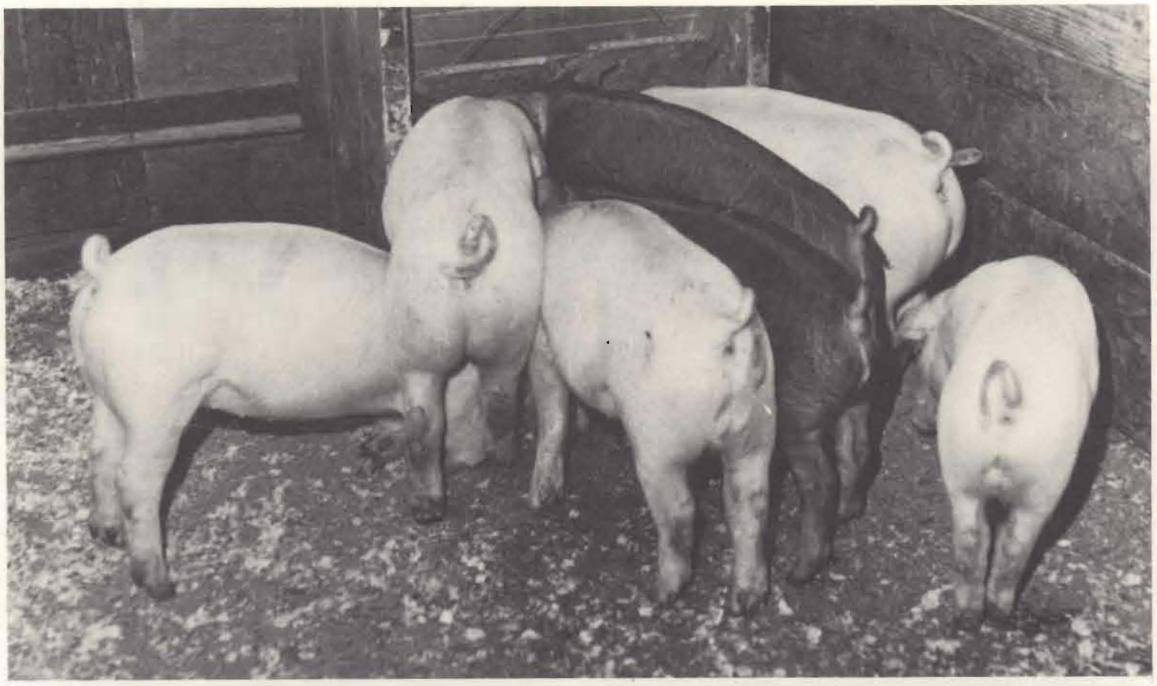

BARLEY IN RATIONS FOR BABY PIGS

J. E. Roers, R. L. Harrold, C. N. Haugse and W. E. Dinusson

A myth that barley does not perform well as an ingredient in creep rations for pigs has been popular for decades. The hull and fiber content, lower energy (bulkiness), and lack of palatability have been given as reasons for the infrequent use of barley in rations for baby pigs. The National Research Council (NRC) 1973, lists a requirement of 1600 kcal of Digestible Energy (DE) per pound of ration for 10 to 20 pound pigs to gain about 0.66 pounds per day. In the same publication the energy value of barley is listed as 1419 kcal of DE per pound. Thus, it would be difficult to formulate a creep ration using barley as any appreciable amount of the ration and still meet the suggested energy requirements. The grains usually suggested as those of choice in creep rations have been oat groats (oat meal), corn and wheat.

Barley has about one-third higher protein content than corn, 12 per cent as compared to 9 per cent. It is available in many areas where corn would have to be imported and is usually a cheaper feed than wheat. It is possible that the lack of palatability of barley rations for early weaned pigs could be overcome by pelleting the otherwise bulky, dusty, barley meal rations.

