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Comparison of blood plasma growth hormone levels in young dairy and beef cattle

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ABSTRACT

The characteristics of the growth hormone (GH) secretion pattern in the peripheral blood plasma of young dairy and beef cattle were described. Ten Black and White (BW) and nine Piemontese cattle of both sexes, aged 11 months, were tested. The blood was sampled through catheters at 15-min intervals over a period of 4 h. The GH concentration was determined by double antibody radioimmunoassay. Pulse characteristics of GH were calculated using the PULSAR program. The results obtained confirmed the pulsatile nature of GH release in the analyzed breeds. Moreover, significant differences ($P<0.01$) of mean GH values between BW and Piemontese heifers (17.8 vs 2.8 ng/mL) and of smooth mean (9.5 vs 1.3 ng/mL), as well as the peak amplitude between BW and Piemontese bulls (20.8 and 6.7 ng/ml, respectively) were found. A high GH concentration appears to be characteristic of young dairy cattle when compared with beef cattle, and to reflect a genetic potential for high milk production.

KEY WORDS: growth hormone, blood plasma, dairy cattle, beef cattle

INTRODUCTION

Growth hormone (GH) is a single-chain peptide with 191 amino acids and two disulphide bridges. It is a heterogeneous hormone existing in multiple forms in the circulation (Hart, 1981). The correlation between the immunoreactive and biologically active forms of GH is not good, making it difficult to study its role and mechanism of action. It is generally recognized that not all of the structure of

native GH is necessary for different biological activities of the hormone. The N-terminal portion contains the anabolically active site, with a minimum sequence of amino acids for bovine GH of 16-113 being necessary for any growth promoting effect (Roche and Quirke, 1992).

The level of growth hormone in the blood shows episodic fluctuations due to the pulsatile nature of its release (Anfinson et al., 1975). Therefore, a frequent blood sampling regime over an extended time period is required to characterize the growth hormone status of any animal. Because single samples for GH determination have been used in many studies, inconclusive and conflicting results were obtained.

Several researchers have investigated the relationship between the GH profiles in the peripheral blood of cattle and its physiological function, in particular, with regard to lactation (Klindt et al., 1988; Schams et al., 1991; Kazmer et al., 1992; Olbrich-Bludau et al., 1993). The GH secretory pattern has also reported for beef cattle such as Angus steers (Wheaton et al., 1986) and double-muscled bulls (Arthur et al., 1990). To our knowledge, there is no information on the GH concentration in Piemontese cattle, which is a breed with excellent meat productivity.

Comparison of the GH level in dairy and beef cattle at young ages may be useful in the identification of superior individuals for milk or meat production. It is hypothesized that traits expressed in young bulls may predict the level of production of their progeny and increase the accuracy of selecting young bulls for progeny testing.

The objective of the study was to compare the levels of blood plasma growth hormone in 11 month old heifers and bulls of dairy and beef genotypes kept under standard feeding conditions. For our purpose Black and White cattle, the main dairy breed in Poland with high milk performance, was used as well as Piemontese which is an excellent beef breed for improving the meat productivity of other breeds.

MATERIAL AND METHODS

The study was performed with 10 Black and White (BW) and 9 Piemontese cattle of both sexes. Black and White cattle were the progeny of 5 Holstein sires from England and 10 Polish Friesian cows. The Piemontese originated from 3 sires and 5 cows from Italy by use of an embryo transfer technique.

Animals were fed a diet of maize silage, hay and concentrates at 06.00 a.m. and 04.00 p.m. The ration was formulated to provide nutrient requirements under standard feeding conditions according to breed, sex and age. Also, feed intake data were collected on an individual animal basis between 6.5 and 8.0 months of age for BW and from 9.0 to 11.0 months of age for Piemontese cattle. At this time,

animals were fed *ad libitum* once daily at 06.00 a.m. The ration for BW consisted of 6.5 MJ metabolizable energy(ME) and 152 g crude protein (CP) per kg dry matter (DM) for concentrates and 4.1 MJ ME and 147 g CP per kg DM for hay. This feed promoted average daily liveweight gains of 1.3 kg and 1.6 kg for heifers and bulls, respectively. The ration for Piemontese cattle contained 5.3 MJ ME and 133 g CP for concentrates and 3.0 MJ ME and 85 g CP for hay. It was fed for average daily liveweight gains of 1.1 kg for heifers and 1.3 kg for bulls.

