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Barley in Rations for Layers

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Contents

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This bulletin reports a series of experiments in which barley and corn serve as principal grain sources for layers. Particular attention is given to factors influencing efficient utilization of the barley-containing diets.

Review of Literature

In an attempt to study the value of barley as a feedstuff, considerable data have been reported where limited amounts of barley (approximately 50% or less) have been used to replace similar or variable amounts of corn (Petersen and Lampman, 1955; Berg et al., 1956; Meuller, 1956; and Petersen et al., 1957); wheat (Anderson and Draper, 1956; and Halbrook, 1956) or mixed grains (Anderson and Draper, 1956; Petersen and Lampman, 1955; Berg et al., 1956; and McCluskey, 1958). The extensive review of the early literature by Crampton (1939) likewise reveals much data of a similar nature. In other instances where more than 50% barley has been used comparisons often have been made with various combinations of mixed grains (Anderson and Draper, 1956; Berg et al., 1956; and Anderson and Wagstaff, 1958). In relatively few reports of recent origin has complete replacement of barley been attempted with other grains (Peterson and Zweigart, 1954; Berg and Bearse, 1958; and Nelson and Hutto, 1958, for corn; and Anderson and Wagstaff, 1958, for wheat).

Complete replacement of one grain with another in studies of this nature is desirable particularly in view of the suggestion by Anderson and Draper (1956) that rations containing barley as the sole grain may be deficient in leucine and reports by Fry et al. (1957 a & b) regarding water treatment and use of amylolytic enzymes to improve utilization of barley for chicks. Recent data involving amylolytic enzymes (Nelson and Hutto, 1958) indicated a similar effect on egg production for barley-fed layers; however, in an extensive study by Berg and Bearse (1958) a similar relationship was not observed.

Although Anderson and Draper (1956), Nelson and Hutto (1958), and McCluskey (1958) have reported unfavorable results from including high levels of barley in the diet, favorable or comparable egg production data have been obtained in other studies previously reviewed. Virtually all experiments have shown that feed effi-

ciency is decreased when barley replaces appreciable quantities of corn in laying rations. No adverse effects have been observed on hatchability, fertility, shell thickness ,egg weight and albumen, or yolk quality from high-level barley feeding.

Methods and Results

Experiment 1

This experiment was designed to determine whether barley might comprise the principal grain source in a mash-scratch feeding program. Effect of fat as an energy supplement to a high-barley or lower-energy feed was also studied.

Procedure: Three hundred and twenty White Leghorn pullets[1] were housed and distributed into eight 16 x 16 ft. floor pens of 40 birds each prior to the start of the experiment. The experiment began August 19, 1954, when all pens had reached a production rate of approximately 50%. Daily egg production and mortality, monthly feed consumption, and initial and final body weight data were recorded for a 10-month period (302 days). Calculations were made on a hen-day basis. At least 14 hours of light were provided from October through May. No culling was practiced during the experiment.

Duplicate lots received the following rations: (1) corn mash + corn scratch; (2) corn mash + barley scratch; (3) barley mash + barley scratch; and (4) barley mash containing 10% animal fat[2] + barley scratch. An attempt was made to maintain a 60:40 mash-scratch ratio. Rations used are shown in Table 1. No attempt was made to adjust protein level following addition of fat. Oyster shell and granite grit were supplied free-choice.

Results. Data summarized in Table 2 show no differences in egg production from including barley in the diet. However, when 10% animal fat was added a significant decrease in production occurred as compared to the ration containing corn as the sole grain. Feed consumed per hen increased as barley content of the diet increased. Feed per dozen eggs increased with an increase in barley content, and increased even further with the addition of fat because of the decreased egg production noted above. Body weight gains decreased, but not significantly, as barley content of the feed increased where no fat was added. In the presence of fat, a significant increase in gain was noted

[1] All White Leghorn pullets used in this and subsequent experiments were of a strain maintained by the Oregon Agricultural Experiment Station.

[2] Calogen (Swift and Co., Portland, Oregon) stabilized with Tenox R which is composed of citric acid (anhydrous), 20%; butylated hydroxyanisole, 20%; and propylene glycol, 60%.

Table 1. COMPOSITION OF RATIONS USED (EXPERIMENT 1)

