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GROWTH POTENTIAL OF BEEF CATTLE IN RELATION TO BIOCHEMICAL TRAITS, MUSCLE PROTEIN TURNOVER AND HORMONAL STATUS

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ABSTRACT

In this experiment young beef bulls of two breeds with large differences in meat producing capacity (Holstein, H, vs Belgian Blue Breed, BBB) were compared with regard to blood metabolites, urinary excretions and hormone profiles. Daily growth rates were slightly higher with the H bulls (1.36 vs 1.24 kg/d) although weight gain composition revealed a higher proportion of fat. Blood and urinary creatinine increased with animal weight and were markedly higher for the BBB group (10.7 and 19.4 g/d). Expressed per kg muscle weight creatinine excretions were similar : 73.0 vs 76.0 mg/d/kg muscle. Excretions of 3-methylhistidine were higher for the BBB group. On a creatinine basis however they were lower, indicating a lower muscle protein breakdown per unit muscle mass. Plasma growth hormone (GH) concentrations revealed the well-known pulsatile pattern. GH decreased in time over the experimental period especially with the H group. IGF 1 rose in time and was higher for the H group, while the opposite was true for insulin.

INTRODUCTION

Meat production can be defined as the process of transforming dietary nitrogen into myofibrillar protein of skeletal muscle. Beef cattle perform this transformation with a poor yield. The conversion can be improved at the digestive tract level by manipulation of rumen fermentation, or more efficiently at the cellular level by the use of growth promoting substances. Although anabolic agents have been used extensively in beef meat production, relatively little information is available on their mode of action. Even from a more general point of view, a sound theoretical knowledge of the factors governing the growth process is lacking. A better insight in this process and understanding of its important factors might eventually lead to new ways of growth stimulation. The aim of this study was to examine possible relationships between growth rate and some biochemical blood and urine parameters, muscle protein turnover and plasma hormone profiles in growing fattening young bulls of two breeds featuring large differences in meat production potential. In this respect the Belgian Blue Breed (BBB) as a double muscled highly productive beef breed was compared to the Friesian Holstein Breed (H) famous for its high milk production capacity but having poor beef characteristics.

MATERIAL AND METHODS

Animals : 6 six months old double muscled young bulls of the Belgian Blue Breed and 6 four months old Friesian Holstein bulls were alotted to two treatment groups. Average initial weights were 264 kg and 165 kg respectively. The bulls were given a fattening diet composed of :

1 kg hay, 1.5 kg soya bean meal, rolled barley in a ratio of 20% of total diet and dried sugar beet pulp ad libitum. The diet was supplemented daily with 150 g of a mineral and vitamin mixture while additionally 500000 IU of vitamin A and 50 mg vitamin E were given once a week.

Measurements : animals were weighed weekly and feed intake was recorded daily. Urine and faeces collections were performed during 10 days periods on weeks 4, 14, 22 and 31 for measuring N-balance and digestibility and additionally on weeks 19 and 28 for measuring urinary excretions of urea N, creatinine and 3-methylhistidine, an in vivo marker of muscular protein turnover.

Weekly blood collections were performed on Monday, before the morning meal, for estimating glucose, urea N, alpha-amino-N, creatinine and non esterfied fatty acids (NEFA) concentrations. On weeks 5 and 27 blood collection were done over a whole 24 hours period, every 20 minutes in order to follow nycthemeral hormone profiles of bovine growth hormone (GH), insulin and insuline like growth factor 1 (IGF 1) or somatomedin C and metabolite concentrations (urea N, alpha-amino-N, glucose).

At slaughter carcass weight was recorded and a one rib cut dissected for estimating carcass composition. Samples of longissimus dorsi and latissimus dorsi muscles were freeze dried and analyzed for protein, fat and nucleic acid content.

