

# Rabbit farming for meat purposes

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## Implications

- Rabbits are members of the *Leporidae* family, indigenous throughout most parts of the world, and raised in small-holder and large-scale, commercial production systems.
- Rabbit is marketed as whole or half carcasses, although interest in cuts and ground meat is increasing.
- Rabbit meat has high nutritional value but in developed countries continues to be considered for rural usage or limited to ethnic groups despite its outstanding dietetic properties.

**Key words:** diffusion, meat, nutritional properties, production, *Oryctolagus cuniculus*, rabbit

## Introduction

### **Historical background: origin and diffusion of the domestic rabbit**

By current zoological classification, the order Lagomorpha is split into two large families: the Ochotonidae and Leporidae. Rabbits and hares are members of the Leporidae family. The taxonomic classification of the Leporidae proposed by Wilson and Reeder (1993) has been accepted as divided into 11 genera, one of which, the genus *Sylvilagus*, deserves special mention due to the widespread presence throughout the North American continent of its 13 species (known as the cottontail, among which is *Sylvilagus floridanus*, known in Europe as the “mini-hare”). Two members of the family are the genus *Lepus*, with its 30 species of hares originally from the Old World, and the genus *Oryctolagus*, also originally from Europe, which has only one species, *Oryctolagus cuniculus*, or the European rabbit. The three genera (Figure 1) differ in the number of chromosomes (*Sylvilagus* 2n = 42; *Lepus* 2n = 48; *Oryctolagus* 2n = 44), so crossmatings are infertile and do not generate crossbreeds (Robinson et al., 2002).

Members of the order Lagomorpha are indigenous to every corner of the globe except for Antarctica, Madagascar, a few Indonesian regions, and the southern part of South America. They were only recently brought to New Zealand and Australia by humans.

The origins of the European rabbit are difficult to pinpoint with precision due to the fragility of its bones (Dawson, 1967). Leporidae remains have been unearthed in Eocene era strata (from 37 to 53 million years ago) in northern Spain, whereas rabbits with structures similar to the species of today lived throughout Europe in Pre-Pleistocene (1 to 2 million years ago) times but went extinct during the Würm Glacial Period (from 20,000

to 75,000 years ago) everywhere with exception of those rabbits living in the Iberian Peninsula and southern France (Gibb, 1990). The oldest fossils of *O. cuniculus* (from 300,000 to 600,000 years ago) indicate that the original range of the rabbit was restricted to the Iberian Peninsula and the south of France up to river Loire (Branco et al., 2000).

The first people to provide written testimony of the rabbit and its presence in the Iberian Peninsula were the Phoenicians (1100 BC), who named the area “I-Sephan-im” (Land of Rabbits), subsequently Latinized as “Hispania.” From Spain, the Phoenicians began trading rabbits along the entire Mediterranean coastline. The Greeks, Aristotle in particular, praised the delicacy of their meat. Ample written testimony to the rabbit is also provided by the Romans (Zoccarato, 2008).

The prolificacy of the rabbit has long been a well-known fact: evidence remains of a petition submitted by the inhabitants of the Balearic Islands and the Isle of Lipari to the Emperor Augustus pleading with him to order his legions to free their lands invaded by these animals, which had proliferated from one pair in numbers sufficient to wreak enormous damage on their crops and harvests (Licciardelli and Cortese, 1962).

For gastronomic and economic reasons, the Romans began rearing rabbits in special fenced areas, restricting the area of diffusion to the Iberian Peninsula, however. Starting from the 9th century AD, the rabbit (both wild and domesticated) began spreading to other European regions. Despite their expansion from the area of origin, rabbits were rare and only infrequently reared in the nations to which they had recently come, primarily due to scarce knowledge of their habits and nutritional and environmental needs (Licciardelli and Cortese, 1962). In 1309, in England, a rabbit had the same market value as a pig (Licciardelli and Cortese, 1962). British colonial expansion was responsible for a new wave of diffusion of the rabbit to many islands and continents, primarily because rabbits were raised aboard ships as food for the crews.