Ingredients	Rations			
	1	2	3	4
Mash (60%)				
Corn, yellow, grd., lbs.	1,196	1,200		
Barley, Pacific Coast, grd., lbs.			1,200	1,000
Animal fat[1], lbs.				200
Soybean meal, (44% prot.), lbs.	450	450	450	450
Fish meal, (70% prot.), lbs.	60	60	60	60
Meat & bone meal, (50% prot.), lbs.	50	50	50	50
Alfalfa meal, sun cured, (15% prot.), lbs.	100	100	100	100
Limestone flour[2], lbs.	30	30	30	30
Bone meal, st., lbs.	80	80	80	80
Salt, iodized, lbs.	20	20	20	20
Manganese sulfate, (65%), lbs.	0.5	0.5	.05	.05
Vitamin A & D oil, (2,250 U.S.P.U.-A; 300 I.C.U.-D_3/gm.), lbs.	10	10	10	10
Choline Cl, (25%), lbs.	3			
Riboflavin conc., (4 gm./lb.), lbs.	0.6	0.6	0.6	0.6
Niacin, grams	40	40		
Totals	2,000.1	2,001.1	2,001.1	2,001.1
Scratch (40%)				
Corn, yellow, lbs.	2,000			
Barley, Pacific Coast, lbs.		2,000	2,000	2,000
Totals	2,000	2,000	2,000	2,000
Calculated analysis (based on feed intake—see Table 2)				
Protein, %	15.4	15.7	16.0	15.4
Fat, %	3.5	2.6	1.9	7.5
Fiber, %	3.3	4.5	5.6	5.3
Energy, metabolizable Cal./lb.	1,384	1,235	1,114	1,224
Calcium, %	.95	.97	1.01	1.0

[1] See footnote 2 of text.
[2] Supplemental oystershell supplied.

Table 2. INFLUENCE OF BARLEY, CORN, AND FAT ON PRODUCTIVE CHARACTERISTICS OF WHITE LEGHORN LAYERS (EXPERIMENT 1)

Grain component		Average 10-month data					
Mash	Scratch	Egg. prod.	Feed cons.	Feed/doz. eggs	Body wt. gain	Mortality	Actual Mash :scratch ratio
		%	*Lbs.*	*Lbs.*	*Lbs.*	%	
Corn	Corn	63.5	67.5	4.23	.63	13.8(80)[1]	57.5 :42.5
Corn	Barley	60.1	72.4	4.79	.55	18.8(80)	56.5 :43.5
Barley	Barley	59.4	73.0	4.88	.34	11.3(80)	57 :43
Barley + 10% fat	Barley	55.9	72.4	5.14	.85	16.3(80)	56.5 :43.5
L.S.D. ($p < .05$)		6.5	4.1	.41	.37	nts[2]	

[1] Figures in ( ) represent number of pullets started.
[2] Not treated statistically.

when comparison was made to the all-barley program. Differences in mortality were not consistent. Mash to scratch ratios obtained approached the 60:40 intended.

Experiment 2

This trial was designed to compare an all-mash vs. a mash-scratch system of feeding in which barley or corn would serve as the sole grain source. Addition of animal fat to an all-mash barley feed was also studied. Comparative data were also obtained on all-mash barley or corn rations with White Leghorn and New Hampshire layers.

Procedure. Three hundred and ninety-nine White Leghorn pullets were housed and distributed into ten 16 x 16 ft. floor pens of approximately 40 birds each prior to the start of this experiment on August 15, 1955. Likewise, 4 similar pens totaling 159 New Hampshire pullets[3] were housed under conditions similar to those described for White Leghorn pullets. Management and records obtained have previously been reported in Experiment 1. The trial covered a 10-month period (306 days).

Duplicate lots of White Leghorns received the following rations: (1) corn mash; (2) barley mash; (3) barley mash containing 6% animal fat; (4) corn mash + corn scratch; and (5) barley mash + barley scratch. New Hampshires were fed rations 1 and 2 above. An adjustment was made in protein content of the mash to accommodate added fat as well as the higher protein level in the barley. Rations used are shown in Table 3.

Results. Results for this experiment are summarized in Table 4. Although significant breed differences were observed for each character tested, no significant differences in egg production or feed efficiency were observed between groups of White Leghorns, including the layers fed barley mash containing 6% of added fat. Significantly more feed was consumed by White Leghorns fed barley mash + barley scratch ration as compared to those fed corn mash + corn scratch ration. Use of barley in mash feed for New Hampshires appeared to reduce rate of lay and feed consumption, although statistically significant differences were not obtained. However, the amount of feed required by these layers to produce a dozen eggs on the barley ration was significantly increased.

Addition of fat to the barley ration resulted in significantly greater body weight gains as compared to barley rations without fat. Significantly greater weight gains were evident for layers fed corn

[3] All New Hampshire pullets used in this and subsequent experiments were originally of the Nichol's strain and have been maintained as a closed flock at the Oregon Agricultural Experiment Station for several years.

Table 3. COMPOSITION OF RATIONS USED (EXPERIMENT 2)

Ingredients	Rations				
	1	2	3	4	5
Mash (50-100%)					
Corn, yellow, grd., lbs.	1,519			1,037.5	
Barley, Pacific Coast, grd., lbs.		1,543	1,398		1,086.5
Animal fat[1], lbs.			120		
Soybean meal, (44% prot.), lbs.	275	250	275	550	500
Fish meal, (70% prot.), lbs.	60	60	60	120	120
Alfalfa meal, sun cured, (15% prot.), lbs.	60	60	60	120	120
Limestone flour[2], lbs.	20	20	20	40	40
Bone meal, st., lbs.	50	50	50	100	100
Salt, iodized, lbs.	10	10	10	20	20
Manganese sulfate, (70%), lbs.	0.3	0.3	0.3	0.6	0.6
Vitamin A & D oil, (2,250 U.S.P.U.-A; 300 I.C.U.-D_3/gm.), lbs.	3	6	6	6	12
Vitamin D_3, (1,500 I.C.U./gm.), lbs.	0.5			1	
Choline C1, (25%), lbs.	2			4	
Riboflavin conc., (4 gm./lb.), lbs.	0.5	0.5	0.5	1	1
Niacin, grams	20			40	
Totals	2,000.3	1,999.8	1,999.8	2,000.1	2,000.1

