



## Application of Multi-Criteria Methods and Neutrosophic Logic for the Analysis of Productive Factors

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### Abstract

This article explores the innovative application of multi-criteria methods and neutrosophic logic in the analysis of productive factors, highlighting how these approaches can offer a more nuanced and comprehensive view of industrial and business dynamics. Multicriteria methods allow different aspects to be evaluated simultaneously, considering complex variables that affect productivity and efficiency in various sectors. On the other hand, neutrosophic logic introduces a theoretical framework that manages the uncertainty and imprecision inherent in many business decisions, offering tools to better interpret and manage the variabilities and ambiguities that influence productive results. This integrative approach not only seeks to improve accuracy in the evaluation of critical factors such as cost, quality and time, but also to promote more informed and strategic decision making in competitive and changing environments. By combining rigorous analysis with interpretive flexibility, the door is opened to new methodologies that can effectively adapt to the complexities of the globalized market and the dynamic demands of consumers. This article examines case studies and practical examples to illustrate how these methods can be successfully applied in the optimization of production processes and in the formulation of business strategies that seek not only to remain competitive, but also to anticipate and proactively respond to emerging challenges.

**Keywords:** Neutrosophic Logic, Neutrosophic Multicriteria, Productive Factors

### 1. Introduction

To approach factor analysis using multicriteria methods and neutrosophic logic, it is crucial to understand the inherent complexity involved in the evaluation of multiple interrelated variables in diverse contexts. This approach combines decision principles that allow a systematic and exhaustive evaluation, considering not only traditional quantitative criteria, but also qualitative aspects and those that present uncertainty or ambiguity. This integration becomes essential in fields where decisions must take into account not only objective data, but also subjective perceptions and fluctuating environmental conditions. Multi-criteria methods offer a structured framework for evaluating alternatives against multiple criteria simultaneously, allowing the weighting and comparison of different options in a transparent and fair manner. This capability is essential in situations where decisions affect multiple stakeholders with diverse perspectives and priorities [1]. On the other hand, neutrosophic logic expands this approach by considering the ambiguity and uncertainty inherent in many decisional problems, providing tools to model and manage imprecision in data and human perceptions.

In factor analysis, the application of these methods not only seeks to optimize quantifiable results, but also integrate human judgment and qualitative evaluations that can influence strategic and operational decisions [2]. This integration is particularly relevant in contexts where the variables at play are interdependent and can affect each other in complex and non-linear ways. Therefore, the combination of multi-criteria methods and neutrosophic logic not only improves the objectivity and robustness of the analyses, but also offers a flexible framework to adapt to different contexts and changing conditions. The adoption of these approaches in factor analysis represents a significant advance towards more efficient and effective management of the complexity inherent in contemporary problems. By considering the diversity of perspectives and the dynamic nature of decisional environments, more informed and adaptive decision-making is promoted, capable of responding to the demands of an increasingly interconnected and changing world. Furthermore, these methods encourage transparency and justification in decision making by providing a clear and structured framework to evaluate and compare alternatives in an objective and equitable manner [3].

In practice, the application of multi-criteria methods and neutrosophic logic requires not only technical competence, but also analytical and communication skills to adequately manage complexity and uncertainty [4]. This implies effective collaboration between different disciplines and areas of expertise, as well as the development of tools and platforms that facilitate the integration and analysis of heterogeneous and often contradictory data. This holistic integration allows problems to be approached from multiple perspectives, improving the ability to anticipate and mitigate potential risks while maximizing emerging opportunities [5]. The application of multi-criteria methods and neutrosophic logic in factor analysis represents an innovative paradigm that not only improves the quality and robustness of strategic and operational decisions, but also strengthens the organizational capacity to face complex challenges with resilience and adaptability. This integrative and dynamic approach promotes more effective management of uncertainty and ambiguity, providing a solid framework for continuous innovation and continuous improvement in decision making in an increasingly complex and globalized world.

