Biochemical Studies on Bovine Growth and Development From Birth to Weaning

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Story in Brief

Oxidative metabolic activity of muscle tissue was compared in eight small scale beef calves (Angus) and eight large scale beef calves (Charolais). Succinate dehydrogenase activity was determined spectrophotometrically by reduction of 2 (p-Iodophenyl) 3-p-nitrophenyl - 5-phenyl Tetrazolium Chloride (INT). Activity was determined on the dilute salt (0.2M Na_2 $HPO_4 \bullet 7$ H_2O, pH 7.5) soluble fraction of the whole tissue. Results indicated a decrease in activity from 4.73 x 10^{-2} units to 1.81 x 10^{-2} units over the 168 day evaluation period for the large scale calves.

The small scale calves had a reduction in net activity from 3.69 x 10^{-2} units to 2.59 x 10^{-2} units over the same phase. A slight increase in activity was noted for the small scale calves in Period 4 not noted in the large scale calves. These results suggest the small scale calves were more "chemically mature" at birth than the large scale calves.

Introduction

In general, skeletal muscles are composed of two basic fiber types, the Type I (Red) fiber which is rich in the oxidative enzymes and poor in phosphorylase and adenosine triphosphatase and the Type II (White) fiber which is poor in the oxidative enzymes and rich in phosphorylase and adenosine triphosphatase (Dubowitz and Pearse, 1960a, b). A third "intermediate" fiber type has been identified which shows a moderate reaction to oxidative enzymes but an intense reaction to phosphorylase and adenosine triphophatase (Brooke, 1966). It has also been shown that the type I fiber is the predominant fiber type in early postnatal life, whereas the Type II fiber becomes more prominent as chronological age increases. Some species are fully differentiated at birth, while in others fiber differentation occurs post-natally (Dubowitz, 1963, 1968). The state of fiber differentiation at birth is related to the length of gestation and physical maturity at parturition.

The purpose of this study was to compare the state of chemical maturity of an early maturing and late maturing bovine breed, utilizing oxidative enzyme changes associated with post-natal muscle fiber differentiation as an "index" of chemical maturity.

Materials and Methods

In this study, eight grade Angus steer calves were selected to represent the early maturing bovine breed and a similar number of Charolais (7/8 Charolais x 1/8 Angus) steer calves were selected to represent the later maturing breed. The test calves were kept with their dams until weaning (approximately 205 days of age), under similar range conditions. Muscle samples were obtained by live animal biopsy (Guenther, 1972) at approximately 35 days of age (Period 1) and at three subsequent 56 day periods (Periods 2, 3, and 4). Muscle samples were wrapped in aluminum foil, frozen in liquid nitrogen and stored at —20°C awaiting chemical analysis. Fiber differentiation was estimated by the determination of total oxidative and total glycolytic activity of the muscle tissue. Activity was measured spectrophotometrically by the enzymatic reduction of tetrazolium salts (Beecher, 1965) utilizing succinate dehydrogenase to represent the oxidative activity and lactate dehydrogenase for glycolytic activity.

Results

Results are presented as the period mean values for the eight animals within each breed. Units of activity are expressed as net change in optical density per 15 minute per mg. of extractable protein. Extractable protein is the dilute salt (0.2M Na_2 $HPO_4 \bullet 7$ H_2O, pH 7.5) soluble protein as determined by the Biuret method (Layne, 1957).

Figure 1 represents a comparison of the total oxidative activity of the two breeds by period. It is apparent that the initial oxidative activity of the Charolais calves was higher (4.73×10^{-2} units) than that of the Angus (3.69×10^{-2} units). This would indicate that the Charolais were less "chemically mature" at this phase of their lifetime than the Angus, based on the assumption that fiber differentiation results in the lowered oxidative capacity of the tissue.

Between Periods 1 and 2 (56 days) there was little difference in the rate of change between the two breeds (1.40×10^{-2} units for the Angus and 1.26×10^{-2} units for the Charolais). However, during the next 56 day increment (between Periods 2 and 3), the mean activity for the Angus decreased only 0.26×10^{-2} units whereas that of the Charolais decreased 1.38×10^{-2} units or 5.5 times the Angus difference. This apparent plateauing effect noted for the Angus calves may reflect a state of "chemical maturity" for the early maturing breed which was not yet apparent for the later maturing breed. Between Periods 3 and 4, a reduction in activity of only 0.28×10^{-2} units was noted for the Charolais which was quite similarto the 0.26×10^{-2} units of change between Periods 2 and 3 of the Angus.

