SUPPLEMENTING WHEAT STRAW IN THE WINTERING RATIONS OF BEEF CATTLE

by

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INTRODUCTION

The major problems with which the livestock producer is concerned are procuring good livestock and getting economical gains in weight. For the producer of beef cattle, getting cheap weight gains is not as much a problem as with other classes of livestock. Beef cattle are ruminants and therefore large quantities of roughages can be used in their rations. The roughages used in the ration of beef cattle are usually of medium or high quality. Frequently small amounts of low quality roughages are used. Low quality roughages have been used to some extent as extenders of the high quality feeds, but for the most part they have been used as bedding.

With the increase in the number of livestock being fed, the demand for high quality feeds has exceeded the supply. This caused the cattle feeder to use more low quality feeds. Wheat straw is a low quality feed that is produced abundantly in Kansas. The value of wheat straw in cattle rations has not been fully understood. If wheat straw can be used successfully in rations of beef cattle, the producer of beef would have access to a feed that is cheap and plentiful. The large supply of wheat straw would make this very important in years of droughts when the production of the higher quality roughages is curtailed.

The purpose of this work was to determine if wheat straw could be used successfully in the wintering ration of beef cattle. The three factors considered were gain in weight, the cost of gain, and the feed which best supplemented the use of wheat straw.

REVIEW OF LITERATURE

Wheat Straw Composition

According to Morrison (53) the percentage composition of wheat straw is total dry matter, 92.5 percent; digestible protein, 0.3 percent; total digestible nutrients, 40.6 percent; with 10 therms of net energy per hundred pounds.

Cereal Straws as Livestock Feeds

Because of the similarity of cereal straws, oat straw and barley straw will also be included in the review of literature.

Feeding trials have been conducted at various experiment stations in an effort to establish the value of cereal straws in livestock feeding. Among the most complete works reported in the literature is that of McCampbell (43-49) of the Kansas Station. In his work with wheat straw McCampbell used "headed wheat straw". He stated that "headed wheat straw is finer straw than that obtained from bound wheat". In his first work he reported that 3.5 pounds of alfalfa hay is a satisfactory protein supplement for wheat straw. In later work, McCampbell observed that wheat straw alone is not a satisfactory ration for pregnant cows in that it does not allow them to increase in weight during the wintering period (46). In the experiment from which he made this observation, ten cows fed wheat straw alone for 120 days lost 253 pounds. The ration which gave the best results was all the wheat straw they would eat, 30 pounds of sorghum silage and two pounds of cottonseed meal. In 1924, McCampbell et al (48) reported that cows can be wintered successfully on wheat straw alone with only a small loss of weight. In 1927 (49) he reported that cottonseed hulls fed ad libitum are better for wintering beef cattle than

wheat straw when both are supplemented with two pounds of cottonseed meal daily. The gains per ton on the two rations were, respectively, wheat straw, 29.50 pounds and cottonseed hulls, 70.96 pounds.

Arnett and McChord (5) reported that beef cattle can be wintered on wheat straw alone if they are in good condition at the close of the grazing season, if the weather is not too severe, and if the winter feeding period is short. In their experiments, cattle fed wheat straw supplemented with 5 to 10 pounds of hay daily, this prevented the extreme loss of weight that occurred when wheat straw alone was fed. One pound of cottonseed cake or 5 pounds of alfalfa hay was of equal value as a supplement to wheat straw. Wheat straw and 1.5 pounds of oil meal were not sufficient to maintain breeding cows which were extremely thin at the end of the grazing season. They also stated that cows and yearlings will maintain their weight on wheat straw, free choice, and 40 pounds of sunflower silage daily.

Shutt (57) stated that rust tends to arrest the development of the wheat plant and to induce premature ripening, resulting in a greater feeding value of the straw. Chemical analysis of this straw revealed that it had a higher protein content and a lower fiber content than the rust free straw. Cattle ate the rusted straw with relish but they refused straw seriously affected with rust.

Watson (69) states that straw has such a low feeding value that it can add little to the ration, unless there is a shortage of feed, in which case it may be used to furnish bulk to the ration. Grinding or chopping had no effect on its feeding value.

Duitsman and Kessler (21) using wheat straw, 1.5 pounds of cottonseed meal and midland milo fed at levels of 15.38, 13.61 and 15.38 pounds reported average daily gains of 1.11, 1.27 and 1.48 pounds. Two pounds of molasses

was added to the ration that gave 1.27 pounds of daily gain to replace two pounds of grain. The sprinkling of two pounds of molasses per head daily on the wheat straw increased the consumption of wheat straw 1.68 pounds. The costs per hundred pounds of gain were $51.99, $46.23, and $40.59 respectively. The cost per hundred pounds of gain was reduced $5.76 when molasses was used. This reduction was due in part to the molasses being cheaper per pound. Vitamin A was added to the ration in which the gain was 1.48 pounds and the cost $40.59 per hundred pounds. Wheat straw alone was worth less than 1/2 the value of Ellis silage in terms of gain.

Vinke and Arnett (66) reported that fleshy cows in good condition could be wintered on oat straw or barley straw alone if plenty of warm water and salt were provided. The addition of 5 pounds of mixed hay per head per day lowered the winter losses. They found that 1 pound of cottonseed meal or 5 pounds of alfalfa hay were of equal value in supplementing wheat straw. With 4.77 pounds of alfalfa hay substituted for an equal amount of oat straw in the ration, the winter gain increased from 60.1 pounds to 114.6 pounds.

