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ADÉL DOROTTYA ERDŐS, SZILVIA MOLNÁR, LÁSZLÓ SZŐLLŐSI

University of Debrecen, Hungary

EFFICIENCY OF TABLE EGG PRODUCTION IN DIFFERENT HOUSING SYSTEMS AND FARM SIZES: A CASE STUDY BASED ON THREE HUNGARIAN FARMS[1]

Key words: egg production, enriched cage, aviary, barn, cost-benefit analysis, efficiency

ABSTRACT. In the European Union, alternative housing systems (aviary, barn, free-range, organic) are increasingly used in laying hen populations (49.6%). Hungary is one of the member states where modified cage housing technology is prevalent, but this may change in the future. For this reason, the economic aspects of egg production farms with different housing technologies should be examined in Hungary. The aim of this study is to present the production and economic indicators of three different sized Hungarian egg producing farms using three different housing methods (enriched cage, aviary, barn). The main finding is that all three farms are profitable, regardless of farm size and technology used. The obtained results, in conformity with technical literature sources, show that the cost of eggs is the lowest in the cage-based farm. However, economies of scale also play an important role in the case of the examined farms. In addition, higher sales prices were observed in the case of smaller farms using alternative technology, which is both due to the direct sales channel and the higher value of eggs produced by alternative technology recognised by consumers.

INTRODUCTION

Eggs play an important role in human nutrition and are part of a balanced diet, even in economically advanced countries with a high quality of life, since it is rich in vitamins, minerals and amino acids, despite being one of the cheapest sources of animal protein. Because of these properties, eggs are associated with factors such as "the most perfect thing in the Universe" or "food miracle" [Ruxton et al. 2010, Pllana et al. 2015, Griffin 2016, Szőllősi et al. 2017].

Global egg production exceeded 80 million tons in 2017, an increase of about 34% over the past nearly 10 years. The world's top 3 egg producing countries are China (39%), the USA (8%) and India (6%) [FAO 2019]. In parallel with egg production, the yearly consumption of eggs per capita increased and exceeded 9 kg per person per year in 2013. However, there is a significant difference in consumption between countries. In 2013, most

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eggs were consumed in Japan (19.2 kg/person/year). In comparison, it was 24% lower in the US [FAO 2019]. In the same year, the yearly consumption of eggs per person in the European Union was 12.5 kg, which increased by 4.8% by 2018 [EC 2018].

In contrast to global production, the European Union's (EU-28) production of table eggs did not change significantly over a decade, reaching almost 6.6 million tons in 2018. Among the largest egg producers in Member States are France (889,000 tons), Germany (832,000 tons), Spain (793,000 tons), Italy (770,000 tons), the United Kingdom (680,000 tons), the Netherlands (625,000 tons) and Poland (535 thousand tons), which together account for 78% of total European Union production [EC 2019]. EU egg production is forecast to grow by 9.5% and consumption by 8.6% over the next decade [EC 2018].

Contrary to the international trend, egg production has decreased significantly in Hungary. While 4.7 billion eggs (296,000 tons) were produced in 1990, by 2017 this value fell to 2.4 billion (150,000 tons), which is a 49% decrease [HCSO 2018, EC 2019]. In parallel with the decline in production, the annual consumption of eggs per capita also decreased drastically. In 1990, egg consumption was 389 eggs/person/year, while, in 2017, it was only 238 eggs, showing a 39% decrease [HCSO 2018].

According to Council Directive 1999/74/EC, producers had to cease the production of laying hens in conventional cages from 1 January 2012. Among other things, this Directive has led to a change in the weight of the different housing methods in the EU, with 50.4% of hens in enriched cages in 2018 and 49.6% in alternative (aviary, barn, free range, organic) housing. Alternative technologies are dominant in Luxembourg (100%), Austria (99.2%), Germany (93.5%), Sweden (90.8%) and the Netherlands (83.9%). In contrast, enriched cage technology plays a significant role in Poland (84.5%), Spain (82.3%), Portugal (90.1%) and Hungary (70.4%) [EC 2019]. The role of alternative technology is expected to grow further in the future [McDougal 2017].

Previous research [Damme 2011, Bessei 2011, Dekker et al. 2011] shows that, from cage housing to alternative technologies, not only production efficiency (stocking density, egg yield per hen, feed consumption) deteriorates, but there is also higher specific labour utilisation and forage area demand, as well as less favourable energy use and greenhouse gas emissions (carbon dioxide, ammonia, nitrogen oxide, methane). In addition, the unit cost is 17% higher in barn compared to enriched cage and 32% in free range [Van Horne 2019].

