EFFECT OF FEEDING VARIOUS CEREAL GRAINS ON PERCENT SHRINKAGE, QUALITY, AND EFFICIENCY OF PRODUCTION OF BROILERS

by

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INTRODUCTION

The use of any feed ingredient which will increase the pounds of live broilers the producer has to sell, and the amount and quality of edible meat the processor, retailer, and consumer ultimately receives, is of primary interest to the broiler industry.

Some interest has been shown in the possibility that the cereal grains used in broiler rations have an influence on the percent shrinkage and quality of birds. Maw (1935) reported that feeding various cereal grains had a definite influence upon the distribution of fat in the carcass and composition of tissues in roasting chickens. If by feeding certain cereal grains, the location and amount of fat deposition in broilers could be influenced, this would have an effect upon the percent shrinkage and carcass quality. Maw's investigation and other research by Poley et al. (1940b) suggests that further studies should be conducted with broilers to determine if the cereal grains fed have any effect upon the percent shrinkage.

Four experiments were conducted in an effort to accomplish the following objects: (1) determine if the different cereal grains have any effect upon the percent shrinkage; (2) compare the carcass quality of the dressed birds fed diets containing the various cereal grains; (3) determine which grains give the most efficient and economical gains; and (4) compare the growth promoted by the various grains.

REVIEW OF LITERATURE

The influence of various cereal grains on the percentage of fat in the edible meat of poultry was observed by Maw et al. (1936a). They fed Barred Plymouth Rock cockerels fattening diets containing the single cereal grains: corn, wheat, oats, and barley, plus 6 percent animal protein for 21 days. They reported that the amount of fat found in the edible meat was 8.95, 6.99, 4.81, and 3.43 percent for corn-, wheat-, oats-, and barley-fed birds, respectively; indicating that corn was superior from the standpoint of producing fat.

Using the same cereal grains and similar experimental procedure, Holcomb and Maw (1934) studied the effects of the grains on distribution of fat in the carcasses of fattened roasting birds. They found that ground yellow corn caused a higher percentage of total body fat to be deposited in the flesh and a lesser amount as subcutaneous and abdominal fat; whereas, oats, barley, and wheat showed in varying degrees the reverse effect. North (1941) also found this to be true in turkeys. He reported that the corn diets had a tendency to deposit more fat in the flesh, while the wheat, oat, rye, and barley diets caused more fat to be deposited internally.

Maw and Maw (1939) were unable to find any significant differences of fat distribution in White Leghorn broilers fed various cereal grains. This led the authors to conclude that the age of the birds was a factor in determining the relationship between fat distribution and the grains in the diets.

Gutteridge (1937) reported that the various cereal grains when fed in a fattening ration, had no influence on fat distribution in roasters. He did find that a significant correlation existed between the percentage of fat in the skin and subcutaneous regions and fat in the abdominal cavity. This indicated that fat was deposited in the depot areas in a similar ratio, regardless of the diets fed. Harshaw (1939) stated that the distribution of fat in chickens is largely a physiological process dependent on the functions of individual birds.

Cruickshank (1937) observed that birds fed a ration consisting of milk and oats had a soft fat, while birds fed milk and barley had a very hard fat. This confirmed earlier work by Herner (1936).

Harshaw (1939) studied the effects of cereal grains on the physical and chemical composition of cockerels 12 weeks of age. Analyses were made on the edible portion of cockerels reared on diets containing the single grains: corn, wheat, oats, and barley supplemented with dried buttermilk, minerals, and cod liver oil. One lot was reared on a standard all-mash ration and used as a control. Compared with the birds fed the control diet, the oat- and barley-fed birds had nearly the same proportion of leg and breast muscle, while the wheat- and corn-fed birds had considerably less leg and breast muscle. When considering the percentage of total edible portion, the control birds were superior, followed in order by birds fed oats, barley, wheat, and corn. The corn-fed birds had the highest percentage of fat in the edible portion; whereas, the oat-fed birds had the least fat in the edible portion.

Conflicting results were reported by Poley et al. (1940a) who found that corn- and wheat-fed fryers and roasters had significantly more total edible meat than barley-fed birds.

Differences in flavor and texture of meat from cockerels fattened for 21 days on diets containing the single grains: yellow corn, wheat, oats, and barley were observed by Maw (1935a). He found that the fat deposited in the flesh replaced the moisture, and the amount of fat laid down was the factor which influenced the moisture content of the flesh. He concluded that the fat carried the flavor; therefore, a high degree of fatness was necessary to obtain good eating quality. Cooking and palatability tests proved this to be correct. The meat from the corn-fed birds was more moist, had the highest flavor and best texture; whereas, the wheat-fed birds were drier and had poorer flavor and texture. The meat from the oat-fed birds was similar to the meat from the wheat-fed birds while the barley-fed birds' meat was similar to the meat from corn-fed birds.

Poley et al. (1940a) were unable to find any appreciable differences in aroma, flavor, juiciness, or tenderness in meat from fryers and roasters which received corn, wheat, or barley in the growing and finishing rations.

Maw et al. (1936b) reported in regard to the relationship of fat distribution to cooking losses in graded dressed chickens. The results of the cooking test showed that a close relationship existed between analysis of the carcasses by grade and cooking qualities; the top grades showing a larger amount of edible meat and lower cooking losses. They concluded that the amount of fat

in the edible portion is apparently correlated with the amount of moisture in the flesh, thus a lower fat content in the flesh results in a greater moisture loss during cooking.

The relationship between the cereal grains in fattening diets and the percentage of dressing loss of turkeys was reported by Herner (1936). For 48 days prior to dressing, individual lots of turkeys were fed fattening diets containing the following grain or grains; wheat; oats; barley; wheat and oats; wheat and barley; oats and barley; wheat, oats, and barley. Dressing losses were computed on dressed weights. The percent of shrinkage varied among the different lots from 7.52 to 8.48. The oat-fed birds had the lowest percentage shrinkage, while the barley-fed birds had the highest percentage shrinkage. In later work, Poley et al. (1940b) were unable to find any significant differences in dressing percentages of fryers and roasters fed diets containing corn, wheat, or barley.

Various workers have conducted experiments to determine the influence of the different cereal grains on growth and feed efficiency when included in various types of rations. Maw (1935b) fed mature cockerels fattening rations for 21 days which contained the single grains: corn, wheat, oats, and barley. When the grains were compared from the standpoint of feed efficiency, corn was superior followed by wheat, oats, and barley. This was later confirmed by Gutteridge and O'Neil (1941a) who found that with roasters, feeding corn resulted in the greatest increase in body weight on the least amount of feed. Ground buckwheat was found to give gains equal to corn, but more feed was required to produce

each pound of gain.

The same year, Gutteridge and O'Neil (1941b) conducted a similar experiment comparing the value of ground hulled oats and ground yellow corn. They found that coarsely ground hulled oats were definitely superior to ground yellow corn in production of efficient gains during fattening.

At the completion of a four-year study, Poley and Wilson (1939) were unable to find any appreciable differences in the growth rate of turkeys fed growing and finishing diets in which the individual grains: corn, wheat, oats, and barley constituted a large percentage of the diets. When the feed efficiency of the different grains was compared, wheat was nearly equal to corn in the growing ration and superior to corn in the finishing ration, two out of four years.

An experiment comparing the effect of fattening rations containing individual cereal grains and combinations of grains on gains was conducted by Gutteridge and O'Neil (1943). Rations containing ground oat groats; ground whole oats; ground yellow corn; ground whole oats and corn were fed to mature cockerels for two weeks. They observed that the oat groat-fed birds made more efficient gains than either the corn- or whole oat-fed birds. The birds fed the corn and oat rations had gains intermediate to the gains produced by the other two grains. In an earlier report Maw (1939) reported that certain grain combinations were equal or better than single grains in the fattening ration.

Scott et al. (1947) observed the effect of carbohydrate source on growth, feed efficiency, and feathering in chicks.

A diet containing 68 percent corn properly supplemented was found to be excellent in these respects. Replacing the corn in the diet with increasing amounts of pulverized oats progressively depressed growth, feed efficiency, and feather development.

