

## **RABBIT NUTRITION – AN OVERVIEW**

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**Anna Meredith** discusses the importance feeding regimes have on pet rabbit health, from the choice of material to the introduction of new eating patterns

**FEEDING an appropriate diet to a rabbit is probably the single most important factor in maintaining its health.**

Rabbits are now the third most popular mammalian domestic pet in the UK. They are also an extremely important livestock species and laboratory model worldwide.

A great deal of literature relating to the nutrient requirements of production and laboratory rabbits is available, but relatively little relates specifically to pet rabbits.

Pet rabbits have the potential for much longer lifespans than the short-lived production or experimental rabbit. Many of the diseases commonly seen in pet rabbits can be directly attributed to, or associated with, the feeding of an inappropriate diet and could be largely prevented. However, manufacturers have responded to the need for good diets for pet rabbits, and in general the level of awareness of many of those involved with keeping pet rabbits has increased.

Rabbits are hindgut fermenters, adapted to digest a high-fibre diet consisting mainly of grass. The gastrointestinal tract makes up between 10 and 20 per cent of bodyweight, and in relative proportions, rabbits have the largest stomach and caecum of any monogastric animal. Gut transit time is rapid and eliminates fibre from the digestive tract as soon as possible, unlike other hindgut fermenters, such as horses (colon fermenter) and ruminants.

Gut retention in rabbits has been measured at about 17 hours, compared with 68 hours in cattle. In the wild, feeding takes place mainly in the early morning, evening and at night. Rabbits fed ad libitum have been shown to exhibit frequent feeding up to 30 times a day, of 2g to 8g intake over four to six minutes.

When considering the diet of a pet rabbit, it is important to be aware of the dietary habits of wild rabbits. In terms of their teeth and digestive system, rabbits are adapted to eat a herbaceous diet that is high in fibre, low in fat and low in starchy carbohydrates.

In a natural setting, wild rabbits select the most tender, succulent plant parts that are most nutrient-dense. They are referred to as concentrate selectors, allowing them to meet their dietary requirements in the minimum time above ground (when they are prone to predation). However, the natural diet is not “concentrated” to the same degree as commercial diets, and is still naturally high in fibre.

Pet rabbits will eat a wide variety of foods, but generally show a preference for fibre and often eat hay or straw rather than a concentrate ration. However, it can be difficult to persuade a rabbit to eat a new food item once it has become accustomed to a particular diet. Food preference is influenced by the mother’s diet at weaning.

Rabbit kits raised by mothers fed different diets during pregnancy and lactation show a clear preference for the diet of their mother at weaning (Bilko et al, 1994). It can be particularly difficult to persuade some rabbits to eat hay if they have not been introduced to it at an early age. In the wild, rabbits eat at dusk and dawn, and this is reflected in pet rabbits, which are most likely to eat in the early evening or overnight and may not appear hungry during the day.

The other source of nutrients is the caecotrophs, which are packets of partially digested food, bacteria and bacterial products, including vitamins, eaten directly from the anus. Cellulose, hemicellulose, pectin and lignin are mainly digested by the caecal bacteria, although a degree of pre-caecal digestion is thought to be achieved by pectinases and xylanases of microbial origin in the stomach and small intestine. Volatile fatty acids produced by the fermentative action of the caecal bacteria are absorbed across the caecal epithelium and used as an energy source.

Acetic acid (60 to 80 per cent) butyric acid (eight to 20 per cent) and propionic acid (three to 10 per cent) are produced, and proportions vary according to time of day, developmental stage of the rabbit and diet. Butyric acid is the preferred substrate for colonocytes, and the liver is the main organ to metabolise propionic and butyric acid.

Acetic acid is available for extrahepatic tissue metabolism. It is estimated that the rabbit obtains up to 40 per cent of its maintenance energy requirement from volatile fatty acids (VFA) produced by caecal fermentation.

Caecotrophy is affected by energy and protein levels in the diet. If the diet is energy deficient, rabbits will consume the total quantity of the produced caecotrophs. During ad libitum feeding, caecotroph intake depends on the protein and fibre content of the diet, being greater if the diet is lower in protein or higher in fibre (Fekete, 1989). Fibre also has an important effect, both on appetite and caecotrophy. Low-fibre diets depress voluntary food intake (Bellier and Gidenne, 1996) and diets high in fibre increase the rabbit's appetite for caecotrophs (Fekete and Bokori, 1985).

Sweet foods are generally palatable, and molasses is used in some commercial foods to improve palatability (Cheeke, 1994). Bitter tastes are also welltolerated, such as the saponins in alfalfa (Cheeke, 1987).

