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RESEARCH ARTICLE

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Multi-criteria decision-making model in the strategic planning of table egg production in the Republic of Croatia

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Abstract

Until 2012, egg production in Croatia was mostly in cages, which was not in accordance with the European Union standards on the welfare of laying hens. Therefore, producers of table eggs could not continue their current practice and had to use those systems permitted in the EU member countries, such as organic, free-range, indoor or enriched cages. The aim of this study was to analyse and evaluate various systems of table-egg production using a method of multi-criteria analysis called the Analytic Hierarchy Process (AHP). Thus, the aim was to determine scientifically which production system was the favoured option for the Croatian poultry sector. According to the results, production of eggs using an indoor system for housing hens was the best option (priority 0.317). This was followed by a free-range system (priority 0.242). The third-ranked alternative egg production system was in cages (priority 0.237), while the fourth and the least acceptable alternative refers to egg production according to organic principles (priority 0.202). Based on the results of the multi-criteria analysis and respecting the worldwide trends that reflect changes in consumers' habits and their concerns for food safety and quality, as well as their preference for local markets and local products, it is recommended that eggs be produced in an indoor system of keeping laying hens. In this sense, egg production on small farms provides the possibility of self-employment and creation of additional income to contribute towards overall economic and social development of rural areas.

Additional keywords: egg production system; Analytic Hierarchy Process; indoor system of keeping hens.

Abbreviations used: AHP (Analytic Hierarchy Process); AU (Animal Unit); CI (Consistency Index); CR (Consistency Ratio); CV (Coefficient of Variation); EU (European Union); FD (Feeding Day); HRK (Croatian Kuna); RI (Random-like Matrix).

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Introduction

In recent years, there has been a noticeable decrease in table egg production in the Republic of Croatia. Self-sufficiency in egg production in 2013 was about 94.4%. After several years of continuous decrease in egg production, during 2013 there was an increase in production of 3.5% compared to the previous year. However, production was still significantly lower than in 2009 (Ministry of Agriculture, 2014). Intensive changes and measures to adjust egg production were associated, not only with an increase in prices of food and energy on the input market, but also with harmonisation of Croatian legislation on the welfare of laying hens with European Union standards (Crnčan *et al.*, 2013). Therefore, producers of table eggs had to use those systems for keeping laying hens permitted in the EU member countries, such as: organic, free-range, indoor and enriched cages.

A particular issue in this sector is provision of facilities for keeping laying hens, which need to be in accordance with the regulations on laying hens' welfare, since, until 2012, eggs in Croatia were produced mostly in cages. The European Union Council Directive 1999/74/EC regulation (EC, 1999) affects the economics of egg producers. On example of eight EU countries Van Horne & Bondt (2017) estimated that additional costs directly related to EU legislation are 16% of the total production costs of eggs for the situation in 2015. For small producers in Croatia, large problem are the

investment costs necessary to ensure the requirements of the EU regulation. Changes in keeping facilities required significant additional investments, which resulted in reducing or even ceasing production, while producers that continued with production faced reduced efficiency caused by lowering of the number of animals kept in existing production areas, as well as additional investments. Producers have to combine strict regulations on animal welfare with efficient and cost-effective business. Any sector of agricultural production, including egg production, aims to ensure sustainability of agricultural business entities, to use inputs rationally and to protect the environment. Therefore, in making business decisions, it is important to choose technological processes of production and technical means in order to achieve organisational and economic objectives. Business decisions should not be based on the optimisation of only one element, ignoring other technological and economic factors (Srđević, 2003; Kay *et al.*, 2007). In order to deal with the issue of several criteria, principles and some unknowns, there are methods of multi-criteria decision-making that are used to find solutions by taking into account a decisive factor (Tiwari *et al.*, 1999; Hadelan, 2010).

The data collected in this study were processed by the method of multi-criteria decision-making called Analytic Hierarchy Process (AHP). Besides calculation of organisational and economic indicators of production in organic, free-range, indoor and cage systems of keeping laying hens, the overall assessment also included qualitative indicators, *i.e.* technological and market indicators. The purpose of analysing systems of keeping laying hens was triggered by a change in corresponding legislation, which had been complied with by only 48% of 147 producers so far (Ministry of Agriculture, 2014). Laying hens were mostly kept in cages, and organic production was the least represented. The necessity for assessing and ranking of systems of keeping laying hens was prompted by high investment costs and the growing interest of consumers for organically produced food. There is the issue raised on efficiency of producing eggs in alternative systems (organic, free-range, indoor housing), as well as on assessing market value of such products.

