RESPONSES TO DIETARY FAT BY FOWL

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Abstract

Many aspects of lipid metabolism in fowl are different from mammals. The small intestine forms very low density lipoproteins (VLDLs) from digested fat and overloading the system delays digesta transit. These delays usually increase dietary ME through improved recovery of nutrients other than fat. VLDLs and short chain fatty acids go to the liver where modifications in length and unsaturation improve compatability for subsequent body usage. Heat arises to the extent of modification and NE is reduced accordingly.

Heat is also released if fatty acids are synthesized from acetyl CoA or catabolized to provide energy. Added dietary fat is of productive advantage during growth when the heat loss of synthesis would be avoided and detracts when circumstances necessitate oxidation. Large amounts of dietary fat may be productively used during the early aspects of sexual maturation because the capacity for depot growth is greatly accentuated.

Fatty acid synthesis in fowl is confined to the liver and total lipogenesis relates to a limited number of hepatocytes. Supplementary fat during the finishing period stimulates growth by avoiding this limitation and depot expansion provides the differential in gain. Once past the initial aspects of sexual maturation, depot capacity is approached, and the response to added fat dissipates. Dietary fat may be strategically used to either encourage or discourage depot development depending upon the objectives of production.

INTRODUCTION

Adding fat to the feed of high performance meat birds is widely practiced to improve their growth rate. Typically, this response is negligible through juvenile development and maximal prior to marketing. Mammals do not respond to fat to the same degree. Fowl also differ in many aspects of lipid metabolism from mammals. These unique aspects of fat utilization are examined in the following text to rationalize the nature of this growth stimulation and its variability.

FAT ABSORPTION AND THE "EXTRA CALORIC EFFECT"

Both fowl and mammals digest triglycerides to 2-monoglycerides and free fatty acids for uptake by the small intestine. However, fowl enterocytes reassemble these products exclusively as VLDLs. Absorptive capacity for fat is rapidly attained and control mechanisms are invoked that inhibit gastric evacuation while the distal progression of existing digesta is slowed[1].

Food passage through the fowl's GI system is very short, and delays in the small intestine can have a large relative impact on transit time.

Mateos and Sell[2] and Mateos *et al.*[3], reported that control feed without added fat required 3.22 hours for GI transit and a 14% increase occurred from the addition of 5% yellow grease (Table 1). They suggested that this additional time improved the digestibility of accompanying feedstuffs to yield an "extra caloric effect". Variability in obtaining this extra caloric effect would then be a function of this time advantage and the "ease" to which the associated ingredients could be reduced to an absorbable form.

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Table 1 Effect of added dietary fat on gastrointestinal transit time, fat digestibility, and total dietary metabolizable energy content with laying hens[1]

% fat added	Marker time minutes	Fat digestibility % apparent	MJ Dietary ME/kg Cals.	Det'n	Δ %
0	193	77.3	10.88	10.91	0
5	219	88.0	11.60	11.74	1
10	214	88.1	12.32	12.73	3
15	227	87.6	13.02	13.50	4
20	251	89.7	13.74	14.76	7
25	250	87.1	14.46	15.06	4
30	270	90.7	15.18	15.96	5

[1]Selected data from Mateos and Sell[2] and Mateos et al.[3]

Fats that contain a substantial proportion of short and medium chain fatty acids are less likely to give an extra caloric effect than with long chained fatty acids. Carbon chains less than 14 are not reesterified in the enterocyte but pass through in free form to the portal system.

FATTY ACID MODIFICATIONS AND NET ENERGY

The VLDLs formed by enterocytes together with any volatile, short and medium chain fatty acids enter the portal system for transportation to the liver. Only the hepatocyte in fowl has any extensive capacity for fatty acid synthesis, elongation, and desaturation. Chung et al.[4] fed 10% hydrogenated coconut oil to turkeys from 6 to 16 weeks of age and found medium chain fatty acids associated with various depot, but to a lesser extent than provided from the feed. Moran et al.[5] [6] fed soybean oil and beef tallow in excess of 5% of the diet to male turkeys from 8 to 23 weeks of age. While most of the stearic acid in tallow was desaturated to oleic acid, the high level of linoleic acid in soybean oil was perpetuated.