Biely et al. (1951) reported that wheat replacing corn in equal proportions in a broiler ration did not alter the growth rate, when no adjustment of protein level was made. In a similar experiment the protein content of the rations was balanced to adjust for the differences in the protein content between corn and wheat. This adjustment for protein content resulted in a lower growth rate of birds fed the wheat ration.

The effect of different cereal grains on feed efficiency, egg quality, and shell thickness was reported on by Grimminger and Scott (1954). They fed four groups of White Leghorn pullets all-mash rations which differed only in the type of cereal grain used. Each group of pullets was fed each of the four rations for a period of three weeks in a reversible type of experiment. They found that none of the cereal grains exhibited any influence on egg weight, shell thickness, or egg quality.

Maw et al. (1939) found that the length of time that the various cereal grains were fed determined to some extent the results that were obtained. Comparisons of gains from the cereal grains were made at the end of 7, 14, and 21 days. No differences in rate of gains were observed between the diets the first 14 days, but after 21 days the corn- and wheat-fed birds had made more rapid and efficient gains than the oat- and barley-fed birds. During the same year Maw and Maw (1939) confirmed these results,

using White Leghorn broilers in a similar experiment.

MATERIALS AND METHODS

All experiments were conducted in the Poultry Nutrition Laboratory at the College Poultry Farm. Room temperature was maintained between 70 and 75 degrees Fahrenheit, by thermostatically-controlled gas stoves. Lighting was automatically provided for 14 hours daily.

A six-deck starting battery with 12 separate compartments, and heaters suitable for small experimental lots of chicks was used.

Temperature, feeders, and waterers were adjusted in keeping with the growth and age of the chicks. The chicks were transferred to growing batteries at five weeks of age.

In all experiments, 240 day-old sexed chicks were randomized into 12 lots of 10 male and 10 female chicks each. Crossbred chicks (New Hampshire x Kansas State College Strain White Plymouth Rocks) were used in all experiments. All chicks were wing banded for identification, weighed at one day of age, and every seven days thereafter, throughout the duration of the experiments. Weekly feed consumption records were maintained. Live virus Newcastle vaccine was administered, in the drinking water, to all the chicks at four days and four weeks of age.

For all experiments, six diets were prepared and replicated. The individual cereal grains or combination of cereal grains constituted 60 percent of the diets in all experiments. Hereafter, the percentage figures refer to the 60 percent carbohydrate

portion of the diet. The protein content of the diets in all experiments was adjusted to approximately 20 percent. Analysis of the ingredients used in computing the diets was obtained from analyses compiled by Sievert and Fairbanks (1954).

All diets were mixed at the feed mixing building at the College Poultry Farm. The diets were prepared by weighing the ingredients used in large quantities, on a portable platform scale, and the ingredients used in smaller quantities on an analytical balance. The minerals and vitamins were separately premixed using soybean oil meal in a small closed container and added to the basal ingredients as they were being mixed. The antibiotic supplement was added to the vitamin premix. All diets were mixed in a small horizontal-type mixer for 15 minutes. Two equal portions of each diet were weighed, placed in covered containers, and stored in the Poultry Nutrition Laboratory. The remaining portions of the diets were stored in the feed mixing building. Additional quantities of each diet were mixed as needed. All cereal grains used in the experiments were obtained either from supplies at the poultry farm or from local grain dealers.

At the end of eight weeks, the female chicks were removed in all of the experiments. If any lots lacked 10 males, because of mortality or inaccurate sexing, females were retained and substituted for the missing males. At the termination of the experiments the males and substituted females in each lot were processed in the Poultry Processing Laboratory in Waters Hall on the Kansas State College campus.

The methods used for killing and dressing compared as nearly

as possible to those used in a commercial dressing plant. A scalding temperature of 138 degrees Fahrenheit was used. A large percentage of the feathers were removed by a mechanical picker. Any remaining feathers were removed by hand. After the birds were dressed, they were immediately immersed in crushed ice to facilitate rapid cooling of the carcass and to maintain a desirable external appearance. Live, dressed, and eviscerated weights were recorded for all birds.

Preceding evisceration, the birds were segregated by lots and graded for fleshing and finish. A record was maintained of the number and types of breast deformities such as crooked keels, and pointed breasts.

After the birds were eviscerated, individual birds were scored according to the amount of fat which was present around the viscera and attached to the abdominal walls.

Experiment I

The following cereal grains were substituted at the rate of 60 percent in diets 1 to 5: oats, corn, wheat, milo, and barley, respectively. Diet 6 consisted of a combination of the cereal grains, corn and milo, combined at the rate of 50 percent each. Composition of the six diets is presented in Table 1. The experiment was terminated at the end of eight weeks and four days.

Experiment II

Diet 1 was identical to diet 1 used in Experiment I. The following combinations of cereal grains were substituted at the

rate of 50 percent each in diets 2 to 6: oats and milo, oats and corn, oats and wheat, oats and barley, and milo and wheat, respectively. Cellu flour was added to diet 6 to increase the fiber level, making it comparable to the fiber level in the other five diets. Composition of each diet is presented in Table 2. The experiment was terminated when the chicks were 10 weeks old.

Experiment III

The following cereal grains were combined at the rate of 50 percent each in diets 1, 4, 5, and 6: wheat and barley, milo and barley, corn and barley, and corn and wheat. Corn and milo were substituted at the rate of 25 and 75 percent in diet 2; whereas, at the rate of 10 and 90 percent in diet 3. The percentage of fiber in all diets was adjusted to approximately the same level. Composition of each diet is presented in Table 3. The experiment was terminated at the end of 10 weeks.

Experiment IV

Diets 1 and 6 consisted of corn and wheat, and corn and milo combined at the rate of 50 percent each. Oats and milo were combined at the rate of 10 and 90 percent in diet 2, and 25 and 75 percent in diet 3. Diets 4 and 5 consisted of wheat and milo substituted at the rate of 10 and 90 percent and 25 and 75 percent, respectively. Composition of each diet is presented in Table 4. The fiber level was adjusted as in Experiments II and III. The experiment was terminated when the chicks were 10 weeks of age.

Table 1. Composition of the diets for Experiment I.

Ingredients	Diets 1	2	3	4	5	6
	Pounds					
Ground yellow corn	-	60.00	-	-	-	30.00
Ground wheat	-	-	60.00	-	-	-
Ground oats	60.00	-	-	-	-	-
Ground barley	-	-	-	-	60.00	-
Ground milo	-	-	-	60.00	-	30.00
Wheat standard middlings	7.50	-	12.50	4.00	6.50	1.50
Alfalfa meal (17% Dehyd.)	1.00	1.00	2.00	1.50	2.00	1.00
Soybean oil meal (44% solvent ext.)	24.00	29.50	17.50	26.00	24.00	30.00
Menhaden fish meal	2.00	2.00	1.00	1.00	2.00	1.00
Cellu flour	-	2.00	1.75	2.00	-	1.25
Calcium carbonate	2.00	2.00	2.00	2.00	3.00	2.25
Steamed bone meal	2.00	2.00	1.75	2.00	1.00	1.50
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin mix*	1.00	1.00	1.00	1.00	1.00	1.00
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00
Manganese sulfate (Added per 100 lbs. diet)	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g

* NOPCO (Vit. A)	40.00 g	(Supplies 10,000 USP units of vitamin A per g of supplement)
"Delsterol" (Vit. D_3)	20.00	(Supplies 1,500 I.C. units of vitamin D_3 per g of supplement)
Riboflavin (1 oz.= 1 g)	10.00	
Choline chloride (25% mix)	80.00	
Niacin (Crystalline)	10.00	
Calcium pantothenate (Crystalline)	1.00	
"Aurofac"	126.00	(Contains 1.8 mg B_{12} and 1.8 g aureomycin /Chlortetracycline/ per lb. of supplement)
Soybean oil meal (Filler)	167.00	
Total (gms)	454.00	

Table 2. Composition of the diets for Experiment II.

