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

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TABLE OF CONTENTS

1. BACKGROUND AND OBJECTIVES.....	2
2. MATERIALS AND METHODS.....	3
3. RESULTS AND DISCUSSION.....	7
3.1. EFFECT OF GENOTYPE	8
3.1.1. SEPARATE EFFECTS OF GENOTYPE (PLARGE AND HUNG).....	8
3.1.2. COMPARISON OF THE BREEDS OF THE PANNON BREEDING PROGRAM, SLAUGHTERED AT THE SAME AGE.....	9
3.1.3. COMPARISON OF THE BREEDS OF THE PANNON BREEDING PROGRAM, SLAUGHTERED AT SIMILAR WEIGHTS	10
3.1.4. EFFECT OF DIVERGENT SELECTION FOR THE VOLUME OF MUSCLE ON THE HIND LEGS	11
3.2. EFFECT OF HOUSING	12
3.2.1. SEPARATE EFFECTS OF HOUSING GROWING RABBITS IN CAGES OR IN PENS	12
3.2.2. EFFECT OF FLOOR TYPE ON GROWING RABBITS	13
3.3. EFFECT OF FEEDING	15
3.3.1. SEPARATE EFFECT OF FEEDING OF GROWING RABBITS	15
3.3.2. FEED RESTRICTION.....	16
3.4. COMBINED EFFECT OF GENOTYPE, HOUSING AND FEEDING	20
3.5. SOCIAL ASPECTS	21
3.6. CRITICAL POINTS	23
4. CONCLUSIONS AND RECOMMENDATION	25
5. NEW SCIENTIFIC RESULTS	28
6. LIST OF AUTHORS' PUBLICATIONS IN THE FIELD OF THE DISSERTATION.....	29

1. BACKGROUND AND OBJECTIVES

World rabbit meat production has more than tripled since 1961. China and Italy dominate the market. For the last 15 years, China has been the leader, not only in terms of production, but also in the volume of exports. Although Hungary was ranked 14th among major rabbit meat producing countries (6.496 tons), 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). 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 (47%) and foreign hybrids (40%) are used (Juráskó, 2014). Former are unique breeds. Two of them (Pannon White and Pannon Large) have been selected for a long time for carcass traits based on the data of computer tomography (CT). Intensive systems of housing, feeding and reproduction are widespread: intensive breeds and hybrids, closed systems with wire-mesh cages, pelleted feeds, and artificial insemination. There is a growing interest in colored breeds kept in alternative housing systems and fed by less intensive feeding. Reduction of feeding cost, which is about 80% of total cost of fattening period, is of primary importance to rabbit producers. 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. This approach would be valid only if the whole supply chain was owned by one enterprise. 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.

Objective 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.

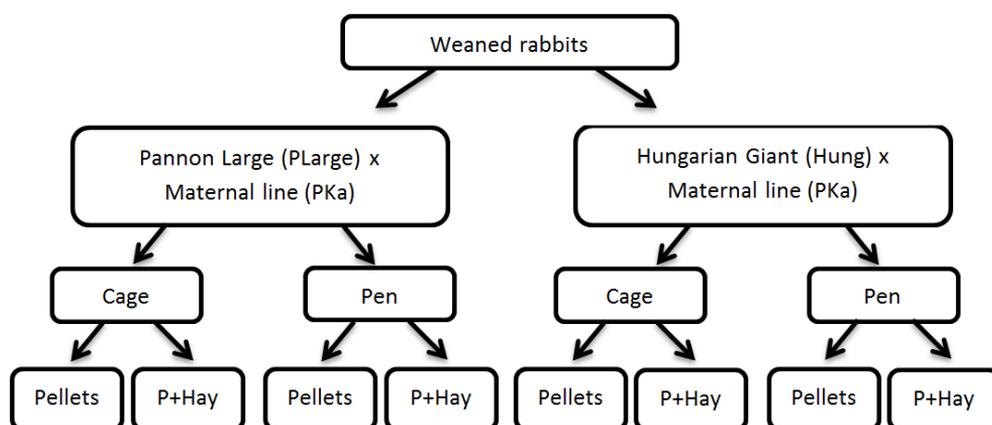
2. MATERIALS AND METHODS

Animals and housing

All of the experiments were carried out at Kaposvár University. The three breeds of Pannon Breeding Program were examined: Pannon Ka (PKa, maternal line, selected for litter size), Pannon White [PWhite, selected for

