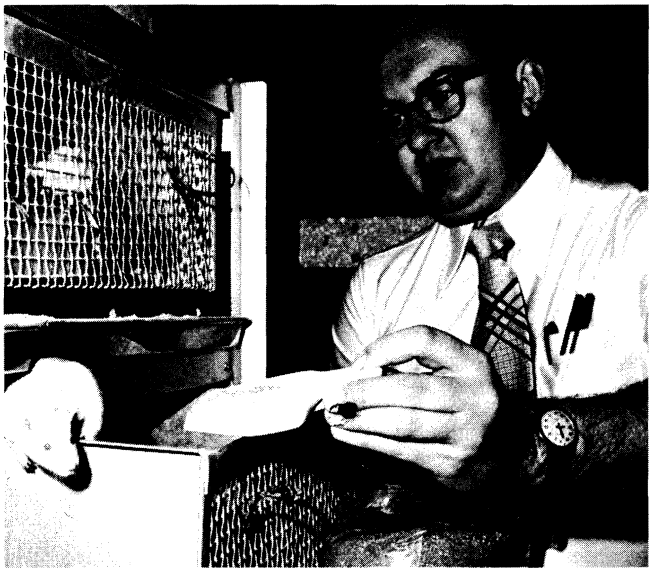

Dr. Harrold at the feeding cages.

Digestible Energy Content of Selected North Dakota Grains

R. L. Harrold

Grains are the backbone of rations for non-ruminants and the energy content of the grains determines the efficiency of utilization of the final ration. Digestible energy values were determined for barley, oats and corn grown in North Dakota. The limited sample size dictated that the rat would be the experimental animal.

Digestible energy values are necessary if rations for any species of livestock are to be formulated for optimum efficiency. Knowledge of energy content permits the calculation of effective nutrient ratios and estimation of the amount of feed required per pound of gain. The development of accurate energy values for grains grown in North Dakota is essential as the energy values for grains grown in other areas may not represent material grown in our cooler climate. For example, it is possible that the utilizable energy content of high quality barley and oats could be greater than that of lighter weight grain produced in warmer growing areas. Conversely, the digestible energy content of lightweight corn could be less than that of the heavier test-weight grain produced in the traditional "Corn Belt".

The experiments reported here were conducted to determine the digestible energy content of barley, oats, corn and hull-less barley grown in North Dakota. Each test utilized the ground grain supplemented with vitamin and minerals. No supplemental protein was used in order that the energy values obtained would be determined directly.

Procedure

The varieties of barley utilized in experiment 1 were grown in Fargo and made available through the courtesy of Drs. M. K. Anderson and A. E. Foster of the Department of Agronomy. Dr. G. S. Smith of the Department of Agronomy provided the oat varieties utilized in the second experiment. These oat samples were grown at Minot and at Carrington and represented equal

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The samples utilized were obtained from a variety of sources. Drs. M. K. Anderson and A. E. Foster provided the barley varieties for experiment 1, while Dr. G. S. Smith provided the oat samples for the second experiment. The bulked samples of corn, barley and oats used in experiment 3 were obtained from the various branch experiment stations. The hull-less barley was obtained from the Dickinson Experiment Station through the courtesy of Mr. J. L. Nelson.

The majority of the analyses were completed by Mrs. Penny Kurz and it is a pleasure to acknowledge her expertise. Dr. M. K. Anderson critically reviewed the manuscript and made several constructive comments.

amounts from each production location. The various branch experiment stations cooperated in providing grain samples for analysis, and the barley, oats and corn available for experiment 3 came from bulking a portion of each sample received from these sources and essentially represent a statewide composite. The hull-less barley (experiment 3) was provided by the Dickinson Branch Experiment Station and represented material that had been purchased and utilized in a portion of the experimental work at that location.

A semi-purified ration based upon lactalbumin as the protein source, and corn starch, sugar and corn oil as energy components, was fed in each experiment to serve as a means of comparing results between experiments. The rats utilized in the experiments were approximately 28 days of age and had been weaned approximately one week before the experiments began. Rats were housed in pairs and fecal collections for determination of the digestible energy content of the rations were made during the second week of each 21-day experiment. Animals were weighed individually at 7-day intervals, and feed consumption of each pair of rats was determined at that time.

Results

The results of Experiments 1, 2 and 3 are presented in Tables 1, 2 and 3, respectively.

Experiment 1. All rations supported reasonable weight gains and resulted in feed per gain values which were extremely good in view of the fact that test rations did not include supplemental protein. The analyses represent a fairly typical view of the composition of barley with the exception that the ash content of the rations reflects the supplementation of all rations with minerals to meet the apparent requirements of the rat. For all practical purposes, there was no difference in the gross energy of the barley rations. Analyses for cell wall and acid-detergent fiber are given, as the difference between these values is assumed to represent the hemicellulose content of the material. Hemicellulose is a readily digested fibrous material, and the apparent digestibility of hemicellulose from the barley rations approximated that of all dry matter in the rations.

