DECISION SUPPORT FOR THE SELECTION OF TABLE EGG SUPPLIERS

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ABSTRACT

In the paper, for the purpose of selecting a supplier of table eggs in an agribusiness company, a multi-criteria decision-making method was applied. Through expert opinion, ten given criteria were evaluated using the fuzzy variant of the Simple Weight Calculation (SiWeC) method, and the selection itself was made using the COmpromise Ranking from Alternative Solutions (CORASO) method. The results show that the best rated criterion is „product quality", while the choice for the best supplier went to the first supplier. The research confirms a successful and systematic approach in the application of the used method, as well as a literary contribution in the complex situation of supplier selection. In future research, it is necessary to expand the selection model in the analyzed area, as well as to include a larger number of decision makers and evaluation criteria. Also, it is necessary to continue improving the existing research method.

Introduction

Poultry farming, like the production of table eggs, is a complex production process. Mass production of table eggs requires specific conditions and a pre-secured market where the resulting product can be marketed.

The egg production segment is characterized by the high biological value of the proteins present in eggs, which are closest in composition to the amino acids of human proteins, and by a more favorable position compared to other animal products (Magdelaine,

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2011, Perši et al., 2011; Rehault-Gudber et al., 2019). Poultry is characterized by high reproductive capacity, rapid growth and a high degree of food utilization, which enables, thanks to these biological properties, the production of large quantities of meat and eggs in a relatively short period of time. Feed consumption per unit of growth is lower compared to other types of domestic animals, which is extremely important for the producer. In a fairly short period of time, it is possible to create products (meat and eggs) at slightly lower costs, so they are more attractive compared to other types of meat (Crnčan, 2016).

Given that the aim of the research in the paper is to choose the best (optimal) supplier of edible eggs in an agribusiness company, the decision process is therefore very complex. For this purpose, we most often use multi-criteria decision-making methods (MCDM), which have proven to be one of the foundations of rational choice. We find confirmation of this in the previous works of domestic and foreign authors, which will be mentioned in the next chapter "literature review" of this work. Also, in the continuation of the work, the methodology of the work, that is, the method used, will be explained, and the obtained results will be presented with the corresponding conclusions and recommendations.

Literature review

As already mentioned, the choice of suppliers is a complex and responsible job, especially when it comes to agribusiness and agriculture. On that occasion, one should take into account numerous factors that influence to a greater or lesser extent, and which often collide. Thus, according to Stević et al. (2019), the success of the entire supply organization largely depends on the correct choice of suppliers, while Kennan et al. (2013) see the choice of suppliers as a vital component of every business organization. Multi-criteria decision-making tools are most often used in the development of the decision-making models themselves. There, the decision is made based on the evaluation of alternatives and according to predetermined criteria (Puška et al., 2018). On that occasion, the defined criteria can be qualitative and quantitative (Rozman et al., 2016). When using quantitative criteria in research, classical methods of multi-criteria decision-making are used, while when using qualitative criteria, it is necessary to use fuzzy variants of multi-criteria decision-making (Liu et al., 2019; Durkalić et al., 2019; Nedeljković et al., 2021; Nedeljković et al., 2021a; Alavi et al., 2021; Goodarzi et al., 2022; Nedeljković et al., 2025; Pantovic et al., 2025). One part of the application of the mentioned methods in the field of supplier selection in agribusiness and agriculture can be seen from the references presented in the following table 1.

Table 1. Overview of used fuzzy MCDM methods in the area of supplier selection

Reference	Method
Puška et al., 2021	FPIPRECIA and FMABAC
Ada, 2022	Fuzzy ANP and VIKOR
Puška and Stojanović, 2022	Fuzzy SWARA
Wijaya et al., 2022	FAHP
Aka, 2023	Fuzzy-Trapezoidal DEMATEL
Puška et al., 2023	Fuzzy Rough LMAW and MABAC

Reference	Method
Puška et al., 2023a	Fuzzy TRUST CRADIS
Zeng et al., 2023	BWM and EDAS
Hajiaghaei-Keshteli et al., 2023	Pythagorean Fuzzy TOPSIS
Magableh, 2023	Fuzzy VIKOR
Atli, 2024	Fuzzy AHP and ARAS
Ben Abdallah et al., 2024	Fuzzy AHP and FMABAC
Atli and Senir, 2024	Fuzzy WASPAS
Öner et al., 2024	Fuzzy AHP
Tufan and Ulutaş, 2025	LODECI and CORASO
Miyangaskary et al., 2025	Fuzzy Multi-Objective Model