Modifications to fatty acids from each dietary fat result in a heat loss which decreases the net energy value. Fuller and Rendon[7] measured total heat loss with broiler chickens given dietary fats having different chain lengths and degrees of unsaturation (Table 4). Fat rendered from poultry carcasses led to the lowest heat loss. Presumably, this fat provided maximum compatability and required minimum modification.

Table 2 Total heat loss with boiler chickens between 4 and 7 weeks of age when given dietary fat having different fatty acid chain length and unsaturation

Dietary fat	Gain g	GE gain ME cons.	Kcal heat /Bird/Day	kg Gain
Basal (1.6% Fat)	873	.31	202	4859
+ 10% Coconut Oil	879	.35	195	4659
Corn Oil	957	.37	191	4191
Tallow	984	.36	203	4332
Poultry Fat	966	.39	188	4087

[1]Selected data from Fuller and Rendon[7]

FAT DEPOSITION AND PRODUCTIVE ENERGY

The productive energy obtained from dietary fat largely depends upon its extent of deposition. Deposition may be either as a structural component in membranes or held by depots as an energy reserve. If fat deposited had been derived from de novo synthesis, then about 10% of the original ME of glucose would have been lost in the biochemical manipulations to heat at the time of conversion. Reversing these biochemical activities such that fat is used as energy source creates a like amount of heat,

Growth requires fat deposition as membranes or depots. Adding fat to the feed to the capacity for deposition avoids the heat loss which would occur from synthesis and the productive energy realized increases proportionately. If added fat exceeds capacity for deposition, then the excess must be oxidized and this heat loss progressively detracts from the gains obtained from lower levels of inclusion, Fuller and Rendon[8] added progressive amounts of corn oil to feed for broiler chickens. Heat production arising with each kg of gain decreased up to 10% corn oil, thereafter it increased (Table 3).

Table 3 Total heat loss with broiler chickens between 5 and 8 weeks of age when given corn oil is progressively added to the feed[1]

% added	Gain (g)	Body fat % 'as is'	Body fat Gained/Absorbed	Kcal heat Bird/Day	Kcal heat kg Gain
Basal (1.5%)	869	10.5	2.91	256	6182
5	938	11.7	0.93	268	6022
10	1030	12.2	0.61	278	5663
15	999	12.1	0.43	280	5880
20	1009	12.7	0.41	292	6077

[1]Selected data from Rendon and Fuller[8]

The nature and extent of fat deposition that occurs during growth vary with stage of development. Membrane expansion is relatively the greatest with rapid early growth while depots fill at a particularly rapid rate with onsetting sexual maturity. Especially large amounts of fat may be deposited with early sexual development; thus, the productive advantage of added dietary fat is prominant through the finishing period.

NATURE OF THE GROWTH STIMULATION

The growth stimulation that results from added fat is not directly related to the aforementioned effects that it can have on ME, NE, and PE; but, appears to arise from the restriction of fatty acid synthesis to the liver. During the initial aspects of secual maturation, body depots rapidly develop and the capacity for deposition is speculated to exceed the ability of a limited number of hepatocytes for de novo synthesis. Added dietary fat is viewed as simply by-passing this restriction with the resulting growth advantage being largely as an increased rate of depot expansion.

The growth advantage provided by fat is a transitory one and dissipates with time as the depots "fill". Moran[9] fed large'type male turkeys between 18 and 22 weeks of age with finishing feeds having the same energy-protein ratio with 5% of an animal-vegetable blend being either included or excluded from the formulation. During the 18-20 week interval, a significant increase in body weight occurred but disappeared 2 weeks later (Table 4). Grading for the degree of fat infiltration along the lower back area with chilled carcasses indicated an advantage with early marketing, but not two weeks later, In order to capitalize on the growth advantage or, conversely, minimize body fat accrual, one must know the bird's developmental characteristics then feed and market accordingly.

Table 4 Growth, feed conversion, and caracass finish responses to added dietary fat during early and late aspects of the finishing period[1]

Parameter	% Added fat 0	% Added fat 5	Δ %	Significance
20 weeks				
Weight, g	12,173	12,471	+2.4	*
18-20 wk F/G	3.88	3.48	-1.0	**
Finish, % A	57.9	74.5	+28.7	***
22 weeks				
Weight, g	13,374	13,579	+1.5	NS
20-22 wk F/G	5.88	5.44	-0.7	*
Finish, % A	94.3	97.5	+3.4	NS

[1]Selected data from Moran[9]

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