Ingredients	Diets 1	2	3	4	5	6
	Pounds					
Ground yellow corn	-	-	30.00	-	-	-
Ground wheat	-	-	-	30.00	-	30.00
Ground oats	60.00	30.00	30.00	30.00	30.00	-
Ground barley	-	-	-	-	30.00	-
Ground milo	-	30.00	-	-	-	30.00
Wheat standard middlings	7.50	6.00	6.00	11.00	8.00	8.50
Alfalfa meal (17% Dehyd.)	1.00	1.00	1.00	1.00	1.00	2.00
Soybean oil meal (44% solvent ext.)	24.00	25.00	25.00	20.00	23.00	23.00
Menhaden fish meal	2.00	2.50	2.50	2.50	2.50	1.00
Cellu flour	-	-	-	-	-	2.00
Calcium carbonate	2.00	2.00	2.00	2.00	2.00	2.00
Steamed bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin mix*	1.00	1.00	1.00	1.00	1.00	1.00
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00
Manganese sulfate (Added per 100 lbs. diet)	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g

* NOPCO (Vit. A)	40.00 g	(Supplies 10,000 USP units of vitamin A per g of supplement)
"Delsterol" (Vit. D_3)	20.00	(Supplies 1,500 I.C. units of vitamin D_3 per g of supplement)
Riboflavin (1 oz.= 1 g)	10.00	
Choline chloride (25% mix)	80.00	
Niacin (Crystalline)	10.00	
Calcium pantothenate (Crystalline)	1.00	
"Aurofac"	126.00	(Contains 1.8 mg B_{12} and 1.8 g aureomycin /Chlortetracycline/ per lb. of supplement)
Soybean oil meal (Filler)	167.00	
Total (gms)	454.00	

Table 3. Composition of the diets for Experiment III.

Ingredients	Diets 1	2	3	4	5	6
	Pounds					
Ground yellow corn	-	15.00	6.00	-	30.00	30.00
Ground wheat	30.00	-	-	-	-	30.00
Ground oats	-	-	-	-	-	-
Ground barley	30.00	-	-	30.00	30.00	-
Ground milo	-	45.00	54.00	30.00	-	-
Wheat standard middlings	8.50	1.00	1.00	4.00	3.00	3.00
Alfalfa meal (17% Dehyd.)	1.00	1.00	1.00	1.00	1.00	2.00
Soybean oil meal (44% solvent ext.)	22.00	28.50	28.50	26.00	27.00	25.00
Menhaden fish meal	1.50	1.50	1.50	2.00	2.00	2.00
Cellu flour	1.50	2.50	2.50	1.50	1.50	2.50
Calcium carbonate	2.00	2.00	2.00	2.00	2.00	2.00
Steamed bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin mix*	1.00	1.00	1.00	1.00	1.00	1.00
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00
Manganese sulfate (Added per 100 lbs. diet)	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g

* NOPCO (Vit. A)	40.00 g	(Supplies 10,000 USP units of vitamin A per g of supplement)
"Delsterol" (Vit. D_3)	20.00	(Supplies 1,500 I.C. units of vitamin D_3 per g of supplement)
Riboflavin (1 oz.= 1 g)	10.00	
Choline chloride (25% mix)	80.00	
Niacin (Crystalline)	10.00	
Calcium pantothenate (Crystalline)	1.00	
"Aurofac"	126.00	(Contains 1.8 mg B_{12} and 1.8 g aureomycin /Chlortetracycline/ per lb. of supplement)
Soybean oil meal (Filler)	167.00	
Total (gms)	454.00	

Table 4. Composition of the diets for Experiment IV.

Ingredients	Diets 1	2	3	4	5	6
	Pounds					
Ground yellow corn	30.00	-	-	-	-	30.00
Ground wheat	30.00	-	-	6.00	15.00	-
Ground oats	-	6.00	15.00	-	-	-
Ground barley	-	-	-	-	-	-
Ground milo	-	54.00	45.00	54.00	45.00	30.00
Wheat standard middlings	3.50	3.00	3.50	1.50	2.00	1.50
Alfalfa meal (17% Dehyd.)	2.00	1.00	1.00	1.00	1.00	1.00
Soybean oil meal (44% solvent ext.)	25.00	26.50	27.00	28.00	28.00	30.00
Menhaden fish meal	2.00	2.00	2.00	1.50	1.00	1.00
Cellu flour	2.00	2.00	1.00	2.50	2.50	1.25
Calcium carbonate	2.00	2.00	2.00	2.00	2.00	2.25
Steamed bone meal	2.00	2.00	2.00	2.00	2.00	1.50
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin mix*	1.00	1.00	1.00	1.00	1.00	1.00
Total (lbs.)	100.00	100.00	100.00	100.00	100.00	100.00
Manganese sulfate (Added per 100 lbs. diet)	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g	25.00 g

* NOPCO (Vit. A)	40.00 g	(Supplies 10,000 USP units of vitamin A per g of supplement)
"Delsterol" (Vit. D_3)	20.00	(Supplies 1,500 IC. units of vitamin D_3 per g of supplement)
Riboflavin (1 oz.= 1 g)	10.00	
Choline chloride (25% mix)	80.00	
Niacin (Crystalline)	10.00	
Calcium pantothenate (Crystalline)	1.00	
"Aurofac"	126.00	(Contains 1.8 mg B_{12} and 1.8 g aureomycin /Chlortetracycline/ per lb. of supplement)
Soybean oil meal (Filler)	167.00	
Total (gms)	454.00	

RESULTS AND DISCUSSION

Experiment I

Percent Shrinkage (Dressing and Evisceration Losses). Diet, average percent shrinkage, and average fat score for each lot are shown in Table 5. Analysis of variance is presented in Table 6.

Table 5. Experiment I, diet, average percent shrinkage, and average fat score for eviscerated birds at eight weeks and four days of age.

Lot	Diet	Average percent shrinkage	Average fat score*
1	Oats-60%**	29.02	0.50
2	Corn-60%	28.09	1.55
3	Wheat-60%	29.55	1.85
4	Milo-60%	28.96	1.60
5	Barley-60%	28.85	1.38
6	Corn-50% + Milo-50%	27.36	2.05

* The carcasses were scored for internal fat on the basis of 5 being superior and 0 inferior.

** Represents 100% of the carbohydrate portion of the diet.

Table 6. Experiment I, analysis of variance of percent shrinkage of birds dressed and eviscerated at eight weeks and four days.

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Diets	5	59.85	11.97*
Within subclasses	110	468.85	4.26
Total	115	528.70	16.23

* Significant-$P < .05$

Although the average percent shrinkage for the different lots varied only approximately 2 percent, an analysis of variance showed these differences to be significant. These results are not in agreement with the findings of Poley et al. (1940b), who were unable to find any significant differences in percent shrinkages of fryers and roasters fed the cereal grains: corn, wheat, and barley.

A study of Table 5 reveals that corn and milo equally combined gave the lowest average percent shrinkage of 27.36 and the highest fat score of 2.05. In contrast, the lot fed wheat gave the highest shrinkage of 29.55 percent and the second highest fat score of 1.85. A comparison of the relative rank of the percent shrinkage and the fat scores of the latter two lots, indicates that probably there is no direct correlation between these two factors. The remaining four lots which received corn, barley, milo, and oats had percent shrinkages of 28.09, 28.85, 28.96, and 29.02, respectively. In similar studies with turkeys, Herner (1936) observed that the oat-fed turkeys had the lowest percent shrinkage.

A decrease in the percent shrinkage was observed when corn and milo were combined equally. A comparison of the shrinkage reveals that the lot of chicks fed corn and milo was 0.33 percent lower than the lot fed corn, and 1.6 percent lower than the lot fed milo. On the other hand, chicks in the various lots fed the individual grains, wheat, oats, milo, and barley had 1.46, 0.93, 0.87, and 0.76 percent higher shrinkages than the lot fed corn.

Quality of Dressed Birds. Diet, carcass score, number, and classification of breast deformities are reported in Table 7.

Table 7. Experiment I, diet, carcass score, number, and classification of breast deformities of eight week and four day old dressed birds.