daily weight gain (replaced by 21-day litter weight since 2010) and carcass traits measured by CT] and Pannon Large (PLarge, terminal line, selected for daily weight gain and for volume of muscle on hind legs measured by CT). Besides, Hungarian Giant (Hung) was also evaluated.

Rabbits were weaned at 5 weeks of age and the experiments finished when the animals were 10, 11 or 12 weeks of age. Rabbits were housed in a closed building, generally in wire-mesh cages (3 rabbits/cage, 16 rabbits/m²). They were fed *ad libitum*, and they could drink water freely from nipple drinkers. The design of the main experiment is shown in **Figure 1**.



Note: P=pellets

Figure 1. Design of the main experiment

CT measurement

Using CT in selection started in 1992. Based on two CT scans per rabbit (junction of the 2nd-3rd and the 4th-5th lumbar vertebrae), the L-value was measured and expressed in cm². In 2004 L-value was replaced by thigh muscle volume (TMV). TMV was estimated with 11-12 scans taken on hind legs. Main references concerning the methods used: Szendrő *et al.* (1992), Matics *et al.* (2014).

Economic evaluation

Natural indicators: Body weight and feed intake were measured, therefrom weight gains and feed conversion ratios were calculated. At the end of the experiment, rabbits were slaughtered. The slaughtering and carcass dissection procedures followed the recommendations of World Rabbit Science Association (WRSA) described by Blasco and Ouhayoun (1996). After 24 h chilling, the carcasses and their parts were weighed. The dressing out percentage and the ratio of the organs and carcass parts to carcass weight were calculated.

Financial indicators: All figures were calculated in Euro. At the farm level, the first cost factor was the price of a weaned rabbit. Data for weaned rabbit price (1.83 €/kg) was gained from Olivia Ltd. Cost of production was based on feeding cost, which may represent 80% of total production costs in case of growing rabbits (Maertens, 2010) and the cost of mortality. Since cost of feed may vary significantly year by year, the cost analysis was carried out based on the average cost of feed (0.275 Euro/kg, Agribrands Europe Hungary Ltd.) 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 rabbit 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 and from different carcass parts was calculated. Data were gained from Olivia Ltd.¹ 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 lung (0.45). Based on these medium prices, 10% lower and 10% higher selling prices were also calculated on the most valuable carcass parts (loin fillet and thigh meat), because the selling price

¹ Olivia Ltd. is the largest rabbit producing, processing and exporting company in Hungary.

of these items depends on different market prices. 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

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. The survey consisted of 21 structured questions asking respondents their opinions and concerns regarding frequency, healthfulness and price perception of rabbit meat compared to meat of other animal species, 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. Background variables included gender, age, education, type of residency, employment status and household income. The survey was available on-line, in Hungarian.

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. In all of these cases the productive and carcass traits were evaluated by one-way ANOVA. When two factors were analyzed (feed restriction on two genotypes) two-way ANOVA was used. In the case of examination of combined effect of genotype, housing system and feeding method, the productive and carcass traits were evaluated with the means of multi-factor ANOVA. Frequency distributions, cross tables were used in the evaluation of the questionnaire. In addition, mean calculations and significance analysis (Chi²-probe) was performed.

3. 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 of the respective experiments, but in other cases the data of former studies were used. 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.

