Built-in Roughages In High Energy Rations For Finishing Cattle

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Pastures, hays, silages and crop residues such as straw, chaff and corn stalks are the nutritional backbone of rations for cow herds and growing calves. These same roughages may be an expensive and a troublesome source of energy and protein, when compared to grains, in finishing rations.

Roughages in conventional forms do not lend themselves to labor-saving mechanization in feedlots. Further, the lower digestibility of roughages, especially when fed with grains, leaves more excreted waste to be handled and disposed of. Because of the problems and cost often associated with using roughages, several substitutes such as oyster shells, plastic cubes and even sawdust have been used with varying degrees of success.

Several by-products from the processing of agricultural products might possibly be used for their roughage value in cattle rations. Some by-products of processed flax-straw for use in the paper industry appeared to have certain chemical and physical characteristics which might make them suitable to provide a minimum roughage in finishing rations. Two products were available, the flax shives (marketed as Marveliter, Peter J. Schweitzer Division, Kimberly-Clark Corporation) and a finer, almost dusty fraction which was sometimes included with the shives or could be separate. The dust was selected for the initial evaluation.

The approximate analysis of this flax "dust" and Marveliter is given in Table 1, with an analysis of wheat straw, a mature, rather poor quality brome hay and a relatively poor alfalfa hay for comparative purposes. The first six items are the "standard feed analysis", and the other three are a more descriptive analysis of fiber and lignin.

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Table 1. Chemical Composition of Flax Shives "Dust," Marveliter, Wheat Straw, Brome Hay and Alfalfa Hay.

Item	"Dust"	Marveliter	Wheat Straw	Brome Hay	Alfalfa Hay
Moisture %	10.5	8.6	12.4	7.3	9.2
Protein (N x 6.25) %	7.8	3.8	2.9	6.7	15.0
Fat (ether extract) %	2.7	—	1.4	2.0	1.7
Crude Fiber %	31.6	—	38.3	28.5	28.0
Ash (Total Mineral) %	22.1	3.1	5.8	9.1	9.0
Nitrogen-free-extract %	25.3	—	39.2	46.4	37.1
Acid detergent fiber %	51.2	70.5	41.4	40.5	42.1
Acid detergent lignin	15.6	—	6.2	5.4	8.4
Acid insoluble ash (silicates)	3.9	—	—	—	—

As can be seen from Table 1, the nitrogen-free-extract (NFE) portion, which is an indication of the more readily usable energy part of the roughage, is somewhat lower, and the acid-detergent lignin (which is not digestible) is higher when compared to the straw and hays. Comparing the conventional crude fiber fraction of the various roughages shows them to be similar, while the acid-detergent fiber of the flax straw by-products is much higher than the wheat straw or hays. Conventional crude fiber is not a very good measure from which to estimate nutritional value.

For the initial evaluation, it was decided to conduct a digestion trial and determine the digestible energy (DE) value of the "dust." Five cross-bred wethers were offered the "dust" to which chromic acid had been mixed to serve as a reference substance. The wethers refused to eat enough of the material to permit a valid determination. Refusal to eat a roughage suggests a very low energy value. In other words, the more of a roughage ruminants, particularly sheep, will eat, the higher the quality of roughage. It was decided to evaluate the "dust" using the indirect method where the DE is determined by difference.

Barley was ground and mixed with chromic oxide, fed to the wethers, and found to contain 3,476 kilocalories of digestible energy per kilogram (1,580 kcal per pound) on a 100 per cent dry matter basis. Using the conventional conversion factor of 2,000 kcal per pound of total digestible nutrients (TDN), this would give a TDN value of 79 per cent (71 per cent on an air dry basis) for this sample of barley. This low value reflected the quality of the barley (less than 41 pounds per bushel).

