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Effect of dietary intake on somatotrophic axis–related gene expression and endocrine profile in Osmanabadi goats

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ABSTRACT

This study was conducted to establish the effect of different dietary intake levels on the somatotrophic axis–related gene expression and endocrine profile in Osmanabadi goats. The study was conducted in 12 Osmanabadi goats, 6-8 months of age, for a period of 2 months during the summer season (April-May). The animals were randomly divided into 2 groups based on body weight: GI (n = 6; *ad libitum* feeding) and GII (n = 6; 40% less of ad libitum). The goats were fed with feed consisting of 50% roughage and 50% concentrate. Blood collection was done at fortnightly interval. Body weight, plasma growth hormone (GH), insulin-like growth factor 1 (IGF-1), and leptin were evaluated at fortnightly intervals. At the end of study period, all the 12 animals were slaughtered and different organs were collected for histopathological studies, as well as relative gene expression studies. The targeted gene expressions were GH, growth hormone receptor (GHR), leptin, and IGF-1. Results showed that body weight ($P < 0.01$), IGF-1 ($P < 0.01$), and leptin ($P < 0.05$) concentration was significantly lower in GII as compared to GI. However, plasma GH was significantly ($P < 0.01$) higher in GII as compared to GI. Hypothalamus GH and leptin mRNA transcript expression showed the opposite trend between the groups. Furthermore, pituitary GH mRNA transcript expression was found to be higher in GII (1.3 fold) as compared to GI (1 fold) goats. In addition, the corresponding GHR mRNA transcript expression in liver samples was also found to be higher in GII (7.9 fold) as compared to GI (1 fold) goats. Hepatic damage and burden on the liver to cope with the nutritional insufficiency in GII group showed that nutritional stress induced in this study caused changes at the cellular level. The significantly higher plasma GH and lower IGF-1 and leptin level in GII as compared to GI demonstrates that the GII goats were under severe nutritional stress. This study also established the effect of nutritional stress on GH expression in pituitary and GHR gene expression in liver, and these findings may be useful for assessing the impact of nutritional stress in goats.

Introduction

The role of livestock in rural communities is changing rapidly. Goats play a vital role in the livelihoods of small-scale farmers in developing countries (Kumar, 2007). Goats are found in many climatic regions of the world ranging from the arctic cold, temperate, deserts and mountains to subtropical and tropical dry and humid zones. The productivity of goats under the prevailing traditional production system is very low (Singh & Kumar, 2007; Celi et al., 2008) because they are maintained on natural vegetation on degraded common grazing lands, with tree lopping. Even these degraded grazing resources are shrinking continuously as a result of climate change. Hence, research that may identify goat breeds that can withstand low pasture availability is desirable.

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Energy homeostasis is controlled by a complex regulatory system of molecules that affects food intake and maintains a stable body weight (BW). The somatotrophic (growth hormone [GH]; growth hormone receptor [GHR]; insulin-like growth factor 1 [IGF-I]) axis is considered to be one of the most important among them, because of their broad range of effects and central role in growth (Katoh et al., 2007). A well-known cellular effect of GH is the enhanced biosynthesis of IGF1 in the liver (Katoh and Obara, 2001; Saleri et al., 2005). Like GH, IGF1 is also an important polypeptide growth factor and most of it is produced by the liver (Katoh et al., 2004). In addition, IGF1 also plays key roles in cellular transformation, organ regeneration, immune function, development of the musculoskeletal system, and aging. Furthermore, ghrelin is considered an important local hormone to control growth and has a potent orexigenic effect in both animals and humans. This effect is mediated through hypothalamic neuropeptide Y and agouti-related peptide (Dimaraki and Jaffe, 2006).

The expression and secretion of leptin are associated with body fat mass and are affected by alterations in feed intake (Zieba et al., 2005). Food deprivation results in a decline in the circulating leptin, and if untreated, results in a cessation of reproduction in animals (León et al., 2004; Hyder et al., 2013). Leptin stimulates the somatotrophic axis especially in nutritionally stressed animals (Zieba et al., 2005). The leptin gene expression in relevant tissues is considered to be an indirect indicator of nutritional status of the animal (Hyder et al., 2013) and may be useful in welfare measures. Animals have characteristic physiological ability to survive the nutritional stress by altering their leptin levels which are required for maintaining the physiological normalcy (Zieba et al., 2005).

