



Micah Kohles, DVM, MPA

University of Nebraska College of Veterinary Medicine

## Rabbit Nutritional Facts

Rabbits are herbivores, concentrate selectors, and are classified as hindgut (cecum and colon) fermentors. They are mostly crepuscular and nocturnal feeders. They are adapted to digest significant amounts of fibrous food. Rabbits, as well as other herbivores, have a symbiotic microbe relationship (primarily Bacteroides) as they have no mammalian enzymes to break down the cellulose components of their plant-based diets.

## The Digestive System

The rabbit has evolved a particularly complicated digestive system which allows it to overcome poor quality protein. Some of the most common issues with domestic rabbits, both companion and commercial animals, are related to the gastrointestinal system. A basic understanding of lagomorph digestive physiology is essential and has wide-ranging implications in nearly every aspect of rabbit medicine and surgery. The symbiotic relationship rabbits have with the microflora in the cecum allow them to effectively ferment plant structural carbohydrates which provide their main energy source.

## Ingestion of food

Rabbits have a large cornea and laterally placed eyes which gives them a panoramic field of view when grazing and foraging. Food is selected based on smell and tactile perception of the lips. As concentrate selectors, rabbits will choose the most tender, succulent plant parts which are nutrient-dense and lowest in fibre to meet their nutritional needs owing to a high metabolic rate.

Dental formula:  $I2/1 C0/0 P3/2 M3/3 = 28$

Rabbits have hypsodont or open rooted (constantly growing) incisor and molar teeth.

Rabbits' incisors are designed to cut through vegetation. The large upper incisors have two smaller incisors behind them (peg teeth). The occlusion of the upper and lower incisors allows the teeth to be constantly sharpened. Incisors grow at a rate of 2-2.4 mm/day, so malocclusion can quickly occur, resulting in clinical problems.

The premolars and molar teeth, also known as cheek teeth, are designed to process hard, fibrous foods. The fibrous food is ground between the cheek teeth with jaw movements up to 120 per minute. This rapid chewing movement maintains proper dental health. When a rabbit is fed an unsuitable diet, such as low fibre mixes and minimal or no hay, improper dental wear can quickly occur, leading to dental disease.

A suitable diet of high fibre hay and high fibre uniform pellets will help control the growth of the teeth and prevent overgrowth and malocclusion. As concentrate selectors, rabbits, like deer, have a predisposition to 'select' the lower fibre, more tender portions of their diets which, if they are fed cereal-based or mixed pellets, can lead to selective feeding and malnutrition.

If low fibre mixed cereal or seed-based foods are eaten, the rapid chewing activity is no longer required, which can result in dental diseases, such as malocclusion and root elongation, as well as gastrointestinal issues. As the teeth elongate, secondary to inadequate wear, the jaws are forced apart and the radiographic appearance of the diastema increases.

Over time, the jaws begin to no longer occlude properly and mandibular movement is reduced. The condition deteriorates as the teeth become mobile and maloccluded, resulting in the development of spurs that may lacerate and ulcerate the tongue and buccal cavity. The upper molar (cheek) teeth elongate buccally and can ulcerate the buccal cavity whereas the mandibular teeth elongate lingually and can ulcerate and even entrap the tongue.

### **Stomach & Small Intestinal Tract**

The stomach comprises roughly 15% of the GI tract. Stomach pH is very low (pH 1-2) and a well-developed cardia makes vomiting almost impossible. Stomach pH may rise to 3.0 during cecotropes digestion. The stomach acts as a holding chamber and should always contain food. Fasting rabbits prior to anesthesia is neither required nor recommended. Removing food shortly before dental procedures may diminish some of the food particles found in the oral cavity to ease visualization and intubation.

The small intestine, made up of the duodenum, jejunum and ileum, plays only a small part in the active digestion of newly ingested high fibre food. The stomach and small intestine in rabbits digest and absorb nutrients very similarly to monogastric animals. A key function of this component of a rabbit's GI system is the digestion of cecotropes. Cecotropes are coated in a protective mucous which allows them to survive the acidity of the stomach prior to absorption in the small intestine. The transit time of the small intestine is rapid and fibre is quickly moved to the cecum and large intestine.

### **Large Intestinal Tract**

The sacculus rotundus signals the beginning of the large intestine and links to the ampulla coli which forms an intersection of the distal ileum, cecum and proximal colon.

Rhythmic contractions of the cecum constantly mix the ingesta as it undergoes fermentation by the mixed bacterial population, predominantly *Bacteroides* spp. The effects of bacterial fermentation include the production of volatile fatty acids including acetic, propionic and butyric acids which are absorbed across the cecal mucosa and utilized as a major energy source by the rabbit.

There is an almost continuous flux of material between the cecum and the proximal colon. The mixture of fluid and nutrients is moved through vigorous peristalsis in both normal and retrograde directions. These contractions result in large indigestible fibrous particles accumulating in the centre of the colon where they are rapidly transported along the colon to the rectum for defecation, usually within 4 hours of ingestion. Conversely, smaller more digestible fibrous particles accumulate at the periphery of the colon where, through retrograde peristaltic contractions of the haustra, they are returned to the cecum for further fermentation.

Periodically, there is a dramatic change in the peristaltic activity of the cecum and colon, as the retrograde movement of digestible fibrous particles ceases and a large quantity of the cecal content is expelled into the colon. These contents are excreted, usually once to twice daily, as soft, mucous covered cecotropes, starting ~ 4 hours after ingestion.

This process is controlled by the fusus coli, which is a specially adapted area of the colon that acts as a pacemaker for the production of cecotropes. The ability of the colon to rapidly eliminate indigestible fibre and retain digestible fibre for further fermentation makes the rabbit an extremely efficient herbivore, capable of surviving on very low-quality forage.

