

The Influence of Housing for Laying Hens on the Economics of Egg Production

František Zigo^{1*}, Silvia Ondrašovičová², Katarína Veszelits Lakticova³, Mária Vargova⁴

¹ Department of Nutrition and Animal Husbandry, University of Veterinary Medicine and Pharmacy, Košice, Slovakia
*Corresponding author's email: frantisek.zigo [AT] uvlf.sk

² Department of Biology and Physiology, University of Veterinary Medicine and Pharmacy, Košice, Slovakia
Email: silvia.ondrasovicova [AT] uvlf.sk

³ Department of the Environment, Veterinary Legislation and Economy, University of Veterinary medicine and pharmacy, Košice, Slovakia
Email: katarina.veszelitslakticova [AT] uvlf.sk

⁴ Department of the Environment, Veterinary Legislation and Economy, University of Veterinary medicine and pharmacy, Košice, Slovakia
Email: maria.vargova [AT] uvlf.sk

ABSTRACT— *The poultry sector plays an important role in animal production in terms of maintaining a stable production of healthy food for the population. With regard to egg industry, sustainability refers to the treatment of laying hens and especially the systems used for hen housing. The conditions of welfare and housing of laying hens in the production of table eggs are currently of interest to most egg sellers as well as consumers as they directly affect the economy of their production and their price. At present, consumers have a choice of four types of eggs on the shelves. They can come from cage, litter, free range or organic farming. Each farm has well-defined rules that it must follow. Customers are increasingly interested in where and under what circumstances are produced the eggs which they bring home from the store. In addition to price, customers look for a story behind the package and make their decisions accordingly. Although recognizing that issues such as environmental consequences, food safety, and humane treatment of hens are also important, this article focuses on the relationships between hen housing and economy and market eggs production.*

Keywords— Hens, Egg Production, Battery Cage Systems, Alternative Systems, Economics

1. INTRODUCTION

The chicken layer industry, or egg industry, is an important intensive animal production system. Eggs as an important component of human food contain full-value proteins with an optimal composition of amino acids, fats mostly with unsaturated acids, important macro and microelements, vitamins and enzymes necessary for fetal development, but also as components of rational human nutrition. The nutrient composition of chicken eggs is presented in the table 1 [1]. Over the past decade, the egg industry recorded an intensive growth due to the rising per capita consumption of eggs (a little over 200 eggs per year/person) [2].

Table 1: Nutrient composition of fresh chicken egg (per 100 g)

Components	energy (kcal)	water (g)	protein (g)	fat (g)	cholesterol (mg)	carbohydrate (g)	calcium (mg)
whole egg	149	75.33	12.49	10.02	425	1.22	49
yolk	358	48.81	16.76	30.87	1.281	1.78	137
white	50	87.81	10.52	0	—	1.03	6

Source: Singh and Glenn [1].

The consumer's demand, and therefore also the goal of the poultry industry is a continuous supply of fresh eggs to the market. At present, consumers have a choice of four types of eggs, which can come from different laying hen technologies such as cage, litter, free range or organic farming. Each farm has well-defined rules that it must follow. From January 2012, EU welfare standards for laying hens prohibit the use of conventional "barren" battery cages. Current alternative systems that are acceptable under the EU legislation are noncage systems and enriched cages. In enriched cages. This means that the hens have more space and "privacy" than in the past, because they have a perch and a

nest to lay eggs (figure 1) [3,4,5].

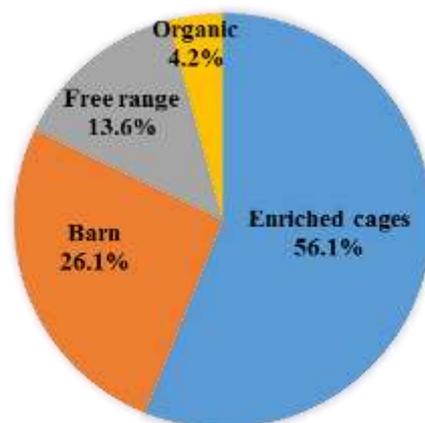
The housing conditions and welfare of laying hens in the production of table eggs are currently of great interest to most sellers and consumers, as they directly affect the quantity, quality and price of the eggs. The quality of table eggs produced by laying hens in the technological systems used depends on a number of internal and external factors, such as animal health and condition, nutrition, appropriate microclimatic and technological conditions of the breeding environment and other [6,7].