Table 3. (Continued)

Ingredients	Rations				
	1	2	3	4	5
Scratch (0-50%)					
Corn, yellow, lbs.				2,000	
Barley, Pacific Coast, lbs.					2,000
Totals	0	0	0	2,000	2,000
Calculative analysis (based on feed intake—see Table 4)					
Protein, %	15.9	16.1	16.0	16.6	16.7
Fat, %	3.5	1.9	7.8	3.4	2.0
Fiber, %	3.2	5.5	5.2	3.3	5.5
Energy, metabolizable, cal./lb.	1,385	1,117	1,231	1,369	1,108
Calcium, %	.90	.97	.97	.97	1.06

[1] See footnote 2 of text.
[2] Supplemental oystershell supplied.

Table 4. COMPARATIVE PERFORMANCE DATA ON USE OF BARLEY, CORN, AND FAT IN RATIONS FOR WHITE LEGHORN LAYERS AND BARLEY AND CORN IN RATIONS FOR NEW HAMPSHIRE LAYERS *(EXPERIMENT 2)*

Grain component		Average 10-month data					
Mash	Scratch	Egg prod.	Feed cons.	Feed/doz. eggs	Body wt. gain	Mortality	Actual Mash:scratch ratio
		%	*Lbs.*	*Lbs.*	*Lbs.*	%	
		WHITE LEGHORNS					
Corn		69.8	71.3	4.01	.57	16.3(80)[1]	100:0
Barley		67.8	72.5	4.20	.37	20.0(80)	100:0
Barley + 6% fat		67.3	71.0	4.12	.76	12.5(80)	100:0
Corn	Corn	66.7	69.3	4.08	.79	15.0(80)	54.3:45.7
Barley	Barley	66.3	74.2	4.41	.31	13.9(79)	55.2:44.8
L.S.D. ($p < .05$)		nsd[2]	4.1	nsd	.37	nts[3]	
		NEW HAMPSHIRES[4]					
Corn		56.4	98.3	6.87	1.10	16.9(78)	100:0
Barley		46.0	92.1	7.87	1.08	20.0(81)	100:0
L.S.D. ($p < .05$)		nsd	nsd	.92	nsd	nts	

[1] Figures in ( ) represent number of pullets started.
[2] No significant difference.
[3] Not treated statistically.
[4] Significant ($p < .01$) breed differences noted for egg production, feed consumption, feed per dozen eggs, and body-weight gain.

mash with corn-scratch ration as compared to a barley mash with barley-scratch ration. A nonsignificant increase in gain was observed for the all corn-mash ration as compared to the all barley-mash ration. No consistent differences in mortality were observed between groups.

When the all-mash system of feeding is compared with the mash-scratch system for White Leghorns, a slight increase in egg production in favor of the all-mash system is observed; however, this difference is not statistically significant.

Experiments 3 and 4

Since pelleting barley-type feeds has shown a marked improvement in growth and feed conversion of broilers (Arscott et al., 1958), effect of pelleting barley-type rations for layers was studied in the following experiment.

Procedure. Three hundred sixty White Leghorn pullets were housed and distributed into eight 16 x 16 ft. floor pens of 45 birds each prior to the start of Experiment 3 on August 1, 1957. Management has been described. Duration of the experiment was approximately 10 months (304 days). Duplicate lots received the following rations: (1) corn mash; (2) corn mash—pelleted; (3) barley-mash; and (4) barley mash—pelleted. A 6/32 inch pellet was used in this and the subsequent experiment. Rations for Experiment 3 are given in Table 5.

Two hundred and seventy-eight White Leghorn pullets were distributed into four 16 x 16 ft. floor pens of about 70 birds each prior to the start of Experiment 4 on August 1, 1958. Duration of the experiment was 9 months (272 days). Duplicate lots received the following rations: (1) barley mash: and (2) pelleted barley mash. The barley ration used is shown in Table 8 as ration 3. Water consumption data were obtained for each pen from November through May. Water intake was determined for a 24-hour period once each month by weighing waterers at the beginning and end of the day and correcting for evaporation from a similar waterer not accessible to the birds.

