Evaluation of the Use of Whey in the Production of Aromatized Beverages by Neutrosophic Multicriteria Analysis

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Abstract

In this study, a thorough evaluation of the impact of whey use in the production of flavored beverages was carried out, using the neutrosophic analysis of variance method as the central research tool· The research focused on analyzing how whey, a byproduct of cheese production, could be used effectively in the production of flavored beverages, exploring its possible benefits and challenges from a comprehensive and multidisciplinary perspective· Through a series of experiments and exhaustive analyses, different variants of flavored beverages were examined, evaluating both their sensory quality and physical-chemical stability, and compared with beverages made without whey, revealing valuable insights about their viability and potential in the beverage industry· food and drinks· The findings of this study not only offer a deeper understanding of the role of whey in the production of flavored beverages, but also highlight the importance of the variance neutrosophic approach in evaluating this complex relationship· By integrating sensory analyzes with physicochemical measurements and stability considerations, a holistic and accurate picture of the effects of whey on the quality and characteristics of beverages could be obtained· These results not only have practical implications for the food industry, but also contribute to the advancement of research in multidimensional analysis methods and their application in the evaluation of innovative and sustainable food products·

Keywords: Multi-criteria decision making; Neutrosophic analysis; Natural sweeteners

1. Introduction

The food industry has experienced constant evolution in the search for new ways to optimize the production and quality of its products. In this context, the use of whey, a by-product of cheese manufacturing, has aroused growing interest due to its potential to enrich and diversify the range of products available on the market [1]. Its application in the production of flavored beverages has been explored, as a strategy to make the most of this food resource and satisfy changing consumer demands. However, evaluating the feasibility and effects of whey in these beverages is a complex challenge that requires advanced and multidisciplinary analytical approaches [2]. The present study aims to address this problem using the Neutrosophic Analysis of Variance Method, an innovative methodology that allows a more complete and nuanced evaluation of the different aspects involved in the production of whey-flavored beverages. This approach not only considers the sensory and organoleptic aspects of the beverages, but also incorporates physicochemical measurements and considerations about the stability of the final product. Thus, we seek to obtain a comprehensive view of the effects of whey on the quality and characteristics of beverages, as well as their acceptability by the consumer [3].

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The study is based on the premise that whey, being a rich source of proteins, lipids, and minerals, can confer unique and beneficial properties to flavored beverages, such as a creamy texture, an improved flavor profile and nutritional value· increased. However, there is also recognition of the need to address potential challenges, such as acidity management and the development of off-flavors that could arise because of incorporating whey into beverage formulations [4-5].

The neutrosophic analysis is presented as an ideal tool to explore these complexities and challenges, since it allows the uncertainty and indeterminacy inherent in this process to be evaluated in a systematic way [6]. By considering multiple factors and variables in the evaluation of whey-flavored beverages, it is expected to obtain significant insights that can guide the development of more innovative, healthy, and attractive products for consumers· Ultimately, this study aims to contribute to the advancement of knowledge in the field of food science and to enrich the range of products available in the food market [7].

2. Related work

2.1. Milky Serum

Whey is a dairy byproduct obtained during the production of cheese or butter· It is often considered waste, but it is a rich source of nutrients and can be used in a variety of ways in the food industry. One of the most common applications of whey is in the production of beverages· Due to its nutritional profile and versatility, whey has become a popular ingredient for creating delicious and healthy beverages. From smoothies to sports drinks, whey adds a touch of creaminess and unique flavor [8].

In addition to its use in beverages, whey is also used in baking. The presence of whey in certain recipes can improve the texture and moisture of the final products, making them softer and fluffier. An interesting aspect of whey is its potential in the nutritional supplement industry. Due to its whey protein content, this dairy byproduct has become a common ingredient in protein shakes and other products designed to aid in muscle recovery and physical development [9].

