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Quality and sustainability in the production process: A study of bakeries using an integrated multi-criteria method based on fuzzy AHP and fuzzy TOPSIS

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Abstract

The objective of the present study is to evaluate, determine, and apply alternatives for improving the quality of the process and the product, with an emphasis on sustainable practices, using an integrated multi-criteria method. For this purpose, an analysis was conducted at a chain of bakeries, aiming to highlight bottlenecks in the production process and in the product. With the support of a literature review, four criteria and seven alternatives were defined to overcome these bottlenecks and, at the same time, contribute to the sustainability of the organization. For data analysis, six decision makers were interviewed and, following their evaluations, an integrated method based on fuzzy AHP and fuzzy TOPSIS was created. The fuzzy AHP was adopted to establish the importance of the criteria, while the fuzzy TOPSIS was used to evaluate and classify the alternatives developed to bypass the bottlenecks. The results revealed that of the criteria, Criterion "Cr1 – Quality" was prioritized. On the other hand, the alternative with the best performance was "A3 – Physical Layout Reorganization". Applying this alternative, the study demonstrates the results achieved such as reduction of errors and accident risks, as well as greater fluidity in the productive space. the present study also makes theoretical and managerial contributions to the field, bringing the theory closer to the reality of companies that operate in the food sector.

KEYWORDS

multicriteria methods, organizational sustainability, quality in the production process

1 | INTRODUCTION

Companies that focus on the production of goods and services and the food sector admit that excellence in quality is a differential when competing in a market.Therefore, organizations have no choice but to continually seek to improve competitive factors through innovations, especially with regard to quality management (Joghee, 2017; Ravichandran, 2019; Sibanda & Ramanathan, 2019; Karagiannis & Andrinos, 2021).

Regarding the bakery industry, it is estimated that, in Brazil, accounts for approximately 36% of the food industry. In 2020, even during the crisis created by the Covid-19 pandemic, it earned approximately R$ 91.94 billion, with the sector having a slight fall in revenue compared with 2019. Thus, knowing that Brazilian style French bread rolls are among the most commonly consumed foods in Brazil, it is important that their quality is improving (ABIP, 2020).

Furthermore, in addition to quality, organizations are under increasing pressure to reduce their impact on the environment, since sustainable bias has influenced customer/consumer decision making (White, 2009; Ross & Milne, 2021). Thus, sustainable actions have become a strategy for companies that aim to enhance their capacity for innovation in a favorable socio-environmental environment (Vimal, Kandasamy & Duque, 2021).

However, achieving sustainability in an organization is not easy. Liern and Perez-Gladish (2018) argued that the sustainability of an organization denotes responsibility with regard to the economic, social and environmental needs of all interested parties today without compromising the satisfaction of future needs.

Studies such as that of Ferguson (2016) provided interesting insights regarding sustainability in bakeries. The author explained the issue of productivity growth as a barrier to a sustainable transition, pointing out that artisanal bakeries, despite producing less than large industries, are more sustainable.

Given the importance of aligning organizations with a sustainable bias, studies have listed ways to improve sustainable performance in bakeries. To this end, they have focused on energy efficiency (Briceño-León et al., 2021), social aspects (Amini-Rarani, Abutoraabi & Nosratabadi, 2021), and the supply chain (Deng et al., 2021).

Considering the positive impact that sustainable practices can have on organizations in the food sector (such as bakeries), the emphasis that consumers place on more sustainable products/services (Salzberg et al., 2019), the premise that transparency and trust in organizations are factors that influence customer decisions (Yost & Cheng, 2021), the importance of the bakery industry for the economy of several countries (ABIP, 2020) and the existing gap of alternatives to improve sustainable performance in bakeries, the following question was asked: how can the sustainable actions of bakeries be improved through the identification of production bottlenecks? And how do these actions help to increase the productivity of companies in this field?

To answer this question, the following research objective was determined: to evaluate, determine and apply alternatives to improve the quality of the process and the product, with an emphasis on sustainable practices, using an integrated multi-criteria method. Multi-criteria methods have aided decision making in a sustainable environment, providing managers with relevant information to help them develop and align strategies to achieve sustainability (Abdel-Basset et al., 2021; Damke et al., 2021; Silva et al., 2021). In this study, the Fuzzy AHP method was used to establish the importance of the four production criteria: Quality (Souza & Alves, 2018), Cost (Steen, 2005), Time (Bloss, 2006), and Resources (Pakdil, Toktas & Leonard, 2018). Furthermore, it is understood that Fuzzy AHP is a multi-criteria technique that aids managerial decision making. In this technique, the criteria are compared and analyzed through linguistic variables, symbolizing triangular fuzzy numbers (Calabrese et al., 2019; Goyal et al., 2021).

To improve the sustainable production performance of the context under analysis, seven alternatives were defined:

To improve the sustainable production performance of the context under analysis, seven alternatives were defined: Personnel Training (Randhawa and Ahuja, 2018), 5S Program (Cannas et al., 2018), Physical Layout Reorganization (Aghazadeh, 2005), Raw Material Management (Williams, 2014), Raw Material Storage (Shunmugasundaram & Maneiah, 2018), Inventory (Nakuja & Kerr, 2018) and Time Standardization (Raval; Kant & Shankar 2018). In this research, we sought to identify the best alternative. Therefore, the Fuzzy TOPSIS method was used. Fuzzy TOPSIS is also a multi-criteria technique whose main objective is to list the degree of priority of the defined attributes (Dos Santos et al., 2019; Goyal et al., 2021).

