

Serum Fatty Acid Analysis and Digestibility Study in the Vancouver Island Marmot (*Marmota vancouverensis*) Fed a Captive Diet Supplemented With α -Linolenic Acid

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Mammals that hibernate must rely on endogenous lipid reserves to survive over winter. This study was conducted to compare the difference in serum fatty acid composition, dietary intake, and apparent digestibility in the Vancouver Island marmot (N = 6) fed the Metro Zoo lagomorph diet supplemented with α -linolenic acid [C(18:3) n-3 (α -LA)]. The experiment was designed as a 3 \times 3 Latin square with three 17-day collection periods. The test diets contained 12.16, 14.85, and 17.05% α -LA as a percentage of fatty acids in the diet supplied through the addition of flaxseed oil (~53% α -LA). Across treatments, dry matter intake (g/d), dry matter digestibility, apparent fat digestibility, and apparent neutral detergent fiber digestibility did not differ significantly ($P > 0.05$). There were no significant differences in serum α -LA concentration between the three levels of α -LA supplementation. However, this supplementation did elevate serum α -LA, eicosapentaenoic acid [C20:5 (n-3)], and docosahexaenoic acid [C22:6 (n-3)] levels compared with feeding the basal zoo lagomorph diet ($P < 0.05$). Thus, supplementation of the basal zoo lagomorph diet with α -LA elevated the serum levels of essential fatty acids in the Vancouver Island marmot. *Zoo Biol* 20:251–259, 2001. © 2001 Wiley-Liss, Inc.

Key words: flaxseed oil; serum fatty acids; apparent digestibility

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INTRODUCTION

Mammals that hibernate (i.e., *Marmota vancouverensis*) must rely on lipid reserves as energy stores during hibernation. Some essential polyunsaturated fatty acids (EFAs) such as linoleic acid [C18:2 (n-6)] and α -linolenic acid (α -LA) [C18:3 (n-3)] cannot be synthesized by mammals and therefore must be obtained from the diet [Cook, 1985]. Dietary intake of EFAs may prove to be a challenge, especially in mammals that hibernate and fast for a prolonged period. The yellow-bellied marmot (*Marmota flaviventris*), a close relative to the Vancouver Island marmot, typically hibernates from September to May [Florant et al., 1990] and demonstrates circannual rhythmicity in body mass and food consumption [Ward and Armitage, 1981].

Free-living yellow-bellied marmots (*M. flaviventris*) typically double their body weight in the summer and preferentially consume plant species with high levels of linoleic acid and α -LA with much of this excess lipid stored primarily in white adipose tissue (WAT) [Florant et al., 1990]. Xia et al. [1993] demonstrated that non-essential fatty acids are oxidized more easily than EFAs, which are selectively retained in some tissues despite high rates of hepatic β -oxidation. These results indicate that polyunsaturated fatty acids may be preferentially retained and saturates oxidized more easily.

Geiser and Kenagy [1987] demonstrated that feeding a diet high in polyunsaturates to hibernating chipmunks (*Eutamias amoenus*) showed significantly longer bouts of torpor, lower minimum body temperatures, and decreased metabolic rates compared with those fed the saturated diet. A more recent study by Florant et al. [1993] indicated that yellow-bellied marmots fed an EFA-deficient diet arose more frequently from hibernation and therefore had significantly shorter hibernation bout lengths than control-fed marmots. The marmots that arouse more frequently from hibernation had lost more body mass by the end of hibernation [Florant et al., 1993]. Therefore, it appears a diet higher in polyunsaturated fatty acids will enable the hibernator to conserve more energy (i.e., lipid mass) during hibernation, thereby, improving winter survival.

Additionally, many hibernating mammals such as marmots store excess energy (above maintenance requirements) for reserves in the form of lipid, rather than storing food for consumption during this period. The additional energy required for hibernation can be obtained either by increasing feed intake or by reducing the energy costs associated with maintenance. Ward and Armitage [1981] demonstrated that yellow-bellied marmots reduce energy maintenance costs in the fall before the inactive season by lowering their metabolic rate (MR), thus implying changes in body mass late in the season (August to September) are more a function of reduced MR than of increased food consumption. Therefore, two physiological adaptations have evolved in the marmot to ensure winter survival: 1) preferential fatty acid oxidation during hibernation and 2) reduced MR.