## Rabbit Farming

Today the rabbit is reared systematically on a vast scale, with global rabbit meat production reaching 1.8 million metric tonnes a year. Such production is, in decreasing order, concentrated in Asia (48.8%), Europe (28.4%), Americas (18.1%), and Africa (4.7%; Figure 2; FAOSTAT, 2012). China is the major rabbit meat producer (735,021 tonnes/year), mainly for the purpose of export, followed by Italy, Spain, Egypt, and France (262,436; 67,775; 56,338; and 52,955 tonnes/year, respectively; FAOSTAT, 2012). In Italy, rabbit farming is the fourth leading zootechnical sector, accounting for 9% of the gross domestic product. About 100 million animals are slaughtered each year, and annual consumption is 2.3 kg *per capita* (averaging commercial and rural estimates).

Up until the 1970s, the rabbit was an animal to which little importance was assigned in the profit accounts of farm and was often decimated by disease or predators such as rats, cats, and dogs. It was an irrational form

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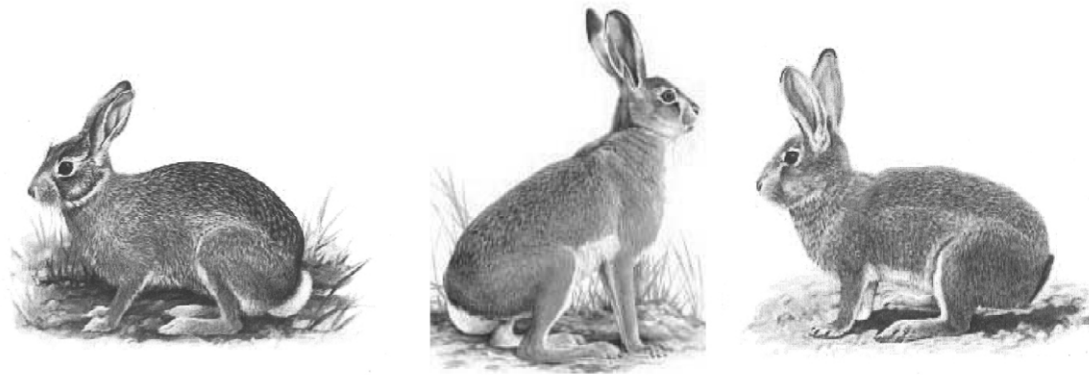


Figure 1. *Sylvilagus*, *Lepus*, and *Oryctolagus* genera (Catalano, 1974).

of farming due to the promiscuity of the rabbit, the impossibility to monitor mating, and the absence of even the barest rules of hygiene, and so was primarily destined for family consumption and only rarely for sale, and even then, only at a local level.

Pure breeds were used along with their crossbreds, locally bred populations of indigenous genetic types that would not be well suited to the rabbit-farming methods of today. An exception would be organic farming production, which is gaining increasing interest (Dalle Zotte and Ragno, 2005; Dalle Zotte, 2007; Dalle Zotte and Paci, 2014; Figures 3 and 4).

The evolution of the zootechnical sector in general and rabbit farming in particular that occurred in the 1970s led to more intensive and more profitable rearing systems developed with the expansion of more intensive rabbit farms with animals kept in cages. These were capable of reaching remarkable productivity with greater control over production factors (Figure 5). The reasons for the interest in this species are its high prolificacy (Figure 6) and the capacity of rabbits kept for reproduction to convert 20% of their protein intake into meat.

Other animal species have lesser capacities in this regard: the value is around 16 to 18% for pigs and 8 to 12% for cattle. The cost of energy expressed as the kcal intake required to produce 1 g of meat is an advantage of the rabbit, with its greater productivity compared with sheep or cattle

(rabbit: 105 kcal/g; sheep for meat purpose: 427 kcal/g; cattle: 442 kcal/g; Bernardini Battaglini and Castellini, 2014). The rabbit has low competitiveness for feed sources, given that rations can be composed of more than one-third alfalfa meal, and therefore, the production of rabbit meat offers an interesting possibility in nations where cereals must be imported. Rabbit meat production is becoming relatively important to the economy of some sub-Saharan Africa countries, even though the development of sustainable programs for small-holder rabbit units is limited by institutional policies, critical environmental conditions (heat stress and inappropriate housing design), and inadequate feeding and management strategies. The provision of suitable breeding stocks adapted to adverse environments, such as local breeds of rabbits, seems to be the one of the key aspects of the diffusion of the rabbit production in Africa (Oseni and Lukefahr, 2014).