Animals averaging 11 months of age were tested. The distribution of breeds, ages and body weights at blood sampling is given in Table 1. Young cattle were kept in tie-stalls during a blood sampling session. Serial blood samples were collected through catheters (Viggo-Spectramed Secalon® Seldy 16 G 42 CM) inserted into the jugular vein 24 h before the first sample. The collection of blood was conducted at 15-min intervals over 4 h, starting at 09.00 a.m. All samples were drawn into heparinized tubes (9ml Vacuette® Greiner Labortechnik). The plasma was separated and frozen at –20°C until assayed.

TABLE 1

Description of dairy and beef cattle used for peripheral blood plasma growth hormone characterization

Breed	Black and White		Piemontese	
	heifers n=5	bulls n=5	heifers n=6	bulls n=3
Time of sampling	III – V/1995	III – V/1995	III – IV/1995	III – IV/1995
Age at sampling, days				
mean	337	322	316	371
range	323 – 368	311 – 329	282 – 352	358 – 392
Body weight at sampling, kg				
mean	268	323	304	418
range	230 – 290	298 – 362	260 – 354	384 – 465

The concentration of growth hormone (GH) was determined by routine double antibody radioimmunoassay (Dvorak et al., 1978). In order to increase the precision of estimation, samples from each animal were analysed within one series of RIA. The assay detection limit was 0.034 ng corresponding to 0.68 ng/mL of plasma sample. The coefficient of variation calculated for control samples containing 0.1, 0.8, and 6.4 ng/tube of GH was 7.4, 2.6, and 5.5 per cent, respectively. The mean concentration of GH for individual animals was calculated from the area under the curve (sum of trapezoid areas between curve and abscissa). Pulse characteristics of GH were generated using the PULSAR computer program developed by Merriam and Wachter (1982) and adapted to operate on an IBM-PC by J.F.Gitzen and D.R. Ramirez (University of Illinois, Urbana, USA). The cut-off parameters for G(n) were set to a 5% error rate assuming normal distribution of data.

Data are presented as mean±SEM. The level of significance for differences between groups of data obtained from plasma GH analysis was computed using a nonparametric test (Kruskal and Wallis, 1952).

RESULTS AND DISCUSSION

Although growth hormone plays an important role in controlling growth and lactation in cattle, there has been little investigation to compare GH characteristics in young beef and dairy genotypes.

As presented in Figures 1 and 2, pulsatile patterns were evident in profiles from individual animals, however, the GH pattern does not show homogeneity between animals. Growth hormone was secreted in a dynamic fashion, with the occurrence of irregularly spaced secretory episodes; this was also observed in young cattle by others (Wheaton et al., 1986; Woolliams et al., 1993). The contrasting patterns in various studies indicate the extent to which factors related to age, weight, breed, climatic conditions as well as metabolic and behavioural status can affect GH release.

The present study provides evidence that GH secretion into the peripheral blood plasma is markedly different between breeds and sexes (Table 2). Black and White cattle had higher mean calculated areas under the curve (17.8±7.4 ng/mL in heifers and 18.7±6.8 ng/mL in bulls) than Piemontese cattle (2.8±1.1 ng/mL and 7.2±4.1 ng/mL, respectively). The GH values for the smoothed mean were 9.5±4.1 ng/mL and 9.6±4.7 ng/mL for BW heifers and bulls, and 1.3±0.6 ng/mL and 3.5±1.6 ng/mL for Piemontese females and males, respectively. However, only the breed differences for the females were significant ($P<0.01$). Several authors reported greater circulating concentrations of GH during lactation in genetically high yielding cows compared to low producing cows (Kazmer et al., 1986; Bonczek et al., 1989). Therefore, it could be speculated that a high GH level is associated with selection for increased milk production.

In view of the ability to trace the sires used to produce the animals in this study, it seems reasonable to link the characteristics of the GH profiles with variation in an index for the particular sire genetic merits. The results of Kazmer et al. (1991) indicated that endocrine traits in mature Holstein sires ($n=16$) are correlated with the genetic merit for economically important milk production traits. It seems that our results are in agreement with this observation, but it should be verified on a larger population.

