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Ghrelin plasma concentration does not covary with energy demand in adult laying hens

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ABSTRACT

The peptide hormone ghrelin is suggested to be involved in food intake regulation in young growing chicken. Whether ghrelin is involved in the regulation of energetic balance associated with laying performance in adult laying hens was studied by use of 4 chicken lines that differ in laying performance and phylogeny (4 lines; 16 hens per line). As housing conditions are also known to affect energy demand, half of the hens per line were housed in single cages and the other half of hens were maintained in a floor housing system. Plasma samples were collected at 17 to 19, 33 to 35, 49 to 51, and 72 wk of age and analyzed with a chicken ghrelin ELISA Kit. From caged hens, individual food consumption and laying performance additionally was recorded. Due to its function in growth and its relationship with ghrelin, also GH plasma concentrations were analyzed. Ghrelin concentrations did not differ between the 4 lines at any of the test periods (all $P > 0.05$). Ghrelin was negatively related to food consumption only in the growing period of the high-performing lines (both $P < 0.0001$). During this phase, floor-housed hens showed greater ghrelin concentrations compared with caged hens ($P < 0.0001$). Our results suggest that in adult layers ghrelin is not involved in regulating energy intake related to laying performance but rather seems to be related to body growth and housing condition before start of lay, the latter possibly due to differences in hens' behavioral activity.

1. Introduction

Ghrelin is a hormone with various physiological functions in both mammals [1,2] and in nonmammalian vertebrates [3]. In the last decades, ghrelin was increasingly studied in domestic fowls, especially in chicken [4–8] but also in other birds [8–13]. This 26-amino acid peptide hormone is predominantly expressed in the proventriculus [14] and one of its main functions is the regulation of feeding and energy balance [3–5,7,8]. In mammals, ghrelin has been described as a hunger signal [2], because it stimulates food intake [15,16] and fasting results in increased ghrelin concentrations [17]. In contrast, in neonatal broiler chickens ghrelin suppresses food intake if it is administrated intracerebroventricularly or injected intravenously (i.v.) [4,5]. However, this effect could not be confirmed in a study with 8-day-old layer chicks [6] in which levels of ghrelin changed with the birds' feeding state possibly indicating that ghrelin may act as hunger signal also in chickens. However, i.v. application of ghrelin did not affect the food intake of chickens in this study. In Japanese quail, food intake was stimulated by i.v. application of small doses of ghrelin but reduced at greater doses [10]. Recent studies in turkeys [12], and coal tit [13] also showed that ghrelin is an anorexigenic hormone in birds. Taken these results together there is evidence that ghrelin reduces food intake at least in juvenile chicken and, thus, may have an opposite function in birds compared with mammals [3,18,19].

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The function of ghrelin in regulating the energy balance in adult laying hens is not clear. Adult layers primarily convert food energy in egg production during laying period [20]. For this reason, we expected a relationship between ghrelin and laying performance. In the present study, we investigated the plasma ghrelin concentration in female birds of four layer lines divergently selected for laying performance. Due to the evidence for an anorexigenic function of ghrelin in birds, we hypothesized (1) that ghrelin concentration in blood will be lower in the high compared with the low performing lines. Moreover, we expected (2) that ghrelin concentrations will be the lowest at the laying peak in all layer lines.

Besides laying performance, housing conditions affect the energy demand of hens. For example, hens kept in free range have a worse food conversion rate, that is, show a greater food consumption per kg eggs produced, compared with hens kept in a cage system, due to the greater behavioral activity required in floor pens compared with cages [21]. Thus, we hypothesized (3) that ghrelin concentrations of laying hens kept in floor housing will be lower than of hens kept in single cages.

An essential hormone for postnatal growth in humans as well as in chickens [22–24] is the growth hormone (GH) which is synthesized in the pituitary gland [22–26]. With increasing age and at the end of the growing period, the level of circulating GH in blood is decreasing [22,27]. Interestingly, ghrelin initially has been identified as a GH-releasing peptide as it stimulates GH secretion in mammals [28] and in chickens [29,30]. Thus, we also analyzed plasma concentrations of GH to analyze the correlation between ghrelin and GH and to obtain a physiological measure for the hens' stage of growth.

