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EVALUATION OF MEAT-AND-BONE MEALS IN RATIONS FOR GROWING CHICKENS

3. EFFECT OF COOKING TIME IN THE PREPARATION OF MEAT-AND-BONE MEAL AND EFECT OF ADDED TALLOW IN POULTRY RATIONS

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SUMMARY

A meat-and-bone meal was subjected to processing conditions, classified by the manufacturer as undercooked, normally cooked, and overcooked. A multi-factorial design was used in an experiment to examine the effect of these products on the growth rate and food conversion ratio (FCR) of replicate groups of male and female chickens. Treatments were the three meat-and-bone meals fed with and without additional tallow in two types of rations—broiler-type rations (B rations) containing 7% meat-and-bone meal and rations containing a high level of 26·5% meat-and-bone meal (HMB rations). Each type of ration was balanced for crude protein, calcium and phosphorus, and chickens received these rations for 8 weeks.

Growth rate of chickens was not significantly affected by the degree of processing of the meat-and-bone meals. With the HMB rations, those containing normally cooked meat-and-bone meals were associated with significantly lower FCR.

At the kcal/protein ratios used, the inclusion of 3% tallow significantly improved overall FCR in chickens at 8 weeks of age but did not affect growth rate.

Both growth rate and FCR were markedly superior in chickens fed B rations compared with those fed HMB rations. This has been attributed to (a) the use of six different protein concentrates in the B rations, compared with meat-and-bone meal as the sole protein concentrate in the HMB rations; (b) the inclusion of additional methionine in the B rations but not in the HMB rations; and (c) the lower amount of calcium and phosphorus in the B rations compared with the HMB rations.

Mortality was higher in chickens receiving the HMB rations, the most consistent post-mortem finding being nephritis.

I. INTRODUCTION

In previous papers (Gartner and Burton 1965; Burton and Gartner 1965) the influence of various components in meat-and-bone meal was examined in relation to the quality of the product. No data were presented on the effect of processing. The present experiment was designed to provide information on meat-and-bone meals deliberately processed by the manufacturer as undercooked, normally cooked and overcooked. In the opinion of the manufacturer these products covered the extreme range of conditions likely to be encountered in the preparation of meat-and-bone meal at this plant.

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Schweigert *et al.* (1952) developed the use of an anti-oxidant to stabilize "inedible" fat, which extended the potential range of energy supply in poultry rations. Early literature on the value of added "inedible" fats in chicken rations has been reviewed by Norris *et al.* (1959). More recent information on protein-energy balance in broiler rations has been reviewed by Combs (1962). The inclusion of tallow in a limited number of poultry rations is only a recent trend in Australia. The opportunity was taken in the present experiment to evaluate the addition of tallow to two types of rations.

II. MATERIALS AND METHODS

General.—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). To increase the number of treatments in this experiment, each battery brooder was divided into two sections.

Chickens.—A commercial strain (T.M.4) of meat-type cockerels and pullets was obtained as day-old chickens.

Meat-and-bone meals.—An average blend of the normal components of meat-and-bone meal was prepared in a single digester. Material was removed 5 min before the estimated time which the "end point controller" indicated was the desired degree of dryness. This gave undercooked material (U). Further material was removed when the control indicated that cooking was completed. This represented a normal cook (N). The residue was left in the cooker for 5 min longer and gave overcooked material (O). The average composition of these meals was: crude protein 54·2%, Ca 9·65%, P 4·48%.

Tallow.—The animal fat used met the following specifications: titre 42·5°–43·5°C, free fatty acid (as oleic acid) less than 2%, moisture less than 0·3%, fair average colour 11A–11B. The iodine value was 43·2 and gas chromatography of the fatty acid methyl esters showed the following percentage composition: C_{14}, 3·5; C_{14} (1=), 1·4; C_{16}, 28·3; C_{16} (1=), 2·8; C_{17} (iso), 1·4; C_{18}, 18·3; C_{18} (1=), 42·4; C_{18} (2=), 1·8.