Comparison of GH characteristics between sexes within breeds resulted in significant differences in young Piemontese cattle. Heifers had lower mean and smooth mean GH values than bulls ($P<0.01$). Keeler et al. (1979) also found the average GH level in Hereford and Angus cattle to be lower in females compared to

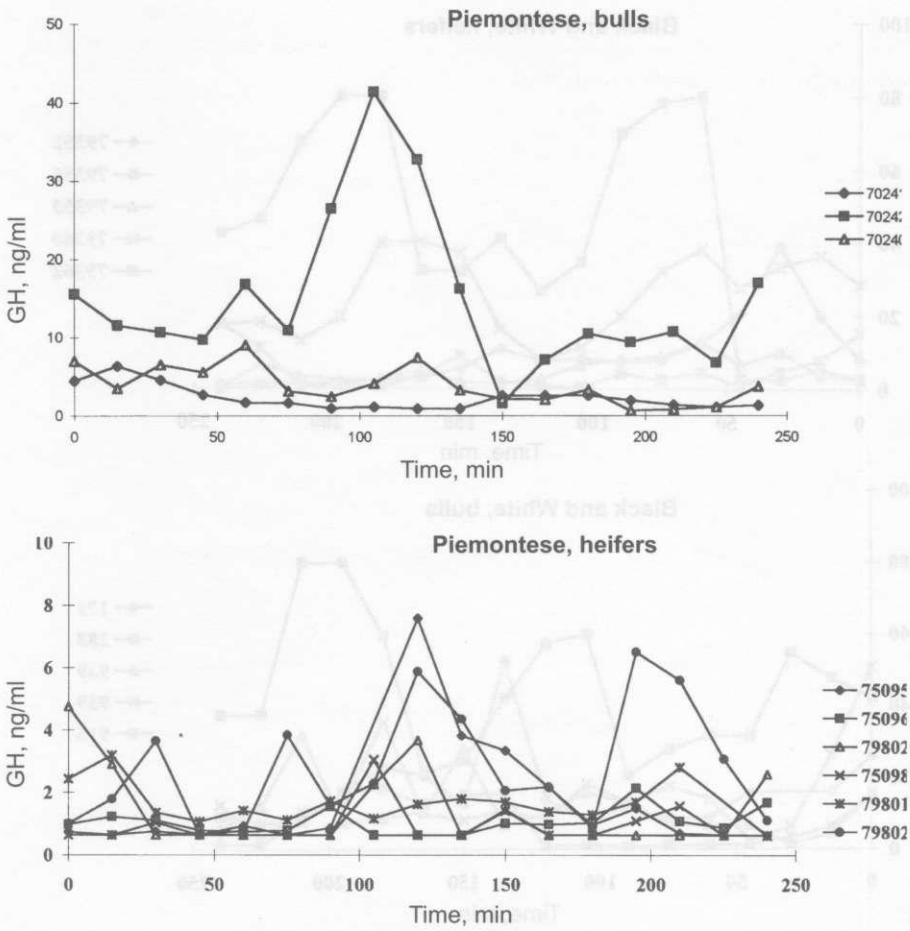

Figure 1. Growth hormone pattern in peripheral blood plasma of Piemontese cattle of both sexes

males at 5 months of age. Our results could indicate that the GH secretory profile may be affected earlier by sex hormones and behavioural states in faster growing Piemontese than in slower growing BW cattle.

According to some authors (Moseley et al., 1988) factors connected with ingestion of food can influence the hypothalamic-pituitary axis to modify the release of GH, with limited pulsatile GH activity occurring 2-3 h after feeding. Thus, blood was sampled between meal-times in the present study to avoid the temporal changes in the GH level following feeding.

Because the first step of growth hormone action is binding to specific membrane receptors, consideration of these receptors is a vital part of an investigation of GH endocrine mediation (Breier et al., 1991). Our preliminary results

