EVALUATION OF MEAT-AND-BONE MEALS IN RATIONS FOR GROWING CHICKENS. 2. EFFECT OF BLOOD MEAL AS A PARTIAL REPLACEMENT FOR MEAT-AND-BONE MEALS

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SUMMARY

Blood meal was examined in two experiments as a partial replacement for meat-and-bone meal in rations fed to chickens from one to eight weeks of age. Two meat-and-bone meals, differing markedly in quality, were tested and blood meal was used in increments of 1 per cent. up to 5 per cent. All rations were balanced for crude protein, calcium and phosphorus.

In Experiment I, the response to blood meal depended on the type of meat-and-bone meal replaced. In Experiment II, body-weights of chickens at four weeks of age were significantly greater at all levels of blood meal compared with no blood meal and food conversion ratio was significantly higher in rations containing no blood meal compared with 1–4 per cent. blood meal. These differences were no longer significant when chickens reached eight weeks of age.

The use of blood meal in these rations in levels up to 5 per cent. did not affect palatability and was in no way detrimental to the chicken.

Growth rate in both experiments and food conversion ratio in Experiment II were significantly superior in chickens fed rations containing the meat-and-bone meal of lower ash content.

Major post-mortem findings were nutritional encephalomalacia and gizzard erosion in Experiment I and nephritis in Experiment II.

I. INTRODUCTION

Blood meal is widely used as a source of protein in poultry rations. Its value lies in its high lysine content, but it is deficient in isoleucine and the sulphur-containing amino acids (Kuppuswamy, Srinivasan, and Subrahmanyan 1958). Reservations on the use of blood meal are based on adverse effects encountered at high levels of inclusion (Serfontein 1947; Squibb and Braham 1955; Findrik and Dumanovsky 1957; Wiseman, Holmes, and Engel 1958; Wilder, Gregory, and Rasmussen 1959; Lockhart, Reece, and Bolin 1960). In Australia, blood meal is not readily available, much of the material being used to raise the protein level of meat-and-bone meals.

Blood meal is a basic constituent of most meat-and-bone meals. Gartner and Burton (1965) showed that the performance of chickens receiving rations containing meat-and-bone meals improved significantly as the percentage of blood meal in the meals was increased from 0 to 12, the upper level of which corresponded to 2 per cent. blood meal in the rations.

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Initial results on the effect of blood meal as a total or partial replacement for a meat-and-bone meal containing no added blood meal have been presented in the Annual Reports of the Queensland Department of Agriculture and Stock for 1957-58, 1959-60 and 1960-61 (Anon. 1958, 1960, 1961). Findings were that high levels of blood meal (10-13 per cent. of the ration) should not be used as the only source of animal protein in chicken replacement rations, which supports the data of Findrik and Dumanovsky (1957). The inclusion of up to 5 per cent. blood meal did not affect weight gains of chickens to any extent, whereas weight gains were significantly lowered at a level of 7·5 per cent.

The object of the two experiments reported in this paper was to examine levels of up to 5 per cent. blood meal as a partial replacement for two types of meat-and-bone meals differing markedly in quality. A summary of findings from one of these experiments was presented at the 1964 Australasian Poultry Science Convention (Gartner 1964).

II. MATERIALS AND METHODS

Experiment I was done in 1960. Experiment II was basically a repeat in design of Experiment I and was carried out in 1964. As far as possible similar materials were used in both experiments. The battery brooders, follow-on cages, methods of sampling and analysis of ration ingredients, measurement of body-weight, and husbandry of chickens were as described by Gartner and Burton (1965). For Experiment II, each battery brooder was divided into two sections.

Chickens.—White Leghorn x Australorp cross-bred cockerels were used.

Basal Mixture.—The basal mixture used in both experiments is given in Table 1. When comprising about 79 per cent. of the experimental rations, this mixture provided a blend of cereal grains, mill offals, and lucerne meal comparable with that found in chicken replacement rations in Queensland.

