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EFFECTS OF GENOTYPE AND MANAGEMENT SYSTEMS ON PERFORMANCE, ECONOMICS AND SOCIETAL PERCEPTIONS IN RABBIT MEAT PRODUCTION

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1. INTRODUCTION

World rabbit meat production has more than tripled since 1961[1]. China and Italy dominate the market and together they are responsible for more than 70% of world production. For the last 15 years, China has been the leader, not only in terms of production, but also in the volume of exports (Szendrő K., 2014). Although Hungary was ranked 14th among major rabbit meat producing countries (6.496 tons), and was responsible for only 0.5% of the world production, it played an important role in terms of foreign trade (export). Domestic rabbit meat consumption was low (1.8-2%), hence around 98% of the slaughtered rabbits were sold to international markets (Juráskó, 2014). With no imports, Hungary's trade balance was exceptional and claimed second place as a net exporter. As a consequence of the export situation, international markets have a considerable impact on the Hungarian production and prices.

The change of political system in Hungary in 1989 highly influenced the production structure. Previously, 90% of purchased rabbits originated from small farms, nowadays small scale rabbit production almost ceased, it gave only 1-2% of the total purchased quantity in 2013 (Juráskó, 2014). There are about 60-65 large rabbit farms, with an average of 1,600 rabbit does (Juráskó, 2013).

Generally, the rabbits from the Pannon Breeding Program at Kaposvár University and foreign hybrids are used. Former are unique breeds. Two of them have been selected for a long time for carcass traits based on the data of computer tomography (CT). The contributions of the Pannon White, Hycole, Zika, Debreceni White and Hyla in Hungarian production were 47,

[1] Venezuela, North Korea, Colombia and Sierra Leone had unrealistically high, probably erroneous, results in their production so they were not considered.

40, 9, 3 and 1%, respectively, in 2013 (Juráskó, 2014). Influencing the development of Hungarian breeds and lines by evaluating carcasses for merit and taking advantage of CT-selection could lead to substantially improved values. The Hungarian Giant is the only traditional breed in Hungary. It originated from a native population (Holdas and Szendrő, 2002). It would be useful to determine the position of Hungarian Giant in the production chain as a labelled product.

Intensive systems of housing, feeding and reproduction are widespread, yet alternative methods also used. Besides intensive breeds and hybrids, closed systems with wire-mesh cages, pelleted feeds, and artificial insemination at 11 days after parturition are mainly used (Coutelet, 2013) and 95% of does in France are inseminated 11 days after kindling. There is a growing interest in colored breeds kept in alternative housing systems and fed by less intensive feeding. Alternative methods include larger group sizes, using cages/pens equipped with elevated platforms, or rearing rabbits on deep-litter, and use of hay supplementation. Besides more natural housing, feeding and reproduction systems, animal welfare has an increasing role in Europe, including Hungary. Due to this fact, most hybrid breeding enterprises trade not only with white terminal lines, but also with males with colored hair to produce growing rabbits reared in alternative conditions.

Reduction of feeding cost is of primary importance to rabbit producers, and the main possibilities include using efficient stock (high productivity and growth rate), good quality diets and feeding methods, limiting losses, and effective farm management (Maertens, 2009). On the other hand, slaughterhouses are interested in realizing higher profit from the products sold. By focusing on individual aspects to obtain better results, there is a lack of complex, interdisciplinary thinking along the supply chain of rabbit meat production: such as obtaining raw materials for feed, feed milling and feed production, in addition to the rabbit farm and the slaughterhouse. Also, the concerns of consumers should be taken into account. Thus far, publications mainly focus on evaluating production and carcass traits. Well-documented reports on economic evaluation for growth and carcass traits (Jentzer, 2009; Mikó *et al*., 2010; Verspecht *et al*., 2011) and on consumer perceptions (Bodnár and Horváth, 2008; Szakály *et al*., 2009) are rare.

2. LITERATURE OVERVIEW

2.1. RABBIT MEAT PRODUCTION AND FOREIGN TRADE IN THE WORLD AND HUNGARY

The key findings and information complied in this chapter are intended to be published in Gazdálkodás (Szendrő K., 2014). I focus only on the main results and statements of that publication, relevant to my thesis.

Between 1961 and 2012 world rabbit production has more than tripled, and exceeded 1.4 billion tons in 2012. Over the past half-century, the distribution of rabbit meat production of the continents has significantly changed. Compared to 1961, the market share for Europe fell from 91% to below 40% by 2012, while Asia was responsible for more than half of world production and had increased from 3% in 1961 to 52% in 2012.

Italy was the leader in production until 1993. Since then, China took the lead (***Table 1***). The highest improvement can be seen in the case of China. It produced about 735,000 tons of rabbit meat in 2012. In recent decades, significant improvements have been made for the purpose of intensive production (Szendrő Zs. and Szendrő K., 2010).

The production in Italy is quite stable, but the other two traditional European l rabbit meat producers and consumer countries, France and Spain, experienced significant decreases lately (***Table 1***). Hungary, despite the 70% reduction in production compared to the early 90's, claimed 14th place in 2012.

Table 1
Rabbit production of the four leading countries and Hungary (1,000 tons), and their share of world production in 2012

	1961	1970	1980	1990	1995	2000	2005	2010	2012	Share of world production, %
World (t)	**397**	**491**	**726**	**783**	**920**	**1008**	**1099**	**1287**	**1409**	**100**
China (%)	10.5	33.0	60.0	96.0	268	370	511	690	735	52.2
Italy (%)	48.9	84.8	175	184	210	212	225	255	263	18.6
Spain (%)	20.6	24.5	66.3	71.2	111	104	70.5	66.2	67.5	4.8
France (%)	7.2	7.8	15.6	49.0	54.0	54.2	54.8	52.3	56.3	4.0
Hungary (%)	**4.0**	**7.6**	**22.8**	**17.2**	**11.4**	**14.0**	**9.7**	**5.4**	**6.5**	**0.5**

Note: Countries were ranked on the basis of 2012 data.
Source: based on the FAOSTAT database

Although there are no data about breeding animals on the FAOSTAT database, the demand for breeding rabbits is high in those countries where production is also high. Therefore, trading of breeding animals is mainly concentrated in France, Spain and Italy. Most of the hybrids are bred in France, hence European slaughter rabbit production is mainly based on French hybrids. There are several replication farms in other countries (e.g. in Spain, Italy and Hungary) for French hybrids. Hybrids will be discussed in more detail in the next section.

China is the most important player in terms of rabbit meat export (***Table 2***). One of its greatest strengths is the low price. Due to the large distance, China exports only frozen meat to Europe, which is against the preference of most European consumers towards fresh and chilled goods. Also, since most of the European consumers are conscientious about high quality standards and animal welfare (which may not be of high priority in the leading countries in export outside of the EU) additional comparative advantage could be achieved by the exporters in the region.

Since 2005, only China, France and Belgium were able to increase their rabbit meat exports. The top six countries shown in ***Table 2*** were responsible for 89% of the total exported rabbit meat (35,920 tons). Although Hungary has lost its former position in production the country still plays a significant role in export.

Table 2
Distribution (%) of the leader countries in rabbit meat export of world export

Country	**1991**	**1995**	**2000**	**2005**	**2010**	**2011**
China	26	40	40	22	28	25
France	8	8	10	12	16	18
Belgium	2	3	3	7	14	17
Hungary	**45**	**16**	**9**	**13**	**11**	**12**
Spain	0	4	8	10	11	10
Argentina	6	11	6	15	8	7
World export, tons	**45,822**	**51,080**	**56,261**	**40,922**	**36,778**	**35,920**

Note: countries are ranked on the basis of data of 2011
Source: based on FAOSTAT database

Since the change of the political situation in 1989, Hungarian rabbit meat production and export significantly declined. At the same time, substantial transformation occurred in the structure of production. Mainly due to the increasing transport costs, small-scale rabbit breeding was not financially feasible. While governmental support for machinery, breeding animal-purchasing, etc. played an essential role in the development of large-scale production, the number and the size of large-scale farms increased significantly. Currently the large-scale farms produce 98-99% of the total purchased quantity (Juráskó, 2014) compared to 10% in the 1970’s and 1980’s.

Over the past two decades, the Hungarian export market has undergone a significant transformation. While in 1991 more than 20,000 tons of rabbit meat was delivered to seven countries, in 2011 only one fifth of that amount was exported, but to almost 20 countries. While in 1991 Italy was our main market with 92% of the export quantity, in 2011 Hungarian rabbit meat was exported mainly to Germany (25.3%, up from 2% in 1991), Italy (24.0%) and Switzerland (21.4%), while the Russian Federation also increased its import demands (***Table 3***). The share of Hungarian rabbit meat in the Russian Federation was 80%, but it was above 50% in Switzerland, too.

The establishment of Olivia Ltd. played a significant role in the rearrangement of the Hungarian export markets, since the construction of a new slaughterhouse by the Swiss owner "opened up" the possibilities towards a well-paying, but demanding Swiss market. On the other hand, simultaneously with the shrinkage of the Italian market share, the role and influence of the Italian traders declined and ceased. The formerly Italian-owned slaughterhouse in Baja was bought by Tetrabbit Ltd., preferring primarily the better-paying markets with focus on the German and Swiss markets. Currently, these two enterprises equally share the entire Hungarian rabbit production and foreign trade.

Table 3
The main five trade (importing) partners of Hungary in 2011

	Country					
	Germany	Italy	Switzerland	Russian Federation	Belgium	**Total**
Export, tons	1,134	1,076	958	504	159	**4,485**

Source: based on FAOSTAT database

In 2011, at least 500 tons of rabbit meat was purchased from abroad by each of the ten largest importing countries. The largest was Belgium with more than 6,000 tons; most of their rabbit meat (70%) was purchased from China, whereas the share from Hungary was only 3%. Germany also purchased twice as much rabbit meat from the Far-East as from Hungary, 45% of their imports had Chinese origin. Furthermore, China supplied mostly the Netherlands and the USA. The rest of the importer countries preferred neighboring countries; the French import mainly from Belgium, the Portuguese from Spain, while the Italians import from France. Italy became not only a shrinking potential market, but also a remarkable regional competitor. Based on the trade balance, China (8,891 tons), Hungary (4,461 tons) and France (4,260 tons) were the most significant net exporters, while Germany (-4,478 tons), Portugal (-1,802 tons), Switzerland (-1,800 tons) and Italy (-1,739 tons) were the most significant net importers.

2.2. FACTORS DETERMINING ECONOMY

2.2.1. Role of the genotype

In the following three sections I focus on collecting general information about the role of genotype, housing and feeding in production of growing rabbits in relation to natural indicators (productive performance and carcass traits). The literature data regarding the given experiments are summarized in the chapter of results and discussion, in order to help the reader better understand and more easily follow the findings in literature which are in close connection with the given experiment.

In developed European rabbit breeding countries most farmers produce with hybrids. Hybrids are crossbreds; in most cases they contain three lines (three-way cross hybrids). Two medium sized maternal lines – which have been selected for 35-45 generations for litter size at birth or at weaning – are crossed. The crossbred parent does are mated with a large bodied terminal line, which has been selected for growth rate. Due to the effect of heterosis, parent does have high reproductive and rearing ability, however their growth rate is low. The weight gain of progeny is increased by the terminal paternal line, however, the terminal lines mature late and their carcass traits are poor. Due to their lower adult weight, maternal lines mature for slaughtering earlier than terminal lines, therefore when slaughtered at the same age or at similar weights, their dressing out percentages and meat ratios are higher. Some alternative producing farms use colored paternal lines, e.g. Argente de Champagne or Fauve de Bourgogne, to sell colored slaughter rabbits.

The first hybrid was developed in France by the scientists of INRA in Toulouse. Most of the hybrids are selected in France, the most known is the Hyplus. This used to be the most popular hybrid in Hungary, but nowadays the Hycole is the most common, and only a few rabbit farms work with Hyla. Formerly, the German Zika was also frequently used in Hungary. In Spain, the University of Valencia has a long selection program but they have produced no hybrid. In the 1970's, a Hungarian hybrid, named White Pearl, was established at Bikal State Farm, however, at the time of the political change, the hybrid no longer existed.

Most of the hybrids have similar reproductive and productive performance (***Table 4***).

Table 4
Reproductive performance, productive performance and carcass traits of some hybrids

Traits	Hybrids			
	Hyplus	Hycole	Zika	Hyla
Kindling rate, %	70-80	75-85	75-85	70-85
Litter size				
total	9.5-10.5	9.0-10.0	8.5-9.5	8.5-9.5
alive	9.0-10.0	8.5-9.5	8.0-8.5	8.0-9.0
at weaning	8.0-8.5	7.5-8.5	7.0-7.5	7.5-8.0
Body weight gain, g/day	38-43	35-40	40-45	40-43
Body weight at 10 wk, kg	2.4-2.5	2.2-2.4	2.2-2.4	2.4-2.5
Feed intake, g/day	125-135	120-130	130-150	130-150
Feed conversion ratio	3.0-3.3	3.1-3.3	3.1-3.3	3.2-3.4
Dressing out percentage, %	58-60	57-59	58-59	58-59

Source: Holdas and Szendrő, 2002

In some experiments the breeds of the Pannon Breeding Program: Pannon White, Pannon Ka and Pannon Large and other genotypes (mainly crossbred animals) were compared. Additionally, the Hungarian Giant was evaluated. The characteristics of these breeds are summarized below:

- **Pannon White** (PWhite) rabbits have been selected for daily weight gain (replaced by 21-day litter weight since 2010) and carcass traits measured by computer tomography (CT) since 1992 [between 1992 and 2004 for cross section of *musculus longissimus dorsi* (loin fillet), and since 2004 for volume of muscle on hind legs]; and adult body weight. The adult body weight is 4.3-4.8 kg (Matics *et al.*, 2014a).
- **Pannon Ka** (PKa, maternal line) was established in 1999 and selected for litter size using BLUP methods. The adult body weight is 4.0 to 4.5 kg (Matics *et al.*, 2014a).
- **Pannon Large** (PLarge, terminal line) has been selected for daily weight gain and carcass traits measured by CT since 2005 (for volume of muscle on hind legs). The adult body weight is 4.8 to 5.4 kg (Matics *et al.*, 2014a).

Using these three genotypes, the advantage of crossing (heterosis) can be utilized, leading to small differences compared to other hybrids, yet as a result of CT-based selection, their carcass traits are exceptional.

In another experiment PWhite and PKa does were inseminated with the sperm of PWhite, PKa, PLarge, terminal line of Hycole hybrid, or colored bucks (Szendrő *et al.*, 2010). The adult body weights of the PWhite, and Color genotypes were medium, and that of the PLarge and Hycole were higher. Examining the effect of sire genotype, the rank order of body weights at 11 weeks and feed intake were: Hycole > PLarge > PWhite > Colour > PKa. The differences between the groups' dressing out percentages were not significant. The ratio of the fore part was higher in groups of PLarge, Hycole and Color, but the ratio of hind part to the reference carcass was the largest in the progeny of PWhite and the lowest in the PLarge and Color progeny It was concluded that the production of growing rabbits was affected by the adult weight of their parents, but the carcass traits were influenced by their own adult weight and by the CT-based selection.

- **Hungarian Giant** (Hung) is a traditional Hungarian breed originated from a native colored population. During the development of this breed, they were crossed with Flemish Giant and other giant breeds (Holdas and Szendrő, 2002). Currently, some breeders also use intensive breeds (e.g. New Zealand White, Pannon White) to improve their performance.

Most countries have one or more local breeds which could play an important role in commercial production. One group of breeds is the giant rabbits. They are used as pet rabbits or for crossing in commercial farms. Several papers have been published about their results: Flemish Giant (Lukefahr *et al*., 1982; Lukefahr and Ozimba, 1991; Bolet, 2002; Prayaga and Eady, 2003; Maj *et al*., 2012), Gigante de España (López and Sierra, 2002), German Giant (Bianospino *et al*., 2006), Moravian Blue (Tůmová *et al*., 2013), Transylvanian Giant (Petrescu-Mag *et al*., 2011), Hungarian Giant (Holdas and Szendrő, 2002; Hungarian Giant Rabbit-breeders Association, 2013). In most cases, the giant breeds showed good growth rates, but low dressing out percentages.

The performance of two giant genotypes, the terminal lines and giant breeds are different, since the first group has been selected for weight gain for several generations, but the other was not selected for productive traits. This is why the use of any giant breeds, including Hungarian Giant, in rabbit production can develop a new (e.g. labelled) product. They have not had any role in intensive production.

2.2.2. Role of the housing system

Housing of rabbits and the main characteristics of cages and pens were summarized in an EFSA report (EFSA, 2005). The majority of farms are closed-cycle type with breeding and growing rabbit buildings at the same place. Rabbits are mainly housed in closed buildings. There are ventilation, heating and cooling systems. Commercial cages for growing rabbits are principally made of wire and always have a wire top. A pen can be made of different materials and may be open-topped. Generally, the number of rabbits housed in a pen is greater than in a cage. Growing rabbits are generally housed in pairs or three rabbits/cage in Hungary and Italy. In some countries growing rabbits are housed in small (5-8 animals in a cage) or larger (e.g. 10-12 rabbits per cage) groups. Cages are mainly made of wire-mesh (floor, walls, top).

The effects of housing system on productive and carcass traits were summarized by Trocino and Xiccato (2006), and Szendrő and Dalle Zotte (2011). Most experiments demonstrated that with increasing group size, the feed intake, weight gain and body weight decreased (Maertens and Van Herck, 2000; Dal Bosco *et al*., 2002; Lambertini *et al*., 2001), and dressing out percentage declined slightly (Lambertini *et al*., 2001; Dal Bosco *et al*., 2002; Szendrő *et al*., 2009b; Combes *et al*., 2010). Bigler and Oester (1996), Szendrő *et al*. (2009c) and Princz *et al*. (2009) observed that the aggressiveness and frequency of injuries on the body increased in larger groups. Despite these results, there is pressure by some specialists and animal rights movements to increase group size (e.g. Four Paws).

Comparing floors made of wire-mesh, plastic-mesh, steel slats and plastic slats, Trocino *et al*. (2008) and Princz *et al.* (2009) did not find significant differences among the groups in productive performance nor were there any differences in carcass traits (Dalle Zotte *et al*., 2009).

Some organic production organizations (e.g. BioAustria, BioSuisse, Naturland) suggest rearing rabbits on deep-litter on at least 50% of the floor. However, the productive performance and carcass traits of rabbits reared on deep-litter were lower than that of rabbits on wire-mesh floor. In addition, the mortality increased (Dal Bosco *et al*., 2000, 2002; Lambertini *et al*., 2001; Metzger *et al*., 2003; Trocino *et al*., 2008). Some authors (Dal Bosco *et al*., 2000, 2002; Lambertini *et al*., 2001) established that the consumption of straw litter with low nutritive value may reduce feed intake. Some of the most serious problems of consumption of litter material mixed with faeces and urine is a risk of digestive diseases (such as coccidiosis), increasing morbidity and mortality, and lowered productivity.

Preference tests showed that more rabbits preferred staying on wire-mesh than on deep-litter floors (Morisse *et al*., 1999; Orova *et al*., 2004). Bessei *et al*. (2002) revealed that the choice of rabbits between the two floor types depended on the temperature. Since rabbits have fur coats and hardly lose any heat when the temperature is higher than the optimum, they do not prefer staying on deep-litter which has less air flow.

In recent years, significant investments were made to develop new housing systems: rabbit cages with platforms were established, where the kits can be reared in their place of birth; cages suitable for group housing of growing rabbits; or growing rabbits reared on deep-litter. The main aim of these improvements was to meet the Swiss and German animal welfare standards.

2.2.3. Role of the feeding method

In the case of rabbit production – just like in other farm animals – feed is the major cost factor, which may represent 60-80% of total production cost (Baselga and Blasco, 1989; Maertens, 2009; Drouilhet *et al*., 2013). Therefore, the most significant improvements in profitability could be achieved in this field. On large-scale farms, rabbits are fed solely on pelleted feed.

One of the alternative methods is applying some fresh or dried forage in addition to pelleted diets. Scientists tested several forages: alfalfa (Bianchi *et al*., 2006; Linga and Lukefahr, 2000; Capra *et al*., 2013), cassava foliage hay (Scapinello *et al*., 2000), guinea grass and verano stylo hays (Bamikole and Ezenwa, 1999), sulla hay (Kadi *et al*., 2011), mulberry leaves (Martínez *et al*., 2005), whole maize plants (Martínez *et al*., 2006), green barley (Morales *et al*., 2009). The results of the experiments in which forages were not mixed as a balanced, pelleted diet showed low productive performance (Carabagño and Fraga, 1991).

Linga and Lukefahr (2000) showed that rabbits receiving only alfalfa achieved very poor production results. Capra *et al*. (2013) compared two feeding strategies: pellets with or without fresh alfalfa *ad libitum*. They found a small, non-significant difference between the two groups. When alfalfa was mixed into the pellet in ratio of 88 or 96% compared to the control diet with 49% alfalfa (Fernandez-Carmona *et al.*, 1998), a slight decline was observed in body weight and in weight gain. Morales *et al*. (2009) added 10, 20 or 30% green barley forage to the pelleted diet and observed that, with increasing green barley, the weight gain decreased.Using different forages, the results could depend on their origin (nutritive value) and their form (fresh or dried, given as pellets plus forage or mixing them into the pellets).

In the last decades several experiments were carried out examining the effect of feed restriction. In the first experiments, authors tried to find the optimal daily duration of eating time during the whole fattening period (Szendrő *et al*., 1988; Jerome *et al*., 1998). The strategy of feed restriction changed when the epizoonic rabbit enteropathy outbreak occurred in 1977. A stronger quantitative feed restriction or limited time access to the feeders were applied after weaning and, during the last period of fattening, rabbits consumed pellets *ad libitum* (Gidenne *et al*., 2012). The aim was to reduce the mortality and to improve the feed conversion ratio, although, the body weight at slaughter and the dressing out percentage were significantly decreased. In spite of the favorable results (lower mortality, better feed conversion ratio), rabbits lost 100-250 g weight.

Several papers were published in the field of housing and feeding, but did not include economic evaluation of their effects. Generally it is known that rearing growing rabbits in alternative housing systems (larger groups, deep-litter floor, etc.) has a negative effect on most productive and carcass traits. If the growing period is longer or the meat production is lower, the income of farms and slaughterhouses is lower if the price of rabbits and carcass are the same. However, most markets pay higher prices for these products, e.g. the price of rabbits housed on deep-litter was higher in Hungary by about 15-20% (Juráskó, 2014).

2.2.4. Evaluation of rabbit production and its economic aspects in France

This chapter is based on the paper published in Baromfiágazat (Szendrő K., 2014)

Only in France data from hundreds of rabbit farms have been collected and analyzed since the 1960's. As some of its characteristics are similar to Hungary's (e.g. net exporting country; high impact of climate on crop yields and therefore on feeding cost; switching to large-scale farming), we could learn from their experience.
In the last 25 years, kindling rate, litter size, feed conversion ratio, number of rabbits sold/kindling or per female/year improved by 22, 24, 20, 40, and 20%, respectively. In addition, natural mating was replaced by artificial

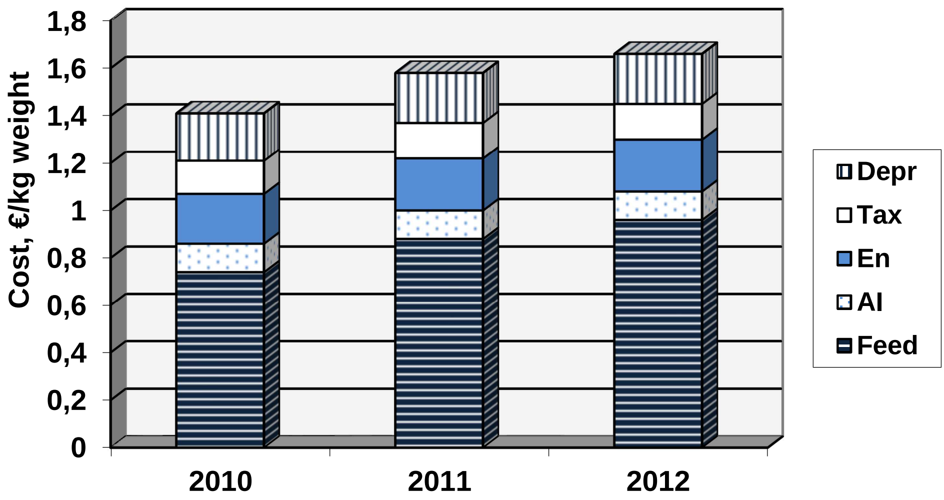
insemination, enabling improvements in efficiency, production intensity, and the development of large-scale rabbit farms. The average number of females on a farm increased almost 3.5-fold in 25 years. Close relationships can be identified between the size of a farm and the production, as well as profit. Small farms experienced a dramatic decline, while production sites with more than 500 does increased their output. Larger farms achieved some profit, while the smaller ones were – more or less – in deficit (***Table 5***). In general, in critical years (e.g. when feed prices were very high), only the production from large-scale farms was profitable.

Table 5
Change in production between 2000 and 2010 depending on farm size in France

Number of does/farm	**Change (%)**
below 20	-71
20-100	-46
100-199	-71
200-499	-55
500-999	11
above 1000	64
Average	**-35**

Source: Braine and Coutelet, 2012

Braine and Coutelet (2012*)* revealed how significantly the production and economic results of the farms have improved in recent decades. Despite the fact that irrigation water is free of charge in France, therefore the price of feed is lower than in Hungary, feed still represents the largest portion of production cost. The weather is of crucial importance for changes in crop yields, and may have a significant influence on the price of feed. As shown in ***Figure 1***, the cost of feed has risen significantly; 216, 260 and 285 €/ton in 2010, 2011 and 2012, respectively. Price changes of the feed determine the profitability (or loss) of the farms. However, in those years, an advance in the price of live rabbits was experienced, from 1.65 (2010) to 1.83 (2011) and 1.95 €/kg (2012).



Notes: Depr: depreciation and financial expenses; Tax: taxes and duties; En: cost of energy, water and litter; AI: cost of artificial insemination and doe replacement; Feed: cost of feed
Source: Braine and Coutelet, 2012

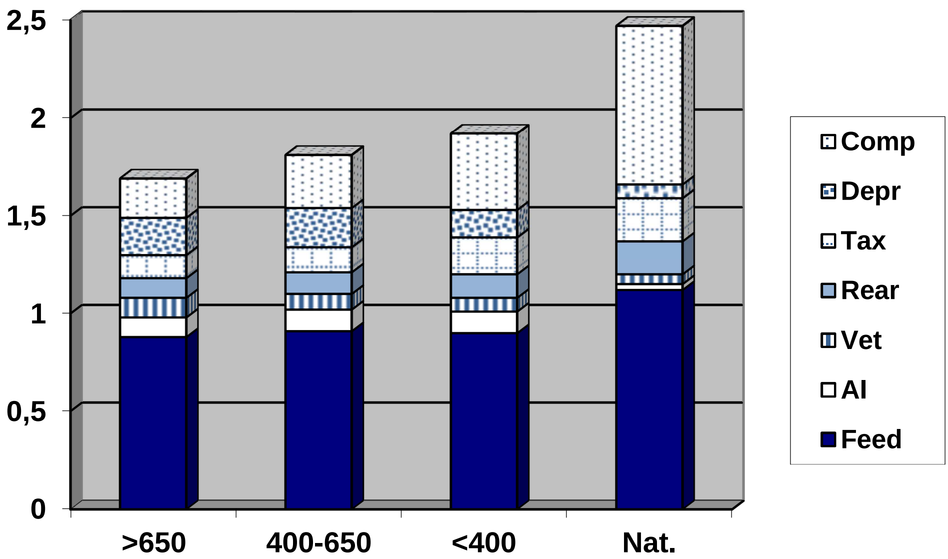
Figure 1 The structure of production costs of farms in France between 2010 and 2012

In Hungary there is no database similar to the French one, the price change, the cost structure of several large-scale farms became available from a specialist of Agribrands Europe Hungary Plc. (*Demeter, personal communication*). At some points, there are significant differences in cost of rabbit meat production between France and Hungary. Comparing the proportion of cost elements, the largest difference in 2012 could be observed in case of feed cost. Feed cost may represent 57.8% of production cost in France, but is 9% higher in Hungary.

Further influencing factors include the weight at slaughter, which depends on consumers' desires. In France, smaller rabbits are slaughtered (2.4-2.5 kg) than in Hungary (2.6 to 2.8 kg), which have two consequences: the fattening period is shorter, and the feed conversion ratio of younger rabbits is better, hence less feed is consumed for producing 1 kg of rabbit meat. According to Maertens (2009), while in France and Spain a rabbit requires less feed (3.60-3.63 kg), in Italy – where rabbits are slaughtered at similar weight as in Hungary – more feed (3.82 kg) is used to produce 1 kg of fattening rabbit. However, it should be noted that due to the lower slaughter weight, feed used in breeding (by the female, male and suckling rabbits) represent a higher proportion of total feed consumption at farm level. Maertens (2009) also stated that 50-60% of total feed consumption goes for reproduction and 40-50% for fattening.