Harrold **et. al.** (1971 a,b) substituted up to 20 per cent barley for corn and soybean oil meal in a semi-complex, pelleted ration for early weaned pigs weighing 14 pounds. No differences were noted in daily gain, daily feed intake or feed per pound of gain. In other research with pigs initially weighing 25 pounds, they demonstrated that barley can replace corn in balanced pelleted rations. In 1972, O'Grady and Bowland reported that of various DE levels, 1455 kcal of DE per pound of ration was optimum for early weaned pigs fed barley- or wheat-based rations. They further reported that protein digestibility increased as the DE increased but nitrogen retention was not affected.

A series of experiments was planned and initiated to investigate some aspects of rations for

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early-weaned pigs. In these experiments pigs were weaned at weights of 10 to 15 pounds and taken to the Animal Science Research Center where they were allotted on basis of sex, weight and litter into uniform lots of three pigs each. The pigs were kept in metal pens with partially slotted raised floors, and fed from self-feeders with fresh water available at all times. The feeders and waterers were checked daily and soiled feed was weighed back. Temperature of the room was set at 25° C. All rations were mixed, pelleted and sampled for analysis of dry matter, protein, ash, calcium, phosphorus and acid-detergent fiber. Individual pig weights were obtained weekly as well as feed consumption and wastage. Data was submitted to analysis of variance and Duncan's multiple range test to assist in interpretation.

Experiment 170-III

This experiment was designed to compare three ration formulations for early-weaned pigs. The formulas are given in Table 1. Ration 1 had been used previously with success, and served as the control. Rations 2 and 3 were simplified by removing oat groats, dried skim milk and fish meal. Low levels of fat (white grease), lysine and methionine were added. Rations were formulated to contain 22 per cent protein, the NRC suggested requirement for pigs of this age. Variations in the ingredients used resulted in the analysis of rations given in Table 2.

Table 1. Ration Formulas, Experiment 170-III.

Ration No.	170-1	170-2	170-3
	%	%	%
Barley	20.0	30.2	30.0
Corn	18.4	39.0	38.8
Soybean Meal	13.4	13.8	23.6
Fish Meal	5.0	5.0	——
Oat Groats	30.0	——	——
Dried Skim Milk	10.0	5.0	——
Dicalcium Phosphate	2.5	1.6	2.0
Limestone	——	.6	.5
Salt (T-M)	.5	.5	.5
Fat	——	3.0	3.0
Vitamins[1]	.7	.7	.7
Lyamine[2]	——	.45	.6
Hydan[3]	——	.15	.3
Zinc Oxide (gm)	30.0	30.0	30.0
Total (%)	100.5	100.0	100.0
Calculated Protein %	22.0	22.0	22.0

[1] *Supplement (Thompson-Hayward) contains the following per lb: Vitamin A, 400,000 USP; Vitamin D_2, 40,000 USP; riboflavin, 400 mg; calcium pantothenate, 1305 mg; Niacin, 3200 mg; choline chloride, 8000 mg; Vitamin B_{12}, 3.2 mg; ethoxyquin, 5000 mg.*

[2] *Lyamine (Merck & Co.) 50% lysine monohydrochloride*

[3] *Hydan (Dupont & Co.) 90% methionine hydroxy analogue*

Thirty-six pigs averaging about 10 pounds in weight were allotted to 12 lots of three pigs each to permit three replicates per treatment. On the first day of the experiment, a break in the water line resulted in spraying water on and chilling some of the pigs, with loss of four. A malfunction of the furnace caused a drop in room temperature to 15-18° C. for two different nights. However, the remaining 32 pigs did not seem to be adversely affected and completed the 21-day experiment.

Table 2. Ration Composition, Experiment 170-III, by Analysis.

Ration No.	170-1	170-2	170-3
	%	%	%
Dry Matter	89.09	88.41	88.31
Protein	21.7	21.0	20.1
Calcium	0.694	0.797	0.726
Phosphorus	0.841	0.860	1.030
Fiber (ADF)	4.70	7.80	7.40

Results are summarized in Table 3. The pigs on all the ration treatments gained similarly and at a rate reasonable for baby pigs under these conditions. Removal of some or all of the oat groats, dried skim milk and fish meal had little effect when soybean oil meal was increased to maintain the protein level. Small amounts of lysine and methionine hydroxy analogue were added to the barley-corn base to supply the calculated limiting amino acids. Fat was added to equalize energy when the oat groats were removed. This is apparent in the acid-detergent fiber (ADF) analysis (Table 2), because the samples were not defatted prior to the fiber analysis.

