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2nd stage
Animal nutrition

Feed standard for growth

Nutritional Requirements for Postnatal Growth of Animals

Rapid growth of skeletal muscle, mainly protein accretion, is economically important for livestock, poultry, and fish industries worldwide. The balance between the rates of protein synthesis and degradation is the determinant of tissue growth. Therefore, over the past 50 years, extensive research has focused on the regulation of intracellular protein turnover in skeletal muscle . The maximal growth rate of animal tissues depends on both genetic and environmental factors. An animal can fully express its genetic potential only when its requirements for energy and all nutrients (e.g., AAs, fatty acids, carbohydrates, minerals, and vitamins) are met.

Components of Animal Growth

The general sigmoid curve of animal growth, expressed as increases in absolute body or tissue weight with age, is shown in Figure (1). This curve consists of four phases: lag, log or exponential, maturity, and stationary. In farm animals, the head and extremities develop early, and the hindquarters and loin region develop very late during the growing finishing period. The patterns of accretion of protein and fat in animals vary with species and developmental stages. However, as age advances, weight gain generally consists of an increasing percentage of fat and a decreasing percentage of water (ARC 1981; NRC 2001, 2011, 2012). In contrast, the percentage of protein in the body generally increases gradually after birth until animals reach sexual maturity..

Nutritional Requirements for Maintenance and Production

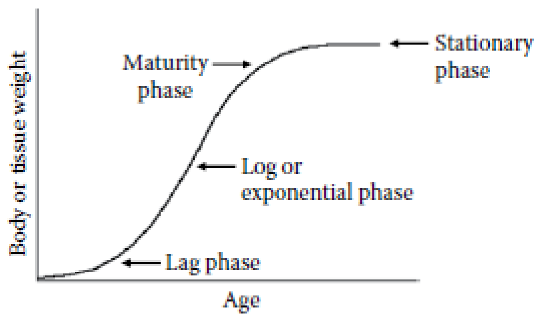

FIGURE (1): The general curve describing animal growth over time (age). This sigmoid curve consists of lag, log, or exponential, maturity, and stationary phases.

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In fully mature animals, excess energy is stored almost entirely as fats, and only a relatively small amount of proteins may be deposited as a cellular component of white adipocytes, muscle ,fibers, hair, and keratinized cells of skin.

An increase in BW is the most common measure of growth due to its simplicity. However, the growth of any animal is characterized by increases in the weight of its muscles, white adipose tissue, bones, and internal organs that are associated with the enhanced accretion of protein, minerals, water, and fats. Since the deposition of 1 g protein in the body is associated with the retention of 3 g water , a net synthesis of 1 g protein in tissues (primarily skeletal muscle, which is 40%–45% of the BW) results in a weight gain of 4 g. Rapid muscle protein accretion leads to fast animal growth. For example, young animals have a higher rate of net protein synthesis and therefore a higher rate of growth than older ones. However, the opposite may not always hold true. This is because weight gain may not necessarily result from lean tissue growth and rather may simply be caused primarily by fat accumulation in the body.

As a hydrophobic molecule, triacylglycerol (TAG, fat) is deposited in the animal body free of water. Although fat may be deposited in various tissues, it is stored mainly in the subcutaneous white adipose tissue, abdominal cavity, and connective tissue. A certain amount of fat among muscle fibers within skeletal muscle (called marbling fat) confers a good taste to meats eaten by consumers. As more fat is accumulated in animals than protein, water content in the body decreases. Thus, in ruminants and pigs, water content is generally 75%–80% at birth but decreases to 45%–50% at their market weights. The expansion of fats during the finishing period results primarily from an increase in the size of white adipocytes.

Despite concern over adverse effects of overweight or obesity on health, animals require fats for normal physiological function. For example, although obesity increases the risk for infertility in both males and females, an adequate amount of body fat is necessary for reproduction, such as the pulsatile gonadotropic hormone (GnRH) release. This can be explained by the facts that:

(1) leptin secretion from white adipose tissue is necessary for attainment of puberty.

(2) testosterone, estradiol, progesterone, and all other steroid hormones are synthesized from cholesterol, which is a lipid synthesized from fatty acids.

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Absolute versus Relative Rate of Animal Growth

The absolute growth rate refers to the amount of weight gain per unit of time (e.g., g/day). The relative growth rate of animals is commonly expressed in terms of changes in BW within a given period of time (e.g., %/day).

Important Roles of Dietary Protein and AAs in Animal Nutrition

1. Metabolic and hormone profiles

a. Maintaining optimal concentrations of AAs and proteins (including albumin) in plasma

b. Maintaining endocrine balance, as well as optimal concentrations of insulin, growth hormone, IGF-I(resemble insulin), and thyroid hormones in plasma

c. Maintaining optimal anti-oxidative reactions; reducing oxidative stress

d. Maintaining optimal synthesis of neurotransmitters

e. Reducing excess deposition of white adipose tissue

f. Maintaining optimal whole-body energy expenditure

2. Nutrient absorption and transport

a. Promoting intestinal absorption of nutrients, including vitamins, minerals, AAs, glucose, and fatty acids

b. Promoting the transport of vitamins, minerals, and long-chain fatty acids in blood and among various tissues

c. Helping to store vitamins and minerals in cells

3. Protein synthesis and growth

a. Promoting protein synthesis and increasing proteolysis in skeletal muscle and whole body

b. Preventing growth stunting of the young; improving development (including cognitive development) of the young

c. Preventing intrauterine growth restriction and its lifelong negative consequences on postnatal growth, metabolism, and health (e.g., increasing risk for obesity, infection, and cardiovascular abnormalities)

d. Increasing skeletal muscle mass; maintaining physical strengths

e. Enhancing feed efficiency

4. Organ structure

a. Preventing cardiac structural abnormalities

b. Preventing the loss of calcium and bones, and dental abnormalities

c. Preventing hair breakage and loss; maintaining optimal production of pigment; maintaining normal hair structure and appearance

d. Preventing pale skin, dry or ,flaking skin, and skin atrophy

e. Maintaining optimal immune responses; reducing risk for, and mortality of, infectious diseases