Masoumeh Bejaei et al., [2011] found that the majority of consumers believe that eggs from free-range or organic production have a higher nutritional value than eggs produced with regular housing methods. In our point of view, nutritional value is influenced by feeding and not the used housing method. Conversely, in Hungary, due to a lack of solvent demand, the role of free-range and organic farming, as well as the proportion of table eggs produced in this way, will not increase significantly [Szabó 2017]. This is also supported by the results of Szilvia Molnár and László Szőllősi [2015], according to which, in Hungary, the price of the product is more important than animal welfare and the method of production when buying eggs.

The aim of the study is to present the production parameters and economic situation of three Hungarian egg producing farms using different housing technologies (enriched cage, barn and aviary) with different farm sizes in a case study form.

RESEARCH MATERIAL AND METHODS

Both primary and secondary data were used in the research. Secondary data were obtained from various Hungarian and international databases and published articles. Primary data was collected and processed from three Hungarian egg production farms, which use different housing systems (enriched cage, aviary and barn) and have different farm sizes. Primary data collection was based on data from 2016-2017 and focused on production and technological parameters (farm size, used hybrid, change in the animal stock, egg production, feed consumption and other expenditure), input and output prices, as well as average cost items. Based on the collected data, the cost and income situation of egg production in the examined farms were determined using a deterministic simulation model similar to the methodology of László Szőllősi and István Szűcs [2014]. The length of the production period differed on the examined farms, therefore, for the sake of the comparability of their economic indicators, the obtained results are provided on a yearly basis.

RESEARCH RESULTS

Farms that use different housing technologies have different sizes. Farm 1 is one of the largest farms in Hungary with 153,000 hens, while farms using alternative technology are smaller (10,000 and 3,000 hens). For this reason, the size of the stables for laying hens also varies. The difference in stocking density is mainly due to technology, as Farm 1 has a multi-storey cage system, Farm 2 has a multi-storey alternative (aviary) and Farm 3 has a single-storey alternative (barn) housing system. The hybrid used was Bábolna Tetra SL and Lohmann Brown Lite. The length of the production cycle was different (52, 73 and 65 weeks for the three farms, respectively). The larger farm produces its own feed materials and produces the compound feed itself. In contrast, the other two farms buy the raw material, but the feed is self-produced. The rearing of pullets is also only done by the larger farm as the other two purchases them on a regular basis (Table 1).

Table 1. Main data of analysed farms

Denomination	Unit	Farm 1	Farm 2	Farm 3
Housing system	-	enriched cage	aviary	barn
Farm size	hen	153,600	10,000	3,000
Stable	m^2	7,000	1,161	480
Stocking density	hen/m^2	21.94	8.61	6.25
Hybrid	-	Bábolna Tetra SL	Lohmann Brown Lite	Bábolna Tetra SL
Length of production period	weeks	52	73	65
Ingredients of feed	-	own-produced	bought	bought
Compound feed	-	own-produced	own-produced	own-produced
Pullet	-	own-produced	bought	bought

Source: own data collection and calculation

Table 2 shows that the average egg production intensity of each farm varied on a yearly basis. Farms 1 and 3 produce according to the values expected by the breeding company (Bábolna Tetra) (~85-86%). In contrast, Farm 2 performs below Lohmann's expected yield (~80%) and is unable to even reach the production levels of the other two. This is basically explained by the high mortality rate in the farm, as well as the problems related to animal health and pullet rearing.

Table 2. Comparison of egg production

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)	Recommendations of the breeding company	
					Bábolna Tetra	Lohmann
Average egg production per year	%	85.97	80.11	84.90	83.96	84.44
Egg production per year	eggs/hen	310.19	281.61	305.68	303.80	311.40

Source: own data collection and calculation and based on [Lohmann Tierzucht 2014, Bábolna Tetra Ltd. 2018]

The estimated one-year egg production per hen is 310 units for Farm 1, while Farm 3 only produces 5 eggs less. In comparison, Farm 2 shows a significantly lower value (281 eggs/hen/year). Compared to the results calculated by László Szőllősi et al. [2019] based on the data of the Hungarian Farm Accountancy Data Network (FADN), it can be concluded that all three examined farms perform better than both the Hungarian average (267 eggs/hen/year) and that of Hungarian farms with similar technology and of similar size (less than 50 thousand hens, cages: 289 eggs/hen/year; between 1 and 10 thousand hens, barn: 273 eggs/hen/year).

