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Evaluation of food safety and halal criteria in supplier selection: an application in food sector with fuzzy COPRAS method

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Abstract

Supplier selection is among the crucial processes for any food industry operation. An incorrect choice when selecting a supplier will pose significant hazards in terms of food safety, and can cause substantial harm to virtually any operation of the enterprise. However, the number of studies focusing on this issue is rather limited, and the supplier selection procedure to serve as a source of reference for food producers has not been developed yet. The present work thus aimed to facilitate the use of food safety and halal criteria in supplier selection processes, and to help food producers in making choices by using the COPRAS-F method. The present work was carried out at an enterprise engaged in dairy products, analysed the processes involving four suppliers providing polyethylene terephthalate (PET) packaging, and evaluated 12 criteria to guide the choice of supplier. The present work is one of the first attempts for supplier selection in food industry based on the COPRAS-F method. Results suggested that the COPRAS-F method could offer a practical method for not just supplier selection processes, but any multi-criteria decision-making problem a company might face.

Introduction

In recent years, we have experienced major advances in any field of economy, which not only limited to technology, which led to a more competitive marketplace. This forces companies in any industry to find more creative solutions. Businesses understood that working only within their own organisation was insufficient, and started to reconstruct their relations with other businesses. Today, effectively managing the supply chain positively affects the success of businesses and creates value (Frej *et al.,* 2017; Taherdoost and Brard, 2019). It is because the performances of individual members of any supply chain have a direct impact on the product/service, and rank high in determining the success/failure of the enterprises. Supplier selection is one of the most important steps in supply chain management.

Even though food industry is one of the largest industries worldwide, there is no supplier selection procedure developed as a reference for food producers. An incorrect choice when selecting a supplier will pose significant hazards to their stakeholders in terms of food safety, and can cause substantial harm to virtually any operation of the enterprise. Thus, it is essential to determine the correct selection criteria for supplier selection in the food industry, and to employ optimal scientific methods for such purposes.

However, there are very limited number of studies focusing on supplier selection in this important sector (Banaeian *et al.,* 2015). A review of the existing studies reveals a dominating focus on the quality, price/cost, delivery, and service criteria in parallel with the leading trend in the literature. The number of studies using food safety and halal criteria in the food industry, including references to other criteria such as the environment, social responsibility, and labour rights which have been drawing increasing attention in recent decades, is very low. Various multi-criteria decision-making (MCDM) techniques have been used in those studies. However, we have not encountered a study performing the COPRAS-F method to date. Thus, the main aim of the present work was to incorporate the food safety and halal criteria in terms of supplier selection using the COPRAS-F method. COPRAS-F technique was adopted due to its unique advantages over other MCDM techniques. Firstly, it addresses concurrent consideration of the ratio to the ideal solution and the ideal-worst solution. Secondly, the method has an easy-to-implement and logical solution procedure. Finally, it takes shorter time to obtain the results as compared to other methods such as AHP

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and ANP (Yazdani *et al.,* 2011; Fouladgar *et al.,* 2012).

Supplier selection criteria

In recent years, the conventional supply chains in the food industry have transformed into a long and winding road involving a multitude of suppliers operating at the international scale (Ahumada *et al.,* 2012). Such a change brings about certain advantages such as cost reduction and increasing market share, while posing difficulties in terms of controlling and managing supply chains (Ali *et al.,* 2017). Supplier selection and the criteria used for selection differ for each industry and the firms operating in those industries (Luo *et al.,* 2009). On the other hand, for food industry, supply chain is about much more than competitiveness, sustainability, and price. There are other criteria involved as well. For example, a food safety hazard which can arise at any step of the supply chain can lead to compensation issues, and difficult to be fixed (Diabat *et al.,* 2012). Therefore, supply chain stands out as the most crucial process for the food industry in general (Amorim *et al.,* 2016). Thus, one should have a comprehensive perspective towards the supplier selection criteria presented in the literature when selecting a supplier in food industry.

