K-12-01

Muscle quality issues explained by metabolomics (#661)

Gavin Boerboom, Theo van Kempen, Alberto Navarro-Villa, Adriano Pérez-Bonilla

Ingredient Research Centre, Researcher Feed Additives, Boxmeer, Netherlands

Short Abstract

Biological problems are usually solved using the traditional cycle of knowledge. This cycle starts with preconceived notions about a problem, which leads to experiments being designed to test a hypothesis. If insufficient information is available, the traditional hypothetico-deductive approach to solve an issue is not a viable option. In this case, the inductive approach can be used. With the inductive approach the strategy should be to generate data that can be used to generate a hypothesis. Metabolomics is a great example of an inductive approach. Metabolomics is a method that gives a molecular fingerprint, which is the downstream result of gene transcription and post-translational protein modification in a cell, tissue, or whole organism in a particular physiological state. Their levels can therefore be regarded as the ultimate response of the biological system to genetic and environmental changes. Metabolomics was used to study the underlying etiology of the muscle defect white striping. The exact etiology was unknown with many hypothesis already tested, which made it a great case for the use of metabolomics. Untargeted metabolomics was used which enables to study as many metabolites as possible, yielding in total 599 metabolites. Results showed a reduction in the concentration of carnitine esters involved in transfer of long-chain fatty acids from the cytoplasm to the mitochondria in WS affected muscles ($P<0.01$). This was associated with an increase in fatty acid intermediates, which can act as detergents on the cell membrane. Levels of cis-5-tetradecanoyl-carnitine especially back-up this theory since this is used as a marker for beta-oxidation defects and show a 4-fold increase in WS cases ($P<0.01$). Likely, mitochondrial -oxidation was inhibited, while less oxygen sensitive peroxisomal -oxidation continued. With regards to the arginine metabolism, citrulline levels were increased and arginine levels decreased, likely indicating an increased production of nitric oxide. The latter is generally used by broilers to enhance blood flow to the muscle. The TCA cycle showed opposing directionality, known as the backflux. This enables the TCA cycle to produce high-energy phosphates in a low oxygen state. Taurine increased 2-fold in WS affected tissue, which has a protective role in hypoxic conditions due to stabilization of the sarcolemma as well as controlling internal calcium levels. Indications of swelling were found with both organic and inorganic osmolytes concentrations increasing in WS affected tissues. WS was mainly associated with hypoxic conditions. A study in Ross 308 broilers was designed to test solutions that were based on the metabolomics results. The results showed that the greatest improvement in meat quality were associated with treatments focusing on improving mineral homeostasis, modulation of energy metabolism, antioxidant status, vasodilatation and/or enhancing muscular tone. These led to reductions in the percentage of severe WS fillets that could be up to 60% in comparison to the control treatment. The results of this research indicates that metabolomics is a useful tool to gain knowledge, better understand and generate solutions for problems with an unclear origin.

Notes