. Lovell
2. Worland
3. Sheridan
4. Torrington

Nebraska
1. Grand Island
2. Scottsbluff
3. Gering
4. Bayard
5. Mitchell
6. Minatare

Colorado
1. Eaton
2. Greeley
3. Windsor
4. Fort Collins
5. Loveland
6. Longmont
7. Brighton
8. Fort Lupton
9. Brush
10. Fort Morgan
11. Sterling
12. Ovid
13. Johnstown
14. Delta
15. Grand Junction
16. Swink
17. Rocky Ford
18. Sugar City

production of a number of by-products, all of which are valuable for stock feed. In the fields are left the tops, consisting of the leaves and crown, that part of the root which, growing above ground, seems to have such a concentration of mineral salts and soluble proteins that it is unfit for sugar making by methods now in use. At the dump there is an accumulation of tails and in the factory is separated the pulp, disposed of as wet pulp, dried pulp and dried molasses pulp. The final residual molasses, too impure to refine, and too bitter in taste for human consumption, has been used as stock feed, both in the making of dried molasses pulp and fed directly to cattle or lambs. This thesis deals with the utilization of the pulp in its three forms, wet, dried, and dried with molasses and, ignoring the other by-products, these will be here called "the by-products" for brevity.

The beets, delivered fresh from the farm, are first weighed then washed. They are sliced by revolving knives in a large drum. The slices are called "schnitzels" by the Germans, "chips" by the English and "cossettes" by the French. The French term is used in this country or they are often called merely "slices". They are triangular in shape and about the size of a lead pencil. Figure 1 shows the shape of the cosettes. This shape gives a maximum of surface for contact with the extracting water.

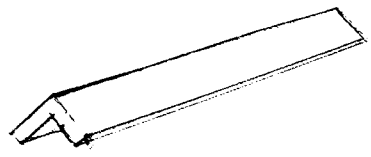


Figure 1.

Sugar is extracted from the slices by osmosis in a battery of ten to fourteen diffusion tanks. Fresh water, entering the last tank containing nearly exhausted pulp, is at a temperature of about 55 degrees Centigrade. As it goes from tank to tank, it is heated until it is at about 88 degrees Centigrade at the fifth diffuser, which temperature is held until the last three or four tanks, where it is allowed to gradually cool to 60 degrees Centigrade in the first tank which the beets enter.

The wet pulp, from the last diffusion tank, is slushed through a large pipe to the pulp silo. This is a large pit at least 500 feet long, 200 feet wide and twelve feet high, having a capacity of as much as 50,000 tons in many plants. Here, the wet pulp is available for hauling by feeders. Usually, it is left for a few days during which time it loses some of its moisture and compacts to a cheesy consistency, being then called "cured pulp". It goes through a curing process similar to that of ensilage.

Where the pulp is to be dried, it is run through a presser instead of going to the silo. Here, it loses about 10% of its water and has about the consistency of cured pulp. It is then dried by a blast of hot gases or, less commonly, by steam. It leaves the drier with a moisture content of about 8%. After this treatment, it is marketed as dried pulp.

Some of the dried pulp is mixed with waste molasses in such amounts that the final product is about 25% molasses.

This is sold as dried molasses pulp.

The extracted juice of the beets, coming from the diffusers, is purified by precipitation with lime and carbon dioxide, by cloth filters, by bone black filters and by centrifuging. Finally, a juice is left that is so impregnated with nitrogenous matter, mineral salts and other impurities that further extraction is impossible by these means. This is the waste molasses that has been used in the past in making dried molasses pulp.

There is now being erected, at Johnstown, Colorado, a molasses refinery which will take the refuse molasses from slicing factories and, by chemical means called the barium process, further extract it for sugar. There will still be a residual waste molasses for making dried molasses pulp, but it will be in greatly lessened amount. This waste molasses will have a higher concentration of impurities, largely of nitrogenous matter and salts.

The factory at Loveland, Colorado, is not installing a presser, which will be used to produce pressed pulp for feeders. This product will be simply wet pulp with about 10% of its water content pressed out. It will make wet pulp available to feeders living at a greater distance from the factory and so will widen the radius of feeding territory.

TABLE II

AVERAGE COMPOSITION OF BEET PULPS

From Henry and Morrison (16)

Feed Stuff	Water	Ash	Crude Protein	Fibre	N Free Extract	Fats
Wet Pulp	90.7	0.04	0.9	2.1	5.7	0.2
Dried Pulp	8.2	3.5	8.9	18.9	59.6	0.9
Dried Mol. Pulp	7.6	5.6	9.5	15.9	60.7	0.7

Table II, from Henry and Morrison, gives the chemical composition of the beet pulps as manufactured and not the chemical components as digested by livestock.

Henry and Morrison (16) state that sugar beets may have a small amount of water soluble B vitamin and water soluble C vitamin but no fat soluble A. No facts are available as to whether any of the vitamin content of beets remains after diffusion or after diffusion and drying.

Table III also from Henry and Morrison, gives the mineral content of dried beet pulp as manufactured.

TABLE III

MINERAL CONTENT OF DRIED BEET PULP IN PERCENTS

Potash	Soda	Lime	Magnesium	Sulfuric Acid	Phosphoric Acid	Silica	Chlorin
K_2O	Na_2O	CaO	MgO	SO_3	P_2O_5	SiO_2	Cl
3.8	2.2	9.2	4.2	3.1	2.4	9.0	.43

A study of the composition of beet pulps shows that they are carbo-hydrate feeds, needing some kind of protein feed to balance them in a fattening ration. They need some feed to supply vitamins. Alfalfa makes a good feed to go with beet pulp. Dried beet pulp is shown by Table III to be a good source of mineral matter, a point which will be brought out in the discussion of feeding experiments. (Page 27)

ALLOTMENT OF PULP*

It is the desire of the sugar manufacturers to have beet growers carry on feeding operations on their farms, for their economic betterment and for the enrichment of the soil. For this reason, they wish to sell a limited allotment of pulp to many growers rather than to sell a large amount of it to a few large feeders who would gladly take it on long time contracts. (18)

Dried pulp and dried molasses pulp are not now allotted although the companies reserve the right to allot them if the demand should increase among the growers. These feeds are sold on the market, the dried molasses pulp usually going to local feeders and the dried pulp being more often shipped east where it is used by manufacturers of commercial stock feeds. It is interesting to note that the present center of distribution of dried pulp is in Georgia. (11) Factories now having driers produce only dried pulp and dried molasses pulp and so make no allotment of wet pulp at all.

*Allotment of wet pulp is not practiced by the American and Holly Sugar Companies in Colorado.

Wet pulp is sold to beet growers only, the supply being divided pro rata on the tonnage of beets marketed. It is allotted to both renters and landlords, with the understanding that it be fed on the farm where the beets were grown or to stock owned by the allotee. Pressed pulp will probably be allotted in the same way as wet pulp on the basis of its water content.

It is figured that 25% of the tonnage of beets marketed will be realized in wet pulp supplied to the feeders but, as many growers do not get pulp, the allotment often is more and has been as high as 70% in certain cases. Atkins (7) estimates that about one half of the growers get their share of pulp. This is dependent partly on the amount of stock feeding being done in the district and, to a greater extent, on the number of distant dumps from which beets are shipped, where the expense of transportation is too great to encourage a demand.

The limited allotment of pulp has discouraged the former practice of feeding unlimited pulp in a fattening ration. This factor has furnished the cause for experiments in feeding lesser amounts of wet pulp with grain and other feeds in fattening operations. Once a daily feed of from 6 to 8 pounds of wet pulp for a lamb and 100 pounds for a steer was common; today 2 to 4 pounds for a lamb and 15 to 35 pounds for a steer are the usual amounts allowed.

The factory management, in its allotment agreement,

reserves the right to require a feeder to haul his share of pulp at any time when the accumulation of pulp in the factory silo becomes too great, with the alternative of losing the part unhauled or having it hauled at his expense.

TRANSPORTATION, HANDLING AND FEEDING PROBLEMS

Dried pulp and dried molasses pulp present no peculiar problems of transportation or handling. They may be shipped, like grain, to a distance by rail or truck. They require only a dry place for storage and they may be fed, alone or mixed with grain, in ordinary grain feeding bunks or troughs. They are, therefore, available to many feeders who, because of distance from the factory or peculiar labor conditions, are unable to use wet pulp.

Wet pulp is heavy, with an unpleasant odor and liable to freeze, both in storage and in feeding. While freezing does not lessen the feeding value, it must be thawed or discarded as stock do not eat the frozen pulp readily. As the liquid dripping from a load of wet pulp is said to injure concrete, (19) there is a tendency for the authorities to prohibit its hauling over certain streets and roads.

The amount of water in wet pulp tends to discourage its shipment by rail and largely limits its use to feeding operations near the factories. Team haul has largely been the practice at distances up to five miles from the factory. A team can handle from three to four tons with good roads and

short hauls. The advent of the truck has increased the radius of profitable use to ten miles and in some cases to fifteen. Where it is possible, the pulp is hauled direct to the feedlot and no attempt is made to store it on the farm. Where it is stored, it is usually piled in the open with little or no protection.

Wet pulp is often and cheaply fed, especially to lambs, through panels, on straw spread on the ground, though it may be fed in bunks with chopped fodder, silage or grain.

As a feeder may find it necessary to keep one or more teams at work hauling and feeding pulp, in all kinds of weather and on all kinds of roads, the labor problem may present a limiting factor on the amount of pulp used. A heavy run of beets at the factory may necessitate the feeder's taking a larger proportion of his allotment early in his feeding period than he is able to do or lose that part which he is unable to haul. This also presents a factor tending to limit the amount of pulp that a feeder will order.

Maynard (20) states that "the advantages of wet pulp depend largely on the length of haul from the factory and labor cost". Table IV, from Maynard (11) shows the cost of pulp delivered at the feedlot. It is based on the actual prices charged in northern Colorado during the current year and on the average factory charge for wet pulp for the season at Fort Collins. It should be remembered that green pulp shrinks a great deal and that a ton of pulp may be worth more or less

according to its moisture content.

TABLE IV

COST OF WET PULP, PER TON, AT THE FEEDLOT

Distance from Factory	Hauling Cost	Average Cost of Pulp	Cost at Feedlot
Up to 3 miles	.50	.85	1.35
3 to 5 miles	.65	.85	1.50
5 to 7 miles	1.00	.85	1.85
7 to 10 miles	1.15	.85	2.00

The figures given above seem to point to the possibility that wet pulp may be hauled to greater distances than formerly and still be a profitable investment in the light of results of experiments given later in this work.

ILLUSTRATIVE FARM PRACTICE

Sugar beet farming is well suited for Colorado irrigated farming. It is intensive in its nature, with good cultivation necessary and high production possible. Its high yield requires rebuilding of the soil with legume crops and manure. This naturally points to stock farming as an adjunct. The following six year rotation from Maynard (11) gives a possible crop rotation for a 160 acre farm with 150 acres under cultivation.