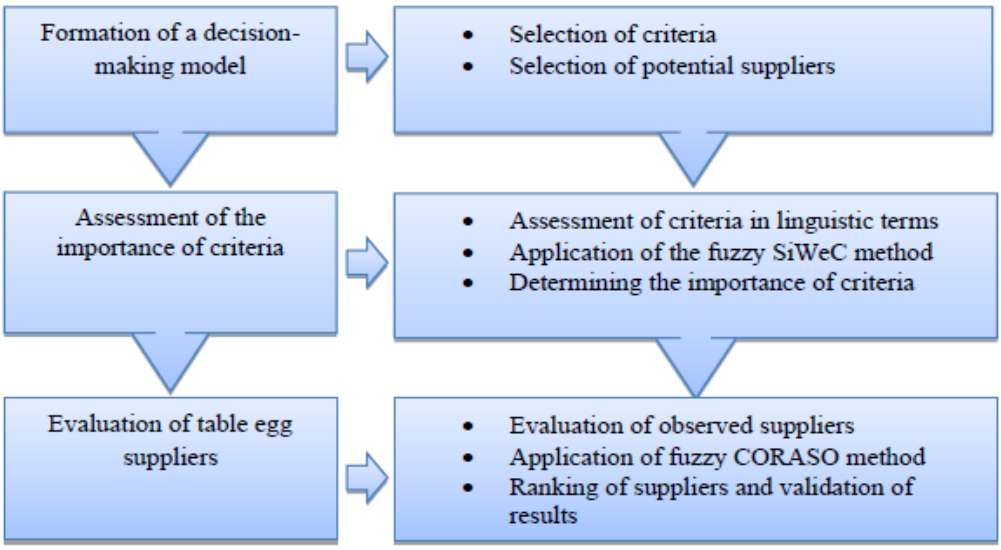
Source: Authors

In his doctoral dissertation, Crnčan (2016) analyzes and evaluates different systems of table egg production in strategic planning, using multi-criteria analysis, i.e. the Analytical Hierarchy Process (AHP) method. Falan et al., (2021) determine the main trends of supply and demand of table eggs in BiH and perform an economic evaluation of egg production on the example of an agricultural company.

Methodology

The methodological approach in the research is graphically presented in the following figure 1, and below we will give a description of the steps foreseen in the application of the given methods. In the first step, the formation of the model itself is approached, that is, the selection of criteria for evaluation and selection of potential suppliers.

Figure 1. Research progress



Source: Authors

The selection of evaluation criteria was made based on the consultation of the company's expert team, in several interactions. The choice was narrowed down from the original 15 to ten criteria, which were agreed upon by everyone involved in the company's team. The name and description of the criteria is given in the following table 2. The alternatives, among which the choice will be made, are eight registered suppliers from the regional market who are engaged in the production and delivery of table eggs.

Table 2. Criteria used

Id	Criteria	Description
C1	Price	Competitive price in relation to the market; Transparent price calculation.
C2	Payment terms	Discounts for quantity or longer cooperation; Deferred payment, invoicing, rebates.
C3	Delivery reliability	Regularity and punctuality of deliveries; Capacity to supply larger quantities; The possibility of urgent deliveries; Own transport or cooperation with reliable suppliers.
C4	Packaging and declaration	Standardized packaging; Resistance of packaging to damage; Clear and legally compliant declaration (date of packaging and expiration date, category and class of eggs, method of keeping chickens, etc.)
C5	Sustainability and ethics	How to grow coca, care for animal welfare, ecological aspects of production and packaging.
C6	Reputation and recommendations	Previous experiences of other customers; Reviews and recommendations; Length of existence on the market; Transparency and openness to cooperation.
C7	Flexibility and communication	Willingness to negotiate; Quick response to inquiries and complaints; Openness to long-term cooperation.
C8	Product quality	Egg category, egg size and weight, egg freshness, shell integrity, uniformity (consistency in size, color and shape).
C9	Food safety and regulatory compliance	HACCP certificate, veterinary control, traceability, presence of antibiotics and pesticides, Compliance with legal regulations.
C10	Consumer/user habits	Using the services of one supplier for a long period of time.