This article makes theoretical and managerial contributions to the field. In terms of theoretical contributions, it reflects on the theme of sustainability in bakeries, developing criteria and alternatives through the literature to aid the development of the theory concerning sustainable alternatives aligned with the production process. As for managerial contributions, in addition to highlighting and analyzing alternatives and criteria applicable to different bakeries to improve the production process in the light of sustainability, the study empirically presents its results by applying the most prioritized alternative to demonstrate the reliability of the findings.

2 | LITERATURE REVIEW

2.1 | Quality of products and processes in bakeries

The volatile market in which food industries operate has prioritized the development of products that meet the quality requirements demanded by customers through fast and accurate technologies (El-Mesery et al., 2019). However, the definition of quality is broad, even more so when it comes to the food industry. The quality of food is not exclusively attributed to sustenance, but also to the characteristics of the product's processes, as customers need additional data about the products that they purchase, due to their greater knowledge (El-Mesery et al., 2019).

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Haas et al. (2021) emphasized that the quality of food can be defined as being adequate for consumption, along with requirements that satisfy the needs and expectations of the customer. These authors also claimed that food quality is subdivided into objective and subjective dimensions. Subjective food quality is usually directly related to process attributes, such as organic production or attention to animal welfare, but it also encompasses attributes such as flavor or price. On the other hand, objective quality encompasses the chemical, microbiological and physical attributes of a food product.

Regarding the quality of processes and products in the food industry, the study by Costa et al. (2020) leveraged Lean Six Sigma (LSS) to identify customer desires, eliminating waste and reducing variability. The authors tested the instrument in the food industry to identify which LSS practices are successfully implemented in that sector, resulting in better performance and competitiveness of the food company under study.

In relation to bakeries, Durak and Aksu (2021) explained that, through dynamic programming (DP), which is similar to that used by Durak and Aksu (2017), they were able to address failures in a timely manner and provide high-quality solutions to correct defects in a bakery's production line. At the same time, a study carried out by Rahayu et al. (2021) reported the beneficial evolution of quality through the use of the Kaizen 5S analysis method, together with the commitment and supervision of employees.

Confirming the above statements, the quality tools are technical, and studies were conducted for the purpose of improving the quality of production processes in organizations and industries, as well as solving certain problems in these processes (Zhao et al., 2021). From this perspective, companies that use quality control mechanisms in their daily operations have greater visibility, customer satisfaction, and employee well-being, with improved productivity, helping to achieve good results, profitability and, finally, success in the market (Rahayu et al., 2021).

2.2 | Sustainable performance in food companies

With the evolution of environmental awareness and social demands, several production models have emerged in terms of product and process quality. This has promoted the renewal of organizations in relation to sustainable practices, improving their goods and services in accordance with the new reality of the global market (Henao et al., 2019; Beamer et al., 2021).

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Organizational sustainability is defined as the state in which organizations present a production flow that ensures that they remain competitive (Malvestiti et al., 2021). According to Beamer et al. (2021), the prioritization of sustainability refers to a multifaceted development of the economy, the environment and society to meet current demand without inadequately exploiting the means that will be used by future generations.

Therefore, Mangla et al. (2020) noted that one of the main adversities found by companies is the adoption of sustainability in operations, beginning to manage waste efficiently. Regardless of the sector, whether service or manufacturing, adapting practices to sustainability is essential for organizations (Moktadir et al., 2021).

Thus, as defined by Dweiri et al. (2021), waste management is known as a term that refers to materials produced by human action, mitigating its effects on health and the environment and recovering waste resources. In this sense, Colares et al. (2019) emphasized that the food sector contributes heavily to the generation of urban solid waste and organic waste. According to these authors, the waste generated by the food sector is mostly made up of organic elements, which could be used for composting or in companies' own gardens.

At the same time, Melquíades et al. (2020) emphasized that sustainable management should also be extended to the bakery sector, due to its importance in the Brazilian manufacturing industry. In their studies, the authors used the methodology of Life Cycle Assessment in the production process of French bread, reaching the conclusion that wheat flour was responsible for the greatest environmental impact.

Therefore, in addition to organizations implementing improvement systems such as quality management, environmental management and health and safety management, this results in an increase in their overall performance, as well as strengthening a foundation for the development of sustainability (Tiwari et al., 2020).

3 | METHOD

To achieve the proposed objective, a theoretical-empirical study was conducted, in which pre-defined steps were followed to ensure assertive and reliable results, demonstrating a decision-making process and a real application of the developed theme. The steps followed for the present study can be viewed in **Exhibit** 1, defined as the Methodological Flow.

The first stage of this study consisted of defining the criteria. In light of the theory, the analysis criteria and their contribution to the sustainable aspect of the organization were listed, as shown in **Exhibit** 2.