Table 3. Effect of Complexity of Diet on Performance of Early-Weaned Pigs, Experiment 170-III.

Ration No.	170-1	170-2	170-3
No. Pigs	11	11	11
Initial Weight (lb.)	10.1	9.3	9.2
Final Weight (lb.)	22.1	21.5	21.1
Avg. Daily Gain (lb.)	0.57	0.58	0.57
Avg. Daily Feed (lb.)	0.94	0.90	0.93
Feed Per Lb. Gain (lb.)	1.65[1]	1.54[2]	1.64[1]

[1] [2] *Means on the same line bearing different superscripts are significantly ($P < .05$) different.*

The pigs on ration 2 (no oat groats) consumed about 4 per cent more feed daily and required 6 per cent less feed per pound of gain. However,

feed wastage was high and these values are of questionable significance even though waste feed was collected and used for correction of feed intake and feed efficiency values.

At the conclusion of this experiment the self-feeders were modified to reduce feed wastage, and auxiliary electric heaters were installed to insure temperature control in case of furnace malfunction.

Experiment 175-I

This experiment was initiated to investigate in more detail the use of barley in the rations for early-weaned pigs. Table 4 gives the ration formulations for four rations containing from 0 to 60 per cent barley. Corn and oat groats were removed as barley was increased. Fish meal and dried skim milk were included to be consistent with an earlier experiment (Harrold **et. al.** 1971 a, b). Rations were formulated to contain 22 per cent protein as recommended in the NRC requirements (1973) for pigs of this age and weight.

Table 4. Ration Formulas, Experiment 175-I, II.

Ration No.	I	II	III	IV
Barley %	0	20.0	40.0	60.0
Corn %	34.7	26.2	15.4	4.6
SBOM %	17.0	15.4	16.2	17.0
Fish Meal %	5.0	5.0	5.0	5.0
Oat Groats %	30.0	20.0	10.0	——
Dried Skim Milk %	10.0	10.0	10.0	10.0
Dical %	2.5	2.5	2.5	2.5
Salt %	0.5	0.5	0.5	0.5
Vitamin Premix* %	0.2	0.2	0.2	0.2
Methionine (90%) %	0.2	0.2	0.2	0.2
	100.1	100.0	100.0	100.0
Calculated Protein %	22.0	22.0	22.0	22.0

* *Supplement contains the following per lb: Vitamin A, 400,000; Vitamin D_2, 40,000 USP; riboflavin, 400 mg; calcium pantothenate 1305 mg; Niacin, 3200 mg; choline chloride, 8,000 mg; Vitamin B_{12} 3.2 mg; Ethoxyquin, 5,000 mg.*

Thirty-six early-weaned pigs, weighing about 12 pounds, were allotted to 12 lots of three pigs each, with three lots per treatment. Management was similar to that of the previous trial. The experiment was terminated after 21 days with the pigs averaging about 23 pounds. Results are given in Table 5. No statistically significant differences were obtained for daily gains, daily feed consumption or feed efficiency. The pigs on ration 3 (40 per cent barley) gained 10 per cent faster than the control (no barley). However, the pigs on ration 4 (60 per cent barley) gained similarly to those on the control and required about 13 per cent more feed per pound of gain. In this trial with early-weaned pigs the gilts performed equally as well as the barrows (Table 6).

Table 5. Barley Level and Performance of Early-Weaned Pigs, Experiment 175-I.

Barley %	0	20	40	60
Ration No.	I	II	III	IV
No. Pigs	9	9	9	9
Initial wt. (lb.)	12.3	12.2	12.0	13.1
Final Wt. (lb.)	23.0	23.8	23.3	22.8
Avg. Daily Gain (lb.)	0.51	0.55	0.54	0.46
Avg. Daily Feed (lb.)	0.97	1.01	1.07	0.99
Feed/Lb. Gain (lb.)	1.90	1.83	1.98	2.15

Table 6. Comparison of Barrows and Gilts, Experiment 175-I.