Rations.—The three prepared meat-and-bone meals were each incorporated in two types of rations. One contained cereal grains, lucerne meal, meat-and-bone meal and additives (high meat-and-bone meal rations, designated HMB). The other was comparable with commercial broiler rations in that it contained, in addition, soybean meal, fish meal, liver meal, blood meal and skim-milk powder (broiler rations, designated B). Rations contained either 3% tallow (T) or starch (S) in place of tallow. Methionine was included in the B rations but not in the HMB rations. The composition of the experimental rations is given in Table 1. The metabolizable energy content of the rations was calculated from published data (Titus 1961), taking the values for starch as approximating those for dextrose. The energy and energy:protein ratios expressed as kcal/lb and kcal:protein were 1504 and 71:1 for the B/T rations and 1436 and 68:1 for the B/S rations. The corresponding values for the HMB/T and the HMB/S rations were 1514 and 72:1 and 1446 and 69:1 respectively.

TABLE 1

Composition of Experimental Rations

Ration	Broiler Ration with Undercooked Meat-and-bone Meal (B/U)				Broiler Ration with Normally Cooked Meat-and-bone Meal (B/N)				Broiler Ration with Overcooked Meat-and-bone Meal (B/O)			
Ingredient	%	Contributing			%	Contributing			%	Contributing		
		Protein (%)	Ca (%)	P (%)		Protein (%)	Ca (%)	P (%)		Protein (%)	Ca (%)	P (%)
Maize meal	35·75	3·00	·007	·089	35·75	3·00	·007	·089	35·75	3·00	·007	·089
Sorghum meal	31·50	3·40	·003	·076	31·50	3·40	·003	·076	31·50	3·40	·003	·076
Lucerne meal	1·50	0·28	·017	·004	1·50	0·28	·017	·004	1·50	0·28	·017	·004
Soybean meal	10·00	5·02	·029	·076	10·00	5·02	·029	·076	10·00	5·02	·029	·076
Fish meal	2·30	1·56	·098	·060	2·30	1·56	·098	·060	2·30	1·56	·098	·060
Liver meal	2·00	1·36	·006	·018	2·00	1·36	·006	·018	2·00	1·36	·006	·018
Blood meal	2·00	1·53	·004	·003	2·00	1·53	·004	·003	2·00	1·53	·004	·003
Skim-milk powder	3·20	1·10	·043	·031	3·20	1·10	·043	·031	3·20	1·10	·043	·031
Meat-and-bone meal	7·00	3·79	·686	·336	6·94	3·80	·659	·298	7·09	3·79	·680	·338
Starch or tallow	3·00	..	..	..	3·00	..	..	..	3·00	..	..	..
Limestone	0·66	..	·264	..	0·57	..	·228	..	0·68	..	·272	..
Sodium chloride	0·50	..	..	..	0·50	..	..	..	0·50	..	..	..
Additives*	0·15	..	..	..	0·15	..	..	..	0·15	..	..	..
Starch	0·44	..	..	..	0·59	..	..	..	0·37	..	..	..
Total	100·00	21·04	1·157	0·693	100·00	21·05	1·094	0·655	100·00	21·04	1·159	0·695
Ration	**Ration with High Level Undercooked Meat-and-bone Meal (HMB/U)**				**Ration with High Level Normally Cooked Meat-and-bone Meal (HMB/N)**				**Ration with High Level Overcooked Meat-and-bone Meal (HMB/O)**			
Maize meal	35·75	3·00	·007	·089	35·75	3·00	·007	·089	35·75	3·00	·007	·089
Sorghum meal	31·50	3·40	·003	·076	31·50	3·40	·003	·076	31·50	3·40	·003	·076
Lucerne meal	1·50	0·28	·017	·004	1·50	0·28	·017	·004	1·50	0·28	·017	·004
Meat-and-bone meal	26·50	14·36	2·597	1·272	26·25	14·36	2·494	1·129	26·70	14·37	2·574	1·282
Starch or tallow	3·00	..	..	..	3·00	..	..	..	3·00	..	..	..
Sodium chloride	0·50	..	..	..	0·50	..	..	..	0·50	..	..	..
Additives†	0·05	..	..	..	0·05	..	..	..	0·05	..	..	..
Starch	1·20	..	..	..	1·45	..	..	..	1·00	..	..	..
Total	100·00	21·04	2·624	1·441	100·00	21·04	2·521	100·00	100·00	21·05	2·601	1·451