## **2. Related Work**

### **2.1. Neutrosophic Logic**

Neutrosophic logic emerges as a theoretical paradigm in philosophy and mathematics, offering a conceptual framework to address the ambiguity, uncertainty and indeterminacy that characterize many phenomena and processes in the real world. This approach goes beyond classical binary logics or even fuzzy logics, by recognizing and formalizing the notion of truth, falsity and indeterminacy simultaneously. In essence, it allows us to capture the complexity inherent in problems where the answers are not simply true or false, but can contain elements of both and, in turn, be undefined in certain aspects. The foundation of neutrosophic logic is found in the neutrosophic theory proposed by Florentin Smarandache, who introduced the concept of neutrosophy as an interdisciplinary field that encompasses logic, mathematics, philosophy and other areas [6]. This theory maintains that in many contexts and situations, especially in the fields of research and decision making, it is crucial to recognize and manage the imprecision and incompleteness of available information. This is where neutrosophic logic unfolds its usefulness by providing formal tools to represent and process this type of ambiguous and not fully defined information.

From an epistemological perspective, neutrosophic logic challenges traditional notions of absolute truth and falsehood by introducing the concept of neutral truth, neutral falsehood, and also neutral indeterminacy [7]. This trichotomous approach allows for a more faithful representation of reality in situations where complete certainty is difficult to achieve or even irrelevant. Rather than forcing binary responses in contexts where the evidence is mixed or incomplete, neutrosophic logic recognizes and formalizes the coexistence of degrees of truth and falsity, along with areas where truth cannot be determined with certainty. In practical applications, neutrosophic logic has been used in fields as diverse as artificial intelligence, medical decision making, economics, and engineering [8]. Its flexibility in modeling uncertainty and ambiguity has been particularly valuable in systems where precision and accuracy are critical but difficult to guarantee due to the complexity of the data and variables involved. This allows researchers and practitioners to take a more nuanced and realistic approach toward representing and analyzing information that would otherwise be problematic with more rigid and simplistic logics.

However, neutrosophic logic is not without criticism and challenges. Its formal complexity and often subjective interpretation of the concepts of neutral truth and neutral falsehood can be difficult to apply consistently and uniformly in different contexts and disciplines. Furthermore, the adoption of this theoretical framework requires a high level of competence and understanding of both the mathematical bases and the associated philosophical and epistemological implications [9]. This poses significant barriers to its widespread and effective adoption in everyday practice outside of specialized academic circles. Neutrosophic logic represents an important advance in the theory and practice of knowledge representation and decision making under conditions of uncertainty and ambiguity. Its ability to integrate degrees of truth, falsehood, and indeterminacy offers a more realistic and flexible

approach to addressing complex problems where simple answers are not adequate. However, its effective application requires deep understanding and careful application due to its intrinsically complex characteristics and the possible varied interpretations of its fundamental principles [10].

## 2.2. Multicriteria Evaluation Method

The Multicriteria Evaluation Method stands as a solid tool in decision-making processes, particularly in complex scenarios where multiple factors influence the result. By integrating various criteria and weighing their importance, this method provides a comprehensive framework for evaluating alternatives and making informed decisions. Its effectiveness lies in its ability to capture the multidimensionality of decision contexts, adapting the diverse perspectives and objectives of stakeholders [11].

At the heart of the Multi-Criteria Evaluation Method is the recognition that decisions often involve trade-offs between conflicting objectives. This method recognizes and navigates these trade-offs by systematically analyzing the impact of different criteria on the decision outcome. Quantifying and comparing Due to the relative importance of each criterion, decision makers can prioritize aspects that align with their objectives and values. One of the key strengths of the Multicriteria Evaluation Method is its flexibility and adaptability to various decision contexts. Whether selecting the best location for a new facility, choosing between competing projects or evaluating policy alternatives, this method can be tailored to fit the specific needs and constraints of each situation. Its versatility makes it a valuable tool in various areas, from urban planning to environmental management [12].

The article presents the application of the multi-criteria evaluation method designed to better evaluate the availability of natural orange juice for the production of isotonic drinks. The system takes into account several predefined parameters. In this study, multi-criteria decision making (MDMC) has been used to formulate the proposed objectives. MDMC allows you to address very complex real-world situations and develop countermeasures that simplify those situations and enable decision-making under specific conditions. This brings us to a state where we can solve the problem. problem [13-14].

