OXIDATION OF GLUCOSE, ACETATE, PALMITATE, ALANINE AND LEUCINE IN SKELETAL MUSCLE OF CATTLE

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Samples of *musculus gluteus medius* were taken from three young bulls at 45, 90, 180 and 360 days of age. Homogenates of the muscle tissue were incubated with ^{14}C-labelled substrates and radioactivity of $^{14}CO_2$ was measured. Acetate, and up to 180 days of age also alanine, were oxidized more easily than glucose, palmitate and leucine. The highest oxidation rate of acetate was observed in samples of muscle tissue taken from calves at 90 days of age. Oxidation of other substrates was maximal at 45 days of age. During growth of bulls, the oxidation of palmitate, alanine and leucine exhibited greater rate of decline with age than the oxidation of glucose and acetate.

cattle; muscle; metabolism

INTRODUCTION

Skeletal muscles represent the largest protein store in the animal body. During ontogenesis, the ratio of muscle protein to total protein increases from approximately 30 to 45% for most animal species (Lobley, 1993). In consequence, muscles dominate the protein and biomass gain during growth. The principal energy sources for skeletal muscles of ruminants are acetate and glucose (Bird et al., 1981; Pethick, Lindsay, 1982). Other energy sources are non-esterified fatty acids and amino acids. The interaction of tissue biosynthesis and energy metabolism is influenced by the age and rumen status (pre-ruminant or ruminant condition). In our previous experiments, skeletal muscles appeared to be the principal site of leucine and alanine incorporation into proteins of suckling lambs (Vovk et al., 1993). In this study we compared the oxidation of several different substrates by homogenates of bovine muscle tissue and assessed the influence of age.

MATERIALS AND METHODS

Three male Holstein calves were fed whole milk until 45 days of age. Calves had a free access to meadow hay and concentrate since 30 days of age. From 46 to 90 days of age calves were fed skim milk, concentrate and fodder beet. In the last period of the trial, young bulls received concentrate, meadow hay and maize silage. Samples of *musculus gluteus medius* were obtained by the biopsy at 45, 90, 180 and 360 days of age and washed by cold 0.9% saline. Lean tissue (0.3 g) was homogenized at 0 °C in Krebs--Ringer phosphate buffer (3 ml; pH = 7.4), using the Elvehjem-Potter homogenizer. Radioactive compounds (1-^{14}C glucose, 1-^{14}C sodium acetate, 1-^{14}C sodium palmitate, 1-^{14}C leucine or 1-^{14}C alanine) were added to 37 kBq per 2 ml of homogenate. The mixture was incubated aerobically at 37 °C in the Warburg apparatus for an hour. Radioactive carbon dioxide was trapped in 0.1 ml 20% NaOH (w/v). The alkaline solution was mixed with a Bray--type scintillation fluid and the radioactivity of samples was measured in a SBS-2 liquid-scintillation counter.

RESULTS AND DISCUSSION

Our results are summarized in Tab. I. The highest oxidation rate (with exception of acetate) was found in homogenates of samples of *musculus gluteus medius*, taken at 45 days of age, i.e. from preruminating calves. The highest oxidation rate of acetate was observed in muscle tissue homogenates, sampled from calves at 90 days of age. The data document that the metabolic activity of young calves before weaning is higher than that of the same animals later. The extent to which acetate and other compounds tested are oxidized to CO_2 is of primary importance in evaluating the ability of the young calf to utilize these substrates. It is shown in Tab. I that rumen development between 45th and 90th day of age greatly increased the ability of the muscle tissue to oxidize acetate. Results of Young et al. (1965) indicated that young milk-fed calves, not actively producing volatile fatty acids, have the metabolic machinery necessary to obtain energy from their metabolism, in spite of the fact that only 3.6, 0.5 and 2.5% of expired CO_2 was derived from oxidation of acetate, propionate and butyrate, respectively. In contrast, acetate and glucose contributed 32–50% and 4–11%, respectively, of the total CO_2 output by lactating dairy cows (Bickerstaffe et al., 1974).

I. Radioactivity* of $^{14}CO_2$ released from labelled substrates in homogenates of bovine *musculus gluteus medius*

Substrate	Age (days)			
	45	90	180	360
1-^{14}C glucose	49 ± 10	26 ± 6	12 ± 1	15 ± 0.3
1-^{14}C acetate	177 ± 11	372 ± 18	87 ± 6	53 ± 1.0
1-^{14}C palmitate	32 ± 6	12 ± 3	5 ± 1	4 ± 0.3
1-^{14}C alanine	147 ± 9	134 ± 11	38 ± 1	12 ± 0.6
1-^{14}C leucine	76 ± 9	41 ± 3	32 ± 1	8 ± 1.0

Means ± SEM (n = 3)
* 10^3 cpm per 1 g of tissue

During growth of calves, the oxidation of palmitate, alanine and leucine exhibited greater rate of decline with age than the oxidation of glucose and acetate. Whereas in preruminating calves the rates of alanine and acetate oxidation were similar, in one-year old animals the rate of alanine oxidation was markedly (ca four times) lower.

Oxidation of leucine to CO_2 in muscle tissue homogenates was lower than oxidation of alanine. Also in suckling lambs, more alanine was oxidized to CO_2 than leucine after intraperitoneal administration of radiolabelled amino acids (Vovk et al., 1993). Oxidation of glucose was much lower than oxidation of acetate. It is the consequence of the fermentive nature of ruminant digestion. Ruminants absorb little or no dietary carbohydrates as hexose sugars and the glucose needs must be met by gluconeogenesis (Phillipson, 1961). It is more advantageous to convert glucose anaerobically to lactate, which is a substrate for hepatic glucose resynthesis, than to oxidize glucose irreversibly to CO_2.

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Oxidace glukózy, acetátu, palmitátu, alaninu a leucinu v kosterním svalu skotu.

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V kosterním svalstvu je obsažena téměř polovina proteinu živočišného těla. Přírůstky živé hmotnosti během růstu se realizují zejména ve svalové tkáni zvířat, která je klíčová i z hlediska tržního zhodnocení produktů chovu. Hlavními zdroji energie pro metabolismus svalové tkáně jsou acetát, glukóza, vyšší mastné kyseliny a aminokyseliny. Cílem naší práce bylo srovnat oxidaci hlavních substrátů homogenáty tkáně čtyřhlavého svalu bederního, odebrané biopsií třem mladým býčkům ve věku 45, 90, 180 a 360 dnů. Býčci byli v prvním měsíci života krmeni pouze mlékem a pak postupně převáděni na rostlinnou potravu. Úplně odstaveni od mléka byli ve věku 90 dnů. Použili jsme substráty radioaktivně značené a průběh oxidace sledovali měřením radioaktivity $^{14}CO_2$. Zjistili jsme, že acetát a do věku 180 dnů rovněž alanin byly oxidovány snáze než glukóza, palmitát a leucin. Největší rychlost oxidace acetátu byla pozorována ve vzorcích svalové tkáně odebrané ve věku 90 dnů. Ostatní substráty byly oxidovány s největší intenzitou již vzorky tkáně z prvního odběru, tj. ve věku 45 dnů. Tento časový rozdíl podle našeho názoru souvisí s nástupem bachorového trávení, které poskytuje intermediárnímu metabolismu velké množství těkavých mastných kyselin. V průběhu růstu intenzita oxidace obecně klesá. Rychlost oxidace palmitátu alaninu a leucinu klesala rychleji než rychlost oxidace glukózy a acetátu.

skot; sval; metabolismus

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