* Additives contributed per lb of feed: 4875 i.u. vitamin A, 500 i.u. vitamin D3, 3·8 mg riboflavin, 14 mg DL-α-tocopheryl acetate, 1 mg menadione sodium bisulphite, 4 mg calcium-D-pantothenate, 454 mg methionine, 57 mg Santoquin, 17 mg 3-nitro-4-hydroxy phenyl arsonic acid, 1 mg olyandomycin and 41 p.p.m. Mn as $MnSO_4.H_2O$.

† As for broiler rations with exclusion of methionine.

Addition of tallow.—Tallow was heated to a temperature of approximately 77°C before mixing with the feed. The anti-oxidant Santoquin (Monsanto "Ethoxyquin") was added to the tallow at the 0·005% level to protect the disperse phase. Mixing was accomplished by atomizing the tallow onto the surface of the feed while it was being churned in a horizontal mixer of 300-lb capacity.

III. EXPERIMENTAL DESIGN

A multi-factorial design was used to investigate the performance of chickens receiving three types of meat-and-bone meal fed at a high level (HMB rations) and at a lower level comparable with current commercial broiler rations (B rations). The rations contained either 3% tallow or starch and two groups of chickens were allocated to each treatment.

A total of 750 day-old chickens was available for this experiment. The lightest and heaviest chickens were culled and initial body-weights ranged from 34 to 41 g. At one day of age chickens were randomly allocated to experimental groups by stratified random allocation on a body-weight basis. Each group contained 12 cockerels and 12 pullets and groups were allocated at random to each treatment.

Chickens were reared in battery brooders from day-old to 4 weeks of age. They were then transferred to follow-on cages, where they were reared for a further 4 weeks. All chickens were individually weighed at weekly intervals and group feed consumption was recorded at each weighing period.

IV. RESULTS

Mortality.—Mortality to 8 weeks was 3·5% in chickens receiving the B rations and 12·5% in chickens receiving the HMB rations. Mortality in the B groups occurred mainly in the first week; however, losses continued in the HMB groups throughout the experiment. Losses were evenly distributed among types of meat-and-bone meal and in groups receiving either tallow or starch. The most consistent post-mortem finding was nephritis.

Sexing errors.—Examination of the chickens at the end of the experiment showed that 5·2% of the pullets were incorrectly sexed as cockerels and 1·4% of the cockerels were sexed as pullets, giving a net sexing error of 3·3%.

Body-weight and food conversion ratio.—Co-variance analysis was used to adjust mean weights in groups containing incorrectly sexed chickens. Assuming the food consumption of pullets is lower than that of cockerels in the same proportion as their weight, no adjustments were necessary to calculate food conversion ratio (FCR).

Group means, standard error of means and significant differences for body-weights and FCR are given in Table 2. The interactions for the weights were not significant. Calculating overall FCR in relation to the types of meat-and-bone meals, N was significantly less than U at 4 weeks and less than O and U at 8 weeks, but there was an interaction between B and HMB with U, N and O which was significant both at 4 weeks ($P < 0{\cdot}01$) and at 8 weeks ($P < 0{\cdot}05$).

Overall FCR at 8 weeks favoured groups receiving tallow, but there was an interaction for FCR at 4 weeks between U, N and O with T and S ($P < 0{\cdot}05$) and between B and HMB with T and S ($P < 0{\cdot}01$). These findings are shown in Table 3.