In this research and analysis, the AHP was applied as one of the methods of multi-criteria decision-making in order to select from the four alternative systems of production: (1) production of eggs in enriched cages; (2) production of eggs in an indoor system; (3) production of eggs in a free-range system; and (4) production of eggs in an organic system.

Enriched cages are similar to conventional battery cages, but contain a nest, perches and litter material and provide 600 cm^2 of 'usable' space per hen. Non-cage systems may be single or multi-tiered (up to four levels), with or without outdoor access. Indoor non-cage systems are also referred to as aviaries. They have a maximum stocking density of 9 birds/m^2 of usable space and one nest for every seven hens. In addition to these requirements, free-range systems must provide continuous access during the day to outside areas, which must be mainly covered with vegetation (Pickett, 2007). The organic system is very similar to the free-range system. Hens must have outside access but must be fed only with organic feed and antibiotics cannot be used as a preventative measure, but can be used in case of illness. Around 60% of laying hens in the Member States of the EU are housed in cages, with the highest proportion (over 97%) occurring in Spain. On the other hand, the highest share (96%) of non-cage egg production occurs in Austria (CIWF, 2013).

Each of the four alternative systems exhibits certain advantages and disadvantages with respect to technological, economic and market requirements. Therefore, there are conditions and requirements provided for the application of multi-criteria decision-making. In a practical sense, the application of the multi-criteria decision-making model provides a comprehensive basis for producers of table eggs, aiming to facilitate better decision-making and long-term planning of production. The aim of this study is to analyse and evaluate various systems of table egg production using multi-criteria analysis, specifically the AHP method, to make decisions about strategic planning of production. Comparison and connection of technological and economic models with multi-criteria decision-making in production planning represents a new approach to the development of system for decision-making support, thus being one of the research priorities in agricultural management (Herrero *et al.*, 1999; Pažek & Rozman, 2007a; Andalecio, 2010; Vera-Montenegro *et al.*, 2014).

Material and methods

This study describes and implements a method of multi-criteria analysis called the AHP (Saaty, 1977). The AHP consists of three elements: aim of decision, criteria for measuring quality of alternatives and alternatives, and assessment of possible solutions, based on which the best solution to a problem can be found (Pažek & Rozman, 2007b; Pascoe *et al.*, 2009).

The structure of the typical decision problem consists of a number (X) of alternatives and a number (Y) of decision criteria. Each alternative can be evaluated in terms of the decision criteria, and the relative

importance (or weight) of each criterion can also be estimated. Therefore, a_{ij} (I = 1,2,3,...X) represents the performance value of the i-th alternative (*i.e.*, A_x) in terms of the j-th criterion (*i.e.*, C_Y). Also, W_Y is the weight of the criterion C_Y. Then, the core of the typical multiple-criteria decision-making problem can be represented by the decision matrix (Triantaphyllou & Mann, 1995):

	Criterion			
	C_1	C_2	C_3 ...	C_Y
Weights	W_1	W_2	W_3 ...	W_Y
Alternatives				
A_1	a_{11}	a_{12}	a_{13} ...	a_{1Y}
A_2	a_{21}	a_{22}	a_{23} ...	a_{2Y}
A_3	a_{31}	a_{32}	a_{33} ...	a_{3Y}
. . . . .				
. . . . .				
. . . . .				
A_X	a_{X1}	a_{X2}	a_{X3} ...	a_{XY}

According to AHP the best alternative (in the maximization case) is indicated by the following relationship:

$$A_{AHP}=\max\sum_{j=1}^{Y} a_{ij} \cdot W_j \text{ for } i=1,2,3\ldots X,$$

where W_j is the relative weight of the j-th criterion.

