Study of carcass, organ, muscle, fat tissue weight, and concentration in rats fed CLA or its precursors by principal component analysis

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[1]*Livestock Development Division, Alberta Agriculture, Food and Rural Development, 7000-113 Street, Edmonton, Alberta, Canada T6H 5T6 (e-mail: laki.goonewardene@gov.ab.ca);* [2]*Agriculture and Agri-Food Canada, P.O. Box 3000, Lethbridge, Alberta, Canada T1J 4B1;* [3]*Department of Agriculture Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada T6G 2P5.*
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Goonewardene, L. A., Mir, P. S., Wang, Z., Okine, E. K., Mir, Z. and He, M. 2004. **Study of carcass, organ, muscle, fat tissue weight, and concentration in rats fed CLA or its precursors by principal component analysis.** Can. J. Anim. Sci. **84**: 537–543. Carcass, organ and muscle weight, and fat tissue data were obtained from 30 weaned male Wistar rats fed one of three diets, (10 rats/diet) over a period of 60 d. The diets were base with synthetic conjugated linoleic acid (CLA), sunflower oil or beef enriched CLA. The CLA diet contained the base diet and 18.2 g kg^{-1} of synthetic CLA (53% *cis* 9, *trans* 11 and 44% *trans* 10, *cis* 12) replacing 26% of the soybean oil, the sunflower oil diet contained the base plus 70 g kg^{-1} of sunflower oil replacing all the soybean oil, and the CLA-enriched diet contained the base plus 200 g kg^{-1} of beef enriched bio-formed CLA replacing the casein. Data were subjected to a principal component analysis (PCA). The first principal component (PC) extracted carcass weight, organ and muscle weight variables and accounted for 41.3% of the total variation. The second principal component included all of the fat tissue variables and accounted for 20.5% of the total variation. The rats fed the synthetic CLA diet were associated with high carcass, liver, kidney, heart, gastrocnemius and soleus muscle weights, and low retroperitoneal and inguinal fat weights, and adipocyte numbers in the fat tissues. In rat models, short periods of synthetic CLA feeding may have a greater impact on decreasing fat accretion in selected fat tissues than feeding CLA-enriched meat. The PC analysis provides means of combining into one or a few components traits that have similar responses, each component being orthogonal to all other components, whereas, in a conventional univariate analysis of variance each dependent variable is analyzed separately in relation to one or more independent variable.

Key words: Conjugated linoleic acid, feeding, principal component analysis, fat, muscle, accretion

Goonewardene, L. A., Mir, P. S., Wang, Z., Okine, E. K., Mir, Z. et He, M. 2004. **Poids de la carcasse, des organes, des muscles, du tissu adipeux et concentration de matière grasse chez les rats nourris d'ALC ou de ses précurseurs selon l'analyse des composantes principales**. Can. J. Anim. Sci. **84**: 537–543. Les auteurs ont déterminé le poids de la carcasse, des organes et des muscles ainsi que recueilli des données sur le tissu adipeux de 30 rats Wistar mâles sevrés auxquels trois régimes (dix sujets par régime) avaient été servis durant 60 jours. Le premier régime consistait en la ration de base plus 18,2 g par kilo d'acide linoléique conjugué (ALC) synthétique (53 % *cis 9*, *trans 11* et 44 % *trans 10*, *cis 12*) au lieu de 26 % d'huile de soja; le deuxième comprenait la ration de base plus 70 g d'huile de tournesol par kilo en remplacement de l'huile de soja et le troisième, la ration de base plus 200 g par kilo d'ALC bioformé de bœuf enrichi à la place de la caséine. Les données ont été analysées en fonction de leurs composantes principales. La première composante regroupait les variables associées au poids de la carcasse, des organes et des muscles et expliquait 41,3 % de la variation globale. La seconde incluait les variables associées au tissu adipeux et expliquait 20,5 % de la variation globale. Les rats recevant l'ALC synthétique se caractérisent par un poids élevé de la carcasse, du foie, des reins, du cœur, du *gastrocnemius* et du *soleus* ainsi que par un faible poids du gras rétropéritonéal et inguinal de même qu'une population réduite d'apidocytes dans les tissus adipeux. Dans les modèles reposant sur le rat, il se pourrait que l'administration d'ALC synthétique pendant de brèves périodes réduise plus l'accrétion des corps gras que l'administration de viande enrichie d'ALC dans certains tissus adipeux. L'analyse des composantes principales permet de combiner un ou plusieurs caractères réagissant de manière analogue, chaque composante étant orthogonale par rapport aux autres, alors que dans l'analyse classique de la variance, chaque variable est analysée séparément par rapport à une ou à plusieurs variables indépendantes.