Various MDMCs have been developed to solve problems in different areas of life and society. [15] However, traditional approaches evaluate alternatives based on explicit values. Due to the complexity of the environment and human subjectivity, MDMC problems are often associated with uncertainty. and the information provided to solve the problem is often confusing or linguistic [16]. To better understand the data used, we present the introductory aspects of the neutrosophic theory, and the methods used. Then it begins with the conclusions and at the end the results obtained and the conclusions derived from them are presented.

**Definition 1**[17]. Let  $X$  be a space of points (objects) whose common elements of  $X$  are denoted by  $x$ . A single-valued neutrosophic set (SVNS)  $A$  at  $X$  can be denoted as:

$$A = \{x, T_A(x), I_A(x), F_A(x) \mid x \in X\},$$

where  $T_A(x), I_A(x), F_A(x) \in [0, 1]$  for each point  $x \in X$  and  $T_A(x) + I_A(x) + F_A(x) \leq 3$ .

Human language or linguistic variables are often used in decision making. Language variables are simply words or phrases used in human language. Therefore, this method based on linguistic variables provides a practical approach for decision makers. Normative judgment can be expressed through linguistic variables. Language variables can be converted to SVNS as shown in Table 1.

**Table 1:** Linguistic variables and single-valued neutrosophic numbers (SVNN): [17]

Definition	SVNS
Extremely Preferred (EXP)	(1,0,0)
Very Very Preferred (VVP)	(0.9, 0.1, 0.1)
Very preferred (VP)	(0.8, 0.15, 0.20)
Preferred (P)	(0.70, 0.25, 0.30)
Equally Preferred (EP)	(0.50, 0.50, 0.50)

Not preferred (NP)	(0, 35,0, 75,0, 80)
Very not preferred (VNP)	(0, 20,0, 85,0, 80)
Very, very not preferred (VVNP)	(0, 10,0, 90,0, 90)
Extremely Not Preferred (ENP)	(0,1,1)

**Definition 2.** Let  $E_k = (T_k, I_k, F_k)$  be a neutrosophic number that defines the classification of the decision maker. Therefore, the weight of the decision maker is represented by [17].

$$\psi_k = \frac{1 - \sqrt{\frac{(1-T_k(x))^2 + (I_k(x))^2 + (F_k(x))^2}{3}}}{\sum_{k=1}^p \sqrt{\frac{(1-T_k(x))^2 + (I_k(x))^2 + (F_k(x))^2}{3}}} \tag{1}$$

When making decisions, it is important to make them as a team. When group decisions are made, the judgments of all decision makers must be integrated into a global and fair decision matrix. This can be done using the

The weighted neutrosophic average (SVNWA) theory [18] is defined as .

**Definition 3** [ 14]. Let's go ([14])  $D^{(k)} = (d_{ij}^{(k)})_{m \times n}$  the single-valued neutrosophic decision matrix and  $a_k$  the decision weight vector.  $\Psi = (\psi_1, \psi_2, \dots, \psi_p)^T$  and  $\psi$  the decision weight vector. The weight vector  $\psi$

$\psi$  is defined as  $\psi = (\psi_1, \psi_2, \dots, \psi_p)^T$  where  $\psi_k \in [0,1]$  the aggregate decision  $d_{ij}$  is calculated as:

$$d_{ij} = (1 - \prod_{k=1}^p (1 - T_{ij}^{(k)})^{\psi_k}, \prod_{k=1}^p (I_{ij}^{(k)})^{\psi_k}, \prod_{k=1}^p (F_{ij}^{(k)})^{\psi_k}) \tag{2}$$

**Definition 4.** Assuming that A and B are two estimated neutrosophic numbers (SVNN), then the standard Hamming distance between them is:

$$d(A, B) = \frac{|TA - TB| + |IA - IB| + |FA - FB|}{3} \tag{3}$$

**2.3. Materials and methods**

**Step 1:** Identify alternative solutions for the evaluation

**Step 2:** Determine the importance of decision makers. The logic of this approach allows each decision maker to create a unique evaluation based on their understanding of the problem, which may differ from other decision makers' evaluations. The goal of the decision-making process is to treat the relative weight of each decision maker as a linguistic variable and pass it to the SVNN to make additional decisions using Equation (1).