Beyond its use in human nutrition, whey also has applications in agriculture· It is used as a food supplement for animals, especially calves and pigs, due to its high content of proteins and essential nutrients. The cosmetic industry has also begun to explore the use of serum in the formulation of skin and hair care products. Its moisturizing and nourishing properties make it ideal for creams, lotions, and shampoos [10]. In terms of sustainability, taking advantage of whey is an important practice to reduce food waste. By finding new ways to use this dairy by-product, we not only maximize resources but also create innovative and healthy products for human consumption.

In short, whey is much more than just a dairy byproduct. Its versatility and nutritional benefits make it a valuable ingredient in the food industry, agriculture, and cosmetics, contributing to both human health and the sustainability of the planet.

2.2. Multicriteria evaluation

Multi-criteria evaluation is a complex but valuable methodology used in various fields, from urban planning to business decision making. In essence, it involves considering multiple factors or criteria when making a decision, rather than relying on a single indicator or metric. This allows for a more complete and balanced evaluation of the available options· One of the key advantages of multi-criteria evaluation is its ability to take into account the diversity of perspectives and objectives. By incorporating a variety of criteria, the preferences of different stakeholders can be better captured and both qualitative and quantitative aspects can be considered [11].

However, effective implementation of multi-criteria evaluation also presents challenges. Selecting appropriate criteria and assigning appropriate weights can be subjective and subject to bias. Additionally, the process of da-ta collection and analysis can be complex and time-consuming. In practice, there are several techniques and tools to perform a multi-criteria evaluation, such as the Analytical Hierarchy Process (AHP) and the linear weighting method. Each has its own advantages and limitations, and choosing the appropriate methodology depends on the specific context and objectives of the evaluation [12].

A common application of multi-criteria evaluation is the evaluation of investment projects. By considering factors such as financial performance, environmental impact and social acceptance, investors can make more in-formed

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and ethical decisions. Another field in which multi-criteria evaluation is invaluable is risk management and contingency planning. By evaluating multiple possible scenarios and their consequences, organizations can be better prepared to deal with unexpected events and take proactive steps to mitigate risks in summary, multi-criteria evaluation is a powerful tool for decision-making in a wide range of contexts. While it has its challenges, its ability to capture the complexity and diversity of factors makes it an invaluable methodology for addressing complex issues and making informed decisions [13, 14].

This study used a multi-criteria evaluation approach to better evaluate the feasibility of using whey to produce flavored beverages using three natural sweeteners. Therefore, some important predefined parameters are considered. In this study, a multi-criteria decision making (MDMC) approach was used to develop the pro-posed objectives. MDMC enables the design of interventions that address highly complex real-world situations and simplify them to aid decision making in specific situations. This means that the original problem has reached a solvable state [15].

Many MDMCs have been developed to address problems in various areas of life and society [16, 17]. However-er, traditional approaches often evaluate alternatives based on publicly defined values. Due to the complexity of the environment and human action, MDMC problems are often associated with uncertainty and therefore the information provided to solve these problems is often confusing or linguistic.

2.3. TODIM and PROMETHEE

The TODIM method (acronym for "Multi-criteria Interactive Decision Making") and PROMETHEE ("Preference Ranking Organization Method for Enrichment Evaluations") are two popular approaches in multi-criteria decision making. Both methods are designed to help decision makers evaluate and compare different options based on multiple criteria [18].

The TODIM method is based on the theory of multi-criteria utility and aims to find the best option considering both the positive and negative aspects of each alternative. It employs a series of interactive steps to guide decision makers through the evaluation process, allowing them to weigh the relative importance of each criterion and make systematic comparisons between available options.

On the other hand, PROMETHEE [19] is a preference ranking method that focuses on the direct comparison of pairs of alternatives. Decision makers rank alternatives according to their preference based on each criterion, and PROMETHEE calculates an overall ranking considering all individual preferences and their respective weights. Both methods have their own strengths and weaknesses. While TODIM is more suitable for situations that re-quire detailed analysis and continuous interaction with experts, PROMETHEE is preferable when clear data is available and a quick and direct ranking of options is needed.