Field Number	1	Alfalfa and grain (New alfalfa)
" "	2	Alfalfa
" "	3	Alfalfa

Field Number	4	Alfalfa
"	" 5	Corn or spuds 15 acres, beets 10
"	" 6	Beets 25 acres

"This gives 35 acres in beets, about as large an acreage as seems feasible to handle. Figuring a production of one ton of alfalfa per acre for the new seeding and two and one-half tons for the old should give a total of 212.5 tons of hay. Allowing 32.5 tons for feeding teams and other stock there would be 180 tons of alfalfa for feeding operations." The feed available as roughage for fattening livestock would be about as follows:

Alfalfa	180 tons
Corn silage (15 A.)	180 tons
Wet pulp ($\frac{1}{4}$ on 525 T. beets)	125 tons
Beet tops ($2\frac{1}{4}$ T. per A.)	79 tons

All of this feed should be utilized in feeding livestock to realize its full value and to return to the soil the needed fertilizer.

Here is enough feed to supply roughage needed in a ration to put a 30 pound gain on over 2500 lambs, for the results of five years' work at the Colorado Experiment Station show that 125 tons of wet pulp and 67 tons of alfalfa will provide roughage for 643 head of lambs making a 30 pound gain; the results of the work of the Nebraska Experiment Station at Scottsbluff in 1925--26 show that the tops from 525 tons of sugar beets and 42.5 tons of alfalfa will supply roughage to

feed out 667 lambs with a gain of 30 pounds per head and 70.5 tons of alfalfa and 92.5 tons of silage will provide roughage for 1500 head of lambs.

This plan presents a method of utilizing all of the roughage raised. It provides a business for the winter months. It provides a supply of manure to keep up soil fertility. It helps to diversify farming.

IMPORTANCE AND TIMELINESS OF THIS STUDY

Sugar beet farming with livestock feeding as an adjunct thereto is an important business in the state and that importance is increasing. It is apparently sound and economic agricultural practice. The value of beet by-products is being recognized more and more by feeders and with this recognition comes the desire for accurate information.

The extension of stock feeding operations to dry land districts and to irrigated districts far from sugar factories should increase the demand for dried pulp.

The establishment of the refining plant at Johnstown, Colorado, soon to be accomplished, will, in all probability, curtail the supply of dried molasses pulp and greatly increase the supply of plain dried pulp on the market.

All of these factors, working together, are making an insistant demand and a great need on the part of feeders for information on the comparative feeding value of sugar beet pulp in its different forms and its value in replacing corn in a basic ration of corn and alfalfa.

HISTORY OF EXPERIMENTAL BEET PULP FEEDING

McMurtrie (5) in 1880 speaks of experiments in France, using wet pulp, linseed meal and hay for fattening oxen. Wiley (21), in 1898 discusses experiments in France at the sugar house of M. Gallois, with sheep, using wet pulp, linseed meal and chopped alfalfa. These early experiments are interesting only from a historical standpoint, in this study, because they were with unlimited pulp rations and were merely proving that it was a practical stock feed, without making any comparisons. In the experiment reported, the sheep gained .3 pound per head daily on a ration of 11.88 pounds of wet pulp, .44 pounds of linseed meal and 1.10 pounds of chopped alfalfa.

At Eddy, New Mexico, in 1898 a feeder tried an experiment with 1100 lambs using 10 pounds of wet pulp daily with alfalfa self-fed, that gave very satisfactory gains. Saylor (22) recounts a number of tests by feeders prior to 1900.

Merrill and Clark (23) and later Clark (24) give results of experiments carried on for four years at the Utah Experiment Station. This work, using wet pulp, shorts and bran with alfalfa was the first western experiment to prove that wet pulp was a practical feed for fattening sheep with a ration of pulp, grain and hay and was the first to make a study of a limited pulp feed. We quote from the summary, "In feeding a ration of alfalfa and beet pulp to sheep, better results, in every instance, were secured when either the alfalfa or the pulp was limited. Larger gains and cheaper production were

secured when the pulp, rather than the alfalfa, was limited." A full feed was compared with half and a fourth of that amount.

Clark also tried an experiment in 1904-05 to determine the effect of feeding wet pulp on the strength of bone in sheep. Ten pounds of pulp per day was fed to yearling sheep for a period of 120 days, after which the animals were butchered and the meat stripped from the bones. Important bones from different parts of the body were tested in a Rhiele cement testing machine. For comparison a second lot was fed no pulp and the bones tested. Table V gives a summary of the results.

TABLE V

COMPARISON OF STRENGTH OF BONE IN SHEEP FED WET PULP AND SHEEP FED NO PULP (IN POUNDS)

Ration	Femur	Humurus	Tibia	Radius	Meta Tarsal
Pulp	829	1019	508	666	761
No Pulp	714	833	488	534	572
Difference	115	186	20	132	189

(in favor of the pulp-fed animals)

Before the time of this experiment, there was an idea that pulp feeding tended to weakness of bone (25), but the positive nature of the results here made seems to have settled the question, for no further experiments along this line seem to have been made. The mineral content of dried pulp (see Table III, page 18) would lead one to believe that this feed is a good source of minerals for bone building.

Feeding experiments were conducted in 1900-02 at the Colorado Experiment Station (25) (26) but these early experiments dealt with an unlimited pulp ration of wet pulp and, as no figures were secured, comparable with those of the present study, dealing with the feeding value of the dry matter of pulp in comparison with corn or between different kinds of pulp, they are not reported here.

Summary of early feeding tests. By 1915, the tests conducted by various experiment stations and feeders had demonstrated that wet beet pulp was a feed of value in fattening sheep. The idea had been gained that its feeding was not harmful to the health nor to the finish of the animal. Tests at Utah had seemed to indicate that a limited ration was more successful than an unlimited ration. Tests at Colorado had led the experimenters to believe that grain and pulp was more valuable than pulp without grain.

Records do not show any experiments with dried pulp or dried molasses pulp prior to 1917, in the United States.

Experiments have been carried on at the Nebraska Experiment Station at Scottsbluff, Nebraska, from 1917 to date and at the Colorado Experiment Station at Fort Collins, Colorado, from 1920 to date bearing directly on the comparative value of the dry matter in wet pulp, dried pulp and dried molasses pulp. The results of these experiments will be discussed in the following pages.

In the study of further experiments the following

abbreviations will be used:

D P is used for dried beet pulp.
D M P " " " dried molasses beet pulp.
W P " " " wet beet pulp.
L O M " " " linseed meal.
C S M " " " cottonseed meal.
Alf " " " alfalfa hay.
Tops " " " sugar beet tops.
Sil " " " corn silage.

In figuring costs of feeds and replacement values for pulp the same prices have been used for all experiments to make them more comparable. In the Scottsbluff, Nebraska, district dried pulp and dried molasses pulp are sold in bulk, unsacked, and so at a cheaper price than in the Fort Collins, Colorado, district. Different prices have, of course, been charged in different years. To reduce these differences to a comparable basis, the current market prices at Fort Collins have been used. These are called "present prices" in the following pages. They are as follows:

Corn	$28.00 per ton	Dried pulp	$25.00 per ton
Alfalfa	12.00 " "	Dried molasses pulp	26.00 " "
C S M	40.00 " "	Wet pulp	1.50 " "
L O M	55.00 " "	Corn silage	6.00 " "
Beet tops	.50 per ton of beets		

FEEDING RESULTS AT THE NEBRASKA EXPERIMENT STATION AT SCOTTSBLUFF, NEBR.

1917 to 1926

The Nebraska Experiment Station at Scottsbluff, Nebraska, has conducted feeding tests during the last seven years to find the value of beet pulp in its different forms for fattening lambs. This work is discussed in the following pages, 30-33.

For the first three years a comparison was made between corn, corn and dried molasses pulp, dried molasses pulp alone and corn and wet pulp, using alfalfa for roughage. The results are summarized in Tables VI and VII.

TABLE VI

A COMPARISON OF THE FEEDING VALUE OF WET PULP AND DRIED MOLASSES PULP AND CORN USING ALFALFA FOR THE ROUGHAGE

Based on feed lot weights.

1917 - 1918 - 1919

Lot	Ration	Gain per Lamb, Lbs.	Cost of Feed per 100# Gain	Profit per Lamb
I.	Corn, Alf.	27.5	$7.36	$0.51
II.	Corn, D M P, Alf.	27.7	6.82	.54
III.	D M P, Alf.	25.6	7.57	.40
V.	Corn, W P, Alf.	30.0	6.93	.89

TABLE VII.

FEED REQUIRED FOR 100# GAIN

Based on feed lot weights

Lot	I.	II.	III.	V.
Corn	313	161		255
D M P		161	338	
W P				1462
Alf.	720	655	837	627
Cost for 100# gain	$8.96	$8.36	$9.42	$8.56

Holden (26), in his summary of these experiments, says that dried molasses pulp "proved to be a good substitute for corn having 80 to 85 percent the feeding value of corn", and "Adding wet pulp to a ration of corn and alfalfa increased the gains per lamb and also increased the selling price."

The work of these three years, according to Table VII., seems to indicate that 161 pounds of dried molasses pulp replaced 152 pounds of corn and 65 pounds of alfalfa. At present prices (see page 29) the replacement value of the dry matter in the dried molasses pulp would be $1.69 per hundred pounds when fed half and half by weight with corn in Lot II. This would give the dried molasses pulp a feeding value of $33.80 per ton compared to corn at $28.00 per ton.

In Lot III, where the dried molasses pulp was fed without corn, along with alfalfa, the test indicates that 338 pounds of dried molasses pulp and 117 pounds of alfalfa hay were needed to replace 313 pounds of corn. At present prices, the

replacement value of the dry matter in the dried molasses pulp when fed alone with alfalfa would be only $1.18 per hundred pounds, or $23.60 per ton.

There is, then, a marked difference in the value of dried molasses pulp when fed alone and when fed with corn. When fed alone with alfalfa replacing all the corn in the basal ration of corn and alfalfa, the dried molasses pulp did not produce the gains, nor the profit and the cost of 100 pounds gain was not as good as when the lambs were fed corn and alfalfa. But when dried molasses pulp was fed with corn, replacing half the corn in the basal ration, the gains made and the profit realized were more than with the basal ration and the cost of 100 pounds gain was less. This fact has been substantiated in other experiments reported later in this thesis.

Feeding tests show that it is possible for the nutritive values of a feed to be improved by the addition of some other feed. In this case the reason is not clear, but the fact remains.

In Lot V, 1462 pounds of wet pulp replaced 58 pounds of corn and 93 pounds of alfalfa. At present prices, 100 pounds of the dry matter in wet pulp would have a replacement value of $1.01 according to the findings in this lot, assuming that the wet pulp had 232.6 pounds of dry matter to the ton. This dry matter content is assumed because the samplings of wet pulp taken as fed at the Colorado Experiment Station in 1925-26, were found to have an average moisture content of 88.37% or

232.6 pounds per ton.

During the second three-year period at the Scottsbluff Station, during 1920, 1921 and 1922, the method of feeding was changed and in Lot II the dried molasses pulp was fed alone with alfalfa for the first sixty days, then corn was added to the ration in increasing amounts while the pulp was decreased in amount until the ration was composed of only corn and alfalfa. As would be expected from the previous work, the average gains over the whole period were not equal to those made on corn and alfalfa. The figures secured are comparable to those secured during the first three years and throw no new light on the value of the dry matter in dried molasses pulp. Figures secured in this second test are given in Table VIII.