Results. Data on pelleting barley and corn mashes are summarized in Table 6. No significant differences for egg production, feed per dozen eggs, or body weight gains are evident. Feed consumption was significantly increased as energy level of mash was lowered by inclusion of barley. Pelleting corn mash also significantly increased feed consumption. Increase in feed consumption was also noted from pelleting barley mash, but this proved statistically nonsignificant. Body weight gains appeared greater with layers fed pelleted feeds and corn mash as compared to those fed barley mash, although no statis-

tically significant differences were evident. Differences in mortality were not consistent.

Results for the pelleted barley ration are shown in Table 7. Egg production, feed consumption, feed per dozen eggs, body weight gains, and mortality data were similar to results previously noted for barley mash and pelleted barley mash (Table 6). Of particular interest was the observation that water consumption was considerably greater for layers fed a pelleted barley ration, although the difference was not statistically significant.

Table 5. COMPOSITION OF RATIONS USED (EXPERIMENT 3)

Ingredients	Rations 1-2[1]	Rations 3-4[1]
Corn, yellow, grd., lbs.	1,519	
Barley, Pacific Coast, grd., lbs.		1,543
Soybean meal, (44% prot.), lbs.	275	250
Fish meal, (70% prot.), lbs.	60	60
Alfalfa meal, dehy., (20% prot.), lbs.	60	60
Limestone flour[2], lbs.	20	20
Bone meal, st., lbs.	50	50
Salt, iodized, lbs.	10	10
Manganese sulfate, (70%), lbs.	0.3	0.3
Vitamin A & D oil, (2,250 U.S.P.U.-A; 300 I.C.U.-D/gm.), lbs.	3	6
Vitamin D_3, (1,500 I.C.U/gm.), lbs.	0.5	
Choline Cl, (25%), lbs.	2	
Riboflavin conc., (4 gm./lb.), lbs.	0.75	0.75
d-Ca pantothenate conc., (32 gm./lb.), lbs.	0.13	0.13
Niacin, grams	20	
Totals	2,000.68	2,000.18
Calculated analysis:		
Protein, %	16.1	16.3
Fat, %	3.5	2.0
Fiber, %	3.1	5.4
Energy, metabolizable, cal./lb.	1,398	1,130
Calcium, %	.90	.98

[1] Mash-pellets respectively.
[2] Supplemental oystershell supplied.

Table 6. EFFECT OF PELLETING CORN OR BARLEY RATIONS ON PRODUCTIVE CHARACTERISTICS OF WHITE LEGHORN LAYERS (EXPERIMENT 3)

Treatment		Average 10-month data				
Grain component	Form	Egg prod.	Feed cons.	Feed/doz. eggs	Body-wt. gain	Mortality
		%	*Lbs.*	*Lbs.*	*Lbs.*	%
Corn	Mash	67.3	68.1	4.00	.65	6.7(90)[1]
Corn	Pellets	70.8	74.2	4.15	.82	8.9(90)
Barley	Mash	70.8	74.1	4.14	.48	11.1(90)
Barley	Pellets	69.6	77.2	4.38	.75	7.8(90)
L.S.D. ($p < .05$)		nsd[2]	4.1	nsd	nsd	nts[3]

[1] Figures in ( ) represent number of pullets started.
[2] No significant differences.
[3] Not treated statistically.

Table 7. INFLUENCE OF PELLETING BARLEY RATIONS ON PRODUCTIVE CHARACTERISTICS OF WHITE LEGHORN LAYERS (EXPERIMENT 4)

Treatment		Average 9-month data					
Grain component	Form	Egg prod.	Feed cons.	Feed/doz. eggs	Water cons.	Body-wt. gain	Mortality
		%	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	%
Barley	Mash	61.2	68.8	4.97	114.5[1]	.45	10.9(138)[2]
Barley	Pellets	62.1	72.3	5.17	123.1	.64	15.0(140)
L.S.D. ($p < .05$)		nsd[3]	nsd	nsd	nsd	nsd	nts[4]

[1] Seven-month data—Nov. to May.
[2] Figures in ( ) represent number of pullets started.
[3] No significant difference.
[4] Not treated statistically.

Experiments 5 and 6

In view of beneficial effects from enzyme supplementation on utilization of barley by chicks as initially reported by Fry et al. (1957b) and since confirmed by others, a series of experiments involving White Leghorn and New Hampshire layers was conducted to determine effect of addition of an amylolytic enzyme supplement to corn- or barley-type rations.

Procedure: These experiments covered about a 3-year period from August 1, 1958, through June 1, 1961. Each experiment lasted approximately 10 months. Data were accumulated during the first and second year in Experiments 5 and 6 for New Hampshires and during the first and third year in Experiments 5 and 7 for White Leghorns. Duration of experiments 5, 6, and 7 was 304, 305, and 308 days, respectively. Data for Experiments 5 and 6 were obtained on a calendar-month basis for 10 months, whereas Experiment 7 data were based on 11 28-day periods. Data within breeds have been combined whenever possible for presentation of results.

In experiments with New Hampshires, 4 lots totaling 192 pullets were used in Experiment 5, and 3 lots totaling 149 pullets in Experiment 6. For experiments with White Leghorns, 4 lots totaling 280 and 201 pullets were used in Experiments 5 and 7, respectively. All layers were housed in 16 x 16 ft. floor pens prior to and during experiments. Management has been described previously.