Significant differences were observed in Dept (depreciation and financial expenses), AI (artificial insemination and doe replacement), as well as in cost of En (energy and water), which were 5.0, 2.6 and 1.2% lower in Hungary. Apparently, Hungarians cannot request as high a price for the breeding animals and insemination as the French.

When analyzing the structure of production costs on rabbit farms with different sizes and reproduction methods (***Figure 2***), some differences can be seen. With increasing farm size, the total cost, the cost of compensation for the breeder's effort and taxes and duties rose, while the cost of depreciation and financial expense declined. The structure of production costs on farms using artificial insemination or natural mating was significantly different. The highest change was in cost of feeding, compensation for the breeder's effort and taxes and duties (with higher costs on farms using natural mating), while the cost of depreciation and financial expenses, veterinary expenses, artificial insemination and doe replacement (no AI) decreased. However, it should be noted that the farmers who used natural mating mainly produced labelled and similar products, and they could sell the rabbits for a higher price.



Notes: >650: more than 650 does, 400-650: 400 to 650 does, <400: less than 400 does, Nat.: natural mating, Comp: compensation for the breeder's effort; Depr: depreciation and financial expenses; Tax: taxes and duties; Rear: cost of doe rearing; Vet: veterinary expenses; AI: cost of artificial insemination and doe replacement; Feed: cost of feed
Source: Jentzer, 2009

Figure 2 The structure of production costs depending on farm size and reproduction method in France

The often unrealistic expectations of animal rights promoters, and the partial or full implementation of these expectations in certain EU recommendations and market demands, greatly increase the cost of production. If these additional costs are not included in the purchase price, the production will be unprofitable. The costly rabbit meat would be more expensive, and the consumption would decline. The situation is even more challenging, since these expectations are valid only in the EU, but not in lesser developed countries. In other words, the more expensive that the European rabbit meat is, the more it is substituted by imports. Unfortunately, a declining trend in European rabbit meat production can be observed, and the reason for this could be mainly due to the increased meat price.

The efficiency of production is partly or mainly dependent on farm management. Braine and Coutelet (2012) showed significant improvement in production results of French rabbit farms over the last decades. Jentzer (2009) found significant differences between the best 25% and the worst 25% rabbit farms on production. The French example shows how farmers deal with difficult financial situations. Increasing the farm size and improving the efficiency or developing labelled production systems can be viable options for long-term survival of the rabbit farms. In Hungary, the two slaughterhouses (with their farms) focus on the market of demanding but good-price-paying countries, and their investments and direction of development follow the expectations of the market.

2.2.5. Other factors influencing economic values

Only a few papers are available in the field of economic analysis of rabbit production in different countries. In some cases, e.g in Ghana or in Tunisia, the rabbit production systems (based on small-scale farms and using local forage etc.) are far from the European conditions. Therefore in this section some Australian and Chinese data showing the effects of age and weight, as well as the importance of CT-based selection will be presented.

Australian and Chinese literature

Prayaga and Eady (2000) gave some economic parameters about the „trait economic value" (in Australian Dollar, AUD). If the mortality from weaning to slaughter decreased by 1%, daily weight gain during fattening increased by 1g or daily feed consumption per young rabbit during fattening period decreased by 1g, the economic improvements per doe per year were 3.11, 1.98 and 0.78 AUD.

Rabbit meat prices in China were much lower than in other countries. In 2009 the price of one ton of rabbit meat was 4,509; 4,308; 3,229 and 3,046 USD in Germany, France, Portugal and Hungary, respectively. At the same time in China, it was only 952 USD (Wu *et al*., 2012). In China, maize was one of major feed grains used by medium- and large-scale rabbit farms. On small farms, local feed resources or agricultural by-products were also used. Presently in China, rabbits are still mainly raised in smaller units, typically involving a husband and wife raising between 3,000 to 5,000 rabbits per year. Raising rabbits is still labor intensive (Karikari and Asare, 2009), but the cost of labor is also low. The competitiveness of China's rabbit meat is based on the low price of feed and labor cost. The disadvantage of China is that they are able to export only frozen meat. However, according to Yan *et al*. (2012) export was not the main business of the China rabbit processing companies. The great demand in China's domestic market has promoted the rapid total development of the industry. Zilin (2011) and Yan *et al*. (2012) published some data about the prices in China. The price of one rabbit was about 6.34 USD, the total rearing cost was between 3.17-3.96 USD in smaller farms and 3.33-4.12 USD in farms with 100-500 does: the gross margin per rabbit was from 2.38 to 3.17 USD.

Effect of age and weight

When evaluating the economic benefit of rabbit farms, one of the factors is the age and weight of growing rabbits at slaughter. Szendrő K. *et al*. (2012a) studied the effect of age and weight at slaughter on the value of loin fillet, thigh meat and whole carcass of rabbits. The animals were 74, 84 and 94 days of age at slaughter, with an average body weight of 2.53, 2.84 and 3.15 kg, respectively, and with five weight categories in each age group (Metzger *et al*., 2011). Within the same age categories, the effect of body weight on the value of the whole carcass, loin fillet and thigh meat was significant in each case. A similar tendency can be seen with the whole carcass, loin fillet and thigh meat with age, but significant differences were observed only between the 74 day rabbits and the two older age groups. The lowest value was achieved at the youngest age or the smallest weight (4.39 and 4.27 €/kg of carcass for the whole and for the total value of parts of carcass, respectively). The highest value was achieved at the oldest age or the heaviest weight (9.10 and 9.31 €/kg of carcass for the whole and for the total valuable parts of the carcass, respectively). The conclusion was that when the values were evaluated, 74-day old rabbits were not mature enough, while 84-day old rabbits were considered favorable for slaughter.

Ramon *et al*. (1996), Piles *et al*. (2004a), Larzul and Rochambeau (2004), Metzger *et al*. (2006a,b) and Szendrő *et al*. (2009a, 2010) revealed a strong connection between the adult body weight and growth rate. In accordance with the results of several authors (Lukefahr *et al*., 1982; Gómez *et al*., 1998; Larzul and Rochambeau, 2004), larger carcasses, carcass parts, and organ weights were found in larger rabbits. Pla *et al*. (1996, 1998), Gómez *et al*. (1998), Hernández *et al*. (2006) compared rabbit lines selected for litter size or growth rate. When carcass traits were compared at the same age the differences for dressing out percentages were lower, compared to the examination when body weight was similar but at different ages. In the latter case, the rabbits of higher adult body weight were less mature at slaughter compared to the examinations made at identical ages. The greater the difference between the adult body weights of the genotypes and the lower the age at slaughter, the greater are the detectable differences for dressing out percentage. Szendrő *et al*. (2009b) established that the carcass traits of PWhite and PLarge were related to the CT-selection for improving meat in the body.

Breeds, CT-based selection

The choice of breed may also play an important role in the economic aspects. Currently, Pannon breeds and Hycole hybrid are the most prevalent breeds in Hungary (Juráskó, 2014). Hybrids could achieve better production yields, especially in reproductive traits, than purebred lines. However, the parent stock needs to be repurchased every year, thus 120% replacement is expected. In the case of purebred rabbits, the replacement is solved by their own progeny, which is significantly cheaper than purchasing the parent stock. It should also be noted that each new rabbit on the farm may increase the chance of disease occurring, while breeding their own replacements minimizes this risk. PWhite and PLarge breeds have a special advantage for slaughterhouses, since they produce more meat than other breeds and lines as a result of CT-based selection (Matics *et al*., 2014).

In the selection centers of hybrid companies the maternal lines are selected for improving reproductive performance (litter size at birth or at weaning), and the objective of selection of the sire lines is the weight gain (Baselga, 2004; Garreau *et al*., 2004; Khalil and Al-Saef, 2008). Generally, carcass traits are not included among the selection criteria. Using CT in selection of rabbits for improving meat volume is a unique *in vivo*, non-inasive method. The CT-based selection has been carried out at Kaposvár University since 1992. During the first 12 years, the average surface of *Musculus longissimus dorsi* (L-value) was measured. In 2004 the L-value was replaced by thigh muscle volume (TMV) which is estimated between the *crista iliaca* of the *os ilium* and the *patella*.

The L-value had moderate heritability (0.33) but this value is higher than the heritability of the thigh muscle volume (0.19-0.25) (Nagy *et al*., 2006, 2010; Gyovai *et al*., 2008, 2012). The genetic trend for the TMV was higher in the PLarge (5.8 cm^3) than in the PWhite (4.0 cm^3) (Gyovai *et al*., 2008; Nagy *et al*., 2013). Using divergent selection, CT-based selection for L-value improved the dressing out percentage by 1.8%, and increased the weight of the mid and hind parts of the carcass (by 5.1 and 2.7%, respectively). Divergent selection for TMV caused differences in dressing out percentage and meat on hind legs (1.1 and 1.9%, respectively) in the second generation (Szendrő *et al*., 2012). Based on economic calculations CT-aided selection generates a substantial profit at the slaughterhouse level (Mikó *et al*., 2010).

Metzger *et al.* (2006a,b) compared different genotypes and revealed how genetic origin influenced the dressing out percentage, which was 0.5-1.5% higher in PWhite progeny than in hybrid progeny. The ratio of the loin to the reference carcass weight was also higher in rabbits sired by PWhite males. Results of the experiments showed that selection based on CT was successful.

Existing publications have mainly focused on evaluating production and carcass traits. Reports on economic evaluation for carcass traits are rare (Mikó *et al*., 2010; Verspecht *et al*., 2011; Szendrő K. *et al*., 2012b). The objective of the Mikó *el al.* (2010) study was to examine the efficiency of the CT-aided selection from the viewpoint of the slaughterhouses. Using the same selling price for PWhite and Hycole rabbits, the whole carcasses or the meat fillet products resulted in 19 and 43 Hungarian Forint (HUF) per kg extra income for the PWhite rabbits. Supposing a slaughter weight of 2.7 kg this value was 51 and 116 HUF/rabbit. Comparing pure PWhite and PWhite x Hybrid genotypes the advantage of the PWhite rabbits was 38 and 78 HUF/rabbit for whole carcass and the meat fillet product, respectively. Based on the data of divergent selection for thigh muscle volume, calculated for 10 generations, selling the whole carcass or the meat fillet product resulted in 67.5 and 216 HUF additional income per individual (average body weight of 2.7 kg) for the slaughterhouse, respectively. It can be concluded that the selection based on CT data is highly advantageous for the slaughterhouses because they obtain more lean meat from a CT selected rabbit which results in substantial extra income.

The economic advantage of CT-based selection was also shown in other animal species, however such investigations are rare. Kvame *et al*. (2004), Jopson *et al.* (1996) and Young *et al*. (1996) revealed that CT scanning of sheep for genetic improvement of carcass growth and composition is generally accepted as offering considerable benefit over the use of ultrasonics. Kvame *et al*. (2004) examined the anatomical scan sites for prediction of weight and composition of four primal cuts of lamb: hind leg, loin, rack and forequarter by using CT in 300 lambs, when the economic benefit of incorporating cut distribution into a breeding program was evaluated. Authors predicted the net benefit from two selection indices for a hypothetical breeding program given a 10-year horizon, and showed higher (1.02 million New Zealand Dollar, NZD) net benefits when selection was for composition of cuts and fat rather than selecting for weight of lean and against fat in the carcass. Jopson *et al.* (1996) estimated the marginal economic benefit of incorporating CT into a terminal sire sheep breeding program. For a single year's investment (i.e. one year's CT scanning) the cumulative net present value was positive by year three (evaluation occurred in year zero) and was nearly maximal by year ten.

2.3. SOCIAL ASPECTS OF RABBIT MEAT

Social aspects may be interpreted in many ways. In this dissertation and also in the literature overview I deal with a limited area: consumer perceptions, concerns and purchasing practices of rabbit meat. Two surveys of consumer preference were published in Hungary by Bodnár and Horváth (2008) and Szakály *et al*. (2009).

Bodnár and Horváth (2008) published the first comprehensive survey about the Hungarian consumers' attitudes about rabbit meat. Differences were found between respondents living in Budapest or in the rural areas. In Budapest, 75% the population had already tasted rabbit meat, but 70% of them ate it only once or twice a year. Self-consumption was frequent among rabbit breeders and they sold live animals and carcasses to their friends, neighbors and also for local markets. Using a multiple choice question, one third of the people bought live animals or the whole carcasses (8% and 26%, respectively) and 46% were looking for specific parts of the rabbit, while 66% of the consumers desired semi-finished or ready-made products. The preferred origin of rabbit carcass supply for housewives in the suburban area was the farmer (70%) or from small butchers instead of supermarkets. Most of them would not have paid considerably more for the rabbit meat than poultry meat. Most of those who had a negative attitude towards rabbit meat were vegetarian or refused consumption due to emotional reasons. Usually those who rejected rabbit meat had never tasted it. The most frequent reason was the lack of rabbit meat and rabbit products in the supermarkets in the country. Thus, urban citizens who liked rabbit meat could not purchase it in their preferred stores; on the other hand 46% of the respondents found rabbit meat too expensive. Respondents stated that more information was needed about rabbit meat, the methods of preparation (recipes) and easier access to domestic production.

Szakály *et al*. (2009) stated that 69% of respondents had not eaten rabbit meat at all, and the remainder rarely consumed it: the frequencies of every other month, 2-3 times a month and 2-3 times a week were 22.6, 15.1 and 2.2%, respectively, which represented 15.6, 10.4 and 1.5% of the total population. Rabbit meat was obtained most frequently from others or their own stock and from specialty shops (between 22-29% each). The judgment of the consumers (on a 1-5 scale) was the highest value (>4) for low fat and cholesterol content, and 3> for low energy and omega-6/omega-3 ratio.

In Spain, rabbit meat consumption is high, so the results could be different from the Hungarian experience. The Catalonian origin was the most preferred (60.7%), followed by Spanish (26.8%) and foreign (12.5%). The highest interest of respondents was to buy a whole carcass (52%), followed by cut-up (32%) and boneless rabbit meat (16%). In relation to the brand attribute, the most important interest was for the quality brand (57%), followed by the commercial brand (22%) and the unbranded rabbit meat (20%). The order of the consumers' interest was: entire rabbit (25%), produced in Catalonia (19%), cut-up rabbit meat (15%), and quality brand (12%). The price was considered less essential than other factors. However non-consumers stated the economic factor as the main limiting factor. Suggestions included marketing tools that were more focused on highlighting the origin of the product with an emphasis on regional quality brands (Kallas and Gill, 2011a,b).

The factors affecting purchasing of rabbit meat in South Africa are rather interesting than useful for a European. Hoffman *et al*. (2004, 2005) studied the ethnic groups (that they classified as White, Black and Colored) in relation to the factors affecting the marketing of rabbit meat. There are many special factors contributing to the low consumption of rabbit meat. Respondents associated rabbits with pets, or ‘unclean meat’, while Blacks associated it with hunting and wildlife, and found it more suitable for men than for women. However, it was clear that rabbit meat was more acceptable to the Blacks than the other ethnic groups. White people would not mind purchasing rabbits without a head, while Black respondents insisted that a carcass should have a head to ensure that it was a rabbit and not a cat. With regard to purchasing rabbit meat, supermarkets, butchers and restaurants were ranked high by White and Colored respondents, while Black respondents rated hunters and butcheries higher. Sixty percent of the respondents were not willing to pay more for rabbit meat than for chicken. The conclusion was that effort is needed to educate people regarding the benefits of rabbit meat in order to increase the demand.

3. OBJECTIVES OF THE DISSERTATION

Since the doctoral dissertation was realized as a cooperation of the two Doctoral Schools (Management and Business Administration and Animal Science) of Kaposvár University, its aim was broad. The objective was to explore the possible contradictions within and between economic and social components of sustainability

- by evaluating the effect of different genotypes, housing and feeding methods on natural indicators (productive performance and carcass traits), and
- estimating these aspects' separate and combined effects on profitability at the farm and at the slaughterhouse level, and
- by evaluating rabbit meat consumption and the Hungarian consumers' perceptions in relation to the analyzed factors.

4. MATERIALS AND METHODS

Due to the diversity of the experiments, a general and a specific material and methods will be given. The general aspects will be summarized in this chapter, however the specifications for each experiment will be presented in the chapter of Results and Discussion in order to better understand all the experiments.

4.1. SECONDARY DATA AND INFORMATION COLLECTION

All of the secondary data (production, trade balance) were collected from the database of FAOSTAT (http://faostat.fao.org), the database of FAO (Food and Agriculture Organization of the United Nations). Data downloaded from different databases did not always correspond and sometimes data were available only up to 2011 but sometimes up to 2012. Consequently, the database between 1990 and 2011 of http://faostat.fao.org/site/537/default.aspx was used for trade (export and import) data, while that of http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569#ancor was used for production data collection up to 2012. In tables, countries are ranked on the basis of data of the latest year available.

Most of the findings from the relevant literature were gained from highly ranked journals, such as Animal, Livestock Science, Meat Science, Journal of Animal Science, Italian Journal of Animal Science and World Rabbit Science, the official journal of the World Rabbit Science Association (WRSA), as well as from the papers of several World Rabbit Congresses, and the French conferences of Journées de Recherches Cunicoles in 2007, 2009, 2011 and 2013.

4.2. PRIMARY DATA AND INFORMATION COLLECTION

Animals and housing

All of the experiments were carried out in the research rabbit farm of Kaposvár University. Rabbits were weaned at 5 weeks of age and the experiments finished when the animals were 10, 11 or 12 weeks of age. In all experiments rabbits were selected randomly regardless of their sex, since there is no sexual dimorphism in productive and carcass traits till the age of 12 weeks (Lebas *et al*., 1997). Rabbits were housed in a closed building, generally in wire-mesh cages (3 rabbits/cage, 16 rabbits/m^2). They were fed commercial pellets *ad libitum*, and they could drink water freely from nipple drinkers. The temperature in the building was between 16 and 25 ^{o}C, depending on the season, and the lighting period was 16 hours light and 8 hours dark.

CT measurement

Using CT in selection of PWhite rabbits started in 1992 (Szendrő *et al*., 1992). Rabbits for CT scanning (generally at 10.5 weeks of age) were placed to a plastic „container" that served for restraining 3 rabbits without anesthesia. Based on two CT scans per rabbit (junction of the 2^{nd}-3^{rd} and the 4^{th}-5^{th} lumbar vertebrae), the L-value was measured and expressed in cm^2. In 2004 L-value was replaced by thigh muscle volume (TMV). TMV was estimated with CT scans taken every 10 mm between the *crista iliaca* of the *os ilium* and the patella, and 11-12 scans were taken. Voxel frequency of density range belonging to the muscle tissue (between +20 and +200 of the HU scale) was determined in each scan. Summing the values of 11-12 scans, the TMV was estimated (Matics *et al*., 2014a).

Economic evaluation

Natural indicators

Body weight and feed intake were measured every second week (at 5, 7, 9, 11 weeks), therefrom weight gains and feed conversion ratios were calculated. Body weight of rabbits was measured individually, but in the case of pellet intake and feed conversion ratio the unit was the cage or pen. At the end of the experiment (at 11 or 12 weeks of age), rabbits were transported to a slaughterhouse located 200 km from the experimental farm. Fasting time was six hours, including the four hours transportation. Rabbits were weighed at the slaughterhouse (slaughter weight, SW). The slaughtering and carcass dissection procedures followed the recommendations of World Rabbit Science Association (WRSA) described by Blasco and Ouhayoun (1996). Rabbits were slaughtered by cutting the carotid arteries and jugular veins after electro-stunning. The slaughtered rabbits were bled, and then the skin, genitals, urinary bladder, gastrointestinal tract and the distal part of the legs were removed. Warm carcasses [with head, set of organs (consisting of thymus, trachea, oesophagus, heart and lungs), liver, kidneys, perineal fat and scapular fat] were weighed, and then chilled at +4 °C for 24 h. After chilling, the carcasses were weighed again. The head, set of organs, liver and kidneys were removed from each carcass to obtain the reference carcass, which included the meat, bones and fat depots. The carcasses were then cut between the 7th and 8th thoracic vertebrae and between the 6th and 7th lumbar vertebrae to obtain the fore-, mid-, and hind parts, which were weighed separately. The dressing out percentage (carcass weight as % of SW) and the ratio of the organs and carcass parts to either the chilled or to the reference carcass weight were calculated.

Financial indicators

All financial figures were calculated in Euro as the mean of the average exchange rates of year 2013 and January 2014 (300 HUF/€) (MNB, 2014). Calculations are presented in ***Table 6***.

Table 6
Calculation of financial indicators

Indicators	**Cost of feed**		
	Low (0.25 €/kg)	**Med** (0.275 €/kg)	**High** (0.3 €/kg)
Cost and revenue based on farm and slaughterhouse level, €/rabbit			
1. Cost of weaned rabbit	1.83 €/kg x weight		
2. Cost of feeding	Feed intake between weaning and slaughtering x cost of feed (+/-10%) (hay: 0.17 €/kg)		
3. Cost of mortality (dead rabbit)	1. + cost of feed (+/-10%) till death		
4. Total cost	1. + 2. (80%) + 3.		
5. Price at slaughter	1.53 €/kg x weight		
6. Revenue from whole carcass	Chilled carcass (g) x selling price (4.3 €/kg)		
7. Revenue from carcass parts	[Loin fillet (12 €/kg); thigh meat (11 €/kg); liver (2.8 €/kg); kidneys (2.5 €/kg); fore part (2.6 €/kg); head, bone, heart and lungs (0.45 €/kg)] x weight of each carcass part		
Profitability			
8. Profit, €/rabbit	Revenue (price at slaughter at farm level or selling price of carcass parts at slaughterhouse level) - Cost (total cost at farm level or price at slaughter at slaughterhouse level)		
9. Cost to revenue, %	Cost/revenue x 100		
10. Profit to cost, %	Profit cost x 100		
11. Cost efficiency	Revenue/cost		

At the farm level, the first cost factor was the price of a weaned rabbit (weight x price of weaned rabbit/kg). Data for weaned rabbit price (1.83€/kg) was gained from Olivia Ltd. (Odermatt, personal communication). According to Maertens (2009) feeding cost may represent 70% of total production costs at the farm level, including the consumption by does, bucks and suckling kits. Since our experiments were carried out on growing rabbits, we used a value of 80% in calculating the cost of production (Maertens, 2010). Mortality cost, as a loss of revenue, was considered as the price of the weaned rabbit and the cost of feed consumed till death. Hence, total expenses included the price of the weaned rabbit, the production cost and the cost of mortality. Since cost of feed may vary significantly year by year, or even during a year depending on the weather (thus the quantity of production), the cost analysis was carried out based on the average cost of feed (0.275 €/kg, Demeter, personal communication) and 10% lower and 10% higher prices than the average price as well (low, medium=med, high price). Since the evaluation was carried out on two levels, price of rabbits at slaughter was considered as revenue at the farm level, but as an expense at the slaughterhouse level. The revenue from the whole rabbit carcass (including head and edible offals) and from different carcass parts was calculated. Data were gained from Olivia Ltd. (Odermatt, personal communication) in €/kg: whole carcass (4.3), loin fillet (12.0), thigh meat (11.0), liver (2.8), kidney (2.5), fore part (2.6), head, bone, heart and lungs (0.45) (Odermatt, personal communication). Based on these medium prices, 10% lower and 10% higher selling prices (low, med, high) were also calculated on the most valuable carcass parts (loin fillet and thigh meat), because the selling price of these items depends on different market prices. In these cases, a price change in whole carcass of +/- 8% was considered. Since the prices of other carcass parts (head, bones, fore part, etc.) are independent of the market, these were calculated on medium price. Besides, profit, cost to revenue, profit to cost ratios and cost effectiveness were calculated. Profit was calculated as the difference between the revenue (price at slaughter at the farm level or revenue from rabbit products at the slaughterhouse level) and the costs. Cost of slaughtering was not identified in the economic evaluation, due to lack of information in relation to the expenses occurring in the slaughterhouse, besides, these are considered as fixed costs regardless of genotype, housing system and feeding method. Thus, the differences among the groups are reasonable and show the effect of different genotypes, housing and feeding methods on profitability, depending on the market price.

Social aspects

Evaluating rabbit meat production is inadequate without analyzing the end user, the consumer. Nationwide consumer research was conducted in 2014 on consumer perceptions, purchasing practices and consumption of rabbit meat. Among non-probability sampling techniques, snowball sampling of data collection was used meaning that the structured survey (see translated version in ***Appendix***) was given to an initial group of respondents (those who used the Internet) selected randomly. After being interviewed, they were encouraged to locate other members of the target population whom they know; i.e. friends, relatives, colleagues, etc. Multiple responses were excluded since the system allowed only one response/IP address. The survey consisted of 21 structured questions asking respondents their opinions and concerns regarding frequency, healthiness and price perception of rabbit meat compared to meat of other animal species (chicken, duck, pork and beef), purchasing decision, location of consumption, distribution, causes of rejection, price perceptions, judgment on nutritional benefits, preferred form of purchase, possible factors increasing consumption, marketing awareness, importance of origin, genotype, housing and feeding methods as well as willingness of paying a higher price. The survey included one open-ended question asking the respondents to share their suggestions to stimulate rabbit meat consumption. The distribution of the sample is presented in ***Table 7***.

Table 7
The distribution of the sample

Description	**N**	**%**
Total respondents	542	100
Gender		
Female	314	57.9
Male	228	42.1
Age, year		
18-29	185	34.1
30-39	179	33.0
40-49	95	17.5
50-59	53	9.8
60+	30	5.5
Education, graduated from…		
College, university	349	64.4
Secondary school	163	30.1
Vocational training school	26	4.8
Elementary school	4	0.7
Type of residency		
Country town	248	45.8
Less than 2,000 inhabitants	79	14.6
2,000-10,000 inhabitants	67	12.4
Capital city (Budapest)	62	11.4
More than 10,000 inhabitants	62	11.4
Abroad	21	3.9
No answer/ Don't know (NA/DK)	3	0.6
Employment status		
White collar workers	329	60.7
Students	99	18.3
Blue collar workers	78	14.4
On maternity leave	30	5.5
On pension	27	5.0
Working in agriculture	15	2.8
Stay-at-home	11	2.0
Other inactive	6	1.1
Unemployed	6	1.1
Looking after family	1	0.2
Household income		
Live well but only a little money is set aside	251	46.3
Just enough, but cannot set aside money	148	27.3
Live very well and high enough to set aside money	72	13.3
Not enough to earn a living	38	7.0
No answer/ Don't know (NA/DK)	25	4.6
Have difficulty in daily living	8	1.5

The survey was available in Hungarian on-line at

https://www.surveymonkey.com/s/SzendroK_Doktori_kerdoiv

Statistical Analysis

All statistical analysis was conducted using the SPSS for Windows 10.0 software package.

In most experiments only one factor (treatment) was analyzed (e.g. breeds, housing system or feeding method). In all of these cases the productive and carcass traits were evaluated by one-way ANOVA:

Equation 1

$Y_{ij} = \mu+T_i+e_{ij}$

Where: μ =general mean, T_i =effect of the Treatment (i=1–2), e_{ij} =random error

When two factors were analyzed (e.g. effect of *ad libitum* and restricted feeding on PKa and PLarge rabbits) two-way ANOVA was used:

Equation 2

$Y_{ijk} =\mu+G_i+F_j+(G \text{ x } F)_{ij}+e_{ijk}$

Where: μ =general mean, G_i =effect of the Genotype (i=1–2), F_j =effect of the Feeding method (j=1–2), $(G \text{ x } F)_{ij}$ = the effect of interaction of level i of factor G with level j of factor F, e_{ijk} =random error

In the case of examination of combined effect of genotype (PLarge or Hung), housing system (cage or pen) and feeding method (pellets only or pellets plus hay), the productive and carcass traits were evaluated with the means of multi-factor ANOVA:

Equation 3

$Y_{ijkl} =\mu+G_i+H_j+F_k+(G \text{ x } H)_{ij}+(G \text{ x } F)_{ik}+(H \text{ x } F)_{jk}+(G \text{ x } H \text{ x } F)_{ijk}+e_{ijkl}$

Where: μ =general mean, G_i =effect of the Genotype (i=1–2), H_j =effect of the Housing system (j=1–2), F_k =effect of the Feeding method (k=1–2), (G x

$H)_{ij}$ = the effect of the interaction of level i of factor G with level j of factor H, $(G \times F)_{ik}$ = the effect the of interaction of level i of factor G with level k of factor F, $(H \times F)_{jk}$ = the effect of the interaction of level j of factor H with level k of factor F, $(G \times H \times F)_{ijk}$ = the effect of the interaction of level i of factor G with level j of factor H with level k of factor F, e_{ijkl} =random error. All main factors (genotype, housing and feeding) were regarded as fixed factors.

Frequency distributions, cross tables (for determining the relation of a variable to the background variables and to other involved variables) were used in the evaluation of the questionnaire. In addition, mean calculations and significance analysis (Chi^2-probe) was performed.

