IS SUGAR HARMFUL IN CATS' DIETS?

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Tim Watson examines the evidence for and against the view that sugar might lead to obesity and diabetes, and whether its addition improves palatability

IT is a criticism of cat foods – especially dry diets with a high carbohydrate content – that they might predispose animals to obesity and diabetes mellitus (Figure 1).

In part, this stems from the association, in humans, of the consumption of sugar-rich processed foods with these diseases and dental caries (Palou et al, 2009). The assumption that cats – as obligate carnivores that have evolved to consume meat-based diets – are poorly equipped to digest and metabolise carbohydrates can also contribute to such censure (Buffington, 2008). However, how valid are the concerns surrounding cat foods' sugar content? Is there any truth in the view that sugar is added to pet foods to improve their palatability?

This article addresses these issues, and examines the role of sugar in feline diets against the background of cats' nutritional evolution, metabolism and feeding behaviour.

The observational evidence and experimental data surrounding the potential contribution of dietary sugar to obesity, diabetes mellitus and dental disease are also reviewed.

Terminology

Use of the terms sugar and sugars can be confusing, not least when they are used interchangeably as synonyms for dietary carbohydrates. However, for nutritional purposes (as well as food labelling), the term sugar is strictly reserved for sucrose, and this is how it is used in this article.

Sucrose is a disaccharide composed of glucose and fructose subunits. Its most common form is as granulated or table sugar, which is largely extracted from sugar beet and sugar cane.

Monosaccharides (such as glucose and fructose) and disaccharides (such as sucrose and lactose) are collectively referred to as sugars or simple carbohydrates. Polysaccharides, such as starch (which consists of multiple glucose subunits), are called complex carbohydrates. Cellulose and other structural carbohydrates are termed non-starch polysaccharides or dietary fibres.

Whereas simple and complex carbohydrates are digested in the small intestine (Figures 2 and 3), dietary fibre is handled differently. Soluble fibres are digested via fermentation in the large intestine, whereas insoluble fibres are excreted, contributing to faecal bulk.

What makes cats carnivores?

Cats are strict carnivores and, in their natural habitat, consume prey that is rich in protein, with moderate amounts of fat and little sugar or carbohydrate.

This heritage is reflected in their requirements for dietary protein and specific amino acids, such as methionine and cysteine. These requirements in cats are substantially higher than those of dogs and other omnivorous species (Zoran, 2002). Cats also have an absolute requirement for preformed vitamins A and D, arachidonic acid and the amino acids taurine and arginine, which can only be met by the consumption of animal tissues.

The predominant food source for feral cats, as well as domestic animals that hunt, is small mammals such as mice and voles, along with rats, rabbits and birds. The protein content of these species is remarkably consistent – 56 per cent to 65 per cent on a dry matter (DM) basis – and generally contributes more than 40 per cent of metabolisable energy (ME) intake (Table 1). Fat content varies between 15 per cent and 33 per cent of DM, while carbohydrates make up between zero per cent and 12 per cent, and provide less than 10 per cent of ME.

Can cats digest sugars and carbohydrates?

Through evolution, cats have adapted to use protein and fat as energy sources, in contrast to dogs and other omnivores, which utilise glucose derived directly from dietary carbohydrates as their primary substrate.

Cats' adaptation to a diet naturally low in carbohydrates might explain why they lack salivary amylase – the enzyme responsible for the digestion of starch. Cats also have low activities of intestinal and pancreatic amylase, and intestinal disaccharidases (such as sucrase and lactase) compared with dogs. The activity of these enzymes cannot be induced by feeding cats increased amounts of sugars or starch (National Research Council – NRC, 2006).

Despite this, cats do not appear to have any difficulty in accommodating diets with varying amounts and types of carbohydrates. The apparent digestibility of glucose, sucrose and various starches in feline diets has been reported to be between 94 per cent and 100 per cent (Morris et al, 1977; Kienzle, 1993a; Kienzle, 1993b; de-Oliveira et al, 2008). High amounts of sucrose – 36 per cent on a DM basis or approximately 7g/kg bodyweight – can, however, result in diarrhoea.

The appearance of glucose and fructose in urine indicates that digestive and/or metabolic capacity is exceeded at such extreme intakes (Kienzle, 1994).