Chemical analyses : most blood and urinary metabolites were determined using colorimetric Technicon Auto analyzer methodology : glucose by o-toluidine, urea by diacetylmono-oxime, alpha-amino-N by trinitrobenzene sulfonate, creatinine by the Jaffé method and nitrogen and protein by Kjeldahl digestion on a Tecator Block and Auto analyzer colorimetry using the Berthelot reaction. 3-methylhistidine and NEFA were estimated by fused silica capillary gaschromatography. Growth hormone, insulin and IGF 1 were analysed by radio immuno assay. Nucleic acids (RNA, DNA) were measured using an automated version of the Tannhauser procedure estimating RNA by the orcinol and DNA by the diphenylamine reaction.

RESULTS AND DISCUSSION

Typical animal performances are given below (Table 1)

Table 1. - ANIMAL PERFORMANCES, CARCASS AND MUSCLE COMPOSITION.

	Holstein	BBB
Average daily growth rate (kg)	1.36	1.24
Feed conversion ratio (kg)	5.5	5.9
Feed intake/100 kg live weight	2.26	1.7
Carcass weight (kg)	261	358
Dressing percentage (%)	55.4	65.8
Carcass composition (%)		
- Muscle	56.07	71.26
- Fat	28.27	15.36
- Bone	15.66	13.38
Muscle composition		
- Protein (% in dry matter)	86.0	90.4
- Fat (% in dry matter)	11.1	5.0
- DNA (mg/g protein)	0.92	0.80
- RNA (mg/g protein)	6.10	7.66

Daily growth rate was slightly higher for the H group (1.36 vs 1.24 kg/d). However, as illustrated by carcass weight and -composition, as well as by N-balance, weight increase composition was rather different especially towards the end of the period where N-retention dropped from 40 g/d to around 30 g/d for the H group. With the BBB animals N-retention remained high (45 g/d) indicating that these animals were still able to synthesize

protein at the end of the experimental period. In contrast the Holstein bulls deposited more and more fat during the same period. Creatinine excretion (Table 2) as well as blood creatinine levels were markedly higher with the BBB group, even expressed per kg live weight.

Table 2.- MEAN BLOOD METABOLITE LEVELS AND URINARY EXCRETION RATES

	Holstein	BBB
Blood Metabolites		
Glucose (mg/l)	1014	988
Urea N (mg/l)	146.5	138.2
Alpha-amino-N (mg/l)	57.1	55.7
Creatinine (mg/l)	11.0	20.3
NEFA (uMol/l)	147.4	153.6
Urinary Excretion Rates		
Urea N (g/d)	63.1	56.4
Creatinine (g/d)	10.7	19.4
(mg/d/kg LW)	31.0	44.6
3-Methylhistidine (uMol/d)	1421	1888

Where for the H group creatinine excretion is in accordance with literature data the 44.6 mg/d/kg LW obtained for the BBB group was substantially higher. However, on a muscle weight base excretions were similar, e.g. : H : 73.0 and BBB : 76.0 mg/d/kg muscle. Creatinine excretions (E) were linearly related to body weight (W) by the following regression lines :

H : $E = 1.202 + 0.027.W$ $r = 0.992$

BBB : $E = 0.814 + 0.043.W$ $r = 0.962$

were E is in g/day and W in kg. The studied weight intervals were : H : 165 to 489 kg; BBB : 264 to 560 kg. Plasma concentrations of glucose, urea N and alpha-amino-N revealed only slight differences between breeds. However, towards the end of the experiment higher urea N and alpha-amino-N levels indicated a decrease in N-efficiency for the Holstein bulls.

Muscle protein (MP) turnover, as related to urinary 3-methylhistidine (3MH) excretion rates (E) was proportional to animal weight (W), as described by the equations :

H : $E = 216.7 + 3.44.W$ $r = 0.989$

BBB : $E = -465.5 + 5.43.W$ $r = 0.975$

were E is in umol/d and W in kg for the above cited weight intervals.

As weight intervals in both breeds are overlapping a common regression could be calculated for both breeds :

$E = -140.3 + 4.58.W$ $r = 0.962$.

Similar linear relationships have been observed by HARRIS and MILNE (1981) and GOPINATH and KITTS (1984). Over the whole experimental period mean 3-MH-excretions were 1421 and 1888 umoles per day for H and BBB respectively. In relation to creatinine excretions 3MH/creatinine excretions were 133.5 and 96.6 for H and BBB indicating a slower breakdown rate per unit muscle mass for the latter.