Lot	Diet	Carcass score*	Deformed breasts	
			Slight	Bad
1	Oats-60%	3.5	1	0
2	Corn-60%	1.5	2	0
3	Wheat-60%	3.0	1	0
4	Milo-60%	2.5-	7	9
5	Barley-60%	3.0-	1	3
6	Corn-50% + Milo-50%	2.5+	5	7
		Total	17	19

* The carcasses were scored for fleshing and finish on the basis of 0 being superior and 5 inferior. A minus number rated superior to a plus number.

When carcasses of birds fed the various diets were compared from the standpoint of fleshing and finish, the chickens fed corn were superior to the other five lots with a score of 1.5. Very little difference was observed in the carcass quality of the birds in the lots fed milo, and corn plus milo; however, their quality was lower than that of the chicks fed corn. Chicks fed either barley or wheat were nearly equal in carcass quality, but had a lower quality than birds fed corn, milo, and corn plus milo. Chicks fed oats had the lowest carcass quality among the six lots with a score of 3.5. This substantiates the observations of North

(1941); however, his study was conducted with turkeys.

A study of Table 7 reveals that the two lots which were fed either milo, or corn plus milo, had a combined total of 28 breast deformities as compared with the other four lots which had a total of only eight. The 16 deformities classified as "badly" deformed, in the milo, and corn plus milo lots were very sharp and pointed at the anterior portion of the keel bone. The term "rocker" breast is sometimes used to describe this particular deformity. On the other hand, the three "badly" deformed breasts found in the barley lot showed the preceding characteristic to a much less degree.

Feed Efficiency. Feed efficiencies were calculated on a chick-day basis as grams of feed required per gram of gain. Weekly efficiencies for each lot and average figures are presented in Table 8.

Table 8. Experiment I, feed efficiency (gm feed per gm gain).

Lot	Weeks								Average
	1	2	3	4	5	6	7	8	
1	2.02	1.95	2.41	2.73	3.87	3.19	3.73	3.50	2.93
2	2.35	2.27	2.04	2.39	2.96	2.86	2.76	3.35	2.62
3	2.40	1.56	2.18	2.34	3.33	2.33	2.80	3.34	2.54
4	2.59	1.95	2.30	2.52	2.74	2.70	2.78	3.33	2.61
5	2.90	2.47	2.87	2.54	3.24	3.15	3.06	3.01	2.91
6	2.68	2.08	2.31	2.30	3.51	2.55	2.92	2.97	2.67

The chicks in Lot 3 which were fed wheat were the most efficient in utilizing feed, with an average feed efficiency of 2.54. In contrast, the poorest feed conversion was 2.93 for Lot 1 which were fed oats. This is not in agreement with Gutteridge and O'Neil (1941a), Maw (1935b), and Poley and Wilson (1939). The first three authors cited, fed the cereal grains to fattening birds; whereas, the latter two authors' work was conducted with growing chicks. The average feed efficiencies for the other four lots are presented in Table 8.

Cost of Production. The cost of production was calculated on the basis of the cost of feed required to produce a pound of gain. Cost of production figures are presented in Table 9.

Table 9. Experiment I, diet, cost of feed per pound, and cost of feed per pound of gain for eight-week-old crossbred chicks.

Lot	Diet	Cost of feed per pound	Cost of feed per pound of gain
1	Oats-60%	$0.0329	$0.0986
2	Corn-60%	0.0439	0.1147
3	Wheat-60%	0.0517	0.1306
4	Milo-60%	0.0422	0.1098
5	Barley-60%	0.0298	0.0842
6	Corn-50% + Milo-50%	0.0392	0.1024

The most economical gains were made by chicks fed barley. They produced a pound of gain with a feed cost of 0.0842 cents. However, the feed efficiency for this lot was less favorable than

other lots (2.91). On the other hand, the three most expensive diets, namely wheat, corn, and milo with feed costs of 0.1306, 0.1147, and 0.1098 cents, respectively, were superior in the utilization of feed. Corn and milo when combined at the rate of 50 percent each, had a feed cost of 0.1024 cents per pound of gain, which was 0.0123 and 0.0074 cents less than the cost of corn, and milo lots, respectively. The lots which received oats had a feed cost of 0.1098 cents (Table 9).

Growth at Eight Weeks. The average weight of the birds for each lot, mortality, and diets fed are presented in Table 10.

Table 10. Experiment I, diet, average weight, and mortality at eight weeks for crossbred chicks.

Lot	Diet	Weight in grams	Percent mortality
1	Oats-60%	862.32 ± 70.14	2.5
2	Corn-60%	964.00 ± 71.37	0.0
3	Wheat-60%	867.38 ± 66.22	0.0
4	Milo-60%	873.45 ± 63.58	0.0
5	Barley-60%	844.15 ± 47.63	5.0
6	Corn-50% + Milo-50%	865.75 ± 82.44	0.0

Growth data for the five lots fed the individual cereal grains are shown in Plate I. Analysis of variance is presented in Table 11.

EXPLANATION OF PLATE I

Diets for lots in Experiment I

Lot 1. Oats-60%

Lot 2. Corn-60%

Lot 3. Wheat-60%

Lot 4. Milo-60%

Lot 5. Barley-60%

The number beside the bar indicates the age of the chicks expressed in weeks.

PLATE I

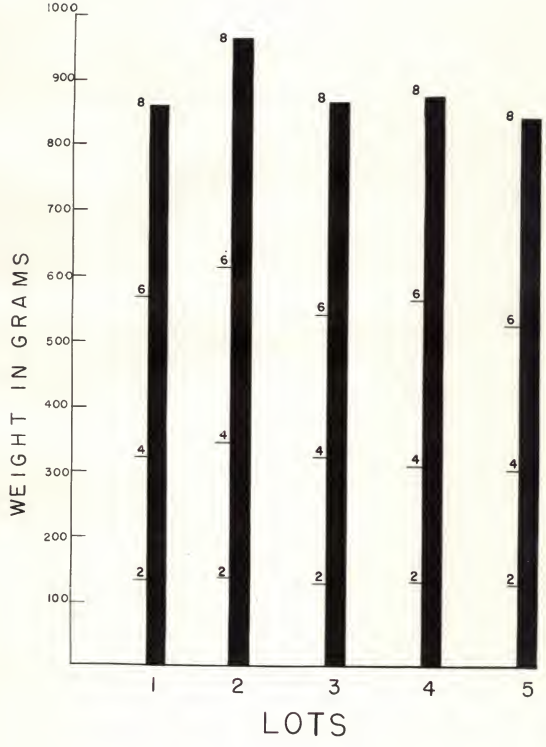
WEIGHT IN GRAMS
1000
900
800
700
600
500
400
300
200
100
8
6
4
2
1
2
3
4
5
LOTS

Table 11. Experiment I, analysis of variance of growth at eight weeks, of lots receiving various cereal grains.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Diets	5	363,736.01	72,747.20**
Sex	1	1,063,503.10	1,063,503.10
Diet-sex interaction	5	64,483.44	12,896.68
Within subclasses	225	2,511,619.85	11,162.75
Total	236	4,003,342.40	1,160,309.73

** Significant-P<.01

An analysis of variance showed a highly significant difference in the growth produced by the different diets. As revealed by a study of Table 10, birds fed corn were observed to be the heaviest with an average weight of 964.00 ± 71.37 grams at eight weeks. Similar results were reported by Gutteridge and O'Neil (1941a) and Scott et al. (1947) who conducted research with roasting chickens and broilers, respectively.

Birds fed barley resulted in the lightest average weight of 844.15 ± 47.63. This was 12.4 percent less than the preceding lot. However, birds in the latter lot had the most uniform growth, as revealed by a study of the standard error of the mean.

Birds fed milo, wheat, and oat diets had average weights which were 9.4, 10.0, and 10.6 percent less, respectively, than the average weight of the corn lot. The chicks which received corn and milo combined resulted in an average weight which was 0.1 percent greater and 10.3 percent less than the average weights of

milo and corn, respectively.