Current information regarding nutritional requirements of indigenous breeds for optimum production and fertility is limited, mostly extrapolated from developed countries. A basic understanding of nutrition and dietary requirements under local conditions is therefore required before one can consider and adopt possible improvements. As growth-related modulations in goat are also mediated through the biological mechanisms on the functioning of the somatotrophic axis, it is important to understand the underlying molecular and endocrine mechanisms by which growth is regulated. This in turn might pave way for identification of suitable biomarkers from somatotrophic axis for nutritional stress tolerance in goats, which may also help in assessment of welfare. An attempt has been made in this study to observe the influence of different dietary levels on the functions governed by somatotrophic axis in growing Osmanabadi goats. The objective of the study was to establish the effect of induced nutritional stress on the somatotrophic axis–related gene expression and endocrine profile in Osmanabadi goats.

Materials and methods

Location

The experiment was carried out at the ICAR-National Institute of Animal Nutrition and Physiology experimental livestock farm, Bengaluru, India, which is located in Southern Deccan Plateau of the country at longitude 77° 38′E and the latitude of 12° 58′N and at altitude of 920 m above mean sea level. The average annual ambient temperature ranges from 15°C to 36°C. The mean annual relative humidity (RH) ranges from 20% and 85%. The average annual minimum and maximum temperature ranges from 15°C-22°C and 27°C-34°C, respectively. The annual rainfall in this area ranges from 200 to 970 mm with an erratic distribution throughout the year. The average annual RH ranges between 40%-85%. The experiment was carried out during April-May. The temperature and RH variations during the study period (April-May) ranged between 24°C-38°C and 30%-38%, respectively.

Animals

Osmanabadi is a dual purpose (meat and milk) hardy goat breed, which originated in the semiarid areas of central tropical India. The study was conducted in 12 (6-8 months old) Osmanabadi kids weighing between 14 to 18 kg. The animals were housed in a well-ventilated shed in east west orientation with the dimensions of 13 × 9 × 3.1 m for length, width and height, respectively. The area allocated to each animal was 4.2 m^2. The roof of the shed is made up of galvalume sheet with 2 sides of the shed kept open with wire mesh and the floor is made up of concrete. The shed has the stocking density of 36 animals. The shed was maintained under proper hygienic conditions. Prophylactic measures against goat diseases such as goat pox, peste des petits ruminants, enterotoxemia, endoparasitic, and ectoparasitic infestations were carried out as prescribed by the health calendar of the institute to ensure that the animals were in healthy condition throughout the study.

Technical details

The study was conducted for a period of 2 months during summer season (April-May). The animals were randomly divided into 2 groups as GI (n = 6; ad libitum feeding) and GII (n = 6; 40% less of ad libitum). Allocation of animals to each group was carried out to ensure there was no significant difference in average BW between the groups. The animals were fed with feed components of 50% roughage and 50% concentrate. The components of the diet include roughage (Hybrid Napier grass) and concentrate mixture (Maize 36%, wheat bran 37%, soya bean meal 25 kg, mineral mixture 1.5%, and common salt 0.5%). The roughage was provided as dry fodder in chopped form. The diet was supplied as a total mixture of roughage and concentrate according to different proportion for each group. The animals were fed and watered daily on individual basis at 8 hours. The feed intake was calculated on individual animal basis. The individual animal's ad libitum nutrient requirement on DM basis was calculated based on Indian Council of Agricultural Research recommendation (ICAR, 2013) at the rate of 3% BW. All GI goats were fed ad libitum based on this calculation, whereas in GII animals, the feed intake was proportionately reduced by 40% from their individual ad libitum level. This procedure was repeated every week, respectively, for both the groups based on the BW changes to maintain their level of feeding. The animals had ad libitum access to water. Table 1 describes the chemical composition, energy, and nutrient content of the diet provided to the animals. The animals were acclimatized to different feeding proportions as per the groups 15 days before starting the actual experiment. Blood collection for endocrine measures was done fortnightly. At the end of study period, all 12 animals were slaughtered and different organs were collected for histopathological studies as well as relative gene expression studies. The study was conducted after obtaining approval from the Institute Ethical Committee for the feeding and experimental protocol.

Blood collection and plasma separation

Blood samples were collected on day 0, day 15; day 30 and day 45 after feeding at 11 hours using 20-gauge sterile needles and plastic syringes from external jugular vein in tubes with heparin anticoagulant. Plasma was separated from blood by centrifugation at 3,500 rpm at room temperature for 15 minutes. The plasma was then divided into aliquots in microcentrifuge tubes and kept frozen at −20°C till further analysis. Plasma samples were used to determine biochemical and endocrine variables.