Socioeconomic and environmental impacts of dehydrated whey protein extraction: an analysis using the neutrosophic PEST-SWOT approach.

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Abstract

The extraction of dehydrated proteins from whey is not only a technological innovation in the field of biotechnology, but also a complex intersection of socioeconomic and environmental factors that deserve detailed evaluation. This article delves into the analysis using the neutrosophic PEST-SWOT approach, revealing how the political, economic, social, and technological dimensions interact with the strengths, opportunities, weaknesses, and threats of this emerging practice. The neutrosophic methodology allows us to unravel nuances that other approaches might overlook, highlighting both the potential benefits and the possible negative repercussions that may arise in different contexts. Whey, traditionally considered waste, is revalued by being transformed into a source of protein, which has profound implications for sustainability and the circular economy. However, neutrosophic analysis also exposes the complexities and ambiguities inherent to this activity. From an environmental perspective, whey extraction and processing pose significant challenges, such as energy consumption and waste generated, that must be carefully managed. In the socioeconomic sphere, the creation of new value chains can generate employment and foster innovation, but it can also destabilize existing markets and generate inequalities. Adopting a neutrosophic approach allows for a more holistic evaluation, recognizing the coexistence of multiple truths and the need for a balance between the various interests involved. Thus, this article invites deep reflection on the implications of technology, proposing an informed and multifaceted debate on its future development and application.

Keywords: Proteins, Serum; SWOT Analysis; PEST Analysis; Neutrosophic Single Value Numbers; Neutrosophic PEST-SWOT Analysis.

1. Introduction

The extraction of proteins in dehydrated form from whey represents a fundamental field of research in modern biotechnology, with applications ranging from the food to pharmaceutical industries [1] Whey, a byproduct of dairy processing, has become a valuable protein source due to its high bioavailability and nutritional profile - However, the efficiency of its use in the extraction of proteins in a dehydrated state depends on multiple factors, the control and optimization of which are crucial to maximize the yield and quality of the final product [2] In this context, the present research aims to evaluate the suitability of serum for the extraction of dehydrated proteins using a complex approach based on the multicriteria neutrosophic method Neutrosophic, an extension of fuzzy

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logic, allows handling uncertainty and indeterminacy more effectively than traditional methods. This approach is particularly useful in biotechnological processes where the variables are numerous and the interactions complex.

The multi-criteria neutrosophic method provides a robust tool to evaluate multiple criteria simultaneously, integrating aspects ranging from the purity of the extracted proteins to the efficiency of the dehydration process [3] Through this approach, we seek not only to quantify the suitability of serum, but also to identify the optimal conditions under which protein extraction is maximized. This level of analysis is essential to advance the understanding of underlying mechanisms and improve industrial practices. The methodology of this research includes the collection of serum samples, the application of advanced chemical and biochemical analysis techniques, and the implementation of the neutrosophic method for multicriteria evaluation - Each stage of the process has been designed to capture the greatest amount of relevant information , allowing a comprehensive and accurate evaluation. The application of the neutrosophic approach ensures that all possible sources of variability and uncertainty are considered, offering a more complete and reliable perspective.

One of the main challenges in extracting dehydrated proteins is the inherent variability in whey properties, which can depend on factors such as milk source, processing method, and storage conditions. These variabilities can significantly influence the efficiency of the extraction process and the quality of the proteins obtained [4] The use of the neutrosophic method allows these variations to be addressed systematically, providing a powerful tool for optimization. The preliminary results of this research suggest that whey is a viable source for the extraction of dehydrated proteins, with a high potential to be optimized using the neutrosophic approach. Analyzes have revealed patterns and relationships that are not evident to the naked eye, highlighting the importance of using advanced methodologies in the evaluation of complex processes. These findings have significant implications for the industry, offering new strategies to improve efficiency and reduce production costs.

In addition to industrial benefits, this research has important implications for sustainability. By improving the efficiency of protein extraction from whey, a commonly discarded by-product, a more complete and sustainable utilization of resources is promoted [5] This not only contributes to waste reduction, but also improves the economic value of whey, promoting more ecological practices in the dairy industry. In conclusion, the evaluation of the suitability of whey for the extraction of dehydrated proteins using a multi-criteria neutrosophic method represents a significant advance in applied biotechnology. This innovative approach allows for a deeper and more detailed understanding of the processes involved, offering valuable tools for optimization and sustainability. The results of this research not only improve our scientific understanding, but also have the potential to transform practices industrial, promoting more efficient processes and sustainable production.