The choice between TODIM and PROMETHEE depends on the specific context of the decision-making process and the preferences of the decision maker. In some cases, it may be beneficial to use both methods together, building on the strengths of each to obtain a more complete and robust assessment of the available options Ultimately, both TODIM and PROMETHEE are powerful tools that can help decision makers make more in-formed and effective decisions in complex, multi-criteria environments. Its correct application can lead to more satisfactory results aligned with the objectives and preferences of the stakeholders involved.

This article describes the TODIM and PROMETHEE methods that use single-valued neutrosophic number (SVNS) [20]. Neutrosophic examines the nature of neutral elements, and everything related to it within a philosophical framework. For the first time, neutrosophic logical functions and neutrosophic sets were introduced· Uncertainty arises for reasons such as lack of information, contradictory information, contradictions, and paradoxes. This study used a neutrosophic ensemble to overcome the inability of traditional methods to deal with unknown and contradictory information typical of the real world [21]. To better understand the information used, introductory aspects of the neutrosophic theory and methodology are presented.

Definition 1 (Neutrosophic Set) [22]: Consider a space of points (objects) denoted by X. Let x be a generic element in X. A neutrosophic set An in X is defined by three membership functions: A truth-membership function $T_{A.}$ A function that represents the degree of membership in an indeterminacy $I_{A.}$ A membership function that represents a false statement. $F_{A.}$ Each function maps from the set X to the open interval $]0, 1+[$:

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$T_A: X \rightarrow]0, 1 + [$ (1)

$I_A: X \rightarrow]0, 1 + [$ (2)

$F_A : X \rightarrow]0, 1 + [$ (3)

The functions TA(x), IA(x), and FA(x) are subsets of the interval] 0, 1+ [. These subsets can be either real standard or non-standard. The distinguishing feature of the neutrosophic set is that there are no limitations on the total of TA(x), IA(x), and FA(x). Therefore, the total of the highest values of these functions can vary from 0 to a value exceeding 3: $0 \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3+$

Definition 2[23]. Let X be a universe of discourse. A single valued neutrosophic set (SVNS) over X is an object having the form:

$$A = \{x, T_{A(x)}, I_{A(x)}, F_{A(x)}: x \in X\} \quad (4)$$

Where

$$T_A: X \rightarrow [0, 1]$$

$$I_A: X \rightarrow [0, 1]$$

$$F_A: X \rightarrow [0, 1]$$

With the condition $A = \{x, T_{A(x)}, I_{A(x)}, F_{A(x)}: \forall x \in X\}$

The numbers $T_{A(x)}, I_{A(x)}, F_{A(x)}$ denote the degree of truth-membership, indeterminacy-membership, and falsity-membership of x to X, respectively.

Linguistic variables [24] are often used to make decisions. Linguistic variables simply represent words or terms used in human language. This approach, based on linguistic variables, is therefore a practical way for decision makers to express their judgments. Standard scores can be expressed in terms of linguistic variables. Linguistic variable can be converted to SVNS as shown in Table 1.

Table 1: Linguistic variables.

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 3. Let E k = (T_k, I_k, F_k) be a neutrosophic number that defines the qualifications of decision maker k. The weight of the decision maker can be written as [17] .

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$$\psi_k = \frac{1\text{-}\sqrt{[(1\text{-}T_k(x))^2+(I_k(x))^2+(F(x))^2]/3}}{\sum_{k=1}^{p}\sqrt{[(1\text{-}T_k(x))^2+(I_k(x))^2+(F(x))^2]/3}} \quad (5)$$

Collaborative decision making requires summarizing all of each decision maker's judgments into a complete and unbiased decision table. This can be done using the neutrosophic weighted average (SVNWA) E [24] .