TABLE 1

COMPOSITION OF BASAL MIXTURE AND ANIMAL PROTEINS USED IN EXPERIMENTS I AND II

Component	Percentage of Total		Crude Protein (%)		Ca (%)		P (%)	
	Expt. I	Expt. II	Expt. I	Expt. II	Expt. I	Expt. II	Expt. I	Expt. II
Wheat meal	25·3	43·0	12·8	15·3	0·02	0·03	0·30	0·28
Sorghum meal	38·0	21·5	11·2	9·4	0·01	0·02	0·27	0·29
Maize meal	25·9	22·8	10·3	7·3	0·02	0·01	0·29	0·25
Pollard	7·6	8·9	18·0	16·4	0·11	0·06	0·76	0·62
Lucerne meal	3·2	3·8	15·0	16·6	1·15	1·02	0·23	0·31
Total basal	100·0	100·0	12·0	12·35	0·06	0·06	0·33	0·31
Meat-and-bone meal M*			57·6	53·6	7·20	6·40	3·55	3·25
Meat-and-bone meal H†			43·9	43·5	15·00	13·76	6·95	6·66
Blood meal			80·9	77·0	0·36	0·22	0·27	0·16

* Ash (%): Expt. I 22·0, Expt. II 21·9.   † Ash (%): Expt. I 38·6, Expt. II 38·7.

Meat-and-bone Meals.—Two meat-and-bone meals were tested in each experiment. Product M represented a meal of moderate ash content; product H represented a meal of high ash content. Meat-and-bone meals used in Experiment II were produced by the same manufacturer as those used in Experiment I. Their composition is given in Table 1.

Blood Meal.—In the preparation of this material, blood was coagulated by the injection of live steam, drained and dried in steam-jacketed driers, which were fitted with rotating beater arms. The average drying time was 5-7 hr and the maximum temperature reached during this period was approximately 250°F. The composition of the blood meal is shown in Table 1.

Rations.—The rations, their ingredients, and their protein, calcium and phosphorus contents are given in Tables 2 and 3. The following points are relevant to the rations in these experiments:

(*a*) Blood meal replaced each meat-and-bone meal in the rations in 1 per cent. increments up to 5 per cent. and this is designated as, for example, M/0 to M/5. This was done on an equivalent crude protein basis. The difference in calcium and phosphorus content at all levels of replacement was compensated by the addition of tricalcium phosphate and calcium carbonate, small residual balances in weight being made up by starch.

(*b*) The crude protein level in rations used for Experiment I was 18·5 per cent. This level was generally used in 1960, whereas at the present time a protein content of about 20 per cent. is more common. To achieve uniformity between experiments, a similar level, 18·4 per cent., was also used in Experiment II. The animal proteins contributed 48·6 and 47·4 per cent. of the total crude protein in Experiments I and II respectively.

(*c*) All rations contained levels of calcium and phosphorus higher than those recommended for this class of livestock by the National Research Council (1954). This was inevitable, as it was essential to equate all rations as far as possible in mineral content to conform with the high mineral and low crude protein levels contributed by meat-and-bone meal H. The Ca:P ratios of the rations in Experiments I and II were 1:0·54 and 1:0·56 respectively.

(*d*) A more comprehensive range of additives was included in the rations of Experiment II as compared with Experiment I. This was done in order to follow a current commercial trend in this direction.

(*e*) The metabolizable energy content of the rations was calculated from published data (Titus 1961), taking the values for starch as approximately those for dextrose. The mean energy and energy:protein ratios expressed as kcal/lb and kcal:protein were 1355 and 73:1 for rations in Experiment I and 1324 and 72:1 for rations in Experiment II.

TABLE 2

COMPOSITION OF RATIONS IN EXPERIMENT I

Component	Rations*											
	M/0	M/1	M/2	M/3	M/4	M/5	H/0	H/1	H/2	H/3	H/4	H/5
Basal mix	79·00	79·00	79·00	79·00	79·00	79·00	79·00	79·00	79·00	79·00	79·00	79·00
Meat-and-bone meal	15·63	14·22	12·82	11·41	10·01	8·60	20·50	18·66	16·82	14·97	13·13	11·29
Blood meal	..	1·00	2·00	3·00	4·00	5·00	..	1·00	2·00	3·00	4·00	5·00
Tricalcium phosphate	4·50	4·88	5·00	5·38	5·63	5·88	..	0·75	1·37	2·00	2·75	3·37
Limestone	0·37	0·37	0·50	0·37	0·37	0·42	..	..	0·06	0·13	0·13	0·13
Salt premix†	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50
Starch	..	0·03	0·18	0·34	0·49	0·60	..	0·09	0·25	0·40	0·49	0·71

* From individual analyses of ingredients, calculated to contain 18·5% crude protein, 3·11% Ca, and 1·68% P.