This is one of the most well-known and most frequently used methods for selecting from or ranking of several available options, based on several criteria of different importance expressed by different ranks (Begičević *et al.*, 2009). The first step in the AHP method is to determine the relative importance of criteria by mutual comparison in pairs. Comparison of AHP elements is carried out by using the Saaty's scale of importance intensity, consisting of nine stages with intermediate values of 2, 4, 6 and 8.

When selecting a system for keeping laying hens for production of eggs from the four possible alternatives (cages, indoor, free-range and organic), apart from the above reported and analysed economic indicators, it is necessary to include technological factors and market indicators. Multi-criteria analysis, as a tool for rationalisation of the business decision-making process, is applied due to the fact that only one of indicators, such as economic indicators, is usually insufficient for making important strategic decisions. The multi-criteria model used, with alternatives, criteria and sub-criteria, is presented in Figure 1.

Applied criteria refer to technological, economic and market criteria. Technological criteria with sub-criteria refer to production risks, utilisation of facilities and provision of comfort for animals, ensuring natural living conditions and welfare. Economic sub-criteria refer to financial results, labour productivity, efficiency

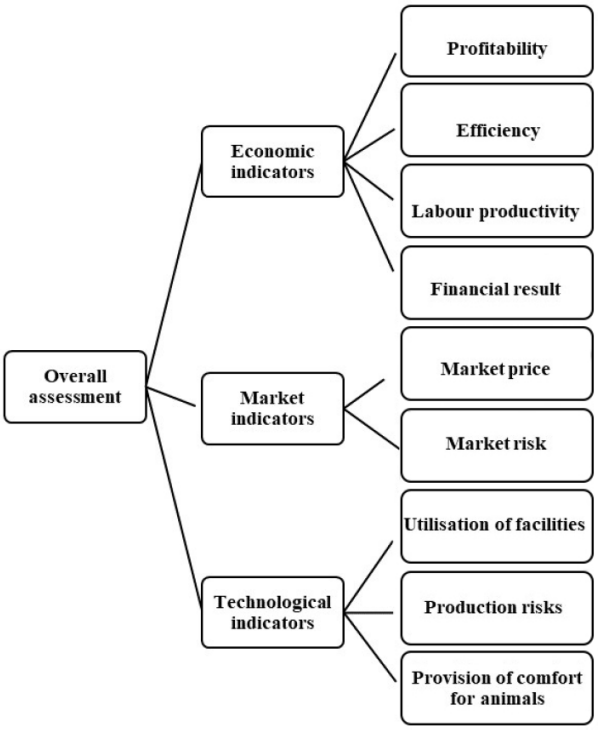

Figure 1. Hierarchical model of decision-making with the appropriate criteria and sub-criteria. *Source*: own elaboration.

(total income/total cost) and profitability of production (net profit/annual cost). For calculation of the values of the reported quantitative economic indicators, data were obtained from a survey carried out among egg producers that were registered in the Register of farms of laying hens in Croatia (n = 42). Market criteria comprise sub-criteria relating to product image (assumption that eggs produced in alternative systems are characterised by a better image than eggs produced by laying hens kept in cages), market risk (implying the impossibility of selling or changes in price of eggs if compared to prices valid at the time of egg production) and the market price of eggs. These qualitative criteria with sub-criteria were assessed by survey participants (n = 41). All the criteria and alternatives were evaluated by 31 experts from the Croatian scientific and educational institution and agricultural advisory service, as well as 10 randomly chosen farmers – eggs producers. Synthesis of individual priorities was then performed to group the assessment of production systems. Quantitative economic indicators or sub-criteria were also added to the analysis to enable the assessment and ranking of the different systems according to all criteria and sub-criteria. Based on assessment of the importance of defined criteria and corresponding sub-criteria, the model was evaluated in the last phase, *i.e.* the assessment and ranking of each system was performed. Intensity of preferences of each survey participant was added to the analysis which was performed using Expert Choice software, which supports AHP. In calculating the weights, pairwise comparison judgments of market and technological indicators were used and the Data grid STEP function used for economic indicators. A characteristic of AHP is to obtain some degree of inconsistency because personal subjectivity plays an important role in the pairwise comparison (Baba *et al.*, 2017). AHP calculates a Consistency Ratio (CR), comparing the Consistency Index (CI) of the matrix with expert judgments versus the consistency index of a random-like matrix (RI). If the CI is in excess of 0.1, the judgments are untrustworthy. Fortunately, the software Expert Choice identifies inconsistency and guides users to review and reconsider or confirm priorities. Aggregation of individual assessments to a group decision is based on the geometric mean.