Layers received the following rations during this experiment: (1) corn mash, (2) corn mash + enzyme,[4,5] (3) barley mash and (4) barley mash + enzyme. Rations used in Experiments 5 and 6 are shown in Table 8. Rations used in Experiment 7 are shown in Table 9 and required no supplemental oystershell as did all previous rations. The enzyme supplement was included at the expense of the ground grain component. Water-consumption data were obtained from October through May in Experiment 5 and throughout the trial in Experiment 7 in the manner described for Experiment 4.

Results. Data summarized in Tables 10 and 11 show no differences in egg production for either breed that may be attributed to the grain component of the ration or the enzyme supplement. Feed consumption for the Leghorns was increased significantly but not with the New Hampshires. Feed per dozen eggs appeared greater but no significant differences were evident.

Water consumption for White Leghorns (Table 10) was signifi-

[4] Dawenzyme (Dawes Laboratories, Chicago, Illinois).

[5] This treatment was not continued during the second year with New Hampshires.

cantly greater with barley mash. When the enzyme was added to the barley ration a slight decrease in water intake was observed. Water consumption with New Hampshires (Table 11), for the year taken, was also greater when barley rations were fed and slightly reduced in the presence of the enzyme. Although no significant differences were noted, hens on corn rations appeared to gain more than those receiving barley, but more variability was encountered with New Hampshires than with Leghorns. No consistent differences in mortality due to treatment were observed.

Table 8. COMPOSITION OF RATIONS USED (EXPERIMENTS 4, 5, AND 6)

Ingredients	Rations			
	1[2]	2	3[1,2]	4[2]
Corn, yellow, grd., lbs.	1,515	1,510		
Barley, Pacific Coast, grd., lbs.			1,540	1,535
Soybean meal, (44% prot.), lbs.	275	275	250	250
Fish meal, (70% prot.), lbs.	60	60	60	60
Alfalfa meal, dehy., (20% prot.), lbs.	60	60	60	60
Bone meal, st., lbs.	50	50	50	50
Limestone flour[3], lbs.	20	20	20	20
Salt, iodized, lbs.	10	10	10	10
Vitamin-trace mineral premix[4], lbs.	10	10	10	10
Enzyme[5], lbs.		5		5
Totals	2,000	2,000	2,000	2,000
Calculated analysis:				
Protein, %	16.1	16.1	16.3	16.2
Fat, %	3.5	3.5	2.0	2.0
Fiber, %	3.1	3.1	5.4	5.4
Energy, metabolizable, cal./lb.	1,395	1,391	1,129	1,126
Calcium, %	.90	.90	.98	.98

[1] Ration used in experiment 4 as mash or pellets.

[2] Rations used in experiment 6.

[3] Supplemental oystershell supplied.

[4] Nopcosol M-6 (Nopco Chem. Co., Richmond, Calif.), supplied/lb. of mixture: Vit. A, 500,000 U.S.P.U.; Vit. D_3, 200,000 I.C.U.; riboflavin, 350 mg.; d-pantothenic acid, 300 mg.; Vit. E, 100 I.U.; niacin, 2 gm.; choline, 20 gm.; Vit. B_{12} act., 0.4 mg.; butylated hydroxy toluene, 11.34 gm.; Mn, 5.4 gm.; I, 109 mg.; Fe, 1.8 gm.; Cu, 181.6 mg.

[5] See footnote 4 of text.

Table 9. COMPOSITION OF RATIONS USED (EXPERIMENT 7)

Ingredients	Rations 1	2	3	4
Corn, yellow, grd., lbs.	1,452.6	1,447.8		
Barley, Pacific Coast, grd., lbs.			1,477.6	1,472.8
Soybean meal, (44% prot.), lbs.	263.6	263.6	239.6	239.6
Fish meal, (70% prot.), lbs.	57.6	57.6	57.6	57.6
Alfalfa meal, dehy., (20% prot.), lbs.	57.6	57.6	57.6	57.6
Bone meal, st., lbs.	48.	48.	48.	48.
Limestone flour, lbs.	19.2	19.2	19.2	19.2
Oystershell, Eastern, med., lbs.	82.2	82.2	82.2	82.2
Salt, iodized, lbs.	9.6	9.6	9.6	9.6
Vitamin-trace mineral premix[1], lbs.	9.6	9.6	9.6	9.6
Enzyme[2], lbs.		4.8		4.8
Totals	2,000.	2,000.	2,000.	2,000.
Calculated analysis:				
Protein, %	15.4	15.4	15.7	15.7
Fat, %	3.3	3.3	1.9	1.9
Fiber, %	3.0	3.0	5.2	5.2
Energy, metabolizable, cal./lb.	1,338.	1,334.	1,082.	1,079.
Calcium, %	2.80	2.80	2.87	2.87

[1] Nopcosol M-6 (Nopco Chem. Co., Richmond, Calif.), supplied/lb. of mixture: Vit. A, 500,000 U.S.P.U.; Vit. D_3, 200,000 I.C.U.; riboflavin, 350 mg.; d-pantothenic acid, 300 mg.; Vit. E, 100 I.U.; niacin, 2 gm.; choline, 20 gm.; Vit. B_{12} act., 0.4 mg.; butylated hydroxy toluene, 11.34 gm.; Mn, 5.4 gm.; I, 109 mg.; Fe, 1.8 gm.; Cu, 181.6. mg.