Enterprises generally wish to work with suppliers that offer optimal performance. However, there is no established standard guides for the supplier selection processes (Taherdoost and Brard, 2019). There are a number of qualitative/quantitative criteria that affect supplier selection which is applied based on the specific priorities of the enterprises involved (Cristea and Cristea, 2017). A glance at the literature on supplier selection criteria reveals that most studies focus on three major criteria proposed by Dickson (1966) namely quality, price, and delivery (Banaeian *et al.,* 2015; El Mokadem, 2017; Jain and Singh, 2020). However, new criteria such as environment, social responsibility, and labour rights have been introduced to the literature to complement these widely accepted criteria in recent years (Banaeian *et al.,* 2018; Rashidi and Cullinane, 2019).

In the literature, food safety is considered as one of the sub-components of quality (Pungchompoo and Sopadang, 2015), and is rarely regarded as a main criterion such as price and quality in any supplier selection work (Lau *et al.,* 2018; Govindan *et al.,* 2018). Yet, while a product of lower quality can still be sold at a lower price as compared to a product of higher quality (Grunert, 2005), a product with food safety risks would not be preferred by customers and consumers at all, regardless of the price. Therefore, food safety cannot simply be considered as an element or factor determining the overall level of quality. Indeed, a number of studies (Lau *et al.,* 2018; Govindan *et al.,* 2018) stated that food safety should be addressed as an independent supplier selection criterion.

At any enterprise, food safety is ensured by a team of professionals experienced on this issue, and working in coordination. That team is usually called the food safety team (Başaran, 2016). Yet, another popular element of food safety is traceability which is a crucial step in ensuring food safety, and is defined through certain regulations and standards (Aung and Chang, 2014). Traceability can be defined as the ability to follow the history, application, movement, and location of an object through specified stage(s) of production, processing, and distribution (ISO, 2018). The implementation of a systematic perspective towards food safety on part of the enterprise, and obtaining internationally-recognised certifications such as HACCP or ISO 22000 play a significant part in shaping the food safety perception (Pascucci *et al.,* 2015).

On the other hand, the increasing globalisation of supply chain increased consumers' concerns about food (Ali *et al.,* 2017). A prominent group of consumers having such concerns consist of approximately 1.8 billion Muslims living in various societies with different cultures and religious beliefs. A major concern harboured by most Muslim consumers is the halal nature of the food they consume (Soon *et al.,* 2017). There are incidents where a number of ingredients forbidden in Islam are found in the analyses of food products which do not mention such ingredients on their labels (Di Pinto *et al.,* 2015). This indicates the importance of such concerns.

The term halal refers to food that is permitted to be consumed by Muslims according to official religious authorities namely the verses of Allah which were communicated to them through the Holy Qur'an, and also the words and behaviours of the Prophet (sunnah). Such food cannot contain forbidden ingredients, which are considered haram. Food safety is defined as the protection of foods from physical, chemical, and biological hazards that may occur along the food chain, or reducing these hazards to acceptable levels and ensuring that foods do not harm consumer health (ISO, 2018). Quality is a relative concept, and is the sum of the objective and subjective perception that consumers expect from that product (Grunert, 2005). A low-quality product can still be sold and consumed, provided that it meets specific food safety criteria. On the other hand, halal concept is about belief and religion. For Muslims, food is either halal or haram. Therefore, a given food either meets the halal requirements in terms of its ingredients, production processes, and transportation requirements, or cannot be considered halal food due to its haram nature. Even though halal food is often considered high-quality and safe (Wilkins *et al.,* 2019), it nonetheless stands out significantly from other concepts related to quality and food safety, due to its inherently religious character. Thus, the organisations which display the halal certificate details on the labels of food they produce should include halal status among the crucial criteria leading to the choice of supplier. Halal certification of an enterprise assumes that other enterprises comprising the supply chain up to the certificate holder also operate in accordance with the requirements of the halal management system, and are also halal-certified establishments (Ali *et al.,* 2017; Soon *et al.,* 2017).