The specific objectives of this review are to discuss the economy of egg production using enriched cages and non-cage systems, determine and compare the economic performance of each management system as well as determine the factors which affects the final price of eggs.

2. LAYING HENS HOUSING SYSTEMS

High yield of laying hens is conditional upon selection of a suitable laying hybrid, proper rearing of pullets and suitable rearing technology that enables to make maximum use of their production potential, i.e. to obtain from each hen 300 - 350 eggs of 60 g weight per year (16 to 21 kg of egg mass) [8,9]. Throughout the world, poultry industry uses mostly large-scale production technologies selected according to the climatic, nutritional, socio-economic and ethical-human conditions of the respective countries. Most hens are kept in halls or sheds, about 76% of them in cage batteries, 13% in halls on deep bedding or slatted floors and 11% in free-range or aviaries. In Argentina, Brazil, Mexico, Iran and Thailand, more than 95% of all hens intended for egg production are kept in cages. The deep litter system is most used in Sweden, over 30% of hens are kept on litter in Austria and Switzerland. Free-range and aviary farms are widespread in Switzerland for up to 60% of hens and are used for about 30% of laying hens in Austria and Ireland [10,11].

Along the way, some systems were found to be unworkable and their development was discontinued, whereas others were found to be sufficiently promising for further investment and refinement. Current alternative systems that are acceptable under the EU legislation are noncage systems and enriched cages (Figure 1).



Graph 1: Housing system in EU laying hen husbandry in 2015.
Source: Windhorst [12].

2.1 Enriched Cages

The construction of enriched cages is made of galvanized sheet metal, profiles and wires. The nests are separated by hinges with an area per laying hen in the range from 125 to 150 cm². A suitable nest lining (artificial grass, etc.) significantly reduces the laying outside the nest [13]. Enriched cages have space for scratching, pecking and dust bathing. The side walls of the cage are made of galvanized metal sheet, the sloping bottom of the cage is plastic in order to prevent damage to the laid eggs while rolling to the automatic collection belt which transports them to the central conveyor. Manure is removed by a belt under each deck of cages. Feed is provided by an automatic system and consists of a feed trough, an automatic feed trolley, a feed conveyor and a storage silo. The supply system consists of water in let regulators, PVC pipes, pin feeders with a stainless steel nipples placed in the cages. The lighting is central for the entire production section of the hall. Ventilation of the hall is ensured by electric fans with controlled dampers, fan openings are equipped with light screens and the entire system is controlled by an automatic control unit, with an audible signal in case of failure [14,15].

While the quality nutrition is important for health and productivity of all hens, enriched cages provide more space for movement and perches which reduce the incidence osteoporosis and hyperkeratosis. Hens reared in this way should have cauterized ("shortened") beaks. The appearance of blood, especially in laying hens that were not subjected to beak

treatment, signals the outbreak of cannibalism [16].

Klecker et al. [17] and Saki et al. [18] stated that the development of cage technologies of hens was aimed at achieving optimum economic results, but also at improving living conditions for laying hens (e.g. improving feeding and watering systems and environmental conditions, and reducing emissions - pre-drying of manure on manure belts). In such cage systems, the laying achieved with the most powerful hybrid combinations of hens exceeded 300 eggs annually at a mortality rate not exceeding 0.5% per month and with a maximum of 6% of non-standard eggs, including contaminated eggs. A certain part of the professional, but especially the lay public is against this system because the demands of laying hens for the development of their innate manifestations and living needs are not fully satisfied in such cage technologies.