In addition to the reported method, which forms the central part of this research, the following analyses and methods were used: descriptive and statistical methods, absolute and relative indicators of production efficiency, and expert evaluation and group decision making. In the descriptive analysis, applied central tendency measures are arithmetic means to mark the average value of an indicator in the sample, and the median as a mean value of numerical characteristic (Kralik *et al.*, 2013). In addition, the Kruskal-Wallis test for non-parametric analysis was also used.

Results

According to data from the Ministry of Agriculture (2014), there were 79 registered table egg producers, of which 42 participated in the survey (53%). According to the number of farms and the type of participant in terms of egg production system, the most well-represented system for keeping laying hens was the cage system (45.24%). This was followed by the free-range keeping system (26.19%) and the indoor keeping system (26.19%); the least well-represented egg production system was the organic system (2.38%).

The Kruskal-Wallis test demonstrated that there was a statistically significant difference between the number of animals kept in each system (χ^2 (3) = 19.60, p = 0.0002). The majority of survey participants (19) produced eggs in cages with an average number of 30,421 laying hens. These data indicate that the largest number of registered egg producers in the Croatian territory produced eggs in cages, and that the largest number of animals were kept in cages. Furthermore, the cage system showed the largest range between the minimum and the maximum number of animals. The largest of number of laying hens per producer using the cage system was 220,000, whilst in the free-range system of keeping laying hens, the highest number of animals per producer was 5,500. This difference in the maximum number of laying hens between the different systems can be linked to the advantages of keeping hens in cages compared with some alternatives, in terms of a larger number eggs produced, lower mortality rate, reduced average consumption and better conversion of feed, and a higher concentration of animals in less space. Data for the organic system are not presented as they relate to just one producer in Croatia, with a capacity of only 150 laying hens.

The highest daily feed consumption was recorded for the free-range system with 130 g/feeding day (FD), while feed consumption by hens kept in cages had the lowest value (123.8 g/FD). In organic production, feed consumption was the highest; the producer reported that chickens consumed 150 g/FD. The average number of eggs and variability in the number of eggs per laying hen kept in each production system are presented in the Table 1, showing significantly higher variability in the number of eggs per laying hen kept in the free-range and indoor systems, with a high CV of 22.39% for the free-range system, and 11.94% for indoor system, compared to the cage system.

Table 1. Average number and price of eggs per hen, and average price of eggs (HRK/egg), based on L class eggs.

Keeping system	Number of producers	Average	Median	SD	CV (%)
Average number and price of eggs per hen					
Cages	19	281.21	287	23.79	8.46
Indoor	11	247.09	250	29.51	11.94
Free-range	11	234.45	220	52.49	22.39
HRK/egg					
Cages	19	0.84	0.80	0.14	17.81
Indoor	11	1.05	1.05	0.15	14.75
Free-range	11	1.18	1.20	0.19	16.85

SD: standard deviation. CV: coefficient of variation. *Source*: Own elaboration.

Producers of eggs using the cage system had a yearly average number of eggs per laying hen that was 12.1% higher than with the indoor system and 16.73% higher than with the free-range system. Organic production achieved on average 175 eggs per hen, which was the lowest number of eggs compared to other systems. According to the survey results for the number of eggs laid per hen, the ranking of the systems was as follows: cage, indoor, free-range and organic.

In addition to the number of eggs per laying hen, production systems also differed in terms of the price of eggs on the market. According to the survey, there was a price difference in favour of alternative systems. Higher CV for prices of eggs produced in cages indicates a greater variability than prices of eggs produced indoors and in a free-range system. According to the data from one producer, average selling price of eggs from an organic system amounted to 1.50 HRK[1] for the L class eggs. Basic statistical indicators with respect to the prices of eggs from different production systems are presented in the Table 1.