Skinner and King (58) found that feeding oat straw instead of clover hay decreased the amount of feed eaten and the gains made but decreased the cost of gain $1.13 per hundred pounds and added $2.77 per steer to the profits. When clover hay was used instead of oat straw in a ration of shelled corn, cottonseed meal, and corn silage, the cattle finished better and sold $0.15 per hundred pounds higher. The feeding of oat straw instead of clover hay in a ration fed twice daily proved to be as efficient a way to fatten cattle as feeding clover hay. It effected a saving of $0.90 per hundred pounds of gain and added $5.11 profit per steer.

Morton et al (52) found that substituting oat straw for alfalfa hay in the ration decreased the daily gains and increased the amount of grain and

cottonseed meal required per hundred pounds of gain, thereby increasing the cost of the gains.

Johnson (34) reported that when alfalfa is in short supply and time is not an important consideration barley straw can be used efficiently in a wintering ration. Chopped alfalfa and ground barley produced daily gains of 1.9 pounds at a cost of $10.73 per hundred pounds. Barley straw and ground barley produced gains of 1.33 pounds at a cost of $10.63 per hundred pounds.

Johnson et al (35) reported barley straw unsatisfactory for wintering calves. In an experiment using calves weighing 436 pounds and feeding alfalfa and barley grain, the daily gains were 1.87 pounds at a cost of $10.66 per hundred pounds. With the same weight calves fed barley grain, alfalfa and barley straw the daily gains were 1.09 pounds at a cost of $13.43 per hundred pounds. On pasture following the winter feeding period the gain made by the calves fed barley straw with alfalfa and barley grain were 1.40 pounds per day at a cost of $10.31 per hundred pounds. For the calves fed alfalfa and barley grain the gains were 1.26 pounds per day at a cost of $9.71 per hundred pounds. Their conclusion was that substituting barley straw for 1/2 the alfalfa hay in rations fed ad libitum with 3 pounds of barley grain for wintering calves is not an economical practice from the standpoint of winter gains or gains made later on pasture.

Potter and Withycombe (55) stated that gains made in winter with any kind of hay, straw, silage or grain are very expensive, so much so that every pound of beef gained cost more than the market price of beef, even when the price of beef was high. In their experiments, calves fed 15 pounds of straw and 1 pound of cottonseed meal daily wintered satisfactorily. Raising the cottonseed meal to 2 pounds increased the daily gain, but not enough to justify the increased cost of the feed. Yearlings did as well as calves, but required more

straw in their daily ration. Calves given 4 pounds of alfalfa hay and all the straw they would eat did little more than maintain their weight. The following year, these last calves, as yearlings, were given 5 pounds of alfalfa hay and all the straw they would eat and had a slight loss of weight. Potter and Withycombe concluded that calves given 4 pounds of alfalfa hay and straw and yearlings given 5 pounds of alfalfa hay and straw free choice can be brought through the winter without any appreciable loss of weight. They also concluded that straw has no place in cattle feeding where any appreciable gain is expected.

Utilization of Cellulose in Livestock Feeds

Cereal straws are high in cellulose and lignin content. Adams and Castagne (1) have determined that wheat straw contains 20.75 percent lignin. According to Anderson and Maynard, this high content of cellulose and lignin is a major factor in feeding trial results with wheat straw.

Corn cobs, another roughage high in cellulose, according to Morrison (53), Maynard (42), and Anderson (4), have been used in several experiments on cellulose digestion and in experiments of low quality roughage in beef cattle winter feeding. Cellulose is a polysaccharide, composed of glucose molecules united by beta linkages. Animals are unable to digest it because they have no enzyme capable of hydrolizing the beta linkage. Some insects and bacteria have enzymes which can hydrolize the beta linkages and according to Anderson (4), Maynard (42), Huffman (33) and Baker and Harriss (6), the ruminants have in their paunch bacteria that possess these enzymes. The cellulose is converted to fatty acids in the paunch by the bacteria and the fatty acids are used by the animal. The principal fatty acids formed are acetic, propionic, and butyric.

Burroughs (10-11) found that the action of the bacteria which digest the

cellulose was affected by the various foods that were in the paunch. Burroughs (10) found that starch retarded the digestion of corn cobs by steers. The protein requirement for efficient roughage digestion was very low when cobs were fed in the absence of starch or starchy grains. Burroughs (11) reported that the dry matter digestion of a ration of corn cobs or of corn cobs and alfalfa hay decreased substantially when corn starch was added. They explained that this was due to the tendency of the bacteria in the paunch to ferment the starch instead of digesting the cellulose.

According to Burroughs et al (8-9), protein favorable influenced the digestion of cellulose by rumen microorganisms. Dried distillers solubles, soybean oil meal, and linseed oil meal appeared to be the most helpful protein feeds for stimulating the cellulose digestion. Burroughs et al (12) stated that casein, when added to a ration low in protein, stimulated the digestion of roughages.

In another experiment, Burroughs et al (15) found that phosphorus and iron, when added to rations high in cellulose, stimulated the digestion of cellulose.