Mots clés: Acide linoléique conjugué, alimentation, analyse des composantes principales, gras, muscle, accrétion

Conjugated linoleic acids (CLA) are a class of positional and geometric isomers of linoleic acid (C18:2), which have anticarcinogenic and antiatherogenic properties (Ha et al. 1987; Ip 1997). Linoleic acid has been identified as a precursor of CLA (Christie 1981; Mir et al. 1999) and feeding oils rich in C18:2 such as sunflower and canola have been shown to increase CLA in meat and milk of ruminants (Jiang et al. 1996; Mir et al. 1997; Mir et al. 1999). In some studies, feeding CLA has been shown to have an inhibitory

Abbreviations: **AIN**, American Institute of Nutrition; **CLA**, conjugated linoleic acid, **PCA**, principal component analysis

effect on tissue fat accretion in mice (Park et al. 1997, 1999) and swine (Dugan et al. 1997, 1999; Ostrowska et al. 1999) and to reduce the yield of milk fat (Loor and Herbein 1998; Giesy et al. 1999) in dairy cattle. However, the relationship between feeding CLA and fat reduction in humans has yet to be clearly established (Atkinson 1999; Blankson et al. 2000; Kelly 2001). The effects of CLA feeding on fat reduction in mice appear to be dose (intake) and fat tissue (region) dependent, and literature shows that the retroperitoneal fat depots showed a decrease at a lower dose of CLA, while inguinal, epididymal and mesenteric fat depots showed a reduction at higher dosage levels (DeLany et al. 1999). Further, Dugan et al. (1997) recognized a reduction in subcutaneous fat but not intermuscular fat in pigs when CLA oil was fed to pigs at 2% of the diet. As evidenced by the literature, feeding CLA or its precursors can have joint effects on different organs and tissues, and the groups of organs or tissues may respond differently to levels of CLA feeding. There is only limited information on the effects of direct (feeding synthetic CLA) or indirect (feeding CLA using an enriched product or a precursor) feeding of CLA and its effect on organs, muscles and fat tissues. These need to be elucidated on animal models before such research can be applied to humans.

Although a univariate analysis such as the classical analysis of variance could determine the cause and effect of one dependent variable at a time, joint effects can only be determined by a multivariate approach such as the principal component analysis (PCA). Furthermore, when a number of diverse responses (or dependent variables) are measured in the experimental unit, multivariate statistical methods such as principal component analysis makes it possible to identify the most important response variables described usually by a few components. The PCA transforms the original response variables into new axes or principal components (PC), which are orthogonal and independent of each other so that the data presented in each axis (component) are uncorrelated with all other components. Each PC is a linear combination of the original variables with coefficients being the correlations (loadings) between PCs and the original variables. The first PC accounts for most of the variation and the successively derived PCs account for decreasing amounts of the variation (Smith 1991). Thus, only the first few PCs are usually sufficient to describe the total variation. The size of the variation for each component (vector) is indicated by the size of the latent root or eigen value (Karlsson 1992). The PC analysis is not used often in animal studies although it is considered a very effective means of data reduction and/or grouping and sometimes precedes a regression analysis (SAS Institute, Inc. 1989).

As described by Naes et al. (1996) and Destefanis et al. (2000), the PCA yields two types of plots to describe the data, namely the loading plot and the score plot, and both plots are presented on an *xy* plane. The abscissa corresponds to the first PC and the ordinate the second PC. Samples that are to the right side of the score plot have high values for variables placed to the right of the loading plot. These relationships hold for positional space to the left, top or bottom of each plot. Objects close together in the plots have similar characteristics, and variables that appear close to each other are positively correlated, while those lying opposite each other are negatively correlated. The greater the positional distance from the axis origin, the better the variables are represented in that plane (Destefanis et al. 2000).