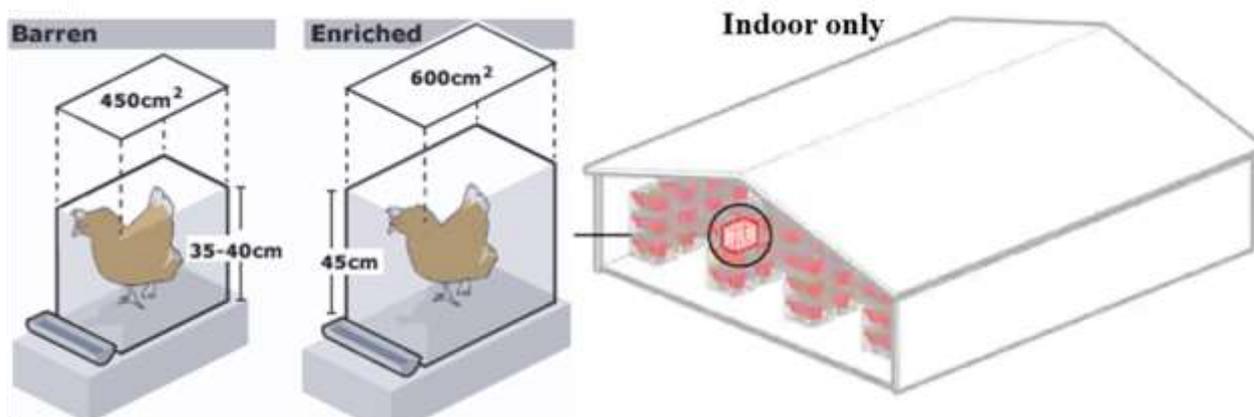


Figure 1: Comparison of living space between barren battery cage and enriched cage system
Source: Modified figure by Brulliard [19] and Windhorst [20].

2.2 Barn Laid System

Keeping laying hens on deep bedding is carried out in breeding halls on 10 - 15 cm litter layer. The quality of bedding significantly affects the breeding environment and animal welfare. The litter must not be cold and wet as this can cause sticking of litter to hens' feet and formation of "mud slippers" and an increased incidence of parasitic and bacterial diseases. At least 1/3 of the floor area must be covered with litter. Maximum density of stocking is 9 hens per 1 m² (at least 1110 cm² per hen). There must be at least 15 cm of perch space per hen and access to a dust bath (Figure 2) [21].

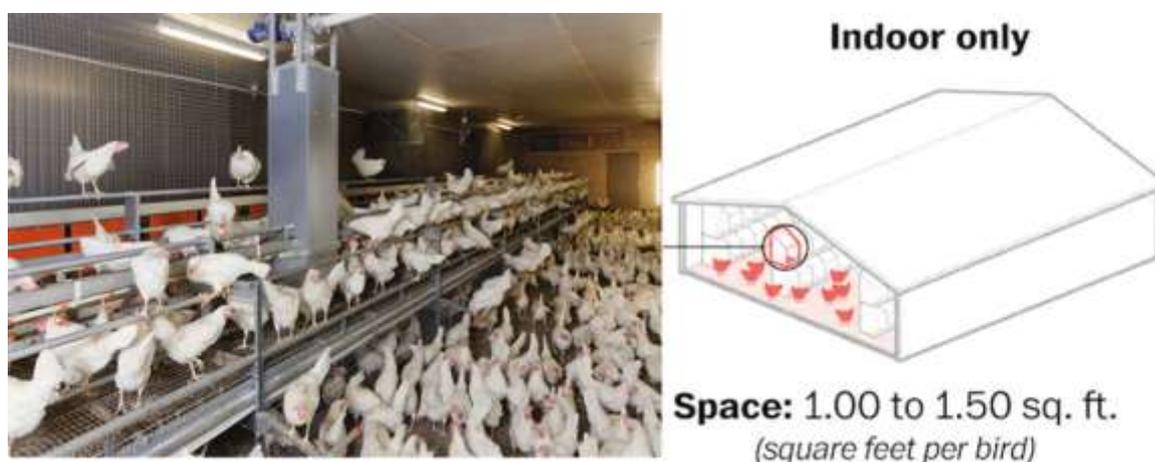


Figure 2: Barn System with litter and slatted floor, automated feed chain, nipple drinkers and manure belt underneath the slatted floor
Source: Modified figure by Brulliard [19] and Windhorst [20].

An important part of the housing is the availability of nest boxes. In the modern system for housing of laying hens on deep bedding, the nests are located in the middle of the hall. This is an important aspect affecting the installation of lines for feeding and watering, as well as the perches for rest. In the middle of the hall, 2 parallel rows of nests made of galvanized sheet metal (deposited on a profile structure) are placed back to back. The nest has a removable floor made of galvanized net, on which artificial grass is placed. The laid eggs roll to an egg collection belt. The nests are equipped

with an automatic ejection system (reduces the retention of the hen in the nest) and ventilation (a slit in the roof of the nest). A removable slatted floor (usually below it is a belt for removal of faeces) connects to the nests. Nipple drinkers with drip cups are most often used. The feeding line is usually arranged as feeding trough with a chain conveyor. Feeders and drinkers are located above the slatted floor (therefore most dung is trapped in the space under the slats) [22,23].