The increase in the digestion of cellulose resulting from the addition of alfalfa hay to a ration, according to Burroughs et al (11) and Huffman (33), can be explained on the basis of the protein and mineral content of the hay. However, both Burroughs et al (14-15) and Meites et al (51) found that alfalfa hay had some unidentified factors that stimulated cellulose digestion. Swift et al (61) found that the addition of alfalfa ash to the ration of sheep increased the crude fiber digestion from 43 percent to 53 percent. Meites et al (51), working with artificial rumens, found that the rumen fluids lost their cellulytic activity upon dialysis, but this cellulytic activity was partially restored by the addition of ashed alfalfa hay to the rumen fluids. Boeson and

Perry (7) reported good gains in beef cattle using corn cobs supplemented with alfalfa hay, and concluded that alfalfa had some factor that stimulated cellulose digestion. Smith et al (59) reported satisfactory gains with corn cobs and soybean meal pellets for wintering beef heifers. Burroughs et al (16) reported that cobs were worth 64 percent as much as corn in cattle rations. Gerlaugh (27) and Gerlaugh and Rogers (28) reported that ground corn and corn cobs were worth 60 percent as much as shelled corn.

Huffman (33) stated that rumen microorganisms could not attack cellulose in the absence of other essential nutrients. In view of this statement and the work cited above it seems reasonable to conclude that ruminants can utilize wheat straw, corn cobs, or other feeds high in cellulose if there is in the ration alfalfa hay, or some other protein to stimulate the cellulose digestion and there are no feeds high in starch or sugar present to depress the digestion of cellulose.

Morrison and Maynard have compared wheat straw and other feeds. Morrison gave the gross energy value of corn and wheat straw as 180.3 and 184.6 therms, and a net energy value of 82.9 and 10.1 therms respectively. Net energy has been described by Anderson (4) as the energy available to the animal from the feed after the work of digestion has taken place minus the energy loss through respiration, excretion and radiation. The high cellulose content of the straw has been given as the reason for the low net energy of wheat straw.

Morrison (53) stated wheat straw has only 1/4 as much net energy as the average hay. Peanut hulls and rye straw are the only other roughages found with lower net energy.

Vitamin A in Livestock Feeds

The furnishing of vitamin A to cattle is another problem for the feeder of livestock. Morrison (53), Maynard (42) and Guilbert and Hart (29-30) have stated that vitamin A is needed in livestock rations for normal growth, to prevent infectious diseases, and to prevent night blindness. Morrison listed the requirement of carotene, the precursor of vitamin A, as 25 mg. daily for 400 pound beef calves. This would give 41,666 units of vitamin A per calf. Maynard listed the requirements as 6 mg. per 100 pounds of body weight or 24 mg. for a 400 pound calf. This would give 40,000 units of vitamin A per calf. According to Morrison's analysis there is no carotene in wheat straw and therefore its use would lead to a deficiency of vitamin A unless it is supplied in the ration from some other source. Riggs (56) found that beef calves 3 to 5 months old developed symptoms of night blindness after 56 days of feeding on carotene deficient rations. He also found that yearlings developed symptoms of night blindness after 6 months of feeding on carotene deficient rations. On the other hand Maynard and Guilbert have stated that carotene does not need to be present at all times in the ration of beef cattle. They stated that young animals have in their livers from .6 to .7 g. of vitamin A during the time they have access to carotene rich feeds. They can then be fed rations deficient in carotene for over 200 days before the liver supply vitamin A would be exhausted.

Duitsman and Kessler (21) reported one case of vitamin A deficiency in fattening steers on wheat straw. They ascribed that case of deficiency to a very high metabolism of food nutrients. The steer that developed the deficiency was the fastest growing steer in the lot. They also reported that the addition of vitamin A to the ration of fattening cattle reduced the cost of

gains by $11.69 per hundred pounds. They admit, however, that this might not be the case except in winters following dry summers when the steer's body reserves of vitamin A would be very low.

EXPERIMENTAL PROCEDURE

Experiment I

Experimental Procedure. Twelve steers, between 7 and 9 months of age, purchased in Texas by the Kansas Agricultural Experiment Station, were used in this work. After a 25 day preliminary feeding period these steers were allotted at random to three lots. Each steer was branded with an idenfitying number.

The three groups, kept together in an exercise lot, each day were separated only for the feeding period. No feed was available in the exercise lot. The feeding was on an individual basis, each steer being in a stanchion from 4:00 p.m. to 7:00 a.m. with access to his own feeding trough. At one end of this trough was a box for the concentrates. The wheat straw was fed loose in the trough. There was very little wastage of the ration. No animal could reach the straw used for bedding purposes. The doors to the feeding stalls were closed when the animals were turned out each morning. The exercise lot had a concrete floor. The animals had access to water and a mineral mixture while in the lot. The mineral mixture consisted of equal parts of steamed bone meal and salt.

At 4:00 p.m. each day the steers were placed in the stanchions. As soon as all the steers were in place, the feed was placed in the troughs. Each steer received the following daily ration: Lot 1, 2 pounds of ground milo grain, 2 pounds soybean oil meal pellets and wheat straw, free choice; Lot 2,

2 pounds of ground milo grain to which had been added 50,000 units of synthetic Vitamin A, 2 pounds of soybean oil meal pellets and wheat straw, free choice; Lot 3, 2 pounds of ground milo grain, 1 1/2 pounds soybean oil meal pellets, 1 pound dehydrated alfalfa pellets and wheat straw, free choice. The amount of wheat straw placed in each trough was governed by the rate of consumption. Straw was available to the animal at all times while in the stanchion. The ingredients used and calculated analysis of the ration is shown in Table 1.