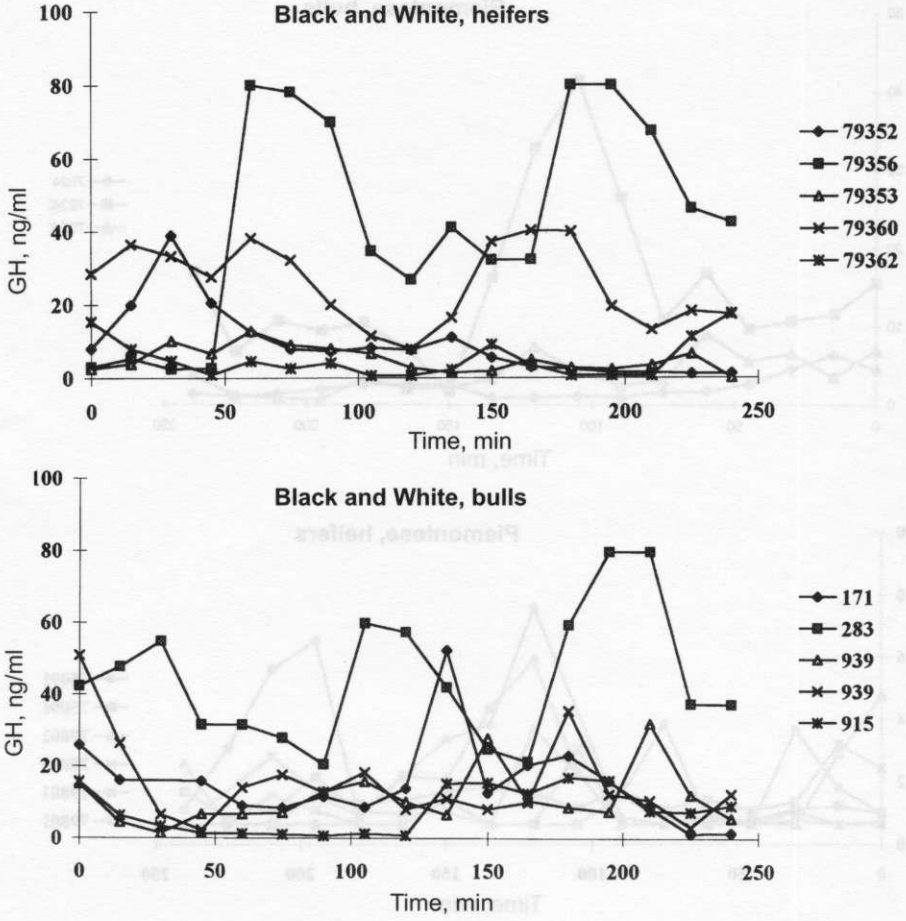

Figure 2. Growth hormone pattern in peripheral blood plasma of Black and White cattle of both sexes

TABLE 2

Growth hormone characteristics in peripheral blood plasma of dairy and beef cattle (mean ± SEM)

Breed	Black and White		Piemontese	
	heifers	bulls	heifers	bulls
Mean[1], ng/mL	17.8^{A}	18.7^{A}	2.8^{B}	7.2^{A}
Smooth mean, ng/mL	9.5^{A}	9.6^{A}	1.3^{B}	3.5^{A}
Peak amplitude, ng/mL	15.7^{AC}	20.8^{A}	3.7^{C}	6.7^{BC}
Peak length, min	45.5	47.3	34.5	47.6
Interpeak interval, min	70.2	84.5	71.0	95.9
Pulse frequency, n/h	0.97	1.02	0.91	0.97

[1] – calculated from the area under the curve

different superscripts in rows indicate the level of significance for differences at $P < 0.01$

(Grochowska et al., 1998) showed no significant differences in GH specific binding in the liver of Black and White and Piemontese cattle (P>0.05). Therefore, it might be assumed that the high plasma GH concentration in BW compared to Piemontese genotypes is not associated with receptor concentrations and reflects selection pressure for increased milk yield.

In conclusion, the high GH level in the peripheral blood plasma seems to be characteristic of young dairy cattle compared to beef cattle and may reflect their genetic merit for milk production.

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STRESZCZENIE

Porównanie poziomu hormonu wzrostu u młodego bydła rasy mlecznej i mięsnej

Badania przeprowadzono na 10 jałówkach i buhajkach rasy nizinnej czarno-białej (ncb) oraz 9 rasy Piemontese w wieku 11 miesięcy. Zmiany stężeń hormonu wzrostu GH we krwi obwodowej oznaczano w próbach krwi pobieranych przez kaniule z żyły szyjnej przez 4 godziny w odstępach 15 minutowych, rozpoczynając w 3 godz. po rannym podaniu paszy. Charakterystykę parametrów stężeń GH wykonano przy użyciu programu PULSAR. Uzyskane wyniki potwierdziły pulsacyjny charakter sekrecji hormonu wzrostu u badanych ras. Ponadto stwierdzono istotne różnice ($P<0,01$) w stężeniu średnim hormonu wzrostu (odpowiednio 17,8 i 2,8 ng/mL) i stężeniu podstawowym (odpowiednio 9,5 i 1,3 ng/mL) między jałówkami rasy ncb a Piemontese oraz w amplitudzie pulsów (odpowiednio 20,8 i 6,7 ng/mL) między buhajami rasy ncb a Piemontese. Wysoki poziom GH we krwi wydaje się być charakterystyczny dla bydła mlecznego, odzwierciedlając jego genetyczne predyspozycje do wysokiej produkcji mleka.