TABLE 2

Group Means, Standard Errors of Means, and Significant Differences for Body-weight and Food Conversion Ratio of Chickens

Variables	Mean Weight (g)		FCR	
	4 Weeks	8 Weeks	4 Weeks	8 Weeks
B rations	346±4·2	1,009±11	1·743±0·015	2·135±0·018
HMB rations	174±4·2	450±11	2·467±0·015	2·928±0·018
Significance	***	***	***	***
Meat-and-bone meal (U) ..	254±5·1	723±14	2·149±0·018	2·548±0·023
Meat-and-bone meal (N) ..	269±5·1	744±14	2·059±0·018	2·478±0·023
Meat-and-bone meal (O) ..	257±5·1	722±14	2·108±0·018	2·569±0·023
Significance	N.S.	N.S.	U>N**	O, U>N*
Tallow	263±4·2	733±11	2·111±0·015	2·501±0·018
Starch	258±4·2	725±11	2·099±0·015	2·562±0·018
Significance	N.S.	N.S.	N.S.	*
Replicate I	259±4·2	730±11	2·118±0·015	2·547±0·018
Replicate II	262±4·2	729±11	2·093±0·015	2·516±0·018
Significance	N.S.	N.S.	N.S.	N.S.
Cockerel	281±4·2	802±11		
Pullet	240±4·2	657±11		
Significance	***	***		

*Significantly higher or lower at 5% probability level.
**Significantly higher or lower at 1% probability level.
***Significantly higher or lower at 0·1% probability level.

TABLE 3

Interactions Between Rations, Meat-and-bone Meals, Tallow, and Starch in Food Conversion Ratio of Chickens

Combination	FCR							
	Meat-and-bone Meal						Tallow	Starch
	U		N		O			
	4 Weeks	8 Weeks	4 Weeks	8 Weeks	4 Weeks	8 Weeks	4 Weeks	4 Weeks
B rations	1·748	2·120	1·758	2·145	1·725	2·140	1·708	1·778
HMB rations	2·550	2·975	2·360	2·810	2·490	2·998	2·513	2·420
Meat-and-bone meal (U) ..	..	..	..	..	..	..	2·188	2·110
Meat-and-bone meal (N) ..	..	..	..	..	..	..	2·018	2·100
Meat-and-bone meal (O) ..	..	..	..	..	..	..	2·128	2·088

The weight of the pullets was 85 and 82% of the cockerel weight at 4 weeks and 8 weeks respectively.

V. DISCUSSION

Growth rate was not affected when chickens were fed a meat-and-bone meal which was subjected to processing conditions classified by the manufacturer as ranging from undercooked to overcooked. There were significant differences in FCR which were related to the type of ration in which the meat-and-bone meals were tested. Taken over all conditions, rations containing normally cooked meat-and-bone meals were associated with lower FCR than rations containing either undercooked or overcooked meat-and-bone meal. However, this was apparent only at high inclusion levels of the meals and not at lower levels more in keeping with commercial broiler rations.

The tallow used in this experiment was a mixture of beef and mutton fats. The fatty acid composition was comparable with that found in beef tallow by Young (1961) in the United States of America and by Lewis and Payne (1963) in the United Kingdom. Tallow when fed at the 3% level improved overall FCR at 8 weeks but did not affect growth rate. Again there was an interaction between both tallow and types of ration and tallow and meat-and-bone meals. In the broiler-type rations, tallow gave a lower FCR at 4 weeks compared with an equivalent weight of starch; however, the reverse was apparent in the rations containing high levels of meat-and-bone meal. Evaluating FCR at 4 weeks for both rations shows an interaction between tallow, starch and meat-and-bone meals; however, the differences were small. Leong *et al.* (1959) reviewed experimental work relating to the addition of fat to rations and showed that some workers found this resulted in improvement in feed efficiency but not in growth rate; others recorded substantial chick growth improvements.