TABLE VIII.

EXPERIMENTAL FEEDING RESULTS

AT THE NEBRASKA EXPERIMENT STATION

1920, 1921, 1922

Ration	Feedlot Gain per Lamb	Cost of Feed per 100# Fain	Profit per Lamb
Corn, Alf	30.2	$6.54	$.70
Corn, D M P, Alf (Corn 40 days D M P 60 days)	28.6	6.74	.56
Corn, C S, Alf	37.3	7.21	.85
Corn, D M P, C S, Alf (Corn 40 days D M P 60 days)	35.3	7.52	.61
D M P, C S, .33#, Alf	34.9	7.23	.70
D M P, C S, .50#, Alf	37.9	7.66	.66
D M P, Tops, Alf	39.1	6.83	.97
D M P, C S, Sil, Alf	38.5	6.83	1.07
Corn, Tops, Alf	34.8	5.92	1.11
D M P, Alf	27.1	6.83	.46

The experiments conducted by the Nebraska Experiment Station at Scottsbluff in 1920, 1921 and 1922 as shown in Table VIII, point to the value of adding cottonseed cake, beet tops or silage to a ration of dried molasses pulp and alfalfa, but no proof is available that these additions gave any greater feeding value to the dry matter in the dried molasses pulp than had been shown in the preceding series of experiments.

The results secured at the Nebraska Experiment Station

in 1925-26 are shown in Table IX.

TABLE IX

A COMPARISON OF THE FEEDING VALUE OF

DRIED PULP AND DRIED MOLASSES PULP

1925 - 1926

Ration	D M P C S M Alf	D P C S M Alf	D M P C S M Tops Alf	D P C S M Tops Alf	D M P C S M Sil Alf	D P C S M Sil Alf
Daily Gain	34.2	35.2	33.5	35.0	35.0	34.7
Feed required for 100# gain.						
Pulp	339	331	345	331	331	333
C S M	95	92	96	92	92	93
Alf	644	574	407	425	369	3.3
Tops (from T. of beets)			2.40	2.62		
Sil					422	411
Cost of feed per 100 pounds gain, (present prices)						
	10.95	9.42	10.05	9.84	9.65	9.11

Figures based on feedlot weights.

In Table IX the results of three direct comparisons of dried pulp and dried molasses pulp are shown. In two of these comparisons, dried pulp produced better gains than dried molasses pulp. It excelled the dried molasses pulp when fed with cottonseed meal and alfalfa and when fed with cottonseed meal, beet tops and alfalfa, while in all three comparisons it produced cheaper gains.

In the comparison using cottonseed meal and alfalfa 331 pounds of dried pulp replaced 339 pounds of dried molasses pulp, 3 pounds of cottonseed meal and 70 pounds of alfalfa. At present prices, this would show that dried molasses pulp had only 88.05% the feeding value of dried pulp.

In the comparison using cottonseed meal, tops and alfalfa the results indicate that 331 pounds of dried pulp, 18 pounds of alfalfa and tops from .72 tons of beets replaced 345 pounds of dried molasses pulp and 4 pounds of cottonseed meal, indicating that the dried molasses pulp had 98.94% the feeding value at present prices that the dried pulp had.

When using cottonseed meal, corn silage and alfalfa 333 pounds of dried pulp and 1 pound of cottonseed meal replaced 331 pounds of dried molasses pulp, 53 pounds of alfalfa and 11 pounds of silage showing that the dried molasses pulp had only 92.46% the feeding value of dried pulp.

This test is the first of a series of three. In it the dried pulp has shown better results than the dried molasses pulp.

During this same year, 1925-26, a test at the Colorado Experiment Station comparing dried pulp and dried molasses pulp showed better results in gains made and cheapness of gains for the dried molasses pulp. This difference in the comparative feeding value of the two feeds may be found to be due to the combination of other feeds used and it may be found to be due to the particular bunches of sheep used.

The latter reason will be easily checked by further experiments which will be conducted in both cases. It is possible for a feed to show different values in different combinations of feeds. However, the chemical analysis of dried pulp and dried molasses pulp would indicate that the dried molasses pulp should show a higher feeding value.

When dried pulp or dried molasses pulp are fed as a supplement to other feeds, it may be possible that the amount of influence they exert is lessened and their values can be figured as about equal. It is for this reason that tests are being made.

FEEDING RESULTS AT THE

COLORADO EXPERIMENT STATION

1920 -1926

TABLE X.

A COMPARISON OF THE FEEDING VALUE OF

WET PULP, DRIED PULP AND DRIED MOLASSES PULP

WITH CORN, USING ALFALFA

Average of all experiments at the Colorado Experiment Station

Ration	Corn W P Alf	Corn Alf	Corn D P Alf	Corn Alf	Corn D M P Alf	Corn Alf
Number of Years	5	5	2	2	4	4
Daily Gain, Lbs.	.31	.28	.29	.29	.28	.27
Shipping Shrink, %	6.6	5.7	5.4	4.6	7.6	6.2
Feed per Day, Corn	.90	1.01	.55	1.00	.56	1.00
Pulp	3.85		.55		.56	
Alf	1.83	2.35	2.28	2.60	2.21	2.27
Feed required for 100# gain						
Corn	286.2	367.4	195.5	356.8	200.4	375.9
Pulp	1289.4		195.5		197.9	
Alf	603.3	859.0	811.1	904.5	803.3	857.6
Feed cost for 100# gain						
	$8.59	10.30	10.04	10.42	10.20	10.41

Gains based on market weights. Prices figured at "present prices".

Table X gives averages of all of the different tests made at the Colorado Experiment Station with sugar beet pulp in its three forms in comparison with corn for feeding lambs. The figures for the different kinds of pulp are not directly comparable one with another, except in a general way, because they were for different periods of years and, therefore, do not show results with equivalent conditions, quality of feeds or equivalent bunches of lambs. The figures for each kind of pulp and the tests with corn for the same period of years are directly comparable as they were made in the same experiments.

This summary gives a good general idea of the gains that might be expected from the use of pulp in a corn and alfalfa ration. They give practical daily rations and the feed required for 100 pounds gain. Being for a greater number of tests than the work from any other one source it is presented to show average results.

These average results indicate that a ton of wet pulp replaced 126 pounds of corn and 241.5 pounds of alfalfa in the average of five years' tests. At present prices this would give wet pulp of 88.37% moisture content a replacement value of $3.21 per ton. The 232.6 pounds of dry matter in the ton would, then be worth $1.38 per hundred pounds.

Two years' tests show that a ton of dried pulp replaced 1650.1 pounds of corn and 955.5 pounds of alfalfa, worth $28.83. Assuming 1802 pounds of dry matter per ton (11), that dry matter would have a replacement value of $1.60 per

hundred pounds.

In four years tests, a ton of dried molasses pulp replaced 1773.6 pounds of corn and 548.8 pounds of alfalfa. This would indicate a replacement value of 28.12 per ton at present prices. The dry matter would have a replacement value of $1.56 per hundred pounds.

For the sake of securing true comparisons the same experiments are arranged in Tables XI and XII to include the years when there was a direct comparison between the different forms of pulp. Table XI shows the results of three years experiments when wet pulp, dried molasses pulp and corn were compared using alfalfa for roughage. Table XII gives the results of one year's experiment when wet pulp, dried pulp and corn were compared using alfalfa for roughage.

TABLE XL

DIRECT COMPARISON OF WET PULP, DRIED MOLASSES PULP AND CORN FOR FATTENING LAMBS

Summary of three feeding tests at the Colorado Experiment Station 1920 - 21, 1922 - 23, 1923 - 24

Lot	I.	III.	IV.
Ration	Corn Alf	Corn D M P Alf	Corn W P Alf
Gain per Lamb	29.1	30.3	33.9
Feed Required for 100 Pounds Gain			
Corn	375	206	267
D M P		203	
W P			1556
Alf	829	764	556
Feed Cost per 100# gain	$13.72	12.24	10.68
Feed Cost per Lamb	3.99	3.71	3.62
Net Return per Lamb	3.46	3.99	4.88

In three feeding tests at the Colorado Experiment Station, Maynard made a direct comparison between wet pulp, dried molasses pulp and corn, using alfalfa for roughage. In these tests the pulp was fed in each case to replace approximately one-half of the corn in the ration, so that all lots received corn with pulp.

Averages of the results of the three years' experiments show that 203 pounds of dried molasses pulp, when fed in equal parts by weight with corn and with alfalfa self-fed, replaced 169 pounds of corn and 65 pounds of alfalfa. In these tests the dried molasses pulp had a replacement value, at present prices, of $27.19 per ton, as compared to corn at $28.00. It proved to have 97% the feeding value of corn. The dry matter in the pulp had a feed value of $1.51 per cwt., according to these tests.

These same experiments, indicate that 1556 pounds of wet pulp replaced 108 pounds of corn and 273 pounds of alfalfa showing a feed replacement value, in wet pulp, of $4.05 per ton. With an average moisture content of 88.37%, the 232.6 pounds of dry matter in the wet pulp would be worth, then, $1.74 per hundred pounds, as compared with $1.51 for dried molasses pulp.

The following quotations from Maynard are of value in this connection.

"Shelled corn, wet pulp and alfalfa hay constitute, at present prices, the most economical ration for fattening of

lambs in the beet growing districts. Experimental figures secured show that uniformly good results can be expected from feeding wet pulp with corn and alfalfa where it is obtainable." (11)

"Dried molasses pulp has given best results mixed in equal proportions, by weight, with corn." (11)

"Dried molasses pulp, fed with alfalfa hay has 75% the feeding value of corn; fed equal parts by weight with corn along with alfalfa, with present prices, has 96.3% the feeding value of corn." (11)

"The wet pulp fed lambs made the heaviest gains and at the cheapest costs." (20)

TABLE XII.

DIRECT COMPARISON OF WET PULP, DRIED PULP AND CORN FOR FATTENING LAMBS

Feeding test at the Colorado Experiment Station

1924 - 25

Lot	I.	III.	IV.	IX.
Ration	Corn Alf	Corn D P Alf	Corn) D P)S F Alf)	Corn W P Alf
Gain per lamb per day	.313	.300	.327	.322
Feed required for 100 pounds gain, market weight				
Corn	333.3	194.6	172.4	313.1
D P		194.6	172.5	
W P				600.6
Alf	864.6	712.1	775.9	775.2
Feed cost per 100# gain	13.15	12.48	12.12	12.52
Net return per lamb	2.94	3.26	3.32	3.09

In the feeding test conducted by Maynard at the Colorado Experiment Station in 1925-26, as summarized in Table XII, a direct comparison was made between wet pulp, dried pulp and corn. Two tests were made with dried pulp, corn and alfalfa. In one the feeds were hand fed in the usual way; in the other the three feeds were ground, mixed and self-fed.

Dried Pulp. When hand fed in equal parts, by weight, with corn, using alfalfa as roughage, 194.6 pounds of dried pulp replaced 138.7 pounds of corn and 152.5 pounds of alfalfa. This indicates a replacement value at present prices of $29.39 per ton of dried pulp. The dry matter content of the dried pulp would be worth $1.64 per hundred pounds in this case.