The objectives of this study were to assess the effect of supplementing a basal marmot zoo diet with α -LA on serum fatty acid composition before hibernation and to compare the intake and apparent digestibilities between the diets.

MATERIALS AND METHODS

Diet

Three experimental diets were fed during the trial with graded levels of supplemental α -linolenic acid (α -LA) (Table 1). The fatty acid composition of the experi-

TABLE 1. Dietary chemical composition of experimental diets

Component	Basal diet	Experimental diets		
		Low	Medium	High
% dry matter				
Crude protein	19.61	15.62	16.18	16.23
Neutral detergent fiber	ND	25.50	25.10	25.10
Acid detergent fiber	ND	14.90	14.10	15.90
Calcium	1.08	1.25	1.26	1.20
Phosphorus	0.71	0.67	0.63	0.65
Potassium	1.31	0.99	1.02	1.02
Sodium	0.25	0.26	0.20	0.19
Crude fat	3.31	2.48	2.65	2.84
α -linolenic acid ^a	9.44	12.16	14.85	17.05

^aRepresented as a percentage of total fatty acids in the experimental diets. ND, not determined.

mental diets was very similar except for three graded levels of α -LA (Table 2). The Toronto Zoo lagomorph diet served as a basal diet to which additional flaxseed oil (Growmark, Mississauga, ON) was added as a source of α -LA. The basal lagomorph diet contained 9.44% α -LA, and the three test diets contained 12.16, 14.85, and 17.05% α -LA. The animals were fed the low diet (12.16% α -LA) 1 week before the start of the digestibility trial to normalize fatty acid status. Before the experiment, the animals were being fed the Toronto Zoo basal lagomorph diet with the inclusion of vegetables, browse, and various fruits.

Serum Fatty Acid Analysis

Blood was collected 2 weeks before commencing the digestibility trial (baseline) and at the end of each experimental feeding period. Marmots were anesthetized with a combination of ketamine hydrochloride (Ketaset; Ayerst Laboratories, Guelph, ON) 15 mg/kg and xylazine (Rompun; Bayer Animal Health, Etobicoke, ON) 1.5 mg/kg intramuscularly to facilitate blood collection. Blood was collected from the tibial or jugular vein into 10-mL non-heparinized Vacutainers (Becton Dickinson, Franklin Lakes, NJ). Blood was left to clot after collection, then the Vacutainers were centrifuged at 3,000 rpm for 10 minutes. After centrifugation, the serum was separated and frozen at -80°C until analysis.

Serum fatty acid analysis was conducted according to the methods of Wright et al. [1999]. Briefly, serum fatty acid composition was quantified after lipid extraction (two extractions with 1:2 chloroform:methanol vol/vol) and transmethylated in the presence of boron trichloride and gas-liquid chromatography (Lipid Analytic, Guelph, ON). Gas-liquid chromatography of the fatty acid methyl esters was determined using a Varian 3800 gas chromatograph (Varian, Palo Alto, CA) with a 30-m DB-23 capillary column with an internal diameter of 0.32 mm [Ferrier et al., 1995]. Identification of individual fatty acids was made by comparing samples with known standards.

Intake and Digestibility Trial

All feeding trials were performed in the animals' home pens at the Toronto Zoo, Toronto, ON. The experiment was performed from late July to September 1998, using six wild-caught Vancouver Island marmots (*M. vancouverensis*). Of these mar-

