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CHANGES OF INTERNAL ENVIRONMENT INDICATORS OF ABERDEEN ANGUS HEIFERS DURING REARING

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ABSTRACT

In the period from birth to weaning we sampled blood from 22 Aberdeen Angus heifers bred in the system of suckling cows at regular intervals to evaluate changes in the indicators of the internal environment. In the plasma we analysed the concentrations of total protein, albumin, urea, glucose, total cholesterol, triacylglycerols, alkaline phosphatase, alaninaminotransferase, aspartatami-notransferase, tyroxine, triiodothyronine. We found that age had a significant effect ($P < 0.01$) on the concentration of total proteins, albumin and urea ($r = 0.69$; 0.49 and 0.48, respectively). A significant ($P < 0.001$) decreasing trend in the catalytic ALP activity was detected in the course of the experiment ($r = -0.65$) as opposed to the ALT and AST activities ($r = 0.39$ and 0.35, respectively; $P < 0.01$). Age was seen to have a significant effect on the T3 concentration ($r = -0.63$; $P < 0.01$). A positive correlation was found between the temperature, cholesterol concentration and activity of alkaline phosphatase ($r = 0.33$ and 0.44; $P < 0.01$). Correlation between the environmental temperature and content of total proteins, tyroxine and AST activity was negative ($r = -0.66$; -0.42 and -0.35; $p < 0.01$). Correlation analyses revealed no significant effect of the growth intensity on changes in the indicators of the internal environment of the animals.

Key words: beef cattle; blood plasma; metabolites; health, nutrition status

INTRODUCTION

To a large extent beef cattle is bred in a system of suckling cows in the Czech Republic. This system, however, allows only limited regular control of the animals as the cattle spend the whole year grazing on pastures. An essential component of present-day agriculture is the very possibility of precise evaluations of the correlations between nutritional factors and production factors by means of monitoring the parameters of the metabolic profile of the animal blood. For high-quality control of the health and nutrition status it is therefore necessary to gain detailed information about the changes in the internal environment during the individual stages of the productive life of the animals (Cavestany et al., 2005). Determination of indicators of the metabolic profile in the course of the breeding season helps to diagnose the metabolic problems of the animals (Verheyen et al., 2007). For instance, qualitative and quantitative restriction of feed has a considerable effect on the level of some metabolites in the plasma (Agenas et al., 2006; Cooke et al., 2008; Ndlovu et al., 2009). Very important in this case is the good quality of the pasture as an important source of nutrition during the grazing season (Chimonyo et al., 2000; Brown and Adjei, 2001). The concentration of metabolites in the animal blood is an important indicator related with the production of the respective animal-based commodities (Casasus et al., 2002; Ban-Tokuda et al., 2007). The technology of breeding is also an important part of this system and may considerably contribute to changes in the blood plasma composition (Coppo et al., 2002; Hickey et al., 2003; Blanco et al.,

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2009). The environmental conditions, i.e. the effect of the temperature, season of the year and also the breed, play a role in the changes of chemical indicators of the plasma (Thrall et al., 2004; Grundwaldt et al., 2005; Yokus and Cakir, 2006; Ndlovu et al., 2009). The objective of the present study was to monitor changes in the indicators of the internal environment of beef cattle bred in extensive conditions of the suckling cows system from birth to weaning and to obtain information inevitable for evaluations of the health and nutrition status of the animals in the productive age.

MATERIAL AND METHODS

The experiment was carried out on a farm in the foothills of the Orlické Mountains at an altitude of 500m and average annual precipitation of 728mm. Figure 1 gives the average monthly air temperatures and relative air humidity. The experiment included 22 calves from heifers born in February and April 2007. During the vegetation period the feed ration at the beginning of the experiment consisted primarily of the mother's milk, then of the pasture herbage, starter and supplement of hay. The winter feed ration consisted of clover-grass hay-lage, supplemented with hay. Table 1 gives the contents of standardized nutrients in the feed rations. For the first time the blood for analysed of the individual indicators of the internal environment was taken at the age of 5 ± 1 day(s) after birth. Then the heifers were divided into two groups of 11 animals each according to the date of birth to minimise the differences among the animals. Using the Hemos system the blood samples were taken from the subcaudal vein at four dates during the experiment, i.e. at the average age of the heifers of 64, 87, 134, 157, 176, 199, 260 and 283 days. The blood samples were stabilised using heparin. The blood was centrifuged at 1200g for 15min and the plasma was kept at a temperature of -20°C until analysis. The following indicators of the metabolic profile were determined in the blood plasma: total proteins (TP), albumin (Alb), urea, glucose (Glu), cholesterol (Chol), triacylglycerols (TAG), alkaline phosphoatase (ALP), alaninaminotransferase (ALT), aspartataminotransferase (AST), tyroxine (T4), triiodothyronine (T3). The automatic XT20i analyser (Fisher Thermo Scientific, Finland) was used to determine the parameters of the internal environment; for the determination of T3 and T4 we used the automatic Immulite analyser (DPC, USA) and the currently available commercial kits (Biovendor-Laboratorní medicína, a.s., CR). During rearing we evaluated the growth intensity by calculations of the body weight gains in the intervals between the individual samplings. Statistical evaluations of the data were performed using the STATISTICA 8.0 programme by one-factorial analysis for the animal age factor. ANOVA was followed by the post-hoc Fischer LSD test for pairwise comparisons, when appropriate. The correlations between the age of the animals, live weight gains, temperature of the external environment and the individual parameters of the internal environment were evaluated by means of the correlation coefficient at the level of probability $P < 0.01$.