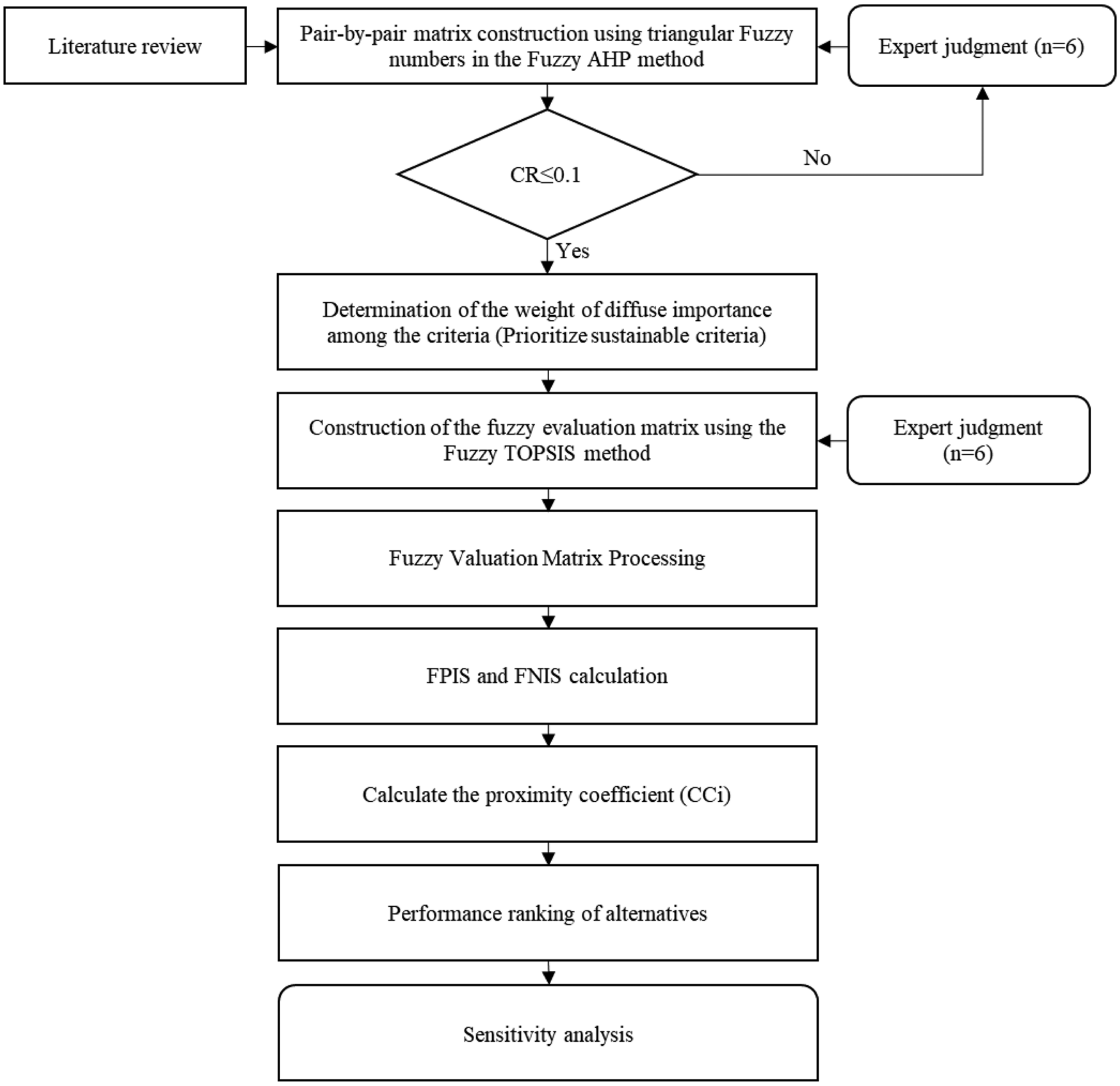

EXHIBIT 1 Methodological flow

EXHIBIT 2 Criteria defined for analysis

Criteria	Authors
Cr1 – Quality	(Souza & Alves, 2018)
Cr2 – Costs	(Steen, 2005)
Cr3 – Time	(Bloss, 2006)
Cr4 – Resources	(Pakdil, Toktas & Leonard, 2018)

Exhibit 2 presents the four selected criteria, listing the different studies that guided their definition for this work. With regard to Cr1 – Quality, it is known that the quality of processes and products adds to the organization because it is a means of making improvements in the three dimensions of sustainability, reducing production costs, creating an organized work environment and reducing the generation of waste that is harmful to the environment (Souza & Alves, 2018). Cr2 – Costs is important because the company's adoption of sustainable practices makes it reduce its costs related to overproduction and waste generation. Thus, it contributes to the economic dimension of sustainability (Steen, 2005).