5. RESULTS AND DISCUSSION

In the dissertation I focused on the following topics: effect of genotype, housing and feeding on productive and carcass traits, and their economic and social aspects. The separate, then the combined effects are presented. In addition to the main experiment, these effects have been evaluated in some other experiments carried out at Kaposvár University. In some cases, I was the leader or a participant on the experiment, but in other cases the data of former studies were used. This is noted at the introduction of each experiment. The description of the experiments was formatted as follows: short aim, materials and methods, economic evaluation. The last is divided into two parts; natural and financial indicators. Subsection of *natural indicators* includes figures on expenditure and yield giving basic information that one can compare to other countries' data. Changes in these indicators depend essentially on the three analyzed factors; genotype, housing condition and feeding methods. The financial indicators subsection consists of objective calculations at the farm level and theoretical model investigations at the slaughterhouse level. The same pattern was conducted in evaluating former experiments (their results are not included in the chapter of literature), in order to follow and understand the experiments better. The chapter ends with the evaluation of social aspects with special regard to the analyzed factors. Based on the experiments and the consumer questionnaire, critical points, as possible contradictions between the farmers and the slaughterhouse, or between the actual needs of animals and the requirements and perceptions of animal welfare by animal rights organizations and consumers were summarized.

This chapter is structured as follows:

Effect of genotype:

- Separate effects of genotype (PLarge and Hung)
- Comparison of the breeds of the Pannon Breeding Program slaughtered at the same age (at different weights) or
- Comparison of the breeds of the Pannon Breeding Program, slaughtered at similar weights (at different ages)
- Effects of divergent selection based on CT measurements

Effect of housing condition:

- Separate effect of housing (cage or pen)
- Effect of floor type (wire-mesh, plastic-mesh, deep litter)

Effect of feeding method:

- Separate effects of feeding of growing rabbits (pellets only or pellets plus hay)
- Effects of restricted feeding (using three methods).

Combined effects:

- Combined effects of genotype (PLarge and Hung), housing (cage or pen) and feeding (pellets only or pellets plus hay)

Social aspects

Critical points

All of these topics are of interest to researchers and farmers.

5.1. EVALUATION OF THE EFFECTS OF GENOTYPE

5.1.1. Separate effects of genotype (Pannon Large or Hungarian Giant) on productive performance, carcass traits and economic values

This section is a part of my compound experiment to examine the separate and combined effects of genotype, housing and feeding on growing rabbits. See a full description of the experiment in Chapter 5.4.

Objective of the experiment

The aim of the experiment was to examine separately the effects of genotype on productive performance, carcass traits and financial indicators in order to get information about the value of the Pannon Large and Hungarian Giant breeds.

Materials and methods

PKa does were inseminated with semen of Pannon Large and Hungarian Giant bucks. The crossbred rabbits (n=336) were weaned at 5 weeks of age. Half of them were housed in cages, and the other half in pens. Two subgroups were formed based on the feeding method. Data were evaluated by multi-factor analysis of variance, but only the effect of genotype was calculated. The design of the experiment is shown in ***Figure 3***.

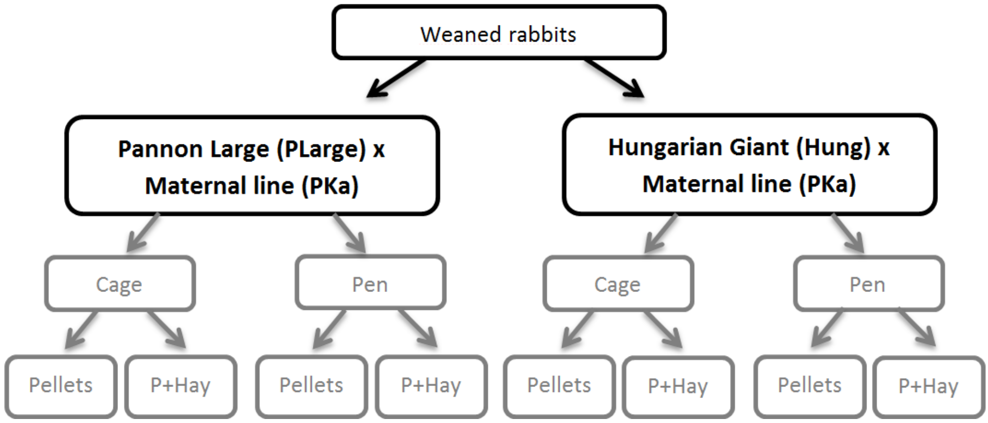


Figure 3. Design of the experiment

Economic evaluation

Natural indicators

The results of productive performances are summarized in ***Table 8***. Significant differences were found in body weight from 5 weeks of age, in favor of PLarge x PKa rabbits. It increased from 72 g at 5 week to 229-249 g at 9-12 weeks. Weight gain of PLarge x PKa rabbits was significantly higher by 3.7 and 7.2 g/day between weeks 5-7 and weeks 7-9, respectively, and it was higher by 2.8 g/day over the whole fattening period compared to Hung x PKa rabbits. The differences in pellet intake were significant at 10, 23, 18 and 15 g/day between 5-7, 7-9, 9-11 and 5-12 week of age, respectively, with higher values in PLarge x PKa rabbits. The effects of genotype on feed conversion ratio and mortality were not significant.

The results point out the differences in growth before and after weaning between the two genotypes. The PLarge genotype was established and selected for improving weight gain (Matics *et al*., 2014a). Body weight and weight gain of Hung rabbits corresponded to the description of the Hungarian Giant (Holdas and Szendrő, 2002; Hungarian Giant Rabbit-breeders Association, 2013), but in the present experiment the results of crossbred rabbits were evaluated. Breeders with small herds do not usually select the Hung breed. Comparing the productive performance of different giant breeds and terminal lines, higher growth rates were published for the terminal lines than for other giant breeds (Feki *et al*., 1996; Bolet, 2002; López and Sierra, 2002; Piles and Blasco, 2003; Piles *et al*., 2004a; Kermauner and Zgur, 2005; Tůmová *et al*., 2013). Parallel with weight gain, the pellet intake of PLarge x PKa rabbits was higher than the Hung x PKa (***Table 8***).

Table 8
Effects of genotype on productive traits of growing rabbits

Traits	Genotype		SE	Prob.
	PLarge x PKa	Hung x PKa		
Weight at 5 wk of age, g	1020	948	5	<0.001
Weight at 12 wk of age, g	3170	2935	16	<0.001
Weight gain, 5-12 wk of age, g	42.3	39.5	0.3	<0.001
Feed intake, g/day (5-12 wk of age)	147	132	2.2	0.002
Feed conversion ratio	3.56	3.39	0.08	0.411
Mortality, %	4.8	9.5	-	0.091

Since weight gain and feed intake of PLarge x PKa rabbits increased, the feed conversion ratios of the two genotypes were similar. Some literature data showed that breeds with different adult weights, body weights at slaughter and weight gains had similar feed conversion ratios (Bianospino *et al*., 2006; Szendrő *et al*., 2009a). The mortality of Hung x PKa rabbits was nearly twice as high as that of the PLarge x PKa group (9.5 and 4.8%, respectively), but the difference was not significant. Since both groups were crossbreds, the mortality could depend mainly on the hygienic conditions in the farm and the nutrition. Since the mortality was low, both factors were satisfactory and since the weaned rabbits consumed medicated pellets, the effect of genotype could be negligible.

Weight of carcasses (warm, chilled, reference) and their parts (carcass parts, organs, tissues) in most cases were significantly larger in PLarge x PKa rabbits than in the Hung x PKa group (***Table 9***).

The weight of carcass, body parts, organs, meat fillet and fat deposits are in close correlation with the body weights of rabbits at slaughter. Lukefahr *et al*. (1982), Gómez *et al*. (1998), and Larzul and Rochanbeau (2004) also found larger carcasses, carcass parts and organs in larger rabbits.

Table 9
Effect of genotype on carcass traits (g)

Traits	Genotype		SE	Prob.
	PLarge x PKa	Hung x PKa		
Weight at slaughter	3109	2881	15.7	<0.001
Warm carcass	1951	1777	10.3	<0.001
Chilled carcass	1906	1736	10.1	<0.001
Reference carcass	1618	1463	8.94	<0.001
Head	156	153	0.69	0.037
Heart + lungs	23.5	22.6	0.19	0.012
Liver	87.8	76.1	1.06	<0.001
Kidneys	18.1	18.4	0.12	0.318
Perineal fat	27.0	21.9	0.66	<0.001
Scapular fat	10.6	7.45	0.24	<0.001
Fore part	444	396	2.30	<0.001
Mid part	542	492	3.54	<0.001
Hind part	596	545	3.08	<0.001
Hind legs	567	516	2.94	<0.001
Meat on hind legs	404	362	3.49	<0.001
Loin fillet	190	173	1.41	<0.001

Significant differences were found in the ratio of carcasses and some carcass parts between the two genotypes (***Table 10***). Dressing out percentage of PLarge x PKa rabbits was 1.1-1.3% better than that of Hung x PKa rabbits. Significant differences were found in carcass parts: the ratio of the fore part to the reference carcass was higher in PLarge x PKa group than in Hung x PKa rabbits, the ratio of the hind part to the reference carcass was higher in Hung x PKa rabbits than in the PLarge x PKa group, however no significant difference was found in the mid part of the reference carcass. The ratios of fat deposits were significantly larger in PLarge x PKa rabbits than in Hung x PKa animals. The reason for the better dressing out percentage of PLarge x PKa rabbits could be caused by the different genetic origin and the CT-based selection. Dalle Zotte (2002) established in a review that when selecting for growth rate, the younger rabbits at slaughter were less mature and their carcass yield reduced. Pla *et al*. (1996, 1998) demonstrated a difference in dressing out percentage between maternal and terminal lines (selected for litter size and growth rate, respectively) with better results in lines with smaller adult body weights and higher degrees of maturity. However, when the effect of selection on carcass traits was evaluated, no significant differences were found between rabbits of the control group and that of rabbits selected for growth rate (Piles *et al*., 2000, Hernández *et al*., 2004). It was concluded that the differences between lines could be due to the different genetic origins, but not because of the selection for growth rate. In the present experiment, the genetic origin of PLarge and Hung rabbits was different, and PLarge rabbits were selected for growth rate and carcass traits based on CT data. It was demonstrated that the selection on carcass traits was effective to improve dressing out percentage (Szendrő *et al*., 2009b, 2010b, 2011). Examining the ratio of fore, mid and hind parts (***Table 10***), similar results were found when lines with different adult weights were compared (Pla *et al*., 1996, 1998; Hernández *et al*., 2006), or the effect of selection for improved growth rate was investigated (Piles *et al*., 2000). The ratio of fore part to reference carcass was larger and that of hind part was lower in PLarge x PKa than in Hung x PKa rabbits. In most experiments the fat deposits were lower in lines selected for growth rate than in maternal lines (Pla *et al*., 1996, 1998; Hernández *et al.*, 2006). In contrast, the ratio of perineal and scapular fat to the reference carcass was higher in PLarge x PKa than in Hung x PKa rabbits.

Table 10
Effect of genotype on ratio of carcass and parts of carcass

Traits	**Genotype**		**SE**	**Prob.**
	PLarge x PKa	Hung x PKa		
Ratio to slaughter weight, %				
Warm carcass	62.7	61.6	0.1	<0.001
Chilled carcass	61.3	60.2	0.1	<0.001
Reference carcass	52.0	50.7	0.1	<0.001
Head	5.05	5.35	0.02	<0.001
Heart + lungs	0.76	0.79	0.01	0.018
Liver	2.81	2.64	0.03	0.002
Kidneys	0.59	0.64	0.004	<0.001
Ratio to reference carcass, %				
Fore part	27.5	27.1	0.1	0.010
Mid part	33.4	33.6	0.1	0.178
Hind part	36.9	37.3	0.1	0.001
Perineal fat	1.64	1.45	0.04	0.011
Scapular fat	0.63	0.50	0.01	<0.001

Financial indicators

Cost of production (cost of weaned rabbits, feed, mortality and production) at farm level, the price of the slaughter rabbits (which is a revenue for the farmer, but expense for the slaughterhouse), the revenue (from whole carcass and from different carcass parts) at the slaughterhouse level, as well as profitability indicators (profit, cost to revenue, profit to cost and the cost efficiency) at both the farm and the slaughterhouse level of PLarge x PKa and Hung x PKa rabbits are shown in ***Table 11***.

At farm level

When the medium feed price was considered, cost of feeding of Hung x PKa rabbits was 0.20 €/rabbit lower than that of PLarge x PKa rabbits. The reason for that is rooted in the lower weight at weaning and at slaughter, and lower feed intake than that of PLarge x PKa rabbits (***Table 8***). Cost of feeding varied according to the price of feed, but, the difference between the groups remained similar. Cost of mortality was twofold in Hung x PKa rabbits compared to PLarge x PKa rabbits, which was mainly due to the different mortality rates between the two genotypes, and to a lesser extent to the age at harvesting (***Table 8***). The different mortality rates resulted in significant differences in production costs from 0.26-0.30 €/rabbit, depending on the feed price. In price at slaughter, a 0.35 €/rabbit difference was found in favor of PLarge x PKa rabbits. At low feed price, Hung x PKa rabbits achieved 82% of the profit of PLarge x PKa rabbits. With medium and high feed price, a profit of 0.31 and 0.13 €/rabbit was calculated with PLarge x PKa, while 0.23 and 0.07 €/rabbit were calculated in the Hung x PKa groups, respectively. The differences in profit to cost ratios were 1.49, 1.30 and 1.13%, in favor of PLarge x PKa rabbits with low, medium and high feed price, respectively, meaning that – in case of the same mortality rates and scheduling – about 1,400-2,200 € less profit can be achieved when Hung x PKa rabbits are reared instead of PLarge x PKa rabbits at a farm of 1,000 does producing 50,000 slaughter rabbits/year. Overall, in each profitability indicator, Hung x PKa group achieved better results than average only when the feed cost was low. On the other hand PLarge x PKa rabbits outperformed even on the medium feed price.

Table 11
Profitability of rabbit genotypes (PLarge x PKa and Hung x PKa) at farm and slaughterhouse levels

Indicators	Genotype					
	PLarge x PKa			Hung x PKa		
	FARM LEVEL					
	Price of feed					
	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.80**	1.98	2.16	**1.62**	**1.78**	1.94
Cost of mortality (€/r)	**0.11**	**0.11**	**0.12**	0.22	0.22	0.23
Total cost (€/r)	**4.28**	4.46	4.64	**4.02**	**4.18**	4.34
PRICE AT SLAUGHTER	***4.77***	***4.77***	***4.77***	***4.42***	***4.42***	***4.42***
Farm profit (€/r)	**0.49**	**0.31**	0.13	**0.40**	0.23	0.07
Farm cost to revenue (%)	**89.8**	**93.6**	97.2	**91.0**	94.7	98.3
Farm profit to cost (%)	**11.40**	**6.87**	2.85	**9.91**	5.57	1.72
Farm cost efficiency	**1.11**	**1.07**	1.03	**1.10**	1.06	1.02
	SLAUGHTERHOUSE LEVEL					
	Selling price					
	Low	Med	High	Low	Med	High
Revenue from rabbit carcasses (€/r)	7.89	**8.58**	**9.26**	7.19	7.81	**8.44**
Revenue from rabbit products (€/r)	8.60	**9.27**	**9.94**	7.74	8.35	**8.96**
SH profit (€/r)*	3.83	**4.50**	**5.17**	3.33	3.93	**4.54**
SH cost to revenue (%)*	55.5	**51.4**	**48.0**	57.0	52.9	**49.3**
SH profit to cost (%)*	80.3	**94.4**	**108.5**	75.3	89.0	**102.7**
SH cost efficiency*	1.80	**1.94**	**2.09**	1.75	1.89	**2.03**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At slaughterhouse level

There is a close relationship between the weight of the carcass and the slaughter weight, therefore the revenue from the carcasses depended on the slaughter weight (***Table 9***). The revenue from Hung x PKa carcass and carcass parts were 9 and 10% lower than that of PLarge x PKa rabbits, respectively. The differences in profit were even higher; Hung x PKa rabbits achieved only 87-88% of the value of PLarge x PKa rabbits. Profit differences of 0.50, 0.57 and 0.64 €/rabbit was achieved in favor of PLarge x PKa rabbits with increasing selling price, respectively. The differences between the profit to cost ratios were remarkable; 5.00, 5.40 and 5.79%, depending on the selling price. Each value was better in PLarge x PKa rabbits, besides, that group could achieve results above the average in two cases (sold at medium or high prices) in contrast to Hung x PKa rabbits (only with the high selling price).

Based on the same selling price, higher profit can be achieved with PLarge x PKa than Hung x PKa rabbits at the farm level, as well as at the slaughterhouse level. Hung x PKa rabbits would be worth rearing at the farm and slaughterhouse if a higher price was paid for them.

5.1.2. Comparison of the breeds of the Pannon Breeding Program (Pannon Ka, Pannon White, Pannon Large), slaughtered at the same age

The evaluation is based on the experiment published by Szendrő *et al.* (2009a,b).

Objective of the experiment

The aim of the present study was to briefly present the main results of the experiment and carry out an economic evaluation of rabbit genotypes differing in growth rate and carcass characteristics based on the most important cost factors, including feed, and the revenue from processed products in more detail.

Materials and methods

PKa, PWhite and PLarge rabbits have been selected for the following criteria: PKa for litter size, PWhite for weight gain and carcass traits, PLarge for weight gain and carcass traits. The meat content (L-value or muscle on hind legs) was measured by CT. Their body weight was different: 4.0-4.5 kg, 4.3-4.8 kg, 4.8-5.4 kg, respectively. Natural indicators of the three genotypes (n=32 of each genotype) were evaluated.

Economic evaluation

Natural indicators

Table 12 shows the results of productive and carcass traits of PKa, PWhite and PLarge rabbits. At weaning and at 11 weeks of age, PLarge had the heaviest, while PKa had the lightest body weights. PKa consumed the least amount of feed, while PLarge rabbits had the highest consumption level between 5 and 11 weeks of age. In the weight of carcass and its parts, a clear order could be seen: PKa < PWhite < PLarge. Dressing out percentage of PWhite was the highest and that of PKa the lowest, while PLarge had an intermediate position. The ratio of fore part to reference carcass was significantly higher in PLarge rabbits than in the PWhite and PKa groups. The ratio of hind parts to reference carcass was larger in PWhite rabbits than in PLarge and PKa rabbits. No differences were found in the ratio of mid part to reference carcass.

These results were similar to our former experiment. It was shown by several authors that the adult weight and the selection method had significant effects on final weight and carcass traits of growing rabbits.

Table 12
Production and carcass traits of different rabbit genotypes slaughtered at the same age

Traits	Genotype			SE	Prob.
	PKa	PWhite	PLarge		
Productive traits					
Weight at 5 wk of age, g	834[a]	849[a]	951[b]	14.0	0.001
Weight at 11 wk of age, g	2458[a]	2677[b]	2949[c]	31.2	<0.001
Weight gain, g/day (5-11 wk)	38.6[a]	43.1[b]	47.4[c]	0.57	<0.001
Feed intake, g/day (5-11 wk of age)	115[a]	121[a]	138[b]	2.21	<0.001
Feed conversion ratio	2.95	2.81	2.93	0.04	0.257
Mortality, %	9.4	3.1	6.3	-	NS
Carcass traits, g					
Whole carcass	1468[a]	1602[b]	1757[c]	20.0	<0.001
Heart + lungs	20.9[a]	22.1[b]	25.4[c]	0.24	0.021
Liver	73.1[a]	85.0[b]	84.1[b]	1.10	0.015
Kidneys	19.4[a]	20.4[b]	23.2[c]	0.21	<0.001
Head	127[a]	131[a]	142[b]	0.64	<0.001
Fore part	315[a]	340[b]	393[c]	2.27	<0.001
Loin fillet	176[a]	197[b]	210[c]	1.64	0.023
Mid part's bone	244[a]	257[b]	284[c]	3.41	0.045
Thigh meat	400[a]	449[b]	476[c]	3.24	<0.001
Thigh bone	53[a]	58[b]	66.8[c]	0.36	<0.001
Ratio of carcass and carcass parts, %					
Dressing out percentage	60.2[a]	61.3[b]	61.1[ab]	0.17	0.031
Ratio of fore part to reference carcass	26.0[a]	25.7[a]	26.9[b]	0.12	<0.001
Ratio of mid part to reference carcass	34.5	34.2	33.9	0.13	0.111
Ratio of hind part to reference carcass	37.3[a]	38.2[b]	37.2[a]	0.08	<0.001

[a,b,c]: Means in the same row with unlike superscripts differ ($P<0.05$).

Most of the publications showed that rabbit lines that originated from larger-sized parents (terminal lines) had better growth rate (Ramon *et al*., 1996; Larzul and Rochambeau, 2004), but lower values of carcass traits (Dalle Zotte, 2002; Hernández *et al*., 2006), since they were not as mature when slaughtered at the same age or weight as progeny of maternal lines which had lower adult weights. Despite the general negative correlation between adult weight and carcass traits, PWhite rabbits achieved the best results, followed by PLarge and then PKa rabbits. Comparing these results with Spanish publications (Pla *et al*., 1996, 1998; Hernández *et al*., 2006), we did not detect any difference between breeds selected for litter size (PKa) or selected for growth rate (PLarge), while the best carcass traits were observed in PWhite rabbits which were the proof of the effectiveness of CT-based selection.

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at slaughterhouse level, as well as profitability indicators at both the farm and slaughterhouse level of PKa, PWhite and PLarge rabbits are shown in ***Table 13.***

At farm level

Rabbits with higher daily weight gain and body weight consumed more feed, which was shown in ***Table 12***. This is the reason for the highest cost of feed found in PLarge rabbits and the lowest in PKa group. Since mortality differed, cost of mortality was highest in the PKa group and the lowest in PWhite rabbits. Cost of production was similar in PKa and PWhite rabbits, but it was higher by 0.56 €/rabbit in the PLarge group. Each profitability indicator showed that PKa and PLarge rabbits had better values than the average only in case of low feed cost; however, the PWhite group had outstanding results in each feed price category. Interestingly, PWhite rabbits reared sold on medium and high priced feed the first and second place in terms of profit, respectively, as well as in all profitability indicators, hence they had higher values than any other group. PWhite rabbits achieved the highest profit (0.84 €/rabbit), while the lowest value was found in the PKa group. When the same feed price was compared, the smallest difference in profit to cost ratio was between PLarge and PKa rabbits: between 1.87 and 1.32%. However, the difference was much more remarkable between PKa and PWhite groups, between 9.11 and 8.20%, in favor of the PWhite rabbits, depending on the feed price.

At slaughterhouse level

The revenue from rabbit carcasses and their parts were the highest with PLarge and the lowest with PKa rabbits. The differences between PWhite and PKa rabbits, with low, medium and high selling prices, were 0.55, 0.60 and 0.65 €/rabbit in case of the whole carcass, and 0.85, 0.93 and 1.01 €/rabbit in the case of carcass parts, respectively. The same revenue figures between PLarge and PWhite were 0.64, 0.70 and 0.75 €/rabbit, and 0.64, 0.68 and 0.73 €/rabbit, respectively. However, the highest profit was achieved in PLarge rabbits, followed by the PWhite group and the PKa rabbits. Diverse rankings occurred with the profitability ratios: the best cost to revenue ratio was found in PWhite rabbits, followed by the PLarge and PKa groups. The ratio of profit to cost was highest in PWhite rabbits, while the lowest was seen in the PKa group. The differences between PWhite and PLarge were 4.55, 5.13 and 5.75% when the selling price was low, medium or high, respectively. The differences in the same values between PLarge and PKa were lower: 2.56, 2.74 and 2.93%, respectively. The cost efficiency was also highest in PWhite rabbits, followed by PLarge and PKa groups. It should be noted that, only PWhite rabbits were able to exceed the average profitability ratios even with a medium selling price.

The results of the evaluation demonstrated the economic benefits of CT-based selection for improving meat in the rabbits, since PWhite rabbits, which have been selected for carcass traits using CT scanning, achieved the best results in all profitability ratios at the farm and at slaughterhouse levels.

Table 13
Profitability of different rabbit genotypes (PKa, PWhite or PLarge, slaughtered at the same age) at the farm and slaughterhouse levels

Indicators	Genotype								
	PKa			PWhite			PLarge		
	FARM LEVEL								
	Price of feed								
	Low	Med	High	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.21**	**1.33**	**1.45**	**1.27**	**1.40**	1.52	1.48	1.63	1.78
Cost of mortality (€/r)	0.19	0.19	0.19	**0.06**	**0.07**	**0.07**	0.15	0.15	0.16
Total cost (€/r)	**3.25**	**3.38**	**3.50**	**3.24**	**3.37**	**3.49**	3.78	3.93	4.08
PRICE AT SLAUGHTER (€/r)	***3.80***	***3.80***	***3.80***	***4.08***	***4.08***	***4.08***	***4.48***	***4.48***	***4.48***
Farm profit (€/r)	0.54	0.42	0.30	**0.84**	**0.71**	**0.58**	**0.70**	0.55	0.40
Farm cost to revenue (%)	**85.7**	89.0	92.1	**79.5**	**82.6**	**85.7**	**84.3**	87.7	91.0
Farm profit to cost (%)	**16.7**	12.4	8.55	**25.8**	**21.0**	**16.8**	**18.6**	14.0	9.88
Farm cost efficiency	**1.17**	1.12	1.09	**1.26**	**1.21**	**1.17**	**1.19**	1.14	1.10
	SLAUGHTERHOUSE LEVEL								
	Selling price								
	Low	Med	High	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	6.08	6.61	7.13	6.63	7.21	**7.79**	**7.27**	**7.91**	**8.54**
Revenue from rabbit products (€/r)	7.67	8.32	8.97	8.52	**9.25**	**9.98**	9.15	**9.93**	**10.71**
SH profit (€/r)*	3.87	4.52	**5.17**	4.44	**5.17**	**5.90**	4.68	**5.45**	**6.23**
SH cost to revenue (%)*	49.5	45.7	**42.4**	47.9	**44.1**	**40.9**	48.9	**45.1**	**41.8**
SH profit to cost (%)*	101.8	119.0	**136.1**	108.9	**126.9**	**144.8**	104.4	121.7	**139.0**
SH cost efficiency*	2.02	2.19	**2.36**	2.09	**2.27**	**2.45**	2.04	2.22	**2.39**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

5.1.3. Comparison of the breeds of the Pannon Breeding Program slaughtered at similar weights

This experiment was conducted under my leadership.

Objective of the experiment

The aim of the experiment was to compare three genotypes (PKa x PKa, PWhite x PKa, PLarge x PKa) slaughtered at similar weights, to examine their productive and carcass traits and economic value. Generally, lines selected for litter size mature at a younger age than lines selected for growth rate. Our hypothesis was that rabbits selected for thigh meat volume (TMV) by CT mature for slaughtering at younger age and achieve good slaughter and economic results at an earlier age.

Material and methods

PKa does were inseminated with semen from PKa, PWhite or PLarge bucks (n=60 in each genotype). Crossbred kits kits (PKa x PKa, PWhite x PKa, PLarge x PKa) were weaned at 35 days of age and reared until 88, 83 and 79 days, respectively, when they reached similar mean weights for slaughtering (2785-2795 g).

Economic evaluation

Natural indicators

Results of productive traits are shown in ***Table 14***. Weight of PKa x PKa at weaning was less than that of the PWhite x PKa and PLarge x PKa groups; presumably due to the lower weight gain of kits between 3 and 5 weeks of age. Significant differences were found in weight gain; the growth rate of PLarge x PKa was the largest, and that of PKa x PKa was the smallest, so they reached similar slaughter weights (2784-2795 g) at different ages (88 and 79 days), as shown by other authors (Ramon *et al*., 1996; Piles *et al.*, 2004; Larzul and Rochambeau, 2004; Metzger *et al.*, 2006a,b) who compared breeds or lines with different adult weights. Daily feed intake of PLarge x PKa rabbits was significantly higher than that of PKa x PKa and PWhite x PKa rabbits. These results were in accordance with those published in the literature (Ramon *et al.,* 1996; Feki *et al*., 1996). The number of feeding days was less in the PLarge x PKa and more in PKa x PKa group, this is why the total feed consumption of PLarge x PKa rabbits was lower than that of PKa x PKa. Significant differences were found in feed conversion ratio between weaning and the end of the fattening period, with the best result for PLarge x PKa and the lowest in the PKa x PKa group. According to previous results (Szendrő *et al*., 2012; Matics *et al.*, 2014a), selection for TMV by CT also improved the feed conversion ratio. Mortality was low, and no significant differences existed between genotypes.

Table 14
Effect of different crossing combinations on productive traits of rabbits slaughtered at similar body weight

Traits	**Genotype**			**SE**	**Prob.**
	PKa x PKa	PWhite x PKa	PLarge x PKa		
Weight at 5 wk, g	889^{a}	947^{b}	923^{b}	5.06	<0.001
Age at the end of the experiment, d	88	83	79	-	-
Weight at the end of the experiment, g	2785	2793	2795	8.05	0.952
Weight gain, g/d	35.6^{a}	39.2^{b}	42.8^{c}	0.29	<0.001
Feed intake, g/d	127^{a}	129^{a}	135^{b}	1.09	<0.001
Feed conversion ratio	3.55^{b}	3.38^{ab}	3.24^{a}	0.04	0.002
Mortality, %	5.0	3.3	0	-	0.257

[a,b]:Means in the same row with unlike superscripts differ (P<0.05).