† Salt premix consisted of sodium chloride to which was added Nutrigain (Nicholas Pty. Ltd.) which contributed 5,600 i.u. vitamin A, 1,125 i.u. vitamin D_3, 2·5 mg riboflavin, 3·0 mg Ca-pantothenate, 1·0 mg vitamin K-bisulphite, and 75 p.p.m. Mn as $MnSO_4.H_2O$ per lb feed.

TABLE 3

COMPOSITION OF RATIONS IN EXPERIMENT II

Component	Rations*											
	M/0	M/1	M/2	M/3	M/4	M/5	H/0	H/1	H/2	H/3	H/4	H/5
Basal mix	78·50	78·50	78·50	78·50	78·50	78·50	78·50	78·50	78·50	78·50	78·50	78·50
Meat-and-bone meal	16·29	14·85	13·41	11·98	10·55	9·12	20·07	18·32	16·56	14·80	13·04	11·29
Blood meal	..	1·00	2·00	3·00	4·00	5·00	..	1·00	2·00	3·00	4·00	5·00
Tricalcium phosphate	4·31	4·54	4·70	5·00	5·23	5·46	..	0·63	1·25	1·87	2·49	3·12
Limestone	0·10	0·17	0·17	0·17	0·17	0·17	..	..	..	..	..	..
Salt premix†	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·80	0·80
Starch	..	0·14	0·42	0·55	0·75	0·95	0·63	0·75	0·89	1·03	1·17	1·29

* From individual analyses of ingredients, calculated to contain 18·4% crude protein, 2·81% Ca, and 1·57% P.

† Salt premix consisted of 0·5 parts sodium chloride and 0·3 parts additives. Additives contributed per lb of feed: 4,000 i.u. vitamin A, 750 i.u. vitamin D_3, 2 mg riboflavin, 6 mg DL-α-tocopheryl acetate, 5 mg menadione sodium bisulphite, 200 mg choline chloride, 4 mg calcium D-pantothenate, 170 mg methionine, 28 mg butyl-hydroxy-toluene, 227 mg Nephtin (22·4% furazolidone), 84 mg Auofac 40 (9·2% aureomycin), 227 mg K_2SO_4, 62 p.p.m. Mn as $MnSO_4$. H_2O, 3·4 p.p.m. Cu as $CuCO_3$, 2·5 p.p.m. Co as $CoCO_3$, and 1·5 p.p.m. KI.

III. EXPERIMENTAL DESIGN

The cockerels were reared from hatching to one week of age in battery brooders on a ration consisting of the basal mixture, salt premix, and 2 per cent. limestone. They were then randomly allocated to each experimental group of 30 chickens by stratified random allocation on a body-weight basis. Groups were randomly allocated to each ration. There were 12 groups in Experiment I; replicates were used in Experiment II to give a total of 24 groups.

Initial body-weights ranged from 42 to 58 g in Experiment I and from 40 to 54 g in Experiment II. Chickens were reared in battery brooders from day-old to four weeks of age. They were then transferred to follow-on cages, where they were reared for a further four weeks. All chickens were individually weighed at weekly intervals and group feed consumption was recorded at each weighing period.

IV. RESULTS

(a) Experiment I

Mortality.—Mortality up to eight weeks was 11·7 per cent. in chickens receiving the M rations and 18·9 per cent. in chickens receiving the H rations. For the first six weeks mortality was 8·9 per cent. in chickens receiving the M rations and from six to eight weeks was only 2·8 per cent. The corresponding figures for chickens receiving the H rations were 7·2 and 11·7 per cent. However, taken over all, the differences in mortality among the 12 groups were not significant.