Mortality. Mortality was negligible during this experiment. One chick died during the fifth week in Lot 1, and two died during the first week in Lot 5. No unusual symptoms or abnormalities were observed.

Experiment II

Percent Shrinkage. Diet, average percent shrinkage, and average fat score for the birds dressed and eviscerated at 10 weeks are shown in Table 12. Analysis of variance is presented in Table 13.

Table 12. Experiment II, diet, average percent shrinkage, and average fat score for eviscerated birds at 10 weeks of age.

Lot	Diet	Average percent shrinkage	Average fat score
1	Oats-60%	29.63	2.39
2	Oats-50% + Milo-50%	29.01	2.79
3	Oats-50% + Corn-50%	29.13	2.53
4	Oats-50% + Wheat-50%	29.14	3.40
5	Oats-50% + Barley-50%	30.14	2.16
6	Milo-50% + Wheat-50%	30.74	2.53

As compared with Experiment I, slight increases in the percent shrinkages and fat scores were observed. The difference in ages at which the birds in the two experiments were dressed and eviscerated makes a comparison of percent shrinkages unjustifiable.

An analysis of variance showed no significant difference among the percent shrinkage of the birds fed the various diets.

Table 13. Experiment II, analysis of variance of percent shrinkage of birds dressed and eviscerated at 10 weeks of age.

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Diets	5	40.16	8.03
Within subclasses	104	1193.92	11.48
Total	109	1234.08	19.51

Quality of Dressed Birds. Generally, the equal combination of oats with the other four cereal grains appeared to have no detrimental effect on the carcass quality of the birds in the various lots, when compared to the carcass quality of the birds fed the single grain diets in Experiment I. However, since the birds in this experiment were nearly two weeks older when dressed and eviscerated, it is difficult to make a valid comparison between lots in the two experiments.

A study of Table 14 reveals that birds fed equal parts of oats plus corn, and milo plus wheat had a high degree of fleshing and finish, as indicated by their respective carcass scores of 1.0 and 1.5+. The lowest carcass quality was observed in the lots where the birds were fed oats plus milo, and oats plus barley. As indicated by their identical carcass scores of 3.0, the birds in these two lots exhibited very poor fleshing and color indicative of a very small deposition of subcutaneous fat. The lots

which were fed oats or a combination of oats and wheat had scores which were nearly equal, but lower than for the lots fed oats plus corn, and milo plus wheat.

Table 14. Experiment II, diet, carcass score, number, and classification of breast deformities of 10-week-old dressed birds.

Lot	Diet	Carcass score	Deformed breasts	
			Slight	Bad
1	Oats-60%	2.5-	4	10
2	Oats-50% + Milo-50%	3.0	1	0
3	Oats-50% + Corn-50%	1.0+	0	6
4	Oats-50% + Wheat-50%	2.0	1	1
5	Oats-50% + Barley-50%	3.0	4	1
6	Milo-50% + Wheat-50%	1.5+	0	0
		Total	10	18

A number of breast deformities were observed. Birds fed oats had the highest incidence of breast deformities. However, this was not consistent with the oat lot in Experiment I, which had only one slight breast deformity, indicating that the cereal grains fed had little if any relationship with the incidence of breast deformities.

Feed Efficiency. The chicks in Lot 6 fed an equal combination of milo and wheat utilized feed the most efficiently, with an average efficiency of 2.55 grams of feed required per gram of gain. Combination of these two grains resulted in an average feed efficiency which was 0.06 and 0.07 less than the average for the

birds in the lots fed milo and corn, respectively, in Experiment I.

A study of Table 15 shows that an equal combination of oats with milo, wheat, and barley in Lots 2, 4, and 5, respectively, resulted in less favorable average feed efficiencies at eight weeks than when the grain was fed individually. The increases were 0.16, 0.09, and 0.21 grams, respectively. On the other hand, equal combination of oats with corn in Lot 3, resulted in a 0.01 lower feed efficiency than that for the lot fed corn, indicating that oats can be equally combined with corn without adversely affecting feed efficiency. These results are not in agreement with the findings of Scott et al. (1947). It was observed that the lot of birds which were fed oats had the poorest feed efficiency, with an average of 3.22.

Table 15. Experiment II, feed efficiency (gm feed per gm gain).

Lot	Weeks								Average
	1	2	3	4	5	6	7	8	
1	2.92	2.37	2.50	3.54	3.18	3.10	3.78	4.37	3.22
2	2.55	1.98	2.13	2.66	2.65	2.98	3.61	3.61	2.77
3	1.95	2.22	2.35	2.48	2.44	2.62	3.29	3.65	2.63
4	1.82	2.33	2.52	2.52	2.45	2.89	3.15	3.34	2.63
5	2.25	2.18	2.28	5.39	2.25	2.79	3.73	4.07	3.12
6	2.57	2.42	2.06	2.30	2.35	2.73	3.03	2.95	2.55

Cost of Production. With one exception, equal combination of oats with the other four cereal grains reduced the feed cost per pound of gain. The lots of chicks that were fed oats combined

with milo, corn, and wheat had a lower feed cost than when the grains were fed individually in Experiment I. The reductions in feed cost were 0.0114, 0.0204, and 0.0243 cents, respectively. The one exception was the lot which were fed oats and barley. The feed cost for this lot was 0.0318 cents which was 0.0137 cents more than that of barley fed separately.

The most economical gains were realized from the birds in the lot fed oats and corn, the feed cost being 0.0943 cents; whereas, the most expensive diet was the milo and wheat, with a feed cost of 0.1200 cents (Table 16).

Table 16. Experiment II, diet, cost of feed per pound, and cost of feed per pound of gain for eight-week-old crossbred chicks.

Lot	Diet	Cost of feed per pound	Cost of feed per pound of gain
1	Oats-60%	$0.0329	$0.1076
2	Oats-50% + Milo-50%	0.0338	0.0984
3	Oats-50% + Corn-50%	0.0341	0.0943
4	Oats-50% + Wheat-50%	0.0392	0.1063
5	Oats-50% + Barley-50%	0.0318	0.0979
6	Milo-50% + Wheat-50%	0.0475	0.1200

Growth at Eight Weeks. Significant differences were found among the average weights for chicks in different lots at eight weeks.

A superior weight of 918.08 $\pm$ 71.73 grams was obtained by chicks fed an equal combination of milo plus wheat. This average

weight was approximately 5.5 percent higher than the average weights of either the lots fed corn or wheat. This indicated that these two grains compliment each other, giving a greater growth response than either of the grains fed separately.

The equal combination of oats with milo, and wheat, produced average weights of 912.40 ± 56.61 and 905.38 ± 60.45 grams, respectively. These weights were slightly better than the average weights of either the lots fed milo or wheat. The percent increase in weights being 4.5 and 4.4, respectively. On the other hand, oats combined equally with corn and barley gave just the reverse response, resulting in average weights of 886.73 ± 83.19 and 828.50 ± 49.82 grams. The latter two average weights being 8.1 and 1.9 percent below the lots fed corn and barley, respectively. These results substantiate the results of Scott et al. (1947), who observed that oats replacing corn in increasing amounts, progressively depressed growth in broilers.

Table 17. Experiment II, diet, average weight, and mortality at eight weeks for crossbred chicks.

Lot	Diet	Weight in grams	Percent mortality
1	Oats-60%	852.09 ± 70.74	7.5
2	Oats-50% + Milo-50%	912.40 ± 56.61	0.0
3	Oats-50% + Corn-50%	886.73 ± 83.19	0.0
4	Oats-50% + Wheat-50%	905.38 ± 60.45	0.0
5	Oats-50% + Barley-50%	828.50 ± 49.82	0.0
6	Milo-50% + Wheat-50%	918.08 ± 71.73	0.0

Table 18. Experiment II, analysis of variance of growth at eight weeks, of lots receiving various cereal grains.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Diets	5	234,117.00	46,823.40*
Sex	1	1,010,427.36	1,010,427.36
Diet-sex interaction	5	77,708.05	15,541.61
Within subclasses	225	3,611,280.42	16,050.14
Total	236	4,933,532.83	1,088,842.51

* Significant-$P < .05$

Mortality. As in Experiment I, mortality was negligible. The lot of chicks fed oats was the only lot to encounter mortalities. One chick was lost in each of the first three weeks. No unusual symptoms were exhibited by the chicks which died.