2. Related Work.

2.1. Protein content in dehydrated form.

This scientific study addresses a multi-criteria approach through neutrosophic theory to evaluate the suitability of the dairy beverage resulting from the cheese making process to extract proteins from it in its dry form. This advanced method is an interesting attempt to understand the complexities protein extraction process from liquids in general, and from dairy liquids in particular, which includes a wide range of factors that must be taken into account [6] Using neutrosophic theory, researchers were able to address these factors and overcome the challenges posed due to the imprecise and incomplete information available.

The study seeks to provide a comprehensive and effective methodology to evaluate the quality of dairy liquids to extract proteins from them and convert them to dry form. This methodology is based on a multi-criteria analysis that takes into account various interrelated factors that can affect the success of the operation. By including the concepts of neutral somatic theory , researchers can achieve greater detail and precision in estimating the quality of different dairy liquids according to their specific objectives and requirements [7]

This study represents an important addition to the research field of protein extraction from dairy beverages and related products, as it opens new horizons for a deeper understanding and improvement of the protein extraction process. Given the multiple challenges facing the protein drying process, the details and comprehensive analysis presented in this study can guide future research towards the development of more effective and sustainable technologies – It is also worth noting that this study has a clearly applied aspect, as that the results and methodologies developed can be used in multiple industries that depend on the use. of protein in dry form, which contributes to improving the quality of products and improving the efficiency of production processes [8]

This study highlights the importance of using neutrosophic theory in various fields of scientific research as it works to broaden horizons, complicate the perspective of research challenges, and provide innovative and effective solutions to complex problems.

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2.2. Serum.

In the world of science and research, natural fluids are a valuable resource to explore and benefit from their many properties, and these fluids include vital fluids such as the protein-rich curd extracted from milk, known as fluids. lactic fluids. Understanding these fluids and evaluating their value and potential uses requires careful analysis and a deep understanding of their chemical and biological nature. Hence the importance of continuing research in this field is to explore new ways to benefit from lactic fluids better and more effectively [9]

The study of lactic liquids and their uses is at the forefront of scientific research aimed at improving industrial processes and developing food products, due to their richness in basic nutrients such as proteins, vitamins, and minerals. Know the components of these liquids and analyze their properties. opens horizons for researchers to explore new and innovative uses for them, whether in the food industry or other industries such as medicine and nutrition.

We cannot ignore the vital role that dairy liquids play in human nutrition and improving health. It is considered an important source of protein, essential for tissue growth and muscle building, in addition to providing many other nutrients. Hence the importance of modern use and advanced technologies to extract proteins from dairy liquids efficiently and economically, to meet the needs of the food and industrial markets [10]

Dairy liquids have enormous potential for use in multiple fields, from the food industry to medicine and biotechnology. Understanding their composition and properties represents an exciting scientific challenge that opens the doors for researchers to new experiments and discoveries and contributes to the development of new technologies. extract and use these liquids in an advanced and innovative way.

In short, studying lactic fluids and evaluating their value and potential uses requires a continuous and deep effort on the part of scientists and researchers, to explore everything that these fluids have to offer in various fields and contribute to the development of effective and innovative solutions. for the challenges facing humanity in the field of nutrition, health, and industry [11]

2.3. SWOT Analysis

SWOT analysis is an essential technique for evaluating the status of a company or project, examining both its internal characteristics (Weaknesses and Strengths) and its external environment (Threats and Opportunities) in a structured matrix. This process is broken down into four phases: analysis external, internal analysis, creation of the SWOT matrix and determination of the strategy to follow. The survival and prosperity of the organization are deeply linked to the environment that surrounds it, which presents both opportunities and threats. These are the key components of the external analysis. Simultaneously, the internal factors of the organization, such as its weaknesses and strengths, depend directly on its internal management [12]