Despite finding no differences in body weight at slaughter, the weight of carcasses (warm, chilled and reference), hind part, hind legs and meat on hind legs were higher in PWhite x PKa and smaller in PKa x PKa rabbits (***Table 15***). At the same time, the weight of the gastrointestinal tract was the smallest in the PWhite x PKa group.

Table 15
Effect of different crossing combinations on carcass traits of rabbits (g) slaughtered at similar body weights

Traits	Genotype			SE	Prob.
	PKa x PKa	PWhite x PKa	PLarge x PKa		
Age at the slaughter, d	88	83	79	-	-
Body weight at slaughter	2785	2793	2795	8.0	0.952
Skin	394[a]	409[b]	390[a]	2.1	<0.001
Distal part of legs	91[a]	95[b]	97[b]	0.47	<0.001
Gastrointestinal tract	491[b]	458[a]	487[b]	4.0	<0.001
Head	135	137	134	0.6	0.244
Warm carcass	1708[a]	1742[b]	1726[ab]	5.9	0.002
Chilled carcass	1648[a]	1678[b]	1665[ab]	5.7	0.016
Reference carcass	1392[a]	1425[b]	1410[ab]	5.3	<0.001
Heart + lungs	23	22	24	0.29	0.128
Liver	81[b]	77[a]	82[b]	0.93	0.048
Kidneys	17	16	16	0.18	0.528
Perirenal fat	25[b]	23[ab]	21[a]	0.52	0.020
Scapular fat	7	7	6	0.25	0.153
Fore part	418	418	425	1.9	0.111
Mid part	430	440	428	2.0	0.148
Hind part	512[a]	537[b]	530[b]	2.2	<0.001
Hind legs	476[a]	501[b]	495[b]	2.1	<0.001
Thigh fillet	378[a]	402[c]	392[b]	1.0	<0.001
Loin fillet	171[b]	174[b]	165[a]	1.22	<0.001

[a,b]: Means in the ssme row with unlike superscripts differ (P<0.05).

In parallel with these results, the dressing out percentages and the ratios of hind part to reference carcass were also higher in PWhite x PKa rabbits (***Table 16***). PLarge x PKa rabbits were between the other two genotypes.

Breeds which grow faster are slaughtered at a younger age, and they are not at the same level of maturity. This is why breeds with smaller adult body weights had better maturity at slaughter and dressing out percentages, but with a lower ratio of the fore part, and higher ratio of the hind part compared to large bodied breeds (Gómez *et al*., 1998; Hernández *et al*., 2006; Pla *et al.*, 1996, 1998). In contrast, in the present experiment, both genotypes with higher adult body weights (PWhite x PKa and PLarge x PKa) had better dressing out percentages and higher ratios of hind part, but lower or similar percentages of fore parts compared to PKa x PKa rabbits. This was the first time when was shown that the PLarge, as a large-bodied breed, had better results in meat production than PKa rabbits.

Table 16
Effect of different crossing combinations on ratios of carcass and carcass parts of rabbits slaughtered at similar body weights

Traits	**Genotype**			**SE**	**Prob.**
	PKa x PKa	PWhite x PKa	PLarge x PKa		
Ratio to slaughter weight (dressing out percentage), %					
Warm carcass	61.3[a]	62.4[b]	61.8[a]	0.12	<0.001
Chilled carcass	59.2[a]	60.1[b]	59.6[ab]	0.11	<0.001
Reference carcass	50.0[a]	51.0[b]	50.5[ab]	0.12	<0.001
Ratio to chilled carcass, %					
Head	8.2	8.2	8.0	0.04	0.055
Heart + lungs	1.4	1.3	1.4	0.02	0.587
Liver	4.9[ab]	4.6[a]	4.9[b]	0.05	<0.001
Kidneys	1.0[b]	0.9[a]	1.0[ab]	0.01	<0.001
Perirenal fat	1.5[b]	1.4[ab]	1.3[a]	0.03	0.016
Scapular fat	0.4	0.4	0.4	0.02	0.206
Ratio to reference carcass, %					
Fore part	30.0[b]	29.3[a]	30.2[b]	0.08	0.002
Mid part	30.9[b]	30.9[b]	30.4[a]	0.08	<0.001
Hind part	36.8[a]	37.7[b]	37.5[b]	0.08	<0.001

[a,b]: Means in the same row with unlike superscripts differ (P<0.05).

Matics *et al*. (2014a) summarized the effectiveness of CT-based selection (genetic parameters, genetic response to selection, experiment of divergent selection, comparison of different breeds), however, the results of the present experiment showed new evidence of this relationship, since the genotypes which have been selected for carcass traits for shorter or longer periods had better results than the maternal line when compared at similar live weight range.

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at slaughterhouse level, as well as profitability indicators at both the farm and slaughterhouse level of different crossing combinations slaughtered at similar weights are shown in ***Table 17***.

At farm level

The average difference in production costs (0.02 €/rabbit) was negligible between the PKa x PKa and PWhite x PKa groups, while a larger difference rabbits (0.30 €/rabbit) was found between the former and PLarge x PKa in favor of PLarge x PKa rabbits, due to their shorter fattening period. Profit of PKa x PKa rabbits was 88.0 and 42.4% than that of the PWhite x PKa and PLarge x PKa group on a medium feed price, respectively. Results show that PLarge x PKa rabbits were able to exceed the average indicators on each feed price compared to the other groups. Therefore a farm with a yearly production of 50,000 growing rabbits may achieve 15,900 € additional profit when PLarge x PKa rabbits are reared instead of PKa x PKa rabbits.

At slaughterhouse level

A different ranking order occurred when the calculation was made at the slaughterhouse level. Revenue from carcass parts was 8.69, 8.50 and 8.39 €/rabbit in PWhite x PKa, PLarge x PKa and PKa x PKa rabbits, respectively, at a medium selling price, while the highest difference in profit was 0.29 €/rabbit. Regarding profitability ratios, the best results were found in the PWhite x PKa group, even at a medium selling price.

Results show a conflicting interest at farm and slaughterhouse level, since the farmer benefits from PLarge x PKa, while the slaughterhouse benefits from PWhite x PKa rabbits.

Table 17

Profitability of different rabbit crossing combinations (slaughtered at similar weight) at farm and slaughterhouse level

Indicators	**Genotype**								
	PKa x PKa			PWhite x PKa			PLarge x PKa		
	FARM LEVEL								
	Price of feed								
	Low	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**
Cost of feeding (€/r)	**1.68**	1.85	2.02	**1.61**	1.77	1.94	**1.49**	**1.63**	1.78
Cost of mortality (€/r)	0.09	0.09	0.09	0.06	0.06	0.06	**0.00**	**0.00**	**0.00**
Total cost (€/r)	**3.87**	4.04	4.20	**3.86**	4.02	4.17	**3.59**	**3.73**	**3.88**
PRICE AT SLAUGHTER (€/r)	***4.27***	***4.27***	***4.27***	***4.28***	***4.28***	***4.28***	***4.29***	***4.29***	***4.29***
Farm profit (€/r)	**0.40**	0.23	0.07	**0.43**	0.27	0.11	**0.70**	**0.55**	**0.41**
Farm cost to revenue (%)	**90.6**	94.5	98.3	**90.0**	93.8	97.4	**83.7**	**87.1**	**90.4**
Farm profit to cost (%)	**10.40**	5.80	1.72	**11.08**	6.62	2.66	**19.50**	**14.77**	**10.57**
Farm cost efficiency	**1.10**	1.06	1.02	**1.11**	1.07	1.03	**1.20**	**1.15**	**1.11**
	SLAUGHTERHOUSE LEVEL								
	Selling price								
	Low	Med	High	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	6.82	7.42	**8.01**	6.95	**7.55**	**8.16**	6.89	**7.49**	**8.09**
Revenue from rabbit products (€/r)	7.76	8.39	**9.01**	8.04	**8.69**	**9.34**	7.87	8.50	**9.12**
SH profit (€/r)*	3.49	4.11	**4.74**	3.76	**4.41**	**5.06**	3.58	4.21	**4.84**
SH cost to revenue (%)*	55.0	50.9	**47.4**	53.3	**49.3**	**45.8**	54.5	50.4	**47.0**
SH profit to cost (%)*	81.8	96.4	**110.9**	87.7	**102.9**	**118.1**	83.6	98.2	**112.9**
SH cost efficiency*	1.82	1.96	**2.11**	1.88	**2.03**	**2.18**	1.84	1.98	**2.13**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

5.1.4. Effect of divergent selection for the volume of muscle on the hind legs

The evaluation is based on the experiment which was published by Szendrő *et al*. (2012).

Objective of the experiment

The objective of the study was to analyze the effects of divergent selection for CT measured thigh muscle volume (TMV). This section focuses on evaluating the economic values at the farm and slaughterhouse levels.

Material and methods

TMV was measured by CT in PWhite growing rabbits at 10.5 weeks of age. Rabbits were selected to increase (PP) or decrease (MM) their TMV during two generations. Production performance, slaughter traits and economic values of their offspring were compared.

Economic evaluation

Natural indicators

Selection had no effect on daily weight gain and body weight at the age of 10 weeks (***Table 18***). Due to a lower amount of fat tissues (fat depot), the PP group had lower feed intake and better feed conversion ratio than MM rabbits. This is explained by the fact that the energy requirement for building fat into the body is higher than that of the muscle (protein). This is why PP rabbits consumed less feed to achieve the same weight gain. A favorable side effect of the CT aided selection is the improvement of feed conversion rate. These results were confirmed when different crossbred rabbits were compared (Szendrő *et al*., 2010).

Table 18
Effect of divergent selection for thigh muscle volume on productive performance of growing rabbits

Traits	Second selected generation		SE	Prob.
	MM	PP		
Body weight at 10 wk, g	2471	2474	209	0.757
Weight gain (5-10 wk), g/day	44.7	45.7	1.05	0.461
Feed intake (5-10 wk), g/day	138	128	2.17	0.002
Feed conversion ratio	3.01	2.81	0.05	<0.001

MM: progeny of the minus-selected parents of the second generation;
PP: progeny of the plus-selected parents of the second generation

Significant differences were found in TMV, weight of hind part, hind leg and meat on hind leg, with higher values in the PP group. Opposite differences were found in kidneys, and perirenal and scapular fat weights (***Table 19***).

Table 19
Effect of divergent selection for thigh muscle volume (cm^3) on carcass traits (g)

Traits	Second selected generation		SE	Prob.
	MM	PP		
CT measured thigh muscle volume	309	336	21.2	0.004
Body weight at slaughter	2454	2445	211	0.863
Skin	350	353	22.7	0.657
Head	116	118	4.81	0.957
Full gastrointestinal	440	410	47.7	0.432
Hot carcass	1485	1504	43.6	0.362
Chilled carcass	1444	1462	42.5	0.476
Reference carcass	1212	1237	44.1	0.175
Liver	81.8	76.2	11.4	0.082
Kidneys	16.7	15.1	2.19	0.008
Heart + lungs	20.8	20.4	3.31	0.412
Perirenal fat	29.4	23.8	6.94	0.020
Scapular fat	13.0	6.05	3.73	<0.001
Fore part	365	364	16.8	0.852
Intermediate part	368	371	19.4	0.735
Hind part	439	473	21.2	<0.001
Hind legs	413	446	19.8	<0.001
Loin fillet	137	142	12.9	0.169
Meat on hind legs	326	355	18.7	<0.001

MM: progeny of the minus-selected parents of the second generation;
PP: progeny of the plus-selected parents of the second generation

The ratio of the full gastrointestinal tract compared to body weight was higher for the MM rabbits (***Table 20***).

Table 20
Effect of divergent selection for thigh muscle volume on ratios of carcass and carcass parts

Traits	Second selected generation		SE	Prob.
	MM	PP		
Percentage of body weight at slaughter, %				
Skin	14.2	14.5	0.93	0.576
Full gastrointestinal	18.1	16.7	2.13	0.415
Dressing out percentage				
based on hot carcass weight	60.4	61.5	2.10	0.396
based on chilled carcass weight	58.7	59.8	2.04	0.501
Ratio to reference carcass, %				
Fore part	30.1	29.4	0.97	0.066
Intermediate part	30.3	30.0	0.88	0.335
Hind part	36.3	38.2	1.06	0.015
Perirenal fat	2.40	1.90	0.66	0.005
Scapular fat	1.07	0.49	0.31	<0.001
Hind legs	34.1	36.1	0.98	<0.001
Loin fillet	11.3	11.5	0.82	0.220
Thigh meat	26.9	28.7	0.89	<0.001

MM: progeny of the minus-selected parents of the second generation;
PP: progeny of the plus-selected parents of the second generation

Compared to the reference carcass, ratios of the fore part, perirenal fat and scapular fat were higher in the MM group, while ratios of the hind part and hind leg meat were higher in PP rabbits. Previously, the efficiency of selection for the L-value was shown by genetic analysis, genetic trend estimation and a divergent selection experiment. The difference between the plus and minus selected groups was 5.8% for the L-value and 5.1% for the weight of the mid part (Szendrő *et al.*, 1996). Breeding values of CT measured animals increased during the three years (Specify Years), studied: 0.12, 0.35 and 0.78, respectively) (Szendrő *et al.*, 2004). The estimated genetic correlation between the L-value and dressing out percentage was 0.47 (Nagy *et al.*, 2006). The effectiveness of selection for

TMV was also demonstrated by Gyovai *et al.* (2008) using the data from the routine breeding. At the same time the volume of fat depots and feed intake decreased while the feed conversion ratio improved.

Financial indicators

Cost of production at the farm level, the price of slaughter rabbits, the revenue (from whole carcasses and from different carcass parts) at the slaughterhouse level, as well as profitability indicators on both the farm and slaughterhouse levels of rabbits selected divergently for decreasing (MM) and increasing (PP) their TMV are shown in ***Table 21***.

At farm level

In the progenies of the second generation of divergent selection for increasing TMV (PP) had lower feed consumption (***Table 18***) than that of rabbits selected for decreasing thigh muscle volume (MM). Thus cost of feeding decreased by 7% in PP compared to the MM group. Negligible costs of mortality were found in both cases. The difference between the price at slaughter (which is considered as revenue for the farmer) was only 0.01 €/rabbit, in favor of the MM group. Based on low, medium and high feed prices, the profit of MM was 0.45, 0.33 and 0.22 €/rabbit, while PP rabbits achieved profits of 0.47, 0.35 and 0.25 €/rabbit, respectively. Differences show that PP rabbits achieve at least 8,300 € more income for a farmer producing 50,000 rabbits yearly on a farm. When the calculation was made on high price feed instead of low feed price, profit in the MM group decreased by 52.6%, while the decline was 47.3% in the PP rabbits. In each feed price category, the cost to revenue of MM group exceeded that of PP rabbits. With increasing feed price, the difference between the MM and PP groups also increased, the differences in ratios were 0.47, 0.73 and 0.84% for low, medium and high feed prices, respectively, in favor of PP rabbits.

Table 21
Profitability of divergent selection for thigh muscle volume (TMV) at the farm and slaughterhouse levels

Indicators	Second selected generation					
	MM			PP		
	FARM LEVEL					
	Price of feed					
	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.21**	1.33	1.45	**1.12**	**1.23**	1.34
Cost of mortality (€/r)	0.10	0.10	0.10	0.08	0.08	0.08
Total cost (€/r)	3.31	3.43	3.55	**3.28**	3.40	3.50
PRICE AT SLAUGHTER (€/r)	***3.76***	***3.76***	***3.76***	***3.75***	***3.75***	***3.75***
Farm profit (€/r)	**0.45**	0.33	0.22	**0.47**	**0.35**	0.25
Farm cost to revenue (%)	**87.9**	91.2	94.3	**87.6**	**90.6**	93.5
Farm profit to cost (%)	**13.72**	9.69	6.07	**14.19**	**10.41**	7.01
Farm cost efficiency	**1.14**	1.10	1.06	**1.14**	**1.10**	1.07
	SLAUGHTERHOUSE LEVEL					
	Selling price					
	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	5.98	6.50	**7.02**	6.05	**6.58**	**7.11**
Revenue from rabbit products (€/r)	6.66	7.18	7.70	6.97	7.53	**8.09**
SH profit (€/r)*	2.90	3.42	**3.94**	3.22	**3.78**	**4.34**
SH cost to revenue (%)*	56.5	52.4	**48.8**	53.8	**49.8**	**46.3**
SH profit to cost (%)*	77.0	90.9	**104.8**	85.9	**100.9**	**115.8**
SH cost efficiency*	1.77	1.91	**2.05**	1.86	**2.01**	**2.16**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At slaughterhouse level

From the slaughterhouse's point of view, the difference in revenue from rabbit products was between 0.31 and 0.39 €/rabbit, in favor of PP rabbits, depending on the selling price. MM rabbits could achieve profitability ratios above the average only when selling rabbit products on well-paying markets (i.e. at high selling prices), while PP rabbits were profitable even at a medium price. The difference between the revenues from carcass parts was remarkable (1.45 €/rabbit). The highest profit (4.34 €/rabbit) was achieved by PP rabbits, while the lowest value (2.90 €/rabbit) was found with the MM group. Consequently, PP rabbits may achieve 50% higher profit than MM rabbits at the slaughterhouse level, depending on the selling price. Concerning cost to revenue, profit to cost and cost efficiency, the differences were between 2.50-2.72, 8.95-11.07 and 0.09-0.11%, respectively, in favor of the PP group.

All of the values showed that the selection for improving muscle on hind legs by CT had significant economic benefits for both the farmer and the slaughterhouse, but higher profits for the slaughterhouse.

5.2 EVALUATION OF THE EFFECT OF HOUSING

5.2.1 Separate effects of housing growing rabbits in cages or in pens on productive performance, carcass traits and economic values

This section is a part of my experiment to examine the effect of genotype, housing and feeding on growing rabbits.

Objective of the experiment

The aim of the experiment was to examine separately the effects of housing conditions on productive performance, carcass traits and economical values, to get information about the difference between caged and pen housed growing rabbits.

Material and methods

Crossbred rabbits (PLarge x PKa and Hung x PKa) were weaned at 5 weeks of age and were reared in a cage or pen [Cage: 3 rabbits/cage, Pen: 14 rabbits/pen, but the stocking density was the same (16 rabbits/m^2)]. They were fed with pellets or pellets plus hay until slaughter at 12 weeks of age. Data was evaluated by multi-factor analysis of variance, and the effect of housing was calculated separately. The design of the experiment is shown in ***Figure 4***.

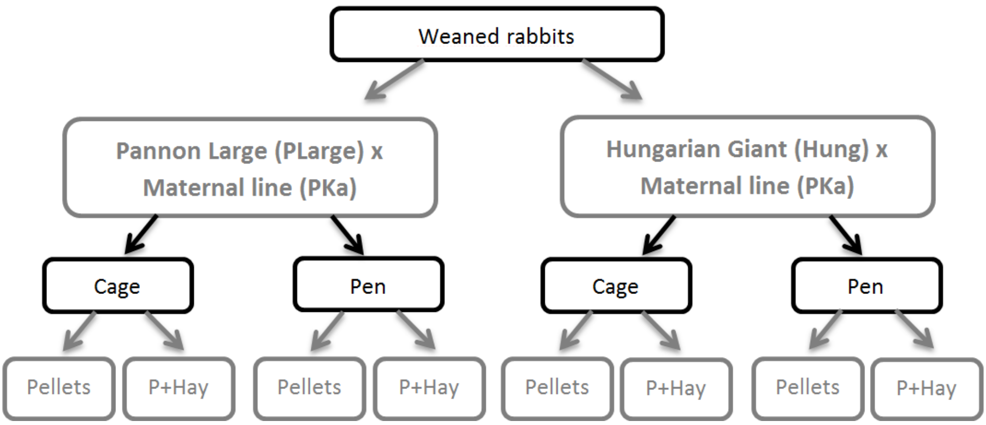


Figure 4. Design of the experiment

Economic evaluation

Natural indicators

The differences in body weight between Cage and Pen rabbits were significant from seven weeks of age, in favor of the Cage group. It increased from 96 g at 7 week to 141 g at 12 week (***Table 22***). The Cage rabbits consumed 13 g/day more pellets between 5-7 weeks and 7-9 weeks than Pen rabbits. The differences in weight gain were significant between 5-7 weeks (6.4 g/day), 11-12 weeks (4.5 g/day), and 5-12 weeks (3.1 g/day), in favor of Cage rabbits, while the differences in feed conversion ratios were not significant. Difference was found in mortality between 9-11 weeks (P<0.05), however it was not significant between 5-12 weeks.

Table 22
Effect of housing conditions on productive performance of growing rabbits

Traits	Housing condition		SE	Prob.
	Cage	Pen		
Weight at 5 wk of age, g	984	984	-	-
Weight at 12 wk of age, g	3123	2982	16	<0.001
Weight gain, 5-12 wk of age, g/day	42.5	39.4	0.3	<0.001
Feed intake, g/day (5-12 wk of age)	141	133	2.2	0.052
Feed conversion ratio	3.48	3.47	0.08	0.956
Mortality, %	5.6	8.3	-	0.398

These results are in agreement with the data in the literature. Most of the authors observed smaller or larger significant declines in weight gain and body weight of rabbits housed in larger groups (Maertens and Van Herck, 2000; Lambertini *et al*., 2001; Dal Bosco *et al*., 2002; Szendrő *et al*., 2009a; Combes *et al*., 2010). The lower growth rate could be related to higher activity, since more energy is required for moving. The largest difference in weight gain was seen between 5 and 7 weeks, which was in line with the observation of Maertens and Van Herck (2000). They experienced higher sensitivity to stress and lower growth rate in larger groups after weaning. Most of the authors (Maertens and De Groote, 1984; Maertens and Van Herck, 2000; Princz *et al*., 2009; Szendrő *et al*., 2009a) did not identify a significant effect of group size on mortality. So we can state that the group size is not the main factor causing mortality of growing rabbits, particularly when rabbits consume medicated pellets.
The weight of the carcass, body parts, organs, meat (fillet) and fat deposits were significantly higher in Cage than in Pen rabbits (***Table 23***).

Table 23
Effect of housing conditions on carcass traits (g)

Traits	Housing condition		SE	Prob.
	Cage	Pen		
Weight at slaughtering	3055	2940	15.7	<0.001
Warm carcass	1906	1826	10.3	<0.001
Chilled carcass	1861	1785	10.1	<0.001
Reference carcass	1577	1507	8.94	<0.001
Head	155	154	0.69	0.225
Heart + lungs	23.5	22.5	0.19	0.006
Liver	83.2	81.1	1.06	0.318
Kidneys	18.6	17.9	0.12	0.004
Perirenal fat	28.6	20.3	0.66	<0.001
Scapular fat	10.16	7.61	0.24	<0.001
Fore part	428	414	2.30	0.004
Mid part	532	503	3.54	<0.001
Hind part	579	564	3.08	0.014
Hind legs	552	532	2.94	0.001
Meat on hind legs	392	376	3.49	0.030
Loin fillet	188	175	1.41	<0.000

The housing condition did not affect the dressing out percentage (***Table 24***). The ratios of the fore and hind parts to the reference carcass were higher in Pen rabbits, and that of the mid part, perirenal and scapular fat were higher in Cage rabbits. In pens the rabbits could move more (Dal Bosco *et al*., 2002; Lambertini *et al*., 2005; Princz *et al*., 2008), thus their weight gain and body weight were lower (Szendrő and Dalle Zotte, 2011). One consequence of lower weight was that the weights of carcasses, carcass parts, organs and tissues were also lower, as was found in the present experiment and by several authors (Dal Bosco *et al*., 2002; Dalle Zotte *et al*, 2009a; Matics *et al*., 2014b). In most of the experiments, the dressing out percentage of penned rabbits was lower than that of caged rabbits, however, as found in the present experiment, in most cases the differences were not significant (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009; Szendrő *et al*., 2009d; Combes *et al*., 2010; Matics *et al*., 2014b). In our experiment – due to the higher locomotor activity in pens – the ratio of hind part to reference carcass increased, and that of perirenal fat and scapular fat decreased, similarly to the results in the literature (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009; Szendrő *et al*., 2009d; Combes *et al*., 2010). The larger ratio of fore part to reference carcass could be also associated with higher activity, however some contrary results were published (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009). Since the ratios of two parts (fore and hind) of the reference carcass increased, the third (mid) part had to decrease in Pen rabbits. As in our results, and in most studies, the mid part to reference carcass was similar in cage and pen housed rabbits (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009; Szendrő *et al*., 2009d).

Table 24
Effect of housing condition on ratio of carcass and carcass parts

Traits	**Housing condition**		**SE**	**Prob.**
	Cage	Pen		
Dressing out percentage, %				
Warm carcass	62.3	62.1	0.1	0.198
Chilled carcass	60.9	60.7	0.1	0.466
Reference carcass	51.6	51.2	0.1	0.117
Ratio to reference carcass, %				
Fore part	27.1	27.5	0.1	0.008
Mid part	33.7	33.3	0.1	0.002
Hind part	36.8	37.5	0.1	<0.001
Perirenal fat	1.76	1.33	0.04	<0.001
Scapular fat	0.63	0.49	0.01	<0.001

Financial indicators

Cost of production at farm level, the price of slaughter rabbit, the revenue at slaughterhouse level, as well as profitability indicators on both farm and slaughterhouse level of rabbits housed in cage and pen are shown in ***Table 25.***

Table 25
Profitability of different housing conditions (cage or pen) at farm and slaughterhouse level

Indicators	**Housing condition**					
	Cage			Pen		
	FARM LEVEL					
	Price of feed					
	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.73**	1.90	2.07	**1.63**	**1.79**	1.96
Cost of mortality (€/r)	**0.13**	**0.13**	**0.14**	0.19	0.20	0.20
Total cost (€/r)	**4.14**	4.31	4.48	**4.07**	**4.24**	4.40
PRICE AT SLAUGHTER (€/r)	***4.68***	***4.68***	***4.68***	***4.51***	***4.51***	***4.51***
Farm profit (€/r)	**0.55**	**0.37**	0.20	**0.43**	0.27	0.11
Farm cost to revenue (%)	**88.3**	**92.1**	95.7	**90.4**	94.1	97.6
Farm profit to cost (%)	**13.19**	**8.61**	4.55	**10.64**	6.32	2.46
Farm cost efficiency	**1.13**	**1.09**	1.05	**1.11**	1.06	1.02
	SLAUGHTERHOUSE LEVEL					
	Selling price					
	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	7.70	**8.37**	**9.04**	7.39	8.03	**8.68**
Revenue from rabbit products (€/r)	8.38	**9.04**	**9.69**	7.99	8.61	**9.24**
SH profit (€/r)*	3.70	**4.35**	**5.01**	3.48	4.11	**4.73**
SH cost to revenue (%)*	55.9	**51.8**	**48.3**	56.4	52.3	**48.8**
SH profit to cost (%)*	78.9	**92.9**	**106.9**	77.2	91.1	**104.9**
SH cost efficiency*	1.79	**1.93**	**2.07**	1.77	1.91	**2.05**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At farm level

In the case of med feed price, cost of feeding was lower by 0.11 €/rabbit (6%) in Pen rabbits than in the Cage group. The reason for the difference is that the incidence of fights is higher so the level of stress is higher in group housed rabbits (Szendrő and Dalle Zotte, 2011) leading to lower feed consumption (***Table 22***). The cost of mortality was higher by about 50% in Pen than in Cage rabbits due to the differences in mortality (***Table 22***). Similar differences were found in the cost of production as was seen in the cost of feeding with an average decrease of 2%, while the differences in price at slaughter were even higher (3.8%). The profit from a group of rabbits housed in cages was average of 0.10 €/rabbit higher than in the Pen group. The lowest cost to revenue and the highest profit to cost ratios belonged to the Cage group fed with low price pellets (88.3% and 13.19%, respectively). The difference in cost efficiency was 0.02%. It is an impressive result that – based on the same mortality rate and scheduling –, a farmer producing 50,000 rabbits yearly is able to achieve at least 5,200 € additional profit with Cage rabbits compared to Pen rabbits.

At slaughterhouse level

The revenue (from the whole carcass and carcass parts) was determined by the weight at slaughter (***Table 22***). Selling rabbits at a medium price, the revenue from the whole carcass and carcass parts were 0.34 (4.1%) and 0.42 €/rabbit (4.7%) lower in the Pen group than in the Cage rabbits, respectively. Significant differences were found in profit: Cage rabbits achieved 6% higher values than Pen rabbits, so the differences were 0.21, 0.25 and 0.28 €/rabbit, depending on the selling price. Thus, it can be stated that at equivalent selling prices higher profit can be achieved with Cage than Pen rabbits. Selling rabbits at med price, costs to revenue in Cage rabbits were 0.5% better than in Pen group. The Cage group achieved 1.65, 1.84 and 2.02% higher profit to cost ratio than Pen rabbits, depending on the selling price. The difference in cost efficiency ratios was 0.02% in each case. At the slaughterhouse level, all of the values and indicators showed that Cage rabbits achieved profitability above the average on medium and high selling price, while Pen group was above average only on high price.