The study aims to acquire more knowledge about the relationship between ghrelin and factors associated with the energy demand such as laying intensity and housing condition in adult laying hens.

2. Materials and methods

All experiments were performed in accordance with the German Animal Protection Law and were approved by the Lower Saxony State Office for Consumer Protection and Food Safety (No. 33.9–42,502-05–10A079).

2.1. Animals and housing conditions

In this study, we compared phylogenetically divergent high-performing white (H-white; WLA) and brown (H-brown; BLA) pure bred layer lines taken from a commercial breeding program with low performing white (L-white; R11) and brown layer lines (L-brown; L68) (for details see [31]). The latter are maintained as nonselected conservation flocks at the Friedrich-Loeffler-Institut. All animals hatched at the same day and chickens of each line (H-white: n = 140, H-brown: n = 76, L-white: n = 147, L-brown: n = 153) were raised separately in a floor housing system until 16 wk of age. Rearing compartments (6 m × 4 m) were littered with wood-shavings and straw and were equipped with perches. Food (wk 1–7: 12.97 MJ AME_N/kg DM, 189.61 g/kg crude protein, 31.38 g/kg crude fat, 9.14 g/kg Ca, 6.94 g/kg P; wk 8–16: 12.82 MJ AME_N/kg DM, 151.67 g/kg crude protein, 30.21 g/kg crude fat, 15.83 g/kg Ca, 8.11 g/kg P) (for details see [31]) and water were provided ad libitum. On the first 2 d of life, light was provided for 24 h before it was reduced to 15 h on Day 3. From wk 1, light period was reduced to 9 h in wk 7 by 1 h per wk and maintained until the end of rearing (wk 16 of age).

At 16 wk of age hens of each line (H-white: n = 48, H-brown: n = 47, L-white: n = 48, L-brown: n = 48) were moved to a single-cage housing system (50 cm × 46 cm × 43 cm) equipped with a food trough, 2 drinking nipples, and a perch. In addition, siblings of the same families were kept in 6 floor pens (each 2.0 m × 4.0 m) separated by line (1 × H-white: n = 28, 1 × H-brown: n = 28, 2 × L-white: n = 56, 2 × L-brown: n = 56). Floor pens were littered with wood-shavings and equipped with perches and nests mounted on a slatted floor 0.5 m above the litter area. In both housing systems, animals had ad libitum access to food (11.68 MJ AME_N/kg DM, 168.11 g/kg crude protein, 29.43 g/kg crude fat, 50.05 g/kg Ca, 5.06 g/kg P) (for details see [31]) and water. From 16th to 23rd wk of age, the light period was increased in steps of 30 min from 9 h to 14 h and stayed constant for the rest of laying phase.

2.2. Periods of investigation

All investigations were done during 4 periods:

First period (P1): 17th to 19th wk of age (before start of lay)

Second period (P2): 33rd to 35th wk of age (maximum of egg production)

Third period (P3): 49th to 51st wk of age (decrease in egg production)

Last period (P4): 72nd wk of age (end of experiment)

2.3. Production traits

Laying performance was recorded at individual level in the single cages. For analyses, we calculated the laying intensity by dividing the number of layed eggs per hen within a period of 21 d by the maximum of 21 possible eggs per hen in a period. The laying intensity is expressed by percentage. One H-white hen and one H-brown hen showed an unusual stop of lay at the end of the experiment. Because these 2 hens did not show a salience in any of the other measures, we did not exclude their data. For caged hens, food consumption was individually recorded every wk and averaged for the duration of periods of investigation. The body weight of both, the caged and the floor-housed hens, was taken every 4 wk. Weight gain (WG) for the periods of investigation were calculated from the following weightings:

First weight gain (WG1): 16th and 19th wk

Second weight gain (WG2): 32th and 35nd wk

Third weight gain (WG3): 49th and 52th wk

Last weight gain (WG4): 69th and 72nd wk

The relative weight gain was calculated based on the first weighing of every period.