Cr3 – Time, focused on production time, directly influences the economic dimension of sustainability. If the process is lengthy, the company reduces its capacity and ends up producing goods in smaller quantities (Bloss, 2006). Cr4 – Resources, on the other hand, is relevant, as the proper use of both human and technological resources

EXHIBIT 3 Alternatives

Alternatives	Contributions
A1 – Staff training	The social dimension of sustainability is closely linked to practices that promote the well-being of employees, among which the training of employees can be highlighted. Empowering workers helps to minimize waste and improve the organization's processes (Randhawa and Ahuja, 2018).
A2 – 5S program	The implementation of the 5S Program provides a motivating, clean and organized environment. Therefore, this tool provides improvements in the three dimensions of sustainability, reducing costs with waste, motivating employees in their work environment and managing the use of resources (Cannas et al., 2018).
A3 – Physical layout reorganization	Reorganizing the physical layout not only improves the company's productivity, it also influences the economic and social dimensions of sustainability. In economic terms, a good physical arrangement means more efficient processes, consequently, reducing production losses. As for the social dimension, the physical layout aids employee well-being because, with good planning, it is possible to create a pleasant and comfortable space for workers (Aghazadeh, 2005).
A4 – Raw material management	An organization that intends to become sustainable make changes in its management methods in order to continuously mitigate environmental impacts. For this purpose, it is necessary for the company to adopt practices that encourage a reduction in the use of raw materials and other resources (Williams, 2014).
A5 – Raw material storage	An environmental feasibility analysis can be conducted through the various forms of raw material storage. Poorly stocked material can lead to various losses and waste for the organization, including economic losses (Shunmugasundaram & Maneiah, 2018).
A6 – Stock	Environmental practices are beneficial to the economy of scale in the acquisition of goods, the scheduling of production and the labor required to manufacture products. They can also reduce the time that products are stocked in company warehouses, minimizing the environmental impact inherent to stock maintenance (Nakuja & Kerr, 2018).
A7 – Time standardization	The standardization of time is extremely important for sustainability, as it can eliminate the inefficient use of electricity due to variations in how long electric machines are in use. Therefore, greater control over time is necessary, meaning that it should be standardized to optimize production (Raval; Kant & Shankar 2018).

Source: Adapted from Randhawa and Ahuja (2018), Cannas et al. (2018), Aghazadeh (2005), Williams (2014), Shunmugasundaram & Maneiah (2018), Nakuja & Kerr (2018), Raval et al. (2018).

helps to generate improvements in the three pillars of sustainability, reducing production costs, minimizing the environmental impacts caused by the creation of waste and motivating the organization's employees (Pakdil et al., 2018).

After defining the criteria (Exhibit 2), alternatives emerged that could mitigate production bottlenecks and at the same time contribute to the sustainable performance of the organization under study. Thus, Exhibit 3 shows the alternatives raised through the literature on the subject.

To apply the research, a medium-sized bakery was defined as the study organization, which, in addition to the head office, had around five branches located in the central region of Rio Grande do Sul State. The justification for this definition was the convenience criterion for participation in the research, willingness to make information available and readiness to welcome the researchers to the company to conduct an initial analysis of the bottlenecks, since the research period was from October 2021 to November 2021, when restrictions on visits were still in place due to the Covid-19 pandemic.

After defining the criteria and alternatives, the decision makers were aligned, defining the general manager of the organization and the employees responsible for production management, totaling six decision makers with an average of 7 years of experience. Data were collected from these decision-makers in the form of a questionnaire, which contained the evaluation scale of criteria and alternatives. The next step was the application of the integrated methodology based on Fuzzy Analytic Hierarchy Process (Fuzzy AHP) and the Fuzzy Technique for Order Performance by Similarity to Ideal Solution (Fuzzy TOPSIS).

The methods were chosen because different studies have successfully used this form of integration in analyses focusing on sustainability and management (Taylan et al., 2014; Chou et al., 2019; Jasiulewicz-Kaczmarek et al., 2021; Goyal et al., 2021).

3.1 | Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

The weights were calculated using the Fuzzy AHP method, proposed by Chang (1996). Fuzzy AHP is an extension of the Analytic Hierarchy Process (AHP) method, developed by Saaty (1980), in which, combined with the fuzzy logic developed by Zadeh (1988), it was improved to be applied in environments that present degrees of uncertainty (Wegner et al, 2021).

The steps used to define the weights of the criteria determined by the method are as follows:

Step 1: A hierarchy was designed to transform a complicated problem into a fundamental form.

Step 2: The relative importance of each criterion was determined by the experts' assessment, for which a comparison matrix was constructed. Thus, the resulting pairwise comparison matrix was defined using Equation (1).

$$Z = [(1,\ 1,\ 1)\ l_{12}m_{12}u_{12}\ \cdots\ l_{1n}m_{1n}u_{1n}\ l_{21}m_{21}u_{21}\ (1,\ 1,\ 1)\ \ldots\ l_{2n}m_{2n}u_{2n}\ \vdots\ \vdots\ \ddots\ \vdots\ l_{n1}m_{n1}u_{n1}\ l_{n2}m_{n2}u_{n2}\ \ldots\ (1,\ 1,\ 1)\ ] \quad (1)$$