A 50:50 mixture of the barley and the dust was mixed with chromic oxide and fed to the wethers. From this trial the mixture was found to contain 2,134 kcal per kilogram (970 kcal per pound) of DE or a TDN value of 48.5 per cent (100% dry matter (DM)). Using the value determined for the barley initially and using the "by-difference" technique it was found that the dust contained 814 kcal per kilogram (370 kcal per pound) or a TDN value of 18.5 per cent (100 per cent DM) or about 17 per cent on an air dry basis. Certainly a roughage of such low energy value would not be useful as a major part of the ration.

Experiment C-23. In order to see if this finely ground, fibrous material (the "dust") could be used as a roughage replacement in finishing rations for cattle, 10 rather fleshy, small-type beef heifers were used in an 84-day feeding trial. The heifers were weighed every 21 days with the feed withheld for the evening and morning feedings prior to weighing to give a "shrunk" weight. The rations used are given in Table 2. The rations were mixed and pelleted and fed in amounts that the heifers would clean up before the morning feeding.

Results of the 84-day feeding trial are given in Table 3. It is interesting to note that the average daily gains for both groups were the same. Since the only difference between the two rations was the 15 per cent flax shive dust in ration 23-1 and 15 per cent ground alfalfa in 23-2 (Table 2) and since the feed per pound of gain is the same for both groups, the dust and alfalfa must have similar energy values when used as a limited roughage in rations of this type.

Table 2. Rations Used in Experiment C-23.

Ration No.	23-1	23-2
Flax Shive "dust"	15	—
Alfalfa (sun-cured ground)	—	15
Molasses (dry)	3	3
Barley	50	50
Durum	30	30
Trace Mineral Salt	0.5	0.5
Limestone	0.5	0.5
Dicalcium Phosphate	0.5	0.5
Premix[1]	0.5	0.5
Calculated Crude Protein	13.0%	14.2%
Estimated TDN	62.2%	66.7%
TDN Calculated from Exp. results	69.5%	70.5%.

[1]Provided Vitamin A 1000 IU/lb. ration; 100 I.U. of Vitamin D/lb. ration, carried on wheat bran.

Table 3. Results of Experiment C-23.

Treatment Lot	15% Flax "dust" 23-1	15% Alfalfa Meal 23-2
Initial wt., lb.	644	645
Final wt., lb.	833	837
Avg. daily gain, lb.	2.28	2.29
Feed per day, lb.	15.9	16.1
Feed/pound gain, lb.	7.07	7.04
TDN/pound gain, lb.	4.92	4.95

The TDN values for the rations were calculated on the basis of generally reported energy values. The energy value of the flax shive dust as determined was used (Table 2). Such a calculation gave a difference of 4.5 percentage units (62.2 vs 66.7 TDN) between the rations. In calculating the TDN needed per pound of gain from the results of the feeding trial, the values change to 69.5 and 70.5 per cent TDN. From the results of the trial the TDN needed per pound of gain was 4.92 and 4.95 pounds. As a further check, the expected TDN needed per pound of gain for animals of this type was calculated (Garrett, et al, J. Anim. Sci. 18:528, 1959) and found to be 4.98 pounds of TDN per pound of gain. This is in close agreement with the TDN values actually found from the trial.

Two possible explanations could be given for this apparent equal value for the flax shive dust and the ground alfalfa. The first is that the energy contribution from limited roughage in high energy (high grain) rations is very limited. The second is that the flax shive dust, being much less digestible than the alfalfa, remained in the rumen longer, delaying the passage of the ingesta and permitting an increased digestibility of the grain portion. In any event, the flax shive dust was used successfully as a "built-in" roughage in a complete pelleted ration. The heifers were easy to keep on feed and there was no adverse effect on the animals for the 84-day feeding period.

Experiment C-25

Experiment C-25 was designed (1) to compare four grains, barley, proso, corn and sprout-damaged durum, in rations for growing calves and for finishing steers when fiber of the rations was equalized, (2) to see if flax shives (trade name, Marveliter) would function as well as alfalfa in high-energy rations, and (3) to test the acceptability of a high lactic acid-cold silage, put up in plastic bags by evacuating the air by means of a vacuum pump.