**Step 3** Convert the expert-specified language classification to SVNN (see Table 1).

**Step 4.** Establish the initial relationship matrix between option  $A = (A_1, \dots, A_n)$  and attribute  $G = (G_1, G_2, \dots, G_n)$ . Therefore, each attribute is represented by  $a_{ij}$ , where  $i = 1, 2, \dots, m$  and  $j = 1, 2, \dots, n$  are the values for attribute A and the options for attribute G. This is represented as:

$$A = \langle (T_{ij}, I_{ij}, F_{ij}) \rangle_{m \times n} \tag{4}$$

$T_{ij}, I_{ij}$ , and  $F_{ij}$  are the degrees of membership, indeterminacy, and nonmembership, respectively, and equation (2) is used to calculate these values.

**Step 5:** Integrate information and make decisions. This means that  $A = (a_{ij})_{m \times n}$  it is normalized. by  $B = (b_{ij})_{m \times n}$ .

**Step 6:** Using equation (5), construct the preference function  $P_j(B_i, B_r)$  of alternative  $B$  with respect to the attribute  $B_{jr}$ .  $G_j$ .

$$P_j(B_i, B_r) = \begin{cases} 0, & d \leq p \\ \frac{d-p}{q-p}, & p < d < q \\ 1, & d \geq q \end{cases} \quad (5)$$

**Step 7:** Calculate the relative weight of the attribute  $j_r$ . This is the relative weight of  $G_{j_r}$ .

$$w_{j_r} = \frac{w_j}{w_r} = (j_r, r = 1, 2, \dots, n) \quad (6)$$

Use the preference index  $\pi(B_i, B_r)$  to define the circle  $B_i$  with respect to  $B_r$ .

$$\pi(B_i, B_r) = \frac{\sum_{j=1}^n w_{j_r} P_j(B_i, B_r)}{\sum_{j=1}^n w_{j_r}} \quad (7)$$

**Step 9:** Calculate  $\Phi_{\text{the input}}^+(B_i)$ , the output  $\Phi^-(B_i)$  and the net flow  $\Phi(B_i)$  as follows: F

$$\Phi^+(B_i) = \frac{\sum_{r=1}^m \pi(B_i, B_r) - \min_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_i, B_r)\}}{\max_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_i, B_r)\} - \min_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_i, B_r)\}} \quad (8)$$

$$\Phi^-(B_i) = \frac{\sum_{r=1}^m \pi(B_r, B_i) - \min_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_r, B_i)\}}{\max_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_r, B_i)\} - \min_{1 \leq i \leq m} \{\sum_{r=1}^m \pi(B_r, B_i)\}} \quad (9)$$

$$\Phi(B_i) = \Phi^+(B_i) - \Phi^-(B_i) \quad (10)$$

**Step 10:** Number all selections  $\Phi(B_i)$ . The higher the number,  $\Phi(B_i)$ , the better the alternative [19,20].

### 3. Case study

To identify valuation alternatives, production factors are examined in the context of the use of a particular product to identify and understand key economic and production factors

**Option 1: Pure Orange Electrolyte Boost (RAA)** This drink is made with 100% natural orange juice, ensuring a reliable source of premium seasonal oranges. This drink is specifically designed to deliver a pure, invigorating surge of electrolytes, making it ideal for rehydration and recovery.

**Option 2: Orange Hydration Plus (IE)** uses state-of-the-art processing facilities to produce a premium isotonic drink. This drink ensures optimal production with the use of specialized equipment, ensuring a uniform and seamless taste and texture. This product is specifically designed to provide reliable hydration for athletes.

**Alternative 3: The technology-enhanced orange yield drink (TK)** uses cutting-edge technology and experienced knowledge during its manufacturing procedure. This beverage features cutting-edge techniques in orange juice extraction and isotonic beverage formulation, delivering exceptional hydration and performance benefits.

**Alternative 4: Cost-Effective Citrus Hydrant (CR):** An affordable isotonic drink that strikes a balance between affordability and high quality. Formulated with 100% natural orange juice, this product prioritizes profitability without compromising taste and effectiveness. Ensures sustainable profitability by providing a delicious and efficient hydration solution.