Item	Barrows	Gilts
No. Pigs	24	12
Initial Wt. (lb.)	12.4	12.4
Final Wt. (lb.)	23.0	23.6
Avg. Daily Gain (lb.)	0.51	0.53
Avg. Daily Feed (lb.)	0.97	1.05
Feed/Lb. Gain (lb.)	1.92	1.97

Experiment 175-II

This experiment was a repeat of the previous one. The same ration formulas were used with the exception that chromic oxide was added to all rations as a reference material to permit a digestibility study of these rations. The pigs were of similar weights to those used in the previous trial and similar management was used. Rations were sampled for analysis and feces were collected daily, composited within treatment and analyzed in triplicate.

The summary of results is given in Table 7. There were no significant differences between treatments for any of the measures of pig performance. In this experiment the pigs on treatment 4 (60 per cent barley) gained 10 per cent faster than those on the control ration and required about 11 per cent less feed per pound of gain. This was just the reverse of the results obtained in the previous experiment (Table 5).

Table 7. Barley Level and Performance of Early-Weaned Pigs, Experiment 175-II.

Ration No. / Barley %	0 I	20 II	40 III	60 IV
No. Pigs	9	9	9	9
Initial Wt. (lb.)	12.5	12.8	13.4	12.7
Final Wt. (lb.)	20.0	21.7	21.1	21.7
Avg. Daily Gain (lb.)	0.35	0.42	0.37	0.43
Avg. Daily Feed (lb.)	0.93	0.98	1.03	1.02
Feed/Lb. Gain (lb.)	2.63	2.38	2.78	2.37
DE/lb. Gain, kcal [1] [2]	3920	3480	4320	3540
DE, kcal/lb. ration [1] [2]	1474	1442	1526	1470

[1] *TDN can be calculated by multiplying by 2000 kcal/lb.*
[2] *90% DM basis.*

The ration composition, by analysis, is given in Table 8. All values are on a 100 per cent dry matter basis. The ADF value for the control ration was higher than expected. Because the fat in the ration is also included in the ADF value, it is possible that the extra fat in the oat groats of the control ration accounted for up to 2½ percentage units of the 7.01 units listed, and that the increasing levels of fiber from the barley was offset by less fat from the reduced level of oat groats.

Table 8. Average Ration Composition in Experiment 175-II by Analysis (100% DM Basis).

Ration No. / Barley %	0 I	20 II	40 III	60 IV
Dry Matter %	89.73	89.60	89.43	89.32
Protein %	24.85	24.88	25.02	25.19
Calcium %	0.832	0.832	0.802	0.839
Phosphorus %	0.790	0.848	0.852	0.847
Gross Energy (kcal/lb.)	2062	2073	2066	2009
Fiber (ADF) %	7.01	6.32	6.75	7.29
Ash %	6.55	6.32	6.61	6.72
Chromic Oxide %	0.316	0.351	0.219	0.207

The apparent digestion coefficients for the various ration fractions and nutrients are given in Table 9 and for energy digestibility in Table 10. The apparent digestibility of the ration dry matter, organic matter and protein-free organic matter was significantly greater for the two higher levels (40 and 60 per cent) of barley than for the lower barley levels. There is no apparent explanation for the significantly lower digestibility of the protein in ration II. The coefficients suggest that there was a greater retention of calcium and phosphorus in the rations with the higher levels of barley, but this experiment was of short duration and may not have measured the mineral balance accurately. The digestion coefficients for the ADF varied widely and do not show a consistent trend.

Table 9. Apparent Digestion Coefficients as Percents, Experiment 175-II.