[2] See footnote 4 of text.

Table 10. INFLUENCE OF ENZYME SUPPLEMENTATION ON CORN OR BARLEY RATIONS FOR WHITE LEGHORN LAYERS (EXPERIMENTS 5 AND 7)

Group treatment	Average 10-month data					
	Egg prod.	Feed cons.	Feed/doz. eggs	Water cons.[1,2]	Body-wt. gain	Mortality
	%	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	%
1 Corn mash[1]	66.7	70.7	4.22	112.6	.75	17.0(121)[3]
2 Barley mash	69.9	76.2	4.32	141.2	.65	6.3(120)
3 As 1 + enzyme[4]	68.3	70.6	4.11	113.6	.80	8.4(120)
4 As 2 + enzyme	70.3	76.0	4.30	131.6	.65	13.9(120)
L.S.D. ($p < .05$)	nsd[5]	4.1	nsd	11.4	nsd	nts[6]

[1] Eight-month data—October to May, in Experiment 5.
[2] Ten-month data in Experiment 7.
[3] Figures in ( ) represent number pullets started.
[4] See footnote 4 of text.
[5] No significant differences.
[6] Not treated statistically.

Table 11. INFLUENCE OF ENZYME SUPPLEMENTATION ON CORN OR BARLEY RATIONS FOR NEW HAMPSHIRE LAYERS (EXPERIMENTS 5 AND 6)

Group treatment	Average 10-month data					
	Egg prod.	Feed cons.	Feed/doz. eggs	Water cons.[1]	Body-wt. gain	Mortality
	%	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*%*
1 Corn mash	53.4	92.7	6.86	146.5	2.1	12.4(97)[2]
2 Barley mash	50.9	97.0	7.55	188.1	1.2	15.4(98)
3 As 1 + enzyme[1,3]	52.6	94.1	7.07	148.2	1.6	8.3(48)
4 As 2 + enzyme	52.9	99.4	7.42	175.2	1.4	8.2(98)
L.S.D. ($p < .05$)	nsd[4]	nsd	nsd	nts[5]	nsd	nts

[1] Experiment 5 only.
[2] Figures in ( ) represent number of pullets started.
[3] See footnote 4 of text.
[4] No significant difference.
[5] Not treated statistically.

Discussion

Barley vs. corn. Results reported herein show that barley may constitute the sole grain component in mash or mash-scratch rations for White Leghorn layers without significantly reducing egg production (Tables 2, 4, 6, and 10). With New Hampshire layers receiving all-mash rations only, somewhat more variability was observed although no significant differences were evident. (Tables 4 and 11).

Feed consumption was generally increased by use of barley. Significant differences between barley and corn rations were consistently observed with White Leghorns fed on mash-scratch programs (Tables 2 and 4). With mash rations a significant increase in feed consumption was noted in two out of three instances (Tables 6 and 10 vs. 4), and with New Hampshires increased feed consumption also was observed except when there was a pronounced difference in rate of egg production (Tables 4 and 11).

No significant differences were noted for feed required per dozen eggs on barley-type rations regardless of the feeding system except for results with White Leghorns on the mash-scratch rations in Table 2 and New Hampshires on all-mash rations observed in Table 4. Throughout these experiments, however, a consistent decrease in feed efficiency was apparent whenever barley replaced corn regardless of the feeding program. It is interesting to note that greater differences result for mash-scratch rations than on all-mash rations, reflecting, possibly, increased energy expended by the hen in grinding the whole grains used.

Layers fed corn rations were observed to be consistently heavier than those fed barley although differences in body weight gains were not statistically significant.

Water consumption was markedly increased when barley replaced corn in rations of White Leghorns (Table 10) and New Hampshires (Table 11).

No differences in mortality due to treatment were apparent. Based on observations made on extent of litter packing and amount of stirring required, litter condition in pens of hens fed barley proved inferior to pens of those fed corn.

Use of fat. A significant decrease in egg production was noted when 10% fat, representing an intake of 5.7% fat in the total ration (Tables 1 and 2), was added to mash in a mash-scratch feeding program containing barley as the sole grain source; however, this decrease did not persist when 6% fat was added to an all-mash feed containing barley with an appropriate adjustment made for protein dilution (Table 4). In both experiments, however, body weight gains were significantly greater than those obtained with layers fed barley

without added fat. In the presence of fat, feed consumption was slightly reduced, but the reduction was not statistically significant. In the groups in which egg production was not decreased, less feed was required to produce a dozen eggs. No differences in mortality were observed.