With regard to the average price of eggs produced in the different systems, it can be concluded that eggs produced in alternative systems achieved a higher selling price compared to eggs produced in cages. Therefore, eggs produced in the indoor system had a selling price that was on average 20% higher than the price of eggs produced in cages, and the price of eggs produced in the free-range system was on average 28% higher than the price of eggs produced by hens in cages. According to the above data, the highest price was attributed to eggs from organic and free-range systems then to eggs produced indoors, and, finally, eggs with the lowest sale price were produced in cages.

Based on the average number of eggs and price of eggs produced in the different systems for keeping laying hens, as well as the survey results, absolute and relative indicators were calculated for 250 heads, *i.e.* one animal unit (AU) during exploitation period of 52 weeks, Table 2. The coefficient for calculating an animal unit for laying hens with an average weight of 2 kg is 0.004 AU, which comprises 250 heads.

By comparing the different systems of keeping laying hens, and according to the calculated indicators of efficiency shown in Table 2, it can be concluded that the indoor system for keeping hens produced the best economic results. Considerably less efficient was the production of eggs in a cage system. This was followed

Table 2. Absolute and relative indicators of egg production efficiency per animal unit (AU).

No.	Elements [1]	Cages	Indoor	Free-range	Organic [2]
1.	Total income (HRK)	61,372.66	67,882.60	70,452.00	67,047.00
2.	Total costs (HRK)	59,572.85	62,097.34	68,890.37	66,915.31
3.	Financial result (HRK)	1,799.81	5,785.26	1,561.63	131.69
4.	Efficiency (TI/TC)	1.03	1.09	1.02	1.00
5.	Profitability (%)	3.02	9.31	2.26	0.19
6.	Productivity of labour	331.61	200.55	119.38	130.59

[1] HRK: Croatian Kuna (1 HRK = 0.135 EUR on 16th June 2017). Productivity of labour = number of eggs/hour. [2] Based on only one producer. *Source:* own elaboration.

[1]HRK = 0.135 EUR by Exchange Rate of Croatian National Bank on 16th June 2017.

by the free-range system, and the least efficient was organic egg production. The highest profit was achieved with the indoor production of eggs, with a production efficiency coefficient of 1.08 and profitability rate of 9.31%. As expected, productivity of labour was the highest in the cage keeping system, amounting to 331.61 eggs/hour.

The results of the overall assessment, based on individual assessments of all criteria and sub-criteria and presented in Table 3, indicate that the production of eggs in an indoor system is the best alternative with the highest priority of 0.317. Ranked second is egg production in the free-range system, with the achieved priority of 0.242. This is followed by egg production in enriched cages with 0.237, while organic egg production is the last alternative, with a minimum priority of 0.208.

The overall assessment of production systems according to selected criteria and total values of their weights is presented in Figure 2.

According to the final results of this study, it can be concluded that variations in the ranking of the different egg production systems are dependent on the criteria which are taken into consideration. Therefore, if only the criteria of economic indicators are taken into account, the most favourable alternative system of egg production is the indoor system, with a priority of 0.520. Based exclusively on the market criteria, the most suitable alternative is an organic system with a priority 0.315. However, taking into consideration the assessment of technological criteria, then the best alternative system of egg production is a free-range system, with a priority of 0.303.

Discussion

The main finding of the study was that the results are not in accordance with the market share of egg production systems in Croatia where production of eggs from hens kept in cages is the most well-represented, meaning that the largest number of laying hens are kept in cages. Related to the above stated, the assumption of this research was that the production of eggs in cages was the most appropriate for producers. According to the overall multi-criteria assessment, the best alternative system of egg production was the indoor system (priority 0.317). This production system, as implied by its name, is organised under controlled conditions in closed facilities, and as such, it is similar to production in enriched cages. In the Republic of Croatia, production in this type of system is increasing, with a total of 270,416 laying hens (19.8%) in 2014. The advantages of this system are reflected in the possibilities for controlling production conditions and in housing larger number of hens per m^2 than in other systems. At the same time, eggs produced in this system do not create adverse perceptions about poor welfare of laying hens, as is the case with eggs produced by hens kept in enriched cages.

Table 3. Alternative systems and criteria according to their importance.

Alternative system	Technical and technological indicators	Market indicators	Economic indicators	Overall result
Enriched cages	0.244	0.163	0.306	0.237
Indoor system	0.224	0.208	0.520	0.317
Free-range system	0.303	0.314	0.110	0.242
Organic system	0.229	0.315	0.064	0.208

Source: own elaboration.