Ration No. / Barley %	0 I	20 II	40 III	60 IV
Dry Matter	77.09[1]	74.76[1]	84.90[2]	84.94[2]
Protein	77.87[1]	73.42[2]	80.49[1]	81.10[1]
Calcium	54.80[1]	54.84[1]	61.46[2]	65.60[3]
Phosphorus	49.77[1]	52.49[1]	63.12[2]	63.78[2]
Fiber (ADF)	46.98	39.36	53.00	55.17
Organic Matter	77.99[1]	75.92[1]	85.27[2]	85.26[2]
Protein Free Organic Matter	79.29[1]	78.41[1]	86.16[2]	86.07[2]

[1] [2] [3] *Means on the same line bearing different superscripts are significantly different ($P < .01$) for Dry Matter and ($P < .05$) for Protein, Calcium and Phosphorus.*

Gross energy values as determined by the Parr Bomb Calorimeter are given in Table 10.

Table 10. Average Digestibility Coefficients, Gross Energy and Digestible (100% DM Basis) Energy Values, Experiment 175-II.

Ration No. / Barley %	0 I	20 II	40 III	60 IV
Digestibility Coefficient %	79.68[1]	77.64[1]	82.58[2]	81.93[2]
Gross Energy (kcal/lb.)	2062	2073	2066	2009
Digestible Energy (kcal/lb.)	1643	1609	1710	1645

[1] [2] *Means on the same line bearing different superscripts are significantly ($P < .05$) different.*

Gross or total energy of the rations was similar. The digestion coefficients for rations III and IV (40 and 60 per cent barley levels) were significantly (P=0.05 per cent) higher than for rations I and II (0 and 20 per cent barley levels). Thus, the two rations with 40 or 60 per cent barley should have been used more efficiently. This was not borne out when the values for pounds of feed per pound of gain were considered (Table 5 and 7). However, increased levels of barley did not reduce efficiency, and therefore was as useful a grain as the mixture of corn and oat groats which it replaced in the ration.

Experiment 175-III

Since barley is low in fat (ether extract), an experiment was initiated to determine if a small amount of added fat would have an effect on the control ration and the 60 per cent barley ration (Table 4). Five per cent fat (white grease) was added to each of these rations without substitution. Table II gives the ration analysis on a 100 per cent dry matter basis. The "dilution" of other fractions and nutrients by adding 5 per cent fat was not appreciable. Chemical analysis reflects that with ether extract a simple calculation of fat content from average reported values is subject to error and, also, that fat analyses are variable. It is worthy of note that the acid-detergent fiber analysis did not measure the entire fat addition, only part of it.

Table 11. Average Ration Composition in Experiment 175-III by Analysis (100% DM Basis).

Barley %	0	0	60	60
Fat %	0	5	0	5
Ration No.	I	I-F	IV	IV-F
Dry Matter	88.27	88.20	88.82	89.08
Protein	26.37	25.03	25.11	24.81
Calcium	0.977	0.902	0.890	0.880
Phosphorus	0.979	0.976	0.961	0.924
Fiber (ADF)	4.74	6.32	6.31	6.57
Ether Extract (analyzed)	5.85	9.35	3.35	8.38
Ether Extract (calculated)	3.74	8.30	1.96	6.63

Summary of the 21-day trial with early-weaned pigs is given in Table 12. There were no significant differences in average daily gains, daily feed consumption or feed per pound of gain, even though the differences in daily gains were not large enough to be statistically significant (largely because of small numbers and variation within lots). The fat addition to ration I increased gains 13.5 per cent and reduced feed per pound of gain by 7.9 per cent. In comparison, adding fat to the 60 per cent barley ration increased gains only 4.5 per cent and increased feed efficiency by 5 per cent. Thus, the barley rations were not benefitted by the fat as much as were the control rations. In this experiment, as in experiment 175-II, the pigs on the control ration required 11 per cent more feed per pound of gain than the pigs on the 60 per cent barley rations.

Table 12. Supplementary Fat and Performance of Early-Weaned Pigs, Experiment 175-III.