All the elements of the matrix (Z, l_{ij}, m_{ij}, u_{ij}) indicate the values regarding the importance of the criteria. The analysis values of the $\imath$th data for the target m were found using the following symbols. All of (j : 1, 2, …, m) M_{gi}^{j} are triangular fuzzy numbers. In addition, $X = (X_1, X_2, \ldots, X_n)$ was the decision set, and $T = (t_1, t_2, \ldots, t_n)$ was the target set of the matrix (see Equation 2).

$$M_{gi}^{1},\ M_{g2}^{2},\ \ldots,\ M_{g3}^{m},\ i\ =\ 1,\ 2,\ \ldots,\ n \quad (2)$$

For the analysis of the decision makers, a scale containing linguistic expressions corresponding to the equivalent triangular fuzzy numbers was used, in which each of the experts was invited to make an assessment. Thus, the expressions and the corresponding fuzzy numbers they are: equal importance (1, 1, 1), little importance (1, 3, 5), great importance (3, 5, 7), very great importance (5, 7, 9) and Extreme importance (7, 9, 9), respectively.

Step 3: Fuzzy values across the target set for each criterion were calculated separately, and the $\sum_{j=1}^{m} M_{gi}^{j}$ value was obtained (see Equation 3).

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j,\ \sum_{j=1}^{m} m_j,\ \sum_{j=1}^{m} u_j \right) \quad (3)$$

Step 4: Each of the fuzzy values in the decision set was calculated, and $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$ was obtained. The inverse vector of $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$ was then calculated, as shown in Equations (4) and (5).

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i,\ \sum_{i=1}^{n} m_i,\ \sum_{i=1}^{n} u_i \right) \quad (4)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i},\ \frac{1}{\sum_{i=1}^{n} m_i},\ \frac{1}{\sum_{i=1}^{n} l_i} \right) \quad (5)$$

Step 5: the synthetic extension value (S_i) for each criterion was calculated using Equation (6).

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \quad (6)$$

Step 6: the degree of possibility of $M_1(l_1, m_1, u_1) \geq M_2(l_2, m_2, u_2)$ was given by Equation (7).

$$V\ (M_1\ \geq\ M_2) =\ sup\, x \geq y\ \left[min\ \left(\mu_{M_1}(x), \mu_{M_2}(y) \right) \right] \quad (7)$$

To calculate the ordinate of the highest intersection point, Equation (8) was used.

$$V\ \ (M_2 \geq M_1 = hgt(M_2 \cap M_1) = \left\{ 1\ if\ m_2 \geq m_1 0 if \geq u_2 \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} otherwise \right\} \quad (8)$$

Step 7: As evidenced by Equation (9), the degree of possibility of a convex fuzzy point being greater than z convex fuzzy points, $M_i (i = 1, 2, \ldots, z)$ was defined.

$$V\ (M \geq\ M_1,\ M_2,\ \ldots,\ M_z) =\ V\ [(M \geq M_1); (M \geq M_2); \ldots; (M \geq M_z)] =\ V\left(M \geq M_p\right),\ p\ =\ 1, 2, \ldots, z \quad (9)$$

Supposing that $z \neq p\ e\ z = 1, 2, \ldots$ and n conditions were met, then Equation (10) was applied.

$$d'\ (A_p) = min\, V\, (S_p \geq S_z) \quad (10)$$

If $A_p (p = 1,\ 2,\ \ldots,\ n)$ were n elements, then Equation (11) was applied.

$$W = \left(d'\ (A_1); d'\ (A_2), \ldots, d'\ (A_n) \right)^T \quad (11)$$

Step 8: normalized weight vectors were obtained in accordance with Equation (12).

$$W\ = (d\,(A_1),\ d\,(A_2),\ \ \ldots,\ d\,(A_n))^T \quad (12)$$

Following the process, the consistency index (CI) was calculated using the λmax, obtained by: CI = (λmax - n) / (n - 1), and to finalize the consistency ratio calculation in: CR = CI / RI. The random index (RI) was obtained by simulation, in general, with an acceptable consistency CR≤0.10

3.2 | Fuzzy Technique for Order Performance by Similarity to Ideal Solution (Fuzzy TOPSIS)

In order to conduct the analysis of the alternatives, the method proposed by Chen (2000), the Fuzzy TOPSIS method, was used. It is stated that this method has been widely applied in different contexts, aiding decision making and the definition of more coherent alternatives for solving problems (Yucesan & Gul, 2020; Damke et al, 2021; Silva et al., 2021).

So that the evaluators could evaluate the alternatives in relation to the criteria, the linguistic performance scale was used, Very Bad (1; 1; 3), Bad (1; 3; 5), Acceptable (3; 5; 7), Good (5;7;9) and Very Good (7;9;9).