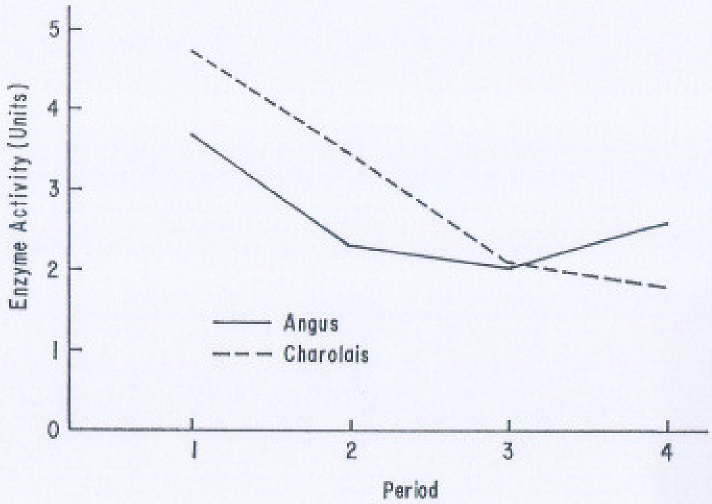

Figure 1. Total Oxidative Activity by Period

An increase in oxidative activity of 0.56 x 10^{-2} units was noted for the Angus calves between Periods 3 and 4. This increase in oxidative activity of the Angus may be indicative of biochemical adaptions of the muscle tissue associated with apparent completeness of skeleton development of the Angus (Gresham, et al. 1973). Figure 2 reflects the growth rate of the left metacarpal at each period between the two breeds. Note that there was a decline in rate of growth of the Angus between Periods 2 and 4, whereas the Charolais rate of growth was still linear. This implies that the Angus may have reached a state of "physiological maturity" not yet evident for the Charolais. Purportedly, the four major tissues develop in the order of nerve, bone, muscle, then adipose. Therefore, the completeness of bone growth would be followed by muscular development. This increased demand for protein synthesis has caused either a regression in the Angus of some Type II fiber back to Type I fibers or a stimulation of the oxidative activity of the muscle tissue.

Regression of fiber types has been reported to occur with starvation and subsequent high nutritional levels (Goldsprink, 1965). Several other workers (Dreyfus and Vibert, 1967; Goldberg, 1967) have shown that red muscle incorporates more amino acids into the sarcoplasmic and myofibrillar fractions than does white muscle. Further studies will, hopefully, define either the control mechanisms responsible for the increased oxidative capacity of the muscle tissue or what has stimulated the regres-

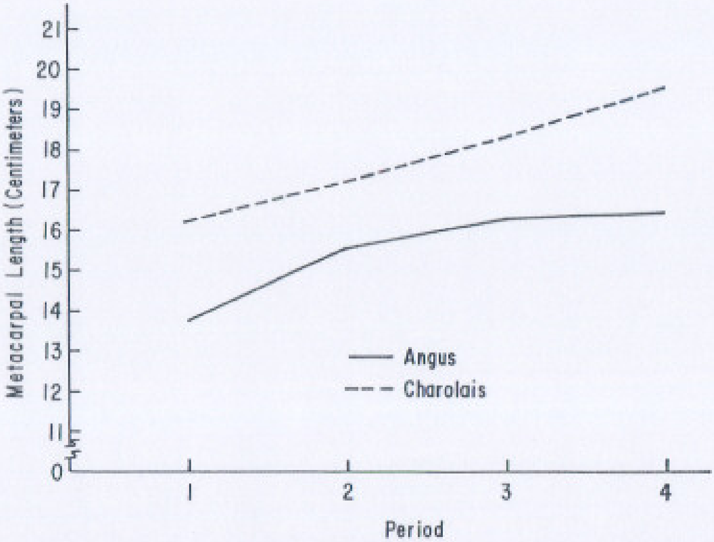

Figure 2. Metacarpal Length by Period

sion of the muscle fibers from glycolytic metabolism back to oxidative metabolism.

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Preliminary Studies on Breed Variations in the Rate of Deposition of Compact and Cancellous Bone During Pre-Weaning Growth in the Bovine

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Story in Brief

Six Angus and six Charolais steer calves were used to study the influence of animal scale on the rate of compact and cancellous bone deposition during pre-weaning growth in the bovine. Experimental data were obtained from radiograms of the left metacarpal bone of each calf taken at four periods during the calves' pre-weaning life. From the radiograms, visual changes in the periosteal and metaphyseal regions of the metacarpal bones were evaluated via a subjective score, based on a scale of 1 to 6.

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