TABLE 2. Fatty acid composition (% of total fatty acids) for experimental diets

Fatty acids	Basal diet	Experimental diets		
		Low	Medium	High
C14:0	0.98	0.60	0.61	0.55
C:14:1	0.06	0.04	0.03	0.03
C15:0	0.04	0.21	0.19	0.17
C16:0	19.59	18.26	16.83	16.01
C16:1	1.02	0.32	0.16	0.17
C18:0	6.73	2.24	2.50	2.56
C18:1	22.30	14.93	16.22	16.59
C18:2 n-6	37.87	48.51	45.98	44.21
C18:3 n-6	0.01	0.00	0.00	0.00
C18:3 n-3 (α -LA)	9.44	12.16	14.85	17.05
C18:4 n-3	0.00	0.00	0.00	0.00
C20:0	0.36	0.35	0.32	0.32
C20:1	0.04	0.53	0.48	0.52
C20:2 n-6	0.17	0.14	0.13	0.12
C20:3 n-6	0.00	0.00	0.00	0.00
C20:4 n-6	0.03	0.04	0.03	0.03
C20:3 n-3	0.02	0.04	0.03	0.03
C20:4 n-3	0.01	0.07	0.06	0.06
C20:5 n-3 (EPA)	0.02	0.07	0.06	0.06
C22:0	0.44	0.46	0.45	0.40
C22:1	0.16	0.21	0.22	0.20
C22:2 n-6	0.10	0.00	0.00	0.00
V22:4 n-6	0.09	0.14	0.13	0.12
C22:5 n-6	0.00	0.00	0.00	0.00
C22:5 n-3	0.00	0.14	0.16	0.37
C22:6 n-3 (DHA)	0.08	0.00	0.00	0.00
C24:0	0.32	0.49	0.45	0.37
C24:1	0.05	0.07	0.10	0.06
Total (%)	100	100	100	100

α -LA, α -linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

mots, two were male and four were female. At the start of the experiment, the age of the marmots ranged from 13 to 73 months, and the weight ranged from 4.50 to 6.03 kg. The marmots used in the study were wild caught during the summer of 1997 and form the basis of a captive-breeding program.

Three 17-day feeding periods were used, consisting of a 10-day adaptation period, followed by a 7-day collection period. Marmots were housed as pairs except during the three 7-day collection periods, in which they were individually housed. The three pens were approximately 2.75 \times 4.30 m and were divided into six separate pens during the collection period. The feeding area was separated from the rest of the pen to reduce bedding contamination. Marmots were fed at approximately 95% of intake, which was determined during a 1-week adaptation period before the trial began.

Total orts remaining per pen were collected each day along with feces. Samples were frozen at -20°C for subsequent dry matter analysis. Urine was not collected during the trial. Before analysis, frozen fecal samples were thawed, pooled by animal and period, and placed in aluminum trays for freeze drying.

Feed and Feces Analyses

Oven dry matter determinations were performed on the feed, orts, and fecal samples using a 60°C oven for 48 hours. Feed and fecal samples were analyzed for crude protein (total N \times 6.25) using the macro-Kjeldahl procedure [AOAC, 1990], acid detergent fiber [AOAC, 1990; Undersander et al., 1993], and neutral detergent fiber according to Goering and Van Soest [1970]. Concentrations of Ca, P, K, and Na were determined using inductively coupled plasma spectroscopy [AOAC, 1990] using a Perkin-Elmer Optima 3000 spectrophotometer (Hartford, CT). Diet analysis was conducted by Agri-Food Laboratories (Guelph, ON).

Statistical Analysis

The experiment was designed as 3 \times 3 Latin square, balanced for residual effects, with 17-day periods. Paired marmots were randomly assigned to one of three pens. Analysis of variance was accomplished using the SAS general linear models procedure [SAS, 1990], and the least significant difference was used to compare treatment means. When appropriate, specific multiple comparisons were made comparing baseline blood values to treatment means. Statistical significance was accepted at $P < 0.05$.

RESULTS

Serum Fatty Acid Composition

Serum fatty acid composition is presented in Table 3. The low α -LA diet tended ($P = 0.06$) to increase α -LA serum values when compared with the other two test diets. However, closer evaluation of individual data showed one high serum value for one individual marmot. This value seemed quantitatively (i.e., more than three times greater than other measured physiological values) higher and was deemed aberrant and was removed from the data set. Upon re-evaluation of the data, no treatment effect was evident. However, when main effects (diet) were compared with baseline serum values, there were significant differences ($P < 0.05$) (Table 3). Inclusion of α -LA increased levels of C18:3(α -LA), C20:5 (n-3) eicosapentaenoic acid (EPA), C22:5 (n-3), C22:6 (n-3) docosahexaenoic acid (DHA), and total (n-3) ($P < 0.05$) compared with baseline values. A number of n-6 fatty acids also increased, specifically, C18:3 (n-6), C20:2 (n-6), C20:3 (n-6), C20:4 (n-6), and total n-6 percentages compared with baseline values.