Each of these four aspects can be classified as positive, driving the development of the organization, or negative, representing obstacles that impede said development - Opportunities are positive factors in the environment that, once identified, can be used to promote the growth of the organization. the organization or project. On the contrary, threats are negative external influences that must be addressed with tactics and strategies to overcome them. Internally, weaknesses are negative elements that need to be overcome through proper management, while strengths are positive aspects that must be exploited and enhanced. The SWOT analysis identifies strengths and weaknesses in areas such as the availability of capital resources, personnel, assets, product quality, internal and market structure, and consumer perception. The results of this analysis are placed in a matrix and are evaluated by experts, whose combined assessment offers a clear vision of the most promising strategies and tactics for the organization or project [13]

2.4. PEST Analysis

The PEST analysis examines the external factors that influence a company, covering Political, Economic, Social and Technological components. This analysis allows us to understand how legislative regulations, economic conditions, sociocultural trends and technological advances impact the organization. For example , political factors include environmental protection laws, antitrust regulations and government stability, while economic factors encompass all variables that affect the market. Sociocultural aspects refer to the configuration and behavior of consumers, and technological factors consider the development and adoption of new technologies [14] The PEST-SWOT methodology is developed in two main stages. First, an exhaustive analysis of external factors is carried

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out from political, economic, social and technological perspectives. In the second stage , the principles of SWOT analysis are applied to evaluate the internal characteristics of the company - Combining both approaches, a comprehensive and detailed vision of the business situation is obtained, identifying external opportunities and threats, as well as internal strengths and weaknesses, which facilitates the formulation of more effective and holistic strategies for the development and sustainability of the company [15]

2.5. Basic concepts about neutrosophy

Unlike traditional PEST-SWOT methods, in this work the evaluations are carried out based on Triangular Neutrosophic Numbers of Single Value. Below are the fundamental explanations on this topic.

Definition 1 ([17, 18]) : The neutrosophic set Nis characterized by three membership functions, which are the truth membership function T_A, the indeterminacy membership functionI_A and membership function to falsehood F_A, where Uis the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^{-}0, 1^{+}[$, and $^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}$.

See that by definition, $T_A(x), I_A(x)$and $F_A(x)$are standard or non-standard real subsets of $]^{-}0, 1^{+}[$and, therefore, $T_A(x), I_A(x)$and $F_A(x)$can be subintervals of $[0, 1]$. and1^{+} They belong to the set of hyperreal numbers.

Definition 2 ([17,18]) : The single-valued neutrosophic set $F_A: U \to [0, 1]$(SVN N) Ais U, $T_A: U \to [0, 1]$where $A = \{< x, T_A(x), I_A(x), F_A(x) > : x \in U\}$and $I_A: U \to [0, 1]$. $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The single-valued neutrosophic number (SVN N) is symbolized by

$N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$and $0 \leq t + i + f \leq 3$.

Definition 3 ([17,19]) : The single- $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$valued triangular neutrosophic number , , is a neutrosophic set in $\mathbb{R}$, whose membership functions of truth, indeterminacy and falsity are defined as follows:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), a_2 < x \leq a_3 \\ 0, \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, x = a_2 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, x = a_2 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$,$a_1, a_2, a_3 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3$.

Definition 4 ([17,20]) : Given$\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and$\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two triangular neutrosophic numbers of a single value andλ any non-zero number on the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,

2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,

3. Investment: $\tilde{a}^{-1} = \langle ({a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.

4. Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda < 0 \end{cases}$$

5. Division of two triangular neutrosophic numbers[21,22]:

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$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle\left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 > 0 \text{ and } b_3 > 0 \\ \langle\left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle\left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

6. Multiplication of two triangular neutrosophic numbers:

$$\tilde{a}\tilde{b} = \begin{cases} \langle(a_1b_1, a_2b_2, a_3b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, \ a_3 > 0 \text{ and } b_3 > 0 \\ \langle(a_1b_3, a_2b_2, a_3b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle(a_3b_3, a_2b_2, a_1b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

Where,∧ It's a norm∨ It is a conorm t.

3. Results and Discussion.

The study is carried out on the factors that have a socioeconomic and environmental impact on the extraction of dehydrated proteins from whey. For this purpose, experts on the subject and specialized literature were consulted. In this way the following factors were identified:

1. **Energy consumption:** The amount of energy used in the whey extraction and dehydration process can impact both economic costs and carbon emissions, affecting the sustainability of the process.