Experiment III

Percent Shrinkage. A very marked decrease in the average percent shrinkage was observed in all of the lots. The variations in percent shrinkage among the lots were small; however, an analysis of variance showed these differences to be significant (Table 20).

The lowest percent shrinkages were 24.09 and 24.12 for the birds fed milo plus barley, and corn plus wheat, respectively. Birds in the lot fed equal parts of corn and barley had a percent shrinkage of 25.00; however, the percent shrinkage for this lot was less favorable than that of the lots fed milo plus barley, and

corn plus wheat.

Table 19. Experiment III, diet, average percent shrinkage, and average fat score for eviscerated birds at 10 weeks of age.

Lot	Diet	Average percent shrinkage	Average fat score
1	Wheat-50% + Barley-50%	25.72	1.88
2	Corn-25% + Milo-75%	25.67	2.94
3	Corn-10% + Milo-90%	25.03	3.05
4	Milo-50% + Barley-50%	24.09	2.90
5	Corn-50% + Barley-50%	25.00	1.95
6	Corn-50% + Wheat-50%	24.12	2.72

Table 20. Experiment III, analysis of variance of percent shrinkage of birds dressed and eviscerated at 10 weeks of age.

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Diets	5	46.74	9.35*
Within subclasses	107	365.01	3.41
Total	112	411.75	12.76

* Significant-$P < .05$

The level at which corn was combined with milo had a slight influence on the percent shrinkage. The lots that were fed a combination of 10 percent corn and 90 percent milo had a percent shrinkage of 25.03. In contrast, birds fed the 25 percent corn

and 75 percent milo diets had a 25.67 percent shrinkage, a difference of 0.64 percent. The highest percent shrinkage was observed with birds in the lot fed wheat and barley (25.72).

Barley replacing oats in individual combinations with corn, wheat, and milo resulted in more favorable percent shrinkages.

As in Experiments I and II, there appears to be no apparent correlation between the amount of fat deposited internally and the percent shrinkage.

Quality of Dressed Birds. There was a general improvement and less variation in the carcass quality of the birds fed the various diets in Experiment III, as compared with Experiments I and II.

As indicated by the carcass score of 1.0+, birds in the lot fed equal parts of wheat and barley had superior fleshing and finish. Very little difference in carcass quality was observed among the birds from the lots fed either corn plus milo, or 25 and 75 percent corn plus wheat; however, their quality was slightly lower than that of the corn and wheat lot as indicated by their scores of 1.5 and 1.5+, respectively.

Milo and wheat replacing oats in individual combinations with barley resulted in an improvement in carcass quality. Birds in lots fed barley combined with wheat, and milo had respective carcass scores of 1.0+ and 2.0-, as compared to scores of 2.0 and 3.0 for the birds fed oats plus wheat and oats plus milo. The reverse response was received when barley was combined equally with corn. The latter lot of birds had a carcass score of 2.5- as compared to 1.0+ for the lot of birds fed oats and corn.

The incidence of breast deformities was lower than in Experiments I and II. No correlation between the diet fed and incidence of breast deformities was observed. The highest number of deformities was observed with birds in the lot fed barley combined with corn and milo (Table 21).

Table 21. Experiment III, diet, carcass score, number, and classification of breast deformities of 10-week-old dressed birds.

Lot	Diet	Carcass score	Deformed breasts	
			Slight	Bad
1	Wheat-50% + Barley-50%	1.0+	0	0
2	Corn-25% + Milo-75%	1.5+	0	2
3	Corn-10% + Milo-90%	2.0	0	0
4	Milo-50% + Barley-50%	2.0-	0	7
5	Corn-50% + Barley-50%	2.5-	0	8
6	Corn-50% + Wheat-50%	1.5	0	0
		Total	0	17

Feed Efficiency. A study of Table 22 reveals that Lot 6 which was fed corn and wheat combined equally, utilized feed the most efficiently, with an average efficiency of 2.70 grams of feed required per gram of gain. However, this combination's feed efficiency was 0.08 and 0.09 grams less efficient than corn and wheat, respectively, when fed individually in Experiment I.

The rate at which corn was combined with milo had an effect upon the feed efficiency of the birds in the lots concerned. Lots 2 and 3, which were fed corn and milo combined at the rate of

25 and 75 percent and 10 and 90 percent, respectively, had average feed efficiencies of 2.96 and 2.79. This indicated that the 10 percent level of corn combined with milo was 0.16 grams more efficient than the 25 percent level. When the feed efficiencies were compared to the feed efficiency of corn in Experiment I; it was observed that the 10 and 90 percent corn and milo, and 25 and 75 percent corn and milo lots required 0.17 and 0.34 grams more feed per gram of gain.

When barley was combined equally with wheat, milo, and corn, feed efficiencies were inferior to those obtained with birds fed single source of grains. It was observed that in Lots 1, 4, and 5 the combinations involving the use of barley as compared with use of the single grains, required an increase of 0.43, 0.26, and 0.35 grams of feed per gran of gain, respectively.

Table 22. Experiment III, feed efficiency (gm feed per gm of gain).

Lot	Weeks								Average
	1	2	3	4	5	6	7	8	
1	2.65	2.31	2.52	2.35	2.61	2.24	4.57	4.54	2.97
2	2.98	2.18	2.32	2.27	2.42	2.22	4.86	4.40	2.96
3	2.96	2.19	2.44	2.38	2.53	2.20	4.26	3.35	2.79
4	2.72	2.07	2.49	2.50	2.50	2.20	4.69	3.69	2.87
5	2.89	2.40	2.67	2.34	2.79	2.33	5.09	3.23	2.97
6	3.03	2.24	2.39	2.27	2.49	1.97	4.05	3.19	2.70

Cost of Production. Barley combined equally with corn, wheat, and milo was observed to give slight reductions in the feed costs required to produce a pound of gain. This was anticipated

since barley had very low feed cost in Experiment I.

Birds in the lot fed milo and barley were observed to have the most economical gains with a feed cost of 0.0940 cents, a 0.0158 cent lower cost than that of the lot fed milo. In contrast, birds in the lots fed equal portions of corn and barley, and wheat and barley had feed costs of 0.1101 and 0.1241 cents, respectively, which were slightly more economical than the corn and wheat lots.

Table 23. Experiment III, diet, cost of feed per pound, and cost of feed per pound of gain for eight-week-old crossbred chicks.

Lot	Diet	Cost of feed per pound	Cost of feed per pound of gain
1	Wheat-50% + Barley-50%	$0.0438	$0.1241
2	Corn-25% + Milo-75%	0.0449	0.1265
3	Corn-10% + Milo-90%	0.0448	0.1198
4	Milo-50% + Barley-50%	0.0334	0.0940
5	Corn-50% + Barley-50%	0.0390	0.1101
6	Corn-50% + Wheat-50%	0.0506	0.1289

The level at which corn was combined with milo had a slight influence on feed costs; however, both lots had higher feed costs than milo. The 10 and 90, and 25 and 75 percent levels of corn and milo had feed costs of 0.1198 and 0.1265 cents, respectively, which were 0.0100 and 0.0167 cents higher than milo. The feed cost of 0.1289 for the birds in the lot fed corn and wheat was the highest among the lots.

Growth at Eight Weeks. An improvement in the growth was observed. The various combinations of grains used in the experiment

gave increased growth responses above that produced by the grains when fed individually in Experiment I. An analysis of variance revealed a significant difference in the average weights of the lots (Table 25).

