The WALTHAM International Nutritional Sciences Symposia

No Effect of Conjugated Linoleic Acid or *Garcinia cambogia* on Fat-Free Mass, and Energy Expenditure in Normal Cats[1–3]

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EXPANDED ABSTRACT

KEY WORDS: • *Garcinia cambogia* • *fat-free mass* • *energy expenditure* • *cats*

Obesity can be defined as an increase in adipose tissue mass resulting from an imbalance between energy intake and energy expenditure. Obesity is influenced by both environmental and genetic factors and is a serious risk factor for metabolic diseases.

Dietary supplements could have an effect on adiposity and/or energy expenditure; thus, they could be effective in reducing body fat accumulation, preventing obesity and the occurrence of associated diseases or act as tools in the management of such diseases.

Traditional herbal medicines may have potential in managing obesity and might contain active components. *Garcinia cambogia* extract, containing (*-*)-hydroxycitric acid (HCA)[5], has been used as a dietary complement for weight management. Numerous studies in animals (1,2) and several randomized clinical trials in humans (3,4) tested the effects of *Garcinia cambogia* on weight. In humans, the results have been conflicting. To our knowledge, no study has yet been performed in cats.

Conjugated linoleic acid (CLA) is a natural substance found mainly in the tissue and milk fat of ruminants. Animal studies showed that CLA lowers body fat and increases lean body mass (5,6). The results of human clinical studies on the effects of CLA on body weight (BW) and composition are inconsistent (7,8). Here also, nothing is known about the effect of CLA supplementation on weight loss and energy expenditure in cats.

Taken together, all of these studies lead us to hypothesize that dietary supplementation with CLA or *Garcinia cambogia* could result in a loss of weight, or prevention of weight gain, resulting in a higher fat-free mass (FFM) in normal-weight cats.

Because BW stability is the result of the balance between energy intake and energy expenditure, we hypothesized that when the same amount of diet is fed, any weight loss could be explained by a higher energy expenditure.

The current study aimed to determine the effect of these 2 supplements on body composition, total energy expenditure (TEE), and least observed metabolism (LOM) of adult neutered cats; they represent the total amount expended and the lowest amount of energy expended, respectively, by the unfed individual at rest.

MATERIALS AND METHODS

Animals and diets

Normal-weight cats ($n = 24$; 12 female and 12 male, 5.5 y old, mean weight 2920 ± 120 g, all neutered, Domestic Shorthair) were used in this study. For the 6 mo before the study, all cats were fed 50 kcal/(kg·d) of a commercially available extruded food [340 g/kg crude protein and 14.64 MJ of metabolizable energy (ME)/kg as fed]. They were allotted to 3 groups, $n = 8$, on the basis of sex, BW, and body composition. During the study, each group was fed for 6 mo the same amount (75 kcal ME/kg BW) of 1 of the 3 experimental extruded diets (500 g/kg crude protein, 243 g/kg total fat, 205 g/kg starch, 45 g/kg total dietary fiber, and 16.62 MJ ME/kg as fed): control; control + 0.4% CLA (mixture 50/50 of *c*9,*t*11, *t*10,*c*12), and control + 0.3% *Garcinia cambogia* extract. Cats fed the CLA-supplemented diet consumed 60 mg/kg BW CLA mixture, and cats fed the *Garcinia cambogia*–supplemented diet consumed 45 mg/kg BW *Garcinia cambogia*. The BW and body composition were measured before and at the end of the study; TEE and the LOM were assessed at the end of the test period.

[1] Published in a supplement to *The Journal of Nutrition*. Presented as part of The WALTHAM International Nutritional Sciences Symposium: Innovations in Companion Animal Nutrition held in Washington, DC, September 15–18, 2005. This conference was supported by The WALTHAM Centre for Pet Nutrition and organized in collaboration with the University of California, Davis, and Cornell University. This publication was supported by The WALTHAM Centre for Pet Nutrition. Guest editors for this symposium were D'Ann Finley, Francis A. Kallfelz, James G. Morris, and Quinton R. Rogers. Guest editor disclosure: expenses for the editors to travel to the symposium and honoraria were paid by The WALTHAM Centre for Pet Nutrition.

[2] Author disclosure: Expenses for authors (V.L. and P.N.) to travel to the symposium were paid by Royal Canin and The WALTHAM Centre for Pet Nutrition.

[3] Financial support for this study was provided by Royal Canin, Aimargues, France.

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[5] Abbreviations used: BW, body weight; CLA, conjugated linoleic acid; FFM, fat-free mass; HCA, (-)-hydroxycitric acid; LOM, least observed metabolism; ME, metabolizable energy; TBW, total body water; TEE, total energy expenditure.

0022-3166/06 $8.00 J. Nutr. 136: 1982S–1984S, 2006.