2. **Waste management:** By-products and waste generated during extraction must be properly managed to avoid negative environmental impacts, such as water and soil contamination.

3. **Access to technology:** The availability and cost of the technology necessary for protein extraction and dehydration can influence the economic viability of the process, as well as its efficiency and sustainability.

4. **Environmental regulations:** Laws and regulations related to environmental protection may impose additional restrictions and costs, but they may also incentivize more sustainable practices.

5. **Impact on biodiversity:** The use of natural resources and the generation of waste can affect local ecosystems, altering the biodiversity and health of habitats.

6. **Job creation:** The implementation of protein extraction technologies can generate new employment opportunities in various areas, from production to research and development.

7. **Food Safety:** Reusing whey, a byproduct of the dairy industry, to produce protein can contribute to food safety by providing an additional source of nutritious protein.

8. **Consumer acceptance:** Consumer perception and acceptance of whey protein-derived products can influence demand and, therefore, the economic success of the industry.

9. **Raw material cost and availability:** The availability and price of whey as a raw material may fluctuate due to factors such as dairy production, affecting the economic viability and stability of the supply chain for the extraction of dehydrated proteins.

By integrating these critical indicators into a comprehensive analysis model, a more complete and balanced view of the socioeconomic and environmental impact of the extraction of dehydrated whey proteins can be obtained.

Building a comprehensive model on the socioeconomic and environmental impact of dehydrated whey protein extraction may face several obstacles that require attention and consideration – the main obstacles include:

1. **High energy costs:** Protein extraction and dehydration can require large amounts of energy, raising operating costs and increasing the carbon footprint of production.

2. **Inadequate waste management:** The lack of effective systems to manage the waste generated can lead to environmental pollution, negatively affecting soil and water resources.

3. **Limited access to advanced technology:** Availability and access to efficient and sustainable technologies may be restricted due to high initial costs or lack of infrastructure, making it difficult to implement optimal processes.

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4. **Strict regulations:** Rigorous environmental regulations can increase compliance costs and limit operational flexibility, presenting challenges for companies in terms of adaptation and sustainability

5. **Negative impact on biodiversity:** Unsustainable processes can alter local ecosystems, causing loss of biodiversity and affecting the health of natural habitats

6. **Market volatility:** Fluctuations in the demand for whey-derived products and in raw material prices can destabilize the economics of operations, affecting their long-term viability

7. **Consumer resistance:** Lack of consumer acceptance towards whey protein-derived products may limit demand and market growth, affecting profitability

8. **Lack of investment in R&D:** Insufficient investment in research and development can limit innovation and continuous improvement of processes, preventing advances in efficiency, sustainability and product quality

Overcoming these obstacles requires a multidisciplinary approach that includes diverse perspectives, encourages collaboration among multiple actors, and employs comprehensive data collection along with meticulous analysis of the complexity and uncertainty inherent in socioeconomic and environmental impact assessment. Based on the PEST analysis, we can categorize the mentioned factors as threats and opportunities in relation to the four components of this analysis.

Threats

1.1 Political

T 1: Changes in environmental regulation

T 2: Political and legislative instability

1.2 Economic

T 3: Fluctuations in whey prices

T 4: Increase in energy costs

1.3 Social

T 5: Consumer resistance to whey-derived products

T 6: Impact on the quality of life of local communities

1.4 Technological

T 7: Technological limitations for efficient processing

T 8: Lack of adequate infrastructure

Opportunities

2.1 Political

O 1: Government support for sustainable innovation

2.2 Economic

O 2: Creation of new markets for whey-derived products

O 3: Increased competitiveness in the dairy industry

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2.3 Social

O 4: Employment generation in rural areas

O 5: Contribution to food security

2.4 Technological

O 6: Advances in extraction and dehydration technologies

O 7: Opportunities for research and development

Weaknesses

W 1: Lack of trained personnel

W 2: Complexity in waste management

Strengths

S 1: Use of by-products of the dairy industry

S 2: Potential to reduce food waste

S 3: Improvement in the sustainability of agricultural production

There was a group of 11 experts, who evaluated the possible combinations of an external factor with an internal factor. To do this, they were asked to evaluate using the linguistic terms that appear in Table 4.

