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Review Article

A Comparative Analysis of the Different Housing Systems of Growing Rabbits

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Abstract | The study aims to present the different technologies used in the husbandry of growing rabbits with special regard to its animal welfare aspects. It was investigated, based on scientific publications, experimental results and practical experiences, how different housing systems contribute to the harmonization of animal welfare and economical rabbit farming. The synchronization of economic and animal welfare aspects often represents a significant challenge; therefore, this study aims to provide a comprehensive evaluation of animal welfare in rabbit housing systems and to identify potential directions for future development. Animal welfare, which is strongly regulated within the European Union, is a top priority for European farmers. The present statutory environment of the EU promotes the unification and the continuous improvement of animal welfare requirements. In order to successfully implement these aspirations and at the same time to ensure the financial and social sustainability of these rabbitries, it is crucial to employ a scientifically unbiased holistic approach. An integrated approach that considers the interconnections between human, animal and environmental health is essential to achieve sustainable animal production while maintaining both livestock numbers and productivity, thereby meeting the increasing global demand.

Keywords | Rabbit housing systems, Animal welfare, Environmental enrichment, Stocking density, Group housing, Housing design

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INTRODUCTION

Rabbit breeding in the EU and in Hungary underwent a significant structural and technological transformation in the last decade (Szendrő and Dalle-Zotte, 2011; EFSA, 2020). The formerly small-scale characterized animal farming was fading in the background, giving place to industrialized, large-scale rabbit husbandry. Continuous supply, homogenous, high volume, planned production order and the potential of product tracking are more and more a demand, required by the market and the processing industry. As a result of these factors, large scale produced rabbit meat products are dominantly present on EU food markets (EFSA, 2020).

In large scale industries, rabbit rearing is typically carried out in caging systems. These animal rearing practices are highly criticized though, by different animal welfare organizations and animal protection movements. As an example to the above-mentioned fact, an initiative, End the cage age can be mentioned, whose aim is to end caged animal rearing. As a reaction to this social pressure EFSA, European Food

Safety Authority initiated the comprehensive evaluation of different rabbit housing systems inside the EU (European Commission, 2021). A renewal of these above mentioned technologies is anticipated due to the expected tightening of the respective regulations (EFSA, 2020).

As an answer to these developments, the professional advocacy of European rabbit farmers has become stronger. ERA European Rabbit Association was founded, representing rabbit farmers of eight European member states Hungary, Spain, France, Italy, Belgium, The Netherland, Portugal, Czech Republic at the moment and operating as a Brussel based, European professional organization. The prime aim of ERA is the representation of European rabbit farmers. The ERA in cooperation with Agricultural ministries and scientific researchers, is taking part in the preparatory phase of the new regualation the elaboration and scheduling of which the European Commission has already determined.

A directive on the breeding of domestic animals was issued by the Council of the European Union, Council Directive 98/58/EC (20.06.1998) which specifies the sufficient care the producers have to provide the livestock on their rabbit farms. Further national directives have been issued by some other member states (e.g. The Netherlands–2006, Hungary–2009, Belgium–2014, Germany–2014, Italy 2014 and 2019).

The Hungarian national regulation is based on both the 32/1999 (III.31.) FVM directive and its modified versions, namely the 20/2002. (III.14.) FVM, and the 72/2004. (IV.29.) FVM directive. The directive, that has been in effect for almost 20 years, regulates the minimum requirements of rabbit rearing, is desperately outdated and does not satisfy the present requirements and expectations of consumers. One of the greatest challenges of European rabbit farming is that it lacks a unified, European standard regulatory framework on the issue of rabbit rearing (EFSA, 2020). Although as it was mentioned above a general directive was issued by the European Council in 1998 (Council directive 98/58/EC), it fails to regulate specifications with regard to rabbit rearing. Although nationwide regulations were introduced and implemented in certain memeber states like The Netherlands, Hungary, Belgium or Germany they vastly differ from each other. The lack of unified, mandatory animal welfare regulations on EU level exposes rabbit farmers, since there is neither unified professional or legal framework, that can constitute a defensive force in cases of one sided and/or excessive animal protection claims. It is of vital importance in the future, to establish a unified, scientifically sound regulatory system, which provides clear framework for both the producers and the authorities alike. In light of these challenges and regulatory gaps, a comprehensive evaluation of current housing systems is required. The aim of this review is to provide a comprehensive evaluation of housing systems used in growing rabbit production, with special emphasis on animal welfare, behavioural responses and production performance. Furthermore, the study aims to identify key factors influencing welfare outcomes and to highlight future directions for the development of sustainable and welfare-oriented rabbit housing systems.