Methods used in supplier selection

The selection of suppliers to be cooperated with in the long term is an even more difficult process due to a set of excessively dynamic criteria based on ever changing needs and forward-looking strategies of the enterprises and priorities of the markets. The best supplier is chosen from among a set of alternatives, with reference to the often-conflicting criteria, which thus necessitate weighing and trade-offs. So, supplier selection should be considered as a multi-criteria decision-making (MCDM) problem, and should be handled with a scientific perspective (Taherdoost and Brard, 2019). Today, MCDM methods are frequently used in supplier selection, and are considered as analytical methods to enable simultaneous consideration of multiple factors thus leading enterprises to correct choices (Soylu, 2010). MCDM methods can simplify choice making process especially in cases of certainty, but fall short of providing adequate input to inform the decision-making models in cases of relative uncertainty. In real-life cases involving complexity and uncertainty, rational decision making requires the employment of fuzzy logic principles in combination with MCDM methods (Keskenler and Keskenler, 2017).

With the increasing levels of product diversity, developments in distribution channels, increase in the number of suppliers, and ignoring the changes occurred in recent years in customer/consumer expectations have brought vertical uncertainties affecting the supply chains in food industry to unprecedented levels (Maloni and Brown, 2006). Hence, in parallel to the developments in other industries, food industry should also make extensive use of MCDM methods for supplier selection processes. A glance at the literature reveals a number of MCDM methods used extensively in food industry including Analytic Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Analytic Network Process (ANP), Multi-Objective Optimisation on the basis of Ratio Analysis (MOORA), Elimination and Choice Expressing Reality (ELECTRE), Tomada de Decisão Iterativa Multicritério (TODIM), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE), Decision Making Trial and Evaluation Laboratory (DEMATEL), Goal Programming (GP), Additive Ratio Assessment (ARAS), VIšekriterijumsko Kompromisno Rangiranje (VIKOR), Flexible and Interactive Tradeoff (FITradeoff), and Grey Relational Analysis (GRA). In many studies of the decision-making process such as supplier selection, the decision-makers' (DMs) judgments are not crisp, and often difficult for a decision-maker to provide the exact numerical values for the evaluation criteria. Besides, it is recognised that human assessments on qualitative attributes are always subjective, and thus imprecise. Fuzzy MCDM methods allow for modelling the decision processes involving imprecise and subjective information expressed with linguistic variables or fuzzy numbers by DMs. Previous works using fuzzy MCDM techniques for supplier selection process include Frej *et al.* (2017), Banaeian *et al.* (2018), and Lau *et al.* (2018). One such method is the fuzzy COPRAS (COPRAS-F) method. To date, COPRAS-F method has been used extensively for performance assessment in technology, tourism, logistics, automotive, construction, infrastructure, machinery, enterprise, and operation sectors (Yazdani *et al.,* 2011; Chatterjee and Kar, 2018).

Materials and methods

Fuzzy COPRAS method

COPRAS (Complex Proportional Assessment) method is a multi-criteria decision-making technique developed by Zavadskas and Kaklauskas (1996) to rank alternatives in terms of their priorities and expected utility. Due to its relatively simple mathematical foundations, COPRAS is one of the most popular MCDM methods to determine best alternative in the light of the ideal solution and worst-ideal solution possible. In response to the classical version's shortcomings regarding fuzzy-decision cases, Zavadskas and

Antucheviciene (2007) developed a fuzzy version named COPRAS-F. In this revised version, the criteria are expressed with variables denoting fuzzy figures, rather than absolute values. The algorithm employed for the CORPAS-F method is explained below (Zavadskas and Antucheviciene, 2007; Yazdani *et al.,* 2011).

Stage 1: determining the evaluation and decision-making criteria, and the variables to be used for evaluation

This stage is often called the planning stage, and defines the decision-alternatives, decision-making criteria, and the variables to be used for assessing the performance/importance thereof. The variables and corresponding triangular fuzzy numbers (TFN) presented in Table 1 can be used to ascribe weights to evaluation criteria, while those in Table 2 can be used to evaluate the decision alternatives' performance levels. Among the various shapes of fuzzy numbers, TFN is the most popular one in MCDM literature due to its simplicity and ease of implementation (Mortaji *et al.,* 2015).