In the H groups at four weeks, the weight of chickens which died between four and eight weeks was 19 ± 5 g less than the weight of those that survived. However, the difference was in the opposite direction and much smaller in the M groups (-2 ± 6 g).

The two most consistent post-mortem findings were nutritional encephalomalacia (36·4 per cent.) and gizzard erosion (32·7 per cent). In only 7·3 per cent. of the dead chickens were both conditions present. Feather picking occurred towards the end of the experiment.

Body-weight and Food Conversion Ratio.—Group means and standard error of means for body-weights and food conversion ratio (FCR) are given in Table 4, together with mean group feed intake.

The weight of chickens receiving M rations was significantly superior overall to that of chickens receiving the H rations at both four and eight weeks ($P < 0.05$, $P < 0.01$ respectively). There were significant differences in feed intake between groups M and H (M > H at both four weeks. $P < 0.05$, and eight weeks, $P < 0.01$), but there were no differences in FCR.

TABLE 4

MEAN BODY-WEIGHT, FOOD CONVERSION RATIO, AND FEED INTAKE OF COCKERELS
IN EXPERIMENT I

Ration	Mean Body-weight (g)		FCR		Mean Feed Intake (g)	
	4 weeks	8 weeks	4 weeks	8 weeks	4 weeks	8 weeks
M/0	171 ± 4	513 ± 15	2·50 ± 0·14	3·08 ± 0·16	303	1,440
M/1	158 ± 4	506 ± 15	2·76 ± 0·14	3·24 ± 0·16	299	1,492
M/2	158 ± 4	491 ± 15	2·73 ± 0·14	3·33 ± 0·16	298	1,472
M/3	157 ± 4	508 ± 15	2·79 ± 0·14	3·07 ± 0·16	300	1,405
M/4	160 ± 4	470 ± 15	2·57 ± 0·14	3·38 ± 0·16	286	1,414
M/5	157 ± 4	442 ± 15	2·60 ± 0·14	3·38 ± 0·16	290	1,340
H/0	136 ± 4	368 ± 15	2·61 ± 0·14	3·35 ± 0·16	229	1,098
H/1	150 ± 4	406 ± 15	2·64 ± 0·14	3·28 ± 0·16	266	1,168
H/2	147 ± 4	402 ± 15	2·62 ± 0·14	3·20 ± 0·16	256	1,146
H/3	159 ± 4	416 ± 15	2·46 ± 0·14	3·47 ± 0·16	270	1,303
H/4	151 ± 4	446 ± 15	2·63 ± 0·14	3·30 ± 0·16	269	1,250
H/5	151 ± 4	426 ± 15	2·87 ± 0·14	3·24 ± 0·16	294	1,242

Previous experiments have shown that weight differences of chickens could be of the same magnitude between replicate groups as within groups, but facilities were not available to accommodate replicate treatments in this experiment. Only in the absence of any interaction between blood meal and meat-and-bone meal can the effect of different levels of blood meal be assessed. However, there appears to have been an apparent significant interaction between meat-and-bone meals and level of blood meal. A second experiment was therefore done in which treatments were replicated.

(b) Experiment II

Mortality.—Mortality up to eight weeks was 13·9 per cent. in chickens receiving the H rations, which was significantly different from 5·6 per cent. in chickens receiving the M rations. At each of the six levels of blood meal, mortality was higher in the H rations, but there was no evidence of any relationship between mortality and amount of blood meal in the rations. For the first six weeks, mortality was 6·4 per cent. in chickens receiving the H rations, and from six to eight weeks 7·5 per cent. The corresponding figures for chickens receiving the M rations were 4·2 and 1·4 per cent.

The weight at four weeks of chickens which died between four and eight weeks was —5 ± 10 g less than the weight of those that survived in the M groups and —4 ± 5 g less in the H groups. Overall, the difference in body-weight at four weeks between those which subsequently died and those which survived was not significantly different.

The most consistent post-mortem finding was nephritis, which was present in 61·8 per cent. of the chickens examined at post-mortem. In view of these findings, tracheal and kidney material was examined from 4-, 6-, and 7-week-old chickens. These gave negative tests for infectious bronchitis virus, using chick embryo passage.