Table 1. Daily rations and calculated analysis used in Experiment 1.

Lot number	1	2	3
Daily ration (pounds)			
Wheat straw	4.141	4.398	4.675
Ground milo grain	2.0	2.0	2.0
Soybean oilmeal pellets	2.0	2.0	1.5
Dehydrated alfalfa pellets			1.0
Vitamin A		50,000 units	
Digestible protein	.951	.951	.923
Total digestible nutrients	5.053	4.951	5.364
Carotene			47.7mg.
Vitamin A		50,000 units	

The ingredients for the concentrate part of the ration were weighed and placed in a paper bag for each steer. This was done in advance, to facilitate proper and prompt feeding. A bale of wheat straw was weighed and put in front of each stall, so that each steer was fed from an individual bale. The weight of each bale was recorded on a chart with the other data of the experiment. No record was kept of the amounts of straw eaten daily or by periods.

The steers were weighed 6 times during the experiment. They were weighed at 28 day intervals for 4 weighings, once at 12 days, and once at 21 days. The weighing was done on scales built in the floor of the barn.

Table 1 shows that the calculated digestible protein and total digestible nutrients were nearly the same for the three lots. Lot 1 was the control lot, and Lots 2 and 3 were the experimental lots. The experiment was so designed that the values of vitamin A and of alfalfa in the wintering ration could be determined.

Results and Discussion. The results of the experiment are given in Table 2.

All the steers were in good condition at the start of the experiment, but were thin by the close of the experiment. The loss of finish occurred in spite of the fact that they had all made gains in weight. At no time did the steers refuse the wheat straw completely, but the consumption of straw was lowest in the first period. Near the end of the experiment the consumption of straw began to decline; however, it did not get as low as in the first period. Two animals, one in Lot 1 and one in Lot 2, refused their concentrates for several days but the daily allotment of concentrates was given to them, and in about 8 days they were eating normally again.

The rate of gain for the 3 lots fluctuated greatly from weigh period to weigh period. The weights are shown in Table 3. Growth curves of lot mean weights are shown in Fig. 1. Lots 1 and 2 lost weight in the first period, while Lot 3 gained weight from the start. During the second period all lots gained at about the same rate. During the third period the rate of gain was less than in the second period. In the fourth period the rate of gain increased, with Lot 3 having the highest increase. In the last period, Lots 1 and 2 had a decrease in rate of gain. The decrease in Lot 3 was very slight.

The vitamin A supplement, given in Lot 2, apparently had no effect on the rate of gain. There were no symptoms of vitamin A deficiency in any of the lots and all animals finished the experiment in apparently good health.

Table 2. Results of Experiment I.

Lot number	1	2	3
number of animals	4	4	4
number of days on feed	117	117	117
average initial weight	441	447	443
average final weight	513	517	548
average gain	72.7	70.25	105.5
average daily gain	.619	.615	.901
feed per hundred pounds of gain			
wheat straw-pounds	660	750	520
soybean oilmeal pellets	322	334	166
ground milo grain	322	334	222
dehydrated alfalfa pellets			111
vitamin A-units		3.7	
Cost per hundred pounds of gain	$26.60	$32.00	$19.02

Table 3. Weight of Animals by Weigh Periods Experiment I.

Steer No.	Jan.6	Feb.4	Mar.4	Apr.1	Apr.13	May 4	Total Gain
Lot 1							
5	465	476	525	520	535	555	90
6	419	404	460	470	480	500	81
7	440	420	465	480	495	500	60
10	440	440	475	480	485	500	60
Total Weight	1764	1740	1925	1950	1995	2055	291
Average Weight	441	435	481	485	498	513	72.7
Lot 2							
2	463	446	505	520	525	530	67
9	465	470	505	530	545	550	85
11	424	400	460	475	475	485	61
12	431	440	480	485	510	505	68
Total Weight	1789	1762	1950	2010	2055	2070	281
Average Weight	447	440	487	502	513	517	70.25
Lot 3							
1	460	474	510	520	540	565	105
3	476	486	545	545	565	580	104
4	418	420	465	468	490	505	87
8	419	430	475	498	510	545	126
Total Weight	1773	1810	1995	2031	2105	2195	422
Average Weight	443	452	498	507	526	548	105

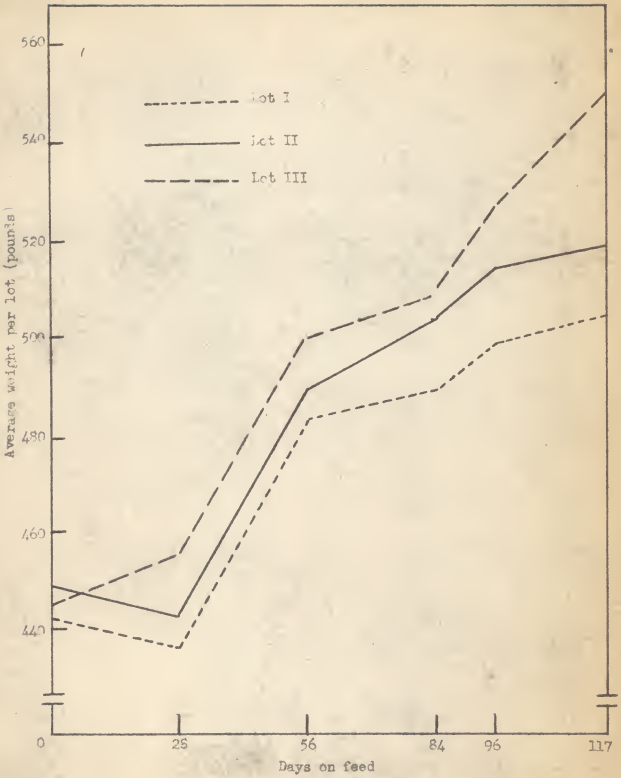

Fig. 1. Growth curves of lot mean weights.