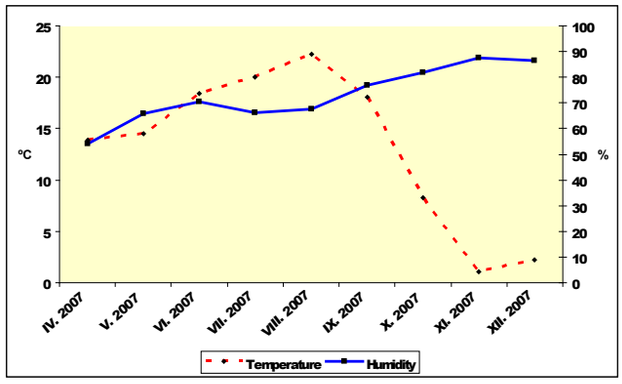

Fig. 1: Average monthly air temperature and relative air humidity

Table 1: Nutrient contents of pasture herbage (period 1 – 3) and winter feed ration (period 4)

Parametr		Period			
		1	2	3	4
Dry matter	%	100	100	100	100
Fat	%	2.02	2.28	2.76	2.48
Roughages	%	25.88	30.59	24.15	21.12
NEV	MJ/kg	5.22	4.91	5.21	6.01
PDIN	g/kg	80.15	68.25	106.38	84.52
PDIE	g/kg	83.61	71.14	94.59	76.15

Table 2: Average daily body weight gains of the animals during the experimental period (g.day^{-1})

Period (day)	Mean g.day^{-1}		SEM
6-64	1011.4		107.5
6-87	1107.1	±	51.3
64-134	1122.8	±	110.1
87-157	1267.5	±	84.8
134-176	1190.4	±	164.1
157-199	1180.5	±	76.5
176-260	761.9	±	37.7
199-281	710.3	±	35.9

RESULTS

In our experiment we monitored the effect of the age on the content of total proteins and albumin [F(7.80) = 16.143, P < 0.001; F(7.80) = 3.441, P < 0.01)]. The average values for these indicators continuously increased from the beginning to the end of the monitored period (Tab 1). A similar trend was detected for the average urea concentration [F(7.80) = 12.817, P < 0.001)]. We noted a significant (P < 0.01) correlation between these three parameters of the internal environment and the age of the animals as expressed by the correlation coefficient 0.69, 0.49 and 0.48, respectively. The glucose concentration did not change considerably during the experiment and ranged between 5.51 and 6.01 mmol.l^{-1}. A significant decrease (P < 0.05) in its level was detected on the 134th day of age of the animals. Considerable changes were detected in the concentration of total cholesterol [F(7.80) = 5.569; P < 0.001)]; we noted that the average levels increased significantly from the beginning of the experimental period; from 2.22 to 5.23 mmol.l^{-1} on 134th day of age. The cholesterol level decreased significantly (P < 0.01) at the end of the experimental period. The TAG concentration also tended to decrease at the end of the experiment but this decrease was not significant. The catalytic activity of ALP increased with age during the entire experiment [F(7.80) = 12.801; P < 0.001)] in contrast to the activity of ALT and AST where the trend was the opposite. The correlation coefficients for correlations between the age of the animal and the activities of ALP, ALT and AST (-0.65, 0.39 and 0.35, respectively) were also in accordance with ANOVA results. From the beginning of the experiment the concentrations of T3 and T4 were seen to decrease significantly until the age of 134 days (P < 0.01). After a slight increase the T3 level decreased to an average level of 2.01nmol.l^{-1} on day 283 of age. The correlation coefficient for the effect of age on the T3 level was -0.65. In contrast, the T4 concentration gradually increased from day 134 of age until the end of the experiment. The results of the experiment showed the evident effect of the temperature of the external environment on the internal environment of the organism. The correlation between the temperature and concentration of cholesterol and activity of alkaline phosphatase was positive (r = 0.33 and 0.44; P < 0.01), while the correlation between the temperature and concentrations of total proteins, tyroxine and AST activity was negative (r = -0.66; -0.42 and -0.35; P < 0.01). No significant correlation was noted between the concentrations of the biochemical parameters and changes in the growth intensity of the animals.