Definition 4. Let ([14]) D (k) = (d_{ij}^k) mxn be a single-valued decision matrix for Neutrosophic and a vector of decision weights for decision k. The weight vector ψ is defined as $\psi = (\psi_1 \psi_2, \dots, \psi_p)^T$Ta where.$\psi_k \in [0,1]$,

$$d_{ij} = \langle 1\text{-}\prod_{k=1}^{p}\left(1\text{-}T_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(I_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(F_{ij}^{(p)}\right)^{\psi_k}\rangle \quad (6)$$

Definition 5. Assuming that A and B are two computed neutrosophic numbers (SVNN), the standard Hamming distance between them is:

$$d(A,B)\frac{|TA - TB|+|IA - IB|+|FA - FB|}{3} \quad (7)$$

Definition 6: Assuming A = (TA, IA, F_A) is a single-valued neutrosophic number SVNN, the complement of SVNN A is A^c.

$$A^C = (F_A, 1\text{-} I_A, T_A). \quad (8)$$

Consider A= (A_1,…, Am) a surrogate set and consists of $G = (G1, G2, \dots, Gn)$of a set of attributes. Where is $W = (w1, w2, \dots, wn)$the weight of the attribute determined $0 \leq wj \leq 1$ y $\sum_{j=1}^{n} w_j = 1$ Let aj (for i = 1, 2…m, ij = 1, 2,…, n) be the value of the selection attribute A_i of the attribute G_j. Therefore, A = $(a_{ij})_{m\times n} = \langle (T_{ij}, I_{ij}, F_{ij}) \rangle_{mxn}$. where T_{ij}, I_{ij} and Fij are the membership degree, the indeterminacy membership degree and the non-membership degree, respectively. T

Step 1: Identify an alternative to evaluate.

Step 2: determine the importance of the decision maker. Because each evaluation is based on each expert's understanding of the problem, the logic of this method allows each decision maker to obtain a unique evaluation that is different from the evaluations of other decision makers. Problems making decisions. The relative weight of each decision maker is considered a linguistic variable and is entered into SVNN.

Step 3: Convert the language classification provided by experts to SVNN. Based on the individual transparent master tables obtained from the review, individual neutrosophic decision tables were created as shown in Table 1.

Obtain the original connection matrix between **option** *A* = (*A* 1,..., *A m*) and feature *G* = (*G* 1, *G* 2,..., *G n), where each feature has its own* $_{aij}$. , *i* = 1, 2... *m,* c = *1,* 2, .., *n* - value of selection attribute *A* and *for* attribute G.

Step 4: Integrate decision information. That is, *we normalize* A = $(a_{ij})_{m\times n}$ *by B =* $(b_{ij})_{m\times n}$. If the decision is a cost factor, the decision information should be modified as an additional group according to equation (9), and if it is a performance factor, it should not be modified.

Step 5: construct the preference function Pj (B $_i$, Br) for the alternative Bi instead of Br for the feature Gj .

$$P_j(B_i, B_r) = \begin{cases} 0, d \leq p \\ \frac{d-p}{q-p}, p < d < q \\ 1, d \geq q \end{cases} \quad (9)$$

Step 6: Calculate relative weight of the characteristic w_{jr}, that is, the relative weight of Gj with respect to Gr.

$$w_{jr} = \frac{w_j}{w_r} = (j, r = 1,2, \dots, n) \quad (10)$$

Determine the priority index π (Bi, Br) of the circuit Bi with respect to Br. using the formula:

[1] $$\pi(B_i, B_r) = \frac{\sum_{j=1}^{n} w_{jr} P_j(B_i, B_r)}{\sum_{j=1}^{n} w_{jr}} \quad (11)$$

Step 7: Calculate the inlet $^+$(Bi), outlet Φ^-(Bi) and net flow Φ(Bi) as shown below.Φ