### Commercial production technology

Rabbit farming is predominantly a closed cycle performed on a single farm with does and bucks reared in individual cages (does in kindling cages) and fattening animals raised in collective cages (Szendró et al., 2012) suited to meet the needs of animal well-being proscribed in EU Directive 98/58/EC 1998 regarding the protection of animals under rearing conditions. It has recently been demonstrated that rearing rabbits in groups (both in cages and in pens)

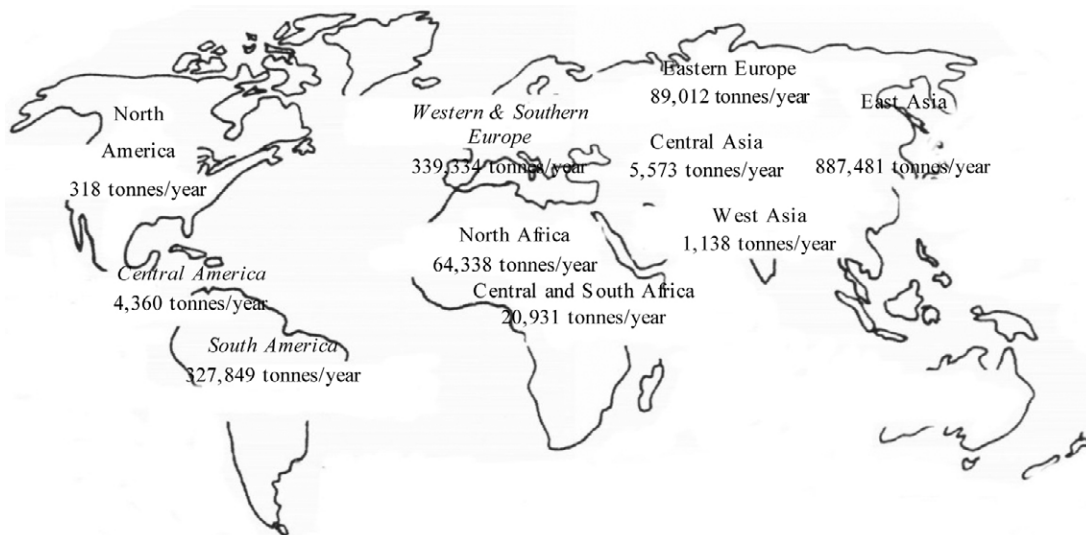


Figure 2. Rabbit meat production and consumption around the world (FAOSTAT, 2012).



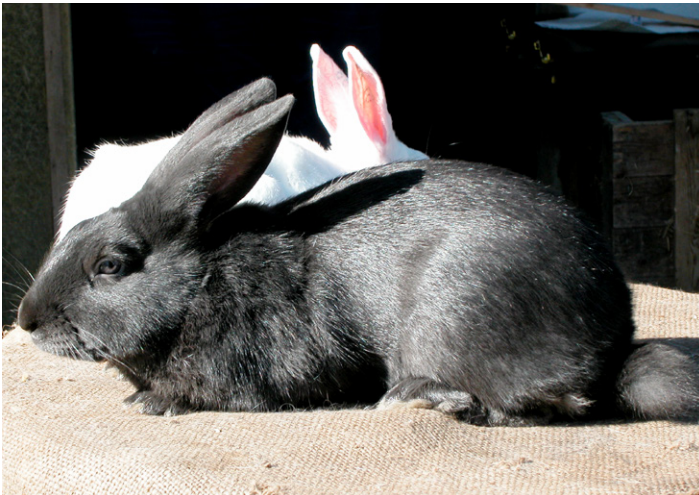


Figure 3. Vienna blue breed (source: Dalle Zotte).



Figure 4. Burgundy Fawn breed (source: Dalle Zotte).

may interfere with the quality of the product because rabbits raised in groups are more likely to be competitive and display aggressive behavior, especially with the approach of puberty. Aggressive individuals may also limit others in their drinking and eating and may even cause them serious injury, producing negative effects on carcass and meat yields (Princz et al., 2008, 2009; Dalle Zotte et al., 2009). The pen rearing system, especially when deep litter is present, compromises the removal of excrement, with the consequent increase in the frequency of pathologies linked to inadequate health/hygiene conditions (Szendrő and Dalle Zotte, 2011; Matics et al., 2014). Rabbits are social and very gregarious animals, but due to their nature (bearing in mind that the European rabbit shows part of the behavioral range of the wild rabbit), they are not overly fond of wide-open spaces. Studies in which rabbits were allowed to choose between cages of various sizes showed that they tend to prefer smaller cages, even when these are more densely populated (Matics et al., 2004).