Table 3: Indicators of metabolic profile of heifers during the experimental period

Age (day)		Indicators of blood plasma										
		TP g.l^{-1}	Alb g.l^{-1}	Urea mmol.l^{-1}	Glu mmol.l^{-1}	Chol mmol.l^{-1}	TAG mmol.l^{-1}	ALP μkat.l^{-1}	ALT μkat.l^{-1}	AST μkat.l^{-1}	T3 nmol.l^{-1}	T4 nmol.l^{-1}
5	Mean	57.87	27.58	4.38	5.57	2.22	0.43	3.36	0.19	1.11	6.32	139.6
	SEM	2.30	1.41	0.50	0.30	0.22	0.04	0.27	0.02	0.12	0.44	14.25
64	Mean	62.86	31.44	4.84	5.86	4.50	0.36	4.57	0.23	1.27	3.29	100.2
	SEM	1.32	0.42	0.31	0.23	0.21	0.10	0.94	0.02	0.10	0.50	4.26
87	Mean	65.08	32.06	4.76	5.89	4.94	0.35	4.09	0.29	1.28	2.57	88.4
	SEM	0.85	0.24	0.24	0.20	0.26	0.03	0.23	0.01	0.07	0.12	3.04
134	Mean	63.71	31.54	4.47	5.19	5.23	0.35	2.80	0.36	1.13	2.20	66.3
	SEM	1.57	0.46	0.29	0.67	0.27	0.08	0.24	0.06	0.04	0.17	6.82
157	Mean	69.42	32.96	4.36	5.85	4.98	0.34	2.95	0.39	1.18	2.30	72.0
	SEM	1.52	0.37	0.34	0.42	0.28	0.05	0.21	0.01	0.07	0.15	3.90
176	Mean	67.60	33.95	5.54	6.01	4.90	0.34	2.38	0.38	1.25	2.59	71.7
	SEM	1.47	0.65	0.48	0.27	0.33	0.05	0.15	0.04	0.15	0.24	7.04
199	Mean	68.58	33.79	5.49	5.96	5.12	0.36	2.53	0.40	1.27	2.73	79.6
	SEM	1.64	0.59	0.39	0.18	0.25	0.03	0.14	0.02	0.19	0.17	6.26
260	Mean	71.20	33.89	5.64	5.61	4.07	0.30	1.17	0.47	1.43	1.96	96.8
	SEM	1.77	0.69	0.24	0.15	0.36	0.04	0.20	0.04	0.12	0.44	18.81
283	Mean	73.60	33.94	5.77	5.51	3.89	0.29	1.09	0.50	1.48	2.01	104.3
	SEM	2.47	1.13	0.23	0.37	0.30	0.04	0.26	0.02	0.18	0.16	10.60
P		< 0.001	< 0.01	< 0.001	< 0.05	< 0.001	0.063	< 0.001	< 0.001	< 0.01	< 0.01	< 0.01

DISCUSSION

In our experiment we found that the age of the animal had a significant effect on the parameters of protein metabolism. With increasing age the concentrations of total proteins, albumin and urea gradually increased. Since albumin is considered to be a sensitive nutritional indicator of protein status (Doornenbal et al., 1988; Slobodianik et al., 1999) and since blood urea concentration is also known to reflect the amount of taken in proteins, the level of feed degradation in the rumen (Brown and Adjei, 2001; Nazi et al., 2003; Thrall et al., 2004) and the dietary composition of the taken in amino acids (Grunwaldt et al., 2005), the changes noted in our experiment are probably due to the increasing content of proteins digestible in the intestine as given in Tab. 1. Chimonyo et al. (2000) likewise confirmed that changes in the plasma protein content were based on the variability of the nutritional composition of the feed ration. The concentration of plasma glucose decreased during the year, i.e. in summer and winter. Several authors (Chimonyo et al., 2000; Grunwaldt et al., 2005; Fraser et al., 2009 and Ndlovu et al., 2009) reported that the reason for the drop in the average values could be the worse quality of grazing in this period. Our results do not correspond with the findings of Cabaraux et al. (2004) who reported that the concentration of plasma glucose decreased with the age of the animal. The increasing concentrations of total cholesterol and TAG in calves aged 3 to 5 months (Ban Tokuda et al., 2007) fully correspond with our results. Towards the end of the experiment, at the time of weaning, we noted that the average levels of cholesterol decreased. Also, Pavlik et al. (2009) reported that the level of cholesterol in weaned Gasconne bullocks and heifers decreased and they assumed that it was due to the changes in the living conditions and was connected with separation from the mother, changed composition of the feed ration and hence lower feed intake. It is actually the insufficient nutrition which causes the concentration of plasma cholesterol to decrease (Také Ban-Tokuda et al., 2007) because ruminants exploit cholesterol as a source of energy (Adachi et al., 1997). The reduced activity of alkaline phosphatase in the course of our experiment was due to the rapid growth of the young animals at the time when ALP is utilised for building the bone tissue and more of it is released into the blood plasma (Kaneko et al., 1997; Knowles et al., 2000). In a recent study, Ndlovu et al. (2009) pointed out the correlation between the bone/muscle tissue and ALP activity. The gradual increase in the catalytic concentration of ALT and AST in the plasma of heifers during rearing is probably due to the changes in the level of metabolic processes which the enzymes are part of.

CONCLUSION

The results of our experiment point out to the significant changes in parameters of internal environment during post-natal ontogenesis of the individual categories of beef cattle reared in extensive conditions and the effect of external environment on these parameters. The values of indicators of the metabolic profile of the animals taken at relatively short intervals will help to carry out precise control of the health and nutritional status as factors involved in the production of top-quality beef.

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