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Overview of the Importance of Leptin as a Signaling Protein in Farm Animals

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Abstract

Leptin is a protein secreted by fat cell and shown to be involved in the regulation of feed intake, metabolism, growth and energy expenditure in farm animals. Apart from its role as a hunger signal, leptin also serves as a metabolic signal interacting with neuro-peptides thereby linking energy status with neuro-hormonal pathways. There are reports of other function of leptin such as its direct role in modulating ovarian activity and its metabolic functions at the onset of puberty and resumption of post-partum reproductive functions.

Keywords: Leptin, feed intake, energy expenditure, growth, reproduction

Introduction

This recently discovered protein Leptin is secreted primarily from adipose tissue and is involved in the regulation of feed intake, metabolism, growth and energy balance in most animals (Barb *et al.*, 2001a). It consists of 146 amino acid molecules and is secreted into the peripheral circulation after cleavage of the 21 amino acid signal peptide. It serves as a metabolic signal as it acts on the hypothalamic-pituitary-ovarian pathway to enhance the release of gonadotrophin releasing hormone (GnRH) and luteinizing hormone to ultimately improve ovarian functions (Barb *et al.*, 2004). Administration of leptin in fasted swine inhibit feed intake bringing about a reduced blood sugar and insulin concentration with an elevation in the plasma fatty acid. It may also regulate appetite, energy metabolism, body composition and reproduction in farm animals (Barb *et al.*, 2001a).

Figure 1 shows a diagram of the major functions of leptin in farm animals and serves as the basis of this overview of what is presently known about the biological role of leptin in farm animal.

Effect of Leptin on Feed Intake and Peripheral Metabolism

The discovery of leptin has increased our scope of understanding and relationships between the fat cells, energy balance, feed intake, growth, metabolism and immune functions in domestic animal species. Leptin has the ability to inhibit feed intake in swine, chicken and fish with no effect on ruminants (Benbow *et al.*, 2000; Volkof *et al.*, 2001). More so, protein synthesis was inhibited by leptin in muscles from rats in contrast to embryonic chick muscles where it caused a stimulatory effect. Its action on carbohydrates will reduce the metabolism of glucose by fat cells probably sparing glucose utilization by other tissues. Leptin stimulates oxygen consumption in rabbits which is associated with increased triglyceride as a result of lipolysis and fatty acid oxidation. Thus, the net result of the metabolic activity of leptin is growth which can be achieved by either cell replication or hypertrophy. Indeed, the compound is believed to contribute to the maintenance of body mass by altering feed intake and energy expenditure (Flier, 1999).

Relationship of Leptin and Growth

Leptin has been reported to affect the growth of a number of tissues. In swine, it increases linear growth which is as a result of proliferation, hypertrophy and calcification of growth plate (Litten *et al.*, 2005). This goes to suggest that leptin might have roles in cartilage and bone growth and also in bone remodeling in domestic animals. Leptin has been demonstrated to stimulate femoral growth in mice through peritoneal injection despite its reduced effect on feed intake.

At physiological concentration, it has been shown to affect hematopoiesis, pro-inflammatory and immune responses in mice, rats and humans. In poultry, it has been shown to stimulate T-lymphocyte proliferations and in quails caused an increase in wing web thickness which is a landmark for perivascular accumulation of T-cells. Leptin has been reported to be elevated within wounds during healing process although its role in wound repair and its function in immune response within the damaged tissue is still subject of controversy (Gainsford and Alexander, 1999; Matarese *et al.*, 2005). It has also been established that it promotes the proliferation of smooth muscle cells which is a critical component of the vascular endothelial cell structure. More so, Leptin may promote early maturation of small intestine causing a shift from fetal-type enterocyte to adult-type enterocyte. Gastric

infusion of leptin increases the length of the small intestine in milk formula fed neonatal swine (Wolinski *et al.*, 2003).