Body-weight and Food Conversion Ratio.—Group means, standard error of means and significant differences for body-weights and FCR are given in Table 5, together with mean group feed intake. Body-weights and FCR of chickens at both four and eight weeks of age were significantly superior for rations containing the meat-and-bone meal of lower ash content. At four weeks of age there were significant differences in FCR within each meat-and-bone meal ration in relation to levels of blood meal, and overall FCR was significantly greater in rations containing no blood meal compared with rations containing from 1 to 4 per cent. blood meal. However, there were no significant differences in FCR at eight weeks. At four weeks there were significant differences in weight gains within each meat-and-bone meal ration in relation to levels of blood meal, and overall weights were significantly greater at all levels of blood meal compared with no blood meal; weights of chickens were also significantly greater at a level of 2 per cent. blood meal than at a level of 5 per cent. Again these differences were no longer significant at eight weeks, except that weights were significantly greater in the M rations at a level of 2 per cent. blood meal compared with a level of 4 per cent.

V. DISCUSSION

Growth rate in both Experiments I and II and FCR in Experiment II were significantly superior in chickens fed rations containing meat-and-bone meal M of moderate ash content (22·0 and 21·9 per cent.) than in chickens fed rations containing meat-and-bone meal H of high ash content (38·6 and 38·7 per cent.). This applied at the six levels of blood meal examined and supports the conclusions of a previous experiment by Gartner and Burton (1965), in which meat-and-bone meals containing 26·7 per cent. ash or less were superior to products containing from 28·7 to 32·7 per cent. ash. In all experiments, rations were balanced for crude protein, calcium and phosphorus.

The percentage of arginine, cystine, isoleucine, lysine, methionine and tryptophan in the rations was calculated from published tables (Lyman, Kiuken, and Hale 1956; Anon. 1957), and compared with the amino acid requirements of starting chicks (National Research Council 1954). All rations were adequate only in tryptophan. Those rations containing less than 4 per cent. blood meal were also adequate in isoleucine. The effect of increasing the levels of blood meal in the rations was to decrease the percentage of arginine and isoleucine and to increase the percentage of cystine, lysine and tryptophan.

TABLE 5

MEAN BODY-WEIGHT, FOOD CONVERSION RATIO, AND FEED INTAKE OF COCKERELS IN EXPERIMENT II

| Measurement | Ration | Blood Meal (%) | | | | | | Meat-and-Bone Meal* | | Standard Error | Necessary Difference | |
		0	1	2	3	4	5	M	H		P < 0·05	P < 0·01
FCR to 4 weeks	M	2·45	2·32	2·26	2·30	2·36	2·37			0·06	0·18	0·26
	H	2·58	2·41	2·37	2·36	2·36	2·43			0·06	0·18	0·26
	Mean	2·51	2·37	2·31	2·34	2·36	2·40			0·04	0·13	0·18
								2·34	2·42	0·02	0·07	0·10
FCR to 8 weeks	M	3·15	3·11	3·11	3·13	3·12	2·98			0·06	0·19	0·26
	H	3·24	3·36	3·34	3·23	3·23	3·31			0·06	0·19	0·26
	Mean	3·19	3·24	3·22	3·18	3·17	3·14			0·04	0·13	0·19
								3·10	3·28	0·02	0·08	0·11
Body-weight at 4 weeks (g)	M	177·6	187·4	201·1	193·2	186·9	181·1			3·9	11·9	16·7
	H	160·3	179·0	180·3	181·0	180·1	177·1			3·9	11·9	16·7
	Mean	169·0	183·2	190·7	187·1	183·5	179·1			2·7	8·4	11·8
								187·9	176·3	1·6	4·9	6·8
Body-weight at 8 weeks (g)	M	586·0	593·8	628·8	596·4	573·2	592·6			14·9	45·9	64·3
	H	512·9	512·9	518·7	523·0	519·2	508·5			14·9	45·9	64·3
	Mean	549·5	553·3	573·7	559·7	546·2	550·5			10·5	32·4	45·5
								595·1	515·9	6·1	18·7	26·2
Feed intake to 4 weeks (g)†	M	323	327	348	338	328	319					
	H	291	317	317	320	315	318					
Feed intake to 8 weeks (g)‡	M	1,704	1,696	1,797	1,723	1,626	1,625					
	H	1,503	1,560	1,574	1,534	1,524	1,528					

* Means for all levels of blood meal from 0 to 5%.
† M > H, P < 0·05.
‡ M > H, P < 0·01.