A study of Table 24 reveals that the level at which corn was combined with milo had an effect upon the growth response. The highest average weight of 1032.73 ± 70.74 grams was produced by the chicks fed a combination of 10 percent corn and 90 percent milo. The average weight of the birds for this lot was 18.2 percent higher than the lot fed milo and 7.1 percent higher than the lot fed corn. On the other hand, the lot fed 25 and 75 percent corn and milo had an average weight of 1003.75 ± 25.05 grams, which was 2.8 percent lower than the preceding diets. However, birds in the latter lot were very uniform in growth as is revealed by a study of the standard error of the mean. When compared to the average weights of corn and milo, the 25 and 75 percent level gave increased growth of 4.1 and 14.9 percent, respectively. The equal combination of corn and wheat produced an average weight of 987.61 ± 30.43 grams which was slightly greater than the corn lot, but 13.9 percent larger than the wheat lot.

The equal combination of barley with wheat, and milo, resulted in marked increases in growth, superior to that observed when the grains were fed separately; however, barley combined equally with corn resulted in only a slight additional growth response. The percent increases in growth were 1.1, 10.9, and 15.9 for the birds fed barley combined with corn, milo, and wheat, respectively.

Table 24. Experiment III, diet, average weight, and mortality at eight weeks for crossbred chicks.

Lot	Diet	Weight in grams	Percent mortality
1	Wheat-50% + Barley-50%	1005.53 ± 67.65	7.5
2	Corn-25% + Milo-75%	1003.75 ± 25.05	10.0
3	Corn-10% + Milo-90%	1032.73 ± 70.74	0.0
4	Milo-50% + Barley-50%	968.85 ± 61.30	0.0
5	Corn-50% + Barley-50%	974.31 ± 59.41	2.5
6	Corn-50% + Wheat-50%	987.61 ± 30.43	5.0

Table 25. Experiment III, analysis of variance of growth at eight weeks for lots receiving various cereal grains.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Diets	5	147,097.59	29,419.52*
Sex	1	2,001,988.20	2,001,988.20
Diet-sex interaction	5	20,119.64	4,023.93
Within subclasses	218	2,079,566.15	9,539.29
Total	229	4,248,771.58	2,044,970.94

* Significant-$P < .05$

Mortality. Mortality was somewhat higher than in Experiments I and II. As a result of perosis, two chicks were lost during the seventh and eighth weeks from the lots fed barley plus wheat and 25 and 75 percent of corn and milo. A majority of the other fatalities were suffered during the first two weeks of the experiment.

Experiment IV

Percent Shrinkage. Slight increases in the percent shrinkage greater than those for Experiments I, II, and III were observed. An analysis of variance showed no significant difference among the percent shrinkage for the lots fed the various diets (Table 27).

A study of Table 26 reveals that with one exception, oats or wheat replacing corn in combination with milo at the rate of 10 and 90 percent and 25 and 75 percent gave higher percent shrinkages. The one exception was for the birds in the lot fed 25 percent oats and 75 percent milo. These birds had a lower percent shrinkage than a similar combination of corn and milo in Experiment III. In all cases where oats and wheat were combined with either milo at 10 and 90, or 25 and 75 percent levels, lower shrinkages were observed than in the case of equal combinations of the grains as in Experiment II.

Table 26. Experiment IV, diet, average percent shrinkage, and average fat score for eviscerated birds at 10 weeks of age.

Lot	Diet	Average percent shrinkage	Average fat score
1	Corn-50% + Wheat-50%	27.22	2.11
2	Oats-10% + Milo-90%	26.59	2.56
3	Oats-25% + Milo-75%	24.99	2.52
4	Wheat-10% + Milo-90%	26.72	2.16
5	Wheat-25% + Milo-75%	26.24	2.67
6	Corn-50% + Milo-50%	27.22	2.11

Table 27. Experiment IV, analysis of variance of percent shrinkage of birds dressed and eviscerated at 10 weeks of age.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Diets	5	63.97	12.79
Within subclasses	104	689.43	6.63
Total	109	753.40	19.42

Quality of Dressed Birds. As indicated by the low range of carcass scores, the birds fed the various diets were more uniform in quality than in Experiments I, II, and III.

Superior carcass quality was observed in the lot fed equal portions of corn and wheat. Birds fed this combination had a carcass score of 1.0-. The chicks fed 25 percent oats plus 75 percent milo, 25 percent wheat plus 75 percent milo, and 10 percent wheat plus 90 percent milo had carcass scores of 1.5-, 1.5, and 1.5+, respectively. As indicated by the scores, these latter three lots were nearly equal in quality. The lowest carcass quality was observed for the birds in the lots fed corn plus milo, and 10 percent oats plus 90 percent milo. Birds fed these combinations had scores of 2.0 and 2.0+, respectively.

In both instances, the 10 and 25 percent level of oats with milo was superior in quality to birds in the lot fed an equal combination of these grains. On the other hand, the 10 and 25 percent level of wheat plus milo gave no improvement in quality over that of the birds in the lot fed equal combinations of the grains.

Approximately the same number of breast deformities were

observed as in Experiments I, II, and III. Birds in the lot fed 25 and 75 percent wheat and milo were the only ones to have an unusual number of breast deformities with a total of 10.

Feed Efficiency. In all cases, the various combinations of grains at several different levels of substitution, resulted in inferior feed efficiency as compared to that of the single grains.

The rates at which oats and corn were individually combined with milo, had an effect on the feed efficiency. The chicks in Lots 2 and 4 fed oats plus milo, and wheat plus milo combined at the rate of 10 and 90 percent, utilized feed most efficiently with average feed efficiencies of 2.70 and 2.78 grams of feed required per gram of gain, respectively. In contrast, birds in Lots 3 and 5 which were fed the 25 and 75 percent level of oats plus milo, and wheat plus milo had equal feed efficiencies of 2.86. From a feed efficiency standpoint, these results indicate that the 10 percent level of either oats or wheat combined with milo is superior to the 25 percent level. When compared to the feed efficiency of milo, birds in Lots 2, 3, 4, and 5 had 0.09, 0.25, 0.17, and 0.25 grams lower feed efficiencies, respectively. Birds in Lot 6 which were fed equal portions of corn and milo were observed to have the poorest feed efficiency with an average of 3.10.

Cost of Production. Excluding two lots, combining of the grains into various combinations at varying proportions, increased the feed cost per pound of gain as compared with feed costs of the lots fed single grains. However, the increases were very slight in most of the lots, and were not as great as in Experiments II and III.

Table 28. Experiment IV, diet, carcass score, number, and classification of breast deformities of 10-week-old dressed birds.

Lot	Diet	Carcass score	Deformed breasts	
			Slight	Bad
1	Corn-50% + Wheat-50%	1.0-	3	1
2	Oats-10% + Milo-90%	2.0+	0	0
3	Oats-25% + Milo-75%	1.5-	5	0
4	Wheat-10% + Milo-90%	1.5+	1	3
5	Wheat-25% + Milo-75%	1.5	3	7
6	Corn-50% + Milo-50%	2.0	1	1
		Total	13	12

Table 29. Experiment IV, feed efficiency (gm feed per gm gain).

Lot	Weeks								Average
	1	2	3	4	5	6	7	8	
1	2.67	2.05	1.99	2.63	2.69	3.12	3.29	4.04	2.81
2	2.49	1.99	2.26	2.53	2.66	3.26	3.17	3.25	2.70
3	2.90	2.06	2.27	2.64	2.93	2.80	3.26	4.05	2.86
4	2.92	1.95	2.06	2.40	2.60	2.81	3.54	3.92	2.78
5	2.64	2.26	1.87	2.76	2.85	3.30	3.02	4.20	2.86
6	2.74	2.59	2.35	2.82	3.04	3.33	3.04	4.92	3.10

The lowest feed cost per pound of gain was 0.1074 cents which was obtained with the lot of birds fed oats and milo combined at the rate of 25 and 75 percent, respectively. On the other hand, the lot receiving 10 and 90 percent oats and milo had a feed cost of 0.1156 cents (Table 30). When the feed costs of the two oat

and milo diets were compared to the costs of the single grains, the 10 and 90 percent combination was 0.0058 cents higher and the 25 and 75 percent combination was 0.0024 cents lower. An equal combination of corn and milo was slightly higher in feed cost than corn or milo when fed separately.

