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Pre- and post-feeding plasma gastrin-17 and insulin concentrations and feed intake in female goats during different physiological stages

L. Todini [a,*], M. Trabalza-Marinucci [b], A. Malfatti [a], O. Barbato [c], G. Stradaioli [d], C. Cavallucci [b], A. Debenedetti [c]

[a] *Dipartimento di Scienze Ambientali – Sezione di Produzioni Animali, Università di Camerino, Via della Circonvallazione 93/95, 62024 Matelica (MC), Italy*
[b] *Dipartimento di Patologia Diagnostica e Clinica Veterinaria, Università di Perugia, Italy*
[c] *Dipartimento di Scienze Biopatologiche ed Igiene delle Produzioni Animali e Alimentari, Università di Perugia, Italy*
[d] *Dipartimento di Scienze della Produzione Animale, Università di Udine, Italy*

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Abstract

Gastrin (GAS) and insulin (INS) play a significant role in the regulation of feed intake, as well as in the homeorhetic adaptations to different physiological stages, nutrient supply and requirements. The aim of the study was to verify if plasma GAS and INS concentrations in adult does are affected by the physiological state, change in response to the meal and are correlated with feed intake and energy balance. Dry matter intake (DMI) and pre and post-prandial plasma concentrations of gastrin-17 and insulin were recorded in 21 female goats fed hay and different quantities of concentrate (maize grain) twice daily in different physiological states. DMI was lower during the week of oestrous activity, compared to the period of anoestrus – progressively decreasing during pregnancy and increasing during the post-partum period, without significant differences between early and late lactation. Plasma GAS concentrations were significantly affected by physiological status, being higher ($P < 0.05$) during lactation than during pregnancy. Overall plasma GAS concentrations increased ($P < 0.01$) from pre-feeding levels (169 ± 24 pg/ml), to 30 min after feed ingestion (185 ± 29 pg/ml). The increase occurred 10 and 20 min ($P < 0.05$) after feeding, regardless of the diet composition. Both pre- and post-prandial GAS concentrations were related to DMI ($P < 0.001$), but not to the energy intake. Plasma INS on the other hand was not significantly affected by the physiological status. The pre-feeding plasma INS concentration, across all physiological states, was 1.36 ± 0.32 ng/ml and increased ($P < 0.01$) to 1.45 ± 0.38 ng/ml 30 min after feeding. Pre-feeding INS, but not post-prandial INS, increased with increasing proportions of maize in the diet and energy intake ($P < 0.05$). Overall INS was negatively correlated ($P < 0.05$) to DMI. It was concluded that cephalic reflexes are efficient stimula for both GAS and INS release in adult goats fed twice daily. Plasma GAS concentrations were related to hay intake and total DMI, thus with the volume of ingesta and presumably the time spent eating. GAS concentrations were not affected by the type of feed, nor the energy intake or the flux into the abomasum. Pre-feeding plasma INS was mainly dependent on the energy intake, while the post prandial increase was not dependent on the size or quality of the meal, or on the energy intake. Dietary manipulation and feed ingestion can thus affect the circulatory levels of these two main endocrine factors.

Keywords: Goat; Feed intake; Gastrin; Insulin; Physiological state

* Corresponding author. Tel.: +39 0737 403435; fax: +39 0737 403402.
E-mail address: luca.todini@unicam.it (L. Todini).

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1. Introduction

Regulation of feed intake is complex and involves metabolic and hormonal signals, which are in turn influenced by the homeorhetic changes induced by pregnancy and lactation (Illius and Allen, 1994; Forbes, 1995). Gastrin (GAS) and insulin (INS) are among the hormonal factors that play a significant role in the regulation of feed intake (Woods et al., 1979; Liddle, 1994).

