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Muscle fiber type profile and postmortem metabolism of Nellore cattle with different growth potential from weaning to yearling (#359)

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Introduction

Intensive selection based on growth rate and muscularity leads to changes in the composition of muscle fibers, increasing the proportion of glycolytic fibers in cattle (Wegner et al., 2000). An increase in the glycolytic fibers is characterized by an increase in glycolytic metabolism, which results from a greater abundance of glycolytic enzymes (Mcgilchrist et al., 2016), and consequently, a decrease in oxidative capacity, as indicated by the reduced activity of mitochondrial enzymes (Hocquette et al., 1998). This work was designed to evaluate the muscle fiber characteristics and postmortem metabolism of Nellore cattle with different weaning growth potential.

Methods

Twenty Nellore non-castrated males (417±61 kg body weight and 22±2 mo. old) with different expected progeny differences (EPD) for post-weaning growth were fed with a 27% roughage (corn silage) and 73% of concentrate (corn grain, soybean meal, mineral mix) diet for 100 days. At the end of the feeding period, animals were slaughtered and samples of the *Longissimus thoracis* (LT) from 10 animals with high (EPD_H) and 10 animals with low (EPD_L) EPDs were collected and immediately frozen in liquid nitrogen and stored at -80°C for metabolic and pH analyzes. For muscle fiber profile analysis, fragments in the longitudinal direction of the muscle fibers were collected, frozen in N-hexane cooled in liquid nitrogen and stored at -80 °C. To determine the muscle fiber profile, samples were stained using nicotinamide adenine dinucleotide tetrazolium reductase (NADH-TR) according to the technique of Pearse (1972) modified by Dubowitz and Brooke (1984). Fibers were classified as slow oxidative (SO), fast oxidative-glycolytic (FOG) or fast glycolytic (FG), as proposed by Peter et al. (1972). To simulate *in vitro* glycolysis, samples of LT were ground in liquid nitrogen and homogenized in a buffer as proposed by England et al. (2014) and aliquots were collected after 0, 30, 120, 240, 480, 720, and 1440 min. The pH samples were prepared using the iodoacetate method as described by Bendall (1973). Lactate, glycogen, glucose, and glucose-6-phosphate (G6P) analyses were performed according to the methodology proposed by Bergmeyer (1984) and modified to 96-well plates (Hammelman et al., 2003). Data were analyzed by analysis of variance using the MIXED procedure of SAS 9.4 (SAS Institute Inc., Cary, NC) as a completely randomized design considering the EPD class (EPD_H and EPD_L) as a fixed effect. The pH and metabolite data were evaluated as time-repeated measures, considering the fixed effects of EPD class, time of measurement and their interaction. Covariance structures were tested for each characteristic and the best fitted was used.

Results

The EPD_H group had a higher frequency of FG fibers (P=0.032) and a lower frequency of SO fibers (P=0.026) than EPD_L animals, whereas no differences were observed in FG fibers (Table 1). Cassar-Malek et al. (2003) and Picard et al. (2006) working with cattle selected based on their muscle growth capacity also observed an increase of fast glycolytic fibers. There was no significant treatments x time interaction for pH, lactate, and glycogen evaluated in the *in vitro* system (Figure 1). Glycogen concentration was greater in EPD_H when compared with EPD_L animals (P=0.008), which is in agreement with findings of Gardner (2001) that stated that muscles with higher proportions of glycolytic fibers possess greater amounts of glycogen. No effect of EPD class was observed for pH and lactate. There was an interaction between treatment and time for glucose (P<0.001) and G6P (P<0.001). The EPD_L animals had greater glucose concentrations than EPD_H group at 240 min (P<0.001), 720 min (P=0.006), and 1440 min (P=0.008) (Figure 2B). No differences between treatments were observed for any other points. No differences between treatments were observed for G6P at 0 min (Figure 2A). However, from 30 min to 1440 min, G6P concentrations were higher in samples from EPD_L treatment compared to EPD_H. Metabolite flux during the glycolysis is controlled by active regulatory enzymes in the postmortem muscle (Hamm, 1977), so once glycogen breakdown was similar between treatments, higher accumulation of these metabolites in EPD_L group could be explained by the differences in muscle fiber type frequency observed between treatments. Oxidative muscle has less glycolytic enzymes abundance and activity and thereby a slower rate of postmortem glycolysis (Matarneh et al. 2017). Moreover, a greater accumulation of glucose when compared to G6P over time was observed, which was likely due to the preference of the pathway for the glycogen residues that are already in the form of G6P, whereas for the transformation of glucose into G6P it is necessary to use energy (1 ATP), leaving the process less economical (Ferguson and Gerrard, 2014).

Notes

Conclusion

Selection for growth potential post-weaning shifts muscle fibers toward the glycolytic type, however, this change does not affect pH decline.

