The effect of fibre on nutrient availability in cats of different ages

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Summary

A series of digestibility trials were carried out with 48 healthy adult cats aged between 18 months and 13 years to investigate the effect of soluble fibre (guar gum) and age on feed intake and apparent macronutrient digestibilities and faeces quality. Each cat participated in a 9–week study during which the response to two diets was evaluated. The first diet was a nutritionally complete canned cat food (total fibre content 0.2 %) and the second was the same product supplemented with 0.4% guar gum (total fibre content 0.6 %). Comparisons between diets were done using paired t tests. The data were also categorised by age group and the results compared using one way ANOVA. There was no effect of diet on food intake. The mean apparent digestible energy intake for all cats receiving diet 1 (standard) was 59.1 ± 17.4 kcal/kg BW/d while the mean intake for all cats receiving diet 2 (plus 0.4% guar gum) was 57.1 ± 17.0 kcal/kg BW/d. However, the inclusion of supplementary guar gum in the standard product significantly depressed the protein apparent digestibility ($p<0.05$). Fat, organic matter and energy apparent digestibilities tended to be lower, although these differences were not statistically significant. There was a significant ($p<0.05$) positive linear relationship between age and food intake and a significant ($p<0.05$) negative linear relationship between age and apparent macronutrient and energy digestibilities for both diets. Diet or age did not affect faeces quality.

Introduction

In recent years a wealth of literature (Wallace and Bell, 1982; Trowel *et al.* 1985; British Nutrition Foundation, 1990) has been published on the role of dietary fibre in human nutrition and its putative benefits for various metabolic and intestinal diseases. Analytically, dietary fibre can be classified as soluble (*e.g.* guar gum, pectin) and insoluble fibre (e.g. wood cellulose, oat fibre, wheat bran) which vary greatly in their physiological effects. For example, soluble fibres tend to depress macronutrient availability in the small intestine, increase intestinal transit time and are rapidly fermented in the colon (Jenkins *et al.* 1978; Delaunois et al, 1990), whereas insoluble fibres can decrease the intestinal rate of passage, are poorly fermentable and increase faecal bulk (Paylor *et al.* 1978; Vinik and Jenkins, 1988; Hansen *et al.* 1992). Much less information is available on the role of fibre in feline nutrition although some studies have been reported (Vock, 1982; Kienzle *et al.* 199 1; Sunvold *et al.* 1995; Papasouliotis *et al.* 1997) As in the human food industry, a variety of predominantly soluble fibre sources are used as gelling agents in canned cat food. These include guar gum, carrageenan, carob and xanthan. The purpose of this investigation was to evaluate the effect of a predominantly soluble fibre source (guar gum) on feed intake, macronutrient apparent digestibilities and faeces quality in healthy adult cats. In addition, studies were carried out using cats of a wide age range to provide information into the effect of ageing on digestive function in cats.

Material and methods

Animal health

Forty eight adult cats (18 neutered males, 30 entire females) aged from 1.5 years to 13 years of age participated in a series of digestibility trials which were carried out at the Waltham Centre for Pet Nutrition (WCPN). The mean (± sd) bodyweight of all cats was 3.7 (± 1.2) kg. Prior to the trials starting, every cat was given a dental examination, and where necessary, teeth were cleaned. To ensure that all the cats were of equivalent health status, the day before the trial started every cat was given a routine veterinary examination and haematological samples were taken for routine biochemistry and haematology, T3, T_4 and free T4. Although the cats at WCPN are virus-free, Feline Immunodeficiency Virus (FIV) and Feline Leukaemia

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Virus (FeLV) tests were carried out for completeness. During the course of the study every cat was weighed weekly. Urine specific gravities were measured daily. The blood measurements were repeated in the middle of the trial (biochemistry and haematology only) and at the end of the trial (biochemistry, haematology and thyroid hormones).

