maize). It may be concluded that the difference in susceptibility to liver steatosis between the 2 strains does not result from a bad dietary efficiency in the Rhine strain, but rather from a defect in TG assembly to nascent VLDL, which is more pronounced in the Landes strain. This phenomenon occurs even when the geese overfeed spontaneously, and is not related specifically to artificial feeding.

LPL and HL activities in golden hamster during the suckling period. Influence of the maternal diet. R Sicart, R Sablé-Amplis, V Millet (*CNRS, Université P-Sabatier, rue F- Magendie, 31400 Toulouse, France*)

Hepatic lipoprotein lipase (HL) and lipoprotein lipase (LPL) are central enzymes in lipid metabolism. The development of their activities has not been studied in the hamster, a suitable model for studies of lipid metabolism. Therefore, we used hamsters *(Mesocricetus auratus)* to study the changes in the activities of HL and of LPL in inguinal adipose tissue and heart from birth to weaning (21 d). We also examined whether the enzyme activities were influenced by the composition of the maternal diet.

Newborns were obtained from mothers fed *ad libitum* either a standard diet or apples in addition to the same diet. LPL and HL activities [Nilsson-Ehle and Ekman (1977) *Artery* 3, 194–209] were expressed as mU/g fresh tissue (1 mU = 1 nmol of free fatty acidmin^{-1}). In parallel, plasma insulin (IRI) was measured by radioimmunoassay and carcass lipid was evaluated gravimetrically. Values are given as means ± SEM of at least 6 determinations.

Inguinal adipose tissue was not detectable at birth, but appeared at 1 d of age. The weight of tissue increased moderately during the early suckling period (10 d) then rose dramatically until weaning. The percentage of carcass lipid was 2% body weight at birth and reached 18% at 21d. LPL activity emerged with the development of the tissue and exhibited 2 peaks: one at 4 d (2 709 ± 435 mU/g fresh tissue), the other at 21 d (1 593 ± 123 mU/g fresh tissue). The lowest activity (406 ± 12) was noted at 10 d after birth. LPL activity in cardiac tissue was doubled from birth (401 ± 10) to 10 d (933 ± 79) then returned to the initial values at weaning (21 d). HL activity was low at birth (40 ± 2) and gradually rose until weaning (303 ± 28). During the first suckling period, changes in LPL activity in adipose tissue were highly correlated ($r = 0.8$, $p < 0.01$) with plasma IRI levels (14.4 ± 2.2 μU/mL at birth, 40.4 ± 3.1 at 4 d, 25.9 ± 3.1 at 10 d). All the examined parameters, except plasma IRI, were significantly lower during the first days of life in hamsters born to mothers fed the apple-enriched diet (LPL: –40% in adipose tissue and –20% in heart; HL: –20%, carcass lipid: –30%).

In conclusion, hamsters are characterized by the absence of white adipose tissue and by relatively high level of plasma IRI at birth. Moreover, LPL and HL activities increased during early life period and are lowered when the mother is fed the apple-enriched diet.

Reduction of turkey plasma cholesterol by dietary copper supplementation. GM Pesti, RI Bakalli, WL Ragland (*Departments of Poultry Science and Avian Medicine, University of Georgia, Athens, GA 30602-2772, USA*)

It is well established that rats fed diets deficient in copper exhibit hypercholesterolemia and elevated liver copper levels [Klevy (1976) *Am J Clin Nutr* 26, 1060–1068; Petering *et al* (1987) *J Agric Food Chem* 25, 1105–1109; Murthy and Petering (1976) *J Agric Food Chem* 24, 808–811]. Liver Cu is believed to regulate cholesterol biosynthesis by reducing hepatic glutathione levels [Kim *et al* (1992) *FASEB J* 6,2467-2471]. Glutathione stimulates the enzyme 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase in rats,

Table I. (GM Pesti *et al*)

Cu (mg/kg)	*Gain* (g)*	*FCR** (g/g)*	*Plasma*	
			Cu (ppm)	*Cholesterol (mg/dL)*
0	376	1.39	22.5	107
63	384	1.30	24.0	109
125	344	1.36	30.5	87
250	375	1.32	37.7	82

* Body weight gain, ** FCR = feed conversion ratio (g intake/g gained).

the rate-limiting step of mevalonate and ultimately, cholesterol biosynthesis, accounting for Cu's effect on cholesterol levels in the rat [Valsala and Krump (1987) *J Biosci* 12, 137–142].