2.3 Outdoor systems

Outdoor systems can either be conventional free-range (or free run) systems or organic systems. They only differ in the stocking density within the hen house. While conventional systems in the EU allow a stocking density of 9 birds per 1 m², organic systems only permit 6 hens per 1 m². The available outdoor space in both systems is 4 m² per laying hen or a maximum of 2,500 birds per hectare. The outdoor range can be available for the hens either directly through openings in the walls or via the covered winter garden [23]. The outside area is mostly covered with grass and should offer trees, bushes or shelters to protect the hens against predators, rain, bright sunshine or cold (Figure 3) [19,20].

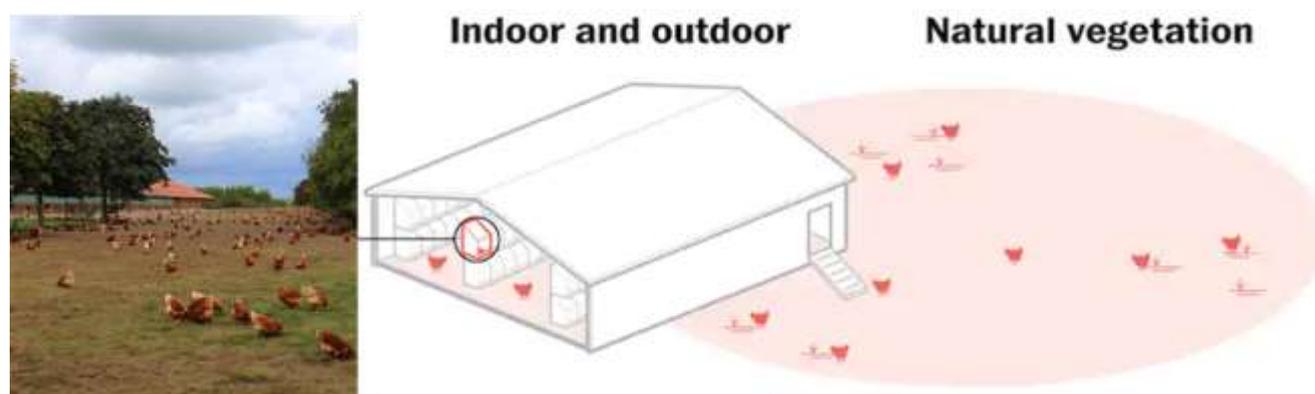


Figure 3: Free range system with range and protecting bushes
Source: Modified figure by Brulliard [19] and Windhorst [20].

2.4 Advantages and disadvantages of the housing systems

Regardless of the farming method, laying hens are susceptible to infectious or productive diseases, but also to varying degrees of damage to the body, from moulting to pecking, wounds and cannibalism. There are a number of underlying genetic and production management causes, including crowding, barren environments, and lack of loose litter. Some hen strains are more likely to develop the behavior than others, particularly the medium-heavy brown hybrid birds [24].

A comprehensive analysis of the welfare of hens kept in various housing systems was undertaken by the LayWel research project, funded by the European Commission and several member countries of the European Union. A collaborative effort among working groups in seven different European countries that examined data collected from 230 different laying hen flocks, the LayWel project evaluated 16 independent experiments to study stress physiology. The researchers found that measures were highly inconsistent; depending on the physiological parameter measured, welfare assessment ran the full spectrum from appearing to improve, compare to, or decrease in cages relative to alternative systems. Given their results, the LayWel project team emphasized that physiological measurements of stress must be interpreted with caution [25,26].

In the system of rearing in enriched cages we often observe feather pecking and cannibalism in flocks of hens the beaks of which were not trimmed. Manifestations of some high-priority needs, such as a dust bathing or foraging, are limited or even impossible to fulfil in the cage systems (Table 2) [27]. In the alternative systems the conditions for expressing normal behaviour are better, however, also in these systems some negative phenomena are observed, for example feather pecking is more difficult to control and there is higher risk of parasitoses or infectious diseases in free ranges. In litter systems combined with a slatted floor, there are large sections where "stress interventions" (flying-in birds, rodents, abrupt turning off light, human entry, noise) cause panic and hens cluster together and may even suffocate (Table 2). Also from an ecological point of view, manipulation with manure and bedding presents problems. The need for straw of 1 kg per m² per day at faeces production of 120 kg per 1,000 laying hens per day becomes an issue as not only so much litter material must be secured and safely stored but all manure after emptying the hall must be adequately treated and safely disposed of [18].