When self fed mixed with corn and alfalfa, in Lot VI, 172.5 pounds of dried pulp replaced 160.9 pounds of corn and 88.7 pounds of alfalfa. This indicates a replacement value of $32.22 per ton of dried pulp and of $1.75 per hundred pounds for the dry matter content of the dried pulp.

Grinding dried pulp, corn and alfalfa and mixing them in definite proportions and self feeding the mixture, gave a higher feeding value to the dried pulp in replacing corn. This is probably due to the faster gains made. The test tends to show that this method is the better and more profitable way to feed dried pulp. However, the lot hand fed in the usual way with corn and dried pulp in equal parts and alfalfa self fed gives a direct comparison with corn and better suits the study made herein.

Dried pulp and corn mixed with ground alfalfa may be safely self-fed to lambs, the test indicated, but straight corn and alfalfa self-fed proves unsatisfactory, as it causes death losses which cannot be controlled.

In this direct comparison with dried pulp we find that 600.6 pounds of wet pulp replaced 20.2 pounds of corn and 89.4

pounds of alfalfa. This indicates a replacement value of $2.73 per ton for the wet pulp. At an average moisture content of 88.37% the dry matter in the wet pulp would then be worth $1.17 per hundred pounds.

TABLE XIII.

DIRECT COMPARISON OF REPLACEMENT VALUES OF THE DRY MATTER IN WET PULP, DRIED PULP AND DRIED MOLASSES PULP FOR FATTENING LAMBS

	Wet Pulp	Dried Pulp	Dried Mol. Pulp
From Table XI	1.74		1.51
From Table XII	1.17	1.64	
Cost at Present Prices	.69	1.39	1.44

The study of the replacement value of the dry matter content of wet pulp and dried molasses pulp as found in the three years' work at the Colorado Experiment Station, described above, shows that the dry matter in wet pulp was worth $1.74 or 252.2% of its cost price while dried molasses pulp was worth $1.51 or 104.9% more than its cost. In the one year's test, comparing wet pulp and dried pulp, the former was worth $1.17 or 169.6% of its cost price while dried pulp at $1.64 or 117.9% of its cost price. This shows the comparison between the feeding value and the cost of beet pulp in its three forms. This can be compared with the cost and value of the dry matter in

corn. The corn used in this experiment had an average moisture content of 16.13% or 1677.4 pounds dry matter to the ton. At $28.00 per ton the dry matter in corn would cost $1.67 per hundred pounds.

The dry matter in dried molasses pulp which cost much less than the dry matter of corn--$1.44 was worth but little less than corn--$1.51. It was worth 104.9% more than it cost, in replacing corn.

The dry matter in dried pulp, which cost only $1.39 was worth $1.64 or practically as much as corn. Its value was 117.9% of its cost price and showed a real saving in replacing half of the corn in a ration with dried pulp.

But the remarkable showing of this table is that of wet pulp. With a value in one case of $1.74 and in the other of $1.17 per hundred pounds dry matter, it cost only $.69 per hundred pounds. When dried molasses pulp showed a feeding value of 104.9% of its cost, wet pulp showed 252.2% of its cost in replacing corn. When dried pulp was shown to be worth 117.9% of its cost, wet pulp was worth 169.6% of its cost.

This fact shows one of the strong points in favor of pulp feeding. They are a source of cheap feed. This is very decidedly true of wet pulp, which showed a value of over two times its cost in these experiments. This is corroborated with further study later in this work.

RESEARCH PROBLEM

A COMPARISON OF THE FEEDING VALUE OF THE DRY MATTER IN DRIED PULP, DRIED MOLASSES PULP AND WET PULP WHEN FED IN A RATION OF CORN, PULP AND ALFALFA TO FATTENING LAMBS

Nov. 10, 1925 to Mar. 26, 1926

Objects of the Experiment

To determine the feeding value of the sugar beet by-products, dried pulp, dried molasses pulp and wet pulp, each fed in a separate ration with corn and alfalfa; and the feeding value of each of these rations in comparison with a ration of corn and alfalfa.

To determine the feeding value of cottonseed meal and of linseed meal, when fed in different rations as supplements to a ration of dried beet pulp, corn and alfalfa; and the feeding value of these rations in comparison with a ration of dried pulp, corn and alfalfa.

Methods of Procedure

Animals used. The lambs used in this experiment were purchased about November 1st at Del Norte in the San Luis Valley in southern Colorado. They were a good grade of Rambouillet range lambs. Many showed markings of an Oxford cross and others showed Hampshire blood. They would be classed as a good grade of "western feeder lambs".

They averaged in weight 68.44 pounds per head, which

is heavier than the ideal feeder but fairly representative of the bulk of feeders now available to the feedlots of the region.

The lambs were ear tagged with an individual number and the same number was branded with sheep paint on the back. The lot number was branded on the rump. Identification was possible under all conditions.

Allotment

Six of ten lots used in the ration experiments at the Colorado Experiment Station are concerned in this study. The original numbers of the lots are retained in this thesis.

The bunch purchased was first culled by cutting out the nine heaviest and the six smallest lambs. The ones left weighed from 52 to 82 pounds.

The lambs were next divided into ten lots of 25 each as nearly equal in weight, sex and condition as possible. In condition they were classed both as to fleshing and as to quality as feeders.

Feeds and Rations

Rations	Lot 1	Corn and alfalfa
	Lot 6	Corn, dried pulp, cottonseed meal, alfalfa
	Lot 7	Corn, dried pulp, linseed meal, alfalfa
	Lot 8	Corn, wet pulp, alfalfa
	Lot 9	Corn, dried molasses pulp, alfalfa
	Lot 10	Corn, dried pulp, alfalfa

Manner of feeding. In all of the lots, the alfalfa was self-fed and an ample supply was before the sheep at all times. All concentrates were fed twice a day in special feeding pens, described later, and in a manner closely approximating local feedlot methods.

The dried pulp and dried molasses pulp were fed mixed with whole shelled corn in equal parts by weight. The cottonseed and linseed meals were mixed with the grain in definite amounts. The wet pulp was fed separately, in definite amounts in a bunk in the regular hay feeding pens.

The lambs were started on a very small feed of concentrates which was increased at intervals of from two to five days by a small amount till at the end of thirty days they were getting the feed on a basis of one pound of corn a day per head. The increases were made as the animals seemed to clean up their feed and show ability to take more. The daily ration was reduced on evidence of going off feed or scouring which showed over feeding.

All increases and decreases of rations were made, as far as possible, uniformly in all lots so that the corn equivalent of all rations was kept, as nearly as possible, uniform.

A maximum daily ration calculated on the basis of 1.5 pounds of corn for Lot 1 was reached on the 80th day, but, after seven days of this feed, the evidences of overfeeding became so strong that the ration was reduced to a corn

equivalent of 1.00 pounds and they did not again reach the maximum feed.

Table XIV shows the daily ration per head at different times during the feeding period to illustrate the method of increasing the ration.

TABLE XIV

DAILY RATION OF CONCENTRATES IN POUNDS PER LAMB AT DIFFERENT TIMES DURING FEEDING TEST, SHOWING INCREASES TO FULL FEED

Lot	Ration	Nov.11	Nov. 21	Dec. 11	Dec. 31	Jan. 26
Days on feed		1	10	30	50	76
I	Corn	.08	.50	1.00	1.28	1.50
VI	Corn	.08	.25	.50	.64	.75
	D P	.08	.25	.50	.64	.75
	C S M	.02	.13	.16	.16	.16
VII	Corn	.08	.25	.50	.64	.75
	D P	.08	.25	.50	.64	.75
	L O M	.02	.13	.16	.16	.16
VIII	Corn	.08	.50	1.00	1.28	1.50
	W P	.16	.80	4.00	4.80	4.40
IX	Corn	.08	.25	.50	.64	.75
	D M P	.08	.25	.50	.64	.75
X	Corn	.08	.25	.50	.64	.75
	D P	.08	.25	.50	.64	.75

On February 3d, the corn in Lot 1 was reduced to 1.00 per head and on the 10th it was necessary to drop it to 5.4 pounds. It was raised to 5.7 pounds on February 21 where it was held for the rest of the time. The other lots were

reduced and raised in proportionate amounts.

Description of feeds. The shelled corn used was #3 yellow dent bought on the market and fed whole. The hay was a fair quality of #2 irrigated alfalfa of first and second cuttings. It was delivered direct from the farm where it was raised. Dried pulp and dried molasses pulp were purchased from the Great Western Sugar Company and shipped from their Brighton factory. The total supply was shipped at once and stored at the feedlot granary. Wet pulp was purchased from the same company and hauled from the Fort Collins factory by team in lots of 3 to 4 tons as needed. Linseed and cottonseed meals were purchased sacked on the market, and stored at the feedlot granary.

Feed costs. Following are the feed costs, per ton.

Corn	$28.00	Alfalfa	$12.00
D P	25.00	C S M	40.00
D M P	26.00	L O M	55.00
W P	1.50	Salt	20.00

Analysis of feeds. Table XV, from Henry and Morrison (16), gives the average digestible nutrients of the different feeds, in percentage. The figures for true protein and therms of energy are from Armsby. (17) Percent of fibre is included in the table, although it is not digestible in calculable amounts.

The feeds were tested by the department chemist for moisture content and his figures used for calculating feeding

value of pulps. Other chemical analyses were not made and calculations were based on the figures in Table XV.

TABLE XV

DIGESTIBLE NUTRIENTS IN FEEDS

In Percents (16) (17)

Feed	Water	D. M.	C. Pro.	Fibre	C. H.	Fats	True Pro.	Therms
D P	8.2	91.8	4.6	18.9	65.2	.8	.7	75.87
D M P	7.6	92.4	5.9	15.9	68.0	.6	3.5	76.28
W P	90.7	9.3	.5	2.1	6.5	.2	.5	8.99
Corn	14.8	85.2	7.1	1.9	64.6	4.4	7.0	85.5
C S M	7.8	92.5	37.0	8.1	21.8	8.6	32.0	90.0
L O M	9.6	90.0	31.7	8.7	37.9	2.8	30.9	85.12
Alf	8.6	91.4	10.6	28.3	39.0	.9	7.1	34.23

Weighing of Lambs

At the beginning of the experiment, the lambs were weighed individually three days in succession. The average of these three weights was taken as the initial weight. On these initial weights, the lambs were allotted to the separate pens. Thereafter, they were weighed individually every thirty days and by lots at ten days' intervals between. At the end of the 91, 99 and 130 days' periods, the lambs to be shipped were weighed three days in succession and the average of the three weights given as final weights. The last of the three weighings, at the end of the 130-day period, was taken in a rain storm which

made weights so inaccurate that this day's weighings were not used in the calculations of final feedlot weights.

The weighings were all made between 8:00 and 10:00 a. m.

Dead animals were weighed as soon after death as possible.

Feedlots

The feedlots were located together at the Experiment Farm. They run north and south, side by side, with tight board fences between them and, outside, on the north and west. The lots slope slightly to the south. All lots are identical as to shelter, drainage and sunshine.

The pens consisted of a hay feeding lot where the lambs were kept all day and a separate grain feeding pen used in turn by two lots.