Diets

During the trial the cats were fed a nutritionally complete, canned and meat-based standard Whiskas® diet or the same diet containing supplementary guar gum *(0.4%).* The cans were processed by heat sterilisation for 60 minutes at 129°C in a retort. The proximate analysis of the two products is shown in Table 1. The protein content was measured by Kjeldahl and fat content by acid ether extraction. Total fibre, insoluble and soluble fibre was determined according to the method of the Association of Official Analytical Chemists (AOAC 1990). The insoluble and soluble fibre content of either diet could not been determined accurately, as the analytical methods are not sensitive enough at such low levels. The guar gum contained 86.9 % total fibre, 2 1.2 % insoluble fibre and 65.7 % soluble fibre.

Both products were designed to provide the same energy density. The predicted metabolisable energy (PME) was calculated using a regression equation (Kendall et *al.* 1985) based on the dietary protein, fat and nitrogen free extract (NFE, calculated by difference) content and was 74.2 and 74.3 kcal/100 g for Whiskas standard and Whiskas plus guar gum, respectively.

Experimental design

The cats were grouped according to age to enable the trials to be carried out sequentially. There were six groups of eight cats each in the age ranges (years) 1.5 to 2, 2–4, 4–6, 6–8, 8–10 and 12-14.

Over two feeding periods of 4 weeks, each diet was fed to 4 cats in each group according to a balanced design. The food was offered *ad libitum* with water freely available. Daily food intakes were recorded. The cats were allowed a one-week pre-feed of the diet, followed by a three-week feeding period during which time all faeces were collected. The three-week period was treated as three l-week collections, thus there were three digestibility values per diet for each animal. During the collection period, each defecation was graded subjectively for consistency using a 9–point category scale with 0.5 step increments. A grade one denotes a very hard and dry defecation and a grade five represents diarrhoea. Following collection the faeces were homogenized, freeze–dried and analysed for proximate nutrients using the same methodology as outlined for the dietary analysis. Gross energy content of food and faeces was determined by bomb calorimetry. The apparent digestibility coefficients of the macronutrients and energy were calculated by difference.

Data analysis

Each cat had three apparent digestibility values per diet that showed close agreement between successive collections. These values were averaged for each animal and the mean value used for statistical comparisons between animals. Individual results were compared using simple regression analysis with age as the independent variable and digestibility parameters as the dependent variables. Where there was significant linear regression the data were categorised by age group and the results compared using one way ANOVA.

Results

Animal health

Every cat tested negative for FIV and FeLV. The biochemical and haematological parameters, T3, T_4 and free T_4 levels and the urine specific gravities for all cats were within the normal ranges for adult cats, except for three animals. These animals displayed biochemical parameters slightly outside the normal ranges that may have been indicative of compromised renal function. As none of these cats displayed any obvious signs of ill-health and are probably representative of ageing cats their data were included in the statistical analysis. Over

Table 1 Proximate composition (%) of diets.

Nutrient Content (%)	Whiskas Standard	Whiskas plus 0.4% guar gum
Moisture	83.0	82.9
Protein	9.5	8.4
Fat	5.4	5.5
Ash	1.9	1.8
Nitrogen Free Extract*	0.2	1.4
Total Dietary Fibre	0.2	0.6

* Calculated by difference

the nine week trial period there was no significant change in bodyweight in any of the cats. There was no apparent effect of age on bodyweight for all cats (Figure 1).

Food intake

The inclusion of guar gum at 0.4 % in the standard product had no significant effect on food intake in cats across all age groups. The mean (± sd) food intake for all cats receiving standard Whiskas and Whiskas plus guar gum was 207 (± 66) and 280 (± 113) g/d, respectively. However, there was a highly significant negative linear relationship between age and daily food intake ($P<0.05$) for both products as presented in Figure 2. Cats in the oldest age group (12 -14 years) ate significantly more ($p<0.05$) of either diet than cats in the other 5 groups.

When expressed as apparent digestible energy (DE) intake in kcal/d or kcal/d/kg SW, no significant difference was evident between the two products and there was no significant effect of age (see Figure 3).

The mean (± sd) DE intake for cats fed standard Whiskas and Whiskas plus guar gum was 203.6 (± 40.2) and 198.6 (± 54.9) kcal/d, respectively. The mean DE intakes for individual cats showed a high degree of variation within each age category, independently of the diet given. The mean (± sd) apparent DE intakes in kcal/kg/BW/d for each age group are presented in Table 2.