Dry matter digestibility of all barley rations averaged 82.8 per cent and was very comparable to the apparent digestibility of energy. Protein digestibility values are typical of those anticipated for barley protein. Calculated values for digestible energy (DE) do not reveal apparent differences due to variety of the barley used in this test.

Experiment 2. Six varieties of oats were utilized in this experiment. Samples of each variety grown without fertilization and samples of two varieties which had received supplemental nitrogen fertilization were fed in this experiment.

Performance of the rats (average daily gain, feed intake and feed per gain) indicates the bulky nature of the oat diets. Ration analysis revealed the variations in energy, protein and cell wall

Table 1. Results of Experiment 1: Barley Varieties.

	Variety					
	Shabet	Vanguard	Larker	Keystone	Nordic	Reference
Average daily gain	3.57	3.41	3.83	4.19	3.25	5.07
True daily feed	14.02	14.52	13.82	15.15	13.26	13.75
True feed per gain	3.93	4.27	3.60	3.61	4.08	2.71
	Ration analysis (as-is basis)					
Gross energy, kcal/gm	3.908	3.947	4.016	4.001	3.960	4.465
Dry matter	90.04	92.13	91.89	91.84	91.84	90.51
Crude protein	13.8	13.3	13.1	15.2	12.9	19.6
Ash	4.84	6.01	4.87	5.44	5.45	4.43
Cell wall	39.6	29.9	32.8	32.2	30.8	3.4
Acid-det. fiber	6.6	6.5	7.5	7.9	8.7	2.8
	Digestibility value, %					
Energy	82.60	81.44	84.00	81.22	83.94	94.86
Dry matter	82.57	81.97	84.29	81.38	83.97	92.83
Crude protein	73.93	71.77	72.30	72.13	73.40	91.73
Cell wall	81.98	72.29	77.45	76.58	76.48	
Acid-det. fiber	39.29	32.49	39.66	40.65	42.53	
	Calculated values (as-is basis)					
Digest. energy, kcal/gm	3.228	3.214	3.373	3.250	3.225	4.236
Digest. protein, %	10.20	9.55	9.47	10.96	9.47	17.98

Table 2. Results of Experiment 2: Oat Varieties.

Variety N Fertilization	Cayuse 0	Dal 0	Dal +	Froker 0	Kelsey 0	Kelsey +	Kota 0	Random 0	Reference
Av. daily gain, grams	1.82	2.58	3.05	2.83	2.03	2.09	2.20	2.03	4.44
Ave. daily feed	7.56	9.05	9.23	9.45	8.45	7.89	9.21	8.73	12.14
Av. feed per gain	4.16	3.51	3.02	3.34	4.16	3.77	4.19	4.30	2.73
					Ration analysis (as-is basis)				
Gross energy, kcal/gm	4.178	4.258	4.369	4.100	4.194	4.175	4.190	4.135	4.378
Dry matter	91.46	91.95	92.14	91.46	92.05	91.63	92.13	91.53	87.66
Crude protein	11.3	16.3	17.1	15.4	12.7	13.9	14.0	13.1	18.0
Ash	4.51	5.73	5.47	6.25	5.32	5.08	5.51	5.66	4.30
Cell wall	37.6	29.7	31.5	35.4	31.0	30.3	33.4	38.4	4.2
Acid-Det. fiber	18.2	15.9	17.9	15.2	14.8	15.5	17.3	18.7	3.4
					Digestibility values, %				
Energy	79.57	74.98	79.91	82.96	77.97	77.37	75.36	76.96	94.51
Dry matter	77.56	72.92	76.77	81.72	76.38	75.32	72.80	75.17	92.00
Crude protein	77.35	78.92	80.59	83.56	79.10	78.43	80.39	78.15	92.39
Cell wall	54.90	36.31	47.19	70.22	46.31	40.77	33.91	54.85	35.97
Acid-Det. fiber	30.30	22.00	45.07	41.88	27.62	24.08	26.83	33.25	26.58
					Calculated values (as-is basis)				
Digest. energy, kcal/gm	3.324	3.191	3.491	3.401	3.270	3.230	3.158	3.182	4.138
Digest. protein, %	8.74	12.86	13.78	12.87	10.05	10.90	11.25	10.24	16.63

content anticipated because of the effect of variety upon these criteria. The hemicellulose content of oat samples was less than that of barley (hemicellulose = cell wall – acid-detergent fiber).

Digestibility values for energy and dry matter were comparable within each dietary treatment, as was noted in experiment 1. Apparent digestibility of crude protein exhibited moderate differences due to variety, with little effect noted for fertilization in the two appropriate varieties. Cell wall digestibility was low, as would be expected for rations based upon oats. Digestibility of hemicellulose (not given in Table 2) exceeded that for dry matter by a considerable percentage.

Calculated energy values indicate that modest differences due to variety and fertilizer application were present. Digestible protein values reflect the broad range to be expected when dealing with oats.

Experiment 3. Performance of rats fed the various grain types represented anticipated values, considering the fact that the diets did not contain supplemental protein. The lack of supplemental protein penalized the corn diet in terms of per-

Table 3. Results of Experiment 3: Feed Grains.