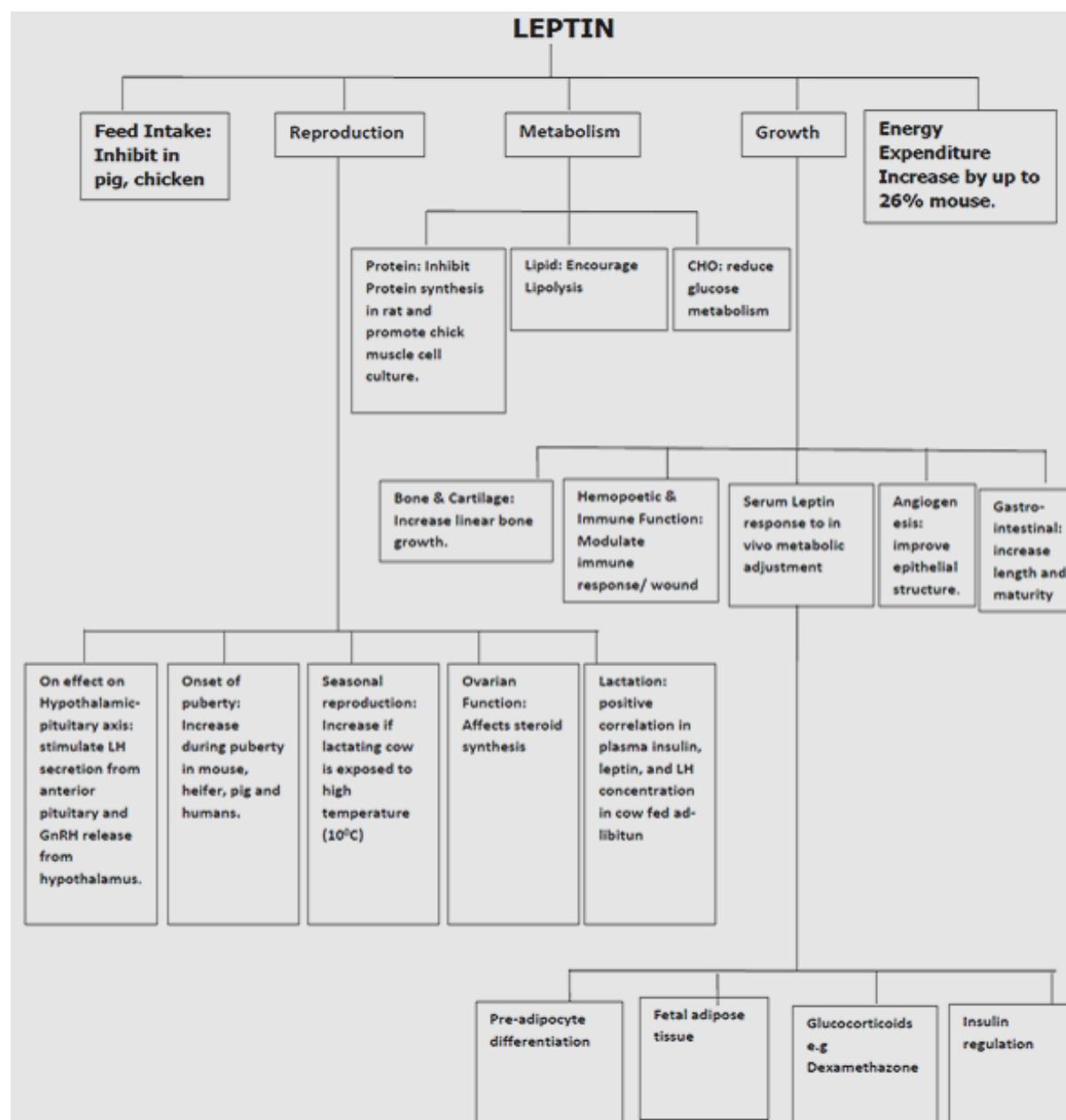


Fig. I: The major functions of leptin in farm animals

Effect of Leptin on Reproduction

In pig, leptin treatment stimulates luteinizing hormone secretion from anterior pituitary and the release of GnRH from the hypothalamus. Its concentration increases during puberty in mouse, heifer and pig. In lactating sows, a positive correlation was observed among plasma insulin and leptin when fed ad-libitum and cows with decreased leptin levels exhibit delayed onset of reproductive function post-partum. Leptin concentration have been reported to encourage steroid synthesis and in lactating cow, leptin concentration increases when exposed to higher temperature and long day length (Dyer *et al.*, 1997; Lin *et al.*, 2000). Metabolic disturbances may alter endocrine functions, thereby delaying onset of puberty and also interfering with normal estrous cycles in farm animals (Barb *et al.*, 1997). Thus, leptin may serve as an important link between metabolic status and the neuroendocrine function and subsequent reproductive function. Overall, leptin may influence gonadotropin secretion and subsequent ovarian function via interaction with other neuronal systems (Figure II).