Table 4: Linguistic terms for evaluations and their associated SVTNNs. See [14-17].

Linguistic Terms	**SVTNN**
Very low (VL)	$\langle(0,0,1);0.00,1.00,1.00\rangle$
Low (L)	$\langle(0,1,3);0.17,0.85,0.83\rangle$
Medium Low (MDL)	$\langle(1,3,5);0.33,0.75,0.67\rangle$
Medium (M)	$\langle(3,5,7);0.50,0.50,0.50\rangle$
Medium High (MDH)	$\langle(5,7,9);0.67,0.25,0.33\rangle$
High (High)	$\langle(7,9,10);0.83,0.15,0.17\rangle$
Very high (VH)	$\langle(9,10,10);0.00,1.00,1.00\rangle$

Specifically, there are the following sets:

$W = \{W_1, W_2\}$ denotes the set of Weaknesses,

$S = \{S_1, S_2, S_3\}$ denotes the set of Strengths,

$T = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7\}$ denotes the set of Threats,

$O = \{O_1, O_2, O_3, O_4, O_5\}$ denotes the set of Opportunities.

The steps are the following:

1. Each expert was asked to evaluate the possible combinations between the elements of SO, ST, WO and WT.

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This evaluation is done in terms of how the extraction of dehydrated proteins from whey would have socioeconomic and environmental repercussions.

2. Linguistic terms are replaced by the equivalent single-valued triangular neutrosophic numbers (SVTNN) in Table 4.

3. A single SVTNN is obtained by calculating the median of the SVTNNs of all experts for each pair of items.

4. The arithmetic mean of the SVTNN is calculated for each quadrant SO, ST, WO and WT.

5. The final result of each quadrant is converted to a crisp value using precision Equation 4. This converts them into values on a numerical scale out of 10 that allows the results to be compared.

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) (4)$$

Tables 5, 6, 7 and 8 summarize the results obtained after applying the previous steps.

Table 5: Calculation results for the SW quadrant. The medians of all experts are shown.

		Opportunities				
		O_1	O_2	O_3	O_4	O_5
Strengths	S_1	V.H.	H	V.H.	V.H.	V.H.
	S_2	V.H.	V.H.	H	H	H
	S_3	H	MDH	V.H.	V.H.	H

Table 6: Calculation results for the ST quadrant. The medians of all experts are shown.

		Threats						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Strengths	S_1	MDH	V.H.	MDH	MDH	V.H.	H	H
	S_2	H	H	H	H	H	H	H
	S_3	V.H.	MDH	H	V.H.	H	MDH	V.H.

Table 7: Calculation results for the WO quadrant. The medians of all experts are shown.

		Opportunities				
		O_1	O_2	O_3	O_4	O_5
Weaknesses	w_1	MDH	MDH	MDH	MDH	MDH
	w_2	MDH	MDH	MDH	MDH	MDH

Table 8: Calculation results for the WT quadrant. The medians of all experts are shown.

		Threats						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
	w_1	H	H	H	H	H	H	H

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Weak-nesses	w_2	MDH	MDH	MDH	MDH	MDH	MDH	MDH

From Tables 5 to 8, we have the following results:

- Potentials (Opportunities+Strengths): $\langle(7.8887, 9.2887, 9.9333); 0.87, 0.25, 0.33\rangle$,
- Risks (Strengths+Threats): $\langle(5.5190, 8.5714, 9.7519); 0.57, 0.25, 0.33\rangle$,
- Challenges (Weaknesses+Opportunities) $\langle(6, 7,9); 0.57, 0.35, 0.23\rangle$:
- Limitations (Weaknesses+Threats): $\langle(6.0, 7.0, 8.5); 0.60, 0.40, 0.50\rangle$.
-

As a last step, these values are converted into a crisp scale with a maximum of 10 using Equation 4. From here we have the following results:

- Potentials (Opportunities+Strengths): 9.6563,
- Risks (Strengths+Threats): 8.4857,
- Challenges (Weaknesses+Opportunities): 7.5241,
- Limitations (Weaknesses+Threats): 6.6852

