CARBON 13 KINETICS IN MILK, BLOOD PLASMA AND RED BLOOD CELLS OF DAIRY COWS

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Introduction

Plant species such as barley which use the Calvin (C_3) cycle in fixing atmospheric CO_2 during photosynthesis become depleted in ^{13}C, whereas species such as corn which use the Hatch-Slack (C_4) cycle remain less depleted in ^{13}C relative to the atmosphere under which they grow (Bender, 1971). Natural feeds can be used to formulate cattle diets with measurable differences in stable isotope concentration (Tyrrell et al., 1984). Six weeks after different diets were fed, CO_2 expired and milk, unlike blood plasma reflected dietary differences in ^{13}C. The objective of the present study was to determine the kinetics of $^{13}C/^{12}C$ ratios in milk, blood plasma and red blood cells after switching dairy cows from C_4 to C_3 based diet and *vis versa*.

Materials and Methods

Thirty-two lactating Holstein cows were assigned to two dietary treatments in a total mixed ration. Rations were made of 46.8% alfalfa silage, 8.3% timothy hay, 3.2% protein supplement, 1.6% minerals and vitamins supplement, 0.8% sodium bicarbonate and either 40.0% of cracked corn (TMR-C) or rolled barley (TMR-B) on a dry matter basis. Experimental treatments (T) were (1) TMR-C from d 1 to d 232 of lactation, (2) TMR-C from d 1 to d 209 and TMR-B from d 210 to d 232, (3) TMR-B from d 1 to d 232 and (4) TMR-B from d 1 to d 209 and TMR-C from d 210 to d 232. Feeding and management of cows and chemical composition of rations used in the present study were published elsewhere (Bilodeau et al., 1989). The $^{13}C/^{12}C$ ratios were measured every second week on feeds, two times before the diet change and every second day for the 1st 6 days and every four days for the following 16 days after the diet change in milk, blood plasma and red blood cells according to procedures described by Tyrrell et al. (1984). The isotopic composition of a sample, $\delta^{13}C$ (‰) is the difference per thousand between the sample $^{13}C/^{12}C$ ratio and the international standard Pee Dee Belemnite. Analysis of variance were performed on feed intake, milk production and composition data and t-test was used to compare the ^{13}C content values between treatments.

Results

Differences between the two periods (3 wk before and 3 wk after diet change) were significant ($P < 0.05$) for dry matter intake (20.6 ± .4 vs 17.4 ± 3 kg/d), milk production (22.3 ± .8 vs 18.9 ± .8 kg/d) and percent milk protein (3.46 ± .09 vs 3.52 ± .06) whereas percent milk fat (3.84 ± .09 vs 3.81 ± .08), feed efficiency (1.05 ± .04 vs 1.05 ± .03 kg 4% fat corrected milk/kg of dry matter intake) and body weight (697.3 ± 12.0 vs 708.1 ± 11.0 kg) were not different ($P > .05$). Feeding treatment had no effect ($P > .05$) on any of these variables. The average $\delta^{13}C$ (‰) content for TMR-C was −21.4 ± 0.9 compared to −26.7 ± 0.6 for TMR-B. Before the diet change, the isotopic composition of milk from cows fed TMR-C was close to that of the diet (figure 1). Two days after the diet change to TMR-B, milk ^{13}C content of cows decreased ($P < .05$) as compared to that of cows maintained on TMR-C (T1 vs 2). On the other hand, the opposite was observed in cows changed from TMR-B to TMR-C (T4) and those maintained on TMR-B (T3). Milk ^{13}C content equilibrium with the new diet was completed after six days ($P > .05$ between T1 vs 2 and 3 vs 4). The plasma ^{13}C content changed ($P > .05$) two days after the diet change but equilibrium was not reached by the time the observations were terminated after 22 days (figure 2). For red blood cell ^{13}C content changes ($P < .05$) could not be observed before six days and this change was minor in terms of absolute value