**Option 5: Isotonic Orange with Compliance Assured (TC):** Emphasizes strict compliance with all food and beverage standards. This drink is guaranteed to meet the most rigorous quality, safety and labeling criteria, making it a trusted choice for consumers looking for reliable and safe hydration options.

When attempting to identify valuation alternatives, a thorough examination of the factors of production within the specific context of utilization of a particular product is imperative. This effort aims to discern and understand the most salient economic and production determinants that underpin the decision-making process. These factors span a spectrum of considerations, ranging from raw material availability to technological prowess and regulatory compliance, all of which collectively influence the viability and sustainability of the business.

Firstly, the evaluation of Raw Material Availability (RAA) acquires fundamental importance, since it delves into the viability of obtaining natural orange juice in the quantities necessary for the production of isotonic drinks.

This assessment goes beyond mere availability to encompass considerations of consistency and seasonality, crucial to ensuring a reliable and uninterrupted supply chain. Second, infrastructure and equipment (EI) emerge as critical determinants, warranting scrutiny regarding the presence of processing capacity and specialized equipment necessary for efficient production. The adequacy and accessibility of said infrastructure are essential to maintain quality and efficiency standards in the production process. Furthermore, the Technology and Knowledge (KT) assessment assumes centrality, encompassing an evaluation of the predominant cutting-edge methodologies for orange juice processing and isotonic beverage production. At the same time, the technical knowledge and experience of the personnel involved in the process are taken into account, as they exert a palpable influence on the performance and quality of the product.

Additionally, an incisive Cost and Revenue (CR) analysis is essential, involving a thorough examination of all expenses associated with sports drink production, including orange juice procurement, labor, energy, and resource expenditures. This assessment serves as a barometer to assess the long-term viability and financial sustainability of the company. Finally, compliance with the Terms and Conditions, which cover regulatory compliance in food and beverage manufacturing, becomes vitally important. Ensuring compliance with quality standards, food safety protocols, labeling requirements and health regulation is essential to facilitate market penetration and safeguard the health and safety of consumers.

Alternative evaluation criteria form the basis for decision support when evaluating the regulation. This allows alternative solutions to problems to be analyzed from a similar perspective. The study is divided into four evaluation criteria and is presented to decision makers for review. During the analysis, the analysts agreed to assign equal weight to each criterion (all weight values  $w = 0.25$ ).

**In this study, we apply the following criteria:**

1. **Availability and availability of raw materials:** Assess the ease of obtaining natural orange juice in sufficient quantity and at a reasonable price. This includes taking into account the seasonality of the fruit, the location of suppliers and delivery logistics.
2. **Manufacturing Process Cost and Efficiency** – Analyze the costs associated with sports drink production, including processing orange juice, adding other ingredients, packaging, and labeling. Evaluate process performance to ensure profitability and remain competitive in the market.
3. **Existing technology and equipment:** Assess the availability of appropriate technology and equipment for orange juice processing and isotonic beverage production. These include factory efficiency, process automation and the availability of unique equipment.
4. **Market entry and consumer demand:** Evaluation of market entry and consumer demand for a fresh orange isotonic drink. This includes analyzing the competition in the market, identifying target market segments and, under.

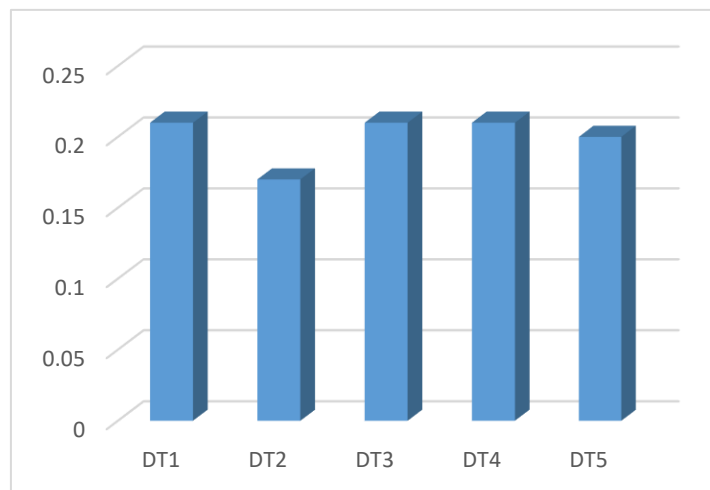
Alternative evaluation criteria serve as guiding pillars in the area of decision support, providing a structured framework for evaluating regulations and navigating through various problem-solving scenarios. This methodological approach facilitates a fair analysis of alternative solutions, fostering a holistic understanding of the United Nations underlying complexities. The study is developed through four different evaluation criteria, meticulously selected and prepared for deliberation among decision makers. In particular, consensus prevails among analysts as each criterion is given equal weight, underscoring the commitment to fairness and objectivity in the evaluation process. Within the scope of this study, a multifaceted evaluation is developed that clarifies key criteria fundamental to the evaluation process. Firstly, the evaluation of the availability of raw materials and procurement logistics takes on fundamental importance, highlighting the ease of access to natural orange juice, scale and affordability. Considerations go beyond mere availability and encompass factors such as seasonal fluctuations, proximity of suppliers and logistics efficiency, all of which underpin supply chain resilience.