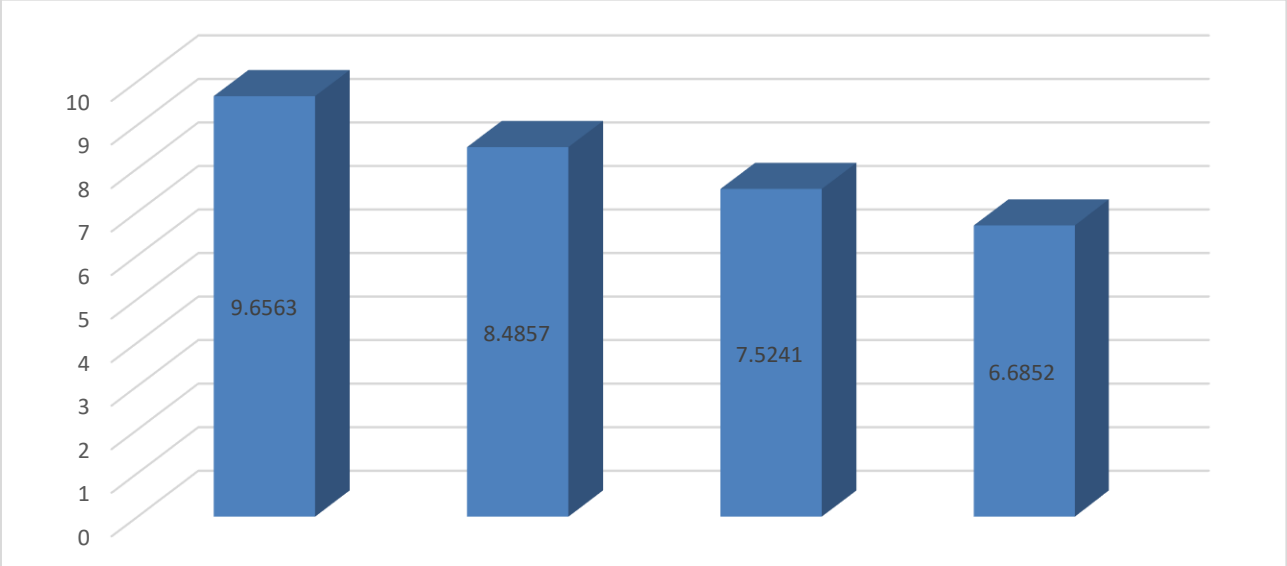

Figure 1: Calculation results for the WO quadrant.

The extraction of dehydrated proteins from whey presents a complex panorama, full of opportunities and challenges. The results of the quantitative analysis reveal that the potentials (combination of opportunities and strengths) reach a value of 9.6563, which indicates a fertile field for development and innovation. However, risks (strengths combined with threats) are also significant, with a value of 8.4857. This balance between opportunities and risks underlines the need for a well-thought-out, multidisciplinary strategy to maximize benefits and minimize disadvantages. From a political perspective, legislative instability and changes in environmental regulation (T1 and T2) represent considerable threats. Companies engaged in the extraction of whey proteins must be prepared to quickly adapt to new regulations and possible changes in the policy. This regulatory dynamism can be both an impediment and an opportunity, depending on the adaptation capacity and proactivity of companies.

Economically, fluctuating whey prices (T3) and rising energy costs (T4) can destabilize the financial viability of

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these operations – Volatile markets can make long-term planning and income stability difficult – However , the creation of new markets for whey-derived products (O2) and increased competitiveness in the dairy industry (O3) offer a positive counterweight. Investing in more efficient technologies and diversifying products can help mitigate these economic risks.

In the social sphere, consumer resistance to whey-derived products (T5) and the impact on the quality of life of local communities (T6) are critical factors to consider. Consumer acceptance is crucial for commercial success, and any negative perception can be a significant obstacle. Employment generation in rural areas (O4) and contribution to food security (O5) are social opportunities that should not be underestimated. These initiatives not only benefit local communities, but can also improve public perception and support for these products. Technologically, limitations to efficient processing (T7) and lack of adequate infrastructure (T8) are barriers that can slow progress. However, advances in extraction technologies and dehydration (O6) and opportunities for research and development (O7) represent fertile ground for innovation. Investing in research and development can offer innovative solutions that overcome these technological barriers, improving efficiency and reducing costs. The weaknesses identified , such as the lack of trained personnel (W1) and the complexity in waste management (W2), must be addressed urgently. Staff training and the implementation of more efficient waste management systems are essential to strengthen the supply chain. value. These weaknesses, if managed properly, can become areas of continuous improvement and competitive advantages.