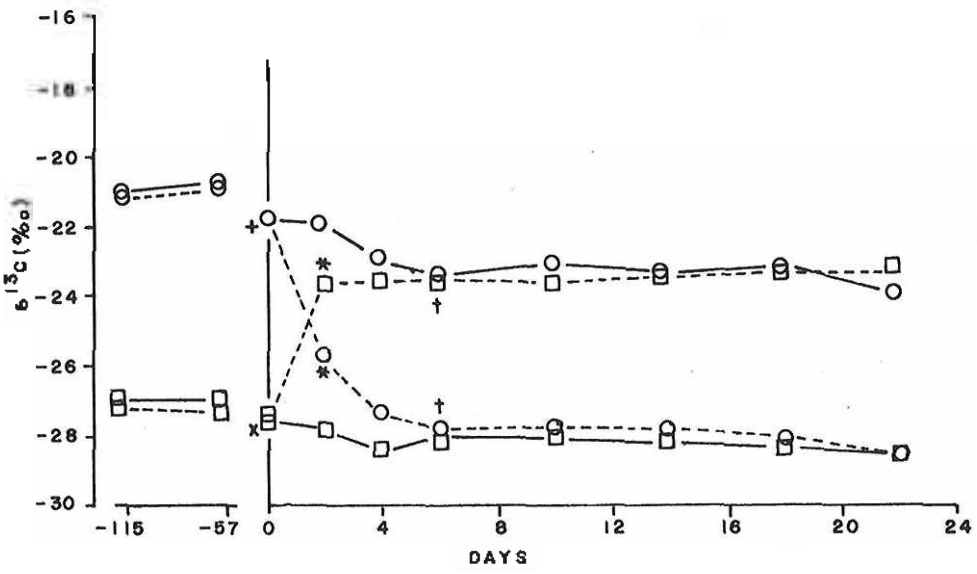

Figure 1. Effect of a diet change on $\delta^{13}C$ (‰) values of milk in dairy cows. Treatments are control cows maintained on corn (○— —○) or barley (□———□) based diets and experimental cows switched from corn to barley (○——○) or from barley to corn (□——□). Symbols + and X are $\delta^{13}C$ (‰) values of corn and barley based diet, respectively. Symbol * indicates first time diet changes were different ($P < .05$) and symbol † not different ($P > .05$) from respective controls.

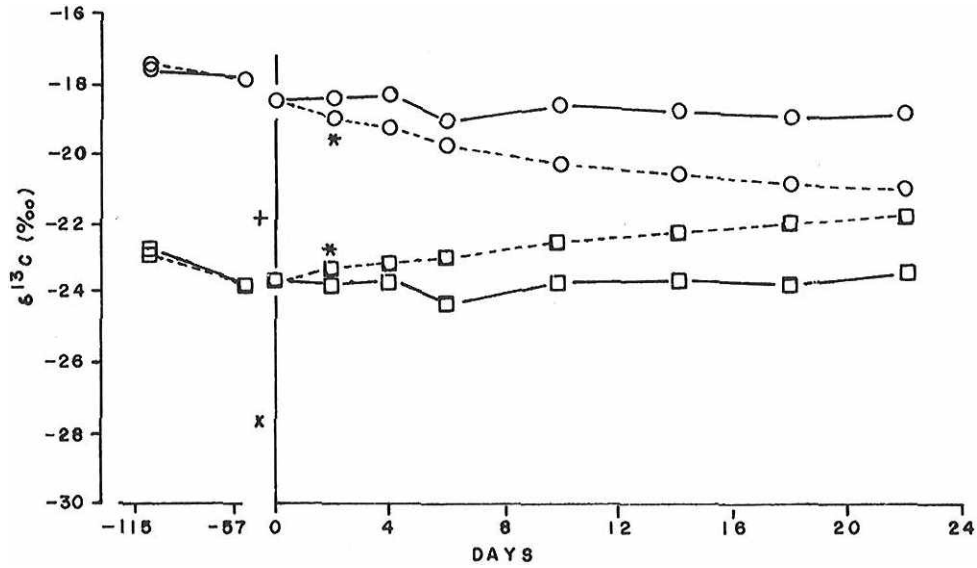

Figure 2. Effect of a diet change on $\delta^{13}C$ (‰) values of blood plasma in dairy cows. Treatments are control cows maintained on corn (○— —○) or barley (□———□) based diets and experimental cows switched from corn to barley (○——○) or from barley to corn (□——□). Symbols + and X are $\delta^{13}C$ (‰) values of corn and barley based diet, respectively. Symbol * indicates first time diet change were different ($P < .05$) from respective controls.

(results not shown).

Discussion

This study showed that the rate of change of $^{13}C/^{12}C$ ratios of blood constituents was different from that of milk. As expected, the faster change occurred in milk since the diet change was made during late lactation where precursors for milk synthesis are mainly derived from dietary sources instead of body reserves. Although a significant change in ^{13}C content of plasma occurred on d 2 after the diet change, it was minor in term of absolute value. Furthermore, the plasma ^{13}C equilibrium with the diet isotopic composition was not reached after 22 days. This phenomenon was observed previously after 6 wk of diet change (Tyrrell et al., 1984). The low rate of change of ^{13}C observed in red blood cells is probably the result of their development from bone marrow which ^{13}C content would be closer to the previous diet and red blood cells seem to have a long carbon turnover time. The present study showed that it is possible to formulate rations naturally enriched or depleted in ^{13}C to trace carbon in cattle.

(Key Words: Carbon 13, Kinetics, Dairy Cows)

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