Table 3 shows that for the three farms, the proportion of Class A eggs is between 95% and 98%. Mortality was highest at Farm 2 (8.8%). In comparison, the other two farms show significantly lower values (2% and 2.5%, respectively). A study by Lesley Nernberg [2018] has also shown that the mortality rate in aviary may even be more than twice that of cage housing, which can be explained, among other things, by low calcium levels and injuries. The daily feed consumption per hen varies in each farm. The lowest value was obtained on Farm 2 (110 g/hen/day), while those of the other two were 14% and 32% higher, respectively. This phenomenon is due to the lower average weight of the hybrid used on Farm 2. To produce a single egg, Farm 1 and Farm 2 need approximately the same amount of feed (145-147 g/egg), while Farm 3 needs 24-26 grams more. This finding is consistent with the calculations of Sanne Dekker et al. [2011], according to which hens kept in a barn system have a higher specific feed requirement.

When analysing the economic indicators of individual enterprises, it is worth examining how input and output prices develop. Farm 1 has the lowest pullet purchase price (2.5 Euro/pullet), which they can obtain due to the fact that they have their own pullet breeding system. In contrast, the other two farms can buy pullet at a price higher by 1.9-2.3 Euro.

Table 3. Other physical efficiency indicators

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)
The rate of "A" class egg	%	95	97	98
Mortality rate in henhouse	%/year	2.0	8.8	1.9
Feed consumption	g/hen/day	125	110	145
Feed consumption	kg/hen/year	45.12	38.70	52.24
Feed consumption	g/egg/year	145	147	171
Average body weight of spent layer (at the end of production)	kg/hen	1.98	1.89	2.10

Source: own data collection and calculation

The prices of feed mixes for different farms followed similar trends. Prices of feed mixes of the examined farms are 2.8-12.1% lower than the average Hungarian prices [HPPB 2017], which is partly due to their own production of feed (Table 5).

The sales price of eggs plays an important role in the development of revenue. It can clearly be seen that the small-sized Farm 3 can achieve the highest selling price, which can be explained by the direct sales channel and the realisation of the alternative technology product in the market price. In comparison, Farm 1 achieves a 20% lower sales price, which is basically explained by the fact that the larger Farm 1 sells a major part of its extensive commodity base to larger multinational retail chains at lower prices. This tendency is also related to the findings of Virág Szabó [2018]. At the same time, the difference in housing technology (the price of cage eggs is lower) is likely to be present, too, but this data cannot be demonstrated and substantiated. The selling price of Farm 2 is around the same as that of Farm 1, even though it uses alternative technology.

Comparing the average egg sales prices of the examined farms with the average of Hungarian companies with similar technology and farm size [Szőllősi et al. 2019, based on Hungarian FADN], Farm 1 could reach a 13% higher price, while Farm 3 had nearly the same value. Compared to the calculations of Virág Szabó [2018] (for the period between 2004-2014), the sales prices in the examined farms are 6-26% higher than the national average of companies with similar technology and farm size. Other sources of revenue for businesses include the sale of spent layers and manure (Table 4).

The cost structure of farms with different housing methods and farm sizes are also different from each other. The highest cost item is the feed cost for each farm, which amounts to 48-55%, depending on the given farm. The second highest cost item is the labour cost, which is the lowest (10%) for large Farm 1. In comparison, the cost of human resources is nearly 4.5% higher on Farm 2 and 16% higher on Farm 3. The depreciation rate of the breeding animal, as the third highest cost item, is similar on all three farms (14-17%).

When comparing farm direct production costs, there are differences in magnitude due to different farm sizes. In terms of direct cost per hen, Farms 1 and 2 are similar, while that of Farm 3 is 6-7 Euro higher, which can be explained by smaller farm size and stocking

Table 4. Input and output prices of the examined farms

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)
Input prices				
Pullet	Euro/pullet	2.47	4.35	4.77
Pre-layer feed	Eurocent/kg	19.82	19.02	21.01
Layer I feed		20.89	19.97	22.10
Layer II. feed		20.14	20.29	20.84
Layer III. feed		-	18.62	-
Output prices				
Class A egg	Eurocent/egg	7.34	7.44	9.18
Class B egg		2.74	-	3.22
Spent layer	Euro/spent layer	0.40	0.93	2.26
Manure	Euro/ton	6.44	4.83	6.44

Source: own data collection

density and higher feed consumption of the latter farm. The direct cost per hen of small-scale Farm 3 is 3 Euro higher than the average production cost per hen of Hungarian farms with similar technology and size [Szőllősi et al. 2019, based on Hungarian FADN]. In contrast, the respective value of Farm 1 is lower by the same amount.