Assuming that all retained N constitutes muscle protein, net MP accretion could be calculated from N-balance, and MP degradation from 3MH excretion. MP synthesis could be estimated from degradation + accretion. The results are depicted in Fig. 1 as related to animal weight. In absolute terms net synthesis is always higher for the BBB than for the H-animals while degradation rates are only higher at the end of the experiment, where in the BBB group weights are substantially higher than in the H group. Consequently synthesis rates are highest for the BBB bulls. However, expressed per unit carcass muscle protein, fractional rates of synthesis (Ks), degradation (Kd) and growth (Kg) are lower for the BBB group (Table 3).

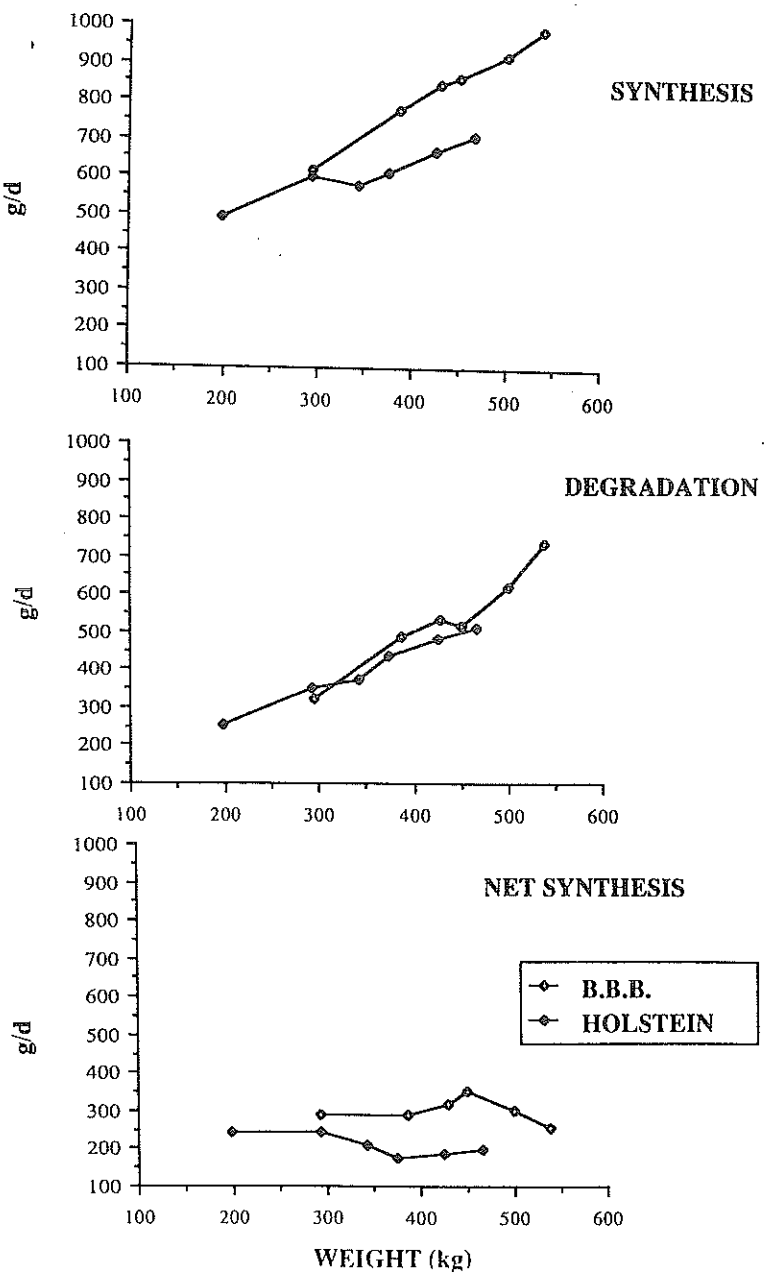

Fig. 1.- MUSCLE PROTEIN SYNTHESIS, DEGRADATION AND NET SYNTHESIS RATES AS A FUNCTION OF ANIMAL WEIGHT FOR HOLSTEIN AND BELGIAN BLUE BULLS.