3.1. EFFECT OF GENOTYPE

3.1.1. Separate effects of genotype (PLarge and Hung)

The *aim* of the experiment was to examine separately the effects of genotype on productive performance, carcass traits and financial indicators.

Materials and methods: PKa does were inseminated with semen of Pannon Large and Hungarian Giant bucks. The results of the crossbred growing rabbits, PLarge x PKa and Hung x PKa (n=336) were compared.

Economic evaluation

Natural indicators: Weight gain and pellet intake of PLarge x PKa rabbits was higher over the whole fattening period compared to Hung x PKa rabbits. Dressing out percentage of PLarge x PKa rabbits was 1.1-1.3% better than that of Hung x PKa rabbits. The ratio of the hind part to the reference carcass was higher in Hung x PKa rabbits than in PLarge x PKa group.

Financial indicators, at farm level: In the 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. 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.

Financial indicators, at slaughterhouse level: A profit difference of 0.50, 0.57 and 0.64 €/rabbit was achieved in favor of PLarge x PKa rabbits with increasing selling price, respectively.

It can be concluded that 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.

3.1.2. Comparison of the breeds of the Pannon Breeding Program, slaughtered at the same age

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.

Materials and methods: PKa, PWhite and PLarge rabbits (selected for different criteria) were reared under the same conditions and slaughtered at 11 weeks of age.

Economic evaluation

Natural indicators: 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. Dressing out percentage of PWhite was the highest and that of PKa the lowest. The ratio of hind part to reference carcass was larger in PWhite rabbits than in PLarge and PKa rabbits.

Financial indicators, at farm level: Cost of production was similar in PKa and PWhite rabbits, but it was higher by 0.56 €/rabbit in the PLarge group. When the same feed price was compared, the smallest difference in profit to cost ratio (1.87 and 1.32%) was between PLarge and PKa rabbits. 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.

Financial indicators, at slaughterhouse level: The highest profit was achieved in PLarge rabbits, followed by PWhite group and PKa rabbits.

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

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

The *aim* of the experiment was to compare three genotypes slaughtered at similar weights, and to examine their economic values.

Materials and methods: PKa does were inseminated with semen from PKa, PWhite or PLarge bucks. Crossbred kits (PKa x PKa, PWhite x PKa, PLarge x PKa) were reared up till 88, 83 and 79 days, respectively, when they reached similar body weight (2785-2795 g).

Economic evaluation

Natural indicators: The growth rate of PLarge x PKa was the largest, and that of PKa x PKa was the smallest. Daily feed intake of PLarge x PKa rabbits was significantly higher than that of PKa x PKa and PWhite x PKa rabbits. 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. Genotypes with higher adult body weight (PWhite x PKa and PLarge x PKa) had better dressing out percentage and higher ratio of hind part. 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.

Financial indicators, at farm level: Concerning production cost, the largest difference was found between PKa x PKa and PLarge x PKa groups 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.

Financial indicators, at slaughter level: A different ranking order occurred when the calculation was made at the slaughterhouse level. 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.

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

The *aim* of the study was to analyze the effects of divergent selection for CT measured thigh muscle volume (TMV) on economic values.

Materials 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. 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. The PP group had lower feed intake, better feed conversion ratio and higher ratio of the hind part and hind leg meat than MM rabbits. It was shown that CT aided selection can efficiently increase TMV, while the feed intake decreased and feed conversion ratio improved.

Financial indicators, at farm level: 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.

Financial indicators, at slaughterhouse level: 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.

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.

3.2. EFFECT OF HOUSING

3.2.1. Separate effects of housing growing rabbits in cages or in pens

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.

Materials and methods: Crossbred rabbits (PLarge x PKa and Hung x PKa) were reared in a cage or pen (Cage: 3 rabbits/cage, Pen: 14 rabbits/pen), but the stocking density was the same (16 rabbits/m²).