Digestibility parameters

The protein digestibility coefficient was significantly reduced ($P<0.05$) in three of the age groups (4–6, 8–10 and 12-14 years) for cats fed Whiskas plus guar gum. There was a tendency for the test diet to exhibit lower fat, organic matter and energy digestibility doefficeints than the standard product but this trend was not significant. Despite these trends, all digestibility coefficients remained within the normal ranges. The group means for apparent protein, fat, organic matter and energy digestibility coefficients are presented in Table 3.

However, there was a significant negative linear relationship between age and apparent protein, fat, organic matter, and energy digestibility ($P<0.05$) with and without the inclusion of supplementary guar gum. The individual data are presented in Figure 4.

Faeces quality

There was no significant effect of supplementary guar gum on wet faeces output although there was a trend towards increased wet faeces output (per 1000 kcal DE eaten) when the cats were fed the test diet. The mean values per age group are presented in Table 4.

There was a significant positive relationship between age and wet faeces output (g/1000 kcal DE eaten) in cats fed standard Whiskas ($P<0.01$). The same relationship was seen in cats fed Whiskas plus guar

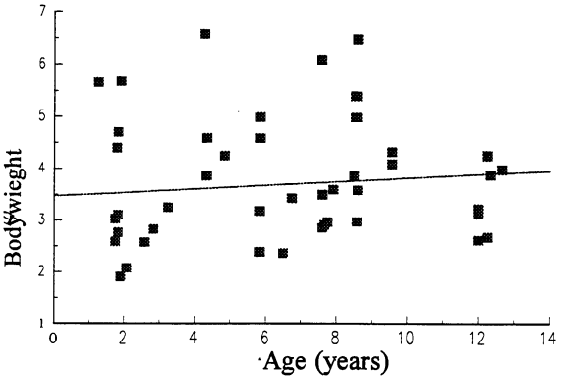

Figure 1 Relationship ($r^2=0.01$) between age and bodyweight in cats (n=47).

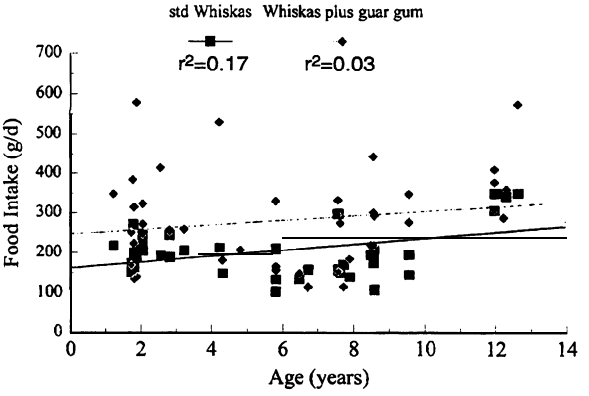

Figure 2 Food intake (g/d) in cats (n= 44) of different ages fed standard Whiskas and Whiskas plus guar gum.

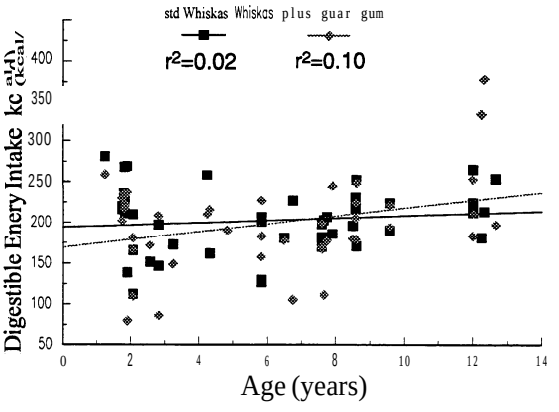

Figure 3 Apparent DE intake (kcal/d) of cats (n=44) fed standard.

gum ($P < 0.01$). This trend reflects the decline in macronutrient and energy digestibility that was observed. The individual data are plotted in Figure 5.