Cats have evolved as solitary hunters and so, unlike wolves (which hunt in packs), they generally take prey with a much smaller body mass than their own. This necessitates several kills per day – a pattern reflected in the way domestic cats take several small meals during the day, even when fed ad libitum. This grazing-type behaviour may help explain why, despite their relatively poorly digestive capacity, cats can tolerate diets with higher carbohydrate contents.

How much sugar and carbohydrate is in cat foods?

Typical wet cat foods contain around 50 per cent protein and 25 per cent fat on a DM basis, with dry foods comprising 35 to 45 per cent protein and around 15 per cent fat on a DM basis. The biggest difference between the two formats, and between dry foods and a prey-based diet, is in the carbohydrate content, which typically represents less than two per cent of DM in wet foods and around 35 to 40 per cent in dry foods (Figure 4).

The main source of carbohydrates in cat food is cereal grains, most commonly maize and wheat, and their by-products, such as flours and meals. These materials mainly consist of starch with some sugars (Table 2).

The total sugar content (all monosaccharides and disaccharides) of both wet and dry foods is very low – less than one per cent “as is” (Table 3). Contrary to popular belief, sucrose is not added during the manufacture of either wet or dry cat foods.

The total sugar and starch content of dry foods reflects the amount of cereals and cereal by-products contained within their recipes, and no sugars are added. Dry cat foods typically contain 20 to 35 per cent starch.

The predominant ingredients of wet foods naturally lack sugars and starch but, in certain circumstances, small amounts are added. For example, caramel is used to provide colour in some products at levels of up to 0.5g per 100g “as is” (equivalent to a total daily intake of about 1.5g).

Cat foods of the chunks-ingravy type may contain small amounts of starch as a thickening agent in the gravy or chunks, with the total amount around five per cent “as is”.

Dietary levels that have been proven to be safe in cats (referred to as safe upper limits) are specified for several sugars and carbohydrates (NRC, 2006). These limits equate to 50g/kg dry matter (DM) to 150g/kg DM for glucose and sucrose, and 50g/kg for lactose.

Although the safe upper limit for starch was specified as 240g/ kg in the NRC's 2006 guidelines (NRC, 2006), studies have confirmed diets containing nearly 400g/kg DM of starch are safe to be fed to cats (de-Oliviera et al, 2008).

Can cats taste sugars and do they influence food preferences?

The sense of taste in cats is believed to be similar to that of other mammals, with the notable exception that they are unable to taste sweet stimuli. This is endorsed by both behavioural evidence and molecular studies of taste receptor expression, which bear testament that cats cannot, and do not, select foods on the basis of sugar content (Li et al, 2006).

Feeding studies show that cats are neither attracted to, nor show avoidance of, the taste of sweet carbohydrates and high-intensity sweeteners (Bartoshuk et al, 1975). They do show a preference for selected amino acids – characteristic of specialised carnivores – and avoid stimuli that are bitter or sour (Beauchamp et al, 1977; Carpenter, 1956). Similarly, taste cells and nerve fibres show responses to salty, sour and bitter stimuli, as well as amino acids, but show no response to sucrose and several other sugars (Boudreau et al, 1971; Boudreau and Alev, 1973).

Is feline obesity related to dietary sugars and carbohydrates?

It is estimated that the prevalence of obesity in cats ranges from 19 per cent to 52 per cent (German and Martin, 2009).

Obesity has been linked to several dietary factors that include increased palatability, high energy and fat contents, and the practice of ad-libitum feeding (Diez and Nguyen, 2006).

Concerns that high carbohydrate intakes might be a factor in the development of feline obesity largely stem from the observation that cats fed commercially manufactured dry foods, especially premium brands, were at increased risk of obesity (Scarlett et al, 1984; Lund et al, 2005).

These findings have not, however, been replicated in other surveys (Robertson, 1999), and there is currently no epidemiological evidence that any association between dry foods and the risk of obesity is specifically due to the sugar or carbohydrate content of such foods.

Replacing dietary carbohydrates with protein has been shown to have no effect on weight gain in cats (Vester et al, 2009). Two earlier studies showed that weight gain is associated with the fat content, and not the amount or type of carbohydrate, in dry foods (Nguyen et al, 2004; Backus et al, 2007).

Put simply, there is no evidence from either observational or experimental studies to indicate that the prevalence of obesity in cats is linked to the consumption of dietary carbohydrates.

Does dietary sugar increase the risk of diabetes mellitus?

Estimates of the incidence of feline diabetes range from one in 50 to one in 400 cats, with experts suggesting the condition is being more commonly diagnosed (Rand et al, 2004).