This paper uses the PC approach to analyze carcass, organ and muscle weights, fat tissue weights and adipocyte numbers in fat depots from a study of rats fed synthetic CLA, a CLA precursor diet containing sunflower oil and CLA-enriched beef, and describes the methodology and usefulness in combining a number of response variables into a few components.

Table 1. Composition of rat diets

	CLA	Sunflower oil	CLA-enriched beef
Ingredient (g kg^{-1} diet)			
Casein vitamin-free	200.0	200.0	–
L-cystine	3.0	3.0	3.0
Cornstarch	529.5	529.5	529.5
Alphacel	50.0	50.0	50.0
Sucrose	100.0	100.0	100.0
AIN-93G vitamin mix	10.0	10.0	10.0
AIN-93G mineral mix	35.0	35.0	35.0
Choline bitartrate	2.5	2.5	2.5
Soybean oil	51.8	–	70.0
Sunflower oil	–	70.0	
CLA	18.2	–	–
BHT	0.0134	0.0134	0.0134
Nutrient composition			
DM (%)	92.41	92.05	93.35
Total lipid (% DM)	11.95	8.00	14.07
Total protein (% DM)	20.51	20.91	12.92
Gross energy (Kcal g^{-1} DM)	4.92	4.88	5.24
Essential amino acids (% DM)			
Histidine	0.55	0.52	0.33
Theronine	0.87	0.85	0.40
Arginine	0.67	0.65	0.54
Tyrosine	0.84	0.80	0.22
Valine	1.29	1.28	0.46
Phenylalanine	1.02	1.01	0.37
Isoleucine	1.01	1.02	0.41
Leucine	1.91	1.89	0.77
Lysine	1.49	1.46	0.77

MATERIALS AND METHODS

Thirty weaned male Wistar rats were housed individually in cages and maintained on a 12-h light:dark cycle at 22 ± 2°C. Rats received pelleted non-purified diet and water for two weeks and animals with a mean body weight of approximately 51 g were allocated to three groups of 10, and each group received one of three experimental diets. The CLA group received a base diet (AIN-93) and 18.2 g kg^{-1} of soybean oil was replaced by synthetic CLA mixture containing 60% CLA, the sunflower oil group was given the base diet in which sunflower oil replaced the same amount of soybean oil which was a component of the base diet and the CLA-enriched beef group was given the base diet and 200 g kg^{-1} of dried CLA-enriched beef which replaced the same amount

Table 2. Means and standard deviations (SD) of the response variables

Response variable	Units	Mean	SD
Carcass weight	grams	270.34	22.88
Heart weight	grams	1.46	0.21
Liver weight	grams	17.54	2.41
Kidney weight	grams	2.92	0.33
Soleus muscle weight	grams	0.37	0.03
Gastrocnemius muscle weight	grams	1.84	0.16
Retroperitoneal fat weight	grams	5.40	1.96
Retroperitoneal adipocyte number	no fat cells mg fat^{-1}	1543944	900106
Inguinal fat weight	grams	6.76	1.81
Inguinal adipocyte number	no fat cells mg fat^{-1}	1572930	698521

Table 3. Correlations among carcass, organ and muscle weight and fat tissue variables[z]

	CAW	HTW	LVW	KDW	SOW	GNW	RFW	RAN	IFW
HTW	0.51*								
LVW	0.64**	0.59**							
KDW	0.56*	0.26	0.65**						
SOW	0.71**	0.44*	0.56*	0.62**					
GNW	0.86**	0.51*	0.57*	0.69**	0.71**				
RFW	0.54*	0.05	0.13	–0.02	0.31	0.23			
RAN	–0.0	0.15	0.10	–0.06	0.01	–0.12	0.29		
IFW	0.23	–0.20	0.07	–0.01	0.04	0.10	0.67**	–0.17	
IAN	0.06	0.13	0.05	–0.17	–0.08	–0.15	0.42*	0.58**	0.13

[z]CAW, carcass weight; HTW, heart weight; LVW, liver weight; KDW, kidney weight; SOW, soleus muscle weight; GNW, gastrocnemius muscle weight; RFW, retroperitoneal fat weight; RAN, retroperitoneal adipocyte number; IFW, inguinal fat weight; IAN, inguinal adipocyte number.
*, ** $P < 0.05$ and $P < 0.01$, respectively.