If the fuzzy rating and decision importance weight was $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $\tilde{w}_{jk} = (w_{jk_1}, w_{jk_2}, w_{jk_3})$, with $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$, respectively, the aggregated values ($\tilde{x}_{ij}$)of the alternative in relation to each criterion were given by $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$, as shown in Equation (13):

$$a_{ij} = min_k \left\{a_{ijk}\right\}, \ b_{ij} = \frac{1}{K}\sum_{k=1}^{k} b_{ijk}, \ c_{ij} = max_k \left\{c_{ijk}\right\} \tag{13}$$

Subsequently, the fuzzy decision matrix was calculated for the alternatives ($\tilde{D}$) and a fuzzy vector for the criteria ($\tilde{W}$), in accordance with Equations (14) and (15).

$$\tilde{D} = \begin{matrix} A_1 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \ldots & \tilde{x}_{mn} \end{bmatrix}, i = 1, 2, \ldots, \text{ m and } j = 1, 2, \ldots, \text{ n;} \tag{14}$$

$$\tilde{W} = (\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n) \tag{15}$$

Thus, the fuzzy decision matrix could be normalized. The raw data were normalized using linear scale transformation to bring the various criteria scales into a comparable scale. The normalized decision matrix $\tilde{R}$ was calculated using Equation (16):

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}, \ i = 1, 2, \ldots, m; \ j = 1, 2, \ldots, n \tag{16}$$

where:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = max_i \, c_{ij} \text{ (Benefit Criteria)}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{ and } a_j^- = min_i \, a_{ij} \text{ (Cost Criteria)}$$

Subsequently, the calculation of the weighted normalized matrix was performed. The weighted normalized matrix $\tilde{V}$ was estimated by multiplying the weights $\tilde{W}_i$ of the evaluation criteria with the normalized fuzzy decision matrix $\tilde{r}_{ij}$, as presented in Equation (17):

$$\tilde{V} = \left|\tilde{v}_{ij}\right|_{mxn}, \ i = 1, 2, \ldots, m; j = 1, 2, \ldots, n$$

where

$$\tilde{v}_{ij} = \tilde{r}_{ij} \, (.) \, \tilde{w}_j \tag{17}$$

In this step, the calculation was made from the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS). Thus, each alternative was calculated in accordance with Equations (18) and (19).

$$A^* = \left(\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*\right) \ where \ \tilde{v}_j^* = \left\{v_{ij3}\right\},$$

$$i = 1, 2, \ldots, m; \ j = 1, 2, \ldots, n \tag{18}$$

$$A^- = (\tilde{v}_1, \tilde{v}_2, \ldots, \tilde{v}_n) \ where \ \tilde{v}_j^- = \left\{v_{ij1}\right\}$$

$$i = 1, 2, \ldots, m; \ j = 1, 2, \ldots, n \tag{19}$$

At this point, the distance of each alternative was calculated, defining the closest distance to the fuzzy positive ideal solution (FPIS) and the most distant from the fuzzy negative ideal solution (FNIS). Therefore, the distance was d_i^*, d_i^- of each weighted alternative, where $i = 1, 2, \ldots, m$. Thus, the FPIS and the FNIS were calculated using Equations (20) and (21), respectively:

$$d_i^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \ i = 1, 2, \ldots, m \tag{20}$$

$$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), \ i = 1, 2, \ldots, m \tag{21}$$

Where $d_v(\tilde{a}, \tilde{b})$ is the measure of distance between the two fuzzy numbers, $\tilde{a}$ and $\tilde{b}$ and $d_v \ (\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]}$

Afterwards, the proximity coefficient (CCi) of each alternative was calculated. The proximity coefficient represents, simultaneously, the distances of the positive ideal solution (A*) and the fuzzy negative ideal solution (A-). The proximity coefficient of each alternative was calculated based on Equation (22):

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \ i = 1, 2, \ldots, m \tag{22}$$

The different alternatives were classified according to the proximity coefficient (CCi), and expressed in descending order. Thus, the best alternative is the one that is closest to the FPIS and farthest from the FNIS. Therefore, the process ended with the performance of a sensitivity analysis, thereby demonstrating alternative decision scenarios, as well as the analysis (Kutlu & Kahraman, 2019; Rani et al., 2020). It should be highlighted that the methods were implemented using electronic spreadsheets, in which the data were collected using the questionnaire were tabulated and analyzed by the specialists.

EXHIBIT 4 Diffuse criteria weights

Criteria	Fuzzy weight prioritized	Defuzzified weight
Cr1 – Quality	(0.353; 0.337; 0.315)	33%
Cr2 – Costs	(0.259; 0.271; 0.265)	27%
Cr3 – Time	(0.225; 0.233; 0.247)	24%
Cr4 – Resources	(0.163; 0.159; 0.173)	16%

4 | RESULTS

4.1 | Analysis of criteria weights using Fuzzy AHP

With the evaluation conducted by the decision makers using the linguistic variables presented, it was possible to establish priorities using the Fuzzy AHP method to calculate the weights for each of the criteria. To calculate fuzzy synthetic extensions, Equation (6) was used. Thus, for each decision maker ($n = 6$), weights were established, with an average of the sum of the weights also used by Taylan et al. (2014), reaching the weights shown in Exhibit 4.

Through the pairwise comparison, it was observed that Cr1 obtained 33%, which means that the highest representation in the criteria is quality. According to the bakery's decision makers, the quality criterion is the most important for the French bread process and for sustainable actions within the organization. The analysis resulted in an RC index of 7%, demonstrating consistency, as it is under 10%.

Pham Thi Phuong and Ahn (2021) referred to the quality of services and products as a factor that directly influences customer satisfaction and loyalty. Furthermore, the quality of the product has a positive impact on the profitability of organizations (Severt et al., 2020).