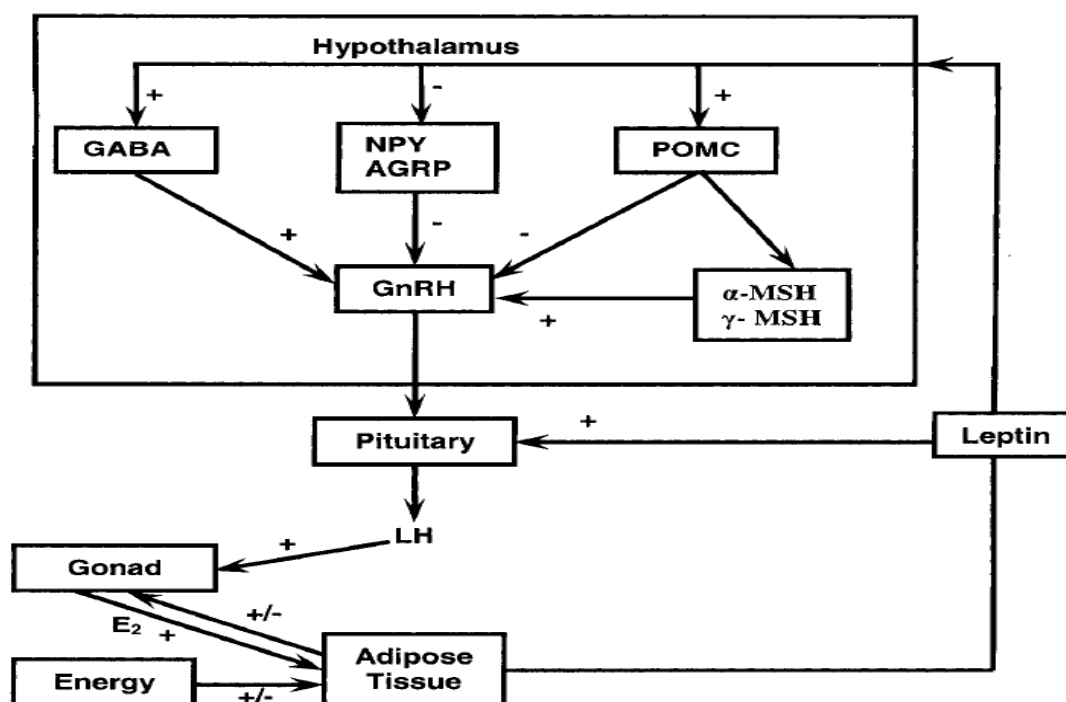


Fig. II: A schematic representation of the role of leptin in reproduction (Source; Barb *et al.*, 2006)

Leptin Secretion

Body weight changes especially due to nutritional plane and are characterized by alterations in several serum hormone and growth factors levels such as insulin, glucocorticoids, GH and insulin-like substance to regulate adipocyte function and development (Barb *et al.*, 2001). According to Saladine *et al.* (1995), administration of glucocorticoids or insulin increases leptin gene expression, demonstrating that other hormonal factors may mediate nutritionally-induced changes in leptin gene expression. Thus, leptin may serve as a metabolic signal which communicates metabolic status to the brain; the neuroendocrine response to acute energy deprivation may be species dependent and/or age dependent (Barb *et al.*, 2006)

Conclusion

Apart from its major roles in energy balance and hunger signal, leptin has been shown to also act as a metabolic gate during the onset of puberty and during the resumption of post-partum reproductive function. It also plays a direct role in modulating ovarian activity.

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