Equipment

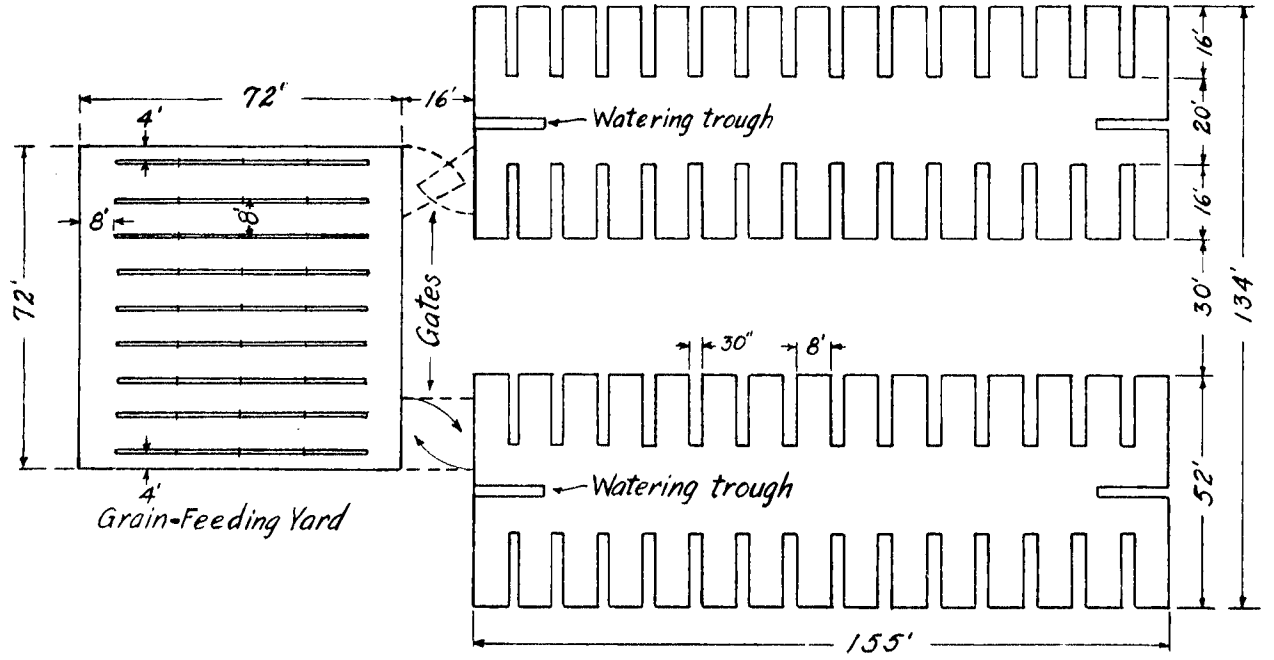
The feedlot equipment was planned to closely duplicate that used in the better equipped feedlots of the region. The hay was fed in self-feeding racks, holding about 1200 pounds. The shape of these necessitated the working down of hay as it was eaten but made it possible for hay to be always available. See page 56.

Grain and other concentrates were fed in reversible troughs, one foot wide and sixteen feet long, resting on

SHEEP-FEEDING EQUIPMENT

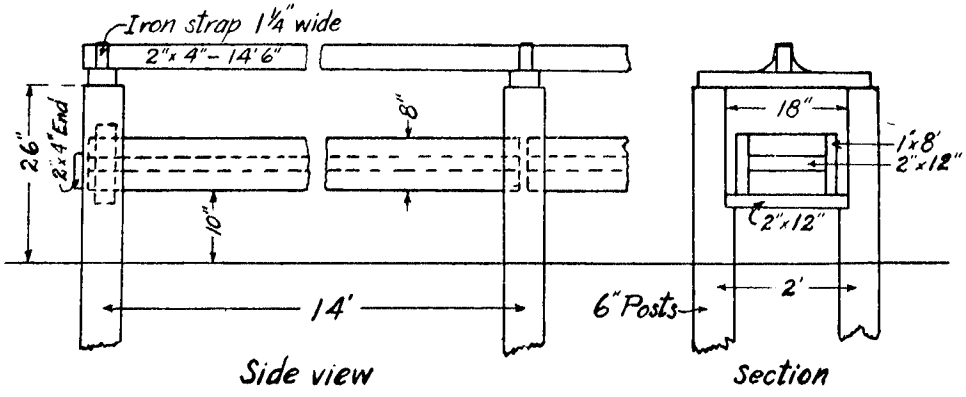
COLORADO AGRICULTURAL COLLEGE
EXTENSION SERVICE

E. J. MAYNARD F. L. COOPER

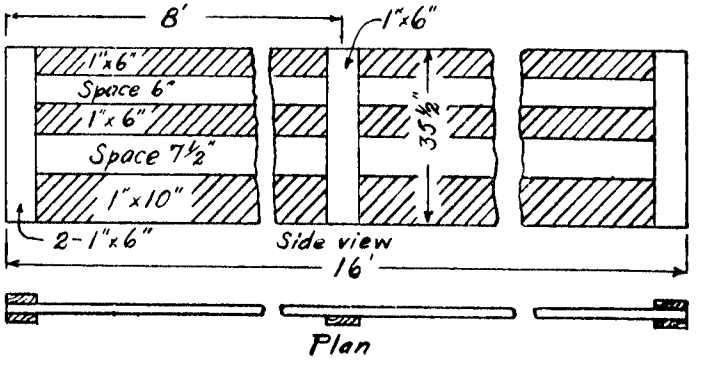


Grain-Feeding Yard

Model Sheep-Feeding Yards.



Reversible Sheep-Feeding Trough.



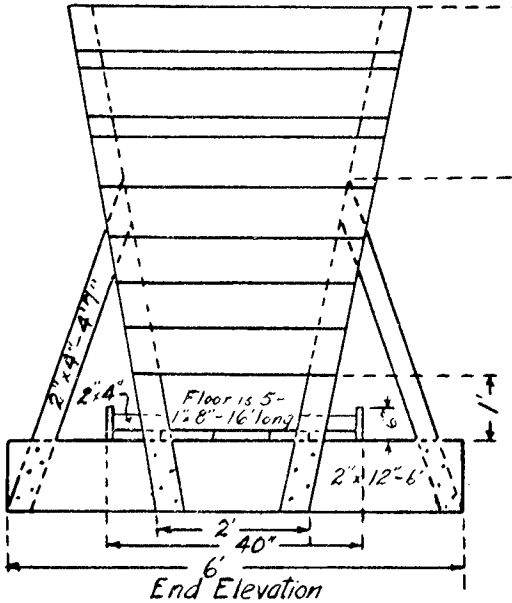
Feeding Panel

SHEEP-FEEDING EQUIPMENT

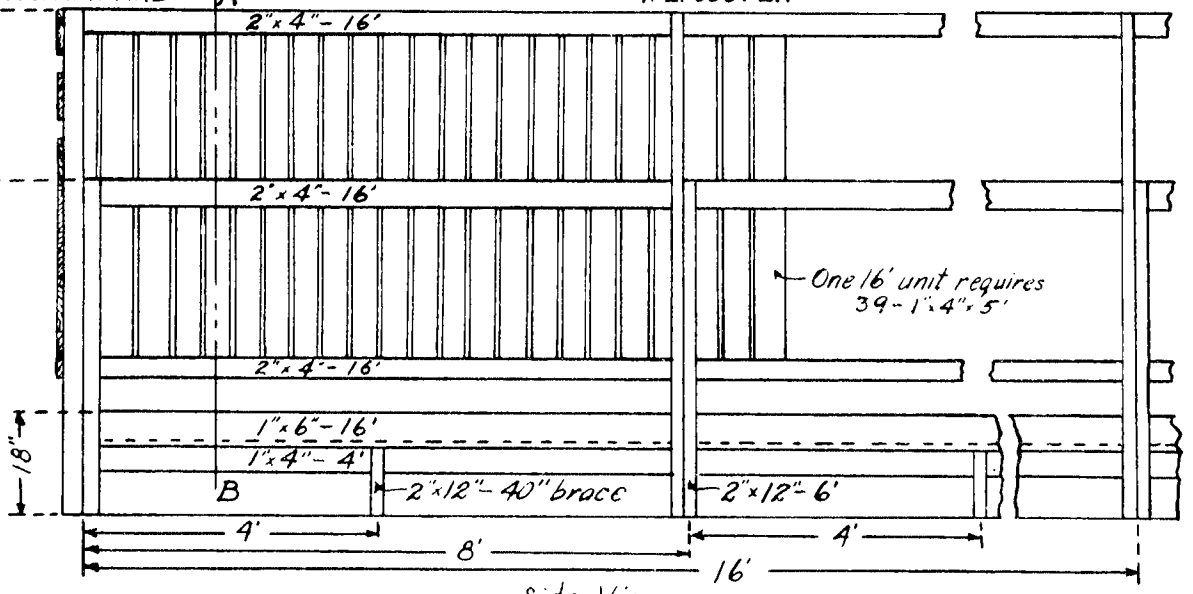
COLORADO AGRICULTURAL COLLEGE
EXTENSION SERVICE

E. J. MAYNARD

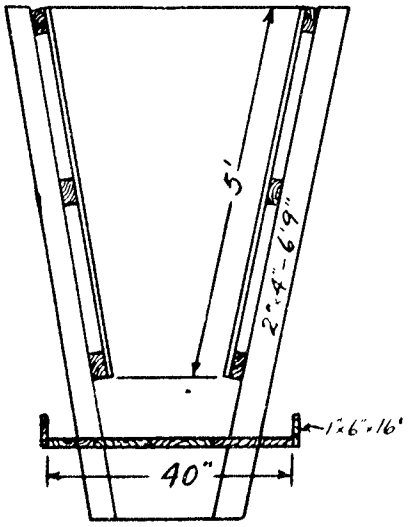
F. L. COOPER



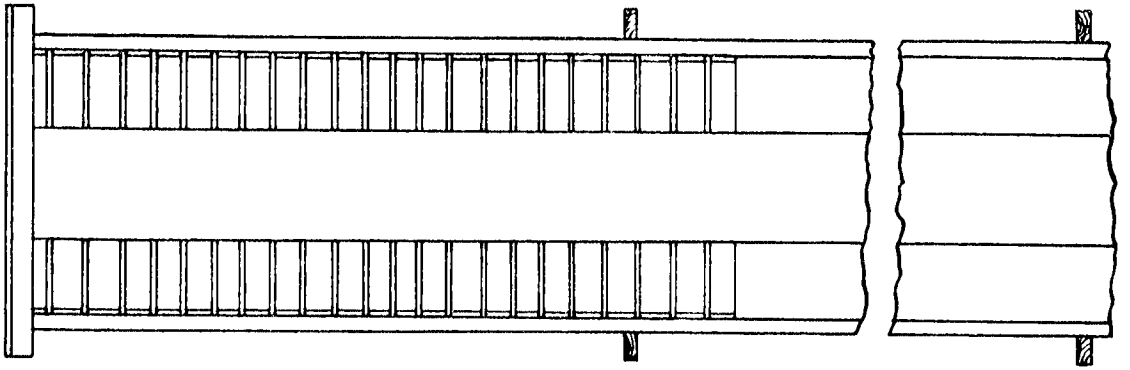
End Elevation



Side View



Section A-B.