## **Links between diet and disease**

Low-fibre and high-carbohydrate diets are linked to dental disease, gastrointestinal disease, obesity and behavioural problems. Excess calcium in the diet can be linked to sludgy urine and urolithiasis in some rabbits, and deficiencies in calcium can be linked to the progression of dental disease.

### **• Dental disease**

Rabbit teeth are aradicular hypsodont and grow constantly throughout life.

The rate of growth should balance the amount of wear produced by grinding fibrous foods, so that tooth length stays constant. Incisor wear, growth and eruption are, in a normal rabbit, balanced at a rate of about 3mm per week. Food is ground by lateral movements of the cheek teeth.

A natural diet of grass and plants, high in silicates, is highly abrasive to cheek teeth, so there is rapid wear of around 3mm per month, with equally rapid tooth growth.

A high-carbohydrate and lowfibre diet will lead to reduced tooth wear and, therefore, elongation of the tooth both above and below the gum. This results in irregular wear, distortion and the formation of sharp, painful spikes. Severe elongation of the cheek teeth can prevent the mouth from closing fully, which ultimately prevents the incisors meeting properly, causing them to also overgrow. Overgrown distorted teeth are predisposed to infection and the development of facial abscesses.

High carbohydrate diets and reduced wear also predispose to caries.

Opinions vary on the significance of dietary calcium levels on dental disease. Many rabbits are selective eaters of coarse mix, favouring items low in calcium and fibre. This can make them prone to osteoporosis, poor tooth and bone quality, and dental disease. Bone growth, development and maintenance is also dependent on the mechanical stresses to which it is subjected. Rabbits that do

not spend prolonged periods grinding fibrous food can also show poor jaw bone quality.

Low vitamin D levels are common in rabbits that have no access to sunlight, and this may also be associated with poor tooth and bone quality. Although rabbits do not require vitamin D to absorb calcium, low levels of calcium and vitamin D are likely to be a significant factor in the progression of dental disease.

Not all dental disease is due to diet, and genetic factors are also important. A congenital maxillary brachygnathism, particularly in extreme dwarf and lop breeds, can also be significant.

### • **Gastrointestinal disease**

Controlling gastrointestinal motility is complex.

Motility is under the influence of the autonomic nervous system, prostaglandins and other hormones, but is also largely stimulated and maintained by a high throughput of indigestible fibre (lignocellulose). Motilin is a polypeptide hormone secreted by enterochromaffin cells of the duodenum and jejunum that stimulates gastrointestinal motility. Fat stimulates its release and carbohydrate inhibits it (Brewer and Cruise, 1994).

Fibre is thus critical to rabbits for gastrointestinal health because of its key role in stimulating and maintaining normal gut motility. Low-fibre diets predispose to gastrointestinal stasis.

Carbohydrates (simple sugars and starches) are an important energy source and are digested and absorbed in the stomach and small intestine.

However, any residual sugars or starch that are not digested and absorbed in the small intestine can pass into the caecum as a substrate for bacterial fermentation. This results in a rapid overgrowth in potentially pathogenic caecal bacteria, such as *Clostridium spiroforme*, which can lead to enterotoxaemia and fatal diarrhoea. This is seen mainly in young, recently weaned rabbits when fed minimal hay and combined with the stress of a change of diet and a recent move, for example from a breeder to a pet shop.

### • **Behavioural problems**

Wild rabbits spend many hours a day eating. With regards to pet rabbits, low-fibre concentrate diets are rapidly eaten and rabbits can develop vices related to boredom, such as increased aggression or repetitive bar biting. Lack of fibre can also lead to fur chewing and barbering.

### • **Obesity**

Fats are used in commercial rabbit diets to improve palatability and provide a non-carbohydrate

energy source. Fat also stimulates gastrointestinal motility, but reduces intestinal absorption of calcium.

Many “treat” foods contain high levels of fat (such as chocolate drops) and should not be fed. High fat levels also increase the risk of hepatic lipidosis developing during periods of starvation. Pet rabbits are prone to obesity, so high-fat diets and ad libitum feeding of concentrates should be avoided.

### • **Urolithiasis**

Excess calcium in the diet can contribute to sludgy urine or urolithiasis. Rabbits invariably have a much higher serum calcium concentration than other mammals – 30 to 50 per cent higher (Buss and Bordeau, 1984) – due to their unusual calcium metabolism.

Serum calcium concentrations reflect dietary intake, and fractional excretion is around 44 per cent, compared to less than two per cent in most mammals. Absorption from the gastrointestinal tract is not believed to be under the control of vitamin D3. Parathyroid hormone (PTH) and calcitonin protect rabbits from dangerous serum calcium levels.