The cecotrope fermentation process depends heavily on an appropriate diet and the action of resident bacteria (especially *Bacteroides* spp) and protozoa which are vital to the gastrointestinal health of the rabbit. Bacterial fermentation produces volatile fatty acids, vitamins (B, C and K) and proteins which are eventually digested in the small intestine after cecotrophy, which occurs once or twice a day, usually at night. Over 74 additional strains of anaerobic bacteria have been isolated from the cecum mucosa of rabbits and of those very few have been identified. The epithelium of the cecum has a high electrolyte transport capability suited to the large absorption of electrolytes.

In healthy and physically able rabbits, the large soft, mucous covered cecotropes are ingested directly from the rectum (midnight snack). Multiple factors, including stimulation of rectal mechanoreceptors, perception of the cecotropes, odour and the blood concentrations of various metabolites and hormones, all stimulate the rabbit to directly ingest the cecotropes. Higher fibre diets increase cecophagy, whereas high protein and low fibre diets decrease cecophagy. Once eaten, the acidity of the stomach breaks down the protective mucous covering of the cecotropes. Continued digestion occurs in the small intestine where cecotropes represent an important component of the diet providing protein, water and vitamins.

In healthy rabbits on a high fibre diet, the cecum contains a mixture of gram-positive bacilli, gram-negative bacteria (predominantly *Bacteroides* spp. and some *E. coli*), some yeasts and protozoa. The usually stable synergistic microbial population in rabbits can be affected by a huge variety of internal and external factors, but four common factors which encourage the overgrowth of pathogens like *Clostridium* and *E. coli* are:

- Oral administration of inappropriate antibiotics can suppress the normal gram-positive flora and permit *Clostridia*, *E. coli* and other pathogenic bacteria to flourish.
- A diet low in fibre leads to low concentrations of fibre in the colon and cecum which can lead to reduced production of volatile fatty acids and an accompanying rise in pH which destabilizes the microflora.
- Inappropriate diets can lead to increased amounts of highly fermentable simple sugars in the cecum which provide the major energy source for *Clostridial* overgrowth.
- Excess dietary protein may cause an elevation of ammonia, dissociation of which can alter cecal pH and cause dysbiosis.

Rabbits are naturally prey animals, so environmental stressors are also thought to act through the intermediary action of adrenaline or cortisol (probably on the *fusus coli*) causing ileus. Other environmental factors, including temperature, housing, and a variety of husbandry related issues can also have a significant impact on the microbial health of a rabbit's GI system.

## Nutrition

The discussion of the rabbit's gastrointestinal system above makes it very clear how integral the proper diet is to the health of rabbits and all small herbivores. The keys to a proper rabbit and small herbivore diet are the following:

- High-quality high fibre grass hay (70%)
  - Grass hay should be fed free choice and available at all times. Any high-quality grass hay such as timothy, orchard or oat is appropriate.
- High fibre uniform pellet (25%)
  - Timothy or alfalfa-based (Lucerne) depends on the life stage
- Fresh or dried greens (~5%)
  - Only appropriate species should be fed and all should be carefully cleaned. Organic products are preferred.
- Treats (~5%)
  - Low sugar, high fibre treats
- Unlimited fresh, clean water

High quality, high fibre grass hay should be available at all times. Although there are multiple varieties available on the market, there is little nutritional difference between them and, therefore, different species, such as timothy, orchard, oat and mixed, are appropriate. Hay is a product of nature and, therefore, there will be variances in colour, texture, feel and taste. Because of this, it is important to transition between hay bags and offers different varieties of hay. Hay not only provides a key component of the nutritional needs of rabbits and other small herbivores, but it also encourages natural behaviours such as foraging and grazing. Stimulating these natural behaviours may diminish boredom based behaviours, increase activity and also provide them with a sense of security.

There are many diets available to pet owners, the two most common being seed/cereal-based mixes and hay-based, uniform pellets. Rabbits are concentrate selectors and if offered a mixed pellet will select certain items from the mix which will lead to improper and unbalanced nutrition. These mixes are often high in carbohydrates and simple sugars which can lead to obesity and GI issues, as well as low in fibre which slows gastrointestinal motility and decreases normal teeth wear. Uniform, hay-based fortified pellets, high in fibre and low in protein, are recommended, as they eliminate selective feeding which guarantees a proper vitamin and mineral intake.

Fresh and dried greens can be an important and enjoyed component of a rabbit's and small herbivore's diet but are not required. They do, however, provide an excellent source of water and enrichment. Varying types and textures is a great enrichment tool. It is recommended to completely wash and clean all greens and organic products are preferable.

Although treats are not required for rabbits or other small herbivores, limited appropriate treats can be beneficial for strengthening the pet/owner bond, training and enrichment. It is important to limit the number of treats and ensure they are low in protein, fat, calcium and sugar. Some examples of inappropriate treats are nuts, seeds, popcorn, bread, crackers and yogurt drops. High fibre grass and alfalfa-based (lucerne) treats are appropriate as are small amounts of dried fruits/veggies. There are far more inappropriate treats on the market, but good products do exist.

Unlimited fresh, clean water is vital and the water requirements of rabbits have been estimated at 50-100 ml/kg/day. It is a good idea to offer herbivores water in more than one manner, such as a sipper bottle and bowl, to stimulate increased water intake. Actual water consumption can be significantly affected by diet and other environmental factors.

\* Although I specifically reference rabbits in the majority of this paper, nearly all of the topics from GI function to proper nutrition relate directly to other small herbivores such as guinea pigs and chinchillas.

## References & Further Reading

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