Body composition

Body composition was determined from isotopic dilution of ^2H_2O before and after the diet. On the day of the study, cats that had been food deprived for 12 h were placed in individual cages for water restriction and body water equilibration from 2 h before to 3 h after tracer injection. Cats were injected s.c. (0.5 g/kg BW) with physiological saline ^2H_2O (99.9% $^2H/H$, Euriso-top). Venous blood samples were obtained before and 2.5 h after injection of the isotope, and plasma was stored at −20°C in sealed vials. Plasma deuterium was determined by Fourier-transform infrared spectroscopy as described previously (9).Total body water (TBW) was determined from the dilution space of the isotope. FFM was calculated as TBW/hydration rate of FFM, using a feline-specific hydration rate of 0.769 (10).

Energy expenditure

The LOM (11) was determined by indirect calorimetry. Cats were food deprived overnight, then confined to a metabolism chamber connected to a breath gas-exchange monitor (Deltatrac II metabolic monitor, Datex) for 14 h, which was calibrated 1 time/h using standard gas mixtures. The open-circuit system was ventilated by atmospheric air, which was pumped through the metabolism chamber at a flow rate of 4 L/min. The rate of CO_2 production (rCO_2) and O_2 consumption (rO_2) were calculated minute-by-minute after a 20-min equilibration period. TEE was calculated using the abbreviated formula: TEE = $[(1.11 \times rCO_2 + 3.94 \times rO_2) \times 4.184]$, where rCO_2 and rO_2 were expressed in L/d (12).

Because LOM is, in principle, the lowest amount of energy expended by the unfed individual at rest, the lowest value for each rolling 30-min period was used. This was calculated from the 15 min before and the 15 min after each reading. Reported LOM is the lowest observed 30-min value.

Statistics

The data are presented as means ± SEM. The effect of diet was investigated using ANOVA with diet as an independent variable. When ANOVA indicated a significant effect, the groups were compared (Student's *t* test for paired values). Differences with $P < 0.05$ were considered significant. All calculations were performed using Statview software (Abacus Concepts).

RESULTS

Body weight

Weight gain over the 6-mo period did not differ among cats fed control diet, *Garcinia cambogia*–supplemented diet or CLA-supplemented diet. When initial body was arbitrarily set at 100%, the BW increased 6 ± 2% in cats fed the control diet, 5 ± 2% in cats fed the *Garcinia cambogia*–supplemented diet and 5 ± 4% in cats fed the CLA-supplemented diet (data not shown).

Body composition

The percentage of body fat mass did not differ before and after 6 mo of consuming the control diet (31 ± 2% before and after the diet) (**Fig. 1**), or the CLA-supplemented diet (28 ± 2 and 29 ± 2%, respectively). Although the increase in BW and the decrease in FFM were not significant, the percentage of body fat mass was significantly higher after 6 mo of consuming the *Garcinia cambogia*–supplemented diet compared with the fat mass of the same cats before the study began (26 ± 3 and 32 ± 2%, respectively).

Energy expenditure

Dietary supplementation with either *Garcinia cambogia* or CLA did not affect TEE when corrected for BW (**Table 1**). Dietary supplementation did not affect LOM when corrected for BW or FFM.

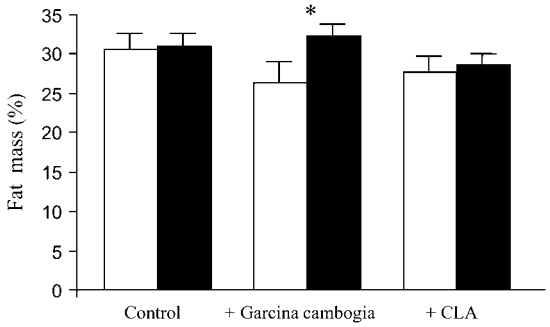

FIGURE 1 Percentage of fat mass before (□) and after (■) consumption of a control diet, a *Garcinia cambogia* diet or a CLA-supplemented diet for 6 mo. Data are presented as means ± SEM, $n = 8$. *Different from the percentage of fat mass in cats fed the *Garcina cambogia*–supplemented diet compared with the same cats before the study began, $P < 0.05$ (Student's *t* test for paired values).

DISCUSSION

Obesity can be considered as a chronic imbalance between energy intake and energy expenditure; thus, any dietary supplementation that might reestablish the balance is of interest.

Various supplementary ingredients that could increase energy expenditure, thereby lowering body fat, have been proposed. In this study, we wanted to assess whether supplementation with *Garcinia cambogia* or CLA could lead to a modification of energy expenditure and body composition in normal-weight cats.

The amounts of active compounds were chosen according to previous studies in humans (13,14), although the absorption rate and the bioavailability of these compounds in cats are unknown. Further studies should be conducted with different dosages to allow more comprehensive conclusions about the effect of these dietary supplements in cats.