Although there was a tendency for the faeces quality to be decreased in cats fed Whiskas plus supplementary guar gum, these differences were not significant. The overall mean (± sd) faeces score for all cats fed standard Whiskas and cats fed Whiskas plus supplementary guar gum was 3.1 ± 0.6 and 3.2 ± 0.6, respectively. Additionally, there was no significant effect of age on faeces quality for either of the products.

Discussion

Food intake

Considering the relatively low level of inclusion of soluble fibre in the present trial, any response in food intake, digestibility, and faeces quality would be expected to be small. However, from a technical point of view, this inclusion level represents the threshold of guar gum inclusion to avoid production difficulties and textural problems. From a commercial point of view, it is highly unlikely that a canned cat product would contain higher levels of guar gum than used in the present trial.

Table 2 Mean (± sd) apparent digestible energy intakes (kcal/kg/BW/d) in cats of different ages fed Whiskas standard and Whiskas plus guar gum.

Age Group (years)	Standard Whiskas	Whiskas plus Guar Gum
1.5 – 2	65.0 ± 18.5	61.5 ± 16.2
2 – 4	67.5 ± 16.9	59.7 ± 20.2
4 – 6	44.9 ± 20.1	49.4 ± 11.7
6 – 8	59.8 ± 14.4	52.2 ± 18.6
8 – 10	49.5 ± 10.4	48.7 ± 9.4
12 – 14	66.2 ± 16.2	70.6 ± 17.2

All means not significant ($P > 0.05$).

Table 3 Mean (± sd) apparent protein, fat, organic matter (OM) and energy digestibility coefficients for cats fed standard Whiskas and Whiskas plus guar gum.

Age Group (years)	Protein		Fat		OM		Energy	
	Standard	Guar Gum	Standard	Guar Gum	Standard	Guar Gum	Standard	Guar Gum
1.5 – 2	0.84	0.82	0.82	0.86	0.80	0.80	0.81	0.80
2 – 4	0.85	0.83	0.83	0.87	0.82	0.82	0.83	0.82
4 – 6	0.84	0.79[a] ± 0.02	0.84	0.83	0.80	0.79	0.79	0.77
6 – 8	0.83	0.80	0.83	0.86	0.79	0.79	0.80	0.78
8 – 10	0.84	0.81[a] ± 0.04	0.84	0.82	0.80	0.79	0.81	0.76
12 – 14	0.82	0.77[a] ± 0.03	0.81	0.80	0.75	0.75	0.74	0.73

[a] Differences between diets not significant ($P > 0.05$) except for three instances in protein digestibility.

Table 4 Mean (±) wet faeces output (g/1000 DE kcal eaten) in cats of different ages fed standard Whiskas and Whiskas plus guar gum.

Age Groups (years)	Standard Whiskas	Whistas plus guar gum
1.5 – 2	163 ± 43	186 ± 35
2 – 4	147± 63	143 ± 31
4 – 6	177 ± 53	237 ± 85
6 – 8	248 ± 99	248 ± 127
8 – 10	194 ± 73	223 ± 98
12 – 14	276 ± 108	316 ± 107

All means not significant ($P > 0.05$).