The feeds used in this two-phase experiment were No. 2 yellow corn, 9.4 per cent protein; proso (Early-Fortune), 13.1 per cent protein; barley (42 lb. per bu.), 12.5 per cent protein, and lightweight sprout-damaged durum, (54 lb. per bu.), 16.6 per cent protein (N x 6.25).

After starting the calves on feed, it became obvious that the amount of the high lactic acid alfalfa silage was limited because of the excessive spoilage due to breaks and holes in the plastic "silo." The usable portions had good odor, 25.4 per cent dry matter and 7.9 per cent protein. This alfalfa silage lasted for 42 days, after which a mixed sorghum-hybrid and corn silage was used to complete phase 1. This silage had 23 per cent dry matter, 2.5 per cent protein and had been cured and stored in a pile on the ground. The supplement used for the growing period (phase 1) was soybean oil meal 75 per cent, sun-cured alfalfa 5 per cent, trace mineral salt 6 per cent, dicalcium phosphate 4.5 per cent, limestone 4.5 per cent and 5 per cent wheat bran which carried the vitamins to provide 18,000 IU of Vitamin A and 2,000 IU of Vitamin D per steer per day. Amounts of the feed fed per day in phase 1 is given in Table 4. The experimental plan was to feed all feeds in same amounts to the different lots so that any differences in average response of lots could be attributed to the different grains fed.

Table 4. Summary Results, Experiment C-25 Phase 1 — (growing phase) 6 steers per lot (105 days — averages of two lots).

Treatment Lot Nos.	Barley 1 & 2	Proso 3 & 4	Corn 5 & 6	Durum 7 & 8
Initial Wt., lb.	382	382	383	380
105 day Wt., lb.	553	550	555	558
A.D.G., lb.	1.62	1.61	1.63	1.73
Feed/lb. gain, lb.	16.2	16.9	16.6	15.7
Feed/day, lb.				
Supplement	2.75	2.75	2.70	2.76
Silage	17.9	17.9	17.9	17.9
Oats	2.25	2.26	2.26	2.26
Barley	2.03	—	—	—
Proso	—	2.09	—	—
Corn	—	—	2.05	—
Durum	—	—	—	1.95

For phase 2 (the finishing phase), it was intended to design a ration to be fed at a level of six pounds per head per day which would provide all the roughage necessary to equalize the fiber in all rations and provide the supplement, and use the respective grains to make up the remainder. However, because this six-pound "supplement" had to contain up to 42 per cent of the flax shives plus 10 per cent alfalfa, it was impossible to mix and elevate in the grain mixing equipment. It was not possible to get it to the pellet mill, so it was fed as a meal mixture with the respective grains.

After a couple of periods, it was noticed that the steers were "sorting" and leaving the flax shives. The rations were then reformulated to pro-

Table 5. Ration formulas used in phase 2 (finishing phase).

	Experiment C-25							
Lot No.	1	2	3	4	5	6	7	8
Flax Shives	—	9.0	—	9.0	—	15.0	—	15.0
Alfalfa (suncured)	18.0	3.6	18.0	3.6	24.0	3.6	24.0	3.6
Wheat Bran[1]	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Limestone	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Dicalcium Phosphate	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Trace Mineral Salt	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Urea	0.6	1.2	0.6	1.2	1.2	1.8	0.6	1.2
Soybean Oil Meal	—	—	—	—	—	3.0	—	—
Barley (13%)	77.4	82.1	—	—	—	—	—	—
Proso (14%)	—	—	77.4	82.1	—	—	—	—
Corn (8%)	—	—	—	—	70.8	72.6	—	—
Durum (14.6%)	—	—	—	—	—	—	71.4	76.2
Crude Protein (analysis %)	13.1	13.2	13.9	14.2	10.5	10.9	14.7	14.9
Acid detergent fiber %	14.9	15.6	14.9	15.6	12.5	14.7	12.5	14.7

[1]Wheat bran was used to carry 0.6 mg. stilbestrol, 900 IU of Vitamin A and 90 IU of D per pound of ration.

vide the same percentages of acid detergent fiber in a total ration and fed in a pelleted form. The formula for this complete pelleted ration is given in Table 5.