Table 1. Variables used to determine the criteria in weighting.

Variable	TFN
Very Low (VL)	(0.0, 0.0, 0.25)
Low (L)	(0.0, 0.25, 0.5)
Medium (M)	(0.25, 0.5, 0.75)
High (H)	(0.5, 0.75, 1.0)
Very High (VH)	(0.75, 1.0, 1.0)

Table 2. Variables used to evaluate the alternatives.

Variable	TFN
Very Weak (VW)	(0.0, 0.0, 2.5)
Weak (W)	(0.0, 2.5, 5.0)
Medium (M)	(2.5, 5.0, 7.5)
Good (G)	(5.0, 7.5, 10)
Very Good (VG)	(7.5, 10, 10)

Stage 2: developing the fuzzy decision matrix

To evaluate the alternatives, the fuzzy decision matrix comprised of n criteria and m alternatives is developed (Eq. 1):

$$\begin{array}{c} \\ \widetilde{D} = \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} \widetilde{x}_{11} & \widetilde{x}_{12} & \cdots & \widetilde{x}_{1n} \\ \widetilde{x}_{21} & \widetilde{x}_{22} & \cdots & \widetilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \widetilde{x}_{m1} & \widetilde{x}_{m2} & \cdots & \widetilde{x}_{mn} \end{bmatrix} \end{array} \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \qquad \text{(Eq. 1)}$$

Assuming that there are "s" decision-making criteria ($\widetilde{x}_{ij}^{s} = x_{ij1}^{s}, x_{ij2}^{s}, x_{ij3}^{s}$), an integrated evaluation score based on the consideration of individual DMs will be required. To do so, one can employ the fuzzy weighted average (FWA) operator (Xu and Da, 2003).

$\widetilde{q}_s$ let s stand for the priority factor ascribed to the decision-making criteria. If all DM are equally important, shall be assumed. The integrated fuzzy decision matrix, in turn, is presented through Eq. 2:

$$\widetilde{D} = (\widetilde{x}_{ij}^{s} = x_{ij1}^{s}, x_{ij2}^{s}, x_{ij3}^{s}) \qquad \text{(Eq. 2)}$$

Here, $\widetilde{d}_{ij} = \dfrac{\sum_{s=1}^{s} \widetilde{q}_s \widetilde{d}_{ij}^{s}}{\sum_{s=1}^{sk} \widetilde{q}_s}$

Stage 3: calculating the priority weight of individual criteria

Once the decision matrix is created, the priority weights of individual evaluation criteria are calculated.

Stage 4: defuzzification of the fuzzy decision matrix and the fuzzy criteria weights

At this stage, the decision matrix and criteria weights are converted to absolute numbers using any defuzzification method. To do so, one can use the Centre of Area (COA) method, which is a simple and practical technique, and is capable of calculating Best Non-fuzzy Performance (BNP) values without a DM choice. When COA method is employed, the BNP value for , a TFN, can be calculated using Eq. 3.

$$x_{ij} = \left[\frac{(ux_{ij} - lx_{ij}) + (mx_{ij} - lx_{ij})}{3} \right] + lx_{ij} \qquad \text{(Eq. 3)}$$

Stage 5: normalisation of the defuzzified decision matrix and criteria weights

The defuzzified decision matrix can be normalised by dividing each entry on the decision matrix (x_{ij}) by the sum of all entries on that column (Eq. 4).

$$\overline{x}_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \quad \text{i = 1,…, n; j = 1,…, m} \qquad \text{(Eq. 4)}$$

Thus, one gets: $\sum_{j=1}^{n} x_{ij} = 1$

Stage 6: building the weighted normalised matrix

The weighted normalised matrix can be calculated by multiplying the criteria weights (w_j) and the normalised decision matrix entries (Eq. 5).

$$\hat{x}_{ij} = \bar{x}_{ij} * w_j \quad \text{(Eq. 5)}$$

Stage 6: calculating the overall values in the weighted normalised decision matrix for utility criteria (P_j)

Doing so, one can calculate the total value of utility criteria representing the criteria in an assessment where higher values represent a better position (Eq. 6).

$$P_i = \sum_{j=1}^{n} \hat{x}_{ij} \quad \text{j = 1,…, k utility criteria} \quad \text{(Eq. 6)}$$

where, k = maximum number of criteria.