The data were analyzed by analysis of variance and by covariance for a one way classification, using the methods of Snedecor (62). The mean gains in weight in the 3 lots were significantly different ($p = .01$). The mean total gain in weight for Lot 3 was higher than the average of Lots 1 and 2 (p .005). There was no significant difference in Lots 1 and 2. The mean amounts of wheat straw eaten in the three lots were not significantly different ($p = .17$). The amount of straw eaten in Lot 3 was not significantly higher than the average of Lots 1 and 2 ($p = .09$).

From the statistical analysis it can be seen that the gains in Lot 3 were significant, and that there was no correlation between the amount of wheat straw eaten and the gains in weight. The question then arises as to what accounted for the gains in weight. Burroughs (11), Huffman (33), Meites et al (51), and Beeson and Perry (7) have found that there is some factor in alfalfa hay that stimulates the digestion of cellulose. Since alfalfa was used in this experiment and since wheat straw contains a large amount of cellulose, it is possible that the alfalfa stimulated the digestion of the cellulose and that the higher percentage of digestion of cellulose accounted for the difference in gains in weight. However, since there was no digestion trial connected with this work, it is not possible to definitely say that there was any increase in the digestibility of the straw.

The absence of digestion trials in connection with this work and the small amount of work that has been done on this subject points up the need for further work on this problem. The fact that the rate of gain in the three lots followed the same pattern from the second period until the last period, and then began to spread apart, also shows the need for further study on this subject. Had this experiment been continued for another 50 days, the results

might have been different. If there had been digestion trials in connection with the work, it would have been possible to determine if there were any differences in the three lots in the digestibility of the wheat straw.

Summary. Twelve steers were used in this experiment. A preliminary feeding period of 25 days was used to accustom the steers to eating the wheat straw. The steers were weighed at the close of the preliminary feeding period and allotted to 3 lots of 4 steers each. They were fed individually during the feeding period of 117 days and were weighed at intervals. The amount of digestible protein and the total digestible nutrient furnished by the concentrate were approximately the same for each lot. The wheat straw was fed free choice. All animals were fed individually once daily in stanchions. They were released for exercise during the day. The wheat straw consumption was lowest in the first and last periods.

The vitamin A supplement given to Lot 2 apparently had no effect on the rate of gain as the average daily gains were: Lot 1, 0.619; Lot 2, 0.615; and Lot 3, 0.902. Apparently the alfalfa pellets increased the rate of gain in Lot 3.

There was no correlation between the rate of gain and the amount of wheat straw eaten. There were no apparent symptoms of vitamin A deficiency. The rate of gain in Lot 3 was significantly higher than the average of the other lots.

Experiment II

Experimental Procedure. This work was conducted at the Fort Hays Branch Experiment Station. Twenty steers were allotted to 2 lots of 10 each and designated as Lots 1 and 2. Five steers in each lot were purchased in Texas,

while the other five came from the station herd. As can be seen from Table 6, there was a difference in the weights of these steers, both individually and as a group. At the beginning of the experiment, the steers from the station herd were in good condition while those from Texas were thin.

The steers were group fed. The daily ration for each animal in Lot 1 was 1.75 pounds of milo grain, 1.25 pounds cottonseed meal, and wheat straw free choice and in Lot 2 0.75 pound milo grain, 1.25 pounds cottonseed meal, 1.0 pound molasses and wheat straw free choice.

The feeding period lasted 122 days, November 29, 1952, to March 30, 1953. The calculated analysis of rations is given in Table 4.

Table 4. Calculated analysis, and rations used in Experiment II.

Lot number	1	2
average daily ration, pounds		
wheat straw	7.66	8.17
milo grain	1.75	.75
cottonseed meal	1.25	1.25
molasses		1.0
Digestible protein	.632	.546
Total digestible nutrients	5.485	5.396

A mineral mix of 1/2 salt, 1/4 bone meal and 1/4 ground limestone was given free choice. The molasses given in Lot 2 was diluted with water and sprinkled over the wheat straw which was fed free choice.

This experiment was designed to determine the value of molasses when wheat straw is used as the only roughage.

Results and Discussion. The results of the experiment are given in Table 5. In Lot 2, where 1 pound of molasses was fed daily per head, there was an increased daily consumption of 0.51 pounds of wheat straw. There was an increase of 0.01 pounds average daily gain. The cost of the gains in Lot 2

was reduced because the molasses was cheaper than the milo grain it replaced. There was no significant difference in the rate of gain due to the feeding of molasses with the straw.

The steers were very thin at the end of the experiment even though they had gained weight. One steer in Lot 2 showed vitamin A deficiency symptoms, but following treatment for this disorder recovered one week before the close of the test.