	Grain				
Type	Corn normal	Barley hull-less	Barley normal	Oats normal	Reference
Average daily gain	1.92	5.23	4.41	4.01	5.19
True daily feed	13.85	18.08	17.65	14.90	13.51
True feed per gain	7.22	3.45	3.80	3.71	2.60
			Ration analysis (as-is basis)		
Gross energy, kcal/gm	3.811	4.027	3.872	4.173	4.290
Dry matter	86.58	90.90	91.69	90.66	89.88
Crude protein	11.7	18.8	14.0	15.7	16.3
Ash	3.60	4.34	4.88	4.25	4.09
Cell wall	17.8	43.6	42.4	36.4	5.4
Acid-det. fiber	4.6	5.2	7.8	15.9	3.9
			Digestibility values, %		
Energy	88.20	83.15	84.58	73.92	94.53
Dry matter	86.84	82.97	82.01	70.90	93.07
Crude protein	83.99	75.87	74.17	75.97	91.14
Cell wall	31.17	83.36	83.29	50.06	51.44
Acid-det. fiber	36.46	54.14	49.72	27.44	26.18
			Calculated values (as-is basis)		
Digest. energy, kcal/gm	3.364	3.349	3.275	3.085	4.055
Digest. protein, %	9.83	14.26	11.13	11.93	14.86

Table 4. D.E. Content per Moist Volume for Rations in Experiment 3.

Item	Ration				
	Corn	Hull-less Barley	Barley	Oats	Purified
D.E., Kcal/gm, 90% D.M.	3.586	3.400	3.294	3.134	3.645
D.E. Kcal/cc, moist[1]	1.692	1.650	1.535	1.119	2.367
Moist D.E./cc, corn = 100	100	98	91	66	140
Moist food volume/day, cc	27.5	36.7	37.6	41.1	23.1
D.E. cons./day	46.6	60.6	57.8	46.0	54.8

[1]*Calculated from volume occupied by 50 gm of ration saturated with water for one hour.*

formance, but not in regard to digestibility of ration components.

The corn diet contained the least dry matter, crude protein and cell wall of all rations fed. The hull-less barley ration contained considerably more cell wall than was anticipated. The gross energy content of the corn and of the normal barley ration was somewhat less than that of the hull-less barley and oat ration.

As noted in the results of the previous experiments, digestibility values for energy and dry matter were very similar. The high digestibility of the protein in corn (relative to that of the other grains) may partially compensate for the low digestibility of the cell wall material from the corn.

Similarity of the digestible energy content of the rations based upon corn, hull-less barley and normal barley was partially related to the moisture content of the rations. Digestible energy (kcal/gram) values on the basis of 100 per cent dry matter for the corn, hull-less barley, normal barley and oat rations were 3.984, 3.778, 3.660 and 3.482, respectively. Expression of digestible energy content on the basis of 100 per cent dry matter content reveals modest differences between the corn and the two barley samples.

Discussion

Results of the experiments presented here indicate that differences due to variety are small for barley and significant for oats (experiments 1 and 2). However, the results of experiment 3 may be of more importance to North Dakota swine producers. The blended samples of corn, barley and oats had bushel weights of 51½, 47, 36½ pounds, respectively. The hull-less barley weighed 58½ pounds per bushel.

Table 4 contains data derived from Table 3 and information not previously discussed. If the common assumption is accepted that animals tend to consume feed until their energy requirements are satisfied (unless limited by bulk or palatability), it is possible to make some significant conclusions from Table 4. Consumption of kilocalories of DE was similar for the rats fed the hull-less and normal barleys and the purified diet. By the same token, the apparent moist volume consumed daily was similar for rats fed the oats and both barley rations. The restriction in DE intake by the rats fed the oats ration was apparently due to the bulky nature of the ration. On the other hand, the restriction in energy consumption from the corn ration was due to another factor, possibly the poor protein quality involved by feeding corn rations that did not contain supplemental protein. The restricted volume consumed by rats fed the purified diet is explained in that their energy requirements were apparently satisfied.

"Normal" swine diets will contain supplemental protein which eliminates protein level and protein quality as variables, leaving bulkiness and energy content as major factors. From Table 4, it can be calculated that the energy content of hull-less and normal barley and oats relative to that of corn (i.e., corn = 100) were 95 per cent, 92 per cent and 87 per cent, respectively. Oats could be slightly overvalued on this basis if consumption of an oats ration would be restricted by bulkiness.

Summary

Three digestion experiments were conducted with rats to evaluate the energy content for nonruminants of grains produced in North Dakota.

Small and potentially insignificant differences were obtained in evaluating barley varieties. Differences between oat varieties were large and of enough practical significance to merit consideration in the selection of oats to be used in swine rations. Hull-less barley was determined to be a highly acceptable feed grain and supported weight gain exceeding that of a purified ration. The corn ration (which did not contain supplemental protein) did not support satisfactory performance, but did contain a high level of digestible energy.

Data were presented which indicated that the bulkiness of the oat ration limited total calorie intake in rats in the third experiment.