Plan

Self-Feeder Hayrack

crosspieces between two posts. They were so constructed that, after one lot was fed, the trough was dumped and the second lot was fed on the reverse side of the trough. See page 55.

Housing

The lambs had no housing throughout the experiment. The only shelter was the windbreak afforded by the fences and hay racks. The pens were not cleaned of manure nor were the sheep bedded excepting two times when, during wet snows, straw was thrown in, in quantities sufficient to supply dry bedding for all sheep. This method of handling is comparable to that used in commercial feedlots of the region.

Water and Salt

Water was supplied in troughs, in the pens and was available to all of the lambs at all times. The troughs were refilled each morning. Salt was supplied in small sheltered boxes and was before the sheep at all times. It was #4 loose.

Records

Permanent records show the amounts of all feeds supplied to the lots each day, all weighings and all weights taken, all lambs that died, together with the date of death, weight and post-mortem findings, analyses of feeds and observations.

Observations

Daily inspections and observations as to the weather, condition and health of lambs, feeding avidity of lots and any other factors affecting the experiment were made and recorded. Daily inspections of feeds were made and ten day samplings were made to be examined by the department chemist.

EXPERIMENTAL RESULTS

Tables XVI and XVIII give a summary of the experimental results of the test. The lambs were consigned to market in three shipments. At the end of 91 and 99 days, all lambs weighing over 97 pounds were marketed. At the end of 130 days, all the lambs left were shipped. The lamb days were calculated by adding together the days that each lamb of the lot was on feed.

Since the lambs were shipped when they were considered ready for market, the final weights of each lot were not far apart, the significant fact being that, in some lots, it took fewer lamb days to produce the requisite weight for market.

At the close of the experiment, the figures for the initial weights per lot were revised by subtracting the initial weight of the lambs that died. The feed that was consumed by these lambs that died,, was also subtracted by a calculation of the lamb days they were in the feedlot and multiplying that by the amount of feed consumed by the lot, per lamb day. Thus, the figures in Tables XVI and XVIII are for the lambs that lived and were shipped to market.

This procedure is believed justifiable because, with small lots of 25 lambs each, the death of one lamb made a loss out of proportion to that experienced in practice. The figures, as given, are readily comparable to local conditions by a calculation on the basis of the normal percentages of death losses.

The death loss, apparently, presents no factor significant to the rations fed, as Lots VII and IX, where there was no death loss, had as much trouble from overfeeding resulting in lambs off feed and scouring as did Lots VIII or X where a lamb died in each lot.

TABLE XVI.

WEIGHTS AND GAINS PER LAMB

Nov. 10, 1925 to Feb. 10, Feb. 18, and Mar. 26, 1926

25 lambs per lot

Lot	I	VI	VII	VIII	IX	X
Ration	Corn Alf	Corn D P C S M Alf	Corn D P L O M Alf	Corn W P Alf	Corn D M P Alf	Corn D P Alf
Initial Wt. at Feedlot	68.60	68.14	68.83	68.04	68.73	68.30
Final Wt. at Feedlot	103.73	103.30	103.29	105.37	103.79	103.08
Feedlot Gain	35.13	35.16	34.46	37.33	35.06	34.78
Market Wt.	98.33	97.50	97.60	98.75	98.0	97.50
Shipping) Pounds	5.39	5.80	5.69	6.62	5.79	5.58
Shrink) %	5.20	5.61	5.51	6.25	5.58	5.42
Net Gain at Market	29.73	29.36	28.77	30.01	29.27	29.20
Carcass Wt.	51.13	50.04	51.38	50.67	48.88	48.96
Dressing %	51.99	51.32	50.53	51.31	49.88	50.21
Lambs shipped	24	24	25	24	25	24
Lamb days on Feed	109.5	107.3	105.0	99.5	103.5	109.5
Av.Gain per day (Feedlot Wt.)	.321	.328	.326	.375	.339	.318
Av.Gain per day (Market Wt.)	.271	.274	.272	.309	.283	.267
Lambs shipped Feb. 10	11	10	10	14	13	11
Lambs shipped Feb. 18	2	5	7	6	5	2
Lambs shipped Mar. 26	11	9	8	4	7	11
Lambs died	1	1	0	1	0	1

REPLACEMENT VALUE OF DRIED PULP, WET PULP AND DRIED MOLASSES PULP IN TERMS OF CORN AND ALFALFA

The replacement value of the different pulp feeds in terms of corn and alfalfa saved by introducing the pulp into a ration of corn and alfalfa is used in this work as an index of value for comparing these feeds.

This gives a figure that can be stated in dollars and cents. It also gives a practical figure for feeders as it shows an actual saving and not a theoretical one.

But this must not be misunderstood. This monetary figure is not an absolute value true under all conditions and for all time. A shifting of prices of feeds very probably will change it, though the figure given is readily translatable to new prices.

A change in the rations used may change the replacement values found. Thus we find a different replacement value in the experiments at the Nebraska Experiment Station in 1925-26, where the pulps were compared with other feeds than corn and alfalfa.

A slight change in the quality of one feed in a ration may cause the lambs to eat less of that feed and more of a self-fed feed like alfalfa, and so affect the replacement value.

The moisture content of the pulp used must be considered in placing a value on it for the amount of dry matter fed is the true measure of the amount of the feed given.

With this explanation of how the replacement value of

a feed is affected, it is readily seen that dependable average values can only be secured by a repetition of experimental tests.

In Lots I, VIII, IX and X, the test attempted a direct comparison of the feeding value of wet pulp, dried pulp and dried molasses pulp with that of corn and with each other.

Results of the test indicate that in Lot VIII, 1178.64 pounds of wet pulp replaced 63.42 pounds of corn and 371.78 pounds of alfalfa. This would give, at present prices, a replacement value of $5.29 per ton for wet pulp. As there was calculated a dry matter content of 232.6 pounds of dry matter to the ton, this dry matter would have a replacement value of $2.275 per hundred pounds.

In Lot IX, 184.32 pounds of dried molasses pulp replaced 195.84 pounds of corn and 22.65 pounds of alfalfa. A replacement value of $31.22 per ton is indicated for the dried molasses pulp and its dry matter content had a replacement value of $1.73 per hundred pounds.

In Lot X, 196.40 pounds of dried pulp replaced 183.87 pounds of corn and 34.25 pounds of alfalfa. From this we can calculate a replacement value of $28.31 per ton for dried pulp giving its dry matter content a value of $1.57 per hundred pounds.

The wet pulp having a replacement value of $2.275 per hundred pounds dry matter, cost $.69 per ton with a haul up to 5 miles from the factory so that it had a value of

229.10% more than its cost. The dried molasses pulp with a replacement value of $1.73 per hundred pounds of dry matter cost $1.44 per hundred pounds dry matter. Its feeding value was, then, 20.10% more than its cost. The dried pulp cost $1.39 per hundred pounds dry matter and its replacement value was $1.57 or 12.90% more than its cost.

These figures show a saving in replacing a part of the corn in a ration of corn and alfalfa with any of the three forms of sugar beet pulp. The greatest saving is made by the use of wet pulp, the next best saving was in using dried molasses pulp and the least saving was affected by the use of dried pulp. These figures are enumerated in Table XXI.

VALUE OF COTTONSEED AND LINSEED MEALS

In Lot VI a ration of corn, dried pulp and cottonseed meal was fed with alfalfa and in Lot VII a ration of corn, dried pulp, linseed meal, was fed with alfalfa. These tests give a direct comparison with Lot X where corn, dried pulp and alfalfa were fed.

In Lot VI, 188.33 pounds of dried pulp and 55.91 pounds of cottonseed meal replaced 191.81 pounds of corn and 84.14 pounds of alfalfa. The dried pulp here had a replacement value of $21.96 per ton. Its dry matter content had a replacement value of $1.22 per hundred pounds.

In Lot VII, 191.53 pounds of dried pulp and 55.70 pounds of linseed meal replaced 188.63 pounds of corn and 128

pounds of alfalfa. This indicates a replacement value of $19.61 per ton or $1.09 per hundred pounds of its dry matter.

In Lot X, where dried pulp was fed with corn and alfalfa without a high protein concentrate, the dried pulp had a replacement value of $1.57 per hundred pounds dry matter. With cottonseed meal added to this ration, the pulp had a replacement value of $1.22 per hundred pounds dry matter and with linseed meal added instead of cottonseed meal, it had a replacement value of $1.09 per hundred pounds dry matter. It will be seen from these figures that the addition of cottonseed or linseed meal lessened the replacement value of the dried pulp, materially. With a cost of $1.39 per hundred pounds dry matter, the cost of the dried pulp exceeded its feeding value in the rations including cottonseed and linseed meals. As the value of dried pulp was greater than its cost in Lot X, it is evident that it was not profitable to add cottonseed meal or linseed meal to a ration of corn, dried pulp and alfalfa in this experiment.

Weights and gains. A compilation of the data on weights and gains is given in Table XVI. In this study, the calculations are based on the final weights at the Denver market, because it is on these weights that a feeder must figure the values of rations fed.

A difference is noted in dressing percent and commercial carcass grades of the different lots, but these figures do not enter into our calculations in this study.

Carcass weights show a difference in dressing percent of the lambs fed different rations, being least favorable to the dried molasses pulp lambs in comparison to the lambs of the other lots. As this has no bearing on the prices received for these lots of lambs, it has been given no place in the study of the comparative feeding value of the pulp feeds.

The carcasses of the lambs of each lot were graded by an expert of the Armour Packing Company of Denver, but these gradings were made largely on weight giving preference to the lighter lambs, as is customary in commercial grading. The finish in the different lots was so uniform that no difference was noted as to quality or condition. The only comment made on quality of flesh in the carcasses was that the lambs in the dried molasses pulp lot in the first shipment had what seemed somewhat softer flesh than the rest. This was enough to be noticed by the author, on examination, the day after the lambs were killed.

A comparison of the gains per day made by the different lots, shows that the lambs of Lot VIII fed wet pulp, corn and alfalfa made the best gains and those of Lot IX on corn, dried molasses pulp and alfalfa made the second best. The other lots were not far apart with a slight advantage for the dried pulp lambs fed cottonseed meal or linseed meal and the poorest showing was made on dried pulp, corn and alfalfa.

The lambs on wet pulp, corn and alfalfa showed the greatest shrink but, in spite of this, they showed the greatest

gains based on market weights. The lambs of Lot X, fed dried pulp, corn and alfalfa showed the lowest gains, but this was partly compensated for by a lesser shrink.

The average daily ration consumed shows that wet pulp made a greater saving of alfalfa than the other pulp feeds. The lambs fed dried pulp ate less alfalfa than those fed dried molasses pulp, though this was compensated for by the greater gains made by the latter.

Observations showed no great difference in the eagerness with which the different lots came to feed. The lambs fed dried pulp and dried molasses pulp took a trifle longer to eat a feed than those fed corn alone. This may be due to the dryness of the pulp and not to any lack of palatability, as these lots cleaned up their rations as well if not better than the others. At the last of the feeding period, the lambs in Lot VIII, on corn and wet pulp, refused to clean up their ration, which necessitated their finishing the last few days on a lower corn basis than the other lots.