The use of food nutrients by animals that are thin is shown by the animals in this experiment. When the animals in each lot were divided according to origin, a vast difference becomes apparent. The Texas steers were thinner than those from the station herd. Though both the station steers and the Texas steers received the same rations, the growth by the Texas steers exceeded that of the station steers. The average daily gain for the two sets of steers were as follows: Lot 1, Texas steers, .291 pounds, station steers, .041 pounds. Lot 2, Texas steers, .27 pounds, station steers, .065 pounds. This is given in Table 6.

Table 5. Results of Experiment II.

Lot number	1	2
number of animals	10	10
number of days on feed	122	122
average initial weight	536	536
average final weight	556	557
average gain	20	21
average daily gain	.16	.17
feed per hundred pounds gain		
wheat straw	4670.5	4745.24
milo grain	1067.5	435.71
cottonseed meal	762.5	726.19
molasses		580.95
cost per hundred pounds of gain	$104.88	$99.50

Summary. Steers used in this experiment were of two origins, one half were purchased in Texas and the others were from the station herd. The Texas steers were thin at the beginning of the experiment and did better on the wintering ration than did the station raised calves. There was no significant difference in gain of weight due to feeding of molasses with the straw.

There was one case of vitamin A deficiency, but it responded to treatment, and cleared up one week before the close of the test. In this experiment the cost of the gain on these wintering rations was too high to make wheat straw appear a practical winter ration.

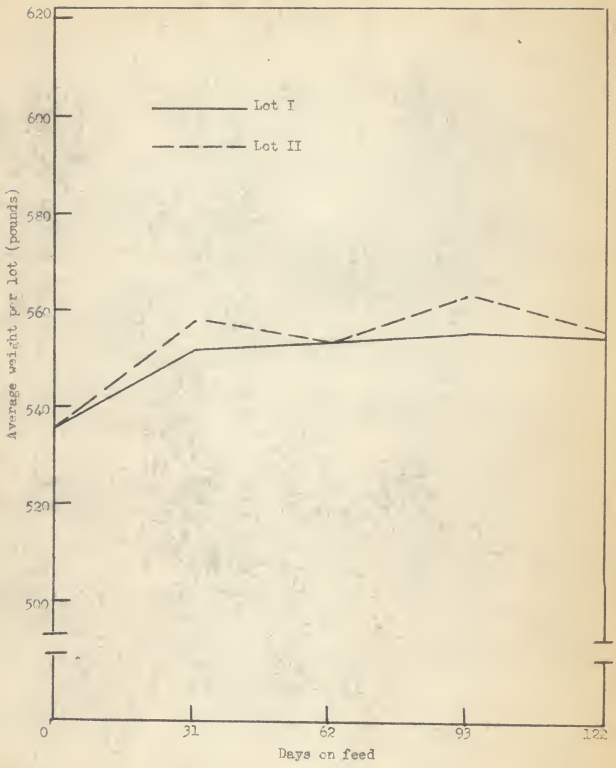

Fig. 2. Growth curves of lot mean weights.

Table 6. Weight of Animals by Weigh Periods Experiment II.

Steers by Origins

Lot 1

Station Steers

Steer No.	Nov.29	Dec.30	Jan.30	Mar.2	Mar.20	Total Gain
215	530	540	550	560	565	35
233	625	635	630	625	625	0
241	600	620	615	605	585	-15
292	550	565	560	540	540	-10
2113	465	450	470	475	480	15
Total Weight	2770	2800	2825	2805	2795	25
Average Weight	554	562	565	561	559	5

Texas Steers

16	515	540	540	545	548	33
34	530	560	560	575	575	45
41	550	565	575	585	590	40
56	510	550	540	545	538	28
83	485	500	505	515	515	30
Total Weight	2590	2715	2720	2765	2766	176
Average Weight	518	543	544	553	553	35.5
Total Lot Weight	5360	5525	5545	5570	5561	211
Average Lot Weight	536	553	555	557	556	21.1

Lot 2

Station Steers

224	540	575	570	575	535	-5
228	610	635	625	635	625	15
242	605	605	610	600	600	-5
272	540	540	540	540	540	0
284	475	500	500	510	510	35
Total Weight	2770	2855	2845	2860	2810	40
Average Weight	554	571	569	572	562	8

Texas Steers

24	500	510	510	540	535	35
25	510	560	535	550	535	25

Table 6. Concl.

27	530	560	550	555	555	25
43	550	575	580	590	580	35
80	500	530	525	550	550	50
Total Weight	2590	2735	2700	2785	2755	165
Average Weight	518	547	540	557	551	33
Total Lot Weight	5260	5590	5545	5665	5565	205
Average Lot Weight	536	529	555	565	557	20.5

GENERAL DISCUSSION

Experiment I and Experiment II show that wheat straw can be used in the wintering ration of beef cattle. The two experiments were similiar in total nutrients furnished by the rations, but the results, rates of gain and cost were very different. As has been pointed out in Experiment I, all lots received substantially the same digestible protein and total digestible nutrients from the concentrates fed. In Experiment II, both lots received similiar allowances but, from the analysis of the rations fed, it can be seen that there was a greater variation than in Experiment I in the digestible protein and total digestible nutrients. Tables 1 and 4 reveal a wide variation in the total gains and the average daily gains. The difference in gains between lots in Experiment I has been explained on the basis of an apparently higher percent of cellulose digestion, stimulated by the addition of alfalfa pellets. However, Huffman (33), Burroughs et al (8-9), Beeson and Perry (7), Maynard (42) and Swift et al (61) have shown that the digestion of cellulose is increased by the addition of protein to the ration. They stated also that alfalfa, in addition to stimulating the digestion of cellulose because of its content of protein and minerals has an additional factor that further stimulates the digestion of cellulose. Starchy grains, starch, glucose, or