Source: Authors

It should be noted that in the process of evaluation of criteria and selection of suppliers, a fuzzy variant of the applied multi-criteria method was used. Fuzzy logic is an excellent method for making decisions in circumstances that are uncertain, unclear, ambiguous, or imprecise. It offers an efficient approach to managing these complexities and can serve as a useful resource in numerous situations, particularly in smart agriculture. In 1970, Bellman and Zadeh significantly advanced decision-making in fuzzy contexts with their introduction. Fuzzy decision-making in precision agriculture enhances crop yield and quality. It improves resource use, minimizes waste, and boosts efficiency and sustainability (Erdoğan, 2022).

The method we used to evaluate the given criteria is fuzzy Simple Weight Calculation (FSiWeC). The fuzzy SiWeC method is used for subjective assessment of the importance of criteria based on the application of linguistic terms. The steps of this method are (Puška et al., 2024):

Step 1. Evaluation of the importance of criteria.

Step 2. Transformation of grades into fuzzy numbers.

Step 3. Data normalization.

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{m}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{u}}{max\ x_{ij}^{u}}$$

Where is $max\ x_{ij}^{u}$ maximum value for all criteria.

Step 4. Calculation of the standard deviation ($st.dev_j$).

Step 6. Plotting normalized scores with standard deviation values.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.dev_j$$

Step 7. Calculating the sum of weights for individual criteria.

$$\tilde{s}_{ij} = \sum_{j=1}^{n} \tilde{v}_j$$

Step 8. Calculating criteria weights.

$$\tilde{w}_{ij} = \frac{s_{ij}^{l}}{\sum_{j=1}^{n} s_{ij}^{u}}, \frac{s_{ij}^{m}}{\sum_{j=1}^{n} s_{ij}^{m}}, \frac{s_{ij}^{u}}{\sum_{j=1}^{n} s_{ij}^{l}}$$

The innovative fuzzy COmpromise Ranking from Alternative Solutions (FCORASO) method will be used to evaluate the suppliers based on the ranking. As concluded by Mahmoodirad & Niroomand (2023), in order to simplify the decision-making process, the methods used must include as few steps as possible, that is, they must be as simple and flexible as possible. It is for this reason that the fuzzy CORASO method was applied, which ranks the alternatives based on how close or far they are from the best or worst values for certain criteria. This calculates the deviation of each alternative and determines the final ranking. The method was developed by Puška et al., 2024 and has the following steps:

Step 1. Evaluation of alternatives.

Step 2. Transformation of grades into fuzzy numbers.

Step 3. Normalization of fuzzy numbers.

$$n_{ij} = \frac{x_{ij}^{l}}{\max x_{j}^{u}}, \frac{x_{ij}^{m}}{\max x_{j}^{u}}, \frac{x_{ij}^{n}}{\max x_{j}^{u}}\text{; for benefit criteria}$$

$$n_{ij} = \frac{\min x_j^l}{x_{ij}^n}, \frac{\min x_j^l}{x_{ij}^m}, \frac{\min x_j^l}{x_{ij}^l}; \text{ for cost criteria}$$

Where is: $x_{j\ min}$ – the minimum value of a particular criterion, and $x_{j\ max}$ – the maximum value of one criterion.

Step 4. Calculation of alternative solutions, namely the maximum alternative solution ($max\ AS$) which is the highest value of alternatives for individual criteria, while the minimum alternative solution ($min\ AS$) which is the lowest value of alternatives for individual criteria.

Step 5. Weighting of normalized data.

$$\tilde{v}_j = \tilde{w}_j \cdot \tilde{n}_{ij}$$

Step 6. Calculation of aggregate values of difficult alternatives.

Step 7. Calculation of deviations from alternative solutions.

$$\tilde{R}_j = \frac{\tilde{S}_j}{\tilde{S}_{j\ max\ AS}}$$

$$\tilde{R'}_j = \frac{\tilde{S}_{j\ min\ AS}}{\tilde{S}_j}$$

Step 8. Defuzzification.

$$R_{j\ def} = \frac{R_i^l + 4R_i^m + R_i^u}{6}$$

$$R'_{j\ def} = \frac{R'^l_i + 4R'^m_i + R'^u_i}{6}$$

Step 9. Calculation of the value of the FCORASO method.

$$Q_i = \frac{R_j - R'_j}{R_j + R'_j}$$

Results and Discussion

The subject of the analysis is an agribusiness company based in the area of the City of Belgrade, which is engaged in the production of confectionery. The company belongs to the ranks of medium-sized companies with over 50 employees and as many seasonal workers in certain parts of the year. The range of products is varied, which represents an additional challenge when it comes to the organization of work and production. In its

mid-term business plan, the company has the task of improving operations, that is, the logistics segment, given that it is dependent on incoming raw materials for production, and at the same time, in that part of the business, to reduce the associated costs. For this reason, the company hires an expert team that, based on this research, should offer the results of the analysis. The expert team, i.e. the decision-makers, consists of six experts with many years of experience in logistics and supply, as well as in the field of food quality and safety.