Calcium is absorbed by both passive diffusion and active transport. Active transport does require a carrier protein synthesised in the intestinal mucosa in response to 1,25-dihydroxyvitamin D3.

Passive absorption is very efficient, and vitamin D is not required for absorption if dietary levels are adequate. The kidney is important for preserving or excreting calcium, and is mediated by PTH and vitamin D3. Although it is normal for rabbits to have calcium carbonate crystals in urine, overweight inactive animals, those with neurological or other problems affecting normal bladder function and emptying, or those with urinary tract infections, seem predisposed to developing disease problems associated with the build up of excessive amounts of “sludge” in the bladder.

Phytates, oxalates and acetates form complexes with calcium and other minerals, and this can hinder their absorption. Phytic acid is present in high quantities on grains and beans. Oxalates are present in many plants (including swede, spinach and alfalfa) in which 20 to 30 per cent of the calcium is in the form of calcium oxalate, which reduces its availability. Feeds high in calcium and low in oxalate include kale, broccoli, turnip, collard and mustard greens.

## **Dietary items**

### • **Grass and hay**

Grass provides a balanced source of protein, digestible and indigestible fibre, vitamins and minerals. Ideally pet rabbits should be allowed to graze for several hours a day. However, this can be impractical for house rabbits.

Grass is approximately 20 to 40 per cent crude fibre. Grass should be grazed or fed freshly cut. Lawnmower clippings should not be used, as they ferment rapidly and can cause digestive disturbance.

Hay should also be considered an essential part of the pet rabbit diet and should be provided ad libitum. Hay can be used as a substitute for grass, or fed in addition. Grass species used for haymaking in the UK include ryegrass, timothy, fescues, meadow grass and cocksfoot (orchard grass), and are generally referred to as meadow hay, often containing a mixture of species, including some clover.

Fibre content varies from 29.8 per cent (meadow grass) to 35.6 per cent (orchard grass). The protein content of grass hays is generally in the range of 6.3 per cent to 16.7 per cent. Quality will vary depending on the time of year. Cutting hay before flowering provides the best quality. Opinion varies as to the best age of hay to feed – some keepers recommend feeding hay that is at least four months old, as young hay may lead to diarrhoea, but others feed new hay with no problems. Prolonged storage of hay can lead to a loss of nutrients, especially vitamins A and D especially if the temperature is warm. Good hay is sweet-smelling, with no mustiness. Lucerne (alfalfa) is used widely in the US and other parts of the world for haymaking, but is not common in the UK.

It is high in protein (16.5 per cent) and calcium. It is, therefore, very useful for growing rabbits, but can lead to obesity and urolithiasis in mature animals. Other legume hays (such as clover) are similarly high in protein, calcium and energy, and are not recommended for adult pet rabbits.

Straw is not recommended as, although eaten, it is low in nutrients and will lead to deficiencies if it is a major part of the diet. Feeding silage is generally not practical, although it has been attempted in some countries.

Anecdotal reports on the use of artificially dried grass in rabbits have been received – they seem to find it very palatable. Nutrient content is often superior to sundried hay, although the vitamin D content will be lower and the carotene and vitamin E content can deteriorate with time unless it is stored correctly.

#### • **Mixes, pellets and extruded diets**

Pet rabbit food has traditionally been sold in the form of mixes, largely consisting of flaked, micronised or rolled cereals, legumes, extruded biscuits and grass pellets. Alfalfa stems are sometimes included as a calcium source and to increase fibre content. Pellets and extruded diets have been made available for pet use, as pellets have been used for commercial production rabbits for many years.

Harcourt-Brown (1996) found that pet rabbits offered mixed diets tend to favour the flaked peas and maize that are high in starch and low in calcium and fibre. Locust beans are sometimes

included, as they are sweet and palatable, but can be swallowed whole and cause intestinal obstruction. Owners tend to discard uneaten items and replenish the feeding bowl regularly, so that the complete balanced mixture of ingredients is never consumed.

Pelleted or extruded diets overcome the problem of selective feeding and provide a consistent ration. Extruded diets are now very popular for pet rabbits, incorporating long-fibre particles without the pellet becoming crumbly. The heated extrusion process improves starch digestibility and reduces carbohydrate overload of the hindgut, and extruded diets are more palatable and digestible than pellets.

### • **Edible plants**

Plants can be either commercially available or wild. Green leafy plants are recommended. Commercially available examples are broccoli, cabbage, chicory, chard, parsley, watercress, celery leaves, endive, radicchio, pak choi, dock, basil, kale, carrot and beet tops.

Wild plants include bramble, dandelion, chickweed, plantain, sunflower, wild strawberry, dock and yarrow.