Table 3.- MEAN FRACTIONAL SYNTHESIS (Ks), DEGRADATION (Kd) AND GROWTH (Kg) RATES OF MUSCLE PROTEIN (in %).

Breed	Ks	Kd	Kg
H	1.90	1.21	0.69
BBB	1.47	0.95	0.55

This observation contrasts with the results of Mc CARTHY et al. (1983) who observed no differences in Ks, Kd and Kg between "small frame" (purebred Polled Hereford) and "large frame" (Simmental, Charolais, Holstein and Angus crosses) animals. It should be noted however that the latter group is rather heterogeneous with regard to meat production potential.

Plasma Growth Hormone concentrations displayed the well-known pulsatile pattern with large differences between animals. Consequently differences between groups were not significant. However, mean overall concentrations and peak concentrations were generally higher for the Friesian animals at the first measurement period while the opposite was true for the second period. Furthermore, the decrease in GH levels in time was much more pronounced with the H- than with the BBB group. With the latter GH concentrations were rather similar for the two days. The decline in GH concentrations with age is a well-known fact. The faster decrease with the Holstein animals could be related to a more advanced physiological age of this breed compared to the slower maturing large BBB breed, although a genetic difference in GH secretion unrelated to age cannot be excluded (VERDE and TRENKLE, 1987). It should be observed also that the evolution of GH levels in time seems to be related to NEFA concentrations variations. ROMMEL et al. (1987) report a similar relationship between GH and NEFA in an experiment studying the effect of fat supplementation on GH secretion in monozygotic twins.

IGF 1 concentrations increased with time in both breeds and were higher for the H group. The opposite was true for insulin levels.

In view of this preliminary observations the obvious differences in animal weights and conformation are poorly reflected in the metabolite concentrations and hormone profiles. Apparently more sophisticated interpretations of relationships between parameters are to be done while also more refined and specific "prediction traits" have to be sought for.

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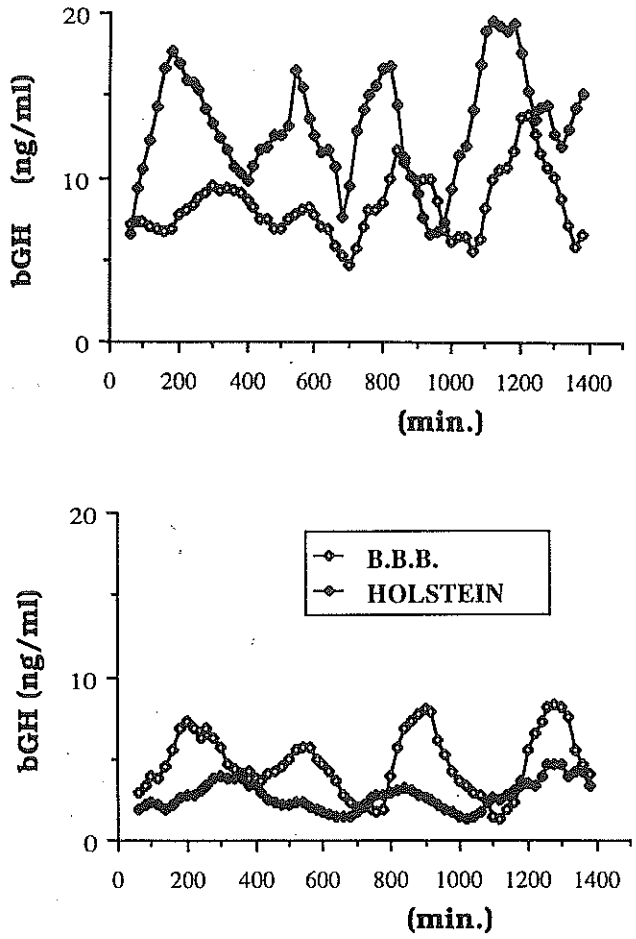

Fig. 2.- GROWTH HORMONE SECRETION PATTERNS AS A FUNCTION OF TIME FOR HOLSTEIN AND BELGIAN BLUE BULLS.