RESULTS AND DISCUSSION

Housing syste ms

The use of conventional fattening cages are still vastly dominant in European rabbit farming, mostly in places where the modernization of the rabbitries have not been carried out yet. Also, the use of smaller, bycellular housing systems can be monitored, in which only two fattening rabbits can be kept. Parallel to traditional housing methods, animal welfare measures are gaining attention. The new, structurally enriched cages often referred to as welfare cages have a larger floor space and can also be used in multi-level arrangements. All these devices contribute to the appearance of natural rabbit behavioural patterns and the reduction of stress (EFSA, 2020).

Vast differences can be observed in the housing systems applied by different rabbitries. One practice is the displacement of fattening rabbits into separate fattening barns at the time of weaning. Whereas if the other, more modern protocol is used, rabbit does are displaced after weaning to a different cage and the litter as a whole, is left at their original place of birth until the end of the fattening period.

Floor space of cages/ stocking density

The measurements of cages used in different housing systems are presented in Table 1 (EFSA, 2020). The size of the cages is more and more determined by animal welfare expectations lately, especially governed by the anticipation of the strictening of European regulations. The employement of a group housing method, where each animal has a floor space of 625 cm^2 would be a favourable solution, as recommended by the European Food Safety Authority (EFSA, 2005), where cage depth reaches to 75-80cm, width to 35-40 cm and height 38-40 cm. It is also recommended to keep the stocking density to a 40 kg/m^2 maximum, until slaughter. The shape and timing of group housing may also affect animal welfare. Recent studies demonstrated that even part-time group housing can influence behavioural responses, reproductive performance and skin injuries (Van Damme *et al*., 2022). This suggests that stocking density cannot be evaluated alone, but in interaction with housing rhythm and social context.

Table 1: Main dimensions of different housing systems of fattening rabbits by EFSA (2020).

Rearing system/type	Width (cm)	Depth (cm)	Height (cm)	Floor space (cm^2)
Conventional, wire cages				
The so called bicellular cages for two growing rabbits	25.4	44	28	1200
Rearing future breeding rabbits or non pregnant does/ growing rabbits	38	43.5–66	28–41	1650–2510
Rabbit does with kits/ growing rabbits (double purpose cages)	38	87–102	32–39	3300–3900
Enhanced floor space version/ Rabbit does with kits/ Growing rabbits (double purpose cages)	46	95–102	35	4370–4700
Structurally enriched cages				
Wired cage with platform (plastic rest grid)	38–46	95–102	60–65	4370–5600
Plastic bars with platform	46–52,5	102	65–80	5600–6400
Alternative systems				
Standing pens (park), plastic bars with platform for does and kits (4 does) or growing rabbits (32) (double purpose)	180–200	80–102	Without top	Aggregated: 18000–25400 / 4500–6350/doe/ 563–800/ growing rabbits
Floor level, deep litter pens	Standard data is not available			
Outdoor systems	Standard data is not available			
Organic systems	Standard data is not available			

As for the industrial reality is concerned, totally different measurment principles are used. The dimensions of the multifunctional cages, namely cages used both for reproduction and fattening, vary between 38-40 cm width, 85-100 cm depth and 29-35 cm height. Under these circumstances, the effective floor space per rabbit can vary between 425–720 cm^2 and consequently, the stocking density is 14-23 rabbits/ m^2 (Trocino and Xiccato, 2006). The so called bicellular cages, used mainly in Italy and Hungary, is worth to be mentioned here. Paired-housing was widely spread when using this system, providing roughly 1200 cm^2 of floor space for the two animals, at a 16-17 rabbits/m^2 stocking density.

Although significant floor space enlargement was advocated by EFSA, the available scientific results, let they be either single or group housing, have failed to justify if this modification would be favourable to both production performance or animal welfare (Combes and Lebas, 2003; Mirabito, 2003; Maertens, 2004).

