



Nutritional Requirements for Rabbits

Amy E. Halls, M.Sc. – Monogastric Nutritionist
Shur-Gain, Nutreco Canada Inc.

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Since rabbit production makes up only a very small percentage of the total animal production in the world, there is little information available or research performed on the nutrition of the rabbit. Based on the existing nutritional information, this Nutrifax will take a look at the general nutritional requirements of rabbits. The digestive system of the rabbit and its specialized digestive strategy can be reviewed in the Nutrifax: *Caecotrophy in Rabbits*.

The nutrients that rabbits require in their diet are grouped in the following categories:

- Protein
- Energy (Carbohydrates and Fat)
- Minerals
- Vitamins

Table 1 (Appendix A) outlines the most recent compiled nutritional requirements of rabbits from the National Research Council (NRC, 1978) and F. Lebas, a prominent French rabbit nutritionist in the 1980s.

Protein

Protein is the fundamental component of animal tissue (muscles, cell tissue), certain hormones and all enzymes. Amino acids are the building blocks of protein. There are over 300 known amino acids in the plant world, but only 20 are considered important in animal tissues, 10 of them being essential. They are “essential” because animals cannot produce these amino acids themselves, and are thus required in the diet. These include arginine, isoleucine, histidine, leucine, methionine, lysine, phenylalanine, tryptophan, threonine and valine. Cereal grains contain low levels of methionine and lysine, and hence are the most limiting in rabbit diets. Diets deficient in methionine and lysine will adversely affect growth and reproduction.

Protein digestibility is influenced by age in the growing rabbit. It decreases following weaning to reach a steady level by the 9th week of age, with the decrease being slower from 5 weeks of age (de Blas & Wiseman, 2003). The slower decrease at 5 weeks of age may be explained by the increase in feed intake. As the rabbit grows, so does its feed intake, which means that they are consuming more protein and hence digestibility is no longer a factor. Rabbits increase their amino acid intake from the consumption of their caecotrophs or soft feces (see the Nutrifax: *Caecotrophy in Rabbits*). Thus their total protein intake is supplied by the dietary intake plus the ingestion of the soft feces. Restricting caecotrophy can reduce protein digestibility by as much as 20%. Lactating does require higher dietary protein when they are also concurrently pregnant. These extremely high levels often result in a negative balance of protein, and the doe must pull protein from their own body reserves (de Blas & Wiseman, 2003). Hence a higher protein level of 17 to 18% is required in the diet (Appendix A).

Energy

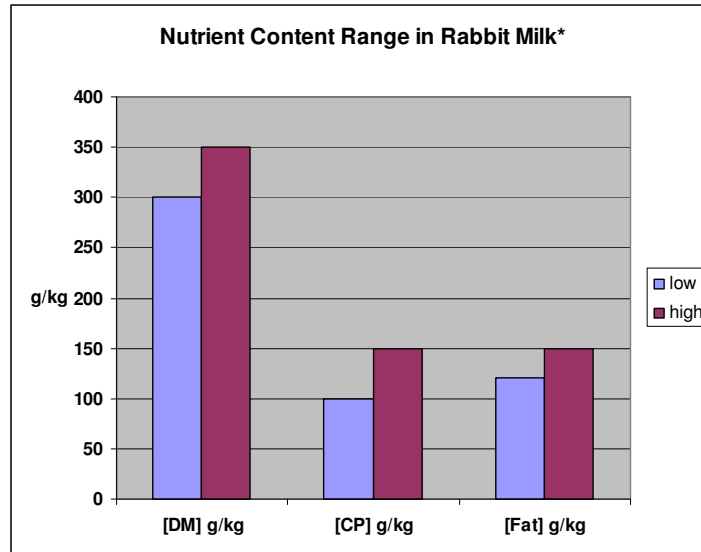
The primary function of **carbohydrates** in rabbit diets is to provide energy. The important carbohydrates in rabbit feed are starch (digestible) and fibre (indigestible). Starch provides energy that is readily available and easily digestible. Although grains are good sources of starch, rabbit diets high in grain can cause a starch overload in the hindgut, leading to enteritis (see the Nutrifax: *Enteric Diseases in Rabbits*). Fibre is important for overall gut health and mobility, caecotrophy and appetite stimulation. The bacterial population in the hindgut allows rabbits to digest fibre to some extent. Rabbits have a high feed intake (65 – 80 g/kg body weight) and a rapid feed transit time (~19 hours) and thus are able to consume lower quality forages and still meet their nutritional needs (de Blas & Wiseman, 2003). Low energy diets also cause an increase in caecotrophy production and ingestion (Jenkins, 1999). However, diets too high in fibre, in combination with feed restriction, can lead to an energy deficiency.