Stage 7: calculating the overall values in the weighted normalised decision matrix for cost criteria (R_i)

To achieve this goal, one would calculate the sum of the values in the weighted normalised decision matrix where smaller values represent better cases (Eq. 7).

$$R_i = \sum_{j=k+1}^{m} \hat{x}_{ij} \quad \text{j = k + 1,.., m cost criteria} \quad \text{(Eq. 7)}$$

where, (m - k) = number of criteria to be minimised.

Stage 8: calculation of relative significance weight (Q_i) for each alternative

Q_i values show the level of significance of various decision alternatives, and are calculated using Eq. 8.

$$Q_i = P_i + \frac{\sum_{i=1}^{n} R_i}{R_i \sum_{i=1}^{n} \frac{1}{R_i}} \quad \text{(Eq. 8)}$$

Stage 9: calculation of K as the optimality criteria, and the significance ranking of alternatives

$$K = \max_i Q_i \quad \text{i = 1, n} \quad \text{(Eq. 9)}$$

The alternatives are ranked from the largest to the smallest, based on their Q_i values. In this context, Q_{max} represents the case where the satisfaction level is the highest.

Stage 10: calculation of utility levels (N_i) of the alternatives

The percentages of which individual alternatives are better or worse than the others are calculated using Eq. 10.

$$N_i = \frac{Q_i}{Q_{max}} 100\% \quad \text{(Eq. 10)}$$

Results

As dairy products are prone to spoil quickly, the supplier selection and criteria employed are crucial and play a large part. Therefore, the present work was based on the case of an enterprise operating in the dairy industry. The long-standing enterprise has been producing milk and dairy products in Istanbul since 1975, and has been among the fastest growing establishments in this field. The enterprise outsources the PET packaging used for its milk products. Given the significance of the issue, the management of the enterprise decided to employ a scientific perspective for the selection of suppliers. In deliberations with the enterprise, the COPRAS-F method was chosen as the means to apply. The following paragraphs provide information about the COPRAS-F method.

The first step in the overall process was to establish a decision committee. A team of four was set up including the general manager, as well as production, procurement, and quality experts working in the company. They are the decision makers in the company's purchasing and supplier selection processes. The committee first decided on the 12 decision criteria to be evaluated in choosing suppliers, and four decision alternatives coded as A_1, A_2, A_3, and A_4 to be considered. The supplier selection criteria were determined by consensus based on the review of the literature, and the knowledge and industry experiences of the experts. Those criteria are given in Table 3. Among these, only the cost criterion is expected to be minimised so as to achieve optimisation, whereas the other 11 criteria would offer the best utility when maximised. The DMs assigned the importance weight of individual criteria using the variables presented in Table 1. All DMs were assumed to be equally important. In this light, a single integrated value was calculated for each criterion conducting the FWA operator shown above. Thereafter, the fuzzy criteria weights were defuzzified using the COA method presented in Eq. 3. The fuzzy and defuzzified weights are presented in Table 4. A glance at Table 4 reveals that quality (0.116), cost (0.105), and halal

Table 3. Evaluation criteria employed in the implementation.