5. Health and reproduction

a. Improving cardiovascular function; preventing hypertension or hypotension; reducing risks for headache and fainting

b. Preventing excess fluid retention in tissues; preventing peripheral and periorbital edema (particularly swelling in the abdomen, leg, hands, and feet)

c. Preventing emotional disorders (e.g., moodiness, severe depression, and anxiety), irritability, and insomnia

d. Preventing a loss of libido; improving fertility (including spermatogenesis in males and conception in females); reducing embryonic loss; enhancing pregnancy outcomes

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The absolute rates of whole body growth in animals increase, but the relative rates .of their whole body growth decrease, as they approach sexual maturity. However, the absolute or relative rates of fat and protein depositions in the body may not necessarily follow the pattern of growth for the whole body. A combination of feed efficiency, animal price, and meat yield determines the market weight of farm animals. Thus, animals are sold to the market at a heavier BW than usual, when their numbers are lower due to disease outbreak or other causes, so that more meat can be produced per animal at the expense of a reduced efficiency of nutrient utilization.

Regulation of Animal Growth by Anabolic Agents

many hormones play an important role in animal growth primarily by regulating skeletal muscle protein synthesis and catabolism. A net increase in tissue protein synthesis (i.e., the rate of protein synthesis is greater than the rate of protein degradation) results in weight gain. Insulin, growth hormone, and insulin-like growth factor-I are anabolic hormones. Interestingly, tissue sensitivity to hormones decreases with advancing age in animals and humans. Thus, the frequency of feeding can affect the pulse of these hormones and other anabolic nutrients in plasma.

This concept can have important implications for improving the efficiency of feed utilization and reducing the costs of animal production. The higher the rate of gain in BW, the shorter the time required for the animal to reach a slaughter weight or full productive performance, and the smaller the proportion of feed used for maintenance. Insulin resistance often occurs in aging animals and in gestating dams during the last trimester of gestation, which leads to their mobilization of fats and a reduction in protein synthesis.

Growth-promoting agents can improve the efficiency of meat production and produce leaner meat. These agents are of two major types in ruminants and nonruminants: (1) hormone-like substances e.g., β-agonists (2) antibiotic-like substances. They also reduce white adipose tissue in the body and enhance the growth of the animals through different mechanisms

Critical Role of Dietary Amino Acid Intake in Animal Growth

Amino Acids (AAs) are the building blocks of protein. As indicated previously, changes in the abundance of skeletal muscle account for most animal growth. Since protein is the most abundant component of DM in muscle, and since AAs are the constituents of protein, dietary AA intake plays a critical role in influencing the growth, feed efficiency, and health of all animals. Dietary protein or AA intake is of great importance for animal producers on the basis of both biological and economic considerations. The efficiency of utilization of dietary energy, fat, and carbohydrates depends on the quantity and quality of dietary protein. Beef cattle are known for their low rate of conversion of dietary protein into body protein, and the efficiency of grazing cattle is only 1/2 that of high-producing dairy cows. Depending on the species, the efficiency of dietary protein used for tissue protein deposition is about 70%–75% in milk-fed neonates and 40%–45% in animals approaching a market weight and consuming corn- and soybean meal-based diets. Thus, sufficient knowledge of protein metabolism and requirements of growing animals (especially ruminants) will increase the efficiency of feed utilization and prevent the waste of energy and AAs.

Classic feeding trials involving several levels of dietary protein or AAs are required to determine total protein requirements for animal growth. The measured endpoints are usually nitrogen retention and weight gain. When energy is insufficient, nitrogen balance may become negative even if sufficient protein is fed. This necessitates adequate provision of dietary lipids, carbohydrates, vitamins, and minerals, as well as drinking water, when studies of nitrogen balance or growth trials are conducted. On the other hand, an excess of dietary protein or AA intake is wasteful, and feeding a surplus of protein or AAs may not increase the protein content of the tissue accounting for live-weight gain and may result in negative impacts on animal health and the environment.

Recommendations of dietary NEAA requirements for animals should depend on expected rates of growth, optimal reproduction, optimal health and, in the case of livestock, poultry and _sh, production performance and feed efficiency. Recent advances in the analysis of all proteinogenic AAs in food and animal-tissue proteins have made it possible to determine dietary.

intakes of these AAs by animals. optimal ratios of AAs (formerly known as ideal AA patterns) in typical corn- and soybean meal-based diets for pigs and chickens at various phases of growth and production. These recommended values are based on the true ileal digestibilities for dietary AA and can be readily converted to percentages of total AA in the diet (g/100 g diet).