feeds high in readily available carbohydrates have been shown to reduce the digestibility of cellulose. The bacteria in the paunch of ruminants will attack the readily available carbohydrate instead of the cellulose. In Experiment II, where the gains were not as great as in Experiment I, it will be noted that there was less protein in the rations than in Experiment I and that a higher percentage of the total digestible nutrients were in the form of carbohydrates. This gives two possible explanations for the reduction in gains. The lower levels of protein in experiment II may have been the limiting factor from the standpoint of protein needed for growth or these lower levels of protein may have limited growth by lowering the digestibility of the cellulose in the wheat straw. Either or both of these factors may have been operating to reduce the gains in Experiment II. The steers in Lot 2 (Exp.2) ate more wheat straw than the steers in Lot 1 (Exp.2) but there was no significant difference in the gains made by them, or in the amount of straw eaten as a result of feeding molasses. The molasses probably lowered the digestibility of the straw. The protein supplement that was fed with the ration in the two experiments probably influenced the digestibility of the straw. Soybean oil meal was used in Experiment I, and cottonseed meal in Experiment II. Burroughs et al. (14) and Beeson and Perry (7) rated soybean oil meal second and cottonseed meal fifth as a stimulant in the digestion of cellulose.

Arnett and McChord (5) have stated that the severity of the weather during the winter feeding periods has an effect on gains made from wheat straw. A study of weather conditions shows that the weather at Manhattan and Hays were very nearly the same and should not have caused difference in the rates of gain made at the two stations (65).

The use of feed nutrients by animals that are thin is shown by the steers in Experiment II. When the animals in each lot were divided according to origin at the beginning of the experiment, the Texas steers in each lot were thinner than the steers from the station herd. Though both the station steers and the Texas steers received the same rations, the growth by the Texas steers exceeded that of the station steers.

From this work it can be concluded that vitamin A in the wintering ration does not increase the rate of gain and apparently does not reduce the cost of gains. In Experiment I, Lot 2, where 50,000 units of vitamin A was given, the average daily gain was .615 pounds, at a cost of $32.00 per hundred pounds. In Lot 1, where no vitamin A was given, the average daily gain was .619 pounds, at a cost of $26.00 per hundred pounds. Duitsman and Kessler (21) reported that vitamin A in the ration of fattening calves reduced the cost of gains $11.49 per hundred pounds. They stated, however, that vitamin A may not have this effect except in winters following a dry summer, when the steer's body reserves of vitamin A would be low.

The vitamin A deficiency in Lot 2 of Experiment II is not easily explained. Riggs (56) produced vitamin A deficiencies in young calves in 56 days of feeding on a ration deficient in vitamin A. Duitsman and Kessler (21) reported one case of vitamin A deficiency in steers fattened on rations deficient in vitamin A. These deficiencies were explained by these workers on the basis of a greater use of nutrients by the faster growing animals, causing a depletion of the body reserves. Morrison (53), Maynard (42), and Guilbert and Hart (29-30) reported that calves could be fed rations deficient in vitamin A for 250 days before the body reserves of vitamin A would be depleted. In Experiment I, Lot 1, where no vitamin A was given, the average daily gain was .619 pounds; in Experiment II, Lot 2, where the case of vitamin A deficiency

developed, the average daily gain was .17 pound. The steers with the higher growth rate did not show vitamin A deficiency symptoms, but one with a lower growth rate did. This was contrary to the findings of Duitsman and Kessler.

Although in Experiment I, none of the steers with higher growth rate (shown by greater gains) showed symptoms of vitamin A deficiency, one steer in Experiment II with a low growth rate did show deficiency symptoms. The results in Experiment I are in line with the observations of Morrison (53) on the tolerance period of feeding.

GENERAL SUMMARY

The experimental work was in two parts and carried out at the Kansas Agricultural Experiment Stations. Experiment I was at the Manhattan Station, and Experiment II at the Fort Hays Station. Twelve steers were fed 117 days in Experiment I.

The purpose of these experiments was to determine the value of wheat straw in the wintering rations of beef cattle, the feeds that are best supplements to wheat straw, and the cost of gain using the various rations.

In Experiment I, three lots of four steers were used. The rations were: Lot 1, 2 pounds milo grain, 2 pounds soybean oil meal pellets; Lot 2, 2 pounds milo grain, 2 pounds soybean oil meal pellets, 50,000 units of vitamin A; Lot 3, 2 pounds milo grain, 1.5 pounds soybean oil meal pellets, 1 pound alfalfa pellets. Wheat straw was fed free choice to all lots. The average daily consumption of wheat straw was: Lot 1, 4.64; Lot 2, 4.389; Lot 3, 4.675. The average daily gains were .619, .615, .902 respectively. The costs per hundred pounds of gains were $26.60, $32.00, and $19.02. The difference in gains of weight was found to be significant. There was no correlation between the

amount of wheat straw eaten and the gain in weight. There were no cases of vitamin A deficiency symptoms, and vitamin A appeared to be of no value in the wintering ration of these steers.