There is no significant difference between the direct costs of Farm 2 and Farm 3 per m^2 of stable. In contrast, this cost is around 2.5 times higher on large Farm 1, due to its higher stocking density. In the case of the direct cost per egg, the lowest value could be realised on Farm 1. This value is 0.9 Eurocents higher for Farm 2 and 2.1 Eurocents higher for Farm 3. Thus, alternative technology farms have a 26-37% higher direct cost per egg (Table 5). According to Peter van Horne [2019], the cost of production per unit of primary product is about 17% and 32% higher in the case of alternative housing methods (barn and free range). Our result is in accordance with this finding, even though the difference in size is a partial reason for this difference.

Table 5. Direct cost of egg production

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)
Direct cost	Euro/year	2,596,826	180,282	70,596
Direct cost per hen	Euro/hen/year	16.9	18.0	23.5
Direct cost per m^2	Euro/m^2/year	371.0	155.3	147.1
Direct cost per main product	Eurocent/class A eggs/year	5.7	6.6	7.9

Source: own data collection and calculation

Of the different elements of production value, the highest proportion is represented by the revenue from the sale of Class A eggs, supplemented by the sales of Class B eggs (except Farm 2), the sale of manure and the subsidies received (except Farm 3). The magnitude difference between farm-level values projected for one year reflects differences in farm size. In terms of production value per hen, Farm 3, which has the smallest farm size, realised the highest value resulting from higher sales prices and favourable yield per hen. In comparison, the other two farms' production value per hen is 6-7 Euro lower. Farm 1 achieved a production value per hen of approximately 1 Euro higher, while Farm 3 reached a production value 3 Euro higher than the average of Hungarian farms with similar technology and farm size [Szőllősi et al. 2019, based on Hungarian FADN]. In terms of production value per m^2, alternative farms reached 2.5 times lower values than Farm 1. The reason for this outcome is related to significantly lower stocking densities and less favourable utilisation of stable capacity. In contrast, in terms of production value per egg, Farm 3 is able to reach the highest value, which is basically due to higher selling prices (Table 6).

Table 6. Production value of egg production

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)
Production value	Euro/year	3,503,309	215,979	87,948
Production value per hen	Euro/hen/year	22.8	21.6	29.3
Production value per m^2	Euro/m^2/year	500.5	186.0	183.2
Production value per main product	Eurocent/class A eggs/year	7.7	7.9	9.8

Source: own data collection and calculation

The difference between the production value and direct production cost is the gross margin. It should be noted that the small farm using barn housing (Farm 3) is able to achieve the same amount of gross margin per hen (~6 Euro/hen) in one year as the large cage farm (Farm 1). The gross margin per hen in the aviary farm is 2 Euro lower than the above mentioned ones, which is explained by a lower production level due to the problems mentioned above. Compared to the average of Hungarian farms with similar technology and farm size [Szőllősi et al. 2019, based on Hungarian FADN], Farm 3 realised similar gross margin per hen, while Farm 1 was able to realise a value significantly higher (by 5 Euro per hen). The amount of gross margin per square meter of stable for Farm 1 is 3-3.5 times higher than for the other two farms, which is related to the better utilisation of stable capacity. The gross margin per unit of main product is nearly the same for Farm 3 and Farm 1. In contrast, Farm 2 realised around half of this value (Table 7).

Efficiency indicators were also compared for each of the examined farms. One of the most important of these indicators is the direct unit cost, which is set per unit of Class A eggs. For the farms surveyed, Farm 1 is able to produce at the lowest unit cost (5.4 Eurocent/egg), which is due, among other things, to the applied housing technology, the

Table 7. Gross margin of egg production

Denomination	Unit	Farm 1 (enriched cage)	Farm 2 (aviary)	Farm 3 (barn)
Direct cost	Euro/year	2,596,826	180,283	70,597
Production value		3,503,309	215,979	87,949
Gross margin		906,483	35,696	17,352
Gross margin per hen	Euro/hen/year	5.9	3.6	5.8
Gross margin per m^2	Euro/m^2/year	129.5	30.7	36.1
Gross margin per main product	Eurocent/Class A eggs/year	2.0	1.3	1.9

Source: own data collection and calculation

below-market level cost of pullets (own pullet production), higher stocking density and economies of scale. Farms 2 and 3 are able to produce a single Class A egg at a 30-33% higher unit cost.