3. ECONOMIC EFFICIENCY OF EGG PRODUCTION

The prerequisite for the economic efficiency of the production of table eggs is the use of effective biological material, optimal breeding environment, full nutrition, treatment, operational management and proper organization of the production process. Use of modern computer technology, consistent registration of income and expenditure and continuous monitoring of the production cycle are recommended [29].

The main cost items for the production of table eggs include:

- rearing - the cost of rearing pullets,
- housing of hens - buildings, maintenance, operation of breeding halls,
- equipment - cages, feeders, drinkers,
- feed - used feed during the laying period,
- work - workers' salaries and administration,
- veterinary service - vaccination, treatment, drugs, veterinary service,
- mortality - loss of laying hens by mortality,
- other costs - energy, water, etc.

The main income items of farms focused on the production of table eggs include:

- sale of eggs,
- sale of hens after laying,
- sale of poultry manure as fertilizer [30,31].

Table 2: Synopsis of the advantages and disadvantages of the housing systems for laying hens

Housing system	Advantages	Disadvantages
Enriched cages	Low risk of diseases and infection with parasites	Risk of increase of feather pecking and cannibalism in non beak-trimmed groups of brown genotypes
	Comparatively low mortality	Substantial use of perches may result in keel bone damage
	Higher space, especially in colony nest systems	Increase of dust resulting from scratch mats and litter provision
	Better bone strength	Problems of depopulation in large colony nest systems with increased risk of bone fractures
	Low risk of bumble-foot	
Barn laid system without outdoor access	Higher space availability enables hens to express most species specific normal behavior patterns	High risk of parasitic diseases and infections due to contact with faeces
	Increased bone strength	High risk of foot pad dermatitis resulting from wet litter
	Higher space availability enables submissive hens to avoid contact with aggressive hens Higher space availability enables hens to express most species specific normal behavior patterns	Increased risk of bone fractures through collision with perches, nests and other amenities Highly variable risk of feather pecking and cannibalism resulting in high mortality values Subordinate hens may have limited access to feed and water because of bullying hens
		Increase of dust resulting from litter
Barn systems with outdoor access (free range systems)	Same advantages as in barn systems without outdoor access	Same as in barn systems without outdoor access
	Ability to forage and dust bathing in range	High risk of predation
		Increased risk of infections with internal parasites High risk of introduction of highly infectious diseases through wild birds

Source: Brulliard [18].

An example of costs and revenues within the production cycle per hen is given in the following Table 3. The table shows the structure of costs and revenues per 1 laying hen under average conditions, the result of the economic result

being favourable, i.e. profit per one laying hen for the laying cycle of 1,395 EUR at a rate of return of 6.42%. The table shows that the main items are feed (53.18%), depreciation of fixed assets (12.6%), pullets (11.52%), wages and other costs around 8%.

The main item in the cost of eggs – the feed, significantly affects production costs. In regions where there is a large and cheap production of feed crops (maize, wheat, soybeans) or access to sea (fish) providing animal protein, these feed mixtures account for up to 70-80% of production costs, thus significantly affecting the economy of egg production (China, India, USA, Argentina, Brazil). The largest producers of feed grains by the sea in the warm zone therefore produce the poultry products - eggs and meat, most efficiently [32].

In addition to feed, the efficiency of egg production is significantly affected by the climatic and local conditions. In the warm zone regions, layers are housed mostly in roofed cage systems or in ventilated halls. In temperate zones, air-conditioned halls are used that in addition to ventilation, must be heated during the cold seasons and their lighting is artificial throughout the year. In the colder zones, the most common are solid buildings with installed air conditioning and hens kept in cages or on floor [33]. Energy costs (heat, light) as well as those of building constructions are higher compared to farms located in warm areas (USA, Argentina, Brazil) and thus production costs per hen or per 1 kg of egg mass are higher [34,35].

Table 3: Cost structure and revenue to 1 hen

Item	Value	
	EUR	%
Rearing of pullets	2.764	11.12
Feed	11.561	53.18
Medicines	0.068	0.35
Wages	2.056	8.28
Depreciation of fixed assets	3.164	12.60
Energy (gas, electricity)	0.576	2.31
Services	0.270	1.09
Other costs (consumption goods, repairs)	2.220	8.93
Overhead	1.995	8.02
Death losses	0.270	1.10
Total costs	21.738	100 %
Sale of eggs	22.710	98.15
• sale of hens after laying	0.409	1.77
• sale of manure	0.020	0.08
Total revenues	23.133	100 %

Source: Halaj and Golian [32].