Regarding criterion "Cr4 – Time", although it was the least prioritized in this study, it is known to be relevant to improving the process and sustainability. This is because resources such as energy and machinery can be wasted and used ineffectively, generating costs and making negative impacts on the environment (Bloss, 2006; Raval, Kant & Shankar 2018; Yadav, Shankar & Singh, 2021).

As shown in Exhibit 2, the triangular fuzzy numbers were determined by the Fuzzy AHP being used as criteria weight for the Fuzzy TOPSIS method.

4.2 | Analysis of the performance of sustainable alternatives using the Fuzzy TOPSIS method

Thus, to achieve the goals of the study, the intention was to focus on the Fuzzy TOPSIS method as a continuation of the Fuzzy AHP method. The aggregated Fuzzy weights for each of the alternatives are presented in Exhibit 5.

After defining the aggregate weights for each of the alternatives, the values were normalized using Equation (16). It was noted that the cost (Cr2) and time (Cr3) criteria were normalized as cost criteria, while the other criteria were normalized as benefit criteria.

After normalization, the matrix was weighted using Equation (17). From this, the FPIS and FNIS were defined (Equations 18 and 19), with the negative and positive distances having been determined, with Equations (20) and (21) being used for this purpose.

Finally, using Equation (22), the performance values of each of the alternatives were generated. Exhibit 6 lists the performances obtained for each of the alternatives evaluated by the decision makers of the bakery under study.

In order to verify the behavior of the ranking of the alternatives and demonstrate how sensitive the final performance of the alternatives is, a sensitivity analysis was performed. Exhibit 7 shows the behavior of the alternatives with changes in the weights of the criteria.

Based on the results obtained from the 14 experiments carried out for the seven alternatives, after all the experiments (Exhibit 5), it was found that the decision-making process is sensitive to the change in the weights of the criteria, since around 57.14% of the experiments in the ranking resulted in significant changes.

4.3 | Application of alternatives and discussion of results

The results achieved through the analysis of the process were described in order to increase the productivity of bakeries together with sustainability. Therefore, the three most relevant alternatives were applied, in accordance with the interests of the and the possibility of immediate implementation. These alternatives were: A3 – Physical Layout Reorganization; A4 – Raw material management; and A7 – Time standardization.

With the reorganization of the physical layout (A3), it was possible to reduce errors and accident risks, since the path became more fluid, also allowing the reorganization of the preparation time, which influenced the standardization of time (A7). In line with the findings of this research, Hanggara (2020) noted that the layout not being properly structured directly impacts the waste of human resources and time. In this respect, the studies by Lufika et al. (2021) emphasized the importance of layout remodeling, as it is one of the pillars of a successful industrial/organizational process. For this to occur, the authors stressed that the attributes of an ideal layout for adequate material handling must be based on flexibility, coordination, use of volume, visibility, accessibility and minimum distance (Lufika et al., 2021).

Furthermore, with better raw material management (A4) after the implementation phase, reports are drawn up every month to check whether the demand for raw material has been met by suppliers. In

EXHIBIT 5 Alternatives aggregated weights

	Cr1	Cr2	Cr3	Cr4
A1	(1;7;9)	(3;8;9)	(1;6.33;9)	(1;6.67;9)
A2	(3;8;9)	(1;7.67;9)	(3;7.33;9)	(3;7;9)
A3	(1;7.33;9)	(1;6,33;9)	(1;6.67;9)	(1;6.67;9)
A4	(1;6.67;9)	(1;7.67;9)	(1;7;9)	(1;7.67;9)
A5	(1;6.67;9)	(3;8;9)	(1;7;9)	(3;7.33;9)
A6	(1;6;9)	(1;7.33;9)	(3;7.67;9)	(3;6.67;9)
A7	(1;6.67;9)	(1;7.33;9)	(1;6.67;9)	(1;7.33;9)
W	(0.353; 0.337; 0.315)	(0.259; 0.271; 0.265)	(0.225; 0.233; 0.247)	(0.163; 0.159; 0.173)

EXHIBIT 6 Ranking of the alternatives

Alternative	Overall performance	Classification
A3	0.417	1st
A4	0.416	2nd
A7	0.415	3rd
A2	0.384	4th
A1	0.362	5th
A5	0.357	6th
A6	0.352	7th

addition, it was decided to acquire a raw material management system in order to have greater control of what is in stock, thereby avoiding waste and lack of inputs in the production of bread. Therefore, the goal was achieved, and there was a reduction in losses and insufficiency of resources, boosting productivity.

Reinforcing the explanations of this study, Glock et al. (2021) claimed that raw material management reduces cost, delivery time and demand from suppliers, aspects that impact the company's performance. In this respect, Bandopadhyay and Khan (2020) emphasized that raw material management is extremely important and must be carried out effectively and efficiently, since, without adequate planning, the company will not reach the ideal level of strategy. management of inventory or business strategy. Bandopadhyay and Khan (2020) also stated that, in addition to reducing costs, it is possible to improve productivity through the proper administration of inputs.

