THE MANIPULATION OF BODY FAT IN BROILER CHICKENS BY CHEMICAL MEANS AND THEIR EFFECTS ON ENERGY METABOLISM

By

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree.

I certify that, to the best of my knowledge, any help received in preparing this thesis and all sources used have been acknowledged in this thesis.

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Abbreviations

AA	amino acid
ACTH	adrenocorticotrophic hormone
AFP	the abdominal fat pad
AMP	adenosine monophosphate
AOV	analysis of variance
APP	avian pancreatic polypeptide
ATP	adenosine triphosphate
$BaCL_2$	barium chloride
$BaCO_3$	barium carbonate
BAT	brown adipose tissue
C	centigrade
$CaCl_2$	calcium chloride
cAMP	cyclic adenosine monophosphate
CAS	50 ppm iodinated diet
CIM	0.5 ppm cimaterol diet
cm	centimetre(s)
CON	controls
CO_2	carbon dioxide
d	day(s)
E	energy

E_m	maintenance energy
et al.	and others
F	fat line birds
FCE	feed conversion efficiency, liveweight gain/feed intake
FCR	feed conversion ratio, feed intake/liveweight gain
FFBW	fat-free body weight, slaughter body weight – (AFP + carcass fat)
g	gram(s)
GE	gross energy
GH	growth hormone
HDL	high density lipoprotein
HP	heat production
KCl	potassium chloride
K_2CO_3	potassium carbonate
kg	kilogram(s)
kJ	kilojoule(s)
KOH	potassium hydroxide
l	litre(s)
L	lean line birds
LDL	low density lipoprotein
LSD	least significant difference
ME	metabolizable energy
MJ	megajoule(s)
ml	millilitre(s)
mm	millimetre(s)
N	nitrogen or number of observations
NADPH	reduced nicotinamide adenine dinucleotide phosphate
NEFA	non-esterified fatty acid

$NaHCO_3$	sodium hydrogencarbonate
NH_4Cl	ammonium chloride
O_2	oxygen
$P<0.10$	statistically significant at 10 per cent level
$P<0.05$	statistically significant at 5 per cent level
$P<0.01$	statistically significant at 1 per cent level
P:E	dietary protein : energy ratio
R^2	the square of the correlation coefficient
RSD	residual standard deviation
SEM	standard error of means
T_3	triiodothyronine
T_4	thyroxine
TSH	thyroid-stimulating hormone
VLDL	very low density lipoprotein
W	body weight (kg)
$W^{.75}$	metabolic body size
%	per cent

Abstract

1. The differences between two genetically fat and lean lines of broiler chickens in growth rate, fat content, heat production and energy and nitrogen balance were studied respectively in two growth trials and two calorimetry experiments using closed-circuit respiration chambers.

2. The effects of a β-adrenergic agonist, cimaterol, on growth rate and body fat in the two fat and lean lines of chickens at 0.2, 0.4 and 0.6 ppm were tested in Trial 1; 0.4 ppm level was taken in Trial 2 and its influence on heat production and energy and nitrogen balance in these two lines were investigated in calorimetry Experiment 1.

3. The effects of 0.5 ppm cimaterol, theophylline and caffeine at 0.1% and 0.05% dietary inclusions, 0.5 ppm cimaterol plus 0.1% theophylline, 50 and 100 ppm iodinated casein, 50 or 100 ppm iodinated casein plus 0.05% theophylline, 50 ppm iodinated casein plus 0.05% caffeine were explored in commercial broiler chickens during the finisher period. The effects of 0.5 ppm cimaterol, 0.5% theophylline and 50 ppm iodinated casein on heat production and energy and nitrogen balance in female commercial broiler chickens were studied in calorimetry Experiment 3.

4. The possible mechanisms by which these compounds exert their effects are discussed.

5. The lean birds showed significantly lower abdominal fat pad (AFP) and carcass fat contents, lower growth rate and final body weight with no difference in fat-free body weight (FFBW) than the fat birds. A better feed conversion ratio (FCR) was seen in

fat birds (only in Trial 2). The lean birds showed a higher heat production ($P<0.05$) due presumably to a higher proportion of lean body mass.

