Plenary 5: Body Weight Regulation

Dietary protein and energy interrelationships and other strategies to control body composition of animals

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Introduction – Body composition has a major influence on the productivity of farm livestock, the health of companion animals and the survival of animals during migration, hibernation and aestivation. This paper will highlight the strategies, used to improve body composition of livestock.

Dietary Strategies – Emphasis in livestock production is to select genetically superior animals that have a high accretion of lean tissue deposition and hence feed conversion efficiency (1). Selection studies with both pigs and chickens have advanced our understanding of the complex relationship between fat and lean deposition, feed intake, growth efficiency, nutrient requirements and genotype. Genetic strategies are only successful when coupled with appropriate nutrition, especially protein (amino acids) and energy intake. The relationship between dietary protein supply and lean tissue deposition is linear up to the point at which protein deposition is maximized provided dietary energy is not limiting (2). After this point additional feed intake will result in rapid fat deposition. Dietary amino acid balance, which should reflect the protein being deposited, is critical to optimising lean tissue deposition (3). In addition to major nutrients a number of dietary additives have also been shown to modulate body composition, particularly the deposition of fat (4). These include conjugated linoleic acid, magnesium, selenium, vitamin E, chromium, betaine and vitamin A. It has also been shown that the inclusion of dietary n-3 PUFAs can be used to manipulate metabolism and carcass composition in man, rodents and poultry (5).

Novel Strategies – Efforts to control fat and lean deposition in animals has largely been focused on post absorptive mechanisms that control nutrient partitioning (6). Somatotropin (growth hormone; GH) alters nutrient use to improve growth rate and feed conversion. Recombinant GH has been shown to produce leaner pork, increase growth rate and feed efficiency provided additional protein is fed to pigs. The administration of GH must be by repeated injection and this form of administration may be inappropriate for large scale applications. The use of ß-adrenergic agonists, such as ractopamine, which are chemically and pharmacologically similar to natural catecholamine, have profound effects on skeletal muscle growth and fat deposition. These agents bind to the ß-adrenergic receptor and initiate metabolic effects that result in nutrient repartitioning in tissues. They have been shown to stimulate metabolic rate, reduce fat deposition and increase protein deposition. Immunisation against adipocyte plasma membranes to reduce fat deposition resulted in varied response in a range of animals. The immunisation procedure was most successful in the rat and the pig, resulting in a consistent reduction in adipocyte cell numbers and, for the pig, a significant decrease in backfat thickness. The immunoneutralisation of somatostatin (an inhibitor of somatotropin release) has been used as an alternative approach to the injection of exogenous GH, but results have also been variable. It was hoped that GH transgenesis could be used to enhance productivity in both sheep and pigs after the substantial improvement observed in transgenetic mice. The growth promoting effects and the altered carcass composition produced by GH transgenesis have produced a number of severe and detrimental side effects in pigs and mice, though more recent constructs deliver more controlled growth stimuli. Genetic polymorphisms in or near the growth hormone gene also subtly influence growth.

Other Animal Observations and Implications – In contrast to farm livestock, cats, dogs and horses are experiencing an obesity epidemic accompanied by increased insulin resistance and associated diseases, that mirrors their owners. Interestingly, in a lifetime study with Labradors (7), it has been demonstrated that a dietary restriction (25%) increased longevity and reduced the incidence diseases associated with aging compared to ad libitum fed litter mates. Adaptation in native animals including migration, hibernation and aestivation (8), that involve substantial metabolic changes, may, if completely understood, have implications for management of body composition and weight control. Is there a role for foetal programming? Ongoing research in growth and development and adaptive metabolic phenomena in concert with advances in molecular biology may provide insights into modulation of nutrient partitioning and body composition to the benefit of the host and society.

References

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