Finally, strengths such as the use of by-products from the dairy industry (S1), the potential to reduce food waste (S2) and the improvement in the sustainability of agricultural production (S3) offer a solid foundation on which to build. These strengths not only improve economic viability, but also contribute to the environmental sustainability and social acceptance of whey-derived products. In summary, the extraction of dehydrated proteins from whey is full of potential, but also faces several obstacles. An approach A strategic strategy that considers all of these variables, supported by interdisciplinary collaboration and proactive adaptive capacity, is critical to maximizing benefits and minimizing risks. This comprehensive analysis, which combines quantitative results with a detailed qualitative assessment, provides robust guidance for decision making and policy development in this emerging area.

4. Conclusion

The extraction of dehydrated proteins from whey presents a complex and dynamic panorama, full of possibilities and challenges. According to quantitative analysis, the combination of positive elements reaches an outstanding value, suggesting fertile ground for innovation and growth. However , significant risks are also identified, underlining the need for carefully designed strategies and interdisciplinary collaborations to maximize benefits and minimize risks. From a policy perspective, legislative instability and changes in environmental regulation represent considerable challenges, demanding rapid and efficient adaptability by part of companies in the sector. Economically, fluctuations in whey prices and increasing energy costs could threaten the financial stability of these operations. Market volatility complicates long-term planning and revenue predictability. Despite Therefore, the opening of new markets and the strengthening of competitiveness in the dairy industry offer opportunities to diversify products and mitigate economic risks. In the social sphere, consumer resistance to products derived from whey and the impact on the quality of local life are critical considerations. Consumer acceptance plays a fundamental role in commercial success, while generating employment in rural areas and contributing to food security represent beneficial social aspects. These initiatives not only benefit local communities, but can also improve public perception and support for these products. Technologically, limitations in efficient processing and inadequate infrastructure are challenges that could slow progress in the sector. However, advances in extraction and dehydration technologies along with opportunities for research and development offer a fertile ground for innovation and improved efficiency. Identified weaknesses, such as lack of trained personnel and complex waste management, must be addressed urgently. Continuous training and implementation of More efficient management are essential to strengthen the value chain and promote a more sustainable operation. These weaknesses, if properly managed, can become areas of continuous improvement and competitive advantages. In conclusion, the extraction of dehydrated proteins from whey offers a potential considerable, but not without challenges. A strategic approach that integrates these elements with interdisciplinary collaboration and proactive adaptive capacity is crucial to capitalize on opportunities and mitigate inherent risks. This comprehensive analysis, which combines quantitative data with detailed qualitative assessments , provides a solid foundation for informed decision making and effective policy development in this emerging and dynamic sector.

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References

[1] KE Almeida, AY Tamime, MN Oliveira, "Effect of total solids content of whey on the acidification properties and viability of lactic acid bacteria", LWT - Food Science and Technology, Praxis. 42, no. 2, pp. 672-678, 2009.

[2] HK Hernández, FP GARCIA, VER CRUZ, YM Santillán, MAM Marceau, "Physical and chemical properties of serum: phosphorus reduction", Universidad Acta, Volume 22, Number 1, November 18, 2012.

[3] HK Hernández, FP GARCIA, VER CRUZ, YM Santillán, MAM Marceau, "Physical and chemical properties of serum: the ability to reduce phosphorus", Acta Universidad, Vol. 22, number 1, November 18, 2012, pp. [Online]. URL: http://www.actauniversitaria.ugto.mx/index.php/acta/article/view/304/282.

[4] RAP Huertas, "Whey: its importance in the food industry", Magazine of the National Institute of Agriculture in Medellín, Vol. 62, No. 1. 4967-4982, 2009. Available: https://www.redalyc.org/pdf/1799/179915377021.pdf.