Cage height

Though cage height, provided for growing rabbits, might be a vitally important factor in animal welfare, there are relatively little experimental data available to corroborate this theory. A previous study (Szendrő *et al.*, 2005) analyzed the cage height with reference to its effect on animal behaviour. Based on the findings of the study it can be declared that cages with different height were not especially preferred by rabbits, whereas they would spend considerably less time in open top cages. These findings lead us to the conclusion that the present industrial standard of 30-35 cm cage height neither constitutes a restriction to fattening rabbits nor influences negatively their comfort and wellbeing.

Effect of stocking density on growth and behaviour

Determining the optimal stocking density in case of fattening rabbits housing systems is of vital importance, since it does not only affects production performance but also influence animal welfare. There are several studies carried out on the production performance and behavioural patterns of rabbits in different stocking densities.

In a former study (Xiccato *et al.*, 1999) the various housing methods (single vs group of three) and two different stocking densities (12 and 16 rabbits/m^2) were comparatively evaluated. No significant differences were detected neither in production indicators nor in behavioural observation results (open-field test, immobility test).

In another study carried out by Trocino *et al.* (2004) the development of rabbits was monitored at stocking densities of 12 and 16 individuals/m^2. Both groups showed balanced development until the end of the experience, the results of which could be corresponded to that of the results of the individual housing system. Differences in eating behaviour could only be detected in the last two weeks of the experiment, where the group of lower stocking density consumed 185g/day, and the group of higher stocking density individuals consumed 179 g/day (P= 0.06).

Matics *et al.* (2004) monitored the rabbits' behaviour in a special rearing system where growing rabbits could freely move among four different-sized cages. Right after weaning, rabbits were prone to stay in groups, sometimes as crowded as 60-70 rabbits/m^2, whereas in time, the individuals split up more evenly, though still preferring smaller cages.

Based on the findings of the study by Morisse and Maurice (1996) it can be established that higher than 20 rabbits/m^2 stocking density or more than 40 kg/m^2 slaughter weight, influenced unfavourably rabbits' behaviour. As per their observation, rabbits reared in a more crowded environment required more time for rest and thus, decreased the time spent on eating and other activities. Experimental results underline that exceeding a certain stocking density, not only affected behaviour but also production performance, negatively. It was a shared finding of several studies that, both production performance and behaviour indicators are negatively influenced over a certain stocking density. A study carried out by Aubret and Duperray (1992) drew the conclusion that stocking density over 20 rabbits/m^2, respectively 46-47 kg/m^2 leads to significant decline in production performance. A similar result was established by Maertens and De Groote (1984), who concluded that stocking density exceeding 15 rabbits/m^2 or over 40 kg/m^2 live weight can lead to critical rearing conditions, and can consequently lead to the deterioration of not only the production performance but also the escalation of animal welfare risks.

The combined effect of different floor types and different stocking densities was examined by Kustos *et al.* (2003), in which they concluded, that deep-littered floors at a lower density lead to more preferable performances, at the same time the deterioration of hygienic conditions posed a threat.

Establishing the optimum stocking density of fattening rabbits, requires complex, long-term research, that evaluates not only the production indicators, the behavioural traits, but also animal welfare and animal health indicators, especially focusing on livestock between 12 and 20 rabbits/m^2 stocking density. All the following factors, such as the type of the cage or the pen, the group size as well as the analysis of the effect of the provided moving space during the whole fattening period is of vital importance. The employment of high tech electronical and behaviour monitoring systems, such as RFID-based, individual identification, 3D movement monitoring and also AI-supported video analysis, are highly recommended and can supply us with unbiased data on animal activity, use of provided space and behavioural traits.

Behaviour and animal welfare

Social behaviour and the effects of isolation

Rabbits are social animals, the lack of social interactions affects their well-being and behaviour. Based on experimental results (Held *et al.*, 1995; Chu *et al.*, 2004) individually housed rabbits display stress reactions in laboratory environment.

Behavioural and physiological indicators are crucial to evaluate the well being of rabbit, as is also emphasized by Hoy and Verga (2006).

Free moving was made possible for rabbits in between two, differently arranged cages, where the sidepanels of one were covered by mirrors whereas in the other cage's side panels were covered by plastic boards in an experiment carried out by Dalle Zotte *et al.* (2009a). Nearly three-fourths of all the animals chose the mirrored space, which can be interpreted as choosing the illusion of social presence facilitated by their own mirror image, thus providing them with social comfort. Individual housing, especially in closed wall cages can significantly deteriorate animals' well being. If, on the other hand the cages have wire-mesh or transparent walls, a minimum amount of social interaction is still available due to visual contact, and this affects both behaviour and well-being favourably.