6. With fat and lean lines of broilers in Trial 1, AFP was significantly decreased at 0.4 ppm cimaterol in sex combined data (19%) and at 0.2 ppm in males (28%); in females, cimaterol at 0.4 ppm reduced ($P<0.05$) both AFP (27%) and carcass fat (14%). Growth rate was depressed ($P<0.05$) in 0.6 ppm cimaterol treatment (6%) but there was no difference in FFBW. In the lean line, cimaterol at 0.2 and 0.4 ppm significantly decreased carcass fat (19% in females and 20% in sex combined data) and growth rate but not FFBW; feed intake was lower in 0.4 ppm cimaterol treated birds ($P<0.05$). In the fat line, the significant reduction in AFP by cimaterol treatment was 34% at 0.6 ppm in males and 24% at 0.4 ppm in females. Carcass fat was not significantly affected. A 12% improvement in FFBW was observed at 0.2 ppm cimaterol treatment ($P<0.05$). In Trial 2, 0.4 ppm cimaterol significantly decreased both AFP (19%) and carcass fat (12%) in fat line but not in lean line. FCR was reduced in both lines ($P<0.05$). Cimaterol at 0.5 ppm showed no effect on either the growth rate or AFP in Trials 3 and 4 with commercial chickens.

   Cimaterol at 0.4 ppm showed little effects on heat production and energy and nitrogen balance in fat birds while cimaterol treated lean female birds had a 4% lower heat production a metabolic body weight ($W^{.75}$) basis ($P<0.05$). In Experiment 3, 0.5 ppm cimaterol led to a 3% higher heat production on a W basis ($P<0.05$) in the commercial female birds.

7. Theophylline and caffeine showed similar effects on growth rate and fat content with 0.1% dietary inclusion having a more dramatic effect than 0.05%. Both alkoloids significantly decreased AFP (37–66% at 0.1% and 19–31% at 0.05%) and carcass fat (21–22% at 0.1%). These reductions in fat content were accompanied by a depression ($P<0.05$) in growth rate, feed intake and FFBW. The lower fat content of birds treated with 0.1% theophylline or 0.1% caffeine compared with their control pair-fed counterparts indicated their effect on reducing fat content over that caused by a

depressed feed intake. Caffeine did not affect FCR at both levels giving it an advantage over theophylline which at 0.1% led to a poorer FCR ($P<0.05$).

Theophylline plus cimaterol decreased AFP (23%, $P<0.05$) in Trial 4 but not in Trial 3; feed intake, growth rate and feed conversion were depressed ($P<0.05$) in both trials.

On both a W and a metabolic body size ($W^{.75}$) basis, 0.05% theophylline resulted in a decreased heat production ($P<0.05$) on the first day of its inclusion and a reduced ME and nitrogen intake leading to a lower nitrogen balance and a lower nitrogen retention efficiency ($P<0.05$) during the 3-day treatment in Experiment 3.

8. Iodinated casein significantly reduced AFP (18–39%) in Trials 8 and 9 and improved FCR in Trial 8. Iodinated casein at 50 ppm caused a reduced energy deposition per unit ME intake on a W basis ($P<0.05$) suggesting a decreased tissue energy density as a result of reduced fat content.

   Iodinated casein plus theophylline resulted in a significant further reduction in AFP up to an average of 54% and an improved FCR at 50 ppm iodinated casein plus theophylline; iodinated casein plus caffeine did not show the synergistic lipolytic effect in Trial 9.

9. The results of the present study demonstrated that cimaterol is effective in reducing body fat in the chicken and shows the potential to improve lean body mass, but its effects on commercial broiler birds needs further trials to be clarified. Both theophylline and caffeine decrease fat content over that caused by a depression in feed intake and their dose-effect relationship makes it worthwhile to test lower levels to overcome the depression in growth. Iodinated casein can reduce fat content while maintaining growth and improving feed conversion at the two levels tested; its combination with theophylline has a synergistic effect on further reducing fat content and such a combination requires economic considerations.

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