Intake and Digestibility Trial

Dry matter intake (g/d), dry matter digestibility, the apparent digestibility coefficient (ADC) of fat and the ADC of neutral detergent fiber did not differ significantly ($P > 0.05$) between the treatment groups (Table 4). ADC for crude protein tended ($P = 0.06$) to be lower for the medium diet. ADC for acid detergent fiber was significantly lower ($P < 0.02$) in the group consuming the medium level of α -LA.

DISCUSSION

To date, we believe this to be the first report involving dietary supplementation of α -LA and serum fatty acid analysis in the Vancouver Island marmot (*M.*

TABLE 3. Serum fatty acid composition (% of total fatty acids) (mean \pm SE)

Parameter fatty acid	Baseline	Experimental diets			P-value
		Low	Medium	High	
C14:0	0.74 (0.07)	0.60 (0.09)	0.60 (0.09)	0.56 (0.09)	n.s.
C:14:1	0.07 (0.01)	0.08 (0.02)	0.06 (0.02)	0.07 (0.02)	n.s.
C15:0	0.08 (0.05)	0.11 (0.04)	0.10 (0.04)	0.08 (0.04)	n.s.
C16:0	16.49 (0.48)	15.25 (0.29)	15.94 (0.29)	15.25 (0.29)	n.s.
C16:1	2.40 (0.16)	2.57 (0.27)	2.12 (0.27)	2.10 (0.27)	n.s.
C18:0	9.52 (0.59)	9.60 (0.64)	10.44 (0.64)	10.66 (0.64)	n.s.
C18:1	51.71 (1.62) ^y	39.91 (2.50) ^x	36.21 (2.50) ^x	35.71 (2.50) ^x	n.s.
C18:2 n-6	13.88 (1.08) ^y	23.67 (2.07) ^x	26.47 (2.50) ^x	27.20 (2.50) ^x	n.s.
C18:3 n-6	0.02 (0.00) ^y	0.05 (0.01) ^x	0.04 (0.01) ^x	0.04 (0.01) ^x	n.s.
C18:3 n-3 (α -LA)	1.98 (0.05) ^y	4.12 (0.43) ^{1x}	2.60 (0.43) ^x	2.71 (0.43) ^x	0.06
	1.98 (0.05) ^y	3.18 (0.36) ^{2x}	2.60 (0.43) ^x	2.71 (0.43) ^x	n.s.
C18:4 n-3	0.05 (0.01)	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	n.s.
C20:0	0.08 (0.01) ^y	0.10 (0.004) ^x	0.10 (0.004) ^x	0.10 (0.004) ^x	n.s.
C20:1	0.37 (0.02)	0.42 (0.02)	0.37 (0.02)	0.39 (0.02)	n.s.
C20:2 n-6	0.50 (0.05) ^y	0.72 (0.02) ^x	0.61 (0.02) ^x	0.58 (0.02) ^x	n.s.
C20:3 n-6	0.09 (0.02) ^y	0.20 (0.02) ^x	0.24 (0.02) ^x	0.27 (0.02) ^x	n.s.
C20:4 n-6	1.23 (0.24) ^y	2.39 (0.22) ^x	2.71 (0.22) ^x	2.82 (0.22) ^x	n.s.
C20:3 n-3	0.06 (0.02) ^y	0.27 (0.09) ^x	0.08 (0.09)	0.08 (0.09)	n.s.
C20:4 n-3	0.01 (0.00)	0.01 (0.004)	0.01 (0.004)	0.0003 (0.004)	n.s.
C20:5 n-3 (EPA)	0.06 (0.01) ^y	0.14 (0.01) ^x	0.15 (0.01) ^x	0.14 (0.01) ^x	n.s.
C22:0	0.07 (0.01) ^y	0.09 (0.01) ^x	0.11 (0.01) ^x	0.10 (0.01) ^x	n.s.
C22:1	0.03 (0.00) ^y	0.04 (0.01)	0.06 (0.01) ^x	0.06 (0.01) ^x	n.s.
C22:2 n-6	0.00	0.00	0.00	0.00	n.s.
C22:4 n-6	0.08 (0.01)	0.08 (0.01)	0.09 (0.01)	0.09 (0.01)	n.s.
C22:5 n-6	0.00	0.00	0.00	0.00	n.s.
C22:5 n-3	0.13 (0.02) ^y	0.27 (0.02) ^x	0.33 (0.02) ^x	0.32 (0.02) ^x	n.s.
C22:6 n-3 (DHA)	0.05 (0.01) ^y	0.08 (0.01) ^x	0.09 (0.01) ^x	0.10 (0.01) ^x	n.s.
C24:0	0.25 (0.04) ^y	0.33 (0.04) ^x	0.34 (0.04) ^x	0.39 (0.04) ^x	n.s.
C24:1	0.07 (0.01) ^y	0.11 (0.02)	0.14 (0.02)	0.14 (0.02)	n.s.
Total n-3	2.34 (0.02) ^y	4.92 (0.40) ^{ax}	3.29 (0.40) ^{bx}	3.38 (0.40) ^{bx}	0.026
Total n-6	15.80 (1.38) ^y	27.1 (0.38) ^x	30.15 (0.38) ^x	31.00 (0.38) ^x	n.s.
n-3/n-6	0.15 (0.01)	0.19 (0.02)	0.12 (0.02)	0.12 (0.02)	0.08
Sat	27.22 (0.55)	26.03 (0.65)	27.62 (0.65)	27.15 (0.65)	n.s.
Unsat	72.77 (0.54)	75.14 (0.75)	72.38 (0.75)	72.85 (0.75)	0.07
Sat/Unsat	0.37 (0.01)	0.35 (0.01)	0.38 (0.01)	0.37 (0.01)	n.s.
Total fatty acid (mg/100ml serum)	1239 (267)	768 (58.4)	661 (48.4)	709 (48.4)	n.s.