Intensified self-grooming, the discovery of the environment (gnawing, scraping) and the decrease in social interactions are all indicators of isolatory behavioural traits. These can all point to the direction of the deterioration of well-being as established by Morisse and Maurice (1996).

Effect of moving space on behaviour

The decrease in provided space affects both the behaviour and performance of rabbits. It was observed by Lambertini *et al.* (2001) that rabbits housed in pens on deep litter higher stocking density led to the decrease in production performance.

During the open-field test, carried out by Ferrante *et al.* (1997), freezing and decreased exploratory behaviour were detected, which behavioural patterns can be identified as passive stress manifestation.

As it was concluded in the study of Trocino *et al.* (2004), behavioural observations implemented at the ages of 57 and 68 days, there were no significant differences among the different stocking density groups. At the same time, rabbits tend to display exploratory behavioural patterns in a more crowded environment during open-field test that was not taken as an unequivocal sign of stress by researchers.

Limited moving space often correlates with a longer resting period, which can be explained as age specified characteristic. Contrary to this, a more difficult access to the feeder could correspond to the decline in feed intake, which can be the consequence of a crowded cage (Trocino and Xiccato, 2006).

Practical experiences in housing of growing rabbits

As above mentioned, rabbits, being social animals, group housing provides them the opportunity to experience and practise social behavioural traits. In case of growing rabbits, contrary to rabbit does, group housing technically can easily be executed, at the same time, the handling of possible aggressive interactions and the spread of diseases requires attention. A group of 7-10 growing rabbits is a regular standard in most countries. In contrast, in the case of Hungary and Italy, the most dominant form of rabbit rearing was that of the paired-housing, in the entire growing period from weaning to slaughter. The reason for the applied hosing system is that in both countries rabbits are reared for a longer period, up to 80-90 days, to achieve the market required bodyweight of 2.5-2.6 kg. This might result in enhanced level of aggression and the danger of injuries.

Studies, carried out in smaller groups (2-4-6) housed in traditional cages, resulted in different findings. As is established, rabbits showed a slightly increased performance in larger groups (Mirabato *et al*., 1999a), whereas in the case of other studies, performance did not show any significant differences (Verga *et al*., 2004). As for behavioural traits, a significant modification could be detected in different group sizes (Mirabato *et al*, 1999b).

Based on scientific results, deep-litter floor do not provide favourable housing conditions for rabbits. When 8-16 rabbits were housed in groups on wire-mesh or deep litter floor, it was found that production decreased in the latter, which could be corresponded primarily to the worse hygienic conditions and subsequently the more common health issues (Dal Bosco *et al*., 2000; Lambertini *et al*., 2001).

Taking behavioural patterns under scrutiny, locomotor activities such as jumping and resting behavioural patterns differ between smaller (6 rabbits/cage) and larger (24 rabbits/pen) groups whereas the frequency of abnormal behavioural traits did not show significant discrepancy, as was established by Martrenchar *et al*. (2001).

Housing on deep litter is suitable for hobby or backyard rabbit farms. Animal welfare is improved when hay or other litter materials are used, promoting the manifestation of natural behavioural traits such as digging or scraping. On the other hand, maintaining a certain hygenic standard is difficult. These systems are difficult to automatise, and the setting up of automatic manure management poses a challenge. These are the reasons why this form os husbandry is not widespread on an industrial level. Based on the above mentioned facts, it can be concluded that though deep litter floor may bring animal welfare benefits, it certainly does pose economical and technological challenges.

Group size, aggression, mortality

Aggression and behaviour

In their natural habitats, wild rabbits live in established, hierarchical groups, which furthers the minimization of conflicts and the sharing of available space. On the contrary, in confined spaces, especially in intensive housing systems, this social structure can not be formed, leading to enhanced aggression and confused behavioural patterns. The escalation of aggressive behaviour is one of the primary problems of larger group-based rearing systems. Aggressive interactions become more common when puberty is reached, leading to increasingly serious injuries on various parts of the body.

The frequency and seriousness of body injuries correlated with both the group size and the age of the livestock was observed by Bigler and Oester (1996). It was also concluded that dominance order was not formed two weeks after weaning, which led to frequent fights, and as a consequence increased number of injuries.