Results showed that housing rabbits in cages had a significant financial impact, its economic benefit for the farmer and the slaughterhouse is remarkable. The stated values show how much higher prices have to be paid to the farmer and the slaughterhouse to make it worthwhile to raise rabbits in large groups and to buy them for slaughter.

5.2.2 Effect of floor type (wire-mesh, plastic-mesh or deep-litter) on productive performance, carcass traits and economic values

The evaluation is based on the experiment carried out by Gerencsér *et al*. (2013).

Objective of the experiment

The aim of the experiment was to examine the effect of different housing conditions (floor type: Wire-mesh, Plastic-mesh and Deep-litter) on productive performance, carcass traits and economic values to get information about the differences among the three groups, and on the welfare (preference) of rabbits depending on the floor type.

Material and methods

Natural indicators: PKa rabbits at weaning (n=126) were housed in pens with basic area of 1.27 m^2 (14 rabbits/pen, 11 rabbits/m^2). The floor type of the pens was different: Wire-mesh, Plastic-mesh or Deep-litter. Productive traits were measured between 5 and 11 weeks of age, then the rabbits were slaughtered and the carcasses were dissected according to the recommendation of the WRSA (Blasco and Ouhayoun, 1996).

Besides the evaluation of natural indicators, a preference test was also carried out among the three floors.

Preference test: At the age of 5 weeks the rabbits were placed to pens with a basic area of 3.8 m^2 (43 rabbits/pen, 11 rabbits/m^2). The floor of the pens was partly wire-mesh (1/3), plastic-mesh (1/3) and straw deep-litter (1/3). Infrared cameras were fixed above the pens. A 24h video recording was made once a week, between 5 and 11 weeks of age. The number of rabbits in each location (wire-mesh, plastic-mesh or deep-litter) of the pens was recorded every 30 minutes.

Economic evaluation

Natural indicators

Table 26 shows the productive performance of rabbits between the ages of 5 and 11 weeks reared on different floor types. The Deep-litter groups had the lowest body weight gain, consumed the least amount of feed, and had the lowest feed conversion ratio, therefore presented the lowest body weight at slaughter. On the other hand, rabbits reared on Plastic-mesh demonstrated the highest values in terms of body weight gain, feed intake and body weight at slaughter, while the Wire-mesh group had the highest feed conversion ratio between 5 and 11 weeks of age. When considering mortality, rabbits reared on Deep-litter had the highest value, followed by Plastic-mesh and Wire-mesh at about half that of Deep-litter. Dal Bosco *et al.* (2002) found significantly higher differences in body weight gain and mortality between rabbits reared in cages or in straw-bedded pens.

Table 26
Effect of floor type on productive traits of growing rabbits

Traits	**Housing condition**			**SE**	**Prob.**
	Wire-mesh	Plastic-mesh	Deep-litter		
Body weight at 11 wk, g	2732	2770	2674	19.88	0.143
Body weight gain, g/day	35.5[ab]	36.6[b]	34.3[a]	0.362	0.04
Feed intake, g/day	127	129	118	2.951	0.29
Feed conversion ratio	3.77	3.74	3.52	0.144	0.733
Mortality, %	4.8	7.1	9.5	-	0.698

[a,b]: Means in the same row with unlike superscripts differ (P<0.05).

No significant differences were found in weight of carcass and carcass parts, although in most cases the smallest values were measured in the Deep-litter group (***Table 27***). On the other hand, significant differences were detected in dressing out percentage; the Plastic-mesh group achieved the best result, and in the ratio of hind part to reference carcass, with highest values were seen in the Deep-litter group (***Table 28***). The rabbits on Wire-mesh floors achieved intermediate results. In the literature, the ratio of fore part increased, while the hind part increased on Deep-litter compared to Wire-mesh (Dal Bosco *et al*., 2000, 2002; Lambertini *et al*., 2001; Metzger *et al*., 2003; Trocino *et al*., 2008). No difference was observed in ratio of dissectible fat to reference carcass.

Table 27
Effect of floor type on carcass traits (g)

Traits	Housing condition			SE	Prob.
	Wire mesh	Plastic mesh	Deep-litter		
Slaughter weight	2765	2731	2696	20	0.358
Warm carcass	1684	1674	1636	13	0.303
Chilled carcass	1633	1629	1584	13	0.241
Reference carcass	1376	1370	1330	12	0.210
Head	141	139	136	0.9	0.080
Heart + lungs	23.8	23.7	24.0	0.40	0.959
Liver	75.3	75.6	78.6	1.10	0.399
Kidneys	17.4	16.3	16.3	0.24	0.099
Perirenal fat	19.5	19.6	19.2	0.88	0.984
Scapular fat	7.36	7.42	6.30	0.33	0.279
Fore part	428	428	408	4.0	0.064
Mid part	410	414	397	3.8	0.184
Hind part	512	503	499	3.7	0.361
Loin fillet	150	145	148	1.5	0.487
Hind legs	481	478	470	1.8	0.422
Hind leg fillet	382	379	371	1.5	0.301

Table 28
Effect of floor type on dressing out percentage and ratios of parts of the reference carcass

Traits	Housing condition			SE	Prob.
	Wire-mesh	Plastic-mesh	Deep-litter		
Dressing out percentage, %	59.0[ab]	59.7[b]	58.7[a]	0.15	0.038
Ratio to reference carcass, %					
Fore part	31.1	31.2	30.7	0.10	0.064
Mid part	29.8	30.2	29.9	0.11	0.243
Hind part	37.3[ab]	36.8[a]	37.6[b]	0.11	0.010
Dissectible fat	1.86	1.82	1.89	0.074	0.938

[a,b]: Means in the same row with unlike superscrips differ (P<0.05).

Preference test

During the whole growing period, the least preferred floor was the Deep-litter, independently of the age (7.3%). Most rabbits chose the Plastic-mesh floor (54.7%), whereas the Wire-mesh floor preference was between the other two groups (38.0%). Matics *et al.* (2003) and Princz *et al.* (2008) reported a higher preference of growing rabbits for Plastic-mesh to Wire-mesh floor. Results of the choice between Wire-mesh and Deep-litter were in accordance with the literature (Morrise *et al*., 1999; Orova *et al*., 2004). Animals choose among the different environmental conditions to find the most comfortable housing system. One may assume that Deep-litter would be more comfortable than Wire- or Plastic-mash floor. However, digestion produces heat which increases the heat load of rabbits, and since rabbits have fur and just a few sweat glands, it is difficult for them to eliminate body heat surplus (Marai *et al*., 2002), thus they prefer staying on cooler floors. These are the reasons why rabbits prefer staying on Wire- or Plastic-mesh floors at medium temperatures.

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at slaughterhouse level, as well as profitability indicators on both the farm and slaughterhouse levels of rabbits housed on Wire-mesh, Plastic-mesh or Deep-litter floor is shown in ***Table 31***.

Table 29
Profitability of housing conditions (Wire-mesh, Plastic-mesh or Deep-litter) at the farm and slaughterhouse levels

Indicators	Housing condition								
	Wire-mesh			Plastic-mesh			Deep-litter		
	FARM LEVEL								
	Price of feed								
	Low	Med	High	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.56**	1.71	1.87	**1.58**	1.74	1.90	**1.45**	**1.59**	1.73
Cost of mortality (€/r)	**0.10**	**0.10**	**0.10**	**0.14**	**0.14**	0.15	0.19	0.19	0.19
Total cost (€/r)	**3.85**	**4.01**	4.16	**3.93**	4.09	4.24	**3.80**	**3.95**	4.09
PRICE AT SLAUGHTER (€/r)	***4.24***	***4.24***	***4.24***	***4.19***	***4.19***	***4.19***	***4.13***	***4.13***	***4.13***
Farm profit (€/r)	**0.39**	**0.23**	0.08	**0.26**	0.10	-0.05	**0.33**	**0.19**	0.05
Farm cost to revenue (%)	**90.8**	**94.5**	98.0	**93.9**	97.7	101.3	**91.9**	**95.5**	98.9
Farm profit to cost (%)	**10.11**	**5.82**	2.01	**6.54**	2.40	-1.29	**8.77**	**4.75**	1.16
Farm cost efficiency	**1.10**	**1.06**	1.02	**1.07**	1.02	0.99	**1.09**	**1.05**	1.01
	SLAUGHTERHOUSE LEVEL								
	Selling price								
	Low	Med	High	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	6.76	**7.35**	**7.94**	6.74	**7.33**	**7.92**	6.56	7.13	**7.70**
Revenue from rabbit products (€/r)	7.59	**8.19**	**8.79**	7.52	**8.11**	**8.70**	7.38	7.96	**8.55**
SH profit (€/r)*	3.35	**3.95**	**4.55**	3.33	**3.93**	**4.52**	3.24	3.83	**4.41**
SH cost to revenue (%)*	55.9	**51.8**	**48.2**	55.7	**51.6**	**48.1**	56.0	**51.9**	**48.4**
SH profit to cost (%)*	79.0	93.1	**107.3**	79.6	**93.7**	**107.8**	78.5	92.6	**106.8**
SH cost efficiency*	1.79	1.93	**2.07**	1.80	**1.94**	**2.08**	1.78	1.93	**2.07**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At farm level

The price of feed consumed was lower in the Deep-litter group than in the other groups. The results of feed intake in this experiment (***Table 26***) and data from the literature (Dal Bosco *et al*., 2000, 2002; Lambertini *et al*., 2001) showed that rabbits on Deep-litter consumed the litter material (Jekkel *et al*., 2008), therefore their pellet intake was lower. Cost of mortality was lowest in the Wire-mesh and highest in the Deep-litter groups due to the differences in mortality. Despite the fact that cost of production was highest in the Plastic-mesh and lowest in the Deep-litter groups, which was mainly caused by the differences of feed costs, due to their higher slaughter weights, the revenue from the Wire-mesh group exceeded the other groups. Negative profit was achieved only by Plastic-mesh (0.05 €/rabbit) with a high feed price. It should be noted that the differences in profit among groups in carcasses and carcass parts are not consistent with the literature; the disadvantage of the Deep-litter group was lower than expected because, in the present experiment, smaller differences were found between among the Deep-litter group and the other two groups than in the literature (Dal Bosco *et al*., 2000, 2002; Lambertini *et al*., 2001; Metzger *et al*., 2003; Trocino *et al*., 2008). The greatest differences in profitability ratios were found between the Wire-mesh and Plastic-mesh groups. Differences in cost to revenue, profit to cost and cost efficiency on medium priced feed were 3.16, 3.42 and 0.03% between the Wire-mesh and Plastic-mesh groups; 2.19, 2.35 and 0.02% between the Plastic-mesh and Deep-litter groups and 0.97, 1.07, 0.01% between the Wire-mesh and Deep-litter groups, respectively.

Rabbits reared on Plastic-mesh had the lowest values, hence – considering the same mortality rates and scheduling for 50,000 growing rabbits – rabbits reared on Deep-litter instead of Plastic-mesh would achieve more than 2,600

€ additional revenue. Similar differences were found between the Plastic-mesh and Wire-mesh groups. Therefore, the difference between Plastic-mesh and Wire-mesh would be twofold, nearly 5,300 €.

At slaughterhouse level

Interesting changes were realized when evaluation was carried out at the slaughterhouse level. The Wire-mesh group had the highest revenue from carcass and carcass parts, followed by the Plastic-mesh group with negligible differences and the Deep-litter group with the lowest, resulting in a 3.0% difference between the highest and the lowest values. Profit above the average was realized with medium and high selling prices for the Wire-mesh and Plastic-mesh groups. In the Deep-litter group profit above the average was seen only with the high selling price. Cost to revenue was the lowest in the Plastic-mesh group, and highest in the Deep-litter group. Plastic-mesh rabbits achieved the highest values for the three profitability ratios, followed by the Wire-mesh group and the Deep-litter group with the lowest negligible differences. Thus, comparing the floor types from the economic point of view, Wire-mesh gave the best results in terms of revenue from carcass parts, however Plastic-mesh gave the best results in profitability ratios.

Different rank orders may occur at the farm and at the slaughterhouse levels. Wire-mesh was the most beneficial at the farm level, followed by Deep-litter, while Wire-mesh resulted the highest revenue, but Plastic-mesh the best profitability ratios at the slaughterhouse.

5.3 EVALUATION OF THE EFFECT OF FEEDING

5.3.1 Separate effects of feeding of growing rabbits (pellets only or pellets plus hay) on productive performance, carcass traits and economic values

This section is part of my experiment to examine the effect of genotype, housing and feeding on growing rabbits.

Objective of the experiment

The aim of the experiment was to examine separately the effects of feeding method on productive performance, carcass traits and economical values to get information about the difference if the rabbits consume only pellets or pellets + hay.

Material and methods

Crossbred rabbits (PLarge x PKa and Hung x PKa) were weaned at 5 weeks of age and were reared in cages or pens and fed with only pellets or pellets plus hay (P+Hay). Rabbits were slaughtered at 12 weeks of age. Pellet consumption was recorded, but the hay intake was not measured because of its waste; but it was calculated on the basis of digestible energy (DE) content. Namely, growing rabbits adjust their feed intakes according to their energy concentration (Lebas *et al.*, 1997). The calculated hay intake was equal to the daily energy intake of pellet-fed rabbits (daily feed intake multiplied by DE content of the pellets) minus energy intake from pellets of the P+Hay group, and the value was divided by the DE content of hay. Data were evaluated by multi-factor analysis of variance, but in this case only the effect of feeding method was calculated. The design of the experiment is shown in ***Figure 5***.

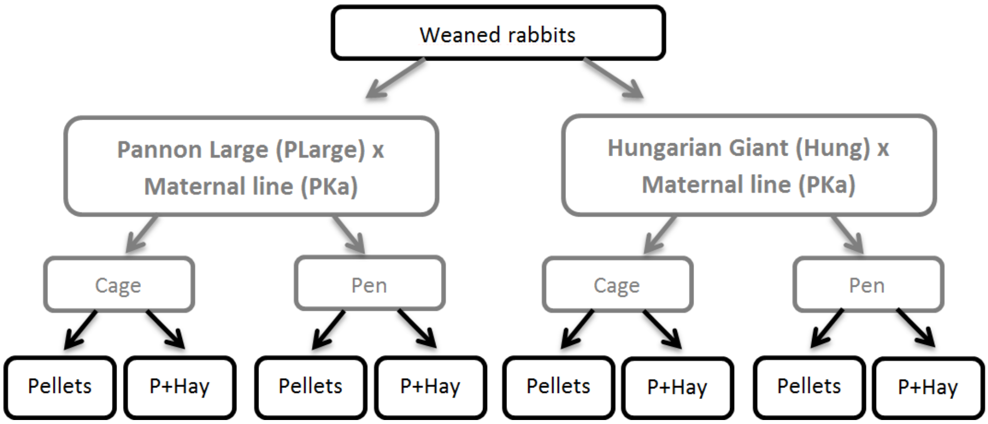


Figure 5. Design of the experiment

Economic evaluation

Natural indicators

The effect of feeding method on body weight was significant from 9 weeks of age, in favor of the Pellet group. The differences at 9, 11 and 12 weeks of age were 68, 85 and 76 g, respectively (***Table 30***).

Table 30

Effect of feeding method on productive performance of growing rabbits

Traits	**Feeding method**		**SE**	**Prob.**
	Pellet	P+Hay		
Weight at 5 wk of age, g	984	984	-	-
Weight at 12 wk of age, g	3093	3017	16	0.019
Weight gain, 5-12 wk of age, g/day	41.6	40.3	0.3	0.038
Feed intake, g/day (5-12 wk of age)	145	134	2.2	0.029
Feed conversion ratio	3.55	3.40	0.08	0.234
Mortality, %	7.7	6.6	-	0.672

Significant differences were found in weight gain. Pellet-fed rabbits had higher gains between 5 and 7, 7 and 9, and 5 and 12 weeks of age by 1.9, 3.3 and 1.3 g/d, respectively, compared to the P+Hay group. The differences in pellet intake were significant between 5 and 7, 7 and 9, 9 and 11, and 5 and 12 weeks of age by 9, 13, 12 and 11 g/d in favor of Pellet-fed rabbits. The calculated hay intake was 10, 14, 14, 14 and 13 g/d between weeks of 5 and 7, 7 and 9, 9 and 11, 11 and 12, and 5 and 12, respectively.

The results could be connected with the low nutritive value, mainly low protein, of grass hay. Linga and Lukefahr (2000) showed that rabbits receiving only alfalfa achieved very poor production. Capra *et al*. (2013) fed pellets with or without fresh alfalfa *ad libitum*. They found a small (34.7 vs 32.9 g/d), non-significant difference between the two groups. When alfalfa was mixed into the pellet at 88 or 96% and compared to the control diet with 49% alfalfa (Fernandez-Carmona *et al.*, 1998), a slight decline was observed in body weight (2290 vs 2150-2160g) and in weight gain (40.3 vs 37.2-37.3 g/d). Morales *et al*. (2009) added 10, 20 or 30% green barley forage to the pelleted diet and as the green barley content increased, the weight gain decreased linearly from 36.9 to 31.2 g/d. The results from feeding forages could depend on their nutritive value and their form (fresh or dried, given as pellets plus forage or mixing them into the pellets). In the current study, significant differences were found in pellet intake between the two groups, but these results did not reflect the real difference, because hay consumption was not measured. When the calculated hay intake was added to pellet intake, the consumption was similar.

The weight of carcass, body parts, organs, meat (fillet) and fat deposits was significantly higher in rabbits fed pellets only (***Table 31***).

Table 31
Effect of feeding method on carcass traits (g)

Traits	Feeding method		SE	Prob.
	Pellet	P+Hay		
Weight at slaughtering	3046	2956	15.7	0.006
Warm carcass	1902	1834	10.3	0.001
Chilled carcass	1859	1791	10.1	0.001
Reference carcass	1578	1511	8.94	<0.001
Head	154	155	0.69	0.341
Heart + lungs	22.8	23.3	0.19	0.218
Liver	83.7	80.7	1.06	0.132
Kidneys	18.4	18.1	0.12	0.358
Perirenal fat	27.4	21.9	0.66	<0.001
Scapular fat	10.13	7.82	0.24	<0.001
Fore part	431	412	2.30	<0.001
Mid part	531	506	3.54	0.001
Hind part	580	564	3.08	0.012
Hind legs	548	536	2.94	0.047
Meat on hind legs	390	379	3.49	0.149
Loin fillet	187	177	1.41	0.001

The dressing out percentage was 0.4-0.7% higher in the Pellet group than in P+Hay rabbits (***Table 32***). The ratio of hind part to reference carcass was higher in the P+Hay group, and that of perirenal and scapular fat were higher in the Pellet group. Feeding method did not influence the ratio of fore and mid parts to the reference carcass. The influence of feeding on carcass traits and meat quality is moderate (Xiccato, 1999). Feed intake is regulated by the energy level of the diet (Lebas *et al*., 1997). Rabbits consume more if the DE content is low or the fiber level is high. If they eat more, the weight and percentage of the digestive tract is higher, therefore dressing out percentage could be lower. The P+Hay group consumed a diet with lower energy and protein levels and higher fibre content than the Pellet group, due to the differences in chemical composition of pellets and hay. Thus, hay supplementation could be the cause of lower dressing out percentages and fat deposits. Pellet plus forage diets were used frequently on small farms but scientific papers were rarely published. In the experiments of Martínez *et al*. (2006) whole maize plants, Morales *et al*. (2009) hydroponic green barley forage, and Capra *et al*. (2013) fresh alfalfa was used. None of them found significant differences in dressing out percentage. Dalle Zotte (2002) noted that in rabbits fed with low-energy diets the dissectible fat decreased in a manner similar to our results.

Table 32
Effect of feeding method on ratio of carcass and parts of carcass

Traits	**Feeding method**		**SE**	**Prob.**
	Pellet	P+Hay		
Ratio to slaughter weight, %				
Warm carcass	62.4	62.0	0.1	0.027
Chilled carcass	61.0	60.6	0.1	0.011
Reference carcass	51.8	51.1	0.1	<0.001
Head	5.10	5.29	0.02	<0.001
Heart + lungs	0.75	0.79	0.01	0.001
Liver	2.75	2.71	0.03	0.361
Kidneys	0.61	0.62	0.004	0.220
Ratio to reference carcass, %				
Fore part	27.3	27.3	0.1	0.816
Mid part	33.6	33.4	0.1	0.312
Hind part	36.8	37.4	0.1	<0.001
Perirenal fat	1.72	1.39	0.04	<0.001
Scapular fat	0.63	0.50	0.01	<0.001

Financial indicators

Cost of production at the farm level, the price of slaughter rabbits, the revenue at the slaughterhouse level, and profitability indicators on both the farm and slaughterhouse levels of rabbits fed by pellets and pellets+hay are shown in ***Table 33***.

Table 33
Profitability of feeding method (pellets or pellets plus hay) at the farm and slaughterhouse levels

Indicators	Feeding method					
	Pellet			P+Hay		
	FARM LEVEL					
	Feed price					
	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.78**	1.95	2.13	**1.75**	**1.91**	2.08
Cost of mortality (€/r)	0.18	0.18	0.19	**0.16**	**0.16**	**0.17**
Total cost (€/r)	**4.25**	4.43	4.60	**4.19**	**4.36**	4.51
PRICE AT SLAUGHTER (€/r)	***4.67***	***4.67***	***4.67***	***4.53***	***4.53***	***4.53***
Farm profit (€/r)	**0.42**	**0.24**	0.07	**0.34**	0.18	0.02
Farm cost to revenue (%)	**91.0**	**94.8**	98.6	**92.5**	96.1	99.6
Farm profit to cost (%)	**9.91**	**5.44**	1.47	**8.10**	4.04	0.42
Farm cost efficiency	**1.10**	**1.05**	1.01	**1.08**	1.04	1.00
	SLAUGHTERHOUSE LEVEL					
	Selling price					
	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	7.70	**8.37**	**9.03**	7.41	8.06	**8.70**
Revenue from rabbit products (€/r)	8.36	**9.01**	**9.66**	8.04	8.67	**9.30**
SH profit (€/r)*	3.69	**4.34**	**4.99**	3.51	4.14	**4.76**
SH cost to revenue (%)*	55.9	**51.8**	**48.3**	56.4	52.3	**48.8**
SH profit to cost (%)*	78.9	**92.9**	**106.9**	77.3	91.2	**105.1**
SH cost efficiency*	1.79	**1.93**	**2.07**	1.77	1.91	**2.05**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At farm level

Since the rate of hay consumption was only 8% of total feed consumption and its price was considered 60% of pellets, only a small difference (0.03-0.06 €/rabbit) was found in cost of feeding between the two groups, with higher values in the Pellet-fed group. Although the production cost was lower in the P+Hay group than with the Pellet-fed rabbits, due to the 0.14 €/rabbit slaughter price difference in favor of the Pellet-fed group, the profit of the P+Hay rabbits was lower with an average of 0.07 €/rabbit. With medium priced feed, the difference in cost to revenue, profit to cost and cost efficiency ratios were 1.27, 1.40 and 0.01%. As a result – based on the same mortality rate and scheduling – a farmer would achieve at least 2,400 € less profit with Pellets+Hay when 50,000 rabbits/year were produced. This difference could be compensated in the selling price.

At slaughterhouse level

The revenue from whole carcass and carcass parts were 0.31 (4%) and 0.34 €/rabbit (4%) higher in the Pellet-fed group than in P+Hay rabbits, respectively, which was in accordance with the difference in their weight at slaughter (***Table 31***). The difference in profit was 0.18, 0.21 and 0.23 €/rabbit, depending on the selling price. Based on low, medium and high selling price, the Pellet-fed group achieved a higher profit by 0.24, 0.26 and 0.29 €/rabbit than the P+Hay rabbits, respectively, meaning an average 3.8% difference. Thus, it is clear that at the same selling price, higher profit can be achieved by Pellet-fed than P+Hay rabbits. At a medium selling price, 0.46% higher cost to revenue (from carcass parts) was found in Pellet-fed rabbits than in the P+Hay group. The lowest value was found with the Pellet-fed group, while the highest was found in P+Hay rabbits. Profit to cost ratio was 1.60-1.81% higher in the Pellet-fed group than in P+Hay rabbits, while the difference in the cost efficiency ratio was 0.02%. All the three indicators were better in the Pellet-fed group. Moreover, their values and ratios were higher than the average with medium and high selling prices as well, in contrast to the P+Hay group (only at the high selling price).

As a conclusion, both at the farm and slaughterhouse levels, higher profit can be realized with pellet-fed rabbits, compared to rabbits fed with pellets+hay.

5.3.2. Feed restriction

Within feed restriction, three experiments were evaluated. Two of them were published several years ago; and I was involved in the third one. The main challenge was to find out which method (how severe and how long the restriction lasted) gives the best results; i.e. lower mortality, better feed conversion rate and nearly full growth compensation at slaughter.

Experiment 1 – Quantitative restriction

The evaluation of Experiment 1 is based on the study carried out by Radnai *et al*. (2005).

Objective of the experiment

The aim of the study was to examine age-dependent, quantitative feed restriction after weaning on the productive and carcass traits of growing rabbits, and on economic values.

Material and methods

Three groups of weaned rabbits (5 weeks of age) were established: control group: *ad libitum (*ADLIB) feeding during the whole fattening period (n=81); RESTR60 group: 60% of the feed consumption of ADLIB during the first week after weaning, 75% in the second week, 90% in the third, 100% in the fourth week and *ad libitum* afterwards (n=81); RESTR70 group: 70% in the first, 80% in the second, 90% in the third, 100% in the fourth week and *ad libitum* till slaughtering (n=81).

Economic evaluation

Natural indicators

Table 34 shows that the daily feed intake of restricted rabbits was significantly lower between 5 and 8 weeks of age, similar between 8 and 9 weeks of age and higher between 9 and 11 weeks of age than that of the ADLIB group (P<0.001). After finishing the restriction at the level of 100%, the feed consumption increased rapidly and declined afterwards.

Daily weight gain of the RESTR60 and RESTR70 groups was lower than the ADLIB rabbits between 5 and 7 weeks of age (P<0.001). The body weight of RESTR60 and RESTR70 rabbits was significantly lower than that of the ADLIB group until 7 weeks of age, but later the difference decreased (at 11 weeks, P = 0.095). The feed conversion ratio was better in the first week in the ADLIB group, while between 7 and 10 weeks of age it was better in the RESTR60 and RESTR70 groups (P<0.001). Mortality was similar in each group.

The feed restriction had no significant effect on most carcass traits but the weight of the fore part of the carcass was numerically higher in the ADLIB group while the liver was slightly heavier in the RESTR60 and RESTR70 rabbits. The perirenal fat content was lowest in the RESTR70 and highest in ADLIB groups (P<0.05), however the differences between the RESTR60 and ADLIB were not significant.

It can be concluded, that restricted feeding after weaning with different levels, then feeding *ad libitum* in the second part of the fattening could be advantageous. But it was also concluded that the quantitative restriction method is not suitable in practice because it is difficult or impossible to apply correctly at farms. This is why, in the next experiments, time-limited access to the feeder was tested.

Table 34
Effect of quantitative feed restriction (RESTR70 and RESTR60) on productive performance and carcass traits of growing rabbits

Traits	**Feeding method**			**SE**	**Prob.**
	ADLIB	RESTR70	RESTR60		
Productive traits					
Feed intake (5-11 wk), g/day	140	126	160	1.2	0.017
Weight gain (5-11 wk), g/day	44.2	42.4	42.9	0.55	NS
Body weight at 11 wk, g	2710	2637	2655	14.4	0. 95
Feed conversion ratio	3.16	3.05	2.98	0.06	NS
Mortality, %	1.2[a]	1.2[a]	7.3[b]	-	<0.05
Weight of carcass and carcass parts, g					
Hot carcass	1670	1632	1636	8.6	NS
Chilled carcass	1615	1585	1582	9.1	NS
Head	138	133	136	1.1	NS
Fore part	387	372	371	3.1	NS
Mid part	437	434	425	4.6	NS
Hind part	507	503	506	3.8	NS
Liver	80.1	83.1	85.3	1.6	NS
Kidneys	16.4[ab]	15.5[a]	18.3[b]	0.28	0.08
Heart + lungs	27.8	28.7	24.7	0.81	NS
Perirenal fat	21.6[b]	21.3[ab]	16.9[a]	0.81	0.029

[a,b:] Means in the same row with unlike superscripts differ (P<0.05).

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at the slaughterhouse level, as well as profitability indicators on both the farm and slaughterhouse levels of rabbits fed *ad libitum* (ADLIB) and restricted (RESTR70 and RESTR60) feeding are shown in ***Table 35***.

At farm level

The difference in the cost of feeding was only 0.03 €/rabbit between RESTR70 and RESTR60 group, while the highest difference (0.17 €/rabbit) was found between ADLIB and RESTR60 with a high feed price in favor of the restricted group. Cost of production was better than the average in the case of the RESTR70 and RESTR60 groups on low and medium feed price level, while ADLIB rabbits exceeded the average only on a low feed price.