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$$\Phi^{+}(B_i) = \frac{\sum_{r=1}^{m} \pi(B_i,B_r) - \min_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_i,B_r)\}}{\max_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_i,B_r)\} - \min_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_i,B_r)\}} \quad (11)$$

$$\Phi^{-}(B_i) = \frac{\sum_{r=1}^{m} \pi(B_r,B_i) - \min_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_r,B_i)\}}{\max_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_r,B_i)\} - \min_{1\le i\le m}\{\sum_{r=1}^{m} \pi(B_r,B_i)\}} \quad (12)$$

$$\Phi(B_i) = \Phi^{+}(B_i) - \Phi^{-}(B_i) \quad (13)$$

Step 8: Sort all options by $\Phi(B_i)$. The higher the number, $\Phi(B_i)$, the better the alternative[15,16,17].

3. Case study

To identify alternative evaluation options, we investigated the benefits of this product and identified and understood the key financial and performance benefits.

1. **Elimination of by-products (WP).** Whey is a byproduct of cheese and other dairy products. Therefore, when used in the beverage industry, it becomes a consumable resource and reduces processing costs, milk residue.
2. **Reduction of cost per product (RCP):** Using whey to make lemonade reduces the cost of key ingredients compared to other whey sources and more expensive ingredients. This significantly reduces the cost of creation and increases the profit of the final product.
3. **Stability improvement (SM):** The use of by-products such as whey in beverage production improves the sustainability of the dairy industry, reduces waste, and promotes more environmentally friendly production methods.
4. **Product Differentiation (DP):** Adding whey to beverages allows the market to offer unique and differentiated products. This could increase demand and acceptance of the product by consumers looking for innovative and healthy options.
5. **Variety of Natural Sweeteners (VENS):** By flavoring your drink with three natural sweeteners, you can appeal to a broader audience, including those looking for low-sugar options and sugar alternatives. System. This increases the consumer base, which increases product sales and profits.

By exploring alternative evaluation options, we delve into the many benefits of this product, capturing the quintessential financial and performance advantages. Firstly, the elimination of by-products (WP) is a fundamental advantage. Whey, from cheese and other dairy processes, becomes a consumable resource in the beverage industry, reducing processing costs and milk waste, thereby improving sustainability.

Secondly, the reduction of cost per product (RCP) emerges as a primary factor. Using whey in lemonade formulation dramatically reduces spend on key ingredients versus other whey sources and more expensive alternatives, thereby substantially cutting production costs and amplifying profits from the final product. Additionally, improved stability (SM) appears as a critical benefit. The integration of byproducts such as whey in beverage manufacturing reinforces the sustainability of the dairy industry, reduces waste and promotes ecological pro-duction practices, thus accentuating respect for the environment. Furthermore, product differentiation (PD) is a prominent point to consider. Infusing whey into beverages opens avenues for unique and distinctive product offerings, potentially increasing consumer demand and acceptance among those seeking innovative, health-conscious options.

Finally, the variety of natural sweeteners (VENS) is another important advantage. By infusing beverages with three natural sweeteners, it engages a broader audience, including those seeking low-sugar and sugar-alternative options, expanding the consumer base, which in turn bolsters product sales and Profits.

Alternative evaluation criteria are decision-making guidelines that form the basis for evaluating regulations. Therefore, alternative solutions to the problem can be analyzed from a similar perspective. The study was divided into four evaluation criteria and presented to policy makers for consideration. For the analysis, the analysts agreed to assign equal weight to each criterion (each weight value w = 0.25).

For this study the following criteria were adopted:

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1. **Cost of raw materials.** Let's look at the cost of whey compared to other soft drinks, as well as the cost of the natural sweeteners used. Comparing these costs to other opportunity costs provides information about the profitability of the product.
2. **Production Efficiency:** Analysis of the efficiency of the production process when adding whey to drinks. This includes evaluating the ease of incorporating the serum into the formula, production time and resources required.
3. **Profitability of the final product:** Calculate the expected profit of a drink made from whey and natural sweeteners, considering the production costs, the sales margin, and the expected purchase price of the product.
4. **Market acceptance of the product:** Market research is conducted to evaluate consumer perception of the product. Identification of market interest and potential for increased demand for beverages with natural ingredients.