According to Rommers and Meijerof (1998) post-weaning period is one of the most sensitive times, in particular. During this period in crowded environment, individual animals, obviously, are quite often in proximity, which leads to the enhancement of dominance fights. The risk of fighting is higher with an excessive number of individuals in groups, lack of hiding places, as well as an improperly arranged rearing environment. Though a direct correlation was not established between group size and the frequency of injuries, a significant proportion of skin lesions was noticed: 6-16% at 73 days of age, 20-41% at the age of 80 days. Rommers and Meijerof (1998) concluded that the number of injuries grew in correlation with aging, independent of the group size. Leaning on the results of these studies, we can rationally consider 80 days as the extreme limit of rearing of growing rabbits, at the same time taking into consideration both the development rate and puberty characteristic of the given breeds or crossbreds.

In a study in various group sizes, ranging from 2, 4, 6, 8 to 10, carried out by Szendrő *et al*. (2009), it was determined, that the trend of the number of injuries correlated with the group size, yielding the least favourable results in groups of 10 rabbits. The proportion of ear injuries at the ages of 9, 10, and 11 weeks was 3,5%, 6,1% and 10,4%, respectively.

As researchers pointed out, the higher number of injuries in larger groups can be traced back to the fact, that in larger groups, one aggressive animal has more opportunities to attack its mates than in smaller groups. This phenomenon should be one of the priority consideration in the face of animal welfare but is not yet so far. Besides social stress, environmental challenges such as heat exposure may further deteriorate behavioural stability. Liang *et al*. (2022) reported that heat stress negatively affects the endocrine and immune functions of rabbits, which can indirectly increase aggression and vulnerability to injuries.

Mortality and its relevance to group size

Scientific results, aiming to establish a correlation between group size and mortality, are ambiguous.

In most of the studies, mortality showed no correlation with group size (Maertens and De Groote, 1984; Maertens and Van Herck, 2000; Maertens and Van Oeckel, 2001; Princz *et al*, 2009; Szendrő *et al*., 2009).

To the contrary, certain studies e.g. Dal Bosco *et al*. (2002), whose experiment focused on 2 or 10 rabbits per group, as well as Lang (2009) with groups of 8-22 animals experienced an increasing mortality rate in correlation with larger group size.

One reason that might explain the differing results can be the fact that in the rearing process, the feed is supplemented with certain medications, e.g. coccidiostats. The effect of those medications can mask the group size related differences, those of which might become apparent only in the post-medication period, together with hidden, subclinical diseases.

Mortality is, though affected by group size, can not be explained solely by this factor, but rather by multiple ones, the likes of excessive stocking density, non-satisfactory hygienic conditions and environmental stressors as well. Higher levels of aggression especially if an order of dominance is not established can further enhance the proportion of injuries and the susceptibility of individuals, which, though indirectly, can lead to a higher mortality rate.

The results of studies indicates that though group size, in itself, is not a determining factor, but its effect intertwines with stocking density, the quality of the environment (cage, pen arrangement), the behavioural traits, the monitoring of those traits and the feeding system. Further studies therefore, should subserviently target to investigate the cause and result correlation of mortality in complex systems, with the primary focus on the interrelatedness of technology, social stress and immune reactions.

Ways of environmental enrichment

The environmental enrichment methods used in the caged housing of growing rabbits e.g. gnawing sticks or deep-litter have very rarely influenced production and slaughter indicators. Despite this, similarly to rabbit does, environmental enrichment promotes the appearance of natural behavioural traits such as seeking of hiding place, rest, and mobility. Environmental enrichment is increasingly recognised as a practical tool to reduce stress and social conflicts among growing rabbits. Modern comparative studies also confirmed that various enrichment strategies can support welfare without compromising production performance (El-Sabrout *et al*., 2024; Elsayed *et al*., 2024).

On one hand, littered surfaces make the appearance of species-specific behavioural traits such as digging or scraping possible, on the other hand, the use of wired cages is the most widespread in rabbitries, due to their obvious technological and hygienic advantages. The occurence of sore hock in growing rabbits is rare, due to the relatively short rearing period, which further supports the relevance of the wired floor cages.