Despite the fact that – due to their higher slaughter weight (***Table 34***) – the highest revenue per rabbit was found in the ADLIB group. RESTR70 rabbits achieved the best values and rates for the profitability indicators, followed by the RESTR60 and ADLIB groups. A yearly production of 50,000 rabbits at a medium feed price resulted in additional revenue of 2,600 and 4,100 € in case of using RESTR70 instead of RESTR60 or ADLIB feeding, respectively.

At slaughterhouse level

A different order occurred when the calculation was made at the slaughterhouse level. Revenue from carcass parts was 7.84, 7.75 and 7.73 €/rabbit in the ADLIB, RESTR70 and RESTR60 groups at a medium selling price, respectively, while the differences in profit were 0.03 €/rabbit between the ADLIB and RESTR70 and between the RESTR70 and RESTR69 groups. The best profitability ratio results were found in RESTR70 group, followed by ADLIB with slight differences, and RESTR60 with the lowest.

Feed restriction to 70% was the most beneficial at both farm and slaughterhouse level.

Table 35
Profitability of feeding method (*ad libitum* or quantitative restriction) at the farm and slaughterhouse levels

Indicators	Feeding method								
	ADLIB			RESTR70			RESTR60		
	FARM LEVEL								
	Price of feed								
	Low	Med	High	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.47**	1.61	1.76	**1.35**	**1.49**	1.63	**1.32**	**1.46**	1.59
Cost of mortality (€/r)	**0.00**	**0.00**	**0.00**	**0.02**	**0.02**	**0.02**	0.13	0.13	0.13
Total cost (€/r)	**3.52**	3.67	3.81	**3.40**	**3.53**	3.66	**3.46**	**3.59**	3.72
PRICE AT SLAUGHTER (€/r)	***4.11***	***4.11***	***4.11***	***4.06***	***4.06***	***4.06***	***4.06***	***4.06***	***4.06***
Farm profit (€/r)	**0.59**	0.44	0.30	**0.66**	**0.52**	0.39	**0.61**	0.47	0.35
Farm cost to revenue (%)	**85.7**	89.2	92.7	**83.8**	**87.1**	90.3	**85.1**	88.3	91.5
Farm profit to cost (%)	**16.70**	12.06	7.92	**19.4**	**14.82**	10.76	**17.52**	13.19	9.32
Farm cost efficiency	**1.17**	1.12	1.08	**1.19**	**1.15**	1.11	**1.18**	1.13	1.09
	SLAUGHTERHOUSE LEVEL								
	Selling price								
	Low	Med	High	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	6.69	7.27	**7.85**	6.56	7.13	**7.70**	6.55	7.12	**7.69**
Revenue from rabbit products (€/r)	7.27	7.84	**8.41**	7.19	7.75	**8.32**	7.17	7.73	**8.29**
SH profit (€/r)*	3.16	**3.73**	**4.30**	3.14	3.70	**4.26**	3.11	3.67	**4.23**
SH cost to revenue (%)*	56.5	**52.4**	**48.9**	56.4	**52.3**	**48.8**	56.6	**52.5**	**49.0**
SH profit to cost (%)*	77.0	**90.8**	**104.6**	77.3	**91.2**	**105.1**	76.5	**90.4**	**104.2**
SH cost efficiency*	1.77	**1.91**	**2.05**	1.77	**1.91**	**2.05**	1.77	**1.90**	**2.04**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

Experiment 2 – Restriction of eating time

The evaluation of Experiment 2 is based on the study carried out by Matics *et al*. (2008).

Objective of the experiment

The aim of the experiment was to study the influence of feed restriction by time-limited access to the feeder after weaning on the productive, carcass traits of growing rabbits, as well as on their economic aspects.

Material and methods

Half of the rabbits (n=107) were fed *ad libitum* (ADLIB) while the other half (n=107) had time restriction for feeding (RESTR). In the latter group, rabbits were allowed to consume pellets for 9, 10, 12 or 14 hours (started at 8am) between 4-5, 6-7, 7-8 or 8-9 weeks of age, respectively, after which they were fed *ad libitum*.

Economic evaluation

Natural indicators

The feed intake was 26.7, 18.3 and 5.3% lower in the RESTR group at the ages of 4-5, 5-6 and 6-7 weeks, respectively (***Table 36***). After 7 weeks of age no difference was found between the groups. Weight gain of RESTR rabbits was 20.9 and 8.5% lower at the ages of 4-5 and 5-6 weeks, respectively, while between 7-8 and 8-9 weeks it was 4.2 and 3.1% higher compared to ADLIB group. This shows a compensatory growth, however, during the whole fattening period (between 4-11 weeks) a significant difference was found in the weight gain between the two groups. Body weight of RESTR rabbits was 9.2% lower at 5 weeks of age compared to the

ADLIB group (871 vs. 959 g) but this was partly compensated at the end of the experiment. Feed conversion ratio of the RESTR group was better compared to ADLIB rabbits. No significant difference was found in mortality. The compensatory weight gain in our study was greater than was found by Perrier (1998) who restricted to 70% or by Gidenne *et al*. (2003) who restricted to 70 or 80% of the *ad libitum*. The results of our experiment were similar to the findings of Gidenne *et al*. (2003) who restricted rabbits to 90% of *ad libitum* for three weeks, or of Radnai *et al*. (2005) who used weekly decreasing restrictions after weaning (70-80-90 or 60-75-90%).

Table 36
Effect of time-limited feed restriction on productive performance of growing rabbits

Traits	**Feeding method**		**SE**	**Prob.**
	ADLIB	RESTR		
Feed intake (5-11 wk), g/day	120	114	0.9	<0.001
Weight gain, g/day	45.6	44.2	0.28	0.016
Body weight at 11 wk, g	2799	2737	16	NS
Feed conversion ratio	2.64	2.54	0.01	0.010
Mortality, %	1.0	3.6	-	NS

Carcass traits showed that time-limited feed restriction mainly affected the muscle development (***Table 37***). The weights of chilled carcass, mid- and hind parts, hind legs, loin fillet, heart + lungs were larger in the ADLIB group than in the RESTR animals. Dressing out percentage and the ratios of hind part, hind legs and the loin fillet to the body weight were higher in ADLIB rabbits. No difference was found in the proportion of perirenal fat. Perrier (1998) observed a decrease in ratios of hind part and fat deposit % in more strongly restricted rabbits.

Table 37
Effect of time-limited feed restriction on carcass traits

Traits	Feeding method		SE	Prob.
	ADLIB	RESTR		
Weight of carcass and its parts, g				
Chilled carcass	1585	1531	7.75	<0.001
Head	133	134	0.51	NS
Heart + lungs	21.7	20.2	0.20	<0.001
Liver	67.6	67.0	0.63	NS
Kidneys	18.7	18.5	0.14	NS
Fore part	365	354	1.83	0.002
Mid part	447	429	3.19	0.005
Hind part	513	491	2.59	<0.001
Perirenal fat	17.6	17.0	0.35	NS
Hind legs	490	468	1.24	<0.001
Loin fillet	191	189	0.77	<0.001
Ratio of carcass and its parts, %				
Dressing out percentage	59.4	58.6	0.12	<0.001
Ratio of fore part to body weight	13.7	13.6	0.05	NS
Ratio of mid part to body weight	16.7	16.4	0.08	NS
Ratio of hind part to body weight	19.2	18.8	0.06	<0.001

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at the slaughterhouse level, as well as profitability indicators on both farm and slaughterhouse level of rabbits fed *ad libitum* or with restricted feeding are shown in ***Table 40***.

At farm level

Due to the difference in feed consumption (***Table 36***), the cost of feeding was lower by an average of 0.08 €/rabbit in the RESTR group than ADLIB rabbits, therefore the RESTR group had a 2% lower cost of production. The more the weight gain, the higher the slaughter weight (***Table 37***), thus 4.29 €/rabbit revenue (price at slaughter) was found in the ADLIB group compared to the 4.20 €/rabbit in the RESTR rabbits. Based on these values, only a negligible difference in profit was detected in favor of the RESTR group. Still, this small difference may result 125-550 € difference yearly in the case of producing 50,000 rabbits, depending on the feed price. Results also show that profitability ratios of the RESTR rabbits exceed the average values even on medium feed prices compared to ADLIB group, which was able to achieve values above the average only when the price of feed was low. Consequently, restricted feeding had a clear financial advantage at the farm level.

Table 38
Profitability of feeding method (*ad libitum* or time-limited restriction) at the farm and slaughterhouse levels

Indicators	Feeding method					
	ADLIB			RESTR		
	FARM LEVEL					
	Price of feed					
	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.47**	1.62	1.76	**1.40**	**1.54**	1.68
Cost of mortality (€/r)	0.00	0.00	0.00	0.01	0.01	0.01
Total cost (€/r)	**2.91**	3.06	3.20	**2.83**	**2.97**	3.10
PRICE AT SLAUGHTER (€/r)	***4.29***	***4.29***	***4.29***	***4.20***	***4.20***	***4.20***
Farm profit (€/r)	**1.38**	**1.23**	1.09	**1.37**	1.23	1.09
Farm cost to revenue (%)	**67.9**	71.3	74.6	**67.4**	**70.8**	74.0
Farm profit to cost (%)	**47.3**	40.2	34.1	**48.3**	**41.3**	35.2
Farm cost efficiency	**1.47**	1.40	1.34	**1.48**	**1.41**	1.35
	SLAUGHTERHOUSE LEVEL					
	Selling price					
	low	med	high	low	med	high
Revenue from rabbit carcass (€/r)	6.88	**7.48**	**8.08**	6.64	7.22	**7.79**
Revenue from rabbit products (€/r)	7.76	**8.38**	**9.00**	7.45	8.04	**8.64**
SH profit (€/r)*	3.47	**4.09**	**4.71**	3.25	3.85	**4.44**
SH cost to revenue (%)*	55.3	**51.2**	**47.7**	56.3	52.2	**48.6**
SH profit to cost (%)*	80.8	**95.3**	**109.7**	77.5	91.7	**105.8**
SH cost efficiency*	1.81	**1.95**	**2.10**	1.78	1.92	**2.06**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

At slaughterhouse level

The rank order changed when the evaluation was made at the slaughterhouse level. The highest revenues from carcass parts were found at the high selling price: 9.00 and 8.64 €/rabbit in the ADLIB and RESTR groups, respectively. An average difference in profit of 5.9% was realized in favor of ADLIB rabbits, while the profitability indicators (cost to revenue, profit to cost and cost efficiency) showed 0.96, 3.61 and 0.04% better results in ADLIB rabbits at medium selling price. It can be concluded that at the slaughterhouse level, the advantage of ADLIB rabbits was noticeable.

Basically, there is a reverse value at the farm and the slaughterhouse levels, since the former gained more profit from RESTR, while the latter had higher values when selling ADLIB rabbits.

Experiment 3 – Effect of restriction in time on two genotypes

The evaluation of Experiment 3 is based on the study carried out by Endrici (2014).

Objective of the experiment

The aim of the experiment was to find a level and duration of restriction after weaning when the compensatory growth is complete, and to examine the effect of restriction depending on the medium or large-bodied breeds.

Material and methods

At the beginning of the experiment (at 4 weeks of age) two groups were formed in both genotypes (PKa and PLarge). In the first group the rabbits received pellets *ad libitum* (ADLIB group). In the other group, rabbits were allowed to consume pellets 9, 10 and 12 hours per day between 4-5, 5-6, and 6-7 weeks of age, respectively (RESTR group). During the restricted period the rabbits could eat only at night. After finishing the restriction (from 7 to 10 weeks of age) rabbits were allowed to consume pellets *ad libitum*.

Economic evaluation

Natural indicators

Since I was involved in this experiment, a comprehensive description of the results is given. Results for productive traits are summarized in ***Table 39***. During the whole growing period PLarge rabbits consumed 12% more pellets than the PKa. According to the results, with the same time-limited access to the feeder, the feed intake of PLarge rabbits decreased more than the PKa rabbits. During the compensatory growth period, (7-8, 8-9 and 9-10 weeks), the PLarge rabbits consumed 14%, 24% and 28% more pellets than PKa. Using *ad libitum* feeding, a 20% difference was found between the two genotypes (Szendrő *et al*., 2009a). The weight gain of PLarge rabbits between 4 and 10 weeks of age was higher by 27% than that of the PKa. The differences were smaller during restriction (5.4, 2.9 and 9.3 g/day between 4-5, 5-6 and 6-7 weeks, respectively). After finishing the restriction, the differences between the two genotypes became larger and larger (12.1, 16.6 and 21.8 g/day between 7-8, 8-9 and 9-10 weeks, respectively). Szendrő *et al.* (2009a) compared the same breeds, and found a 23% difference in body weight gain between 5 and 11 weeks. Comparing the feed conversion rate, significantly better values were achieved in PLarge than in PKa rabbits with the average of 22% between 4 and 10 weeks. We found similar results when rabbits were fed *ad libitum* (Szendrő *et al.*, 2009a). There was no significant difference in mortality between 4 and 10 weeks (PLarge: 7.6%, PKa: 1.6%). In the former experiment we did not observe differences in mortality of growing rabbits between the two genotypes (Szendrő *et al.*, 2009a).

The effect of feed restriction on body weight at 10 weeks within PLarge and PKa rabbits was not significant (***Table 39***), only the weight gain of ADLIB and RESTR groups in PLarge rabbits was different. Even though the differences were not statistically proven, they were important in practice, since rabbits in RESTR group consumed less pellets by 4-6% and they reached the same weight 1-2 days later. Most of the former results showed weight gains of restricted fed rabbits were lower, they reached the slaughter weight significantly later and their feed conversion rate was better (Gidenne *et al.*, 2012). In the present experiment, the small differences among groups could be a result of the short restriction period or the compensatory growth was near total.

Table 39
Effect of genotype and feeding method on productive performance of growing rabbits

Age, weeks	Groups				SE	Prob.
	PLarge		PKa			
	ADLIB	RESTR	ADLIB	RESTR		
Body weight at 10 wk, g	2818[b]	2709[b]	2309[a]	2271[a]	26	<0.001
Weight gain, g/day	52.5[c]	49.6[b]	40.4[a]	39.7[a]	0.39	<0.000
Feed intake, g/day	159[b]	149[ab]	139[a]	134[a]	2.5	0.002
Feed conversion ratio	3.01[a]	2.94[a]	3.58[b]	3.65[b]	0.07	<0.001

[a,b,c:] Means in the same row with unlike superscripts differ (P<0.05).

Results of carcass traits are summarized in ***Table 40***. The weight of carcass, carcass parts, organs and tissues were larger in the PLarge than in the PKa rabbits which can be explained by the difference in final body weight. Dressing out percentages of PLarge rabbits was higher by 1.2% than that of

PKa rabbits. Similar results were published by Szendrő *et al.* (2009b). Examining the different parts of the reference carcass, the ratio of hind part to the reference carcass was larger in PLarge rabbits, and that of fore- and mid parts were larger in PKa rabbits. Different results were published some years ago (Szendrő *et al*., 2009b), where the ratio of fore part to reference carcass was larger in PLarge rabbits and no differences were found in mid- and hind parts. The reason for increasing the ratio of the hind part was that PLarge rabbits were selected for muscle volume on hind legs using data of CT scans for several years (Matics *et al*., 2014a). No differences were found in the ratios of perirenal and scapular fat to the reference carcass, similar to former results (Szendrő *et al.,* 2009b).

Lines selected for litter size or for growth rate were also compared by other research groups. All authors stated that lines selected for growth rate or lines with higher weight at slaughter had better weight gain (Ramon *et al.*, 1996; Larzul and Rochambeau, 2004; Piles *et al.*, 2004; Kermauner and Žgur, 2005). The results of the present experiment were identical with the published data since the CT selection did not affect the weight gain or body weight (Szendrő *et al*., 2009a). Due to the genetic correlation between weight gain and feed conversion ratios, rabbits with higher growth rate had better feed conversion ratios (Ramon *et al.*, 1996). A side effect of CT-based selection was that the rabbits consumed less feed and their feed conversion ratios improved (Szendrő *et al.*, 2012). The carcass traits of maternal and terminal lines are closely correlated with their maturity at slaughter. If the rabbits were slaughtered at the same weight, the large-bodied lines were younger and less mature and their dressing out percentage, ratio of hind part to reference carcass and fat deposits were lower, and the ratio of fore part to reference carcass was higher, than that of maternal lines (Pla *et al.,* 1996, 1998; Gómez *et al.,* 1998). However, when they were slaughtered at the same age, the maturity of the lines was more similar and the differences in carcass traits were smaller thus, the dressing out percentage and fat deposits were also lower (Gómez *et al.*, 1998). We obtained opposite results: dressing out percentage and the ratio of hind part to reference carcass increased as a result of CT-based selection to increase the muscle volume on hind leg (Matics *et al.*, 2014a)

Table 40
Effect of genotype and feeding method on carcass traits

Traits	Groups				SE	Prob.
	PLarge		PKa			
	ADLIB	RESTR	ADLIB	RESTR		
Weight of carcass and carcass parts, g						
Warm carcass	1646[b]	1591[b]	1337[a]	1301[a]	17	<0.001
Chilled carcass	1618[b]	1563[b]	1304[a]	1269[a]	17	<0.001
Reference carcass	1331[b]	1282[b]	1063[a]	1034[a]	15	<0.001
Head	142[b]	137[b]	127[a]	126[a]	1.0	<0.001
Fore part	365[b]	357[b]	299[a]	292[a]	3.7	<0.001
Mid part	428[b]	410[b]	348[a]	336[a]	5.3	<0.001
Hind part	513[b]	490[b]	399[a]	387[a]	5.7	<0.001
Hind legs	488[b]	466[b]	379[a]	368[a]	5.4	<0.001
Meat on hind legs	353[b]	339[b]	272[a]	265[a]	4.3	<0.001
Loin fillet	146[c]	140[bc]	127[ab]	119[a]	2.1	<0.001
Perirenal fat	18.1[b]	17.6[ab]	14.0[a]	14.2[a]	0.53	0.004
Scapular fat	6.46[b]	6.40[b]	4.88[a]	5.30[ab]	0.19	0.005
Heart + lungs	22.4[b]	22.1[b]	17.8[a]	17.3[a]	0.25	<0.001
Liver	100.0[b]	100.1[b]	76.6[a]	72.9[a]	1.52	<0.001
Kidneys	18.3[b]	18.8[b]	16.0[a]	16.0[a]	0.20	<0.001
Dressing out percentage, %						
Chilled carcass	58.9[b]	58.5[ab]	57.5[a]	57.6[a]	0.16	0.002
Ratio to reference carcass in %						
Fore part	27.6	28.0	28.2	28.2	0.09	0.056
Mid part	32.0[ab]	31.9[a]	32.7[b]	32.5[ab]	0.10	0.009
Hind part	38.7[b]	38.3[b]	37.6[a]	37.5[a]	0.08	<0.001
Perirenal fat	1.32	1.33	1.27	1.34	0.04	0.921
Scapular fat	0.47	0.49	0.45	0.51	0.01	0.454

[a,b:] Means in the same row with unlike superscripts differ (P<0.05).

No significant differences were found between the ADLIB and RESTR groups in weight of carcass or carcass parts, or ratio of different carcass parts within the genotypes, while other experiments gave opposite results (Gidenne *et al.*, 2012). Dressing out percentage and ratio of fat deposit were lower in the PKa group.

Our results showed that the effect of restriction was independent of the genotypes. With the medium and large-bodied breeds (PKa and PLarge), no or only negligible differences were found.

Financial indicators

Cost of production at the farm level, the price of slaughter rabbits, the revenue at slaughterhouse level, and profitability indicators on both the farm and the slaughterhouse levels of Large and PKa rabbits fed *ad libitum* and restricted are shown in ***Table 41***.

At farm level

Although PKa rabbits realized better cost values, (an average of 90-92% lower costs of production) and their price at slaughter was 82.6% lower than that of PLarge rabbits, an average profit difference of 0.39 and 0.46 €/rabbit occurred between the genotypes, in the ADLIB and RESTR feeding methods, respectively. Within the genotypes, feed restriction was advantageous for PLarge, while ineffective for PKa rabbits resulting a 0.05 and 0.02 €/rabbit additional profit or loss, respectively, at a medium feed price. Regarding all profitability indicators, only PLarge rabbits, and especially within the RESTR group, were able to exceed the average ratios. Among the profitability indicators, profit to cost ratio resulted in the highest difference between the genotypes: PLarge rabbits achieved a 10.5% higher rate with medium feed prices than PKa group.

It can be concluded that the genotype greatly affected the profitability. The positive reaction of restriction was significant; with crossed combinations (PLarge x PKa) in production, 430-1,250€ additional profit can be realized with a yearly 50,000 rabbit production, depending on the feed price.

At slaughterhouse level

From the slaughterhouse point of view, PKa rabbits were not able to compete with PLarge group, since the revenue from their carcasses and carcass parts – even at a high selling price – did not reach that of PLarge rabbits at the lowest selling price. Therefore, in contrast to the farm level, PLarge rabbits fed *ad libitum* were superior to the restricted group.

Table 41

Profitability of feeding method (*ad libitum* and restricted) at farm and slaughterhouse level, depending on genotype

Indicators	**Groups**											
	PLarge						PKa					
	ADLIB			RESTR			ADLIB			RESTR		
	FARM LEVEL											
	Price of feed											
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Cost of feeding (€/r)	**1.67**	1.84	2.00	**1.56**	1.72	1.88	**1.46**	**1.61**	1.75	**1.41**	**1.55**	1.69
Cost of mortality (€/r)	0.04	0.04	0.04	0.03	0.04	0.04	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total cost (€/r)	3.23	3.40	3.56	**3.09**	3.24	3.39	**2.92**	**3.06**	3.20	**2.85**	**2.99**	**3.12**
PRICE AT SLAUGHTER (€/r)	***4.19***	***4.19***	***4.19***	***4.09***	***4.09***	***4.09***	***3.47***	***3.47***	***3.47***	***3.38***	***3.38***	***3.38***
Farm profit (€/r)	**0.97**	**0.80**	**0.64**	**1.00**	**0.85**	**0.70**	0.55	0.41	0.27	0.53	0.39	0.25
Farm cost to revenue (%)	**77.0**	**81.0**	84.8	**75.5**	**79.3**	**83.0**	**84.1**	88.3	92.3	84.3	88.5	92.5
Farm profit to cost (%)	**29.9**	**23.5**	17.9	**32.5**	**26.1**	**20.6**	18.9	13.2	8.3	18.6	13.0	8.2
Farm cost efficiency	**1.30**	**1.23**	1.18	**1.33**	**1.26**	**1.21**	1.19	1.13	1.08	1.19	1.13	1.08
	SLAUGHTERHOUSE LEVEL											
	Selling price											
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Revenue from rabbit carcass (€/r)	**6.70**	**7.28**	**7.86**	6.47	**7.03**	**7.60**	5.40	5.87	6.34	5.25	5.71	6.17
Revenue from rabbit products (€/r)	**7.24**	**7.80**	**8.36**	**6.98**	**7.52**	**8.06**	5.80	6.25	6.70	5.60	6.04	6.47
SH profit (€/r)*	3.04	**3.61**	**4.17**	2.88	**3.42**	**3.97**	2.33	2.78	**3.23**	2.23	2.66	3.10
SH cost to revenue (%)*	58.0	**53.8**	**50.1**	58.7	**54.4**	**50.8**	59.8	55.5	**51.8**	60.3	55.9	**52.2**
SH profit to cost (%)*	72.6	**86.0**	**99.4**	70.5	**83.7**	**96.9**	67.2	80.2	**93.2**	65.9	78.8	**91.6**
SH cost efficiency*	1.73	**1.86**	**1.99**	1.70	**1.84**	**1.97**	1.67	1.80	**1.93**	1.66	1.79	**1.92**

Notes: Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

5.4 EVALUATION OF THE COMBINED EFFECTS OF GENOTYPE, HOUSING AND FEEDING

The experiment was conducted under my leadership.

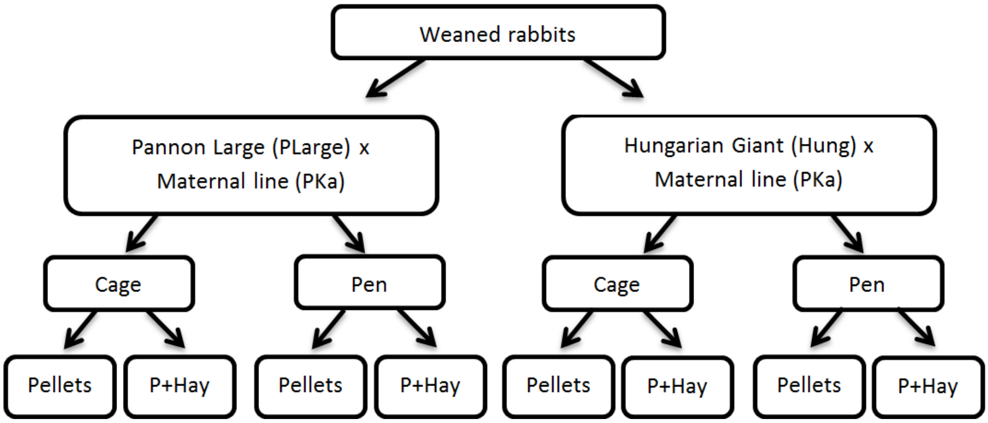
Objective of the experiment

The aim of the experiment was to examine the combined effects of genotype (PLarge or Hung), housing system (cage or pen) and feeding method (pellets only or pellets plus hay) on productive performance, carcass traits and economic value on growing rabbits.

Material and methods

The crossbred rabbits PLarge x PKa (L) and Hung x PKa (H) were weaned at 5 weeks of age. Half of them (168) were housed in cages (C; 3 rabbits/cage), the other half (168) in pens (P; 14 rabbits/pen). The stocking density was the same (16 rabbits/m^2) in each group. Two other subgroups were formed; rabbits that received only commercial pellets (P), or commercial pellets supplemented with grass hay (P+Hay /h/), *ad libitum.* The hay was placed on the top of the cages but in the case of pens it was inserted in the hay-rack. Thus, evaluation of the combined effects included 8 groups: LCP, LCh, LPP, LPh, HCP, HCh, HPP, HCh (the first letter represents the genotype, the second shows the housing method, the third signifies the feeding method).

The design of the experiment is shown in ***Figure 6***.



Note: P=pellets

Figure 6. Design of the experiment

At the end of the experiment, the 12 week old rabbits were slaughtered and dissected following the recommendation of WRSA (Blasco and Ouhayoun, 1996).

Economic evaluation

Natural indicators

The combined effects of genotype, housing condition and feeding method on productive performance of growing rabbits are shown in ***Table 42***. In PLarge x PKa rabbits, the body weight and weight gain decreased from group of Cage-Pellet to Pen-P+Hay: LCP > LCh > LPP > LPh. Comparing the separate and the combined effects of housing and feeding, the effect of feeding was smaller than that of housing. A similar tendency can be seen from group of HCP to HPP rabbits; yet the HPh had average values. In feed intake of PLarge x PKa rabbits, a similar order emerged as in body weight and weight gain, however the pellet intake was the same in the LPh and LPP groups. When the hay consumption (13 g/day) was also calculated, no significant differences were found in feed intake of Cage-Pellets and Cage-

P+Hay or between Pen-Pellets and Pen-P+Hay groups. In Hung x PKa rabbits only the pellet consumption of HCP rabbits differed from the other three groups. Calculating the hay consumption, the feed intake of Cage-Pellet and Cage-P+Hay groups was similar, and Pen-P+Hay rabbits consumed more feed than the Pen-Pellet group, which is in agreement with the higher weight gain of rabbits in this group. Differences were seen in feed conversion ratio, but after including the hay consumption, similar results were found in all groups of the PLarge x PKa and Hung x PKa rabbits.

Despite some minor disparities, the differences and the order in the weight of whole carcasses and carcass parts among groups were similar to the body weights at the end of the experiment (***Table 43***), due to the close correlation between body weight and the weight of the carcasses or carcass parts.

In PLarge x PKa rabbits a slightly decreasing tendency (from LCP to LPh) can be seen in dressing out percentage and the ratio of fat deposits to the reference carcass (***Table 44***). In Hung x PKa rabbits only the share of fat deposit presented a similar trend. The ratio of head and heart + lungs showed a rising tendency in PLarge x PKa rabbits. For the other traits, only the effect of genotype or housing could be depicted.