Risk factors include advancing age, obesity, male gender, neutering, treatment with corticosteroids or progestins, physical inactivity and indoor confinement, together with a believed genetic predisposition in Burmese cats.

The majority of affected cats suffer from type-two or non-insulin dependent diabetes mellitus, which is associated with decreased sensitivity or resistance of the insulin's action, and eventual exhaustion of the insulin-secreting capacity of pancreatic beta cells.

Concerns have been expressed that this might be linked to the sugar and/or carbohydrate content of cat foods. In cats, the hepatic enzymes – responsible for processing glucose so it may be oxidised as a source of energy or stored – are minimally active (Zoran, 2002).

Low levels of these enzymes, and glucokinase in particular, are thought to be the reason why cats clear glucose from their bloodstream more slowly than either dogs or rats.

It is the potentially detrimental effects of increased and prolonged blood glucose concentrations following a meal that has led to speculation that diets rich in sugars or carbohydrates might play a role in the development of feline diabetes mellitus (Rand et al, 2004).

These fears were provoked by a study showing that cats fed a high-carbohydrate diet (46 per cent of metabolisable energy) had significantly higher blood glucose concentrations than when fed diets high in protein or fat (Farrow et al, 2002), and compounded by a demonstration that hyperglycaemia has detrimental effects of on beta cell function in cats (Zini et al, 2009).

Plasma glucose concentrations in the latter study were, however, at 30mmol/L, whereas peak glucose levels following consumption of dry cat food are typically much lower, at less than 8mmol/L (de-Oliveira et al, 2008).

Furthermore, there is no evidence that the long-term feeding of foods with high carbohydrate content impairs insulin sensitivity, diminishes insulin secretion or causes diabetes mellitus in cats (Slingerland et al, 2007; Backus et al, 2009).

The current consensus is that any impact of diet on the diabetes risk in cats is due to its association with obesity, rather than its nutritional composition. Feeding healthy cats foods rich in

carbohydrates will not, therefore, increase the likelihood of diabetes. However, it is appropriate to feed diabetic cats a diet high in protein and low in carbohydrates, because such foods have been shown to improve glucose control, reduce concurrent insulin requirements and improve the rate of remission (Frank et al, 2001).

Does sugar contribute to dental caries in cats?

Sugars play a key role in the aetiology of dental caries in humans because sucrose is a key substrate for bacteria that produce acid, which in turn attacks the surface of teeth or enamel. Caries are, however, uncommon in cats, and no evidence of an association with diet type or formulation has been reported (Crossley, 1991; Niemiec, 2008).

The very low incidence of dental caries in cats is likely to be related to two key factors.

Firstly, the feline oral cavity has a relatively high pH, which may result in the neutralisation of organic acids produced by bacteria that would, under a more neutral pH, be cariogenic.

Secondly, microbiological studies suggest that cats' mouths are not colonised by organisms of the mutans groups, such as *Streptococcus mutans,* which are the primary caries-inducing bacteria in humans.

Conclusions

Despite cats having evolved as carnivores and adapted to animal-based diets, they are able to digest and metabolise dietary sugar and carbohydrates at the levels typically found in wet and dry cat foods.

A consequence of this evolution, however, is cats' inability to taste sweet stimuli. For this reason, sugars play no part in determining dietary preferences or selection by cats, and the palatability of a food cannot simply be improved through the addition of sugar.

Concerns that diets rich in sugar or carbohydrates predispose cats to obesity and diabetes mellitus are unfounded. Dental caries, which have long been linked to sugar consumption in humans, are uncommon in cats and not associated with diet type or formulation.

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SUMMARY OF KEY POINTS

• Cats have evolved as carnivores, and adapted to animal-based diets rich in protein, with

moderate amounts of fat and little or no carbohydrate.

• Cats’ ability to digest and metabolise dietary sugar and carbohydrates is limited, relative to other species, but is effective at the levels typically found in cat foods.

• The sugar content of cat foods is well below the safe upper limit defined by expert bodies.

• One of the consequences of the cat’s carnivorous heritage is the inability to taste sweet stimuli, so the addition of sugar to a food has no effect upon its palatability.

• Observation and experimental studies have shown that diets rich in carbohydrates do not predispose cats to obesity or diabetes mellitus.

• Dental caries are uncommon in cats and there is no evidence of a relationship between sugar intake and other diseases.