Comparing the unit costs of the examined farms with the average data of Hungarian farms with similar technology and size [Szőllősi et al. 2019, based on Hungarian FADN], cage farms reach 21% lower unit costs while that of farms using barn technology is 3% lower.

Farm 1 has a cost-to-profit ratio of 35%, while that of Farm 3 is 26%. The latter is very favourable, considering the small farm size and the barn housing technology. In comparison, Farm 2 has a significantly lower cost-to-profit ratio (8%) but is relatively good compared to other livestock sectors.

Human resource efficiency is most favourable in the large cage farm (13.22 Euro production value per Euro labour cost). In comparison, this value is 43-44% lower on smaller farms using alternative housing technologies.

SUMMARY AND CONCLUSIONS

Altogether, all three farms are profitable, regardless of the size of applied technology. The unit cost was the lowest on the large farm using cage technology (5.4 Eurocent/egg), which can be explained, among other things, with the cage technology, the resulting higher stocking density, economies of scale and the farm's own pullet rearing system. This finding is partly related to various literature sources on housing technology. On smaller farms using alternative technology, the unit cost of eggs was 30-33% higher. The different sales prices of the examined farms were significantly influenced by their geographical location and sales channel. In the case of smaller farms using alternative technology, higher sales prices were found, which is due both to the direct sales channel and the higher value of eggs produced with alternative technology as recognised by consumers. The large cage farm sells its large commodity base to multinational retail chains at lower prices (by about 20%).

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EFEKTYWNOŚĆ PRODUKCJI JAJ W ZALEŻNOŚCI OD WIELKOŚCI GOSPODARSTWA I SYSTEMU UTRZYMANIA NIOSEK: STUDIUM PRZYPADKU TRZECH GOSPODARSTW WĘGIERSKICH

Słowa kluczowe: produkcja jaj, wzbogacona klatka, woliera, stodoła, analiza kosztów i korzyści, efektywność

ABSTRAKT

W Unii Europejskiej stosowane są coraz częściej (49,6%) alternatywne systemy chowu kur niosek (woliera, stodoła, chów wolnowybiegowy, ekologiczny). Węgry są jednym z państw członkowskich, w którym dominuje zmodyfikowana technologia chowu klatkowego, ale w przyszłości może się to zmienić. Z tego powodu podjęto próbę zbadania ekonomicznych aspektów produkcji jaj w gospodarstwach stosujących różne technologie utrzymania kur niosek. Przedstawiono produkcyjne i ekonomiczne wskaźniki trzech węgierskich gospodarstw produkujących jaja o różnych rozmiarach, przy stosowaniu trzech różnych metod chowu (wzbogacona klatka, woliera, stodoła). Stwierdzono, że wszystkie trzy gospodarstwa są rentowne, niezależnie od wielkości gospodarstwa i zastosowanej technologii produkcji jaj. Uzyskane wyniki, zgodnie ze źródłami literatury przedmiotu, wskazują, że najniższy koszt jaj uzyskiwano w gospodarstwie z klatkowym systemem chowu. Jednak w przypadku badanych gospodarstw również ważną rolę odgrywały korzyści skali. Ponadto, wyższe ceny sprzedaży zaobserwowano w przypadku mniejszych gospodarstw, stosujących alternatywne technologie, co wynikało zarówno z bezpośredniego kanału sprzedaży, jak i z wyższej wartości jaj produkowanych przez zastosowanie alternatywnych technologii – docenianych przez konsumentów.

AUTHORS

LÁSZLÓ SZŐLLŐSI, ASSOC. PROF., PHD
ORCID: 0000-0003-3571-1382
University of Debrecen
Faculty of Economics and Business
138 Böszörményi St.
Debrecen, H-4032, Hungary

ADÉL DOROTTYA ERDŐS, PHD STUDENT
ORCID: 0000-0002-2625-7512
University of Debrecen
Faculty of Economics and Business
138 Böszörményi St., Debrecen, H-4032, Hungary

SZILVIA MOLNÁR, DOCTORAL CANDIDATE
ORCID: 0000-0002-9967-3146
University of Debrecen
Faculty of Economics and Business
138 Böszörményi St., Debrecen, H-4032, Hungary