Fat also functions primarily as an energy source. It contains, on the same weight basis, roughly 2¼ times more energy than carbohydrates. The addition of fat in a rabbit diet also increases palatability, reduces fines and aids in the absorption of fat-soluble vitamins (A, D, E and K) in the digestive system. Substituting some of the highly digestible carbohydrates (starches) with fat can increase the energy level of the diet, without reducing the fibre content. Levels of 2 – 5% fat in the diet also helps promote a shiny coat, which is beneficial in show rabbits. Caecotroph consumption (see the Nutrifax: *Caecotrophy in Rabbits*) supplies volatile fatty acids (VFA) in the diet, which are a major energy source for the rabbit.

Maintenance (2100-2200 kcal/kg) requirements comprise the majority of the rabbit's energy needs (Appendix A). Reproduction and growth require 300-500 kcal/kg more than maintenance requirements. Healthy rabbits will consume sufficient amounts of feed to meet their digestible energy (DE) requirements. Rabbits will consume more feed if they are fed a low energy diet, and will consume less feed if they are fed a high energy diet. Increases in DE can affect the composition of body gain and the percentage of energy retained as protein and fat in the body. Feed restrictions can negatively affect growth and reproduction, and can also lead to enteritis.

Due to the high energy demands for pregnancy and lactation, does often have a negative energy balance. They are physically unable to voluntarily consume enough feed due to the high fibre content of their diets. As a result, does will utilize body tissues (fat and protein) as a source of energy to compensate for the insufficient DE intake. The energy output in the milk during lactation is extremely high in the rabbit, compared with other mammalian species. This is due to the rate of milk production (200-300 g/day) and the high concentration of dry matter (DM), protein (CP) and fat (Figure 1). However, does are very efficient in utilizing dietary energy, which is thought to be due to the body fat mobilization for milk synthesis, particularly during mid lactation when milk production is at its peak or when pregnancy is concurrent with lactation (de Blas & Wiseman, 2003).

Figure 1. Nutrient content range in rabbit milk (de Blas & Wiseman, 2003).



Minerals

Minerals are grouped into two categories – macro minerals and micro minerals. Macro minerals include calcium, phosphorus, sodium, magnesium and potassium and are required in grams per day. Trace or micro minerals include copper, zinc, manganese, iron, iodine, selenium and cobalt, and are required in milligrams per day.

Calcium and **phosphorus** are major components of the skeletal system. Calcium plays a key role in organic processes, such as heart function, muscle contraction, coagulation and electrolyte equilibrium of the blood. Phosphorus is also involved in energy metabolism. Rabbits are quite unique in the metabolism of calcium. Calcium is absorbed in the direct proportion to its concentration in the diet, regardless of the metabolic need. Excess calcium is eliminated through the urine. This accounts for the chalky white deposits seen beneath the cages. A dietary ratio of calcium to phosphorus of 1.5:1 to 2:1 is recommended. An excess of calcium (>15g/kg) increases the calcification of soft tissues and can reduce the absorption of phosphorus and zinc, which will lead to deficiencies in those minerals. An excess of dietary phosphorus (>9g/kg) may reduce feed intake and reduce fertility (de Blas & Wiseman, 2003). Legumes are high in calcium and grains are good sources of phosphorus. A combination of both grains and alfalfa will generally meet the calcium and phosphorus needs of the growing rabbit. Rabbit milk is very rich in both minerals, thus lactating does have higher requirements than growing or non-lactating does. Rabbit milk contains, on average, three to five times more calcium and phosphorus than cow's milk (El-Sayiad *et al.*, 1994). At maximum milk production a doe can excrete up to 2 g of calcium.

Magnesium is a major component of bone, a cofactor of several enzyme reactions and is involved in the transmission of nerve impulses. Magnesium deficiency is highly unlikely due to the addition of magnesium rich legumes (alfalfa, clover) in the diet. High levels of dietary calcium increase magnesium requirement, so high alfalfa diets should be supplemented with magnesium. Fur chewing, a common sign of deficiency, can be easily corrected with

magnesium supplementation. As in the case of calcium, excess magnesium is excreted through the urine. Documented requirements range from 0.3 to 3 g/kg diet.