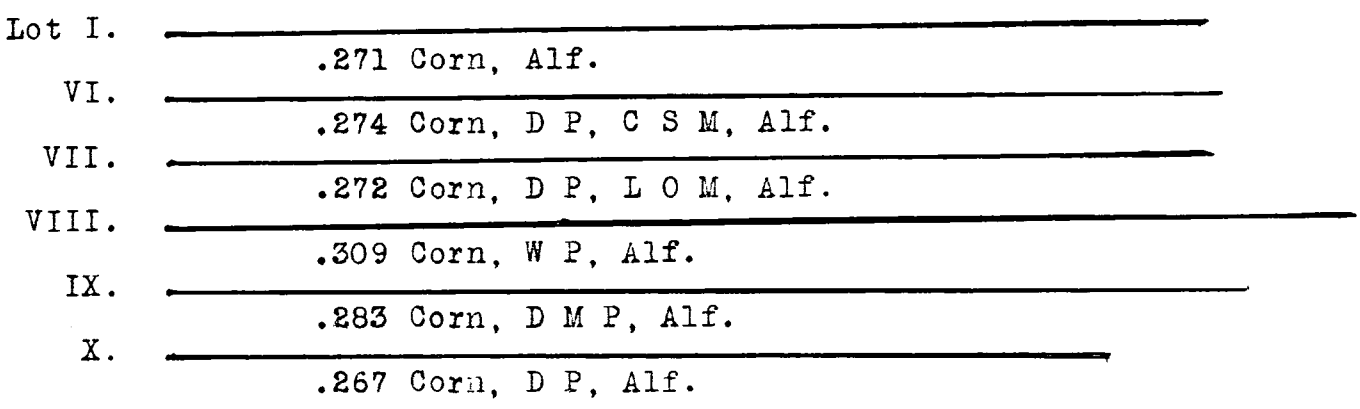
TABLE XVII.

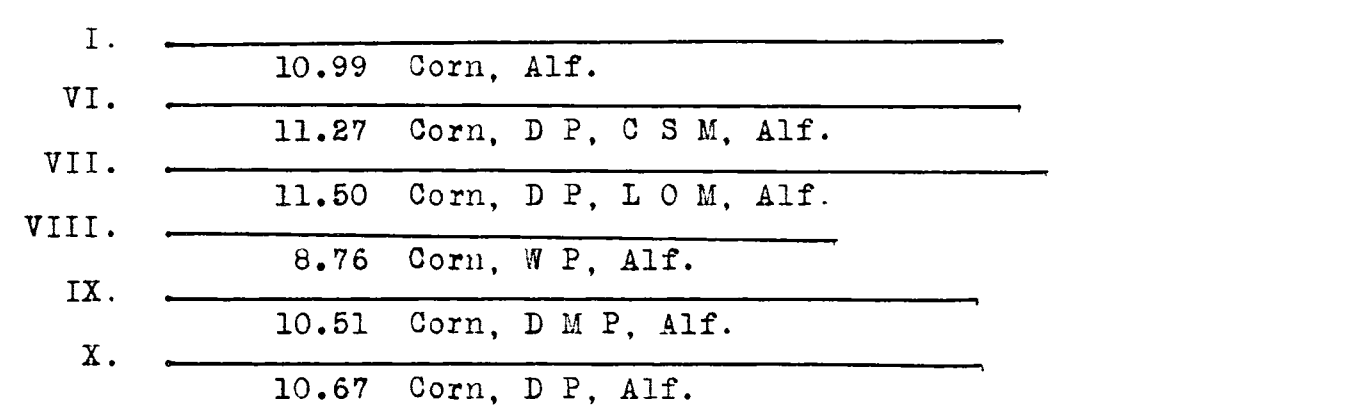
BUSINESS STATEMENT

Lot	I	VI	VII	VIII	IX	X
Ration	Corn Alf	Corn D P C S M Alf	Corn D P L O M Alf	Corn W P Alf	Corn D M P Alf	Corn D P Alf
Average Daily Ration						
Corn	1.03	.52	.52	.98	.52	.52
D P		.52	.52			.52
D M P					.52	
W P				3.64		
L O M			.15			
C S M		.15				
Alf	2.56	2.35	2.32	1.77	2.61	2.43
Cost (per lamb at initial weight at $13.50 per cwt.)	9.26	9.20	9.29	9.19	9.28	9.22
Expense (Interest at 8%, shipping & selling expense at carload rates)	.58	.58	.59	.57	.58	.58
Total Cost (per lamb at market)	13.36	13.34	13.44	12.70	13.19	13.17
Return (per lamb at market at $12.00 per cwt)	11.80	11.70	11.71	11.86	11.80	11.70
Loss (per lamb)	1.56	1.64	1.73	.84	1.39	1.47

The business statement shows the costs and returns of an average lamb of each lot. These being actual results calculated on a carlot basis are readily comparable to practical feedlot conditions by allowing for normal death loss and are comparable one with another on the basis of rations fed.

CHART I.





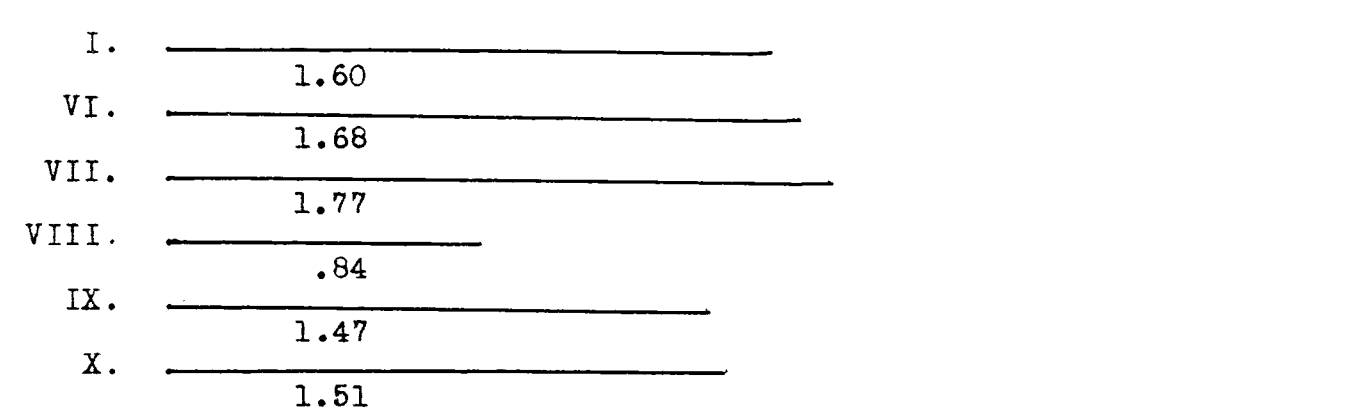


Chart I gives a graphic presentation of the difference between the results in the different lots, in the daily gains per lamb, the feed cost per hundred pounds gain and the loss per lamb.

TABLE XVIII.

FEED CONSUMED

Lot	I	VI	VII	VIII	IX	X
Ration	Corn Alf	Corn D P C S M Alf	Corn D P L O M Alf	Corn W P Alf	Corn D M P Alf	Corn D P Alf
Total Feed Consumed						
Corn	2713.87	1328.05	1378.30	2335.19	1349.70	1376.54
D P		1327.07	1377.50			1376.54
D M P					1348.90	
W P				8686.57		
L O M			400.60			
C S M		394.00				
Alf	6739.17	6061.36	5870.00	4219.58	6745.00	6378.33
Average Daily Feed per Lamb						
Corn	1.03	.52	.52	.98	.52	.52
D P		.52	.52			.52
D M P					.52	
W P				3.64		
L O M			.15			
C S M		.15				
Alf	2.56	2.35	2.32	1.77	2.61	2.43
Feed Required for 100 Pounds Gain						
Corn	360.27	188.46	191.64	316.85	184.43	196.40
D P		188.33	191.53			196.40
D M P					184.32	
W P				1178.64		
L O M			55.70			
C S M		55.91				
Alf	944.31	860.17	816.17	572.53	921.66	910.06
Feed Costs per 100 Pounds Gain						
	10.99	11.27	11.50	8.76	10.51	10.67
Feed Cost per Lamb						
	3.27	3.31	3.31	2.69	3.08	3.11

Moisture Content of Wet Pulp

In comparing the feeding value of wet pulp with that of other feeds, it is important to consider the moisture content of the pulp. As it comes from the factory it is wet enough to be slushed through a pipe. It drains in the silo and loses some moisture in curing.

During the present feeding season, 1925-26, the wet pulp used was weighed when purchased at the company silo, on its arrival at the feedlot granary and as fed to the stock or when hauled away as waste. Below we give the weights on the total amount used during this season by the department, together with the percent moisture in it as calculated from the weights and the moisture content of the pulp as fed.

Total weight at factory	164,150 pounds	91.58% moisture
Total weight at feedlot	159,735 pounds	91.35% moisture
Total weight fed or accounted for	118,812 pounds	88.37% moisture

The average of 30 samples taken over a period of the last five years at the Colorado Experiment Station gives a moisture content of wet pulp as 87.5%. The average of 22 samples taken in the months of November to March, these being the ones in which this experiment was conducted, give an average moisture content of 87.89%. These figures give a good idea of the average moisture content of pulp as fed. The samples ranged from 86.10 to 90.9% moisture.

During the progress of this experiment, samples were

taken at ten-day intervals of the wet pulp as fed. The average of these samples was 88.37% moisture. This is the figure used in the calculations of the value of the dry matter in wet pulp in this study.

TABLE XIX

ANALYSES OF FEED CONSUMED

Lot	Crude Protein	Fibre	Carbo-hydrates	Fats	True Protein	Therms	Ration
Daily Ration per Lamb							
I	.3445	.844	1.6637	.0684	.189	1.7569	Corn, Alf
VI	.3654	.7854	1.6242	.0611	.2189	1.7889	Corn, DP,CS,Alf
VII	.3543	.7778	1.6366	.0521	.2151	1.7713	Corn, DP,LO,Alf
vIII	.27995	.6151	1.6191	.0663	.1553	1.8528	Corn, WP, Alf
IX	.3443	.8312	1.7074	.0495	.1891	1.7347	Corn, DMP, Alf
X	.3184	.7959	1.6227	.0489	.1753	1.6813	Corn, DP, Alf
Feed Required for 100 Pounds Gain							
I	115.08	245.79	562.01	23.45	85.17	597.32	Corn, Alf
VI	133.91	287.13	592.20	22.35	93.47	648.78	Corn, DP,CS,Alf
VII	126.59	275.67	588.10	18.87	89.91	635.94	Corn, DP,LO,Alf
VIII	90.56	199.00	523.79	22.04	70.20	599.40	Corn, WP, Alf
IX	121.66	293.64	603.93	17.51	84.80	613.77	Corn, DMP, Alf
X	119.44	298.40	609.84	18.40	79.73	432.06	Corn, DP, Alf

Table XIX is taken from calculations based on Henry and Morrison (16) and Armsby (17), corrected to 88.37% moisture content. Had they been based on actual chemical analyses of feed, there might have been more correlatio noted in the following pages.