Ergo, hay does not serve the gratification of natural biological needs, but rather factors in behavioural modificationary force, especially in grouped-housing arrangements, where the use of hay acts as agression-supressor. Besides hay, other environment-enrichening devices, such as floor placed or ceiling hung gnawing sticks have been succesfully used. Although the use of these devices has not generally altered production unfavourably (Mirabito *et al*., 2000; Maertens and Van Oeckel, 2001; Verga *et al*., 2004), in cages enriched this way, serious injuries were scarce and a decrease in aggression level could be detected.

As pointed out in certain studies (Morisse *et al*., 1999; Orova *et al*., 2004) if rabbits had a choice between littered and wired cage floors, quite often wired surfaces were preferred and displayed enhanced moving.

The presence of enrichment let they are cage or alternative housing systems has a detectable influence on behavioural patterns. Gnawing sticks hung from the ceiling proved to be especially effective, resulting in improved mobility, in jumping, in the increase of the number of social interactions and the decrease in the level of aggression and the stereotypic behavioural patterns (Dal Bosco *et al*., 2002; Verga *et al*., 2004).

Table 2 illustrates the influence of the different types of enrichments on behaviour and performance indicators. As it can be clearly seen from the data provided, though environment enrichment is not a mandatory expectation as for the financial production is concerned, it is highly recommended from an animal welfare standpoint. The indicators of well- being deriving from behavioural traits, such as gnawing, digging, and moving, gained importance

Table 2: Effects of different environmental enrichment methods on growing rabbits (Mirabito *et al*., 2000; Maertens and Van Oeckel, 2001; Verga *et al*., 2004; Morisse *et al*., 1999; Orova *et al*., 2004; Dal Bosco *et al*., 2002).

Type of enrichment	Effect on behaviour	Performance indicator	Remarks
Deep-litter	Scraping, digging, longer rest period	No change	Hygienical risk, problematic manure management
Gnawing stick (hanged)	Gnawing, jumping, decreased aggression	Neutral	Simple, endurable, well accepted
Chain or plastic pole	Playful interactions, gnawing	Neutral	Cheap, but rather unnatural material
Elevated platform	Exploratory behaviour, longer rest period	Increased feed intake in cases	Provides opportunity to space use preferences
Hiding place (e.g. plastic tube)	Hiding, reduction of stress	Decreased aggressivity	Satisfactory hygiene is a priority

on a regulatory level as well. The introduction of at least one active and one passive device e.g. gnawing sticks and elevated platform would be desirable in all growing rabbit housing units. It is anticipated that a minimum requirement of environment enrichment will be incorporated in future EU regulations.The implementation of manipulable objects or elevated resting areas has been shown to promote natural behaviours such as exploration and jumping, while reducing aggressive interactions among pen-mates (Trocino *et al*., 2019).

Production and slaughter traits in different housing conditions

The main product of industrial rabbit farms is rabbit meat, the quality and quantity of which are determined by several rearing technological factors. The most important factors in maximizing production and slaughter indicators are cage size, stocking density and rearing method. Stocking density namely the data of the number of individuals stocked at a given floorspace is the main indicator of rearing intensity. In cases where stocking density exceeds an optimum level, the level of stress elevates and the well-being and health of animals change unfavourably. If on the other hand, the number of animals stocked is lower than optimum, it can lead to a decrease in performance efficiency, while at the same time, a significant increase in production and slaughter indicators can barely be detected.

The effect of stocking density have been the object of a number of studies (Xiccato *et al*., 1999; Jekkel *et al*., 2006; Princz *et al*., 2009; Szendrő *et al*., 2009). It was stated by Xiccato *et al*. (1999) that stocking density between 12-16 rabbits/ m^2 resulted in no significant difference either in production performance, or in bone development or behavioural tests. A similar conclusion was drawn by Trocino *et al*. (2004), declaring that a favourable production performance can also be maintained even at more than 16 rabbits/m^2. On the contrary, in cases when stocking density exceeded 16-17 rabbits/m^2, the decrease in feed intake, in weight gain, and the slaughter weight at the end of the fattening period, could be detected.

As it is also corroborated by Hungarian studies, stocking density and floor type influence the production and slaughter traits of growing rabbits. On one hand, a favourable weight gain and slaughter traits can be observed in cases where a mixed floor type was implemented, as it is observed in the study of Jekkel *et al*. (2006). On the other hand, in a study, carried out by the same team of Jekkel *et al*. (2008), slaughter traits such as live weight, carcass weight, and dressing out percentage (DoP%) tend to be less sensitive to rearing conditions than behaviour or welfare parameters. In a study by Trocino *et al*. (2004), no significant differences were detected in these parameters in case of different stocking densities. At the same time, stress factors, aggression and the limitation to access to feed, can directly worsen meat quality.