Sodium, potassium and chloride play key roles in the acid-base regulation of the blood and other body fluids. Potassium is also a cofactor for several enzymes. Deficiency symptoms include muscle weakness, paralysis and respiratory distress. Legumes, such as alfalfa, are rich in potassium, and most grains are good sources of potassium, so deficiencies in rabbits are rare. Practical dietary recommendations fall between 6.5 and 10 g/kg. Sodium requirements have not been studied in the rabbit, but practical recommendations are 6.5 to 10 g/kg. Chloride is also involved in protein digestion and its requirements are estimated as being between 1.7 and 3.2 g/kg. Rabbit diets are unlikely to be deficient in chloride as salt (sodium chloride) and lysine hydrochloride are routinely added to the diet as a source of sodium and lysine and hence also supply chloride.

Copper is involved in iron and energy metabolism, as well as collagen and hair formation. Copper deficiencies result in anemia, retarded growth, bone abnormalities and graying of black hair. Research recommendations range from 5 to 30 ppm, with higher levels suggested for breeding does and fur production. Copper is commonly used across the world as a growth promoter in swine and poultry. There are several conflicting results as to whether dietary copper supplementation improves performance in fryer rabbits, particularly those under stress due to poor husbandry and underlying disease challenges. **Zinc** functions as a cofactor of numerous enzymes and is involved in cell division processes. Higher levels are required for reproduction and fur production than for maintenance and meat production. Impaired fertility, hair loss and dermatitis are common signs of iron deficiency. **Manganese** is a coenzyme in amino acid metabolism and cartilage formation. Deficiency causes a malformation of the skeletal system, including brittle bones, crooked legs and decreased bone density. **Iron**, a major component of pigments and enzymes, is involved in oxygen transport and energy metabolism. Anemia occurs with iron deficiencies because of impaired hemoglobin formation, which is the oxygen transporter in the blood. Does are very poor at transporting iron to the milk, but are quite capable of passing iron through the placenta. Provided that the doe is fed a diet with sufficient iron, kits will be born with large iron reserves. These reserves will supply their required iron until they begin to consume solid food. Although the majority of feed ingredients are naturally rich in iron, most commercial rabbit premixes will supplement with an extra 30–50 ppm iron.

Iodine is a component of the thyroid hormones that regulate energy metabolism. Deficiency results in goiter, an enlargement of the thyroid gland in its attempt at producing more thyroid hormones. No requirements of iodine have ever been established for rabbits, although does are more sensitive to iodine deficiencies than fryers. Up until 1957, **selenium** was considered a toxic element. In most species the role of selenium and vitamin E are closely linked, but in the rabbit, it is less dependent on selenium for the removal of damaging peroxides produced during metabolic processes. Thus, the rabbit is more dependent on vitamin E and less on selenium for the prevention of cell oxidation (Jenkins et al., 1970). Dietary supplementation of 0.1 ppm in does has been observed to improve fetal and birth weights, but not with 0.3 ppm (Struklec *et al.*, 1994). Deficiency symptoms include muscle and liver degeneration, impaired reproduction and immunity. Depending on the region, Canadian soils can be selenium deficient and thus it is recommended that at least 0.1 ppm selenium is added to rabbit feeds. The only known role of

cobalt is its involvement in the structural makeup of vitamin B₁₂. Rabbits are dependent on cobalt because the hindgut bacteria require it for the production of vitamin B₁₂. Previous research studies recommend 0.25 ppm cobalt supplementation in the diet (de Blas & Wiseman, 2003).

Vitamins

Vitamins are divided into two categories – fat-soluble and water-soluble. B vitamins and vitamin C are water soluble; vitamins A, D, E and K are fat-soluble. Fat soluble vitamins can be stored within the body in the liver and fat deposits, and if eaten in large amounts, are not needed on a daily basis. Water soluble vitamins are not stored within the body and any unused portions are excreted via the urine. However, the majority of B vitamins are synthesized by the hindgut bacteria and consumed during caecotrophy and thus are not necessarily required in the diet (see the Nutrifax: *Caecotrophy in Rabbits*).

Vitamin A is involved in the growth and maintenance of all body tissues, as well as vision. Deficiency symptoms include retarded growth, blindness, lack of coordination, paralysis and hydrocephalus in fetuses born to vitamin A deficient does. Vitamin A is involved in cartilage formation and a common sign of vitamin A deficiency is drooping ears as the defective cartilage cannot support the weight of the ear. The liver is capable of storing considerable amounts of vitamin A and once it becomes overloaded, toxicity symptoms may appear. Toxic levels of vitamin A can cause reproduction issues in does, including abortion, high kit mortality, hydrocephalus, weak and small litters, and fetal resorption. Since these signs can also indicate deficiency, both aspects must be taken into consideration when these symptoms occur. Little research has been conducted on vitamin A requirements in rabbits, and so in practice, feeding levels of 6,000 IU/kg for fryers and 10,000 IU/kg for breeders are recommended.