Second, scrutiny shifts to the cost and efficiency dynamics inherent in the manufacturing process. An incisive analysis of associated costs, encompassing orange juice processing, ingredient blending, and packaging complexities, illuminates the path to sustainable profitability and market competitiveness. Process optimization emerges as an axis in this area, guaranteeing operational efficiency and profitability. Furthermore, an assessment of existing technology and equipment heralds a discourse on operational capacity and infrastructure adequacy. The evaluation delves into the technological arsenal and equipment necessary for the processing of orange juice and the production of isotonic drinks. Parameters such as factory efficiency, process automation, and equipment sophistication inform the discourse, guiding decisions toward optimal resource allocation and production efficiency.

Finally, market entry strategies and consumer demand dynamics emerge as focal points in the evaluative discourse. An astute examination of the market landscape and consumer preferences illuminates paths to successful market penetration. Delving into market competition, target market segmentation and emerging consumer trends allows decision makers to design strategies that resonate with consumer preferences and market dynamics, thereby ensuring relevance and sustained market growth. Table 2 shows policymakers' evaluations based on the relative importance given to the issue.

**Table 2:** Evaluations given to decision makers according to their importance

Decision makers	Language assessment	SVNN	Numerical value
Decision maker 1	Very important	(0.9;0.1;0.1)	0.21
Decision maker 2	Medium importance	(0.7;0.5;0.5)	0.17
Decision maker 3	Very important	(0.7;0.1;0.1)	0.21
Decision maker 4	Very important	(0.7;0.1;0.1)	0.21
Decision maker 5	Important	(0.75;0.25;0.20)	0.20



**Figure 1.** Evaluations given to decision makers according to their importance.

All the selected criteria are considered profit criteria, so it is desirable to maximize them, except criterion 4. Therefore, the normalized matrix obtained coincides with the normalized matrix shown in Table 3. From it the matrices of degrees of preference. This calculation can be performed using the linear function proposed in equation (5). For this case, it is assumed that  $q = 1$  and  $p = 0$ , resulting in the matrices

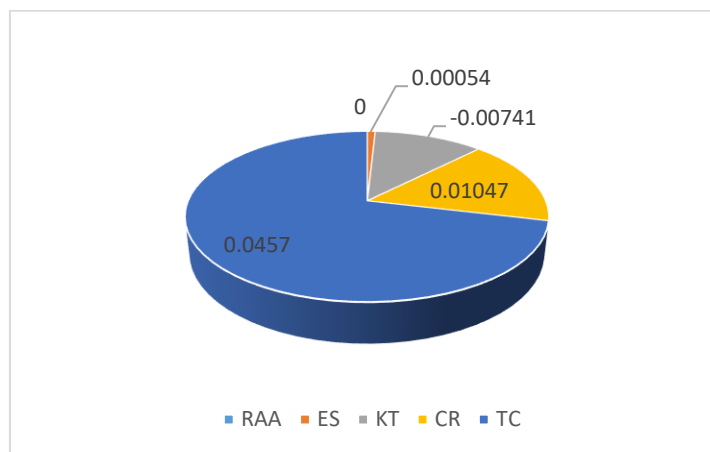
**Table 3:** Normalized decision matrix of alternatives

