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Metabolomic approach using NMR to study the regulation of energy metabolism on chicken lines divergently selected for low or high abdominal fat deposition

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The feed cost represents about 60% of total cost in broiler production. In a context of high prices for raw materials used in animal feed, it is therefore necessary to optimize feed efficacy and particularly the use of dietary energy. For monogastric animals, feed energy is mainly provided by cereals presenting high starch content and oil. The aim of this study was to analyze how broilers can adapt their energy metabolism according to dietary energy source.

For that purpose, we reared 48 chickens issued from two lines divergently selected on the abdominal fat content (3.4 and 1.3% relative to body weight for FL and LL lines, respectively) and fed from 3 to 9 weeks of age with two different diets, HF and LF containing 80 and 20 g of lipids/kg of feed, and 379 and 514 g of starch/kg of feed, respectively. Both diets were isoproteic (190 g crude proteins/kg of feed) and isoenergetic (3000 kcal metabolisable energy/kg of feed). At 9 weeks of age, blood samples were collected on heparin from all chickens, 3 hours after feed distribution in order to analyze plasma metabolites.

A metabolomic approach using the 1D ¹H NMR experiments was recorded on a Bruker Avance 500 spectrometer with a cryoprobe. NOESY 1D NMR sequence including water presaturation was used to obtain plasma metabolic profiles. After identifying metabolites, a statistical approach was applied on data for metabolites discrimination. The statistic tests included univariate (ANOVA, BoxPlot) and multivariate analysis (PCA, PLS-DA) using the free R software and SIMCA P+ (Umetrics®), respectively.

The multivariate analysis allowed discriminating the four groups. Among the 38 identified metabolites, six had the main effects: glutamine, histidine, betaine, lipids, methionine and low density lipoproteins (LDL). FL chickens had lower plasma levels of glutamine and histidine but higher plasma levels of betaine, methionine and lipids than LL chickens. These data confirmed the highest ability of FL chickens to synthesize lipids and to use glucogenic amino acids (AA) for this metabolism thus increasing the plasma level of lipids for a further deposition in peripheral adipose and muscle tissues and decreasing the plasma pool of free glutamine and histidine. Chickens fed with HF diet had higher plasma levels of lipids, glutamine, methionine and betaine and lower plasma level of LDL than chickens fed with LF diet. The circulating lipids were mainly provided by HF diet and were directly deposited in peripheral adipose and muscle tissues with a low return towards the liver explaining the low level of plasma LDL. With HF diet, chickens decreased the hepatic use of glucogenic AA which level then remained high in plasma.

The more interesting was the effect of line and diet on the plasma levels of methyl donors (methionine and betaine) suggesting the implication of methionine and folate metabolisms in the control of hepatic lipid synthesis.

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