Economic evaluation

Natural indicators: The differences in body weight between Cage and Pen rabbits increased to 141 g at 12 week. The differences in weight gain were significant, in favor of Cage rabbits.

Financial indicators, at farm level: 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%.

Financial indicators, at slaughterhouse level: 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.

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.

3.2.2. Effect of floor type on growing rabbits

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.

Materials and methods: PKa rabbits were housed in pens with basic area of 1.27 m². The floor type of the pens was different: Wire-mesh, Plastic-mesh or Deep-litter.

Preference test: At the age of 5 weeks the rabbits were placed to pens with a basic area of 3.8 m². The floor of the pens was partly wire-mesh (1/3), plastic-mesh (1/3) and straw deep-litter (1/3). Rabbits were studied based on video recordings.

Economic evaluation

Natural indicators: 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 best results. When considering mortality, rabbits reared on Deep-litter had the highest value, at about half that of Deep-litter. The Plastic-mesh group achieved the best results in dressing out percentage, and the highest values were seen in the Deep-litter group. *Preference test:* During the whole growing period, rabbits chose the Plastic-mesh floor (55%), followed by the Wire-mesh (38%), while the least preferred floor was the Deep-litter (7.3%).

Financial indicators, at farm level: 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.

Financial indicators, 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.

Result show that different rank orders may occur at the farm and at the slaughterhouse levels.

3.3. EFFECT OF FEEDING

3.3.1. Separate effect of feeding of growing rabbits

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.

Materials and methods: Crossbred rabbits (PLarge x PKa and Hung x PKa) 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, the hay intake was calculated on the basis of digestible energy (DE) content.

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. Pellet-fed rabbits had higher gains compared to the P+Hay group. The dressing out percentage was 0.4-0.7 % higher in Pellet group than in P+Hay rabbits. The ratio of hind part to reference carcass was higher in the P+Hay group.

Financial indicators, at farm level: 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, the profit of the P+Hay rabbits was lower with an average of 0.07 €/rabbit.

Financial indicators, at slaughterhouse level: 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.

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.

3.3.2. Feed restriction

Within feed restriction, three experiments were evaluated. 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

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

Economic evaluation

Natural indicators: The daily feed intake of restricted rabbits was significantly lower between 5 and 8 weeks of age, and higher between 9 and 11 weeks of age than that of the ADLIB group. 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. 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. 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.

Financial indicators, at farm level: Despite the fact that – due to their higher slaughter weight – 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.

Financial indicators, at slaughterhouse level: The best profitability ratio results were found in RESTR70 group, followed by ADLIB with slight differences, and RESTR60 with the lowest.

In conclusion, feed restriction to 70% was the most beneficial at both farm and slaughterhouse level.

Experiment 2

Materials and methods: Half of the rabbits were fed *ad libitum* (ADLIB) while the other half had time restriction for feeding (RESTR). In the latter group, rabbits were allowed to consume pellets for 9, 10, 12 or 14 hours

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 lower in the RESTR group at the ages of 4-7 weeks. Weight gain of RESTR rabbits was lower at the ages of 4-6 weeks, while between 7-9 weeks it was higher compared to ADLIB group. This shows a compensatory growth. Feed conversion ratio of the RESTR group was better compared to ADLIB rabbits. Dressing out percentage and the ratios of hind part, hind legs and the loin fillet to the body weight were higher in ADLIB rabbits.

Financial indicators, at farm level: The more the weight gain, the higher the slaughter weight, 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, slightly higher profit was detected in favor of the RESTR group.

Financial indicators, at slaughterhouse level: The rank order changed when the evaluation was made at the slaughterhouse level. 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.

Basically, there is a reverse value at the farm and the slaughterhouse levels.

Experiment 3

Materials and methods: 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). After finishing the restriction (from 7 to 10 weeks of age) rabbits were allowed to consume pellets *ad libitum*.