The peptidic hormone GAS is mainly secreted by G cells in the gastric antrum and, to a lesser extent, in the duodenum – both in monogastrics (Mulvihill and Debas, 2001) and ruminants (Reinolds et al., 1991). The main biological actions of GAS are the stimulation of gastric acid secretion, mucosal blood flow and parietal cell growth (Mulvihill and Debas, 2001). A suppression in feeding behaviour has been observed in adult sheep within 1–2 min after intravenous injection of both cholecystokinin and gastrin (Ueno and Ohtani, 2002). Secretion of GAS is controlled by the interaction of many chemical (metabolic, endocrine, paracrine, autocrine) and nervous (extrinsic nervous system, enteric nervous system) factors. In monogastric animals the main stimulus is the presence of ingesta in the stomach, and protein breakdown products are particularly efficient (peptones, peptides, aminoacids). Major inhibition of secretion is caused by gastric acidification, a feedback loop involving the increased release of somatostatin by D-cells (Mulvihill and Debas, 2001). Feeding-induced increases in plasma GAS concentration and other gut regulatory peptides are very pronounced in young milk-fed preruminants, as in monogastric species (LeDrean et al., 1997; Lupoli et al., 2001). To the contrary, no, or only very little, variation in GAS release and acid secretion may be observed in adult ruminants fed ad libitum, in which the influx of material into the abomasum is relatively continuous (Hill, 1960; Stangassinger et al., 1992; LeDrean et al., 1997).

The pancreatic hormone INS is a main metabolic signal in the homeorhetic processes which allow the animal to adapt the nutrient partitioning to changes of physiological states and nutrient requirements. Insulin is believed to act as a long-term regulator of feed intake in ruminants. It was the first endocrine signal recognized to act on the central nervous system, reducing feed ingestion (Woods et al., 1979) and potentiating feeding suppression induced by cholecystokinin (Figlewicz et al., 1986). In ruminants Grovum (1995) described a sinusoidal relationship between the INS concentration and feed intake – as higher hormone levels could stimulate intake by lowering the glucose blood concentration. Both feeding and infusion of a volatile fatty acid (VFA) mixture in sheep caused an increase in the circulating INS levels (Matsunaga et al., 1999).

Data concerning plasma GAS concentrations in goats are lacking and those regarding INS are relatively scarce. Moreover, several aspects regarding the regulation of the secretion of these two hormones are still not well elucidated. Nevertheless, their roles in the homeorhetic adaptation to different physiological states, nutrient supplies and requirements are important and their significance as indicators of the energetic metabolism and balance may be particularly so. The objectives of this research were thus to verify if plasma GAS and INS concentrations in adult goats: (i) are affected by the physiological state of the animal; (ii) change in response to the meal; (iii) are correlated with feed intake and energy balance.

2. Materials and methods

2.1. Animals and diet

The study was carried out in Umbria, Central Italy, starting in September (end of summer) until August (mid summer) of the following year. Twenty-one female goats from the local population, aged 2–6 years, weighing 52.9 ± 6.8 kg at the onset of the experiment and with a mean body condition score (BCS) of 2.0 ± 0.2 (on a scale of 0–5) (Santucci et al., 1991) were used.

Trials were conducted during the following periods: two times during the dry period (1 mo before oestrus and the week following oestrus – indicated as D1 and D2, respectively); three periods during pregnancy (13, 17 and 21 wk of gestation – P1, P2 and P3, respectively); two periods during lactation (5 and 13 wk after parturition – L1 and L2, respectively).

Each trial consisted of a 7 d period following a 2-wk adaptation period to both diet and individual housing. The elevated pens (dimensions: $1\,m \times 1.2\,m$) allowed animals to see each other. In the periods between trials, animals were kept together and had free access to native pasture. Before each trial, the goats were allocated to a randomised block design (to prevent carry-over effects from previous treatments) to receive one of the two or three dietary treatments – consisting in different quantities of concentrate (maize grain) (Table 1).

All the animals were fed mixed hay ad libitum and a mineral-vitamin supplement (15 g/head/d) during the entire experimental period. The amount of hay fed exceeded the intake of the previous day proportionately by 15%. When maize was provided, it was given before the hay to ensure that all the concentrate was eaten. Both hay and maize were given in equal parts at 8:30 and 17:30. The composition and metabolizale energy (ME)