Table 30. Experiment IV, diet, cost of feed per pound, and cost of feed per pound of gain for eight-week-old crossbred chicks.

Lot	Diet	Cost of feed per pound	Cost of feed per pound of gain
1	Corn-50% + Wheat-50%	$0.0485	$0.1353
2	Oats-10% + Milo-90%	0.0427	0.1156
3	Oats-25% + Milo-75%	0.0383	0.1074
4	Wheat-10% + Milo-90%	0.0459	0.1098
5	Wheat-25% + Milo-75%	0.0473	0.1339
6	Corn-50% + Milo-50%	0.0392	0.1183

Growth at Eight Weeks. Growth was inferior in all cases to that obtained in Experiment III. The average weights were comparable to those received in Experiment I. An analysis of variance showed no significant difference among the average weights at eight weeks (Table 32). The average weights and mortality are presented in Table 31.

With one exception, the various combinations of grains gave a greater growth than the grains fed individually in Experiment I. The equal combination of corn and wheat gave 7.1 less and 3.3 percent greater growth than corn, wheat, and milo, respectively.

Table 31. Experiment IV, diet, average weight, and mortality at eight weeks for crossbred chicks.

Lot	Diet	Weight in grams	Percent mortality
1	Corn-50% + Wheat-50%	896.40 ± 56.57	0.5
2	Oats-10% + Milo-90%	891.49 ± 53.69	0.0
3	Oats-25% + Milo-75%	887.37 ± 64.81	2.5
4	Wheat-10% + Milo-90%	835.12 ± 53.01	0.0
5	Wheat-25% + Milo-75%	880.52 ± 63.93	0.0
6	Corn-50% + Milo-50%	869.32 ± 49.88	7.5

Table 32. Experiment IV, analysis of variance of growth at eight weeks, of lots receiving various cereal grains.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Diets	5	84,172.50	16,834.50
Sex	1	980,762.50	980,762.50
Diet-sex interaction	5	86,744.26	19,348.85
Within subclasses	222	1,863,189.54	1,025,338.60
Total	233	3,024,868.80	1,025,338.60

The combination of oats and milo, at two different levels, resulted in a growth response that was slightly greater than lot fed milo. Chicks in the lots which were fed oats and milo combined at 10 and 90 percent and 25 and 75 percent levels had weights of 891.49 ± 53.69 and 887.37 ± 64.81, respectively, which were 2.1 and 1.6 percent higher than the lot fed milo.

The one exception was the lot fed wheat and milo combined at

the rate of 10 and 90 percent. This combination had a 4.4 percent lower average weight than milo; whereas, the 25 and 75 percent level of wheat and milo gave a slightly higher growth response. Corn and milo combined equally resulted in average weights which were 9.9 percent and 0.5 percent lower than the average weights of corn and milo, respectively.

SUMMARY AND CONCLUSIONS

A series of four experiments were conducted to determine the effects of the various cereal grains on the percent shrinkage, external carcass quality, feed efficiency, cost of production, and growth in broilers. The five cereal grains--corn, wheat, milo, barley, and oats were fed individually and in various combinations.

Percent Shrinkage

Significant differences were found among the percent shrinkages of the birds dressed at eight weeks and four days, which were fed the single grains. The birds fed corn had the lowest percent shrinkage. Under the same conditions, an equal combination of corn and milo showed a lower percent shrinkage than the grains fed singly.

When oats were fed singly, and combined equally with milo, corn, wheat, and barley, no significant differences were found among the percent shrinkages of birds eviscerated at 10 weeks. An equal combination of milo and wheat was included in this analysis. This was found also to be true for the birds fed corn combined

equally with wheat, milo, and corn; corn combined with milo at 10 and 90, and 25 and 75 percent levels. The birds fed the milo plus barley had the lowest percent shrinkage.

No definite correlation was observed between the amount of fat deposited on the viscera and abdominal walls and the percent shrinkage.

Carcass Quality

When the birds were dressed at eight weeks and four days, the birds fed corn had superior carcass quality among the single grain lots. Among the lots dressed at 10 weeks, which received the combination of grains, the birds fed equal portions of corn plus wheat had superior carcass quality.

There appeared to be no direct relationship between the grains fed and the incidence of breast deformities.

Feed Efficiency

The birds fed wheat were observed to have the highest feed efficiency among the single grain lots. When the individual grains were combined into various combinations, the birds receiving equal portions of wheat and milo were the most efficient utilizers of feed.

Cost of Production

Chicks fed barley had the lowest feed cost per pound of gain of all the various diets investigated (single grain or combinations). On the other hand, among the lots fed the various

combinations of grains, the birds fed milo plus barley combined equally, had the lowest feed cost.

Growth at Eight Weeks

The birds fed corn were found to give highly significantly greater growth when compared to the growth of the other single grains. An equal combination of corn and milo was included in this analysis. On the other hand, significant differences were found among the birds receiving equal portions of corn combined with milo; 10 and 90, and 25 and 75 percent levels of corn and milo, and barley equally combined with corn, milo, and wheat. The birds fed a 10 and 90 percent level of corn and milo had the best growth. Significant differences were also found among the birds receiving equal portions of oats combined with milo, corn, wheat, and barley. An equal combination of wheat and milo included in this analysis gave the best growth.

Under the conditions of this investigation, the following observations and conclusions may be drawn from this study:

1. Corn was found to give a lower percent shrinkage than the other grains fed individually.

2. An equal combination of milo and barley produced the lowest percent shrinkage among the birds fed the various grain combinations.

3. There appeared to be no definite correlation between the amount of fat deposited on the viscera and abdominal wall and the percent shrinkage.

4. When the birds were dressed at eight weeks and four days,

the birds fed corn had superior carcass quality.

5. An equal combination of corn and wheat was observed to produce superior carcass quality in birds dressed at 10 weeks.

6. Wheat was found to give superior feed efficiency.

7. The lowest feed cost per pound of gain was produced by the chicks fed barley.

8. Superior growth was obtained by feeding a combination of 10 percent corn and 90 percent milo.

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EFFECT OF FEEDING VARIOUS CEREAL GRAINS ON PERCENT SHRINKAGE, QUALITY, AND EFFICIENCY OF PRODUCTION OF BROILERS

by

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Four experiments were conducted in an effort to determine the effect of various cereal grains on percent shrinkage, external carcass quality, efficiency of production, and growth of broilers.

Chicks were battery reared and normal husbandry practices were applied. In all lots, the cereal grains constituted 60 percent of the diet. Diets used in Experiment I were as follows: Oats; corn; wheat; milo; barley; corn plus milo. In Experiments II, III, and IV single grains were combined equally in all possible combinations and corn, wheat, and oats were individually combined with milo at 10 and 90, and 25 and 75 percent levels. At the end of eight weeks the females were removed from the experiments. At the termination of the experiments birds were processed at eight weeks and four days in Experiment I, and 10 weeks in Experiments II, III, and IV. Dressed birds were scored for fleshing and finish. After evisceration, birds were scored for amount of fat on the viscera and abdominal walls. Percent shrinkages were calculated on eviscerated weights. Efficiency of production and growth were based on eight week weights.

Significant differences were found among percent shrinkages of birds fed single grains. No consistent significant differences were found among percent shrinkages of birds fed various grain combinations. Among lots of birds fed single grains, birds fed corn had the lowest percent shrinkage, while the birds fed milo plus barley had the lowest among birds fed grain combinations.

It was observed that birds fed corn had superior carcass quality among those fed single grains. Birds fed equal portions of corn plus wheat had superior carcass quality among lots

receiving various grain combinations.

Birds fed wheat were observed to have the highest feed efficiency of lots fed individual grains. Whereas, birds fed an equal combination of wheat plus milo had the highest feed efficiency among those fed grain combinations.

Chicks fed barley had the lowest feed cost per pound of gain of all the various diets investigated (single grain or combinations).

Birds fed corn were observed to give highly significant greater growth when compared to other single grains. No consistent significant differences were found among lots fed various grain combinations. However, birds fed the 10 and 90 percent level of corn and milo had the best growth among various diets investigated.