Green plants are useful to provide variety, micronutrients, water and some dental wear, but it should be remembered that as they are generally 90 to 95 per cent water and often relatively low in fibre, excessively large amounts would need to be consumed to fulfil daily needs. Therefore, they should not be fed in very large quantities.

Any greens should be introduced gradually and preferably fed consistently for caecal bacteria to adapt.

## **Food intake**

Many factors affect food intake, including size, age, environmental temperature and reproductive status. However, very little published information is available for pet rabbits.

Although production rabbits may eat to meet their energy requirements, this is not the case with many pet rabbits that frequently overeat and become overweight or obese. Conversely, if very low-protein and high-fibre diets are fed, especially to small breeds, energy intake may be limited and result in poor growth or weight loss.

Disease states usually increase energy needs but decrease food intake. House rabbits kept in warm ambient temperatures may require less energy than outdoor rabbits, depending on their level of activity.

Neutered rabbits may also require less energy due to reduced activity.

Growing rabbits should be expected to eat up to twice the amount consumed by an adult. Lactating does will eat up to three times the amount usually consumed, but their energy needs often exceed capacity for food intake and weight will be lost.

## Conclusion

Feeding the correct diet to rabbits is fundamental to maintaining health, particularly of the dental and digestive systems.

The best diet for rabbits is one that mimics as closely as possible their natural grass-based diet in the wild. Grass is approximately 20 to 25 per cent crude fibre, 15 per cent crude protein and two to three per cent fat.

The bulk of a pet rabbit's diet should consist of grass and/or good-quality meadow/timothy hay, and this should be available at all times. Hay can be fed from racks or nets to minimise contamination and increase the time spent feeding.

Green foods are also important and a variety should be fed daily to rabbits of all ages. They should be introduced to weanling rabbits gradually. Examples include broccoli, cabbage, chicory, chard, parsley, watercress, celery leaves, endive, radicchio, pak choi, dock, basil, kale, carrot and beet tops. Wild plants can be given if available – such as bramble, groundsel, chickweed and dandelion. All green foods should be washed before feeding.

Commercial concentrate rabbit diets are not essential in adult rabbits if ad libitum hay, grass and greens are available. Commercial rabbit diets can be too low in fibre and too high in protein, fat and carbohydrate. However, many owners like to feed these diets for convenience. They should not be fed exclusively or ad libitum, and it must be emphasised that hay or grass should always be available and make up the bulk of the diet. A good general rule is to feed a maximum of 25g of highfibre pellets or extruded nuggets per kg bodyweight per day. For concentrate foods, crude fibre levels of more than 18 per cent, with indigestible fibre of more than 12.5 per cent, are recommended.

Overfeeding concentrated diets can be a significant factor in gastrointestinal and dental disease, and can also lead to obesity and boredom.

However, concentrate diets have a role in feeding growing, pregnant and lactating and diseased rabbits, and can be used to ensure nutrient requirements are fulfilled in rabbits that are unwilling to consume significant amounts of grass, hay or green vegetables, or where the quality of these items is questionable.

Obesity can predispose to serious health problems, including arthritis, osteoporosis, caecotroph retention around the perineum, urine scalding, fly strike and metabolic disease.



High fat or high carbohydrate/ starchy treats should be avoided completely. These include commercial treats, such as honey sticks, beans, peas, corn, bread, breakfast cereal, biscuits, nuts, seeds, crisps and chocolate.

The best treats to feed are hay treats, which are commercially available, or some favourite herbs or greens. Fruit and root vegetables should be regarded as treat items and fed in limited quantities only, as they are high in simple sugars and low in fibre.

Sudden changes in diet must be avoided. Any change should be made gradually over several days to weeks, starting with small amounts of the new item and gradually increasing them, while making a corresponding decrease in the unwanted item if necessary. Ad libitum hay or grass should always be available, and it is especially important to ensure that weanling rabbits eat plenty of hay or grass.

A sudden change in diet and lack of fibre, combined with the stress of movement, is a significant cause of morbidity and mortality in young rabbits over the period of weaning and moving to a pet shop or new owner. When purchasing a rabbit, it is important for a new owner to be informed of the rabbit's diet so that any changes can be introduced gradually.

Frosted or mouldy food, and lawnmower clippings, should not be fed as these can lead to severe digestive disturbances.

Dietary supplements consisting of vitamins and minerals are not generally necessary if the correct diet is fed. They should be used only under the direction of a veterinary surgeon.

Fresh drinking water must be available at all times. Drinking bottles are easier to keep clean than water bowls, and avoid wetting the dewlap, which can lead to a moist dermatitis.

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