Table 42

Combined effect of genotype, housing conditions and feeding method on productive performance of growing rabbits

Traits	Groups								SE	Prob.
	PLarge x PKa				Hung x PKa					
	Cage		Pen		Cage		Pen			
	Pellets	P+Hay	Pellets	P+Hay	Pellets	P+Hay	Pellest	P+Hay		
Body weight, g	3297	3214	3120	3046	3077	2900	2867	2894	18	<0.001
Weight gain, g/d	44.4	43.5	41.3	40.1	42.8	39.0	37.8	38.3	0.3	<0.001
Pellet intake, g/d	154	145	143	133	141	125	129	126	1.7	<0.001
Feed conversion ratio	3.65	3.50	3.64	3.35	3.43	3.33	3.53	3.34	0.06	0.771
Mortality, %	2.38	4.76	9.52	2.38	9.52	7.14	9.52	11.90	-	0.092

Note: P=pellets

Table 43
Combined effects of genotype, housing conditions and feeding method on carcass traits (g)

Traits	Groups								SE	Prob.
	PLarge x PKa				Hung x PKa					
	Cage		Pen		Cage		Pen			
	Pellets	P+Hay	Pellets	P+Hay	Pellets	P+Hay	Pellets	P+Hay		
Weight at slaughter	3222	3158	3062	2989	2986	2836	2878	2819	17.55	<0.001
Warm carcass	2038	1980	1916	1867	1851	1740	1780	1734	11.85	<0.001
Chilled carcass	1991	1934	1873	1824	1807	1697	1743	1695	11.63	<0.001
Reference carcass	1702	1641	1587	1538	1528	1424	1472	1427	10.42	<0.001
Head	157	157	154	156	153	155	152	153	0.69	0.421
Heart + lungs	23.6	23.9	23.0	23.5	23.5	23.1	21.0	22.5	0.19	0.007
Liver	87.4	89.9	88.0	85.8	80.8	73.8	77.9	71.7	1.11	<0.001
Kidneys	18.4	18.7	17.7	17.7	19.3	18.0	18.1	18.1	0.12	0.018
Perirenal fat	33.0	30.2	26.0	19.1	29.8	20.9	19.5	17.0	0.73	<0.001
Scapular fat	14.0	11.1	9.28	7.72	9.28	6.74	7.68	6.00	0.28	<0.001
Fore part	467	444	436	428	413	382	400	390	2.79	<0.001
Mid part	574	555	529	509	516	480	496	476	3.99	<0.001
Hind part	617	603	588	577	559	534	550	538	3.47	<0.001
Hind legs	587	575	558	548	531	510	522	511	3.31	<0.001
Meat on hind legs	419	412	400	388	375	357	376	359	3.89	<0.001
Loin fillet	202	196	186	177	184	168	174	166	1.57	<0.001

Note: P=pellets

Table 44
Combined effect of genotype, housing conditions and feeding method on the ratio of carcass and carcass parts

Traits	Groups								SE	Prob.
	PLarge x PKa				Hung x PKa					
	Cage		Pen		Cage		Pen			
	Pellets	P+Hay	Pellets	P+Hay	Pellets	P+Hay	Pellets	P+Hay		
Ratio to body weight, %										
Warm carcass	63.3	62.7	62.5	62.4	62.0	61.3	61.8	61.5	0.10	<0.001
Chilled carcass	61.8	61.3	61.2	61.0	60.5	59.8	60.5	60.1	0.10	<0.001
Reference carcass	52.8	52.0	51.8	51.4	51.1	50.1	51.1	50.6	0.10	<0.001
Ratio to chilled carcass, %										
Head	7.89	8.15	8.29	8.62	8.51	9.19	8.75	9.04	0.05	<0.001
Heart + lungs	1.19	1.24	1.23	1.29	1.31	1.37	1.21	1.33	0.01	<0.001
Liver	4.38	4.64	4.70	4.69	4.45	4.33	4.45	4.22	0.05	0.068
Kidneys	0.93	0.97	0.95	0.98	1.07	1.06	1.04	1.07	0.01	<0.001
Ratio to reference carcass, %										
Fore part	27.5	27.1	27.6	27.9	27.0	26.9	27.2	27.3	0.07	0.014
Mid part	33.7	33.8	33.2	33.0	33.8	33.7	33.6	33.3	0.07	0.031
Hind part	36.2	36.8	37.1	37.5	36.7	37.6	37.4	37.8	0.07	<0.001
Perirenal fat	1.92	1.81	1.60	1.21	1.93	1.42	1.30	1.17	0.04	<0.001
Scapular fat	0.81	0.66	0.57	0.49	0.60	0.46	0.51	0.42	0.02	<0.001

Note: P=pellets

Financial indicators

Cost of production at farm level, the price of slaughter rabbits, the revenue at the slaughterhouse level, as well as profitability indicators at both the farm and slaughterhouse levels of the combined effects of genotype, housing and feeding system at both levels are presented in ***Table 45*** and ***Table 46***. Differences in profit to cost ratio from the LCP group is depicted in ***Figure 4*** (at the farm level, with a med feed price) and ***Figure 5*** (at the slaughterhouse level, with a med selling price).

At farm level

Comparing all groups, the HPP rabbits had the lowest production cost, followed by the HCh and HPh groups. The highest price at slaughter (4.94 €/rabbit) – as revenue – was found in LCP rabbits, while the lowest value was in HPh rabbits (4.32 €/rabbit). A similar tendency was found regarding profit and all the profitability ratios. The difference between the groups was 0.37 €/rabbit even with a low feed price, resulting in a significant difference in production costs. In addition, HPh was the only group generating a financial loss (at the highest level of feed cost). Only LCP, LCh, LPh, and HPP rabbits at the on med feed cost exceeded the average values within the profitability indicators. When profit to cost ratio of the LCP group (at med feed price) was considered 100% (***Figure 4***), different combinations show 2.51-8.36% lower results, meaning that in that case a breeder would have three options; try to reduce production cost, endure reduced profitability, or negotiate for a 0.14-0.38 €/rabbit higher price at slaughter for the other combinations. Obviously, in the last case, the higher cost for the slaughterhouse would be compensated in the selling price to the consumers.

Table 45 Effects of genotype (PLarge), housing conditions (Cage and Pen) and feeding method (Pellets and Pellets+Hay) on profitability at the farm and slaughterhouse levels

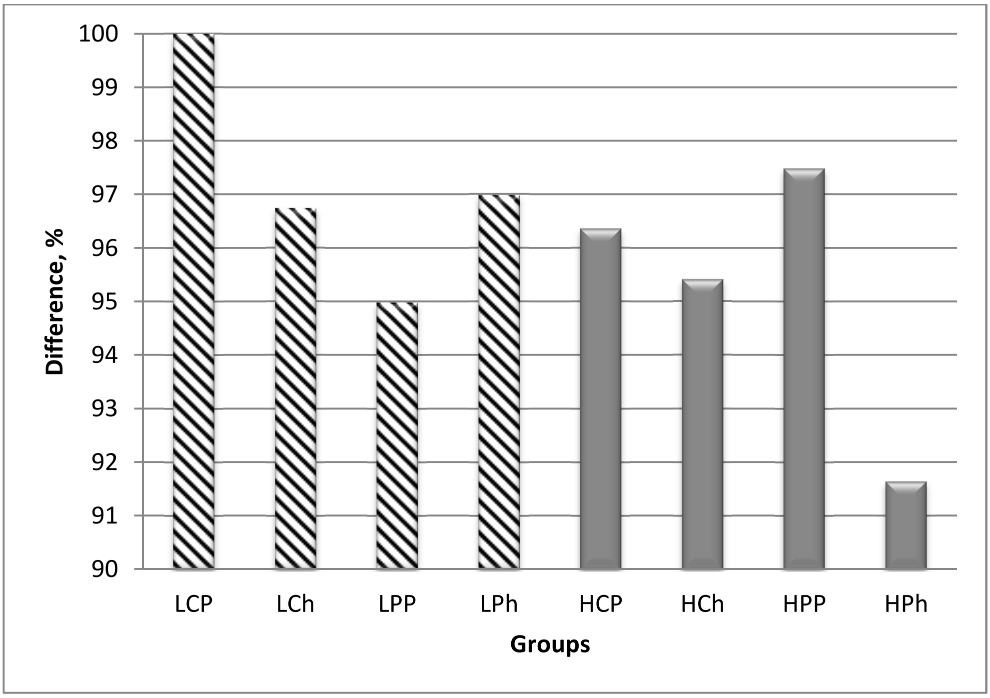
Indicators	Groups											
	LCP			**LCh**			**LPP**			**LPh**		
	FARM LEVEL											
	Price of feed											
	low	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**
Cost of feeding (€/r)	1.89	2.08	2.26	**1.78**	1.95	2.13	**1.75**	1.93	2.10	**1.63**	**1.79**	1.96
Cost of mortality	**0.06**	**0.06**	**0.06**	**0.12**	**0.13**	**0.13**	0.22	0.23	0.23	**0.07**	**0.07**	**0.07**
Cost of production (€/r)	**4.33**	4.52	4.70	4.39	4.57	4.74	**4.33**	4.50	4.68	**4.15**	**4.31**	4.47
PRICE AT SLAUGHTER (€/r)	***4.94***	***4.94***	***4.94***	***4.84***	***4.84***	***4.84***	***4.70***	***4.70***	***4.70***	***4.58***	***4.58***	***4.58***
Farm gross profit (€/r)	**0.61**	**0.42**	0.24	**0.45**	**0.27**	0.10	**0.37**	0.19	0.02	**0.43**	**0.27**	0.11
Farm cost to revenue (%)	**87.7**	**91.5**	95.2	**90.7**	**94.3**	97.8	**92.1**	95.9	99.6	**90.6**	**94.1**	97.5
Farm gross profit to cost (%)	**14.02**	**9.26**	5.04	**10.25**	**6.00**	2.21	**8.54**	4.24	0.41	**10.35**	**6.24**	2.57
Farm cost efficiency	**1.14**	**1.09**	1.05	**1.10**	**1.06**	1.02	**1.09**	1.04	1.00	**1.10**	**1.06**	1.03
	SLAUGHTERHOUSE LEVEL											
	Selling price											
	low	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**
Revenue from rabbit carcass (€/r)	**8.24**	4.02	4.74	**8.01**	**8.70**	**9.40**	7.75	**8.43**	**9.10**	7.55	**8.21**	**8.86**
Revenue from rabbit products (€/r)	**8.99**	**9.70**	**10.40**	8.77	**9.46**	**10.14**	8.46	**9.13**	**9.79**	8.19	8.83	**9.47**
SH gross profit (€/r)*	4.05	**4.76**	**5.46**	3.93	**4.61**	**5.30**	3.77	**4.43**	**5.10**	3.61	4.25	**4.89**
SH cost to revenue (%)*	54.9	**50.9**	**47.5**	55.2	**51.2**	**47.7**	55.5	**51.4**	**48.0**	56.0	**51.9**	**48.4**
SH gross profit to cost (%)*	82.0	**96.3**	**110.5**	81.1	**95.3**	**109.5**	80.3	**94.4**	**108.5**	78.7	**92.7**	**106.6**
SH cost efficiency*	1.82	**1.96**	**2.11**	1.81	**1.95**	**2.10**	1.80	**1.94**	**2.09**	1.79	**1.93**	**2.07**

Notes: LCP: PLarge x PKa-Cage-Pellets, LCh: PLarge x PKa-Cage-Pellets+Hay, LPP: PLarge x PKa-Pen-Pellets, LPh: PLarge x PKa-Pen-Pellets+Hay; Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

Table 46. Effects of genotype (Hung), housing conditions (Cage orPen) and feeding method (Pellets or Pellets+Hay) on profitability at the farm and slaughterhouse levels.

Indicators	**HCP**			**HCh**			**HPP**			**HPh**		
	FARM LEVEL											
	Price of feed											
	low	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**
Cost of feeding (€/r)	**1.73**	1.90	2.07	**1.64**	**1.79**	1.94	**1.58**	**1.74**	1.90	**1.65**	**1.80**	1.96
Cost of mortality	0.22	0.22	0.23	0.18	0.18	0.18	0.22	0.22	0.23	0.29	0.29	0.30
Cost of production (€/r)	**4.16**	**4.33**	4.50	**4.00**	**4.15**	**4.30**	**3.97**	**4.13**	**4.29**	**4.13**	**4.28**	4.43
PRICE AT SLAUGHTER (€/r)	***4.58***	***4.58***	***4.58***	***4.35***	***4.35***	***4.35***	***4.41***	***4.41***	***4.41***	***4.32***	***4.32***	***4.32***
Farm gross profit (€/r)	**0.42**	**0.24**	0.07	**0.35**	0.19	0.05	**0.44**	**0.28**	0.12	0.19	0.04	-0.11
Farm cost to revenue (%)	**90.8**	**94.7**	98.4	**92.0**	95.5	98.9	**90.0**	**93.7**	97.2	95.5	99.1	102.6
Farm gross profit to cost (%)	**10.09**	**5.62**	1.66	**8.66**	4.67	1.10	**11.08**	**6.75**	2.89	4.71	0.90	-2.51
Farm cost efficiency	**1.10**	**1.06**	1.02	**1.09**	1.05	1.01	**1.11**	**1.07**	1.03	1.05	1.01	0.97
	SLAUGHTERHOUSE LEVEL											
	Selling price											
	low	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**	**low**	**med**	**high**
Revenue from rabbit carcass (€/r)	7.48	**8.13**	**8.78**	7.03	7.64	**8.25**	7.22	**7.84**	**8.47**	7.02	7.63	**8.24**
Revenue from rabbit products (€/r)	8.09	8.72	**9.36**	7.58	8.17	8.77	7.91	8.53	**9.16**	7.58	8.18	8.77
SH gross profit (€/r)	3.51	4.15	**4.78**	3.23	3.82	**4.42**	3.50	4.12	**4.74**	3.26	3.85	**4.45**
SH cost to revenue (%)	56.6	52.5	**48.9**	57.4	53.2	**49.6**	55.8	**51.7**	**48.2**	57.0	52.9	**49.3**
SH gross profit to cost (%)	76.7	90.5	**104.4**	74.2	87.9	**101.6**	79.3	**93.4**	**107.5**	75.4	89.2	**102.9**
SH cost efficiency	1.77	1.91	**2.04**	1.74	1.88	**2.02**	1.79	**1.93**	**2.07**	1.75	1.89	**2.03**

Notes: HCP: Hung x PKa-Cage-Pellets, HCh: Hung x PKa-Cage-Pellets+Hay, HPP: Hung x PKa-Pen-Pellets, HPh: Hung x PKa-Pen-Pellets+Hay; Low, Med and High: low, medium and high price of pellets (at farm level) or selling price (at slaughterhouse level); €/r= €/rabbit; SH= slaughterhouse; numbers in bold represent values higher than average; *Cost of slaughtering was not identified at the slaughterhouse level, thus, the differences among the groups are reasonable

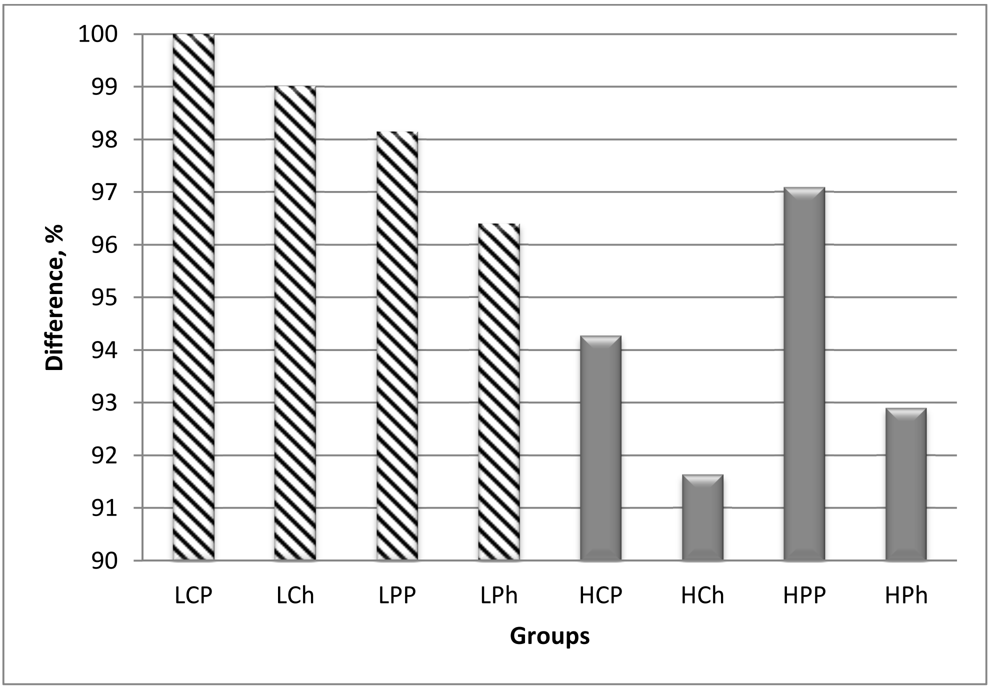


Notes: LCP: PLarge x PKa-Cage-Pellets, LCh: PLarge x PKa-Cage-Pellets+Hay, LPP: PLarge x PKa-Pen-Pellets, LPh: PLarge x PKa-Pen-Pellets+Hay, HCP: Hung x PKa-Cage-Pellets, HCh: Hung x PKa-Cage-Pellets+Hay, HPP: Hung x PKa-Pen-Pellets, HPh: Hung x PKa-Pen-Pellets+Hay; Striped columns show PLarge x PKa genotype, gray columns show Hung x PKa genotype

Figure 7. Differences in profit to cost ratio from the LCP group (=100%) at farm level, at the med feed price

At slaughterhouse level

Despite the fact that LCP rabbits represented the highest cost for the slaughterhouse, the revenue from their carcasses and carcass parts reimbursed the expenses, leading to 8.24 and 8.99 €/rabbit revenue, respectively, even at a low selling price. When profit and the profitability ratios were all considered, only LCP, LCh and LPP groups exceeded the average at a medium selling price. Since there was a 20% difference between the lowest and the highest profits, therefore 20% additional HCh rabbits need to be slaughtered in order to break even the profit of LCP rabbits. When the profit to cost ratio of the LCP group (med selling price) was equal to 100% (***Figure 5***), the other combinations were lower by 0.99-8.36%. Therefore, 0.13-0.93 €/rabbit higher selling price should be received by the slaughterhouse to obtain the same results as for the LCP group.



Notes: LCP: PLarge x PKa-Cage-Pellets, LCh: PLarge x PKa-Cage-Pellets+Hay, LPP: PLarge x PKa-Pen-Pellets, LPh: PLarge x PKa-Pen-Pellets+Hay, HCP: Hung x PKa-Cage-Pellets, HCh: Hung x PKa-Cage-Pellets+Hay, HPP: Hung x PKa-Pen-Pellets, HPh: Hung x PKa-Pen-Pellets+Hay; Striped columns show PLarge x PKa genotype, gray columns show Hung x PKa genotype

Figure 8. Differences in profit to cost ratio from the LCP group (=100%) at slaughterhouse level, at the med selling price

5.5 EVALUATION OF THE SOCIAL ASPECTS

The results included in this chapter represent responses from 542 respondents to an online consumer questionnaire of 22 questions, who were interviewed in 2014. Besides presenting the general scope of each question, the primary focus is on those responses where significant differences were detected.

The first block of questions asked respondents to compare meat from different animal species regarding frequency of consumption, healthfulness and price.

Rabbit meat was rarely consumed by respondents, especially compared to chicken and pork (***Table 47***). Still, this was an intermediate result compared to literature. Bodnár and Horváth (2008) found a higher frequency (70% of respondents who consumed rabbit meat once or twice a year), however Szakály *et al*. (2009) stated that 69% of respondents have not eaten rabbit meat at all. In my case, the majority of respondents (34.5%) said they have never tried eating rabbit meat, followed by a frequency of 1-2 times a year (29.2%) and less frequently than once a year (27.9%). Differences were found in gender (P<0.001) and employment status (P=0.007). There were more women who never consumed rabbit meat (48.0%) than men (17%).

Table 47
Frequency of meat or meat product consumption from different animal species (%)

Answer options	**Chicken**	**Duck**	**Rabbit**	**Beef**	**Pork**
Daily	17.0	0.00	0.00	0.74	8.86
Weekly	76.0	0.92	1.29	10.7	60.7
Monthly	4.61	24.2	7.20	36.7	23.2
Once/ twice a year	1.29	53.5	29.2	34.1	4.61
Less frequently than a year	0.18	12.0	27.9	9.59	0.55
Never	0.92	9.41	34.5	8.12	2.03

The next question required respondents to indicate meat from the listed animal species which they found the healthiest (***Table 48***). Chicken meat was considered the healthiest meat by the respondents. Rabbit meat claimed the second place (27.5%), followed by beef, duck and pork. Differences were found in gender (P<0.001), age (P=0.012), education, employment status and household income. The order differed according to gender;

44.5%, 29.3 and 16.2% of men, while 65.2, 25.9 and 5.8% of women considered chicken, rabbit and beef the healthiest meat, respectively. Rabbit meat was indicated as the healthiest meat by 40-49 year old people (40.0%), those holding a degree (31.3%), those who lived well and were able to set aside money (34.7%), and the least by the youngest generation (17.8%), those who graduated from secondary school (19.6%), and those whose household income was not enough to earn a living (23.7%).

Table 48
Respondents' choice of the healthiest meat

Answer options	Response (%)	Response (n)
Chicken	56.3	305
Rabbit	27.5	149
Beef	10.1	55
Duck	5.2	28
Pork	0.9	5

Chicken, duck, rabbit, pork and beef were individually ranked by the respondents on a 1-5 scale based on their price (1 represented the lowest value, and 5 the highest). Results show that chicken was nominated as the cheapest meat (mean: 2.69; SD: 0.979), followed by pork (mean: 2.83; SD: 0.853), duck (mean: 3.85; SD: 0.756), rabbit (mean: 3.96; SD: 0.81) and beef (mean: 4.30; SD: 0.823). Related to rabbit meat price, significant differences were found in gender (P=0.008); rabbit meat was considered higher in price by women (mean: 4.04; SD: 0.808) than by men (mean: 3.85; SD: 0.808). White collar workers also tended to rate rabbit meat price higher (mean: 4.04; SD: 0.800) than the other employment categories (mean: 3.83; SD: 0.816). The differences in rating according to household income are shown in ***Table 49***.

Table 49
Price-rating of rabbit meat depending on the household income

Answer options	Mean	SD
Live very well and earn enough to set aside a lot (n=72)	3.57	0.80
Live well, but only a little money is set aside (n=250)	3.96	0.79
Just enough, but cannot set money aside (n=149)	4.11	0.78
Not enough to earn a living (n=38)	3.68	0.85
Have difficulty in daily living (n=8)	4.00	0.76

Mean: based on 1-5 scale (1 represented the lowest value, and 5 the highest)

Those respondents in households where income was just enough but could not set aside money ranked rabbit meat the highest on a 1-5 scale (4.11) while the lowest value (3.57) belonged to those who live very well and earn enough to set aside a lot.

Respondents were also asked to indicate whether their purchasing decision was usually made on package or unit price. Almost three quarters (73.6%) of respondents declared that their purchasing decision was made on unit price, while 19.9% indicated package price (***Table 50***). Other responses (6.5%) included quality, origin, expiration date, appearance, both package and unit price, producer, and value for money. Significant differences were found for age, education and household income. Unit price was mainly favored over purchase price by the 30-39 age category (77.1%), respondents who graduated from secondary school (76.1%) and those whose household income was just enough, but cannot set aside money (78.5%), while it was favored the least by 60+ year old respondents (63.3%), those graduated from vocational training school (48.1%), and those whose household income was not enough to earn a living (63.2%).

Table 50
Influence of package and unit price on purchasing decision

Answer options	Response (%)	Response (n)
Package price	19.9	108
Unit price	73.6	399
Other	6.5	35

In the next block of questions, respondents were asked about their buying and consumption behaviors with respect to rabbit meat products. Most of the respondents consumed rabbit meat at home (43.5%), followed by as guests (23.1%), at restaurants (11.4%), while 1.7% gave it to his/her child as baby food. Other responses (2.8%) included workplace and conferences and 37.5% said they didn’t consume rabbit meat products. Within the consuming rabbit meat at home category, a 9% difference was found in gender with men highest (P=0.044). According to the type of residency (P=0.006), the highest percentage (63.8%) for home consumption was found in those living in municipalities with less than 2,000 inhabitants. The larger a town, the fewer respondents consumed rabbit meat at home, with the lowest value (33.9%) in Budapest. Home consumption was favored also by 73.3% of those working in agriculture (P=0.031).

Respondents were asked to reflect on the origin of the rabbit meat supply using a multiple choice question (***Table 51***). More than half of them (51.3%) did not purchase rabbit meat from anywhere, while 10.0% had their own production unit. For those respondents who purchased rabbit meat (n=210), the primary source was breeders (75.2%), while 14.8%, 14.8%, 12.4%, 1.4% and 1.4%, purchased from a market, a butcher, a hyper-/supermarket, a convenience store or a discount store, respectively, while 12.9% indicated other; i.e. received from friends and family members, purchased from a slaughterhouse or hunted (this could be hare meat).

Table 51
The origin of rabbit meat supply

Answer options	Response (%)	Response (n)
Nowhere	51.3	278
Other breeders	29.2	158
Own breeding	10.0	54
Market	5.7	31
Butcher	5.7	31
Other (please specify)	5.0	27
Hypermarket/ supermarket	4.8	26
Convenience store	0.6	3
Discount store	0.6	3

The survey asked respondents (especially those who had never eaten or rejected rabbit meat) about their concerns. My findings were in line with the study of Bodnár and Horváth (2008). Respondents stated that the reason for a negative attitude towards rabbit meat and refusing consumption was mainly due to emotional reasons and the lack of rabbit meat and rabbit products in the supermarkets in the country.

- A large group (35.9%) listed regret as the main concern. Within this category, gender played a role (P<0.001), 7.9 of men and 28.4 of women felt sorry for the rabbits, respectively. Differences were also found among age categories (P=0.003). With increasing age, the shares of those who felt sorry for the rabbits were 28.1, 16.8, 10.5, 22.6 and 10.0%. Among students, 31.3% said that they regret killing the animal compared to any other employment status (17.2%) (P=0.002).
- Rabit meat did not fit the eating habits of 94 respondents (31.2%) including 21.4% of men and 14.4% of women (P=0.039).
- Rabbit meat was not liked by 19.9% of the respondents. Women especially tended to dislike rabbit meat compared to men; with 15.0 and 5.7% of them, respectively (P>0.001). Based on employment

status, only 8.2% of white collar workers mentioned dislike as a factor of rejection (P=0.011).

- Suspicion of rabbit meat was listed by 13.6% of respondents. Differences were found in the case of students; 13.1% of them had concerns, compared to any other employment status (6.3%) (P=0.033).
- Lack of knowledge of where to buy the meat was listed by 13.6%.
- Cost was a concern for 5.6% of the respondents. This result is much less than in the study of Bodnár and Horváth (2008), where 46% of the respondents found rabbit meat too expensive.
- Complex preparation methods worried 3.3% of the respondents.
- There were 1.7% of the respondents who claimed to be vegetarian.
- Other responses (11%) included having rabbits as pets, difficulty of accessing rabbit meat, lack of tradition, time or information in preparation, did not get used to it in childhood.

The survey asked respondents to quantify their perception about prices. The responses were as follows: on average, thigh meat was thought to be 2,063 HUF (6.88 €) per kg, while loin fillet was 2,503 HUF (8.34 €) per kg. Women indicated slightly higher values (average of 0.19 and 0.17 €) for thigh meat and loin fillet, respectively, compared to men. The lowest and the highest values (6.17 and 7.03 €) for thigh meat were found in the 30-39 and 50-59 year old age categories, respectively.

Consumer perception of rabbit meat price (n=337) in relation to the income of the household was measured on a 1-5 scale, and resulted a mean of 3.94, although 37.8% of respondents chose NA/DK (No answer/ Don't know). The results of the different categories are presented in ***Table 52***. The perception of rabbit meat price increased with declining household income (P=0.001).

Table 52
Consumer perceptions of rabbit meat price in relation to household income

Answer options	Mean	SD
Live very well and earn enough money to set aside a lot (n=42)	3.57	0.91
Live well, but only a little money is set aside (n=158)	3.89	0.71
Just enough, but cannot set aside money (n=105)	4.08	0.77
Not enough to earn a living (n=22)	4.23	0.81
Have difficulty in daily living (n=2)	5.00	0.00

Respondent awareness of certain characteristics was measured on nominative (1-5) scale (***Table 53***).

Table 53
Respondents' perceptions on certain characteristics of rabbit meat

Answer options	Mean	SD	DK/NA (%)	Prob.
High protein content	4.37	0.80	25.3	NS
Lower fat and cholesterol content than chicken, turkey, beef or pork	4.32	0.94	25.3	NS
Unsaturated fatty acid (mainly Omega-3) content within total fatty acids is beneficial for health status	4.10	0.90	42.3	<0.01
Easily digestible	4.09	0.97	29.7	<0.05
Especially rich in certain vitamins and minerals	4.07	0.93	29.0	<0.05
Healthier than chicken, turkey, beef or pork	3.93	1.16	25.3	<0.001
Tasty	3.80	1.27	23.8	NS
Simple preparation	3.30	1.20	24.5	NS
Low price	1.96	0.95	25.1	NS

Among those who reported opinions, respondents mainly agreed on high protein content of rabbit meat, followed by lower fat and cholesterol content than chicken, turkey, beef or pork and its unsaturated fatty acid (mainly Omega-3) content within total fatty acids being beneficial for health status. However, the highest percentage of respondents (42.3%) indicated the last characteristic with NA/DK. The lowest value was found in cheap price; which was the only factor receiving a result below the average.