Criterion	Description
Quality (Q):	**Q1:** Compliance of product quality with the specifications **Q2:** Quality management system documents
Cost (C):	**C1:** Unit price of the product **C2:** Price stability **C3:** Efforts for improving the price
Service (S):	**S1:** Compliance with the requests for change in the product **S2:** Compliance with the requests for change in the order **S3:** Compliance with the requests for change in the payment terms **S4:** Providing information and products in the face of emergencies **S5:** Ease of communications and transparency **S6:** Warranty policy **S7**: Bilateral agreement / contract
Delivery (D):	**D1:** Compliance with the delivery volume **D2:** Compliance with the delivery schedule **D3:** Delivery speed **D4:** Compliance with the requests for change in delivery terms **D4:** Acceptability of the delivery vehicle
Technical Position (TP):	**TP1:** Personnel numbers and capabilities **TP2:** Technological infrastructure **TP3:** Research and development **TP4:** Production capacity
General Perception of the Supplier (GPS):	**GPS1:** Reliability **GPS2:** Experience in the Industry **GPS3:** Geographical location **GPS4:** References **GPS5:** Financial capabilities **GPS6:** Number / adequacy of shipping vehicles **GPS7:** Existence of a supplier management system
Supplier Audit Performance (SAP):	**SAP1:** Audit score
Environment Concerns (EC):	**EC1:** Recycling **EC2:** Energy consumption **EC3:** Waste management **EC4:** Green logistics **EC5:** Green packaging **EC6:** Environment management system certificates

Food Safety (FS):	**FS1:** Food safety team **FS2:** Traceability system **FS3:** Food safety management system certificates
Social Responsibility (SR):	**SR1:** Child labour **SR2:** Collective labour agreement labour union organisation rights **SR3:** Discrimination **SR4:** Work hours **SR5:** Remuneration **SR6:** Disciplinary practices **SR7:** Forced labour **SR8:** Social responsibility certificates
Occupational Health and Safety (OHS):	**OHS1:** Occupational health and safety team **OHS2:** Occupational health and safety management system certificates
Halal Perspective (HP):	**HP1:** Halal certification system

Table 4. DM preferences and criteria of weights.

Criterion	Fuzzy weight	Crisp weight
Quality	(0.75, 1.0, 1.0)	0.116
Cost	(0.625, 0.875, 1.0)	0.105
Service	(0.563, 0.813, 1.0)	0.100
Delivery	(0.563, 0.813, 1.0)	0.100
Technical position	(0.313, 0.563, 0.813)	0.071
General perception of the supplier	(0.5, 0.75, 1.00)	0.094
Supplier audit performance	(0.25, 0.5, 0.75)	0.063
Environment concerns	(0.188, 0.375, 0.625)	0.050
Food safety	(0.563, 0.813, 0,938)	0.097
Social responsibility	(0.125, 0.25, 0.5)	0.037
Occupational health and safety	(0.25, 0.5, 0.75)	0.063
Halal perspective	(0.625, 0.875, 1.0)	0.105

perspective (0.105) criteria ranked the highest among all DMs in terms of their significance.

Once the criteria were weighted, the DMs evaluated the alternatives with reference to individual criteria, using the linguistic variables presented in Table 2. Operator FWA was utilised to build the fuzzy decision matrix, which was then transformed into crisp values through defuzzification based on the BNP formula shown in Eq. 3. Then, the defuzzified decision matrix was normalised through Eq. 4. The fifth stage of the method saw the weighing of the normalised matrix using Eq. 5 with the previously calculated criteria weights. Then, it was followed by the calculation of the Q_i values showing the relative weight of decision alternatives using Eq. 8 so as to enable the ranking of the alternatives based on their importance.

As noted above in the assessment, the cost criterion was expected to be minimised so as to achieve optimisation, whereas the other criteria were deemed to exhibit utmost utility when maximised. Finally, the (N_i) figures denoting the level of utility of each alternative were calculated using Eq. 10. The P_i, R_i, Q_i, and N_i values calculated accordingly for each alternative are presented in Table 5. According to Table 5, alternative A_3 which stood out with the highest level of utility (100) was the best supplier alternative.

Table 5. Results of the application of COPRAS-F.

	A_1	A_2	A_3	A_4
P_i	0.181	0.228	0.245	0.241
R_i	0.025	0.027	0.027	0.027
Q_i	0.201	0.247	0.265	0.260
N_i	76.02	93.28	100	98.34
Ranking	4	3	1	2

Discussion

The selection of the best supplier will have a direct influence on the competitiveness of firms. Therefore, it should be considered as a strategic problem. Any supplier selection process should take into account a number of often conflicting criteria such as quality and cost, in combination. Thus, supplier selection is essentially an MCDM problem. Given the fact that conventional MCDM techniques have certain shortcomings in terms of modelling the thinking and judgment processes of people, fuzzy MCDM techniques combining MCDM techniques with fuzzy logic principles are recommended instead. The present work used a relatively new fuzzy MCDM technique, COPRAS-F method, in the context of supplier selection process of a dairy products firm operating in the food industry.