Rabbits have a short reproductive cycle (30- to 32-day gestation) and are highly prolific, with up to 40 to 60 kits/year (approximately 8 to 12 kits/birth). Mating may be performed immediately after kindling (giving birth) or a few days later due to the greater receptivity of the doe in this period. In the traditional rearing system, mating is usually performed after weaning of the kits 35 to 42 days after birth (another period of high receptivity of the

doe). The adoption of semi-intensive reproductive cycles with insemination 11 to 18 days after kindling is a compromise that allows the does more efficient energy recovery, which leads in turn to greater output (8 to 9 kindlings/year). On small farms, natural mating is favored, whereas on large farms, artificial insemination is commonly employed (Szendrő et al., 2012).

To improve the reproductive yield of the does, in addition to artificial insemination, the following management procedures are adopted:

- equalizing of the litters, or rather the transfer of the newborn kits among nests to reach an average of 8 to 9 kits per nest;
- programmed lactation, in which the rabbit doe suckles the litter only once daily for a few minutes; and
- cycling of the operations where rearing activities are programmed for the purpose of obtaining homogeneous groups of does in different phases of reproduction and the division of the work throughout the various days of the week.

These procedures help increase the level of well-being of the does and the kits, permit uniform growth of the latter, and enable optimum control of all of the animals by the breeder.



Figure 5. Intensive rearing (reproduction sector).



Figure 6. Newborn rabbit kits.



From 28 to 45 days of age, a period that varies depending on the time of weaning, the kits can be weaned and transferred to the fattening area until reaching slaughter age. Feeding is based on the provision of balanced diets suited to the needs of the various physiological states (gestation, lactation, weaning, and fattening). The ingredients usually include dehydrated alfalfa, cereal meal, bran, protein flour, vitamins, and minerals and are usually provided in the form of pellets, which in addition to ensuring simultaneous consumption of all of the nutrients required, permit the use of automatic dispensers that simplify management. Feed given to does may contain 13 to 14% crude fiber and 17 to 18% crude protein, whereas the feed for fattening rabbits may contain 14.5 to 15.5% crude fiber (16 to 17% during weaning) and 15 to 16% crude protein (16 to 17% during weaning). Feed intake may vary from 180 to 200 g/day for pregnant does to 350 to 400 g/day for lactating does. For fattening rabbits fed ad libitum, the feed intake is around 100 to 150 g/day with growth of around 35 to 40 g/day.

### Types of product

Unlike other forms of zootechnical production, the rabbit is still linked to a traditional form of distribution based primarily on whole or half carcasses (Figure 7). This is probably due to the form of sale, estimated as 42% sold by mass distributors and 58% sold through traditional sales (42% butchers and 16% local markets, direct sales, and personal consumption). The need to respond to changing consumer demands for food products that can be quickly and easily prepared is currently stimulating the development of pre-portioned (loins and thighs) and processed products (ground meat, skewered, and meatballs) in the rabbit sector (Petracci and Cavani, 2013).

Rabbits are slaughtered at the age of 9 to 13 weeks, depending on the degree of maturity desired and the body weights required by the market, the latter ranging from 2 to more than 2.6 kg. Slaughter age and weight are both important variables due to their effect on the quality of the meat; generally as slaughter age and weight increases, slaughter yield, carcass meatiness, and the dietary and nutritional characteristics of the meat improve (Parigi Bini et al., 1992).

### Dietary and Nutritional Properties of Rabbit Meat

Rabbit meat offers excellent dietary nutritional properties (Dalle Zotte, 2002; Hernández and Dalle Zotte, 2010) with protein contents as high as 22.4% in the loin (Table 1). The leanest cut of meat in the rabbit carcass is the loin, which contains an average lipid content of 1.8 g/100 g of meat, whereas the fattest is the foreleg, with an average lipid content of 8.8 g/100 g of meat. The quantitatively most important cut is the hind leg, with a moderate lipid content (an average of 3.4 g/100 g) compared with



Figure 7. Rabbit carcasses.

most types of meat consumed today. Lipid content depends on the portion considered and productive factors, especially diet (Dalle Zotte, 2002). Rabbit meat has a moderately high energy value (from 603 kJ/100 g in loin meat to 899 kJ/100 g in foreleg meat) that essentially depends on its elevated protein content, which accounts for 80% of its energy value.