The primary role of **Vitamin D** is the regulation of calcium and phosphorus absorption, influencing bone mineralization and mobilization. In most species, calcium absorption is controlled by a calcium binding protein, which is regulated by vitamin D. Rabbits are unique in that they do not require this calcium binding protein to absorb calcium. As discussed previously, the amount of calcium absorbed is in relation to the dietary amount. Excess vitamin D, rather than a deficiency, is more likely to be a problem in practical conditions. Levels as low as 2300-3000 IU/kg, have been shown to be toxic to rabbits. Toxicity symptoms include impaired movement, loss of appetite and calcification of the soft tissues, such as the arteries and kidneys. Toxicity cases have been reported due to excessive levels added to rabbit feeds, and thus levels of 1000 to 1500 IU/kg have been recommended (Mateos & de Blas, 1998).

Vitamin E functions in close relationship to selenium and is involved in the prevention of cell oxidation and maintaining the immune system. Deficiencies of either selenium or vitamin E results in muscular dystrophy (destruction of muscle tissue), infertility or fetal resorption. Recommended levels are based on either old data or on extrapolation from other species. It is then recommended that 15 and 50 ppm of vitamin E for fryers and does, respectively. Further supplementation is recommended for cases of impaired immunity or coccidiosis infection. Bernardini *et al.* (1996) have shown that high doses of vitamin E (>200 ppm) have improved the

quality of rabbit meat after slaughter. Meats from rabbits fed high doses of vitamin E had greater stability, better colour, less dripping losses and longer shelf-life than cuts in the control animals.

Vitamin K is essential for blood clotting. Symptoms of vitamin K deficiency are abortion and placental hemorrhage in does, and prolonged bleeding following a minor injury. Deficiencies are rarely seen in rabbits because they obtain their requirements through bacterial production in the hindgut and its ingestion through caecotrophy. Levels of 1 to 2 ppm vitamin K in the feed is more than adequate for most situations, however supplementation is recommended for pregnant does and those with subclinical cases of coccidiosis.

The **B complex vitamins** include thiamin, riboflavin, niacin, biotin, pantothenic acid, pyridoxine, folic acid, vitamin B₁₂ and choline. These vitamins are all synthesized by bacteria in the hindgut of the rabbit, which are then packaged into caecotrophs and ingested by the rabbit, where they can be absorbed in the small intestine. Previous studies have shown that rabbits do not respond to B vitamin supplementation, which indicates that their requirements are fulfilled through caecotrophy.

Thiamin (Vitamin B₁) is a cofactor for certain enzymes involved in carbohydrate and fat metabolism. Deficiencies cause a loss of appetite and muscle paralysis. **Riboflavin** is a component of several compounds that are involved in the oxidation of glucose within cells. Riboflavin deficiency causes retarded growth and a reduced feed conversion. **Niacin** functions similarly to riboflavin and is also a component of cofactors that are involved in glucose oxidation within cells. Niacin can easily be synthesized by the amino acid tryptophan. **Biotin** plays a metabolic role in fatty acid metabolism. Deficiency symptoms include dermatitis and hair loss. **Pantothenic Acid** is essential for energy metabolism. Deficiency of this vitamin has never been produced in the rabbit. **Pyridoxine** (Vitamin B₆) is involved in amino acid metabolism. Deficiencies are extremely rare in rabbits due to the abundance of this vitamin in forage and grains, as well as the synthesis by intestinal bacteria. **Folic acid** and **vitamin B₁₂** are involved in nucleic acid synthesis. Anemia is the common deficiency symptom of both vitamins. Folic acid also plays a role in the interconversion of amino acids. Although cobalt is required for vitamin B₁₂ synthesis in the hindgut, even extremely low experimental cobalt diets were impossible in producing vitamin B₁₂ deficiency (de Blas & Wiseman, 2003). **Choline** can be synthesized by the rabbit and is thus often questionable as to its label as a vitamin. Experimentally induced deficiencies have resulted in retarded growth, anemia, muscular dystrophy and death.

Vitamin C (ascorbic acid) is synthesized in the liver and thus is not required in the diet. It is involved in the biochemical reactions involving oxygen. Under adverse conditions, such as hot weather, stress, weaning and sub clinical diseases, ascorbic acid production is reduced and supplementation of vitamin C is beneficial during these times.

Shur-Gain Rabbit Diets

Since reproduction and growth generally have the same nutrient requirements, using one feed for all stages of production is economically ideal. Shur-Gain offers commercial and backyard rabbit feeds for rabbit producers. Our Homestead Rabbit Pellet is ideal for small rabbitries and pet rabbits. The 16% Rabbit Ration is a higher quality ration designed for commercial rabbitries.