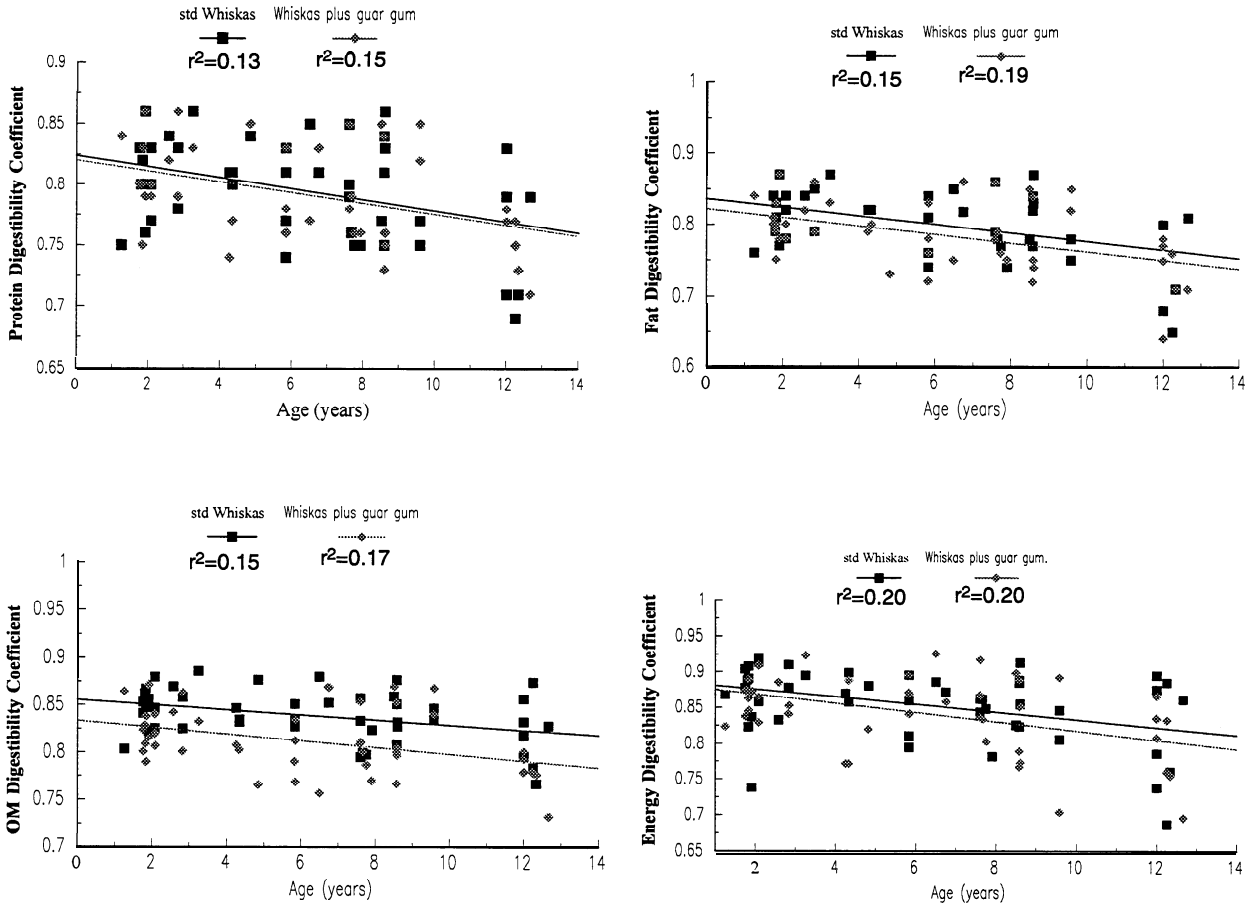

Figure 4 Apparent protein, fat, organic matter and gross energy digestibility in cats (n=44–48) fed standard Whiskas and Whiskas plus guar gum.

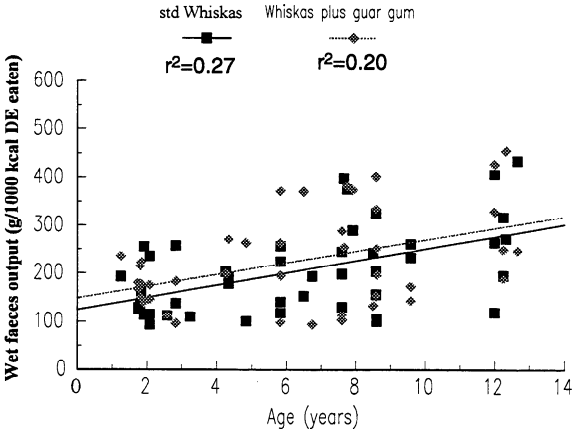

Figure 5 Relationship between age and wet faeces output (g/1000 kcal DE eaten) in cats (n=44–47) fed standard Whiskas and Whiskas plus guar gum.

The inclusion of 0.4 % supplementary guar gum in the standard product had no effect on food intake in cats across all age groups. Other studies investigating the effects of dietary soluble fibre on palatability have found a negative relationship between fibre content and food intake although these have generally been at higher inclusion levels than in the present study (Kienzle *et al.* 1991).