Pellets. Pelleting mash rations containing barley or corn failed to increase egg production of White Leghorn layers (Table 6). Feed consumption was greater whenever rations were pelleted; but significant differences were noted only when corn was the sole grain component. Feed required per dozen eggs and body weight gains were increased when increases in feed consumption were noted although differences obtained were not significant. Water consumption was increased after pelleting a barley-type ration (Table 7); however, this increase was not statistically significant. No important differences in mortality were observed.

Enzymes. Addition of an amylolytic enzyme to barley or corn rations for either White Leghorns or New Hampshires failed to have any beneficial effect on egg production, feed consumption, feed per dozen eggs, body weight gains, or mortality as compared to unsupplemented rations containing barley or corn (Tables 10 and 11). Although no significant differences were noted, a slight decrease in water consumption was observed with both breeds from adding the enzyme to barley rations.

Results and the literature. It is expected that over the time covered by these experiments, a number of reports relating to this problem will have appeared in the literature.

The fact that barley may constitute the entire grain component in place of corn without adversely affecting egg production, with increased feed consumption, and decreased body weight gains, are in accord with the observations of Peterson and Zweigart (1954), Berg and Bearse (1958), Berg (1959, 1961), and Anderson et al. (1960), but not with those of Nelson and Hutto (1958), and Petersen et al. (1960). It should be noted, however, that in experiments of Petersen et al. corn or barley did not comprise the sole grain component. Also there were greater differences in energy levels between their treatments resulting from use of higher levels of wheat bran in barley rations than between treatments in studies reported here. Increased water consumption data noted for barley containing rations in this report are in accord with findings of Berg (1959).

Addition of 6% fat to the barley-mash ration of White Leghorns, while significantly increasing body weight gains with slightly less feed intake, did not affect mortality. These results agree with

those of Donaldson and Gordon (1960) for White Leghorn layers fed added fat. Results reported do not agree with those of Weiss and Fisher (1956) who observed increased mortality with caged Leghorns fed fat on corn-type rations. Recently March and Biely (1962) reported no increase in total mortality in White Leghorns receiving added fat on corn-wheat rations, although they noted that mortality from liver derangement was doubled with layers fed 5 or 10% fat.

The failure of pelleted corn or barley rations to improve egg production but still increase feed consumption and body weight gains, agrees with the report of Black et al. (1958). On the other hand, Petersen et al. (1960) while reporting increased feed consumption within given energy levels also noted increased production on low-energy rations by use of crumbles.

Inability of an amylolytic enzyme supplement added to barley rations to improve egg production or decrease feed consumption agrees with findings reported by Berg and Bearse (1958), Berg (1959, 1961), and Anderson and Wagstaff (1958), but not with those of Nelson and Hutto (1958).

Relative value of barley vs. corn. Since barley and corn are major variables in experiments reported here, differences noted for feed efficiency should reflect differences due to these grains. By summarizing data obtained with White Leghorns and New Hampshires with respect to feed required per dozen eggs and omitting those results when egg production was adversely affected (Tables 2, 4, 6, 10, and 11), the following observations may be made on relative worth[6] of barley and corn:

1. Barley has a value of 96[7] and 90% of corn for White Leghorns and New Hampshires, respectively, in mash rations. In the presence of fat a value of 97% was obtained for barley with White Leghorns.

2. Barley has a value of 90% of corn with White Leghorns on mash-scratch rations.

3. Barley in pelleted rations has a value of 95% of corn for White Leghorns.

4. Barley in rations supplemented with an enzyme has a value of 96 and 92% of corn for White Leghorns and New Hampshires, respectively.

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[6] (Feed/dozen eggs on corn ration ÷ feed/dozen eggs on barley ration) 100.

[7] Includes comparisons involving pellets and/or enzyme since no improvements from these treatments were evident.

If on the other hand, metabolizable energy values for corn- and barley-type rations are considered (Tables 1, 3, 5, 7, and 9) barley has an estimated caloric worth[8] of 81% of corn, regardless of the feeding system employed. It is evident, therefore, that barley has greater nutritional worth for White Leghorns and New Hampshires than is indicated by calculated metabolizable energy content of barley rations. Furthermore, on the basis of results obtained, barley appears to be utilized more efficiently by White Leghorns than by New Hampshires.

Summary and Conclusions

In a number of experiments with layers fed rations composed of barley or corn as the principal grain component, the following observations were made:

(1) Egg production was not adversely affected when barley constituted the principal grain component in a layer ration for either White Leghorns on mash and mash-scratch rations or New Hampshires on mash rations.

(2) Feed consumption and feed required per dozen eggs were higher for barley than for corn. Differences were more evident for mash-scratch rations than for mash rations.

(3) Body-weight gains were greater when corn constituted the only grain in the ration.

(4) Water consumption was increased and litter condition was inferior when barley replaced corn in the ration.