TABLE XX

RANK OF LOTS AS TO GAINS AND NUTRIENTS CONSUMED

Lots are placed in order of rapidity of feedlot gains, and of amounts of elements consumed; 1 being greatest.

Daily ration per lamb

Rank	Crude Protein	Fibre	Carbo-hydrates	Fats	True Protein	Therms	Daily Gain
1	VI	I	IX	I	VI	VIII	VIII
2	VII	IX	I	VIII	VII	VI	IX
3	I	X	VII	VI	IX	VII	VI
4	IX	VI	VI	VII	I	I	VII
5	X	VII	X	IX	X	IX	I
6	VIII	VIII	VIII	X	VIII	X	X

Feed required for 100 pounds gain

1	VI	X	X	I	VI	VI	VIII
2	VII	IX	IX	VI	VII	VII	IX
3	IX	VI	VI	VIII	I	IX	VI
4	X	VII	VII	VII	IX	VIII	VII
5	I	I	I	X	X	I	I
6	VIII	VIII	VIII	IX	VIII	X	X

Table XIX gives the chemical analyses of the daily ration per lamb in each lot and of the feed required for 100 pounds gain in each lot. Table XX shows the different lots ranked according to daily gains based on feedlot weights and on consumption of different nutrients of the feeds, in an attempt to find some factor in the ration that would show a correlation with the gains produced.

In the light of this study the author is unwilling to ascribe any of the difference in the different lots to a difference in the chemical constitution of the rations fed without the influence of other factors. Each attempt at correlation is confronted with some contradiction and some of

these are apparantly contradictory to accepted ideas.

Thus we find that Lot VIII, which made the most rapid daily gains, consumed the least amount of protein and carbohydrate nutrients daily. But Lot X, which made the poorest gains was next to Lot VIII in consumption of proteins and carbohydrates. We do find that the ration of Lot VIII was high in fat content; but the ration of Lot I which made second lowest gains was even higher in fat content than that of Lot VIII and it was high in carbohydrates and fairly high in proteins also. Lot VIII was fed a ration that was highest of all lots in therms of energy per day and the most of the other lots are ranked in order of gains in the same order as their rations are ranked for therms of energy. But Lot IX, which made second most rapid gains, was fed next to the least amounts of therms of energy per day.

A deeper study into the chemical analysis of the rations used will probably discover light where darkness has baffled the author of this study. We must not overlook the effect in some cases of the succulence of the wet pulp ration of Lot VIII. More knowledge of the action of vitamins may solve the problem. A further discussion of the subject will be taken up under the study of replacement value of the pulp feeds.

TABLE XXI

REPLACEMENT VALUES OF

DRIED PULP, WET PULP AND DRIED MOLASSES PULP

		Dried Pulp	Dried Mol. Pulp	Wet Pulp
Replacement by 1 T.	(Corn, lbs.	1872.7	2125.9	107.6
	(Alfalfa, lbs.	348.3	245.3	630.9
Value replaced	(Corn	$ 26.22	29.76	1.51
	(Alfalfa	2.09	1.47	3.79
Av. % moisture as fed		9.90	9.81	88.37
Pounds D. M. per ton		1802	1803.8	232.6
Replacement Value per T.		$ 28.31	31.23	5.29
Present price per T.		$ 25.00	26.00	1.50
Replacement Value per cwt. D. M.		$ 1.57	1.73	2.275
Cost per cwt. D. M.		$ 1.39	1.44	.69
% value over cost		12.9	20.1	229.1

Note--The present price per ton of wet pulp is for a haul up to five miles from factory.

The replacement values of the dry matter of dried pulp, dried molasses pulp and wet pulp are set forth in Table XXI. These figures are based on the moisture content of the feeds as sampled every ten days during the experiment and tested by the department chemist. The values are calculated on the present prices of feeds (See page 29).

CHART II

REPLACEMENT VALUE OF ONE TON OF WET PULP, DRIED PULP AND DRIED MOLASSES PULP IN TERMS OF CORN AND ALFALFA

Wet Pulp	$ 5.29	
Dried Pulp	28.31	Value
D. M. Pulp	31.23	Cost

REPLACEMENT VALUE OF 100 POUNDS OF THE DRY MATTER IN WET PULP DRIED PULP AND DRIED MOLASSES PULP IN TERMS OF CORN AND ALFALFA

Wet Pulp	2.275
Dried Pulp	1.57
D. M. Pulp	1.73

TABLE XXII

REPLACEMENT VALUE OF BEET PULPS ON BASIS OF ENERGY VALUE

		Dried Pulp	Dried Mol. Pulp	Wet Pulp
Replacement Value per 100# D. M. (Table XX)		$ 1.57	1.73	2.275
Energy Value per 100# dry matter (Table XV)	Therms	84.2	84.5	77.3
Replacement Value per Therm		$ .0174	.0205	.0209

Table XXI shows the replacement value of dried beet pulp, dried molasses pulp and wet pulp in comparison with the energy values calculated from Armsby (17), for the same. This calculation seems to indicate that there is no correlation between the replacement value and the energy value of the different forms of beet pulp. Apparently such factors as succulence of the ration exert considerable influence in the feed values.

TABLE XXIII

CHEMICAL COMPOSITION OF DRIED PULP, DRIED MOLASSES PULP AND WET PULP COMPARED WITH THAT OF CORN AND ALFALFA REPLACED.(16)(17)

	Crude Protein	C H & Fx 2.25	Carbo-hydrates	Fats	True Protein	Therms
Wet Pulp	7.37	102.45	95.81	2.95	7.37	132.51
Feeds replaced	31.89	143.84	134.03	4.36	22.34	130.43
Dried Mol. Pulp	10.87	127.84	125.34	1.11	6.45	140.60
Feeds replaced	4.29	99.28	83.42	7.05	6.82	124.15
Dried Pulp	9.03	131.58	128.05	1.57	1.37	149.00
Feeds replaced	4.67	95.12	80.22	6.62	6.81	117.89

TABLE XXIV

COMPARISON OF AMOUNT OF EACH CHEMICAL COMPONENT OF REPLACED FEEDS IN PERCENTS OF THAT COMPONENT IN PULP FED

	Crude Protein	C H & Fx 2.25	Carbo-hydrates	Fats	True Protein	Therms
Wet Pulp	4.32	1.40	1.39	1.48	3.03	.98
Dried Mol. Pulp	.39	.77	.67	6.35	1.06	.88
Dried Pulp	.52	.72	.63	4.22	4.97	.79

From the amounts of different feeds required to produce 100 pounds gain, is figured the replacement value of the different kinds of pulp in terms of the equivalent amounts of corn and alfalfa. (See page) Table XXIII is a compilation of the chemical composition of these two equivalent feeds. Table XXIV gives the amount of each chemical unit in the equivalent feeds that is replaced by a unit of the same kind in the pulp. (This figure is found by dividing the amount of a certain chemical unit in the replaced feed by the corresponding number in the pulp, shown in Table XXIII just above.)

It is very evident from this calculation that there is no correlation between the amounts of nutrients in corn that will be replaced by the nutrients in the pulps. Thus, one therm in wet pulp replaced .98 therm in corn and alfalfa while a therm in dried pulp only replaced .79 therm in corn and alfalfa. A gram of carbohydrate material in wet pulp, dried pulp or dried molasses pulp does not replace the same amounts of carbohydrates in the feeds replaced. Column 2, in

Tables XXIII and XXIV, is found by calculating the energy value of the fat in terms of carbohydrates by multiplying by 2.25 and adding that to the carbohydrates.

Such difference, then, as may be found in the replacement value of dried pulp, wet pulp and dried molasses pulp cannot be ascribed to any certain components in the chemical composition and the ability to satisfy body needs in different proportions nor to the difference in the energy value contained in the pulp.

TABLE XXV

REPLACEMENT VALUES OF

DRIED PULP, DRIED MOLASSES PULP AND WET PULP

FROM DIFFERENT EXPERIMENTS

In terms of corn and alfalfa at "present prices".

Experiment	Dried Pulp	Dried Mol. Pulp	Wet Pulp
Nebr. Exp. Sta. 3 years		$ 1.69	$ 1.01
Colo. Exp. Sta. All Experiments (Non-comparable basis)	$ 1.60	1.56	1.38
Colo. Exp. Sta. Tests (Comparable with Wet Pulp)	1.60	1.36	2.16
Colo. Exp. Sta. 1925-26	1.57	1.73	2.275

Table XXV is given as a summary of the different studies made of the feeding value of wet pulp, dried pulp and

dried molasses pulp. It illustrates the fact that different values are obtainable under different conditions. It gives a good general idea of the value of the pulp feeds as determined by experimentation with lambs up to the present time.

SUMMARY

The feeding value of sugar beet by-products is a problem of great importance to the livestock feeders of Colorado and contiguous territory.

The more eastern agricultural colleges have, in the past, emphasized the importance of using farm raised feeds, but, in the western part of the plains region, a study of some commercial by-products seems justified by the disadvantages in corn production, the high prices of corn and the steadily increasing prices of alfalfa hay due to bacterial blight and other troubles.

The present study of the feeding value of the sugar beet by-products, dried pulp, dried molasses pulp and wet pulp, when fed in a ration of corn and alfalfa to fattening lambs may be summarized as follows:

1. Wet pulp, where it is practical to use it with a ration of corn, and alfalfa, is more valuable at present prices, than dried pulp or dried molasses pulp and more valuable than corn without pulp, chiefly because of the low cost of dry matter it contains. One hundred pounds of dry matter in wet pulp which costs only $.69 at present prices,

when hauled five miles or less from the factory, was shown in the present tests to have a feed replacement value of $2.275 or 229.1% more than its cost in replacing part of the corn in a ration of corn and alfalfa.

2. Dried molasses pulp, when fed in a ration of corn and alfalfa to fattening lambs, was less valuable than wet pulp, more valuable than dried pulp, and more valuable than corn without pulp at present prices. One hundred pounds of the dry matter in dried molasses pulp which cost, at present prices, $1.44 in the feeding test proved to be worth $1.73 or 20.1% more than its cost, in replacing part of the corn in a ration of corn and alfalfa.

3. Dried pulp, when fed in a ration of corn and alfalfa to fattening lambs, seemed to have, at present prices, the lowest comparative feeding value of any form of pulp. One hundred pounds of the dry matter in dried pulp, which cost $1.39, had a feed replacement value of $1.57 or only 12.9% more than its cost, in replacing part of the corn in a ration of corn and alfalfa.

4. Dried pulp, when fed in a ration of corn, pulp, cottonseed meal or linseed meal and alfalfa, did not have the replacement value that it did when fed in a ration of corn, pulp and alfalfa, without a high protein supplement, indicating that it did not pay, in this test, to add linseed meal or cottonseed meal to the ration of corn, pulp and alfalfa.

5. The study of this problem has given no clue to the

reason for the difference in the feeding value of the dry matter in dried pulp, dried molasses pulp and wet pulp.

6. The cost of the dry matter in dried pulp, dried molasses pulp and, more especially, wet pulp compared to the cost of the dry matter of corn shows that these feeds are priced much below their feeding value compared with corn and are, therefore, profitable substitutes for part of the corn in a ration of corn and alfalfa at present prices.

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