of casein in the base diet (Table 1). The base diet contained 200 g kg^{-1} casein, 3.0 g kg^{-1} L-cystine, 529.5 g kg^{-1} corn starch, 50 g kg^{-1} Alphacel, 100 g kg^{-1} sucrose, 10 g kg^{-1}of the American Institute of Nutrition (AIN)-93G vitamin mix, 35 g kg $^{-1}$ AIN-93G mineral mix, 2.5 g kg^{-1} choline bitartrate, 70 g kg $^{-1}$soybean oil, 0.0134 g kg^{-1} BHT, and was the recommended AIN diet for rats. The CLA-enriched beef was obtained from ribeye steaks by feeding beef steers a diet containing 6% sunflower oil on a dry matter basis. The fatty acid composition of the diets and CLA isomers was reported by Mir et al. (2003). Table 1 Provides detailed information on the three diets. The CLA used in this study was a feed-grade free fatty acid CLA containing 60% of CLA, in which 53 % was *cis*-9, *trans*-11 CLA isomer, 44 % was *trans*-10, *cis*-12 CLA isomer, and very little of the other isomers (Bioriginal Food and Science Corp., Saskatoon, SK). Experimental rats were fed ad libitum for 60 d. Every 2 wk body weight and feed intake were monitored. On day 60, rats were sedated with CO_2 and processed (Mir et al. 2003).

The fresh carcass, heart, liver, kidney, soleus and gastrocnemius muscles, inguinal and retroperitoneal fat pads were dissected and weighed. The organs were then stored at –20°C for further analysis. The number of adipocytes that existed in the fat pads was determined by an osmium fix method (Cartwright 1987). Duplicated 50-mg portions of tissue were fixed in osmium tetroxide. After removing the blood cells, stromal vascular cells and preadipocytes, the number of adipocytes was determined using a coulter counter. Experimental details on the rats, diets and assay procedures were reported by Mir et al. (2003). All rats were maintained according to the Canadian Council on Animal Care (1993) guidelines.

A total of 10 variables were analyzed and they included: carcass weight, heart weight, liver weight, kidney weight, soleus muscle weight, gastrocnemius muscle weight, retroperitoneal fat weight, retroperitoneal adipocyte number, inguinal fat weight and inguinal adipocyte number. The data were analyzed by PRINCOMP and CORR procedures of the SAS Institute, Inc. (1989). The PRINCOMP procedure standardizes the variables to a mean of zero and a standard deviation of one. The correlation matrix was used to generate principal component eigen values and associated eigen vectors. The loadings (eigen vectors) in each principal component were retained when the loadings were greater than the absolute average eigen value for that component (SAS Institute, Inc. 1989).

RESULTS

Table 2 shows the means and standard deviations for the 10 response variables while Table 3 shows the correlations between the variables. There were several significant ($P < 0.05$) correlations among the traits. The weight traits were in general positively correlated with each other and these traits were either negatively or not correlated with fat tissue weight and fat concentration traits. Within the fat depot measurements, the correlation between retroperitoneal fat weight and inguinal fat weight was high (0.67) and so was the correlation between retroperitoneal adipocyte number and inguinal adipocyte number (0.58).

The results from the PCA are shown in Tables 4 and 5 for the first two principal components. Two significant principal components were extracted from the data describing 41.3% (PC1) and 20.5% (PC2) of the variation, respectively. The first principal component had high loadings for carcass, organ and muscle weight traits, while the second PC had high loadings for the fat tissue weight and adipocyte number. Thus, all the data were adequately described by two principal components. In PC1, carcass and muscle weights had high contributions (15–17%) to the total variation followed by organ weight loadings (12–14%). In PC2, retroperitoneal fat weight and inguinal adipocyte number had high loadings (22%) contributing more to the total variation followed by retroperitoneal adipocyte number (17%) and inguinal fat weight (15%). The loading plot (Fig. 1)

Table 4. Principal component eigen values for the first two principal components (PC)

Principal component	Eigen value	Proportion of total variance (%)	Cumulative variance proportion (%)
PC1	4.13	41.25	41.25
PC2	2.04	20.47	61.72
ΣPC3-PC10	9.99	38.28	100.0