Both feeds contain high fibre levels, provided by dehydrated alfalfa meal to maintain a healthy intestinal tract. Dehydrated alfalfa meal is the preferred source of fibre in Shur-Gain rabbit rations. The rabbit rations provide the energy required for optimal production without sacrificing fibre content. Energy is provided by a combination of ingredients to help prevent starch overload. The energy content of the ration is important for growth rates and milk production in nursing does. Highly digestible proteins supply the correct balance of amino acids, which is important for growth and tissue maintenance. Shur-Gain rabbit feeds contain a complete compliment of macro and micro minerals, as well as all vitamins required by the rabbit on a daily basis.

	16% Rabbit Pellet	Homestead Rabbit Pellet
Crude Protein (Min)	16.00%	16.00%
Crude Fat (Min)	3.00%	3.00%
Crude Fibre (Min)	19.00%	18.00%
Calcium (Actual)	1.00%	1.10%
Phosphorus (Actual)	0.50%	0.50%
Sodium (Actual)	0.20%	0.20%
Vitamin A (Min)	11,000 IU/kg	11,000 IU/kg
Vitamin D (Min)	1,460 IU/kg	1,460 IU/kg
Vitamin E (Min)	50 IU/kg	40 IU/kg

Table 1. Nutrient guarantees of the Shur-Gain Rabbit feeds.

A medicated 16% Rabbit Pellet containing Robenz is available for the prevention of Coccidiosis in weaned and growing rabbits, a parasitic disease that can have devastating effects in a rabbitry. Robenz is the only CFIA approved anti-coccidial medication for rabbits in Canada. It will help protect young rabbits from coccidiosis while they develop their immune system. This medication has a 6 day withdrawal period before slaughter, at which time Shur-Gain 16% Rabbit Ration Plain should be fed. Robenz should not be fed to lactating or pregnant does - they can be fed Shur-Gain's non-medicated 16% Rabbit Ration.

Appendix A: Nutrient requirements of rabbits based on the NRC *Nutrient Requirements of Rabbits* (1977) and F. Lebas (1980) (Cheeke *et al.*,1987).

		Growth	Maintenance	Gestation	Lactation	Does & Litter Fed One Diet
Digestible Energy (kcal/kg)	NRC (1977)	2,500	2,100	2,500	2,500	--
	F. Lebas (1980)	2,500	2,200	2,500	2,700	2,500
Crude Fibre (%)	NRC (1977)	10 - 12	14	10 - 12	10 - 12	--
	F. Lebas (1980)	14	15 - 16	14	12	14
Crude Fat (%)	NRC (1977)	2	2	2	2	2
	F. Lebas (1980)	3	3	3	5	3
Crude Protein (%)	NRC (1977)	16	12	15	17	--
	F. Lebas (1980)	15	13	18	18	17
Calcium (%)	NRC (1977)	0.40	--	0.45	0.75	--
	F. Lebas (1980)	0.50	0.60	0.80	1.10	1.10
Phosphorus (%)	NRC (1977)	0.22	--	0.37	0.50	--
	F. Lebas (1980)	0.30	0.40	0.50	0.80	0.80
Sodium (%)	NRC (1977)	0.20	0.20	0.20	0.20	--
	F. Lebas (1980)	0.40	--	0.40	0.40	0.40
Magnesium (%)	NRC (1977)	0.03	0.03	0.04	0.04	--
	F. Lebas (1980)	0.03	--	0.04	0.04	0.04
Potassium (%)	NRC (1977)	0.60	0.60	0.60	0.60	--
	F. Lebas (1980)	0.80	--	0.90	0.90	0.90
Copper (mg/kg)	NRC (1977)	3	3	3	3	--
	F. Lebas (1980)	5	--	--	5	5
Manganese (mg/kg)	NRC (1977)	8.5	2.5	2.5	2.5	--
	F. Lebas (1980)	8.5	2.5	2.5	2.5	8.5
Iron (mg/kg)	NRC (1977)	--	--	--	--	--
	F. Lebas (1980)	50	50	50	50	50
Zinc (mg/kg)	NRC (1977)	--	--	--	--	--
	F. Lebas (1980)	50	--	70	70	70
Vitamin A (IU/kg)	NRC (1977)	580	--	>1,160	--	--
	F. Lebas (1980)	6,000	--	12,000	12,000	10,000
Vitamin D (IU/kg)	NRC (1977)	--	--	--	--	--
	F. Lebas (1980)	900	--	900	900	900
Vitamin E (IU/kg)	NRC (1977)	40	--	40	40	--
	F. Lebas (1980)	50	50	50	50	50

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