Barley %	0	0	60	60
Fat %	0	5	0	5
Ration No.	I	I-F	IV	IV-F
No. Pigs	9	9	9	9
Initial Wt. (lb.)	14.2	13.9	13.9	13.7
Final Wt. (lb.)	22.0	22.8	23.0	23.1
Avg. Daily Gain (lb.)	0.37	0.42	0.43	0.45
Avg. Daily Feed (lb.)	0.71	0.75	0.75	0.75
Feed/lb. Gain (lb.)	1.91	1.78	1.72	1.67
DE/lb. Gain kcal [1] [2]	2820	2760	2460	2560
DE/lb. Ration kcal [1] [2]	1474	1534	1426	1536

[1] *Calculated from proximate analysis and digestion coefficients from previous experiments.*
[2] *90% DM basis.*

Discussion

If the data from all experiments on the various levels of barley in rations for early-weaned pigs were combined by adjustment to a common treatment, the comparisons become more meaningful (Table 13). On the relative pig performance, all treatments were compared to the 20 per cent barley level because it was common in all experiments, whereas the "O" barley level was not included in experiment 170-III. These combinations and comparisons show that the pigs on the "O" level of barley gained only 88 per cent as fast as those on the 20 per cent barley level, and were 7 per cent less efficient in feed use.

The barley used in these experiments was good quality, averaging 48-49 pounds per bushel, whereas the corn averaged only 54 pounds per bushel.

These experiments show that barley can be used in pelleted rations for early-weaned pigs with no appreciable effect on the pig performance. At least this is so on well-formulated, pelleted rations with high quality barley. It is likely that high levels of barley in rations fed in meal form

Table 13. Summary of the Adjusted Performance of Early-Weaned Pigs Fed Barley Using the 20 Per Cent Barley Level as a Comparison.[1]

	Barley Level (Per Cent)				
	0	20	30	40	60
Relative Pig Performance					
Avg. Daily Gain %	88	100	101	96	97
Avg. Daily Feed %	95	100	98	104	101
Feed/lb. Gain %	107	100	96	107	104
Adjusted Pig Performance					
Avg. Daily Gain (lb.)	0.45	0.51	0.51	0.49	0.50
Avg. Daily Feed (lb.)	0.93	0.98	0.96	0.94	0.99
Feed/lb. Gain (lb.)	2.09	1.95	1.87	2.09	2.03

[1] *Calculated by taking ADG, ADF and feed/lb. gain values and using the following formula:*

$$\frac{\text{0, 40 or 60\% barley}}{\text{20\% barley}} \times 100 = \text{\% of 20\% barley level.}$$

Once the average percentages for each ration were obtained, these percentages were multiplied times the average performance values for the 20 per cent barley level (i.e., 0.51 x 88% = 0.45).

would be dusty and not as palatable. Further, lower quality barley would have higher fiber levels, which might affect pig performance.

Summary

1. Use of up to 60 per cent barley in pelleted rations for early-weaned pigs did not adversely affect pig performance.
2. Adding 5 per cent fat to barley rations did not prove to be economical.
3. Simplifying the ration formula by reducing or omitting dried skim milk, fish meal and oat groats and adding soybean oil meal plus lysine and methionine is suggested when ingredient prices warrant.

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(From the Director . . . from page 2)

to present their evaluation of the Station and Extension programs. At a larger meeting several state government units were also invited to make presentations to the Committee on their respective relationships between their units and the Station and Extension programs. The study also included consideration of a report and recommendations from a private auditing firm which examined North Dakota State University with particular emphasis on the Agricultural Experiment Station and the Cooperative Extension Service. Extensive materials were prepared and submitted to the Committee by Station and Extension personnel, and these materials were discussed in detail during meetings of the Committee.

Legislative Council Budget Committee "B" will conclude the study with a written report to the Legislative Council. This report will be useful to members of the Legislature in the subsequent considerations for support of the Agricultural Experiment Station and the Cooperative Extension Service.

Budget Committee "B" is to be commended for the manner in which the study was conducted. The meetings provided an opportunity for many interested and concerned persons and organizations to present themselves to key legislators and to express their viewpoints. Attendance at each meeting of the Committee by its membership was excellent, providing an opportunity for each of them to become much better informed about the Agricultural Experiment Station and Cooperative Extension Service as integral parts of North Dakota State University. And many Station and Extension personnel were granted the privilege of communicating directly with the committee members.

This study has already been mutually worthwhile for those who participated in it, and will also undoubtedly be fruitful in the future.