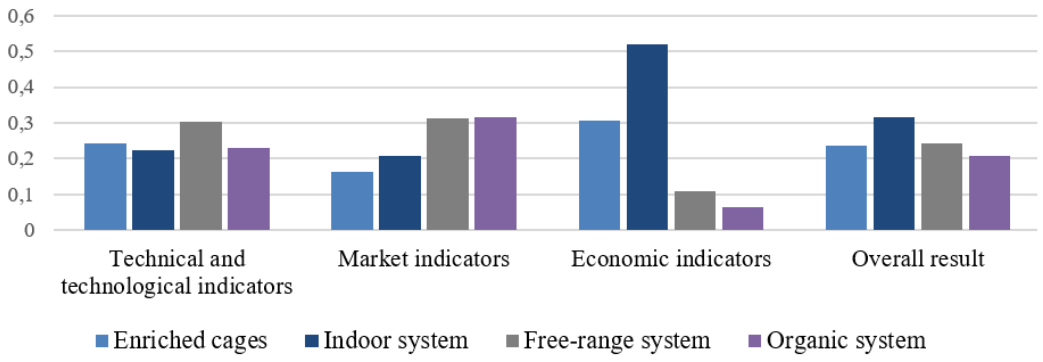

Figure 2. Overall assessment of egg production systems. *Source*: own elaboration.

The second ranked alternative, with slightly lower overall assessment, was the free-range system of keeping hens and producing eggs (priority 0.242). This production system, according to the data available in the Register of laying hens (2014) in the Republic of Croatia, represented 22 producers with 27,763 laying hens (2.0%). According to the survey data, compared to the other systems, feed consumption per laying hen kept in free-range conditions is higher, the average number of produced eggs is lower, but the prices that can be achieved on the market are slightly higher. Accordingly, the question was raised about the reasons for under representation of egg production from the free-range system, although this system of production is ranked second according to the multi-criteria analysis. On the other hand, in some countries this situation is reversed. In the Netherlands and UK, the production of eggs in the free-range system is more well-represented than production in cages, while in Germany, these two systems of egg production are equally represented. Differentiation of eggs produced in free-range system refers to their quality, packaging design, and service. When comparing the weight of eggs and its main parts, in terms of their quality, the studies (Maksimović *et al.*, 2013) have confirmed that there is no significant difference in terms of quality between table eggs produced in a free-range system and in a cage system.

Production of eggs in cages as the third ranked alternative (priority 0.237) is focused on achieving higher labour productivity and profitability of production. It is interesting that this type of egg production is the most widely spread in the Republic of Croatia, with 78.2% of the total number of laying hens in Croatia. The reason for such discrepancy is the existence of large specialised farms with capacities higher than 100,000 hens, which directly affects the order of average number of animals kept in analysed keeping systems. Those farms supply the largest proportion of the Croatian market with eggs.

According to the overall assessment, the system that achieved the lowest priority is the organic system of egg production (priority 0.208). If selecting different sub-criteria, such as environmental impact, benefits for consumers' health, number of organic producers, or potential for export, it is certain that this type of egg production would have a higher ranking. In Croatia, only one egg producer who operated according to organic farming principles. It is assumed that this type of egg production requires a relatively large production area, which is a limiting factor of such production. First of all, organic production of eggs implies availability of large production areas, production of own feed (*i.e.* raw materials for animal feed), as well as broad expertise for managing such production. Organic egg production generates on average 175 eggs per laying hen, which is clearly the lowest number compared to the other systems studied. This is probably the most significant reason for organic egg production representing a negligible share of the Croatian market.

According to economic indicators only, the indoor production system was the alternative system with the highest priority weight. This was followed by the cage system, the free-range system, and the organic system. Such results of the multi-criteria analysis are not in accordance with the previous research results, in which economic aspects indicated that production of eggs in cages was the best alternative. In previous researches authors determined increased egg production costs of alternative systems ranging from 8% to even 59% when compared to the production in cages (Fisher & Bowles, 2002; Van Horn, 2003; AGRA CEAS, 2004; Elson, 2008) which can lower profit margin. The reason for the best economic performance of indoor production in this study can be found in the concentration of laying hens. Namely, the results of multi-criteria analysis, as well as the results of absolute and relative economic indicators, are based on the observed data related to AU. By increasing the capacity (*i.e.* by having a number of hens greater than that of the observed AU), it is possible to achieve better performance of economic indicators in cages.