Alternative evaluation criteria serve as guiding principles in decision-making, laying the foundation for evaluating regulations and possible solutions to relevant problems. Through a similar lens, alternative resolutions can be examined, offering nuanced perspectives on problem-solving approaches. In this study, the analysis was compartmentalized into four distinct evaluation criteria, carefully selected, and presented to policymakers for consideration. To maintain analytical integrity, a consensus was reached among analysts to assign a uniform weight to each criterion, with each weight value set at 0.25.

Within the scope of this research, a set of criteria was carefully selected to facilitate a comprehensive analysis. Firstly, the cost of raw materials emerges as a key consideration. Comparing the cost of whey to other soft drink ingredients, along with the cost of the natural sweeteners used, provides invaluable information on the profitability of the product versus alternative cost structures. Secondly, production efficiency emerges as a crucial parameter. Evaluating the effectiveness of integrating whey into beverage production encompasses a variety of facets, including seamless incorporation of whey into formulations, production duration, and resource allocation efficiency. Thirdly, the profitability of the final product is a fundamental criterion. By meticulously calculating anticipated profit margins for beverages made with whey and natural sweeteners, considering production expenses, sales margins, and projected product purchase rates, a holistic view of financial viability is achieved.

Lastly, market acceptance emerges as a critical dimension. Conducting market research to measure consumer perceptions of the product, discern market interest, and uncover the potential for increased demand for beverages with natural ingredients underscores the importance of aligning product offerings with changing consumer preferences. The following table shows the ratings assigned to decision makers based on their relative importance to the topic under discussion.

Table 2: Classification of decision makers according to their importance.

Current solutions	**Language assessment**	**SVNN**	**Numerical value**
Decision making 1	Very important	(0.8;0.1;0.1)	0.20
Decision making 2	medium importance	(0.6;0.5;0.5)	0.18
Decision making 3	Very important	(0.8;0.1;0.1)	0.20
Decision making 4	Very important	(0.8;0.1;0.1)	0.20
Decision making 5	important	(0.85;0.25;0.20)	0.25

After the decision maker has individually evaluated the given alternatives based on each criterion or attribute selected for evaluation, they are transformed to create a meaningful options decision matrix, which is presented in Table 3.

Table 3: General replacement decision matrix.

	Cost of raw materials	Production Efficiency	Profitability of the final product	Market acceptance of the product

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W.P.	(0.71424;0.38677;0.36487)	(0.77429;0.32671;0.28374)	(0.7727;0.2374;0.2081)	(0.7267;0.2743;0.2619)
RPC	(0.66763;0.44347;0.42777)	(0.6;0.6;0.6)	(0.67731;0.43279;0.41301)	(0.6;0.6;0.6)
YE	(0.78797;0.31304;0.2988)	(0.64297;0.47088;0.46666)	(0.47187;0.64413;0.6616)	(0.7024;0.4097;0.3789)
DP	(0.79071;0.30929;0.29623)	(0.71723;0.38377;0.36244)	(0.47187;0.64413;0.6616)	(0.6773;0.4327;0.413)
VENS	(0.6;0.6;0.6)	(0.66763;0.44347;0.42777)	(0.6;0.6;0.6)	(0.7446;0.2666;0.2666)

All selected criteria are considered winning 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 priority matrices 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 the matrices P_1 through P_4.