	C1	C2	C3	C4
<b>RAA</b>	(0.81424; 0.38688; 0.36488)	(0.88429; 0.32681; 0.28384)	(0.8828; 0.2384; 0.2081)	(0.8268; 0.2843; 0.2619)
<b>IS</b>	(0.66863; 0.44348; 0.42888)	(0.6;0.6;0.6)	(0.68831; 0.43289; 0.41301)	(0.6;0.6;0.6)
<b>K.T.</b>	(0.88898; 0.31304; 0.2988)	(0.64298; 0.48088; 0.46666)	(0.48188; 0.64413; 0.6616)	(0.8024; 0.4098; 0.3889)
<b>C.R.</b>	(0.5;0.5;0.5)	(0.55653;0.44347;0.42667)	(0.5;0.5;0.5)	(0.7445;0.2555;0.2555)
<b>T.C.</b>	(0.69071;0.30929;0.29523)	(0.61623;0.38377;0.35244)	(0.47187;0.54413;0.5515)	(0.5673;0.4327;0.413)

All selected criteria are considered profit criteria, that is, they should be maximized, except criterion 4, so that the resulting normalized matrix matches the normalized matrix shown in Table 3. From here we can determine the profit matrices. priority  $P_j$  ( $B_i, B_r$ ) relative to  $G_j$ . This calculation can be performed using the linear function proposed in (4). In this case, we assume  $q = 1, p = 0$ , which leads to matrices  $P_1$  to  $P_4$ . Using equation (7), the integral priority index is determined as shown in matrix  $\Pi$ . The inputs and outputs are calculated as follows

**Table 4:** The inputs and outputs

Alternatives	$\Phi^+$	$\Phi^-$	$\Phi$
RAA	0.18257	0.21723	-0.03466
IS	0.11673	0.11619	0.00054
K.T.	0.167	0.16411	-0.00741
C.R.	0.16155	0.15108	0.01047
T.C.	0.16138	0.11681	0.0457



**Figure 2.** Net Flows ( $\Phi$ ).

According to the net flows ( $\Phi$ ), the ranking of the alternatives is:

- CT (0.04457)
- CR (0.01047)
- ES (0.00054)
- KT (-0.00741)
- RAA (-0.03466)

Option 1: Isotonic Orange with Compliance Assured (TC): Emphasizes strict compliance with all food and beverage standards; this drink is guaranteed to meet the most rigorous quality, safety and labeling criteria, making it a trusted choice for consumers looking for reliable and safe hydration options.

Alternative 2: Cost-Effective Citrus Hydrant (CR): An affordable isotonic drink that strikes a balance between affordability and high quality. Formulated with 100% natural orange juice, this product prioritizes profitability without compromising taste and effectiveness. Ensures sustainable profitability by providing a delicious and efficient hydration solution.

Option 3: Orange Hydration plus (IE) uses state-of-the-art processing facilities to produce a premium isotonic drinks; this drink ensures optimal production with the use of specialized equipment, ensuring a uniform and seamless taste and texture; this product is specifically designed to provide reliable hydration for athletes.

This ranking indicates that the TC alternative is preferred, followed by CR, IE, KT and finally RAA.

#### 4. Conclusion

This study examines the challenges and opportunities in the production of isotonic drinks using natural orange juices as raw materials. It highlights the importance of ensuring a constant supply of natural orange juices, maintaining infrastructure and equipment and investing in cutting-edge technology. The study also highlights the need for continued research and development in food processing technology and beverage formulation to improve product quality and innovation. The study also suggests managing production costs effectively to ensure long-term profitability and maximize revenue. It recommends analyzing operating costs, optimizing processes and developing effective marketing strategies to increase demand and expand the customer base. The study also suggests periodically reviewing trade agreements to ensure they remain appropriate and reflect market changes. The study concludes that establishing strong and transparent relationships with business partners and customers can foster trust and mutual collaboration.

Furthermore, research should be conducted on the development of algorithms to calculate the standard Hamming distance between neutrosophic numbers; this metric would be valuable in assessing the similarity and divergence of different assessments, thus refining the accuracy of the decision-making process. By advancing these methodologies, future work can contribute to the creation of more effective strategies.

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