Table 5. Coefficients of the loadings (eigen vectors) for the first two principal components (PC)

Response variables	PC1 (%)	PC2 (%)
Carcass weight	**0.45***a* (17)	0.08 (3)
Heart weight	**0.31***a* (12)	–0.03 (1)
Liver weight	**0.39***a* (14)	–0.05 (2)
Kidney weight	**0.37***a* (14)	–0.23 (9)
Soleus muscle weight	**0.41***a* (15)	–0.06 (2)
Gastrocnemius muscle weight	**0.44***a* (16)	–0.11 (5)
Retroperitoneal fat weight	0.19 (7)	**0.55***a* (22)
Retroperitoneal adipocyte number	0.02 (1)	**0.42***a* (17)
Inguinal fat weight	0.08 (3)	**0.36***a* (15)
Inguinal adipocyte number	0.01 (0.3)	**0.55***a* (22)
Total loadings (absolute)	2.69 = 100	2.46 = 100

a Variables with loading greater than the mean of the absolute loading value in each principal component.

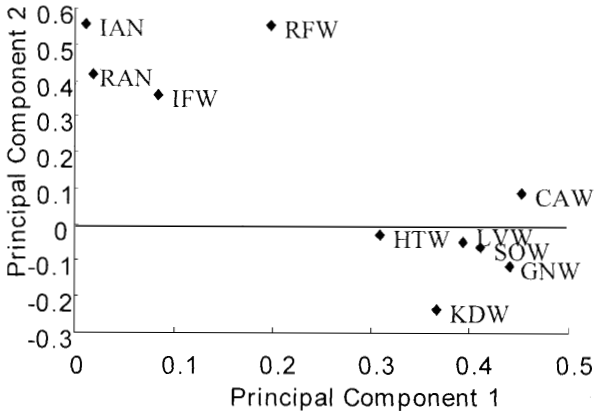

Fig. 1. Loading plot describing the relationship among carcass, organ, muscle, fat tissue weight and fat concentration. CAW, carcass weight; HTW, heart weight; LVW, liver weight, KDW, kidney weight; SOW, soleus muscle weight, GNW, gastrocnemius muscle weight; RFW, retroperotoneal fat weight; RAN, retroperitoneal adipocyte number; IFW, inguinal fat weight; IAN, inguinal adipocyte number.

showed that all the organ, muscle and carcass weight variables had large and positive loadings and were correlated with PC1, which was the component combining carcass, muscle and organ weight. All the organ and muscle weight traits had high positive loadings and appeared to be close to carcass weight, which had the highest positive loading (0.45). Thus, all the organ and muscle weights were clustered together and closely associated with carcass weight. This is confirmed by the correlations between carcass weight and organ and muscle weights, which were always greater than 0.51 (Table 3).

The fat depots and number of fat cells in the depots were described in and were correlated with PC2 (Table 5) as all the loadings were positive. Also in the loading plot these were spatially located far from the carcass, organ and muscle weight traits cluster (Fig. 1). The plot also shows that all the fat tissue measurements were positively correlated as they were close together in a cluster, and not associated (orthogonal) with weights of the carcass, organs and muscles.

The score plot (Fig. 2) showed that the samples from the diets (CLA, CLA-enriched meat and sunflower oil) were in two clusters. The CLA fed group appeared in one cluster and the second cluster contained the groups representing the rats fed sunflower oil and CLA-enriched meat. There was much overlap between the CLA-enriched meat and sunflower oil fed diet groups. This meant that there was some similarity in the response variables among these two diets. The rats on the synthetic CLA diet in general had lower scores for PC2 than those fed the other two diets. Thus PC2 described the differences in diets. Combining the information of the loading and score plots (Figs. 1 and 2), rats fed synthetic CLA in general had high values for the carcass, organ and muscle weight traits, but low values for the traits associated with fatness whereas, the rats fed either meat enriched CLA or sunflower oil showed high values for fat tissue weights and adipocyte numbers. The plots further suggest that feeding either CLA-enriched meat or sunflower oil will not have the same impact in reducing fat level and adipocyte concentration in fat tissues as would feeding synthetic CLA.