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Notes

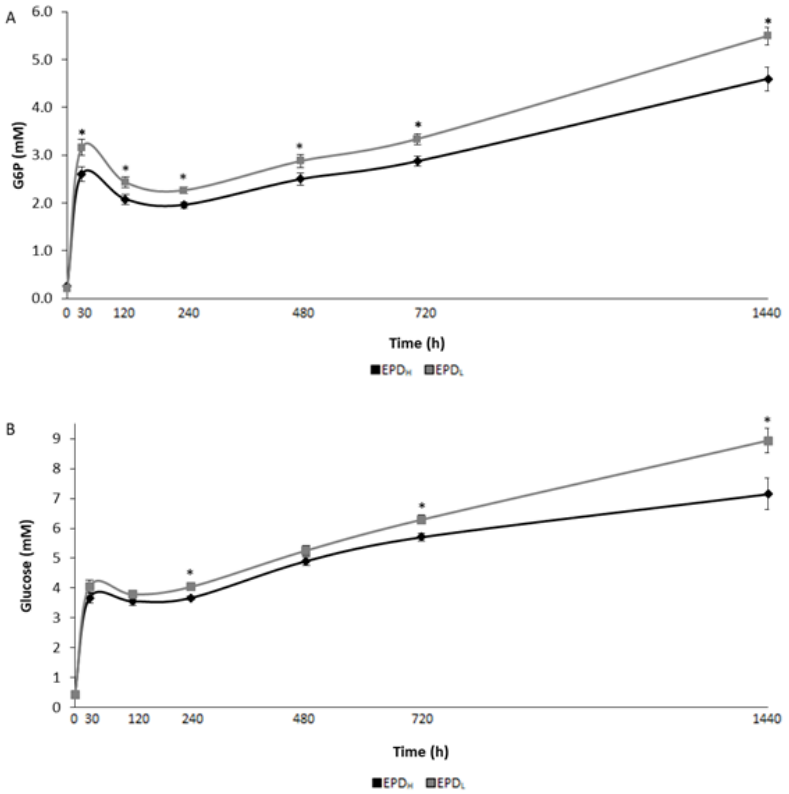

Figure 2. Mean of G6P and glucose in vitro, as a function of postmortem time and growth potential.
*treatments differ within time ($P < 0.050$); EPD_H: high EPD for post-weaning growth; EPD_L: low EPD for post-weaning growth; G6P: glucose-6-phosphate.

Notes

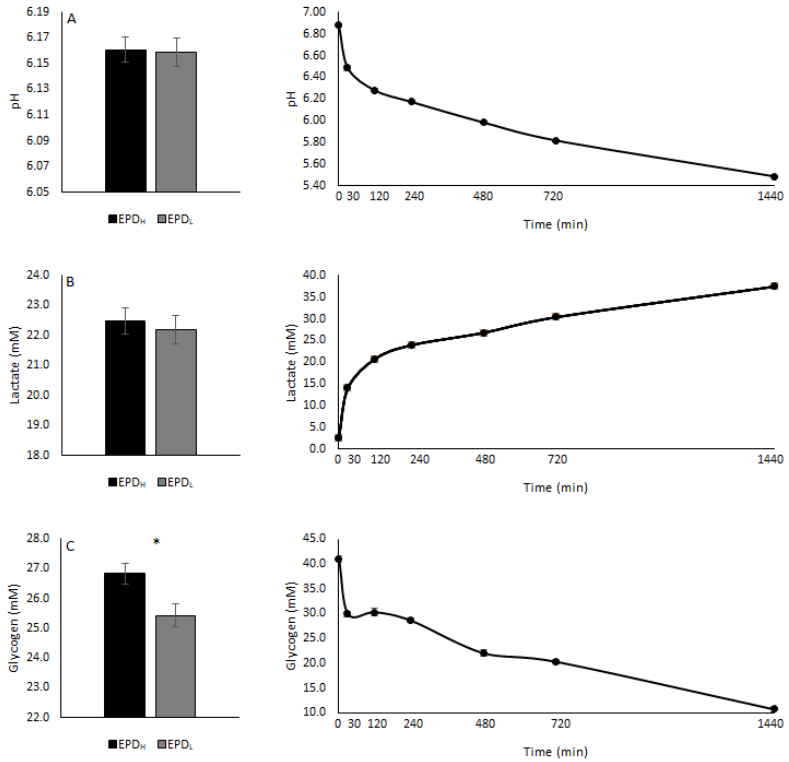

Figure 1. Mean and standard error of the mean (SEM) of pH, lactate and glycogen in vitro.
*treatments differ ($P < 0.050$); EPD_H: high EPD for post-weaning growth; EPD_L: low EPD for post-weaning growth;

Notes

Characteristics	EPD		SEM	*P*
	High	Low		
Frequency (%)				
SO	32.6	39.2	1.68	0.026
FOG	36.8	33.5	1.21	0.094
FG	30.5	26.9	0.91	0.032

Table 1. Mean, standard error of the mean (SEM), and the probability of muscle fibers frequency.
SO: slow oxidative; FOG: fast oxidative-glycolytic; FG: fast glycolytic;

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