Based on the questionnaire, the experts gave ratings for each of the given criteria, whose linguistic values are presented in the following table 3. Based on the corresponding linguistic scale (table 4), the rating values were converted into numerical expressions and shown in table 5.

Table 3. Evaluation of the importance of criteria

CRITERIA	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Expert 1	VG	G	G	ML	MG	G	G	G	G	M
Expert 2	G	VG	MG	MG	M	G	G	VG	MG	M
Expert 3	G	G	G	ML	M	MG	VG	VG	G	L
Expert 4	G	VG	MG	ML	M	MG	G	VG	M	L
Expert 5	VG	MG	VG	ML	M	VG	G	VG	MG	ML
Expert 6	MG	MG	G	M	M	VG	G	VG	MG	M

Source: Authors

Table 4. Linguistic scale

Very low	VL	(1,1,2)
Low	L	(1,2,4)
Medium Low	ML	(2,4,6)
Medium	M	(3,5,7)
Medium Good	MG	(5,7,9)
Good	G	(7,9,10)
Very good	VG	(9,10,10)

Source: Puška et al., 2024

Table 5. Expert assessment

CRITERIA	**C1**	**C2**	**C3**	**C4**	**C5**	**...**	**C10**
Expert 1	(9,10,10)	(7,9,10)	(7,9,10)	(2,4,6)	(5,7,9)	...	(3,5,7)
Expert 2	(7,9,10)	(9,10,10)	(5,7,9)	(5,7,9)	(3,5,7)	...	(3,5,7)
Expert 3	(7,9,10)	(7,9,10)	(7,9,10)	(2,4,6)	(3,5,7)	...	(1,2,4)
Expert 4	(7,9,10)	(9,10,10)	(5,7,9)	(2,4,6)	(3,5,7)	...	(1,2,4)
Expert 5	(9,10,10)	(5,7,9)	(9,10,10)	(2,4,6)	(3,5,7)	...	(2,4,6)
Expert 6	(5,7,9)	(5,7,9)	(7,9,10)	(3,5,7)	(3,5,7)	...	(3,5,7)

Source: Authors

The final expert ratings of the given criteria are given in table 6, and there we can see that some criteria have the same ratings, that is, importance. Thus, the most important criterion is "product quality", which includes egg category, egg size and weight, egg freshness, shell integrity, uniformity, etc., followed by criteria C1, C2 and C7, i.e. "price", "payment terms" and "flexibility and communication". In the final evaluation of the criteria, the quality of the goods was decisive, given that it is about the goal of increasing competition and preserving quality in the company's operations. Economic criteria such as payment conditions, i.e. the price of the product itself, as well as the supplier's willingness to negotiate, quick response to inquiries and complaints, as well as openness to stable cooperation, still play a major role. The research partly coincides with the results of supplier selection in other studies in the field of agribusiness (Nedeljković, 2022; Puška et al., 2023a), according to which the most important factor, i.e. the criterion of expert evaluation, is precisely economic, i.e. price.

Table 6. Criteria weight

Criteria	w_{ij}		
C1	0,08	0,12	0,17
C2	0,08	0,12	0,17
C3	0,08	0,11	0,17
C4	0,03	0,06	0,11
C5	0,04	0,07	0,13
C6	0,08	0,11	0,17
C7	0,08	0,12	0,17
C8	0,10	0,13	0,17
C9	0,06	0,10	0,16
C10	0,02	0,05	0,10

Source: Authors

Based on the applied steps of the FCORASO method, we obtain the final ranking (order) of the selected suppliers, which is presented in Table 7. The highest value of the coefficient Q_i was obtained by the first supplier, while the lowest value, i.e., the rating, was obtained by supplier 2.