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4. PRICE AND SALE OF EGGS

The monetization of eggs determines the extent of demand, it depends on their price, potential economic power of consumers and the popularity of egg foods. In this respect, the supply of eggs must be continuous, uninterrupted at reasonable prices, of high quality, fresh and commensurate with the demands of consumers [36]. After the conversion of farms with conventional cages (banned from January 2012) to those with enriched cages, there has been a noticeable discrepancy between production costs and egg prices at sale, i.e. production became more expensive and unprofitable. The reduction of hens in conventional cages and compliance with welfare requirements rapidly increased the cost of production of table eggs and thus also their price, resulting in decreased consumption of eggs per capita particularly in countries with lower purchasing power and reduced egg production in many EU countries and increased imports from Asia or overseas where most laying hen farmers still produced eggs in conventional (obsolete) cage systems at lower cost [12].

The final price of the egg from its production to the counter is influenced by several factors. At one end is the hen farmer who grows or buys quality GMO-free feed. He can decide whether to lock them in cages or release them into free range. Of course, he has to live with his family out of something. At the opposite end is the trader who is trying to give saleswomen a decent wage, meets legislative obligations and increases the culture of sales in stores. Low price is one angle of vision and high price is the opposite one. Taking both aspects into account, it is impossible to clearly define that one angle of vision can permanently bring to balance the determination of the price of eggs [37].

Table 3 shows the difference between the prices of eggs sold on the farm that produces them and their prices in the market network - shops, wholesalers or retail chains. The table shows that there are significant differences in the prices of eggs sold on the farm and in the market network. The difference in the prices of eggs depends on the country. The increase by 19.2% in the Czech Republic and decrease by 4.5% in Switzerland indicates state subsidies for egg production in Switzerland while in other countries the change involves sales overhead. Significant differences are in the prices of eggs on the market where the costs of packaging, storage, sales overheads and the so-called trade margin are considered. Here the market price increase compared to cost of production is higher by 26% in India and 198% in the USA [32].

Table 3: Egg prices compared to production costs

Country	Cost of 1 egg/ US cents	Price of 1 egg/US cents		% price increase/100%	
		farm	marked	farm	marked
USA	3.66	3.92	10.92	7.10	198.0
Argentina	3.75	3.75	6.92	0.0	84.5
India	2.58	2.67	3.21	3.50	26.0
Hungary	6.42	6.67	9.0	3.8	40.2
Czech Republic	6.50	7.75	1.33	19.2	58.9
Japan	8.75	10.42	11.58	19.05	32.4
Switzerland	19.17	18.33	49.50	- 4.5	158.5

Source: Halaj and Golian [32].

The pricing policy for poultry products deserves special attention, as the retail chains sometimes increase their trade margins unjustifiably, which increases the price of eggs, lowers their consumption and is paid for by the middle and lower strata of society [38]. One way to reduce the price of eggs is to make them available to the consumer as soon as possible through market places, either directly on the farm (sale from the yard) or through buyers or large storehouses and moved to various trade organizations for sale or processing or long-term storage. The farmer may sell part or all of his production directly on the farm, or he may prefer different trade organizations that have their own trade chains [37].

5. CONCLUSION

Despite the inappropriate time pressure of retail chains to stop the sale of eggs from poultry farms by 2025, egg-producing farmers gradually try to reconstruct their farms for the use of free-range systems of rearing that are much safer than conventional litter systems in terms of egg quality and animal welfare. However, customers need to understand the fact that "mass" egg production is not compatible with alternative farming methods and the improvement of the welfare of laying hens. If the farmer satisfies the hen's daily needs and the hen has access to grassy run for foraging and to limestone for good quality of egg shells, its eggs cannot be sold for the price eggs produced in a cages, which are the cheapest.

6. CONFLICTS OF INTERESTS

Authors declare that there are no conflicts of interest.

7. ACKNOWLEDGEMENT

This work was supported by the Slovak project KEGA no. 006UVLF-4-2020 'Implementation of new scientific knowledge in teaching and improving the practical training of students in breeding technology from subject Animal husbandry'.

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