The kcal:protein ratio of both the B and the HMB rations was comparable and within the suggested levels of Combs (1962) for meat-type chickens. The rations were so equated that the superior performance of chickens fed B rations compared with those receiving HMB rations in both weight gains and FCR ($P < 0 \cdot 01$) can be attributed to the three variables between ration types, namely:—

(i) *The six types of protein concentrates in the B rations compared with only meat-and-bone meal in the HMB rations.* Specifically 10·0 parts of soybean meal, 2·3 parts of fish meal, 2·0 parts of liver meal, 2·0 parts of blood meal, 3·2 parts of skim-milk powder and 7·0 parts of meat-and-bone meal (= 26·5 parts contributing 14·36 parts of protein to the B/U ration) provided a more digestible protein and/or a superior blend of amino acids than the 26·5 parts of the same meat-and-bone meal contributing 14·36 parts of protein to the HMB/U ration. McDonald and Solvyns (1964) tested chicken performance over 6 days using similar ration comparisons. Their broiler-type ration contained soybean meal, blood meal, liver meal, coconut meal, linseed meal and meat-and-bone meal. Chickens receiving these rations were significantly heavier ($P < 0 \cdot 01$) than those receiving a high meat-and-bone meal ration, but the FCR was not significantly different.

(ii) *The exclusion of methionine from the HMB rations.* Carpenter (1958) suggested that in processing damage of animal proteins, both lysine and cystine could be similarly affected. Later Carpenter *et al.* (1962) showed that the content of 'available methionine' falls more than that of 'available lysine' in herring press cake during controlled heat treatment, and the same has been demonstrated as a result of storage (Carpenter *et al.* 1963). Thus it was considered that a better assessment of changes in protein quality due to processing would be obtained by excluding methionine from at least one of the ration types in this experiment.

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). The levels for cystine, isoleucine, lysine and methionine were higher in the B rations than the HMB rations. Levels of tryptophan and arginine were comparable. From the published amino acid requirements of starting chicks (National Research Council 1954) it is evident that, following the addition of methionine, the B rations were adequate except for a slight deficiency in arginine whereas the HMB rations were deficient in arginine, cystine and particularly in methionine.

(iii) *The greater amount of calcium and phosphorus in the HMB rations.* McDonald and Solvyns (1964) compared meat-and-bone meals by rearing chickens on rations containing soybean meal, skim-milk powder, meat-and-bone meal and tallow. They concluded that weight gains in chickens were inversely correlated with ash, bone and calcium levels in the rations but not with phosphorus content. On the other hand, Sathe and McClymont (1964) concluded from their experiments that the poorer growth rate of chickens on a ration where meat-and-bone meal replaced soybean protein, compared with a ration containing both meat-and-bone meal and soybean meal, was not due to the higher calcium or bone content of diets containing meat-and-bone meal as the major protein source. Skim-milk, tallow and starch were the other components of these rations.

In experiments involving young chickens, it is advisable to carry them through to a stage when their secondary sexual characteristics are defined in order to correct for any initial sexing errors at day-old. It was more difficult to differentiate between sexes in these meat-type chickens than in purebred strains. It was only at approximately 8 weeks of age that their sex could be accurately determined by visual examination, whereas in both Australorp and White Leghorn chickens and in their reciprocal crosses secondary sexual characteristics are more clearly defined at this age. Despite this limited difference in secondary sexual characteristics between pullets and cockerels, the meat-type pullets in this experiment were still only 82% of the weight of cockerels at 8 weeks. This difference in the weight between sexes was of the same order as that found in White Leghorn x Australorp crossbred chickens by Gartner and Burton (1965). C. P. McPhee (personal communication) found that the weight of pullets compared with cockerels at 8 weeks of age was 83% in the White Leghorn x Australorp cross, 86·5% in the reciprocal cross, 88% in White Leghorn and 91% in Australorp chickens.

In commercial practice, meat-type chickens are grown on well-balanced rations. It was therefore not unexpected that the performance of this type of chicken was superior in our experiment on rations containing a range of protein concentrates, added methionine and low mineral content compared with rations containing high levels of meat-and-bone meal and minerals and no added methionine. However, the magnitude of the difference in growth rate was unexpected and in addition mortalities were less on the broiler-type rations. The beneficial effects of added tallow were small at the particular kcal:protein ratios used in this experiment. This suggests that in practice the decision to feed animal fat and the level of inclusion in commercial rations will be governed largely by the cost of this component.

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