Table 7. Rang alternative

Alternative	Q_i	Rank
1	0,13	1
2	-0,11	8
3	-0,03	5
4	-0,06	7
5	0,04	3
6	0,08	2
7	-0,01	4
8	-0,04	6

Source: Authors

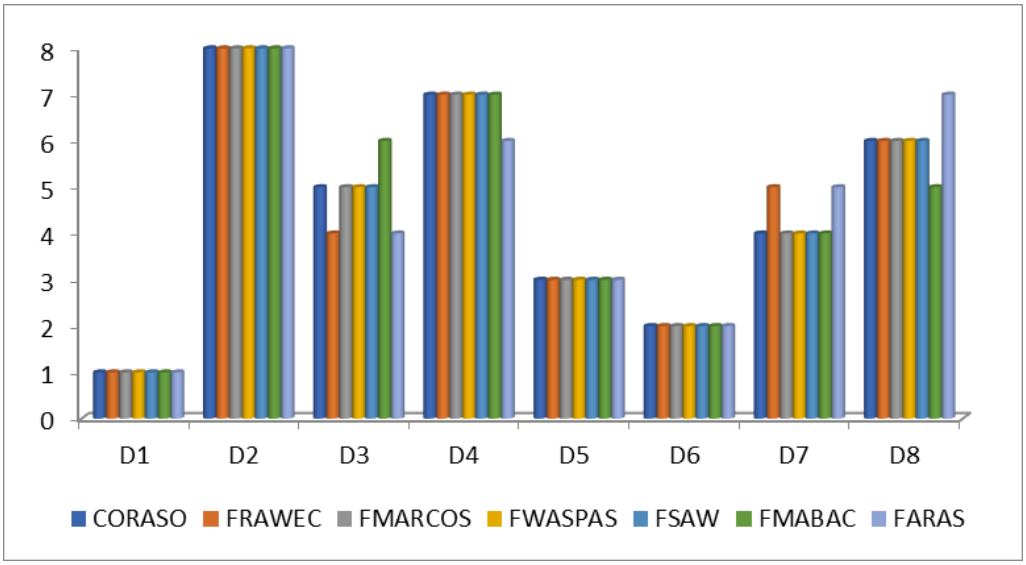
In the last stage, before drawing conclusions in the work, we validated the obtained results in such a way that the ranked results obtained by the FCORASO method were

compared with the ranked results of other methods using the Spearman correlation coefficient using the following expression (Božanić et al., 2022):

$$SCC = 1 + \frac{6\sum_{i=1}^{n} D_i^2}{n(n^2-1)}$$

In this equation, D_i is the difference between the rank of an item in the vector *w* and the rank of the corresponding item in the reference vector, and *n* is the number of ranked items. (Božanić et al., 2022) The value of SCC varies between -1 and +1. An SCC value of 1 indicates a perfect positive relationship. An SCC value of -1 indicates a perfect negative relationship. A SCC value of 0 means that there is no relationship between the variables. (Katranci et al., 2025)

Figure 2. Ranking of alternatives using different MCDM methods



Source: Authors

The resulting correlation matrix shows that almost all variables are highly correlated. The lowest correlation is between FMABAC and FARAS (ρ = 0.857). This means that the value ranks between most factors are very similar, that is, the variables move in the same direction (monotonically related). (table 8)

Table 8. Correlation matrix

	FCORASO	FRAWEC	FMARCOS	FWASPAS	FSAW	FMABAC	FARAS
FCORASO	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FRAWEC	0.964	1.000	0.964	0.964	0.964	0.893	0.964
FMARCOS	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FWASPAS	1.000	0.964	1.000	1.000	1.000	0.964	0.929

	FCORASO	FRAWEC	FMARCOS	FWASPAS	FSAW	FMABAC	FARAS
FSAW	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FMABAC	0.964	0.893	0.964	0.964	0.964	1.000	0.857
FARAS	0.929	0.964	0.929	0.929	0.929	0.857	1.000

Source: Authors

Conclusion

In the conducted research, a selection of regional suppliers of edible eggs was made in an agribusiness company. Of the given criteria, the "product quality" criterion, which included egg category, egg size and weight, egg freshness, as well as shell integrity and uniformity (consistency in size, color and shape), was rated the best. Also, the criteria "price", "payment terms" and "flexibility and communication" received a good rating. Of the suppliers, the first supplier is ranked best. The research in this case study showed the justified role of the applied integrated innovative method of multi-criteria decision-making fuzzy SiWeC-CORASO, and created solid assumptions for the continuation of research in this area, i.e. business development on the strengthening of influencing factors when it comes to the supply of raw materials. In the following, the applied research method should be further developed, as well as the scope of the research should be expanded to a larger number of criteria and suppliers, and the transparency of such research in the field of supply in agribusiness and agriculture should be increased. This would lead to an increase in rational decisions in the business of companies in this area.

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Conflict of interests

The authors declare no conflict of interest.

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