Economic evaluation

Natural indicators: During the whole growing period PLarge rabbits consumed more pellets and their weight gain was higher than that of the PKa. The differences were smaller during restriction. After finishing the restriction, the differences between the two genotypes were higher. Comparing the feed conversion rate, significantly better values were achieved in PLarge than in PKa rabbits. Dressing out percentages of PLarge rabbits was higher by 1.2% than that of PKa rabbits. The ratio of hind part to reference carcass was larger in PLarge rabbits, and that of mid parts were larger in PKa rabbits. Our results showed that the effect of restriction was independent of the genotypes.

Financial indicators, at farm level: Within the genotypes, feed restriction was advantageous for PLarge, while ineffective for PKa rabbits. 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.

Financial indicators, at slaughterhouse level: In contrast to farm level, PLarge rabbits fed *ad libitum* were superior to the restricted group.

3.4. Combined effect of genotype, housing and feeding

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.

Materials and methods: Half of the crossbred rabbits PLarge x PKa (L) and Hung x PKa (H) were housed in cages (C; 3 rabbits/cage), the other half in pens (P; 14 rabbits/pen). Two other subgroups were formed; rabbits that received only commercial pellets (P), or commercial pellets supplemented with grass hay (P+Hay /h/), *ad libitum*. 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).

Economic evaluation

Natural indicators: 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. A similar tendency can be seen from group of HCP to HPP rabbits. In Hung x PKa rabbits only the pellet consumption of HCP rabbits differed from the other three groups. In PLarge x PKa rabbits a slightly decreasing tendency (from LCP to LPh) can be seen in dressing out percentage.

Financial indicators, 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. Only LCP, LCh, LPh, and HPP rabbits at the on med feed cost exceeded the average values within the profitability indicators.

Financial indicators, 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. 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%, 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.

3.5. SOCIAL ASPECTS

According to the findings of the questionnaire, 34.5% of respondents said they have never tried eating rabbit meat. Compared to other animal species, rabbit meat claimed the second place regarding healthfulness, while its price was considered slightly more expensive than the average meat price. For those respondents who purchased rabbit meat, the primary source were breeders. Most of the respondents consumed rabbit meat at home. The main concern of those who rejected rabbit meat was regretting the animal. Consumer perception of rabbit meat price in relation to the income of the household was measured on a 1-5 scale, and resulted a mean of 3.94. 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 Omega-3 contents being beneficial for health status. The preferred form of purchase was thigh and loin fillet.

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 (45.6%), followed by cheaper price (35.6%) and better-known nutritional and health benefits (28.6%). Regarding marketing activities, 95.4% of respondents have never seen or heard of any program or advertisement promoting rabbit meat. Out of three breeds, the Hungarian Giant was known by 51.7%, followed by Hungarian intensive breeds with 44.5%. The least known were the foreign hybrids (19.7%). Origin, genotype, housing system and feeding method was individually ranked on a 1-5 scale based on their importance. Feeding method was mostly considered important (4.48), followed by housing system (4.23), origin (3.72) and genotype (3.14). 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%) and cage housing (10.2%). The only open-ended question asked respondents to propose suggestions for stimulating rabbit meat consumption. Respondents mentioned more advertisements and more effective marketing activities, and raising the awareness of the positive characteristics (healthfulness, nutritional benefits) of rabbit meat. Some suggested lower price. 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. Another idea was supporting the breeders. 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.

3.6. CRITICAL POINTS

Conflicts of interest arose along the rabbit meat production chain within the analyzed production combinations and in some experiments, researches 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.

4. CONCLUSIONS AND RECOMMENDATION

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. 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. 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.

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 faces, 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 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. 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. 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 *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. This experiment also proved that the success of feed restriction was independent of genotype.

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.

5. NEW SCIENTIFIC RESULTS

The new scientific results discussed in the dissertation:

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.

6. LIST OF AUTHORS' PUBLICATIONS IN THE FIELD OF THE DISSERTATION

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