Moreover, as the bakery did not have time standardization before (A7), this alternative proved to be relevant, making managers more concerned about this issue, as they saw, in practice, its efficiency and influence on the organization's productivity, as well as making savings on costs. Bures and Pivodova (2015) stressed the importance of time consumption and management, pointing out that this alternative must be constantly observed. Furthermore, studies such as that of Adizue et al. (2020) demonstrated the effectiveness of applying time standardization alternatives in the production process, corroborating the results found in this study, in which overall costs showed relevant reductions.

5 | FINAL CONSIDERATIONS

The purpose of this research was to evaluate, determine and apply alternatives to improve the quality of the process and the product, with

EXHIBIT 7 Sensitivity analysis

Experiments	Definition	A1	A2	A3	A4	A5	A6	A7
EXP 1	WC1–C4 = (1;1;3)	0.379	0.387	0.432	0.432	0.382	0.380	0.432
EXP2	WC1–C4 = (1, 3, 5)	0.404	0.412	0.456	0.457	0.407	0.402	0.456
EXP 3	WC1–C4 = (3, 5,7)	0.409	0.424	0.463	0.464	0.415	0.409	0.463
EXP 4	WC1–C4 = (5,7,9)	0.413	0.432	0.468	0.468	0.420	0.414	0.467
EXP 5	WC1–C4 = (7, 9,9)	0.430	0.458	0.485	0.486	0.441	0.433	0.484
EXP 6	WC1 = (7,9,9), WC2-WC4 = (1,1,3)	0.262	0.278	0.289	0.285	0.260	0.255	0.284
EXP 7	WC2 = (7,9,9), WC1, WC4 = (1,1,3)	0.456	0.230	0.255	0.254	0.459	0.229	0.254
EXP 8	WC3 = (7,9,9), WC1-WC2-WC4 = (1,1,3)	0.229	0.466	0.255	0.255	0.230	0.458	0.255
EXP 9	WC4 = (7,9,9), WC1, WC3 = (1,1,3)	0.259	0.271	0.284	0.291	0.272	0.267	0.289
EXP 13	WC2 = (1,1,3), WC1, WC4 = (7,9,9)	0.428	0.423	0.450	0.452	0.440	0.397	0.450
EXP 14	WC3 = (1,1,3), WC1, WC4 = (7,9,9)	0.393	0.456	0.450	0.451	0.405	0.431	0.449

an emphasis on sustainable practices, using an integrated multi-criteria method. To achieve this goal, a quantitative and qualitative study was conducted using primary and secondary data, which were collected through observation and a structured questionnaire with a sample of six decision makers from a network of bakeries located in the region of Southern Brazil.

Through linguistic variables, the six decision makers rated how important the criteria were, comparing them pairwise. Using the Fuzzy AHP method, it was possible to establish the weights of the criteria, with the most prioritized criterion being Cr1 – Quality. The quality of products is important for the organization to be successful, in addition to influencing customer decision making (Yang et al., 2020). Furthermore, it is relevant that organizations that work with food production build quality monitoring systems, since an ineffective production process with bottlenecks can influence the quality of the final product (Yu et al., 2020).

Moreover, production quality is also about understanding the customer's needs, designing the product accordingly within a specific time (Farahani & Tohidi, 2021). Current studies, such as that of Brizek et al. (2021) who, during the Covid-19 pandemic, studied the improvement of quality in services and products, showed that this was one of the main strategies implemented by managers to remain active in the market. Thus, the present study corroborates this observation, as it identified that what is most prioritized by decision makers in the bakery is quality.

To analyze the listed alternatives, the Fuzzy TOPSIS method was used, establishing a ranking based on the evaluations of decision makers, and the alternative that received the most attention was "A3 – Reorganization of the Physical Layout". Different studies, such as Pelagagge (2021), Aghazadeh (2005), Mohan, Sivakumaran and Sharma (2013), Styk and Bogacz (2019), and Bassem and Al-Kindi (2020), argued that the reorganization of the physical layout has an influence on production, quality and even customer purchase. Therefore, it helps the organization to achieve greater success. This alternative also contributes to the organization's sustainability, preventing unnecessary movements. With this, the risk of accidents and loss of raw material is minimized, as both the production process and the provisions of the environment where customers circulate influence the organization's success.

In addition to the contributions already discussed, this research has theoretical and managerial implications. With regard to the theoretical implications, it contributes to the literature on sustainable production management, focusing on the quality of processes and products. Furthermore, it provides empirical information about a type of organization that is little discussed, namely, bakeries and their production process, focusing on this process to reveal an alignment with sustainability. With regard to the managerial implications, this research presents different alternatives for the production process to leverage the sustainability of bakeries, putting into practice the alternatives with the best performance in the light of expert evaluations. It also clarifies the improvements found, which other managers of this type of organization can put into practice to improve their company's productivity and sustainable performance.

A limitations of the study is that it was conducted in a single network of bakeries within a specific region. This limitation was due to the pandemic, which made it impossible to reach a wider range of organizations in this field during the research period. A recommendation for future studies is to evaluate alternatives using methods that gauge the relationships between the alternatives, verifying which of them has the greatest influence on the quality of the production process and, at the same time, the sustainability of the organization.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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