When questioned about the preferred form of purchase, 46.3% of the consumers indicated carcass parts; i.e. thigh and loin fillet, whereas, 31.4% favored the whole carcass, 11.3% prepared food and 6.6% semi-finished food, 5.5% live rabbits (this result may include the responses of those who consider rabbits as pets). On the other hand, 31.2% would not purchase rabbits or rabbit meat at all. Although purchasing carcass parts achieved exactly the same percentage as stated by Bodnár and Horváth (2008), the preference for semi-finished or ready-made products was three times what was found in the former study. In Spain, where rabbit meat consumption is high, Kallas and Gill (2011a,b) revealed that the highest interest was towards buying whole carcass (52.1%) followed by the pieced (31.8%) and the boneless rabbit meat (16.0%).

Table 54 shows that most of the respondents stated that they would increase the amount of meat they consume if it would be available at more places; thus easier to access, followed by cheaper price and better-known nutritional and health benefits. On the other hand, 23.4% of respondents would not have changed their consumption for any reason. My results were partly in contrast to the Spanish survey (Kallas and Gill, 2011a,b), where price was considered less important than any other factor (origin, brand, quality).

Table 54
Potential influences to enhance consumption of rabbit meat

Answer options	**Response (%)**	**Response (n)**
More availability; easier access	45.6	247
Lower price	35.6	193
Better-known nutritional and health benefits	28.6	155
Would not change by any method	23.4	127
Familiarity of the methods of preparation (e.g. recipes)	18.1	98
Change in liking	14.2	77
Change in habits	11.4	62
Other	3.1	17

In the case of easier access to rabbit meat, 57.2% of men, and 37.4% of women stated that they would increase their consumption (P<0.001) with easier access. Differences were also found in age categories (P=0.001); the least affected by access the young (35.7%) and those who had not enough money to earn a living (31.6%), whereas the most affected were the 40-49 year old respondents and those who live well but only a little money to set aside (57.9% and 50.4%; P=0.006 and P=0.013, respectively). Cheaper price and better-known nutritional and health benefits would influence more men (44.5 and 34.5%) than women (29.4 and 24.6%) (P<0.001; P=0.013, respectively). Employment status was an important factor (P=0.030), 21.0% of white collar workers would increase rabbit meat consumption if they were familiar with the methods of preparation in contrast to all other employment categories (13.6%). Women (32.3%) and 10.9% of men would not increase their consumption by for any reason (P<0.001). The highest resistance was found in the youngest age category (31.4%) and those whose income was not enough to earn a living (26.3%), while the least was found in 40-49 year old respondents (10.5%) and those who live very well and high enough to set aside money (16.7%) (P=0.003; P=0.011, respectively).

A large proportion (95.4%) of respondents have never seen or heard of any program or advertisement promoting rabbit meat. Those who had experienced such marketing tools referred to presentations, the recipes booklet of AMC (Agrarmarketing Centrum), rabbit meat tastings, EU-program (2010), papers in Journal of Mezőhír (2012) and campaigns of the Hungarian Rabbit Breeders' Board, the Internet, gourmet restaurants, the Hungarian Conference on Rabbit Production, baby food, Kaposvár Livestock Days, a National Agriculture and Food Exhibition (OMÉK), or „Nyúl-unk a munkáért" (supporting backyard breeding) program. Those who hold a degree (6.9%) were especially aware of marketing activities (P=0.009).

Out of three breeds, the Hungarian Giant was known by 51.7%, followed by Hungarian intensive breeds (e.g. Pannon White or Debreceni White) with 44.5%. The least known were the foreign hybrids (19.7%), while 36.2% were not familiar with any of the listed genotypes.

Origin, genotype, housing system and feeding method was individually ranked on a 1-5 scale based on their importance. Although no significant differences were found regarding background information, women tended to give higher values in all cases (***Table 55***). Housing system was mostly considered important by 30-39 year old respondents (4.32) and those whose income was just enough, but cannot set aside money (4.27), while feeding method played an important role with 40-49 year old respondents (4.55) and those who live very well and high enough to set aside money (4.08).

Table 55
The importance of origin, genotype, housing system and feeding method

Answer options	Mean	SD
Origin (n=447)	3.72	1.38
Genotype (n=430)	3.14	1.24
Housing system (n=460)	4.23	1.09
Feeding method (n=459)	4.48	0.94

Respondents were asked to quantify the extra amount (if any) they are willing to pay for different genotypes (Hungarian intensive breed vs. Hungarian Giant), for rabbits reared in different housing systems (2-3 rabbits in a cage vs. 12-15 rabbits in a pen and floors of Wire-mesh or Plastic-mesh) and for rabbits fed with different feeding methods (pellets only vs. pellets+hay) compared to 1000 HUF. The survey included pictures to assist the decisions of those who were not familiar with these housing systems. Although, multiple choices included values of 1,100; 1,200; 1,300; 1,400 or 1,500 HUF, the results are reported in percentages. The greatest resistance against paying more was found with wire-mesh (75.6%), pellet feeding (74.2%), pens (71.3%) and plastic-mesh (71.3%). Also, the percentage of respondents willing to pay anything extra was the lowest in these categories (5.2, 5.3, 6.1 and 6.2%, respectively). Among all aspects, respondents appreciated origin the most; they agreed to pay the highest price rise for the Hungarian Giant (18.0%), followed by pellets+hay feeding (16.8%), the Hungarian intensive breed (15.7%), deep-litter (15.6%). Of course, the willingness of consumers to pay more should be treated with skepticism. It is much easier to say they will pay more than to actually pay it.

The only open-ended question asked respondents to propose suggestions for stimulating rabbit meat consumption. It needs to be noted that some respondents answered in a complex manner, mentioning more than one statement. The most frequent answers of 235 respondents are summarized in ***Table 56***. The majority of respondents mentioned more advertisements and more effective marketing activities without more clearly defining their suggestions. However, some of those who would raise the awareness of the positive characteristics (healthfulness, nutritional benefits) of rabbit meat mentioned the effective campaign of Mangalica and chicken meat. In the study of Bodnár and Horváth (2008) respondents also stated that more information would have been needed about rabbit meat and the methods of preparation (recipes) and easier access to domestic production.

Table 56
Suggestions for stimulating rabbit meat consumption

Answers	Response (%)	Response (n)
Advertisement/ marketing activities	30.2	71
Raising awareness of positive characteristics (healthiness, nutritional benefits) of rabbit meat	21.7	51
More availability; easier access	20.4	48
Lower price	12.3	29
Awareness of recipes/ gastronomic TV shows	11.5	27
Gastronomic festivals/ events/ tasting	8.1	19
Reshaping thinking/ modifying stereotypes	6.8	16
Should not stimulate	6.4	15

Although, 12% of respondents suggested lower price, an interesting answer advised drawing attention to the fact that "we are willing to spend much more on food (or any other things) perceived to be healthy". Regarding communication tools, television, newspapers and free targeted press (at pharmacies, medical stations), billboards (even at butchers), online social networking service (e.g. Facebook) were mentioned. Some other suggestions included more availability at restaurants and canteens. The latter would serve two purposes; familiarization with rabbit meat at early age and it could be a base for market research to determine the amount of state funds needed in the sector. Another idea was supporting the breeders (e.g. by extending the existing backyard breeding program, creating an extension service network, or integrating breeders for taking advantage of community marketing). To avoid identifying rabbit meat with the Easter Bunny, and feeling regret for the animal, advertisements should not show live animals, also processed products may attract more attention. Some suggested reviewing of the activities of animal welfare organizations. Interestingly, Kallas and Gill (2011a,b) reported that, in Spain, marketing tools should be more focused on highlighting the origin of the product with an emphasis on regional quality brands, while these factors were less important in Hungary (suggested by only three respondents), also origin and genotype were considered less important (see ***Table 55***).

5.6 CRITICAL POINTS

Conflicts of interest arose along the rabbit meat production chain within the analyzed production combinations and in some experiments, which are as follows:

Concerning genotype

Rearing and processing of PLarge x PKa (at farm level) *vs* PWhite x PKa (at slaughterhouse level) genotypes. Results showed a conflicting interest at the farm and at slaughterhouse levels, since the former benefits from PLarge x PKa, while the latter benefits from PWhite x PKa rabbits. The contradiction may be resolved by a mutually agreed price for slaughter rabbits.

Concerning housing

Rearing on wire-mesh (at farm level) *vs* plastic-mesh (at the slaughterhouse level) had different rank orders along the production chain, since wire-mesh was the most beneficial at farm level, followed by deep-litter, while housing on wire-mesh resulted the highest farm revenue, but rabbits reared on plastic-mesh had the best profitability ratios at the slaughterhouse.

The housing condition caused contradictions not only between producers and processors but with consumers and the rabbits. Consumers prefer rabbits reared on deep litter but the rabbits prefer the plastic mesh. Despite the fact that consumers were willing to pay a higher price for rabbit meat reared on deep-litter, the animals preferred staying on the deep-litter floor least in favor of plastic-mesh and wire-mesh, respectively. Besides, rearing rabbits on deep-litter resulted in worse productive performance and carcass traits due to litter-consumption. Based on these results it should be easy to find the optimal floor type for the animals, however a question may arise whether rearing rabbits on a floor-type which is in contradiction to their preference and causes higher mortality is not against animal welfare?

Concerning feeding

There is a reverse interest at the farm and at slaughterhouse levels, since the former gained more profit when using a restriction in feeding time feeding, while the latter had higher values in the case of selling meat of *ad libitum* fed rabbits. To resolve the contradiction, additional experiments are needed to determine which feeding method causes lower mortality and therefore assists achieving better animal welfare conditions.

Concerning social aspects

Potential influences exist on enhancing consumption *versus* respondents' concerns about rejecting rabbit meat. While respondents stated that the most important factors for increasing rabbit meat consumption included more availability and easier access, lower price, better-known nutritional and health benefits, and familiarity with the methods of preparation, these factors received low results when the reasons for rejecting of rabbit meat consumption were asked. Rabbit meat was considered the second most healthful meat on the list, while the nutritional and health benefits were also highly regarded. Still, 34.5% of the respondents have never eaten rabbit meat. Since some of the suggestions were not in line with the reasons for rejecting rabbit meat, one may wonder whether changing these factors would stimulate rabbit meat consumption in Hungary.

6. CONCLUSIONS AND RECOMMENDATIONS

Experiments were carried out at an experimental farm, thus better conditions and greater attention were probably provided than on a commercial farm. The advantage was that experiments were based on reliable data, although mortality was lower than in practice. It should be noted that only growing rabbits, their production and carcass traits were examined; hence these served as basis for deducing conclusions and recommendations. Experiment results demonstrated that alternative production and animal welfare methods were more costly and eventually have to be paid by the customer. The aims of the comparison of genotypes was partly to evaluate the three breeds of the Pannon Breeding Program and to learn more about the productive performance and carcass traits of the Hungarian giant. Extensive data are available on the productive traits of Pannon Ka, Pannon White, and Pannon Large. In addition to proving the effectiveness of CT-based selection, it was a novelty to establish that – contrary to the general trend of hybrid terminal lines – not only Pannon White, but Pannon Large rabbits were proved to be mature enough when slaughtered at similar weight. In addition, to better carcass traits, the most valuable parts, the hind legs and thigh meat, were larger than the Pannon Ka. Economic evaluations have shown that CT-based selection results in minor additional profit at the farm level (due to the better feed conversion), however the benefit at the slaughterhouse level was significant. The results of the possible crossing with the traditional breed, the Hungarian giant, for producing e.g. labelled products were published for the first time. Economic evaluations stated the values have to be paid to the farmer and the slaughterhouse to make it worthwhile to raise Hungarian Giant rabbits and to buy them for slaughter.

Our data and that in theliterature were available about the differences in production performance and carcass traits between caged and penned rabbits. However, simultaneous comparison of wire-mesh, plastic-mesh and deep litter floors was evaluated for the first time in this experiment. It is well-known by researchers but not the public that the production and carcass traits of rabbits reared on deep-litter are lower. This is partly due to the consumption of litter containing faeces, causing an increase in mortality as well. Although it was not in the scope of this dissertation, it is worth mentioning that preference tests of rabbits on different floor types proved that rabbits stayed less time on deep-litter (even if it was dry and clean), than in wire floored pens. Economic evaluations revealed the price difference by which the usage of any examined alternative housing system would be worthwhile at the farm and slaughterhouse levels.

Two experiments were carried out to evaluate feeding methods. In one case there was an alternative feeding method using hay supplementation. In the other case feed restriction after weaning was evaluated. Pellets plus hay feeding was not beneficial from either the farm or the slaughterhouse point of view, since this method reduced production, slightly decreased costs, but would increase labor inputs and reduced profit at both levels. It cannot be used at farms with mechanical feeding systems. Despite this, hay supplementation is one of the easiest alternative feeding methods. Again, economic evaluations provided information about the exact amounts the prices at the farm and slaughterhouse levels that be received to make hay feeding a worthwhile method. Feed restriction after weaning played a role only at intensive farms where alternative methods are required to reduce digestive diseases and mortality. This is an important issue, especially in light of the antibiotic ban and other medication restrictions by the European Union. Our healthy stock and the generally good housing conditions challenged these experiments, since the main role of feed restriction is reducing mortality, which was already low in the control (*ad libitum*) group of our experiments. In particular, the third experiment successfully determined the level and duration of restriction in time, after which rabbits receiving *ad libitum* feeding achieved almost full compensatory growth. At the end of the experiment, no significant differences were found between body weights. This experiment also proved that the success of feed restriction was independent of genotype. Feed restriction had a stronger effect on PLarge rabbits, however they experienced larger compensatory growth as well, thus the end result was the same as in Pannon Ka.

The main challenge of the dissertation was to simultaneously use (the combination of) three factors (genotype, housing system and feeding method), which had not previously been examined. The evaluation of the combined effects of these factors on productive performance, carcass traits and economic values led to a more complex outcome. With the combination of the factors (eight groups), the changes in production and profitability (profit, break-even or loss) were outlined. The sequence of the eight groups could be depicted by any of the three factors (genotype, housing system and feeding method). All of these scenarios allow either the farmer or the slaughterhouse to determine the value of use of alternative combinations in different financial conditions. It should be noted that in all three factors, the intensive form resulted the greatest profitability. The introduction of any other alternative methods and their combination may be realistic only in the case of receiving a higher price for slaughter rabbits (farmers) and for meat products (slaughterhouse).

The results of the questionnaire revealed that respondents basically found rabbit meat healthy, however better knowledge of positive physiological effects would lead to increased consumption. The vast majority of respondents (95%) said that they had never seen or heard of any program or advertising promoting rabbit meat. Children's catering, gastronomical programs, events particularly arranged on this purpose and direct communication (e.g. meal tasting) could play a significant role in introducing rabbit meat and meals and in bringing the benefits of rabbit meat into public awareness. Since rabbit is usually associated with the Easter Bunny, as a charming animal, and many regret to consume it, the promotion of rabbit meat could be realized in the form of semi-finished or prepared food, e.g. as an extended menu selection of restaurants. In order to increase consumption, rabbit should not be regarded as premium (priced) food. Breeders were the primary source of supply; however respondents highlighted the difficulty in access at other places. This concern could be bridged by butchers and popular supermarkets, especially due to the fact that the most desired form of purchase was carcass parts; i.e. thigh and loin fillet. Respondents' main concern was the feeding method for the rabbits, followed by housing system, while origin and genotype were considered less important. Respondents were willing to pay the highest price for Hungarian Giants, followed by pellet+hay feeding, Hungarian intensive breeds and housing on deep-litter. Transforming public awareness may also include the criticism of housing systems suspected to be "humanitarian". The experiment-proven conditions, in which – in contrast to human empathy and preconceptions – rabbits indeed feed well and are "happy", should be presented to the public.

7. NEW SCIENTIFIC RESULTS

The new scientific results of the dissertation are summarized in this chapter.

1. It was demonstrated that the CT-based selected meat type rabbit breed (Pannon Large) or its crossbred population, showed significant benefits and superiority in carcass traits and profitability, both to the farmer and the slaughterhouse.
2. Experiments revealed that the profitability of the tested floor types showed the following rank order at the farmer's level: 1. wire-mesh, 2. plastic-mesh, 3. deep-litter. At the slaughterhouse level plastic-mesh ranked first, the worst being deep-litter.
3. Economic evaluations quantified the additional payment the farmer requires for his slaughter rabbits, or the slaughterhouse for its meat for the products to remain profitable (or efficient) when using the various alternative systems.
4. A survey was conducted in Hungary using a new approach to monitor consumer perceptions concerning rabbit meat regarding types of meat and management systems including housing and feeding methods used in the production system.
5. The experimental and the survey results demonstrated the nature of contradictions between the needs of the rabbits and the requirements and perceptions of animal welfare and animal rights organizations and a large proportion of consumers or potential consumers.

8. SUMMARY

The objective was to explore the possible contradictions within and between economic and social components of sustainability by evaluating the effect of different genotypes, housing and feeding methods on natural indicators (productive performance and carcass traits), and estimating these aspects' separate and combined effects on profitability at the farm and at the slaughterhouse level, and by evaluating rabbit meat consumption and the Hungarian consumers' perceptions in relation to the analyzed factors.

The following experiments were carried out and/or reported: separate and combined effects of genotype (Pannon Large and Hungarian Giant), housing (cage or pen) and feeding (pellets only or pellets plus hay); comparison of three genotypes of the Pannon Breeding Program (Pannon Ka, Pannon White and Pannon Large), carcass characteristic of rabbits slaughtered at the same age or at the same weight; the effect of CT-based divergent selection; the effect of floor type (wire-mesh, plastic-mesh and deep litter) and the effects of restricted feeding or feeding time.

Targeted experiments and the evaluations of the main factors of the rabbit production chain aimed at quantifying the combined and separate effects of the various elements (genotype, housing and feeding) on economic values at the farm and slaughterhouse levels.

After analyzing the individual factors, it can be stated that both the farmer and the slaughterhouse benefit from a maternal line crossed with Pannon Large (PLarge) instead of Hungarian giant (Hung); from growing rabbits

reared in cages rather than pens; and feeding with pellets without supplementation of hay. While evaluating the combined effects, advantageous results were realized for either the farmer or the slaughterhouse, based on the evaluations on economic (natural and financial) indicators. Out of the eight combinations of genotype-housing-feeding methods, PLarge rabbits reared in cages and fed with pellets achieved the best, and Hung rabbits housed in pens and fed with pellets plus hay achieved the lowest profitability.

It was confirmed that within the CT-based selected genotypes, besides results with the Pannon Large were contrary to the previously accepted statement about hybrid lines indicating that breeds with smaller adult weight, thus earlier maturity had better, and the terminal line had poorer, carcass traits. CT-aided selection for muscle volume on the hind leg was efficient for the farmer, because – as an indirect effect – rabbits improved their feed conversion ratio, while at the slaughterhouse level, more meat from a rabbit with the same weight could be processed, leading to a more appealing product.

In some cases of the analyzed production combinations, conflicts arose along the production chain. Improved profitability was achieved by rearing Pannon Large x Pannon Ka at the farm level, while processing Pannon White x Pannon Ka at the slaughterhouse level was more profitable. Rabbits reared on wire-mesh or plastic-mesh were more profitable for the farmer and the slaughterhouse, respectively. Although, restricted feeding meant better cost-effectiveness at the farm level, *ad libitum* feeding was more beneficial at the slaughterhouse level. Choosing any of the alternative methods, would more or less worsen natural indicators (productive performance and carcass traits). Financial evaluations revealed the additional amount that had to be paid for slaughter rabbits to the farmer and for rabbit meat to the slaughterhouse to be efficient when dealing with rabbits reared in alternative systems.

There are also contradictions in certain cases between the actual needs of rabbits and the requirements and perceptions on animal welfare of some of the animal rights organizations and consumers. While deep-litter is recommended by some animal rights activists, and consumers stated that they would pay more for rabbit meat originated from such a housing system, the mortality was higher in that group, and also a preference test showed that rabbits favored wire- or plastic-mesh to deep-litter. All these indicate that faulty views affect rabbit meat production, which may be disadvantageous to the production and adoption of rabbit meat.

In addition to the consumer tests on consumption and purchasing practices for rabbit meat, consumer perceptions in relation to genotype, housing and feeding methods were also studied. The majority of consumers consume rabbit meat only 1-2 times a year, and most rabbit meat was purchased from breeders. The most desired form of purchase was carcass parts; i.e. thigh and loin fillet. The main cause of rejecting rabbit meat consumption was regretting killing of the animal. Out of three breeds, the Hungarian Giant was the most known, followed by Hungarian intensive breeds, and foreign hybrids. Respondents' main concern was feeding method, followed by housing system, origin and genotype. Among the listed aspects, respondents appreciated origin the most; they were willing to pay the highest price increase for Hungarian Giant, followed fed by pellets plus hay, Hungarian intensive breeds and housing on deep-litter.

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13. CURRICULUM VITAE

Katalin Szendrő was born on 29 March, 1981 in Budapest. She graduated from the College of Szolnok in 2004, studied at Sydney College of Business and Information Technology in Australia, and received a Diploma of Business Management in 2007. She graduated from the University of Pécs, and received her Master's degree in Applied Management from Middlesex University in 2009. She received a certificate in advanced level Business English in 2009. Applied and was admitted to the Doctoral School for Management and Business Administration of Kaposvár University in 2010. Worked at different enterprises in Hungary and abroad, such as DPD Hungary, Avante IT, Volvo Cars Australia and OTP Bank. Since she finished her Ph.D courses in 2013, she has been employed as assistant lecturer at Kaposvár University, Department of Marketing and Trade. Lectures to regular (full-time) and correspondence (part-time) courses on BSc and on higher-level vocational training. Developed learning materials for an English MSc course, and participated in organizing the 3rd and 4th International Conferences of Economic Sciences for 100-150 participants as the secretary of Organizing Committee. Involved in national and international projects. Editor of Regional and Business Studies, the scientific journal of Kaposvár University – Faculty of Economic Science, and edited five proceedings of conferences. Author of 49 papers: 11 scientific papers and 18 full papers in proceedings. Half of them were published in English.

14. APPENDIX

The translation of the original Hungarian questionnaire.

GREETING

Dear Respondent!

Katalin Szendrő, doctoral candidate of the Doctoral (PhD) School for Management and Business Administration of Kaposvár University, respectfully ask you to fill in my questionnaire to support the successful completion of my PhD research. The survey is voluntary and anonymous.

Thank you in advance for your help!

***1. How frequently do you consume meat and meat products from the following species?**

	Daily	Weekly	Monthly	1-2 times per year	Less frequently than a year	Never
chicken	○	○	○	○	○	○
duck	○	○	○	○	○	○
rabbit	○	○	○	○	○	○
beef	○	○	○	○	○	○
pork	○	○	○	○	○	○

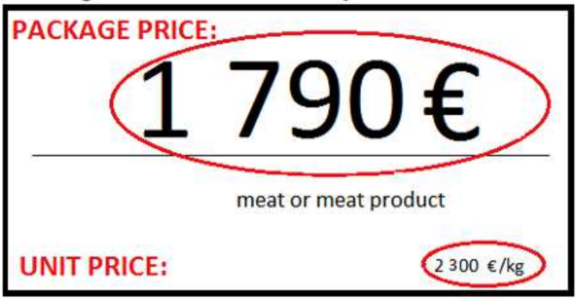
***2. In your opinion, which of the following meat products is the healthiest? (1 choice only)**

- ○ chicken
- ○ duck
- ○ rabbit
- ○ beef
- ○ pork

***3. Please rate on the following meat varieties based on their price! (1 - very cheap, 5 - very expensive)**

	1	2	3	4	5
duck breast/ thigh	○	○	○	○	○
rabbit loin/ thigh	○	○	○	○	○
beef sirloin / rump (thigh)	○	○	○	○	○
pork loin/ thigh	○	○	○	○	○
chicken breast/ thigh	○	○	○	○	○

The image below assist in the next question:



***4. Your decision in buying meat or meat products is mostly made on the package price (€/pack) or unit price (€/kg)?**

- ○ Package price
- ○ Unit price
- ○ Other, such as...

***5. Where do you usually consume rabbit meat or rabbit meat products? (multiple choice)**

- ☐ Home
- ☐ Treat/ visiting someone
- ☐ Restaurant
- ☐ Give it to my child as baby food
- ☐ Nowhere
- ☐ Other, such as...

***6. Where do you get rabbit meat / meat products? (multiple answer)**

- ☐ own breeding
- ☐ other breeders
- ☐ market
- ☐ butcher
- ☐ Smaller grocery
- ☐ discount
- ☐ Hypermarket / Supermarket
- ☐ nowhere
- ☐ Other, such as...

7. If you never consume rabbit meat and rabbit meat products, what is the reason of it? (multiple choice)

- ☐ I do not know where to purchase
- ☐ Preparation is complex
- ☐ Does not fit in my eating habits
- ☐ Cannot afford it
- ☐ I do not like it
- ☐ I'm a vegetarian
- ☐ I feel sorry for the animal
- ☐ I have doubts about rabbit meat
- ☐ Other, such as...

***8. Relative to the monthly income of your household?**
(1 - very cheap, 5 - very expensive, DK/NA - Do not know / no answer)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ DK/NA

***9. To what extent do you think the following characteristics are true for rabbit meat?**
(1 – strongly disagree, 5 – completely agree, DK/NA – Do not know / no answer)

	1	2	3	4	5	DK/NA
High protein content	○	○	○	○	○	○
Specially rich in certain vitamins and minerals	○	○	○	○	○	○
Lower fat and cholesterol content than chicken, turkey, beef or pork	○	○	○	○	○	○
Unsaturated fatty acid (mainly Omega-3) content within total fatty acids is beneficial for health status	○	○	○	○	○	○
Healthier than chicken, turkey, beef or pork	○	○	○	○	○	○
Low price	○	○	○	○	○	○
Simple preparation	○	○	○	○	○	○
Tasty	○	○	○	○	○	○
Easily digestible	○	○	○	○	○	○

***10. In what form whould you buy rabbit/ rabbit meat?**

- ☐ live
- ☐ whole carcass
- ☐ only loin and/ or thigh meat
- ☐ semi-finished product
- ☐ prepared food
- ☐ I would not buy in any case

***11. By which factor(s) would you increase your rabbit meat consumption? (multiple choice)**

- ☐ If it would be available at more places; it would be easier to access
- ☐ If it was cheaper
- ☐ If the positive nutritional and heath effects of rabbit meat would be more well-known
- ☐ If I would like it
- ☐ If I get used to it
- ☐ If I knew better the methods of preparation (e.g. recipes)
- ☐ I would not change by any effect
- ☐ Other, such as...

***12. Have you ever seen/ heard of any program or advertising promoting rabbit meat?**

- ○ No
- ○ Yes, such as:

***13. Have you heard of any breed below? (multiple choice)**

- ☐ Hungarian intensive breeds (e.g. Pannon White or Debreceni White)
- ☐ Hungarian Giant
- ☐ Foreign hybrids (intensive breed)
- ☐ None

***14. How important for you the...**
(1 – strongly disagree, 5 – completely agree, NA/DK - No answer/ Do not know)

	1	2	3	4	5	NT/NV
...origin?	○	○	○	○	○	○
...genotype/breed?	○	○	○	○	○	○
...housing condition?	○	○	○	○	○	○
...feeding method?	○	○	○	○	○	○

The images below assist in the next question:

***15. Relative to HUF 1,000 base price, how much would you be willing to pay for...**

	would not pay more	1100 Ft	1200 Ft	1300 Ft	1400 Ft	1500 Ft
...Hungarian intensive breed?						
...Hungarian Giant?						
...rabbits reared in cage (2-3 rabbits in a cage)?						
...rabbits reared in pen (12-15 rabbits/pen)?						
...rabbits reared on wire-mesh?						
...rabbits reared on plastic-mesh?						
...rabbits reared on dep-litter?						
...rabbits fed by commercial pellet?						
...rabbits fed by pellet plus hay?						

16. Please propose suggestions stimulating rabbit meat consumption!

***17. Your gender?**

- Female
- Male

***18. How old are you?**

Age:

***19. What is your education background?**

- Elementary school
- Vocational training school
- Secondary school
- College, university

***20. What is the type of residency you permanently live at?**

- Capital city (Budapest)
- County town
- More than 10,000 inhabitants
- 2,000-10,000 inhabitants
- Less than 2,000 inhabitants
- Abroad
- NA/DK

***21. What is your employment status? (multiple choice)**

- Students
- Working in agriculture
- Blue collar workers
- White collar workers
- Stay-at-home
- On maternity leave
- On pension
- Other inactive
- Unemployed
- Looking after family

***22. How do you consider your household income?**

- live very well and high enough to set aside money
- live well but only a few is set aside
- just enough, but cannot set aside
- not enough to earn a living
- have difficulty in daily living
- NA/DK