$$P_1 = \begin{Vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0187 & 0.0199 & 0.0000 \\ B_2 & 0.0239 & 0.0000 & 0.0426 & 0.0438 & 0.0000 \\ B_3 & 0.0000 & 0.0000 & 0.0000 & 0.0012 & 0.0000 \\ B_4 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_5 & 0.0484 & 0.0245 & 0.0671 & 0.0683 & 0.0000 \end{Vmatrix}$$

$$P_2 = \begin{Vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_2 & 0.0721 & 0.0000 & 0.0102 & 0.0492 & 0.0244 \\ B_3 & 0.0619 & 0.0000 & 0.0000 & 0.0390 & 0.0142 \\ B_4 & 0.0229 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_5 & 0.0476 & 0.0000 & 0.0000 & 0.0247 & 0.0000 \end{Vmatrix}$$

$$\boldsymbol{P_3} = \begin{Vmatrix} & \boldsymbol{B_1} & \boldsymbol{B_2} & \boldsymbol{B_3} & \boldsymbol{B_4} & \boldsymbol{B_5} \\ \boldsymbol{B_1} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_2} & \mathbf{0.0683} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_3} & \mathbf{0.1198} & \mathbf{0.0515} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0225} \\ \boldsymbol{B_4} & \mathbf{0.1198} & \mathbf{0.0515} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0225} \\ \boldsymbol{B_5} & \mathbf{0.0973} & \mathbf{0.0290} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \end{Vmatrix}$$

$$\boldsymbol{P_4} = \begin{Vmatrix} & \boldsymbol{B_1} & \boldsymbol{B_2} & \boldsymbol{B_3} & \boldsymbol{B_4} & \boldsymbol{B_5} \\ \boldsymbol{B_1} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_2} & \mathbf{0.0827} & \mathbf{0.0000} & \mathbf{0.0364} & \mathbf{0.0290} & \mathbf{0.0815} \\ \boldsymbol{B_3} & \mathbf{0.0463} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0451} \\ \boldsymbol{B_4} & \mathbf{0.0537} & \mathbf{0.0000} & \mathbf{0.0074} & \mathbf{0.0000} & \mathbf{0.0525} \\ \boldsymbol{B_5} & \mathbf{0.0012} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \end{Vmatrix}$$

3. Using Equation (6), the integral priority index is determined, as shown in the matrixΠ, which gives the inlet, outlet, and liquid flow rate of each option, as shown in Table 4.

$$\Pi = \begin{Vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.000 & 0.000 & 0.005 & 0.005 & 0.000 \\ B_2 & 0.062 & 0.000 & 0.022 & 0.030 & 0.026 \\ B_3 & 0.057 & 0.013 & 0.000 & 0.010 & 0.020 \\ B_4 & 0.049 & 0.013 & 0.002 & 0.000 & 0.019 \\ B_5 & 0.049 & 0.013 & 0.017 & 0.023 & 0.000 \end{Vmatrix}$$

	Φ+	**Φ–**	**Φ**
W.P.	0	1,000	-1,000
RPC	1	0.000	1,000
YE	0.791	0.036	0.654
DP	0.655	0.167	0.388

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VENS	0.603	0.150	0.553

The preference matrix presented reflects the relationships between the evaluation criteria, establishing a hierarchy of preferences based on their relative valuation· Each cell of the matrix represents the preference of one criterion over another, rated on a scale ranging from -1 to 1, where -1 indicates a total preference towards the criterion in the column, 0 denotes neutrality and 1 indicates a total preference towards the column criterion· the criterion in the row· This matrix representation allows a clear and concise visualization of the preference relationships between the criteria.

When examining the values of the matrix, it is observed that the criterion "Production Efficiency" (MS) receives a high preference compared to the other criteria, with a rating of 0·791 compared to "Cost per Product" (RPC), "Differentiation of Product". (DP), and "Variety of Natural Sweeteners" (VEN). This suggests that efficiency in the production process is highly valued compared to the other criteria evaluated.

On the other hand, the criterion "Product Market Acceptance" (AS) shows a Neutrosophic preference over the other criteria since its rating is 0 in all comparisons. This indicates that market acceptance does not lean strongly toward any other criteria, suggesting relative fairness in its importance compared to the other aspects evaluated.