(5) Six percent fat added to a barley-mash ration for White Leghorns had no effect on egg production. Increased body-weight gains and slightly improved efficiency of feed utilization were noted.

(6) Pelleting barley or corn rations for White Leghorns resulted in increased feed consumption. No effect on egg production and an increase in feed required per dozen eggs were noted. Water consumption and body-weight gains also were increased on pelleted rations.

[8] (Cal. metabolizable energy of barley rations ÷ Cal. metabolizable energy of corn rations) 100.

(7) An amylolytic enzyme supplement added to mash rations for White Leghorns or New Hampshires showed no effect on egg production, feed consumption, feed per dozen eggs, body weight gains, or mortality. A slight decrease in water consumption for layers receiving the barley ration was noted when the enzyme was used.

(8) Barley was shown to be 96 and 90% as efficient as corn when it was included in a mash ration for White Leghorns and New Hampshires, respectively. Barley was worth 90% of corn on a mash-scratch ration for White Leghorns.

References

Anderson, J. O., and C. I. Draper, 1956. Protein supplements for laying rations high in wheat. Poultry Sci. *35*:562-566.

Anderson, J. O., and R. K. Wagstaff, 1958. Barley for your laying hens. Farm and Home Sci. *19*(2) :35, 51, 52, 56.

Anderson, J. O., R. K. Wagstaff, and D. C. Dobson, 1960. Value of barley and hulless barley in rations for laying hens. Poultry Sci. *39*:1230.

Arscott, G. H., W. H. McCluskey, and J. E. Parker, 1958. The use of barley in high efficiency broiler rations. 2. Effect of stabilized animal fat and pelleting on efficiency of feed utilization and water consumption. Poultry Sci. *37*:117-123.

Berg, L. R., 1959. Enzyme supplementation of barley diets for laying hens. Poultry Sci. *38*:1132-1139.

Berg, L. R., 1961. Effect of adding enzymes to barley diets at different ages of pullets on laying house performance. Poultry Sci. *40*:34-39.

Berg, L. R., and G. E. Bearse, 1958. The effect of adding amylolytic enzymes to barley rations for laying hens. Poultry Sci. *37*:1184.

Berg, L. R., G. E. Bearse, R. S. Hansen, L. S. Jensen, and J. McGinnis, 1956. *Energy level of the diet for laying hens in Western Washington.* Washington Agric. Exp. Station, Technical Bull. 22.

Biely, J., and B. March, 1961. Effect of dietary fat level on rate of mortality in caged layers. Poultry Sci. *41*:9-12.

Black, J. G., R. C. Jennings, and T. R. Morris, 1958. The relative merits of pellets and mash for laying stock. Poultry Sci. *37*:707-722 .

Crampton, E. W., 1939. The comparative feeding value for poultry of barley, oats, wheat, rye and corn. Report No. 29, National Research Council, Ottawa, Canada.

Donaldson, W. E., and C. D. Gordon, 1960. The effect of 3% added animal fat on laying hen performance. Poultry Sci. *39*:583-587.

Fry, R. E., J. B. Allred, L. S. Jensen, and J. McGinnis, 1957a. Influence of water-treatment on nutritional value of barley. Proc. Soc. for Exper. Biol. & Med. *95*:249-251.

Fry, R. E., J. B. Allred, L. S. Jensen, and J .McGinnis, 1957b. Influence of cereal grain component of the diet on response of chicks and poults to dietary enzyme supplements. Poultry Sci. *36*:1120.

Halbrook, E. R., 1956. The value of barley and fats in feeding chicks and laying hens. Feedstuffs *28*(33) :55.

McCluskey, Bill, 1958. Mash-scratch ratios for meat type layers. The Eggsaminer *35*(12) :10-11.

Mueller, W. J., 1956. The influence of energy source, energy-fiber concentration and protein source of the diet on certain egg quality characteristics. Poultry Sci. *35*:1074-1078.

Nelson, F. E., and D. C. Hutto, 1958. The effect of enzyme and water treated barley on the performance of breeding hens. Poultry Sci. *37*:1229.

Petersen, C. F., and C. E. Lampman, 1955. *Barley—A valuable feed for egg production.* Idaho Agric. Exp. Station Bull. 238.

Petersen, C. F., E. A. Sauter, A. C. Wiese, and D. H. Conrad, 1957. Effect of energy level and laying house temperature on performance of White Leghorn pullets. Poultry Sci. *36*:1148.

Petersen, C. F., E. A. Sauter, D. H. Conrad, and C. E. Lampman, 1960. Effect of energy level and laying house temperature on the performance of White Leghorn pullets. Poultry Sci. *39*:1010-1018.

Peterson, D. W., and P. A. Zweigart, 1954. Feeding trials with laying hens indicate barley used as grain in ration is as efficient as corn. California Agric. *8*(3) :15-16.

Weiss, H .S. and H. Fisher, 1957. Plasma lipid and organ changes associated with the feeding of animal fat to laying chickens. Jour. of Nutrition *61*: 267-280.