Together with its increased protein content, rabbit meat contains high levels of essential amino acids (EAA). Compared with other meats, rabbit meat is the richest in lysine (2.12 g/100 g), sulfur-containing amino acids (1.10 g/100 g), threonine (2.01 g/100 g), valine (1.19 g/100 g), isoleucine (1.15 g/100 g), leucine (1.73 g/100 g), and phenylalanine (1.04 g/100 g; Dalle Zotte, 2004). Increased and balanced content of EAA combined with easy digestibility give rabbit meat proteins their increased biological value. Furthermore, rabbit meat does not contain uric acid and also has a low purine content (Hernández and Dalle Zotte, 2010).

The variation of vitamin content in meats is greater than with other meat nutrients because of the strong effect of the diet composition and the level of vitamin supplementation. The amount of vitamin E contained in rabbit meat may be increased by more than 50%, for example, with the use of the right supplements (Castellini et al., 1998). Vitamin E is involved in numerous physiological functions, is an essential nutrient for reproduction,

**Table 1. Proximate composition (g/100 g) and energy value (kJ/100 g) of cuts of rabbit meat.\***

	Fore legs		Loins ( <i>M. L. thoracis et lumborum</i> )		Hind legs		Whole carcass	
	Average ± SD	No. †	Average ± SD	No.	Average ± SD	No.	Average ± SD	No.
Water	69.5 ± 1.3	4	74.6 ± 1.4	24	73.8 ± 0.8	33	69.7 ± 2.6	6
Protein	18.6 ± 0.4	3	22.4 ± 1.3	21	21.7 ± 0.7	31	20.3 ± 1.6	6
Lipids	8.8 ± 2.5	4	1.8 ± 1.5	24	3.4 ± 1.1	36	8.4 ± 2.3	6
Ash	-	-	1.2 ± 0.1	14	1.2 ± 0.05	20	1.8 ± 1.3	4
Energy	899 ± 47	2	603	1	658 ± 17	7	789 ± 106	3

\* Source: Hernández and Dalle Zotte, 2010.

† Number of studies considered.

and is a powerful anti-oxidant. The latter function of vitamin E makes it an essential nutrient for improvement of meat quality because it prevents the oxidation of the fatty acids and promotes the color desired in the meat.

Meat is an important source of bioavailable vitamin B, with contents that vary from one species to another and even from one cut of meat to another in the same species, while cooking reduces the original content (Lombardi-Boccia et al., 2005). On average, the consumption of 100 g of rabbit meat provides around 8% of the riboflavin (vitamin B<sub>2</sub>), 12% of the pantothenic acid (vitamin B<sub>5</sub>), 21% of the pyridoxine (vitamin B<sub>6</sub>), and 77% of the niacin (vitamin B<sub>3</sub>) required daily (Hernández and Dalle Zotte, 2010). The lack of vitamin B<sub>12</sub> created by the popularity of vegetarianism is a growing cause of concern in the most developed nations of the world. Meat from ruminants and rabbits are the richest sources of vitamin B<sub>12</sub>, and the consumption of 100 g of rabbit meat provides three times the recommended daily intake (RDI) of vitamin B<sub>12</sub> (Dalle Zotte and Szendrő, 2011).

Meat is also an important source of minerals. Red meats, beef in particular, are among the richest sources of iron (1.8, 2.0, and 3.3 mg/100 g in beef, lamb, and mutton, respectively; Williams, 2007). Rabbit meat, like other white meats, contains only modest amounts of iron (1.3 and 1.1 mg/100 g in the hind leg and loin, respectively; Parigi Bini et al., 1992). However, the iron contained in meat is principally heme iron, which is easily absorbable, and for this reason, rabbit meat may contribute to meeting a part of our daily iron RDI. Rabbit meat is characterized by a low content of sodium: 37 mg/100 g in the loin and 49.5 mg/100 g in the foreleg (Parigi Bini et al., 1992). This characteristic makes rabbit meat particularly suited for inclusion in the diets of people suffering from hypertension.