The meat composition, especially its fat fraction and the fatty acid profile, shows strong compliance to housing conditions. In a study executed by De Smet *et al*. (2004), the amount and type of fat independently of species, feed and genetic background determines fatty acid profile. In correlation with higher fat quantity, it was observed that the proportion of saturated fatty acids (SFA) and monosaturated fatty acids (MUFA) increases faster than that of the polysaturated fatty acids (PUFA). As a consequence of this, the meat of growing rabbits, housed in larger groups, contains less fat and so the proportion of PUFA can be relatively higher (Dal Bosco *et al*., 2002; Lazzaroni *et al*., 2009).

As is determined by certain studies, in the meat of group housed rabbits in comparison with the meat of caged rabbits a higher proportion of SFA, PUFA, n-6 and n-3 fatty acids were detected, all at the same with a decreasing proportion of MUFA (Dal Bosco *et al*., 2002; Dalle Zotte *et al*., 2009b; Lazzaroni *et al*., 2009).

CONCLUSION AND RECOMMENDATIONS

Based on national and international research findings, it can be clearly declared that rabbit housing parameters especially stocking density, cage size, available space and group size are complexly influencing the production, behaviour, meat quality and welfare of the animals.

It can be further declared and at the same time emphasize, that finding the delicate balance between production efficiency and animal welfare is still an addressable challenge, since the enhancement of animal welfare conditions e.g. environment enrichment, cage size enlargement in themselves do not always result in detectable production advantage, but can contribute to the acceptance in the society and the compliance with regulations.
Based on the above findings, the following recommendations can be formulated:

1. Complex, long term researches are required, which can evaluate all production, welfare and behavioural parameters, with a special focus on a stocking density between 12-20 rabbits/m^2, as well as the influance analysis of different cage types and group sizes.
2. The introduction of advanced observation and data collecting systems (e.g. RFID, 3D motion observation, AI supported behaviour analysis) is recommended in order to enable individual monitoring of rabbits, that can result in the objective tracking of critical animal behavioural traits (e.g. aggression, space use and stress).
3. A minimum requirement of environmental enrichment criteria is expedient to incorporate in the upcoming regulations, in the form of at least one active (e.g. gnawing stick) and one passive (e.g. resting platform) device, since the introduction of which effects animal welfare and behaviour without compromising performance indicators.
4. The elaboration of a scientifically unbiased regulatory system on EU level is neccessary, that can provide a unified framework for rabbit housing practices and at the same time provides protection towards excessive or extreme animal protection pressure.
5. The organization and elaboration of educational and producer training program is requisite in the distribution of right practices, in the framework of which, producers get to know the new housing methods, the interpretation of animal welfare indicators as well as the practical use of the up to date behaviour monitoring systems.
6. It is expedient to expand meat quality examinations, in order to enable the unified analysis of housing conditions, behavioural factors and technological solutions, as these heavily influense the stress level, balance of growing as well as fat quantity and fatty acid profile.

Overall, the development of housing systems for growing rabbits can only be successfully achieved through a scientifically grounded, animal-centred approach that considers production, welfare and market aspects simultaneously.

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NOVELTY STATEMENT

This review provides a comprehensive and up-to-date evaluation of the housing systems used for growing rabbits, integrating scientific evidence, practical experiences, and regulatory considerations. Unlike previous summaries, this study synthesizes recent findings on stocking density, group size, cage design, and environmental enrichment together with modern welfare-monitoring technologies such as RFID-based tracking, 3D motion analysis and AI-supported behaviour assessment. The work also highlights the gaps in the current European regulatory framework and proposes scientifically grounded directions for future legislation. By bridging production outcomes, welfare indicators and technological innovations, this review offers a holistic perspective that supports the development of sustainable, welfare-friendly rabbit husbandry systems across the EU.

AUTHOR'S CONTRIBUTION

R.J. contributed to the conceptualization and preparation of the manuscript.
C.D., Z.G., A.M. and Z.M. contributed to the literature collection, scientific supervision and revision of the manuscript.
B.B. coordinated the manuscript preparation, analyzed the literature and prepared the final version of the article.
All authors read and approved the final manuscript.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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