The apparent significant interaction between meat-and-bone meals and level of blood meal obtained in Experiment I was no longer evident when tested with replicate groups of chickens in Experiment II. In the latter experiment, there were significant differences in weight gains and FCR of chickens at four weeks of age within each meat-and-bone meal ration in relation to levels of blood meal. Weight gains and FCR of chickens receiving rations containing from 1 to 5 per cent. blood meal were superior to those fed rations with no added blood meal. This is in agreement with the previous findings of Gartner and Burton (1965), who showed that the performance of chickens receiving rations containing meat-and-bone meals improved significantly as the percentage of blood meal in the meat-and-bone meals was increased from 0 to 12 per cent., the upper level of which corresponded to 2 per cent. blood meal in the ration.

The significant differences found in weight gains and FCR at four weeks of age in Experiment II were no longer significant at eight weeks of age. This illustrates one of the obvious advantages gained by pursuing nutritional experiments of this nature for periods longer than four weeks and certainly for periods longer than one week, a period frequently used in chicken-rearing experiments.

Both experiments indicated that up to 5 per cent. blood meal in replacement chicken rations did not appear to be detrimental. Any differences in response from 1 per cent. increments up to 5 per cent. were to some extent dependent on the particular meat-and-bone meal replaced by the blood meal. Squibb and Braham (1955) found blood meal most effective in all-vegetable protein rations for chickens when fed at 2-4 per cent. of the rations. M. W. McDonald (personal communication) found that 6 per cent. blood meal in chicken rations could replace an equivalent amount of meat-and-bone meal without reduction in weight gain or increase in FCR.

For comparative purposes, the level of blood meal used in both experiments was calculated as a proportion of either the meat-and-bone meals replaced or of the crude protein content of the rations. Up to 45 per cent. of the meat-and-bone meals and up to 22 per cent. of the crude protein content of the rations was replaced by blood meal. Serfontein (1947, p. 21) found that 25 per cent. of the meat meal in poultry growing rations could be replaced by blood meal. Wiseman, Holmes, and Engel (1958) showed that poultry blood meal was a satisfactory source of animal protein in typical grower, broiler and layer rations when used to replace up to approximately one-sixth of the crude protein content of corn-soybean type rations.

The feed intake data in both experiments with both types of meat-and-bone meals gave no evidence that blood meal was unpalatable when included in a chicken ration at levels up to 5 per cent. This agrees with the findings of Lockhart, Reece, and Bolin (1960) for turkey poult diets.

Mortality in both experiments was higher in chickens receiving the H rations than in those fed the M rations, significantly so in Experiment II at each of the six levels of blood meal. The reasons for this are not known, but the meat-and-bone meals of highest bone content must be incriminated.

It is of interest that the principal post-mortem findings were nutritional encephalomalacia and gizzard erosion, in Experiment I, and nephritis in Experiment II. The incidence of nutritional encephalomalacia only in Experiment I would appear to be related to differences in the additives used in the two experiments. Additives in Experiment II included both vitamin E and the antioxidant BHT, neither of which was included in Experiment I. Prevention of nutritional encephalomalacia by administration of vitamin E was first reported by Dam et al. (1938), and has been repeated many times. Bunnell et al. (1955) showed that 2,6-di-tertiary butyl-4-methyl phenol (BHT) was also effective in preventing nutritional encephalomalacia. The overall weight of chickens which died in Experiment I between four and eight weeks of age was less than the weight of those that survived. This was unexpected, for nutritional encephalomalacia is normally found in the fastest growing birds in the flock (Ames 1956). The incidence of nephritis in poultry in Queensland was much higher in 1964 than in 1960 (L. G. Newton, personal communication). This is possibly the explanation for the incidence of nephritis in chickens from Experiment II.

VI. ACKNOWLEDGEMENTS

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