DISCUSSION

The PCA gives a global representation of the data in a two dimensional plane defined by two components in a multivariate type of analysis, which the conventional univariate analysis will not reveal. As each component is both independent and orthogonal, and the correlated traits within each component are identified, it is also more effective than the typical correlation analysis where pairs of variables are compared without taking into account other correlated variables and partial correlations. In a conventional univariate analysis of variance, these data would be analyzed by declaring diets as independent and each trait measured being a dependent variable. Such an analysis would identify differences between diets for each dependent variable. In the PC analysis, traits that are associated will be expressed as one group based on their loadings as a single component and the traits included in the second and subsequent components are orthogonal to each other. The PCA is therefore a good choice for grouping and data reduction, and as seen from our data, where a number of possibly similar and/or dissimilar variables are analyzed simultaneously. In our data, the muscle and organ weights were described in one component and

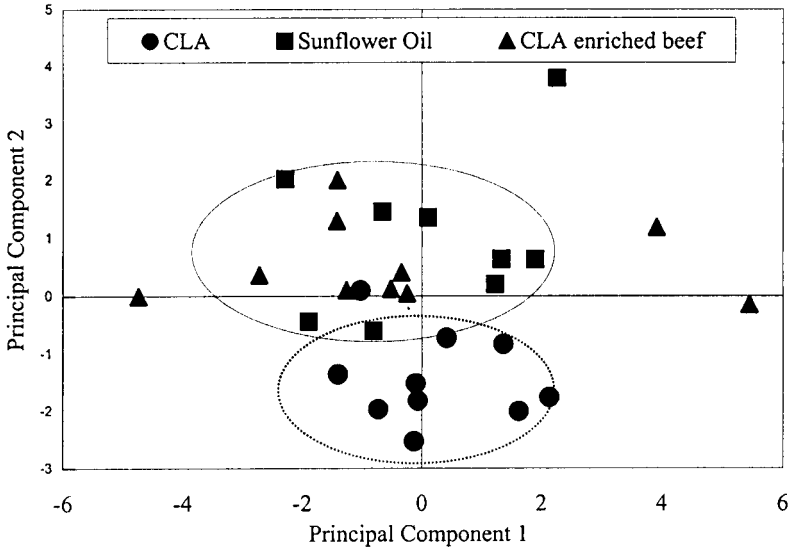

Fig. 2. Score plot of the two principal components.

orthogonal to that were the fat traits, which were described in a second component. However, there are times when the PCA approach is used that certain traits will not fit into any of the primary components.

Among the two fat depots the retroperitoneal fat tissue weight had a high loading of 55% for PC2 (Table 5), which indicates that this tissue responded to feeding synthetic CLA more than the inguinal fat depot. This finding agrees with DeLany et al. (1999) who showed that the largest dose-related decrease in fat accretion by feeding CLA was in the retroperitoneal fat depot. In addition, the dose of CLA required to elicit a response in this fat tissue was also lower than for other fat depots.