In Experiment II, two lots of 10 steers each were fed 122 days. One half of the steers in each lot came from the station herd and the other half had been purchased in Texas. The rations fed were: Lot 1, 1.75 pounds midland milo grain, and 1.25 pounds cottonseed meal; Lot 2, 1.75 pounds midland milo grain, 1.25 pounds cottonseed meal, and 1 pound molasses. The wheat straw was fed free choice and the daily consumption in Lot 1 was 7.66 pounds and in Lot 2, 8.17 pounds. The average daily gains were .16 and .17 respectively. The costs per hundred pounds of gain were: Lot 1, $104.88; Lot 2, $99.50. The cost of gain in Lot 2 was lowered by substituting molasses for part of the milo grain. The cost of gain in both lots was extremely high. The use of molasses made no significant difference in the amount of straw eaten or in the rate of gain made. Lot 2 had one case of vitamin A deficiency symptoms, which cannot be explained in view of Experiment I or the literature reviewed for this work.

The Texas raised calves were thinner than the station raised calves at the start of the experiment and made better gains than did the station raised calves.

CONCLUSIONS

I. Wheat straw can be used as the only roughage to winter beef cattle.

II. Beef cattle can be wintered on rations deficient in vitamin A.

III. Apparently alfalfa has some unidentified factor which increases the utilization of wheat straw.

IV. Vitamin A in the rations of beef cattle does not increase the rate of gain in the wintering period.

V. Cattle in thin condition gain better on wheat straw than those that are in good condition at the start of the wintering period.

SUGGESTIONS FOR FURTHER STUDY

The writer of this work feels that the results in Experiment I, Lot 3, indicated that further work on winter feeding of wheat straw, alfalfa, soybean oil meal in combination with other feeds than milo would further develop the efficacy of wheat straw as a winter ration.

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SUPPLEMENTING WHEAT STRAW IN THE WINTERING RATIONS OF BEEF CATTLE

by

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The major problem confronting the producer of livestock is getting economical gains in weight. This is not as much a problem in the production of beef cattle as in some other classes of livestock. Beef cattle are ruminants and therefore large quantities of roughages can be used in their ration. The roughages used in beef cattle rations are usually of medium or high quality. Low quality roughages are used as extenders of high quality roughages, but are used mostly for bedding.

Wheat straw is a low quality roughage that is produced abundantly in Kansas. If wheat straw could be used successfully in the wintering rations of beef cattle, livestock producers would have a feed that is cheap and plentiful.

Work done by many research workers indicate that wheat straw is high in cellulose and lignin and low in net energy. It has been shown also that the cellulose and lignin content of the wheat straw is responsible for its low net energy.

The work of cellulose digestion by ruminants has shown that cellulose is digested in the paunch of ruminants by bacteria. Minerals, protein, small amounts of carbohydrates and unidentified factors of alfalfa hay stimulate the digestion of cellulose by rumen bacteria. Starch, starchy grains or feeds high in readily available carbohydrates depress the digestion of cellulose by the rumen bacteria.

Vitamin A, necessary for animal growth, is not supplied by wheat straw. It has been reported that beef cattle can be fed a ration deficient in Vitamin A for 200 days without the cattle developing Vitamin A deficiency symptoms. Most wintering rations for beef cattle would have little Vitamin A, if any, when wheat straw is used as the only roughage.

The experimental work was in two parts and carried out at the Kansas Agricultural Experiment Stations. Experiment I was at the Manhattan Station, and Experiment II at the Fort Hays Station. Twelve steers were fed 117 days in Experiment I.

The purpose of these experiments was to determine the value of wheat straw in the wintering rations of beef cattle, the feeds that are best supplements to wheat straw, and the cost of gain using the various rations.

In Experiment I, three lots of four steers were used. The rations were: lot 1, 2 pound milo grain, 2 pound soybean oil meal pellets: lot 2, 2 pound milo grain, 2 pound soybean oil meal pellets, 50,000 units of vitamin A: lot 3, 2 pound milo grain, 1.5 pound soybean oil meal pellets, 1 pound dehydrated alfalfa pellets. Wheat straw was fed free choice to all lots. The average daily consumption of wheat straw was: lot 1, 4.64; lot 2, 4.389; lot 3, 4.675. The average daily gains were .619, .615, .902 respectively. The costs per hundred pounds of gains were $26.60, $32.00, and $19.02. The difference in gains of weight was found to be significant. There was no correlation between the amount of wheat straw eaten and the gain in weight. There were no cases of vitamin A deficiency symptoms, and vitamin A appeared to be of no value in the wintering ration of these steers.

In Experiment II, two lots of 10 steers each, were fed 122 days. One half of the steers in each lot came from the station herd and the other half had been purchased in Texas. The rations fed were: lot 1, 1.75 pound midland milo grain and 1.25 pound cottonseed meal; lot 2, 0.75 pound midland milo grain, 1.25 pounds cottonseed meal and 1 pound molasses. The wheat straw was fed free choice and the daily consumption in lot 1 was 7.66 pounds, and in lot 2, 8.17 pounds. The daily gains were .16 and .17 respectively. The costs per hundred pounds of gain were: lot 1, $104.88; Lot 2, $99.50. The

cost of gain in lot 2 was lowered by substituting molasses for part of the milo. The cost of gain in both lots was prohibitive. The use of molasses made no significant difference in the amount of straw eaten or in the rate of gain. Lot 2 had one case of vitamin A deficiency symptoms, which is not explainable in view of Experiment I or the literature reviewed for this work.

The Texas raised calves were thinner than the station raised calves at the start of the experiment and made better gains than did the station raised calves.