The results of analysis relating to market criteria favour egg production according to ecological principles, which is a top priority in accordance with previously published data from several studies (Deže *et al.*, 2008; Hidalgo *et al.*, 2008; Lončarić *et al.*, 2009; Tolušić, 2011). In these studies, it was reported that more consumers preferred organic products to conventional ones. The same authors stated that the most important motive for buying such products was their effects on health, then their taste and environment protection factors.

The result of the overall multi-criteria assessment greatly depends on the selection of survey participants. This study presents the most common answers and evaluations given by academic experts. By detected difference in the income level between individuals or groups, and assuming that there is the inequality in income level, the answers given by groups with lower income level would certainly differ in terms of prices and perception of eggs and their purchase choice than the answers provided by participants in this study.

Furthermore, by using the multi-criteria decision-making AHP method, the result of alternatives ranking is unquestionable because the overall assessment was not made intuitively by an individual, but was generated and hierarchically directed (Lampkin, 1997; Lansink & Jensma, 2003). It was also influenced by a heterogeneous group of survey participants, consisting

of experts who differ in their interests, knowledge, skills, attitudes and formal education, as well as in individual experiences and characteristics.

The application of multi-criteria analysis in choosing production systems can contribute to the quality of decision-making in the management of farms specialising in table egg production. The results of the applied model of multi-criteria decision-making, namely the AHP, are used for preparation of the development strategy framework of the best-ranked alternative, as well as for fulfilment of strategic aims of egg production. Undertaking activities towards directing and coordinating the production process and its external surroundings can lead to a big change in creating a distinctive and attractive product and in systematic differentiation among competing producers.

In relation to the strategic planning of egg production, this paper describes the multi-criteria decision-making model. By using the AHP method, systems of egg production were selected as a concrete example for this procedure. This method facilitates scientifically based comparison and quantification of qualitative indicators and data.

According to the results obtained, the necessity of meeting legal requirements for poultry production led to the reconstruction of existing production capacities and caused the reduction in poultry and egg production. This survey involved producers of table eggs that were registered in the Register of laying hens' farms as of August 2014. Data were collected on the quantity of inputs spent in production, number of eggs produced and their market price. Comparison of those data according to their economic criteria showed economic efficiency of egg production per AU, and led to the conclusion that production of eggs by keeping laying hens in indoor facilities achieved the best results.

An overall result for each system of egg production was created based on individual assessments of the survey participants and by using the software Expert Choice. Production of eggs indoors was determined as the best alternative. This was followed by the free-range system of keeping hens and egg production in cages. The fourth and the least acceptable alternative was organic egg production.

If the results obtained by multi-criteria assessment are respected, and if trends in the EU and the rest of the world are followed which reflect changes in consumer habits and concerns about food safety and quality, as well as consumer preference for local markets and products, it is recommended that the production of eggs be organised in the indoor system of keeping laying hens. The number of producers and quantity of eggs produced in this system is increasing, however, undertaking activities in the sense of directing and coordinating the production, as well as in external surroundings through producers' clusters, could lead to creating distinctive products and assuring their systematic differentiation. This can be achieved by using local autochthonous breeds of laying hens or by producing eggs in special conditions in order to change certain ingredients in the eggs. In this sense, egg production on small farms in an indoor system of keeping hens provides self-employment, generates additional income, and positively influences development of rural economies, as well as socio-demographic processes.

It is necessary to point out that until now in Croatia the application of multi-criteria decision-making in agricultural production is poorly present, while studies related to multi-criteria decision-making in the production of consumer eggs have not been made. The aforementioned lack of research at the same time constitutes the limitation of this research, due to the inability to compare with the previous research, but also presents the fundamental contribution to agribusiness literature. Future research with continuous monitoring of the number of animals and production management would contribute to a more precise recommendation to egg producers about systems of keeping laying hens.

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