In summary, the preference matrix provides a valuable tool for decision making, offering a clear representation of the preference relationships between evaluation criteria. These findings can be used by decision makers to prioritize and guide their actions towards the most valued aspects of the alternative evaluation.

The positive and negative lines of this type of analysis show the degree of preference and dis-preference compared to other alternatives. In this sense, from the results of the analyzes carried out, the use of byproducts has a higher priority than other regulations. In addition to lower production costs, the versatility of natural sweeteners is the least popular· On the other hand, when analyzing the resulting negative capital flows, we find that product diversification is a form with a higher level of disincentives compared to other laws· In this case, all benefits have the same degree of non-prioritization, except for the use of by-products, which in this case has the least importance.

4. Conclusion

The use of neutrosophic methods in the present study highlights the effectiveness of these methods in solving complex problems in various areas of real life and society. Associations, especially manufacturing industries. The use of monovalent neutrosophic frameworks allows for review and problem solving, thereby overcoming the uncertainty and ambiguity inherent in this practice. The preference matrix revealed in our study provides a nuanced description of the intricate interplay between evaluation criteria, outlining a discernible hierarchy of preferences based on their relative valuations. Each cell within this matrix encapsulates the predilection of one criterion over another, ranked along a spectrum extending from -1 to 1. In this delineation, -1 signifies an unambiguous preference toward the criterion in the column, while where 0 denotes a state of equilibrium, and 1 means an unequivocal preference toward the row criterion. This graphical representation allows for a lucid and succinct visualization of the nuanced interrelationships be-tween the criteria.

When delving deeper into the values included in the matrix, a noticeable inclination towards the "Production efficiency" (MS) criterion emerges, manifesting a strong preference compared to its counterparts. With an impressive score of 0.791 against "Cost per Product" (RPC), "Product Differentiation" (DP) and "Variety of Natural Sweeteners" (VEN), it is evident that the efficiency inherent in the production process is attaches utmost importance to it in relation to the set of criteria under scrutiny. On the contrary, an intriguing revelation emerges in the form of the criterion of "product market acceptance" (AS), in which a state of equilibrium reigns among its counterparts. As evidenced by a consistent score of 0 across all comparisons, it is evident that market acceptance remains decidedly Neutrosophic, with no pronounced bias toward alternative criteria. Such findings suggest a semblance of fairness in the importance given to market acceptance versus other dimensions under evaluation. Considering these insights, several implications and recommendations come to the fore. First, the paramount im-portance placed on production efficiency underscores the imperative for stakeholders to prioritize streamlining and optimizing production processes to improve overall efficiency and effectiveness. Second, the Neutrosophic stance of market acceptance requires further exploration and elucidation, urging researchers and practitioners to delve deeper into the complexities of consumer preferences and market dynamics. Finally, the comprehensive insights gained from the preference matrix pave the way for informed decision making, empowering stakeholders to navigate the complexities of the alternative assessment with greater insight and discernment.

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This drink consists of whey, water and three sweeteners and has been tested to determine the ideal T2 formula (composed of A1B2, 90% whey, 10% water and agave honey). Determine the best treatment method based on physical and chemical criteria. The values obtained from the quality assurance reports of Multianityca SA, parameters and analytical tests determined according to the NTE INEN 1101 standard and based on microbiological, and nutritional analyzes confirm that the drink meets the carbonation requirements. Economic studies of the best treatments determined the final price of a drink containing aloe and honey. The re-tail price of a 300 ml drink is determined by the consumer and is USD 2.00. The analysis shows that unlike other drinks offered to consumers such as soft drinks, wine, and soft drinks, which contain a high percentage of sugar and are very harmful to the body, these contain nutrients such as proteins and carbohydrates and are rich in calories. The fat content is also low, medium, and long term for health.

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