The mechanisms whereby CLA causes reduction in body fat accretion in growing animals is not clearly understood. Some of the mechanisms suggested are reduced de novo synthesis, reduced use of preformed fatty acids, increased rates of lypolysis and energy expenditure, apoptosis of adipocytes or a combination of some of these processes (DeLany et al. 1999; Kelly 2001). Further there is no consensus on how CLA affects lipid metabolism; thus mechanisms appear to be multifaceted (Bauman et al. 1999). However, the effect of CLA on decreasing fat accretion appears to be dose and tissue dependent, and the intake level of CLA required to reduce fat in the retroperitoneal tissue was less than the dose required for the inguinal body fat (DeLany et al. 1999). In addition, factors such as feeding duration, age and sex have been reported to affect the response to CLA feeding in mice (Kelly 2001; Poulos et al. 2001). The dose of CLA that is required to inhibit the synthesis of body fat appears to be higher than the dose required to inhibit of milk fat in dairy cattle (Ostrowska et al. 1999; Baumgard et al. 2000). In our study, the rats fed synthetic CLA received 110.52 (54.73 of 9 *trans*-11 and 55.80 of *trans*-10 *cis*-12) mg rat^{-1} d^{-1}, those on the CLA-enriched beef diet received 12.55 (11.46 of 9 *trans*-11 and 1.09 of *trans*-10 *cis*-12) mg rat^{-1} d^{-1}, and those on the sunflower oil diet received 0.89 (0.61 of 9 *trans*-11 and 0.28 of *trans*-10 *cis*-12) mg rat^{-1} d^{-1} of CLA (Mir et al. 2003). It was estimated from the study reported by DeLany et al. (1999) that with inclusion of CLA at 1% of body weight, mice consumed between 310–445 mg CLA d^{-1}, and at 0.75% of body weight mice consumed between 263 and 334 mg CLA d^{-1}, over a range of body weights. At these two rates of CLA feeding, fat accretion was decreased in the retroperitoneal, inguinal, epididymal and mesenteric fat depots (DeLany et al. 1999). It appears that the dosage of synthetic CLA used in our study was therefore adequate to reduce fat accretion in the retroperitoneal fat tissue but the dose in the CLA-enriched meat was not sufficient to elicit a response. Also, the CLA molecule exists as different isomers: *trans*-10 *cis*-12, *cis*-9 *trans*-11 (rumenic acid) and of these isomers, the *cis*-9 *trans*-11 octadecadienoic acid is the most abundant in milk and ruminant fat (Bauman et al. 1999; McGuire and McGuire 1999). However, in relation to decreasing body fat in growing mice it is the *trans*-10, *cis*-12 isomer that was active and the *cis*-9, *trans*-11 isomer is reported to have little or no effect (Bauman et al. 1999; DeLany et al. 1999; Park et al. 1999; Pariza et al. 2001). Our study showed that rats on the CLA-enriched beef diet were not associated with reductions in either retroperitoneal or inguinal fat. Furthermore, the predominant CLA isomer synthesized by ruminants is the *cis*-9 *trans*-11, although more of this isomer is found in milk fat than in beef fat (Bauman et al. 1999; Baumgard et al. 2000). Hence, in our study, the CLA-enriched beef diet probably had very low amounts of the *trans*-10, *cis*-12 isomer, which was inadequate to effect fat reduction in the two depots. A complete analysis of the fat

acids and CLA isomers in the liver, inguinal and retroperitoneal fat depots of the rats on the three diets were reported by Mir et al. (2003).

Based on the synthetic CLA composition where the *trans*-10 *cis*-12 isomer accounted for 44% of the total CLA, in our study the rats fed synthetic CLA received 174 mg of the *trans*-10 *cis*-12 CLA d^{-1}. Pariza et al. (2001) have indicated that the proportions of both the *cis*-9 *trans*-11 and *trans*-10, *cis*-12 CLA isomers in ruminant meat and milk are diet dependent. Feeding a milk fat depressing diet containing 70% concentrate, 25% forage and 5% soybean oil, the *trans*-7, *cis*-9 and *trans*-10, *cis*-12 CLA isomers were elevated and the *trans*-11-18:1 and *cis*-9, *trans*-11-18:2 were decreased in the milk of dairy cows (Piperova et al. 2000). Hence, by dietary manipulation, if the level of the *trans*-10, *cis*-12 CLA isomer can be increased in designer foods such as CLA-enriched beef, one could expect a decrease in fat accretion when humans consume such products in sufficient quantities.

CONCLUSIONS

The principal component analysis described carcass, organ and muscle weight and fat tissue data in two principal components. The first principal component identified carcass weight, organ and muscle weight variables and accounted for 41.3% of the total variation. The second principal component included all of the fat tissue variables and accounted for 20.5% of the total variation. The rats fed the synthetic CLA diet were associated with high carcass, liver, kindey, and heart, gastrocnemius and soleus muscle weights and low weight and numbers of adipocytes in the retroperitoneal and inguinal fat tissues. In rat models, short periods of synthetic CLA feeding may have a greater impact on decreasing fat accretion in selected fat tissues, but feeding CLA-enriched beef will have an effect only if sufficient levels of the specific isomer are present. In data that contain many response variables or traits, the PCA is an alternate method of grouping, and provides a means of combining into one or a few components traits that have similar responses, which are orthogonal to all other components. This multivariate approach provides information that a conventional univariate analysis of variance, linear correlation or regression would not.

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