Some urea was added to all rations in an attempt to equalize protein. Additional soybean oil meal was added to the corn ration with the flax shives (Lot 6). Upon analysis, both corn rations were slightly lower in protein than intended, but should have been adequate in protein for cattle of this size.

For these experiments, 48 very uniform Hereford steer calves were obtained from the same herd and allotted at random into eight lots. The steers were fed inside with access to outside paved lots where water was available at all times. Weights were taken every 21 days and feed withheld evening and morning feedings prior to weighing. The grain and supplement was fed twice a day, and in the growing phase the silage allowance was fed at noon. No effort was made to weigh back "silage" so that the silage is actually offered rather than consumed, although very little silage was wasted.

Results and Discussion

The pertinent results of phase 1, the growing phase, are reported in Table 4. The lots on the same grain were combined for the table because the responses were very similar. The supplement, silage, and oats portions were fed in equal amounts to all lots so that any differences in performance could be attributed to the different grains. There were no significant differences in gains between the treatments. The tenth of a pound greater gain in the durum treatment was not large enough to be significantly different from the other three. Feed efficiencies were all similar. The small difference in total feed per pound of gain can be explained on the possible variations in moisture content and weighing errors in the silage portion. The "vacuum packed" alfalfa silage was well accepted by the steer calves. However, a large part of the silage was damaged because of breaks in the plastic. The plastic "silo" was not very satisfactory because of the curiosity of interested livestock men who opened the plastic silo several times to look at the silage. Later the cold weather caused the plastic to break and tear, causing further loss of preservation.

Table 6. Summary of Results, C-25.

	(Phase II, 210 days)							
Lot	1	2	3	4	5	6	7	8
Grain	Barley		Proso		Corn		Durum	
Roughage	Alf.	F.S.	Alf.	F.S.	Alf	F.S.	Alf.	F.S.
Initial Wt., lb.	558	547	552	548	559	551	553	561
Final Wt., lb.	1043	1007	990	1023	1040	1017	1017	1064
A.D.G., lb.	2.31	2.19	2.03	2.20	2.29	2.25	2.21	2.29
Feed/lb., gain lb.	7.68	8.18	8.85	8.26	7.99	8.14	8.08	7.83
Feed/day, lb.	17.7	17.9	17.9	18.2	18.3	18.2	17.8	17.9
Dressing %[1]	56.9	58.3	57.3	57.2	59.1	58.7	56.9	57.8
USDA grade[2]	9.3	9.6	9.2	9.0	10.2	9.2	9.5	10.2
Abcessed livers[3]	4/6	5/6	3/5	1/5	4/6	4/5	3/6	4/5

[1]Calculated from final Wt. off experiment and hot carcass Wt. 20 hours later.
[2]9 = high good, 10 = low choice etc.
[3]4/6 means 4 of 6 in lot, 5/6 - 5 of 6 in lot etc., one entire carcass condemned at slaughter due to a general infection not due to treatment in lot 2, one steer in each of lots 3 and 4 lost from bloat, one steer in each of lots 6 and 8 sold early, one steer in lot 7 foundered 14 days prior to slaughter.

Table 7. Summary of Results by Treatments.