¹value included, ²value not included.

Means within a row with different superscripts differ significantly ($P < 0.05$).

^{a-b}compare main treatment effects, ^{x-y}compare baseline value to treatment ($P < 0.05$).

α -LA, α -linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; n.s., not significant.

vancouverensis). Linoleic acid and α -LA, the precursors of the n-6 and n-3 family of fatty acids, respectively, are EFAs and have to be supplied by the diet [Nair et al., 1997]. On average, flaxseed oil, the source of α -LA used in this study, contains 53.3 g of α -LA acid per 100 g of raw oil [Bhatty, 1995]. Flaxseed oil also contains 13% linoleic acid [Hornstra, 1982], making flaxseed oil a good source of EFAs. Linolenic acid is the precursor to EPA [C20:5 (n-3)], and DHA [C22:6 (n-3)] [Holub, 1995]. These fatty acids can replace arachidonic acid [C20:4 (n-6)] produced from linoleic acid in the phospholipid membranes of platelets, erythrocytes, neutrophils, mono-

TABLE 4. Dry matter intake and apparent digestibilities of dietary components (mean ± SE)

Parameter	Digestibility of experimental diets (%)			P-value
	Low	Medium	High	
DMI (g/d)	95.7 (9.2)	83.7 (9.2)	84.2 (9.2)	n.s.
DMD (%)	66.50 (0.92)	65.00 (0.92)	67.50 (0.92)	n.s.
ADC CP (%)	63.61 (1.4) ^a	60.06 (1.4) ^b	65.43 (1.4) ^a	n.s. (0.06)
ADC NDF (%)	38.65 (2.0)	34.02 (2.0)	37.44 (2.0)	n.s.
ADC ADF (%)	30.94 (2.4) ^a	20.67 (2.4) ^b	33.76 (2.4) ^a	0.02
ADC fat (%)	85.58 (1.1)	87.44 (1.1)	87.43 (1.1)	n.s.

Means within a row with different superscripts differ significantly ($P < 0.05$).

DMI, dry matter intake; ADC, apparent digestibilities; DMD, dry matter digestibility; CP, crude protein; DNF, neutral detergent fiber or total cell wall; ADF, acid detergent fiber; n.s., not significant.

cytes, and hepatocytes [Simopoulos, 1991]. In the current study, α -LA, EPA, and DHA all significantly increased from baseline values after flaxseed oil supplementation. A number of n-6 fatty acids, specifically, C18:3 (n-6), C20:2 (n-6), C20:3 (n-6), and C20:4 (n-6), significantly increased in the marmots receiving the flaxseed oil-supplemented diets. This is likely due to the proportion of linoleic [C18:2 (n-6)] acid in the flaxseed oil. Through the process of elongation and desaturation, linoleic acid can be further metabolized into other n-6 fatty acids [Kinsella et al., 1990].