In a recent report, we presented data confirming the hypothesis that dietary Cu is inversely related to plasma and muscle cholesterol levels in the chicken [Bakalli *et al* (1994) *Poult Sci* 73 (Suppl 1) (in press)]. This inverse relationship exists in chickens fed nutritionally adequate amounts of Cu. Plasma and breast muscle cholesterol and plasma triglycerides and reduced glutathion (GSH) were inversely related to dietary Cu supplements. The duration of Cu supplementation was also inversely related to tissue cholesterol contents. Cholesterol in the edible muscle of broiler chickens was reduced by about 25% without altering the chicken's performance or substantially increasing the Cu content of the meat. The present experiment was conducted to see if the turkey's response is similar to the chickens'.

The experiment was conducted with female poults in wire-floored battery brooders for 21 d. The basal diet was based on maize and soyabean meal and was formulated to meet all National Research Council (1984) nutrient level recommendations including Cu (8 ppm). Cu supplementation was from feed grade cupric sulfate pentahydrate or cupric carbonate (basic). No significant differences due to Cu source were observed, and only main effects are presented.

Significant effects were found for dietary Cu on gain and plasma copper and cholesterol levels. It appears that the turkey poult responds much like the broiler chick to dietary. Cu supplements in large excesses of the nutritional requirements.

The levels of dietary Cu that reduce cholesterol in the birds are often fed as growth promotants and mold inhibitors. Thus, we suspect that the poultry meat supplies are very variable in their cholesterol contents. Dietary Cu supplements in excess of what is nutritionally adequate may provide a safe and economical way to lower dietary cholesterol intakes.

Heat-induced changes in lipid metabolism in broilers. H Aïn Baziz[1], PA Geraert[2], JCF Padilha[3], S Guillaumin[2] ([1] *Institut Technique des Petits Élevages, Algiers, Algeria;* [2] *INRA, Recherches Avicoles, 37380 Nouzilly, France;* [3] *CNPq–Universidade Federal Santa Catarina, 88049 Florianópolis, Brazil*)

In broilers, the first consequence of heat exposure is a reduction of feed intake resulting in a reduction in metabolic heat production and thus maintaining homeothermy. However, even when compared to pair-fed birds exposed to thermoneutrality, heat-exposed chickens exhibited a lower growth [Geraert *et al* (1993) *Proc Nutr Soc*, 52, 165A] and an enhanced fatness [Aïn Baziz *et al* (1993) Proc 11th European Symposium on the Quality of Poultry Meat, NPSA, vol 1, 52-58].

The present study was performed in order to analyze the adipose tissues affected by chronic heat exposure: abdominal, sub-cutaneous, inter- or intramuscular and their lipid and fatty acid compositions. The objective was also to determine the origin of the divergence in fatness as changes in lipogenic or lipolytic activities.

The experimental model was based on 3 treatments: TA22 (22°C, *ad libitum* feeding), TA32 (32°C, *ad libitum* feeding) and TR22 (22°C, pair-feeding on the heat-exposed TA32 birds), 36 chickens per treatment. Ambient temperature was kept constant between 4 and 6 weeks of age.

At 6 weeks of age, TA32 chickens had a lower weight gain (–41%) compared to TA22 and –22% when compared with pair-fed birds. Heat-exposed chickens were also fatter; the abdominal to body-weight ratio reached 3.28% in TA32, 2.85% in TA22 and 1.86% in TR22. The dissection of adipose tissues from the leg revealed increased subcutaneous and intermuscular tissues in heat-exposed birds while intramuscular depot remained unchanged.

Lipid content of abdominal fat was not different between TA22 and TA32 but it was significantly decreased in the restricted-fed group (TR22). Fatty-acid profiles were modified under heat exposure. While saturated fatty-acid proportions, particularly palmitic acid (C16:0) were increased, unsaturated fatty acid in per cent of total fatty acids were decreased, especially oleic (C18:1) and linoleic (C18:2) acids. Such changes would suggest a decrease in hepatic desaturase activity in heat-exposed broilers. While plasma triglyceride concentrations were little affected by hot conditions, plasma-free fatty-acid contents were significantly reduced in either fasted or fed TAF32 birds compared to control-exposed chickens. The enhanced fatness observed under hot conditions would thus be due more to a reduction in lipolysis than to an increase in lipogenesis.