	Experiment C-25					
Lots	1 & 2	3 & 4	5 & 6	7 & 8	1,3,5,7	2,4,6,8
Treatment	Barley	Proso	Corn	Durum	Alfalfa	Flax Shives
A.D.G., lb.	2.25	2.12	2.27	2.25	2.21	2.23
Feed/lb. gain, lb.	7.9	8.6	8.1	8.0	8.2	8.1
Feed/day, lb.	17.8	18.0	18.2	17.9	17.9	18.1
Dressing %[1]	57.6	57.3	58.9	57.4	57.6	58.0
USDA Grade[2]	9.5	9.1	9.7	9.9	9.6	9.5
Abcessed livers[3]	9/12	4/10	8/11	7/11	14/23	14/21

[1] [2] [3] See footnotes Table 6.

Pertinent results from the 210-day phase 2, (finishing phase) of Experiment C-25 are given in Table 6 and a summary by major treatments in Table 7.

The small differences in rates of gain between lots or treatments were not large enough to be statistically significant. That is, the variations in rates of gain within treatments were as large as the variations in gains between treatments. In Lot 3, the proso-alfalfa treatment, the lower gains were primarily due to the chronic bloater that died midway in the experiment. In general, the gains were about as expected for cattle of this type and quality.

The daily feed intakes of the rations were similar between treatments, and averaged about two per cent of the live weight daily (two pounds per one hundred pounds of body weight daily). This is normal for rations containing TDN levels above 65 per cent. At the beginning of the finishing period when the rations were fed in the meal form, the steers did tend to "sort out" and leave some of the flax shives. When fed as a complete pelleted ration all rations appeared to be equally acceptable.

Two steers, one each in Lots 3 and 4, were chronic bloaters and died about half-way through this phase. The bloating was probably not due to the ration. Two steers, one each from Lots 6 and 8, were removed from experiment and sold for slaughter after 168 days on the finishing rations, weighing about 800 pounds and already carrying excessive condition. One steer in Lot 7 foundered about two weeks prior to the close of the experiment but dressed well and graded low choice. One carcass was condemed at slaughter because of a general infection. No signs of illness were apparent prior to slaughter.

The feed required per pound of gain varied from a low of 7.68 pounds (Lot 1, barley-alfalfa) to a high of 8.85 pounds for Lot 3 (proso-alfalfa). This was a difference of 13 per cent. However, Lot 3 was one of the lots with a chronic bloater, which contributed to this poorer efficiency. The next poorest lot in feed efficiency (Lot 4 - proso-flax-shives 8.26 pounds) also contained a chronic bloater. If these two lots are not considered then the difference is only 6 or 7 per cent. From Table 7 where the lots fed the same grains were combined, the barley fed lots were the most efficient and the proso lots (with the chronic bloater) the least efficient with the corn and durum fed lots in between. The same was true when all lots receiving alfalfa or flax shives were combined.

If it is assumed that the barley contained 75 per cent TDN, then by calculation it appeared that the proso had a similar value and the corn and sprout-damaged durum must have contained 76 or 77 per cent TDN. By the same calculations, if flax shives has a TDN content of 30 per cent, then the alfalfa in these rations had an estimated TDN value of about 35 per cent rather than 50 per cent as expected. This has been observed before on high energy rations (A. F. Stewart, M. S. Thesis NDSU - 1963; H. H. Casper, M. S. Thesis, NDSU 1968).

Carcass data were obtained at slaughter. The dressing percentages were calculated from hot carcass weights and final weights off experiment the previous day with no shrink correction made. Therefore, they are somewhat low, but are useful for comparisons between treatments. The low USDA grade (9 = high good, 10 = low choice etc.) reflects a lack of marbling, which is not the fault of ration. Over 60 per cent of the livers from these cattle were condemned due to abscesses. This was unusually high. No antibiotics had been included in the ration to assist in reducing the incidence of abscesses. Observations of cattle on several experiments have not suggested the reasons for the variations from experiment to experiment of the incidence of abscessed livers.

Summary

1. By-products from the processing of flax straw for the paper industry were useful as substitutes for most of the alfalfa in high-energy rations (over 65 per cent TDN) for finishing cattle.

2. When rations for finishing cattle were equated for the acid-detergent-fiber content, the grains were similar in their TDN content.