Phosphorous, the second-leading mineral in meat in terms of quantity, is particularly abundant in rabbit meat (234 and 222 mg/100 g in the foreleg and the loin, respectively; Parigi Bini et al., 1992).

**Table 2. Proportions of the various types of fatty acids (% total fatty acid methyl esters) and cholesterol content (mg/100 g) in various cuts of rabbit meat.\***

Fatty acid†	Loins ( <i>M. L. thoracis et lumborum</i> )		Hind legs		Whole carcass	
	Average ± SD	No.‡	Average ± SD	No.	Average ± SD	No.
SFA	38.5 ± 4.8	17	39.3 ± 5.5	18	40.5 ± 1.6	4
MUFA	28.3 ± 4.4	17	28.3 ± 3.6	17	32.3 ± 2.4	4
PUFA	32.9 ± 6.7	17	31.9 ± 8.4	17	26.5 ± 2.0	5
EPA	0.17 ± 0.13	10	0.06 ± 0.02	11	0.012 ± 0.003	2
DHA	0.37 ± 0.34	10	0.17 ± 0.27	10	0.007 ± 0.001	2
n-6/n-3	5.1 ± 2.2	10	10.0 ± 3.7	13	6.6 ± 1.3	4
Cholesterol	47.0 ± 7.9	5	61.2 ± 5.2	17	55.3 ± 18.5	3

\* Source: Hernández and Dalle Zotte, 2010.

†SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

‡ Number of studies considered.

The quantity of selenium contained in rabbit meat varies widely on the basis of the amount added to the diet, ranging from 9.3 µg/100 g of meat in non-supplemented diets to around 39.5 µg/100 g of meat in feeds enriched with 0.50 mg of selenium/kg of feed (Dokoupilová et al., 2007). According to Rayman (2004), 140 g of meat from rabbits fed selenium-enriched diets is capable of meeting the RDI of selenium for adult individuals.

Based on fatty acid (FA) composition, rabbit meat is highly suited to human consumption (Table 2). In rabbit meat, unsaturated fatty acids (UFA) account for approximately 60% of the total FA, and the quantity of polyunsaturated fatty acids (PUFA) that accounts for 27 to 33% of total FA is greater than that of other meats, including poultry (Wood et al., 2008). Linoleic acid (18:2n-6), the principal FA in the feeds given to all animal species, is derived entirely from the diet. In the rabbit, it accounts for 22 ± 4.7% of the total FA. Like linoleic acid, α-linolenic acid (18:3n-3) is also an essential FA and abounds in the diets fed to rabbits because it is the principle FA in alfalfa, the chief component of rabbit diets. Rabbit meat is particularly rich in α-linolenic acid (which represents 3.3 ± 1.5% of the total FA; Dalle Zotte and Szendrő, 2011) compared with the amount contained in other meats (1.37% of the total FA in lamb, 0.95% in pork, and 0.14 to 2.34% in beef; Enser et al., 1996).

Rabbit meat also contains significant proportions of long-chain PUFA (C20–22), which are formed from the linoleic and α-linolenic acids. Other important products include arachidonic acid (20:4n-6) and eicosapentaenoic acid (EPA, 20:5n-3), each of which plays a different metabolic role. The content of EPA in rabbit meat depends on portion considered (Table 2). Another nutritionally important long-chain PUFA in the n-3 series is docosahexaenoic acid (DHA, 22:6n-3). In the rabbit meat DHA represents the 0.37 ± 0.34% and the 0.17 ± 0.27% of the total FA in the loin and hind leg, respectively (Table 2). Rabbit meat has lesser levels of cholesterol than

any other common meat: considering a lean meat portion (*M. Longissimus thoracis and lumborum* for rabbit, beef, veal, and pork, and *M. Pectoralis major* for chicken), the average cholesterol level is 47.0, 48.7, 52.3, 62.7, and 55.3 mg/100 g of meat, respectively (Dalle Zotte and Szendrő, 2011).

## Conclusions

Rabbit production requires careful management of environment, diet, and breeding parameters. The dietary and nutritional properties of rabbit meat suggest its frequent consumption, especially by children and adolescents, pregnant women, athletes, and the elderly, can be strongly recommended.



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