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A diet lower in digestible carbohydrate results in lower postprandial glucose concentrations compared with a traditional canine diabetes diet and an adult maintenance diet in healthy dogs

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ABSTRACT

The aim of this study was to compare the effects of three diets with varying macronutrient and fibre contents on postprandial plasma glucose, triglyceride, free fatty acid, and insulin concentrations over a 12 h period in 12 healthy neutered lean dogs. Each diet was fed to each dog for 3 weeks in a three-period cross-over study. Plasma analyte concentrations were measured prior to and after a meal at the end of the third week of each period. Postprandial glucose concentrations for the moderate carbohydrate and fibre diet were 0.4–0.7 mmol/L (8–12 mg/dL) lower than for both higher carbohydrate diets ($p \leqslant 0.02$). Postprandial glucose, insulin, and triglyceride concentrations in some dogs did not return to baseline by 12 h after feeding of each of the three diets. These results indicate that the moderate carbohydrate and fibre diet warrants evaluation in diabetic dogs. Variables should be measured over at least 12 h after feeding to fully evaluate postprandial dietary effects on these analytes.

1. Introduction

Dietary recommendations for diabetic dogs have been influenced by studies in human diabetes mellitus (Lean et al., 1992; Weinstock and Levine, 1988) and previous canine nutritional studies. Some of these canine studies investigated the effect of feeding high complex carbohydrate diets with varying fibre content and source to alloxan-induced and spontaneously diabetic dogs (Kimmel et al., 2000; Nelson et al., 1991, 1998), and found feeding high carbohydrate diets with high insoluble fibre (6.4–7.3 g/100 kcal) resulted in lower postprandial glucose compared with lower fibre diets (2.4–2.7 g/1000 kcal). Therefore diets traditionally recommended for diabetic dogs are high in complex carbohydrates (CHO) (50–55% metabolizable energy (ME)), moderate to high in dietary fibre (with a large proportion as insoluble fibre), contain high quality dietary protein in excess of minimum daily requirements, and are restricted in fat (Nelson and Lewis, 1990; Remillard, 1999). However no comparison has been made between high fibre and lower fibre diets containing moderate amounts of carbohydrate.

Recently, the results of two studies in diabetic and healthy dogs do not support the recommendation that diabetic dogs should be fed high carbohydrate diets with fibre content increased above that typically recommended for adult maintenance (Fleeman et al., 2009a; Hoenig et al., 2001). This is comparable to the current position of an expert committee for insulin-treated diabetic humans (American Diabetes Association, 2008). In the diabetic dogs, two moderate carbohydrate-high fibre diets (CHO 24–28%ME, TDF 4.6–5.2 g/100 kcal) provided no glycaemic or clinical benefit compared with a reduced carbohydrate diet containing moderate fibre (CHO 2%ME, TDF 2 g/100 kcal) (Fleeman et al., 2009a). While in the healthy dogs, varying dietary fibre content (TDF 0.9–4.9 g/100 kcal) in moderate carbohydrate diets (25–37%ME) did not significantly influence glycaemia (Hoenig et al., 2001). Re-evaluation of the traditional recommendation of high carbohydrate-high fibre diets for diabetic dogs is therefore necessary.

An important finding in one canine nutritional study was that the amount of starch or digestible carbohydrate was the main determinant of postprandial glucose concentrations when healthy dogs were fed a range of complete pet foods (Nguyen et al., 1998). This finding suggests that diets lower in digestible carbohydrate might result in a lower glycaemic response following eating, which may be of clinical benefit for diabetic dogs (Comazzi et al., 2008). In

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the canine study, postprandial response was only evaluated for 90 min following the meal (Nguyen et al., 1998). An investigation of postprandial responses over a longer period in healthy dogs might be of value without the confounding effects in diabetic dogs of exogenous insulin and variable glycaemic control. Results of such a study could provide a valuable basis for future studies in dogs with diabetes mellitus and dyslipidaemia.

Canine diabetes mellitus predominantly results from absolute insulin deficiency secondary to pancreatic beta cell destruction, and exogenous insulin is the main therapy (Alejandro et al., 1988; Montgomery et al., 1993). Blood glucose concentrations are not measured daily in most diabetic dogs and, once stabilized, exogenous insulin is usually given long term at a fixed dosage every 12 h with food (Fleeman et al., 2009b; Monroe et al., 2005). Therefore, the composition, timing, and amount of the meals needs to be consistent to minimise fluctuations in postprandial glucose concentrations and to reduce the risk of hypoglycaemia (Fleeman et al., 2009b; Remillard, 1999). This might be easier to achieve with the use of commercially available complete pet foods with consistent composition than with home made diets (Remillard, 1999).