The importance of EFAs to hibernators cannot be underestimated. Florant et al. [1990] demonstrated that EFAs are preferentially stored in WAT of yellow-bellied marmots and may have a thermoregulatory role during hibernation. Thorp et al. [1994] reported that feeding an EFA-deficient diet [low in C18:2 (n-6) and C18:3 (n-3)] to yellow-bellied marmots increased MR during entrance to hibernation, deep hibernation, and arousal periods. This can prove to be energetically costly because arousals from hibernation can account for as much as 88% of the total energy expenditure during the winter hibernation period [Wang, 1989]. Also, marmots fed the EFA-deficient diet had significantly lower WAT percentages of linoleic and α -LA post-hibernation compared with control-fed marmots [Thorp et al., 1994]. These studies indicate the nutritional importance of EFAs in animals like the marmot, which hibernate and depend solely on lipid reserves. It is interesting to note in our study that serum linoleic values showed a higher increase than the α -LA values, even though flaxseed oil contains substantially more linolenic acid than linoleic acid. Florant [1998] commented after reviewing the current literature that linolenic acid concentration in neutral lipid from WAT and liver of marmots decreased significantly between the summer and hibernation periods. These findings suggest that α -LA might have some yet undetermined physiological role in hibernators [Florant, 1998] and that polyunsaturated fatty acids are preferentially retained and saturated fatty acids are oxidized more readily [Xia et al., 1993].

In our study, we were capable of improving the EFA status using supplemental α -LA compared with feeding just the basal lagomorph diet without compromising fat digestibility. Further research is required to determine whether improving the EFA status of marmots before hibernation has beneficial effects on hibernation and subsequent reproductive performance. Additionally, it would be worth investigating EFA concentrations in WAT because excess lipid is stored primarily in this site [Florant et al., 1990] and serves as an energy reserve during hibernation.

Why the low α -LA supplemented group showed the highest α -LA serum val-

ues compared with the medium and high treatment groups is unclear but may be explained by individual animal variation as experienced in this study and by the low number of animals used per treatment. The lack of treatment effect may be partially due to the fact that the length of supplementation was not sufficient to detect a significant difference, thus creating a carryover effect between periods. Alternatively, the relative difference between inclusion levels of α -LA between treatment groups may have been too subtle to detect physiological serum fatty acid changes. Because the diets formulated were similar in proximate analysis (Table 1), the observed difference in apparent digestibility of crude protein and acid detergent fiber may reflect true differences in individual digestive physiology. There are no comparable digestibility studies in the Vancouver Island marmot to compare current digestibility values. There was a non-significant trend for animals to consume less of the medium and high α -LA diets compared with the low dietary treatment, which may be related to the higher energy densities of these two diets because the three test diets were not isocaloric. The main objective of this study was to assess serum α -LA levels without changing any other dietary ingredients except the amount of fat in the diet. Precautions must be taken not to over-interpret the data because only two animals could be used per treatment. The nutritional literature base for the Vancouver Island marmot is sparse, if not devoid of literature on captive marmots. Therefore, the information provided here may prove helpful in the future for formulating diets of captive marmots.

CONCLUSIONS

1. There is a critical shortage of nutritional information on the Vancouver Island marmot fed a zoo diet. Knowledge of fatty acid metabolism and nutritional requirements of this species will aid in the formulation of well-balanced captive diets. Together with very few marmots in captivity and individual physiological variation, these factors may negate significant treatment effects. However, the main focus of this study was to improve the EFA status of the marmot and gather otherwise unknown digestibility information.

2. Inclusion of α -LA in the diet increased serum levels of C18:3 (α -LA), C20:5 (n-3; EPA), C22:5 (n-3), C22:6 (n-3; DHA), and total n-3 ($P < 0.05$) compared with baseline values. Improving the EFA status of marmots before hibernation may improve their capacity to survive over winter and subsequently improve reproductive performance.

3. Additional studies are required to assess serum fatty acid status post-hibernation in the Vancouver Island marmot fed a zoo diet enriched with α -LA. Because WAT is the preferable lipid storage depot before hibernation, analysis of WAT may prove to be beneficial in the future.

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