In this study, cats were adult, nonobese, and their BW was nearly stable. It is possible that dietary supplements could be more effective in young growing cats, in which both lean mass and fat mass increase more than in adult cats whose weight and body composition tend to be stable.

We showed an adverse effect of *Garcinia cambogia* on body composition because the percentage of fat mass increased with no effect on energy expenditure. The increase in fat mass should obviously be considered in relation to physiologic relevance and the methodological error margin. Our method used the isotopic dilution of injected ^2H_2O in body water. TBW was determined from the dilution space of the isotope. Although the methodology has been validated and is accurate in dogs (9), it is not fully validated in cats, and further studies might be useful to achieve that goal.

TABLE 1

Effect of CLA or Garcinia cambogia on TEE and LOM in cats[1]

	Control	+ 0.4% CLA	+ 0.3% *G. cambogia*
TEE, *kJ/kg BW*	198 ± 9	215 ± 17	220 ± 13
LOM, *kJ/kg BW*	155 ± 9	158 ± 8	168 ± 7
LOM, *kJ/kg FFM*	218 ± 10	220 ± 9	244 ± 8

[1] Values are means ± SEM, $n = 8$. The effect of diet was investigated using ANOVA with diet as an independent variable. The 3 groups of cats did not differ.

HCA is the principal acid extracted from the rind of the Indian fruit, *Garcinia cambogia*, and is its active ingredient (15). It is available as an herbal supplement, commonly used in Southeast Asia as a food preservative, flavoring agent, and carminative. In recent years, HCA received considerable attention because of its putative weight reduction effects. Various studies tested these effects in humans and animals. The investigations into weight loss by HCA in humans are very controversial. Some authors concluded that *Garcinia cambogia* did not produce a significant weight loss and fat mass loss in overweight subjects (3,16) or in stable normal or overweight subjects (4), whereas some authors observed a weight loss (13,17). These differences could be explained by the different dosages used in these studies. Moreover, some studies tested the effect of *Garcinia cambogia* alone, or in combination with other compounds, or accompanied by a restrictive diet. Animal studies seem to be more unambiguous (1,2,).

The weight loss observed in rats after HCA supplementation can be explained by a decline in lipogenesis. HCA is a competitive inhibitor of the enzyme ATP citrate lyase (EC 4.1.3.8), which catalyzes the conversion of citrate and CoA to oxaloacetate and acetyl CoA, which is used in the synthesis of fatty acids, cholesterol, and triglycerides. This enzyme is particularly important during the lipogenic nutritional state produced by consumption of a high-carbohydrate diet (18). The putative weight reduction effect of HCA is due to suppression of fatty acid and fat synthesis. In addition, HCA could lower food intake in rats (19), via loss of appetite by stimulation of liver gluconeogenesis (20). Nevertheless, this anorexigenic effect was not observed in humans (17). Alternatively, an upregulation of genes encoding serotonin receptors was shown in adipose tissue in rats (21), which could represent the molecular target of HCA and explain the effect of its supplementation on adipose tissue.

Another part of this study was the effect of CLA on energy expenditure and body composition in cats. At the dose we tested, our results did not support any effect of CLA on BW, body composition, or energy expenditure in cats. CLA refers to a group of PUFA that are stereoisomers of conjugated dienoic octadecadienoate. CLA are produced by bacteria in the ruminant gut (22). CLA preparations are produced and result from isomerization of linoleic acid, containing primarily the *cis*-9, *trans*-11 and *trans*-10, *cis*-12 octadenoic acids in a 1:1 ratio. Various studies demonstrated that dietary CLA lower the proportion and amount of body fat in mice (23), rats (24), pigs (6), and humans (8). Other authors did not demonstrate any effect on BW and body composition in rats (25). The differences in efficiency between these results could be explained by the isomer chosen. An inverse association was shown between the *t*10*c*12-CLA isomer, but not the *c*9*t*11-CLA isomer, and BW in subjects with type 2 diabetes (8). No definitive mechanism has been found to explain the modifications of body composition that occurred in some animal studies. CLA might have different physiologic actions depending on the animal species, the genetic strain, or tissue-related responses (26). The peroxisome proliferator role that CLA is thought to play in mice (27) could explain the regulation of lipid metabolism and therefore its antilipogenic effect through binding and activation of peroxisome proliferator-activated receptor-α, and could explain the loss of BW observed in some studies.

The objective of this study was to assess the effects of dietary supplements on energy expenditure and FFM in cats. We did not show any effect of CLA or *Garcinia cambogia*. Further studies, with different component dosages in young growing kittens and/or in obese cats, are nevertheless warranted to allow comprehensive conclusions to be made about the effects of these supplements. In addition to determining the potential influence of CLA in preventing obesity and related diseases, it would be important to study possible modifications of adipose tissue and possible redistribution of adipose tissue in the body.

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