Dogs and diabetic humans are considered to have increased risk of acute pancreatitis with triglyceride concentrations greater than 11 mmol/L or 1000 mg/dL (American Diabetes Association, 2008; Bauer, 2000). This is supported by various studies which found high fasting triglyceride concentrations in diabetic dogs and Miniature Schnauzers (Fleeman et al., 2004; Xenoulis et al., 2006), and high postprandial triglyceride concentrations in overweight and obese dogs (Verkest et al., 2008) were associated with laboratory evidence of canine pancreatic disease. Although the traditional diabetic diets have restricted fat content (10–25%ME) and low calorie density, and thus likely to result in lower postprandial lipid concentrations than moderate fat diets (20–35%ME), they may not be ideal for routine use because some diabetic dogs were found to lose excessive body weight when fed similar diets (Fleeman et al., 2009a; Graham et al., 2002). Therefore, triglyceride concentrations should be monitored in diabetic dogs, and diets with less restriction of fat content (for example, 25–35%ME) might be more appropriate in thin diabetic dogs (Fleeman et al., 2009a).

The aim of this study was to compare the effects of three diets varying in macronutrients and fibre content on postprandial plasma glucose, insulin, triglyceride, and free fatty acid concentrations over 12 h after eating in healthy dogs.

Comparison was made between a diet with moderate carbohydrate, high protein, moderate fibre and fat content; a diet high in carbohydrate and fibre with moderate protein and restricted fat (similar to that traditionally recommended for diabetic dogs); and a high carbohydrate, moderate protein, fibre and fat commercially-available, adult maintenance diet.

2. Materials and methods

2.1. Dogs

Twelve (six females and six males), clinically healthy, cross-bred dogs weighing 12–23 kg were studied. All dogs were considered healthy based on results of physical examination, routine urinalysis, haematology, serum biochemical analysis, and negative commercial heartworm antigen testing. Dogs were vaccinated using the standard canine viral vaccines and were on a monthly heartworm and intestinal parasite prophylactic regimen. Accurate ages of the dogs were not known but all dogs were estimated to be between 10 months and 3 years old. Dogs were acquired from council shelters and would otherwise have been euthanised. The dogs were re-homed as pets at the conclusion of the study. The study protocol was approved by the University of Queensland Animal Ethics Committee (425/04 and 570/05) and by the WALTHAM ethical review committee.

Table 1
Energy distribution expressed as percentage of metabolizable energy (%ME) and total energy content for the three test diets.

	Test diet	Traditional diet	Maintenance diet
Carbohydrate %ME[a]	25	55	45
Fat %ME[a]	32	23	31
Protein %ME[a]	43	22	24
Fibre g/100 kcal	3	10	2
Total ME kcal/100 g	351	288	378

[a] The composition of the three diets was determined using modified Atwater figures (National Research Council (U.S) Ad Hoc Committee on Dog and Cat Nutrition, 2006).

2.2. Experimental protocol

The three different processed diets were extruded dry formulations and varied in digestible carbohydrate, protein, fat, and fibre content, with the test diet (T1) having the lowest carbohydrate content at 25%ME, the traditional diet (T2) highest at 55%ME, and the maintenance diet (M)[1] intermediate at 45%ME (Table 1). Corn was the predominant source of digestible carbohydrate and poultry was the predominant fat and protein source in all diets. The diets were made and analysed by the same manufacturer, and varied in fibre and minor fat sources, and other additives (Table 2).

Three diets were compared in healthy dogs in a randomised controlled trial with cross-over design using meal feeding tests. Each dog was randomly assigned to one of the three diet sequences defined by a reduced 3 × 3 Latin square, by drawing the names of dogs from a container (Ott, 1993). The three diet sequences were M-T1-T2, T1-T2-M, and T2-M-T1. Each diet was fed for a 3 week period and followed immediately the next day by a meal feeding test with the diet being fed. A 3-week period was chosen to allow any carry-over effects from the previous diet to dissipate and effects of the new diet to stabilise. No wash-out period was used within each dog, and each diet was followed immediately by the next diet. Daily food requirement was initially calculated using the formula: maintenance energy requirement (MER) as kcal/day = 1.6 × resting energy requirement (RER) (Michel, 2000) and RER (kcal) = 70 + (30 × bodyweight (kg)). The amount of food fed was then adjusted on a weekly basis to ensure that each dog maintained lean body condition (4–5 on a nine point scale (Laflamme, 1997)), and that each dog's bodyweight did not vary by more than 5% between each of their three meal challenge tests.

2.3. Meal feeding test

Blood samples were collected at 1 h and 5 min prior to a meal, then 1, 2, 3, 4, 5, 6, 9, and 12 h after the meal. Dogs were weighed prior to their meal feeding test and the median quantity of food eaten on test days, based on total metabolizable energy, was 63 kcal/kg bodyweight. Blood samples were collected from the cephalic vein via an indwelling 20 gauge (1.1 × 30 mm) catheter[2] placed percutaneously (Elliott et al., 2010). Catheter patency was maintained by flushing first with 5 mL saline solution and then with 0.5 mL of 1 IU/mL heparinised saline solution after each sample. Prior to sample collection, 0.3 mL of heparin-saline diluted blood was removed and discarded. To minimise the effect of heparin on measured lipid concentrations, low-doses of heparin were used

[1] Royal Canin Medium Adult®, Royal Canin S.A., Aimargues, France.
[2] Twenty-gauge 1.16 inch. BD Insyte™ peripheral venous catheter (1.1 mm × 30 mm), Becton, Dickinson and Company, Sandy, UT, USA.