We found that the cats refused diets containing 5% pectin. Diets containing 5% dried apples or dried sugar beet pulp were also refused although the poor acceptance may have been related to factors other than soluble fibre content.

It is usually assumed that, as cats age, physical activity declines and energy intakes decline accordingly although there are no studies to support this assumption. In fact, one report has suggested that DE intakes remain constant in cats throughout adult life (Burger, 1994). The food intake data from the present trial indicated that the senior cats often tended to consume more than the younger adults. Thus, gross energy intake was higher which, it might be assumed, would lead to weight gain. However, since the older cats exhibited a decline in the apparent digestibility of energy, the overall DE intake was consistent across ages and thus all the cats maintained their bodyweight.

Digestibility parameters

Adding guar gum to the standard product had a significant negative effect on apparent protein digestibility in many of the cats and tended to depress apparent fat and energy digestibilities. Nonetheless, the apparent digestibility values remained within normal ranges. Vock (1982) when looking at the effect of different inclusion levels of carrageenan made similar observations in semi-purified diets fed to cats. Carrageenan tended to depress the digestibility of the major nutrients with a more marked effect as the inclusion level increased. Many other studies have reported that the addition of soluble fibres to standard diets results in decreased apparent protein digestibility and evidence suggests that this is related to the viscous nature of such fibres (Khokhar and Kapoor, 1990). The reasons for the reduced macronutrient digestibility in the present study may therefore be linked to the effect of guar gum on the viscosity of gut contents. Guar gum has been reported to increase viscosity and thereby increase gastrointestinal transit time (Roehring, 1988; Delaunois et *al.* 1990). Viscous solutions alter the convection of luminal contents by inhibiting digestion and by decreasing the access of products of digestion to the cell surface (Read, 1990).

The significant decrease in apparent protein and fat digestibility with age combined to give a highly significant decline in energy digestibility. Consequently, the older cats with compromised digestive efficiency consumed more food in an effort to meet daily maintenance energy requirements. The fact that apparent digestible energy intakes were not significantly different across all ages shows that cats with compromised digestive function increased intakes accordingly.

In contrast, Anantharaman-Barr *et al.* (199 1) reported that there were no significant differences in digestive efficiency in cats aged 1 year, 3-5 years and > 10 years. Nevertheless, even in this study the digestibility of fat in the oldest cats was shown to be 0.80 compared with 0.88 in the 3-5 year olds.

As the question over dietary protein content and renal failure in cats continues to be debated the present findings have significant implications for the design of senior cat products. Senior cat diets often contain low or moderate amounts of protein to compensate for the possibility of compromised renal function. Given the results of the current study it is recommended that the protein content of senior diets should not be reduced and at least be equivalent to the level in adult maintenance products.

Faeces quality

Both diets elicited faeces quality that was regarded as acceptable. The inclusion of guar gum in the standard diet tended to decrease faeces quality. Guar gum is a fermentable fibre and the end-products of fermentation, short-chain fatty acids, have an osmotic effect in the colon. This usually results in an increase in the faecal water content, often to the extent of diarrhoea. Thus the observed decrease in faeces quality and increased wet faeces output was probably linked to the fermentability of guar gum.

The observed significant positive relationship between age and wet faeces output in cats fed both diets is consistent with the decline in apparent macronutrient digestibility.

In conclusion, the addition of 0.4 % dietary guar gum to a standard canned cat food had no effect on feed intake but even at this low level tended to inhibit macronutrient digestibility in cats.

Comparison of present results with those of others studies are difficult as the amount and source of soluble fibre vary greatly and little research has been conducted in the cat. However, the findings seem to be in general agreement with reported effects of various viscous soluble fibres on nutrient availability, faeces consistency and wet faeces output.

The study showed a significant negative relationship between age and digestive efficiency in cats which, particularly with regard to apparent protein digestibility, tended to be exacerbated by the inclusion of supplementary guar gum. The level of gelling agents should therefore be kept to a minimum in products designed for senior cats in order to maximise nutrient digestibility.

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