In the present work, we specifically focused on the food safety and halal criteria besides other supplier selection criteria widely used in the literature. As a result of the application, the most important criteria in supplier selection were determined to be quality and cost, respectively. This result is not surprising, and it largely overlaps with the literature. Halal and food safety, which are the focused criteria of the research, were in the 3rd and 5th place among the 12 criteria, respectively. This result is considered to be an important finding in terms of showing the risk perception of a company related to halal, in a country where the majority of the population is Muslim. When the findings are evaluated with respect to food safety, quality and food safety practices are intertwined in many of the businesses. This situation is thought to have an effect on the food safety criteria ranking. Halal and food safety certificates help to reduce both religious and health concerns by giving confidence to stakeholders in the food chain. In addition, it promotes the purchasing behaviour of consumers. However, it may be misleading to consider only the certificate as a counterpart of "trust". As a matter of fact, both the academic literature and the emerging food scandals points to the inadequacy of standards and regulations. Therefore, it has been stated that verifying certified products with audit and laboratory analysis, and establishing a monitoring mechanism will make a significant contribution to both the halal assurance system and food safety (Van der Spiegel *et al.,* 2012; Lau *et al.,* 2020). In recent years, within the framework of halal food integrity, consumers have not only been interested in the halal certificate logo, but also in many new situations, including cross-contamination in the entire production and supply process such as raw materials, production, logistics, and storage (Supian, 2018). In addition, due to some differences in the concepts of halal and haram between Muslim countries, the reliability of the local certificate in the global halal supply chain is open to discussion. It has also been stated that the halal certificate cannot fully meet the intangible issues that ensure the integrity of halal food. Based on this, it has been expressed that the relatively less mature halal food industry's excessive dependence on standards and certificates may harm the integrity of halal food (Ali and Suleiman, 2018). At this point, it can be easily said that the opinions expressed with the halal certificate are also valid for the ISO 22000 certificate, which represents food safety. This is because halal and food safety practices are integrated. The globalisation of the food industry will cause more suppliers to emerge. It should not go unnoticed that certificates are still an important tool in controlling companies in the global supply chain.

The COPRAS-F method will be useful for the DMs and managers of the food industry, as it incorporates full support of the management to utilise their experiences concerning the business processes of the company, and thus eliminate the biases in the selection procedure of the appropriate supplier. In addition, it can hasten the reaching of consensus among multiple DMs, which will reduce resistance. Besides, the suggested methodology is flexible enough to add extra criteria or DMs in the process.

The food sector is represented by thousands of companies, and has a significant share in the Turkish and world economies. It is known that supplier selection is a critical process that affects many operations of businesses, especially food safety. In the present work, which is one of the first attempts to address supplier selection with the COPRAS-F method, it is suggested to include the concepts of food safety and halal as the main decision criteria. It is revealed that the proposed methodology is a robust decision support tool for supplier selection in the presence of multiple conflicting criteria in a fuzzy environment.

Conclusion

Despite the aforementioned merits, the present work is not without limitations. The introduced framework does not allow taking into account the interdependencies between decision criteria, which can be considered as a shortcoming. Disregarding such interactions may lead to different final ranking. A future study can be undertaken to cover interactions and dependencies among criteria or alternatives using the fuzzy ANP or DEMATEL methods to verify the findings of the present work.

It is also worth noting that the decision-making approach presented in the present work is not limited to PET packaging supplier selection. Future research may focus on real-world applications of the proposed framework to handle other MCDM problems. Furthermore, in addition to the certification issue in order to reduce consumer concerns in terms of both halal and food safety, it is considered important to implement new practices, to develop monitoring systems focusing on food integrity throughout the supply chain, and to take the initiative of the public in this sense.

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