[5] MJ Jáuregui Vásconez, "Composition of animal and vegetable nutritional supplements for athletes", Master's thesis, Universidad Interamericana, Quito, 2020 [Online]. Available: http://dspace.udla.edu.ec/handle/33000/12188.

[6] to . Kotinas et al., "Whey valorization: development of innovative integrated technologies for initial production in the dairy industry," Bioresource Technology, vol. 100, no. 1. 3734-3739, 2009.

[7] M. Londoño, J. Sepúlveda, A. Hernández and J. Parra, "Fresh cheese drink fermented from whey mixed with Lactobacillus casei", Revista del Colegio Nacional Agropecuario de Medellín, vol. 61, No. 1. 1 page 4409-4421,

[8] AD López Hernández, "Microencapsulated mucus by spray", Cuban Journal of Pharmaceutical Products, vol. 44, no. 1. 3, pp. 381-389, 2010. Available: http://sky.sld.cu/sky.php?script=sci_arttext&pid=S0034-75152010000300013&length=one&tlng=one.

[9] Diaz-Bustamante, M. L., Keppler, J. K., Reyes, L. H., & Solano, O. A. A. (2023). Trends and prospects in dairy protein replacement in yogurt and cheese. Heliyon, 9(6).

[10] Różyło, R. (2020). Recent trends in methods used to obtain natural food colorants by freeze-drying. Trends in Food Science & Technology, 102, 39-50.

[11] JR Nora Sais, "Process design for the production of whey protein through spray drying", Master's Thesis, National University of Chimborazo, 2017.

[12] Yasir, M. Zafar, A. Anas, M. (2023). Implementation and execution of NEP-2020: a study conducted using neutrosophic PESTEL analysis. Journal of International Journal of Neutrosophic Sciences, 20 (2), 86-106.

[13] Benzaghta, M.A., Elwalda, A., Mousa, M.M., Erkan, I. and Rahman, M. (2021). Applications of SWOT analysis: An integrative review of the literature. Journal of Global Business Insights, 6(1), 54-72.

[1 4] Yasir, M. Zafar, A. Anas, M. (2023). NEP-2020's Implementation & Execution: A Study Conducted Using Neutrosophic PESTEL Analysis. Journal of International Journal of Neutrosophic Science, 20(2), 86-106.).

[1 5] Longsheng, C., Shah, S.A.A., Solangi, Y.A., Ahmad, M. and Ali, S. (2022). A multi-criteria integrated SWOT analysis on the implementation of sustainable waste-to-energy in Pakistan. Renewable Energy, 195, 1438-1453.

[16] Farrokhnia, M., Banihashem, S.K., Noroozi, O. and Wals, A. (2024). A SWOT Analysis of ChatGPT: Implications for Educational Practice and Research. Innovations in International Education and Teaching, 61(3), 460-474.

[1 7] Vázquez, ML, Hernández, JH, Batista- Hernández, N.., Salvatierra, JAA, and Baryolo, OG (2018). A framework for PEST analysis based on fuzzy decision maps. Spaces, 39, 13.

[1 8] Matović, I.M. (September 2020). PESTEL analysis of the external environment as a success factor for a

DOI: https://doi.org/10.54216/IJNS.250127
Received: December 11, 2023 Revised: February 02, 2024 Accepted: July 03, 2024

startup. In Proceedings of the ConScienS conference (pp. 96-102). Scientia Moralitas Research Institute.

[19] Joselyne, I. Marina, C. P., P. Cagin, T. (2024). Fusion of Expert Judgment using the Neutrosophic Delphi Method to Evaluate Tax Behavior. Journal of International Journal of Neutrosophic Science, 23(4), 302-307.

[20] Elisabeth, Nery. , I., Anderson. , E., Isaac. , N., Mirian. , Kümmel, Christian. Neutrosophic Delphi method to analyze the impact of Internships on the comprehensive development of university students. Journal of International Journal of Neutrosophic Science, vol. 24, no. 4, 2024, pp. 223-232.

[21] Abd El-khalik, W. (2022) " A Machine Learning Approach for Improved Thermal Comfort Prediction in Sustainable Built Environments ", Sustainable Machine Intelligence Journal , 1, pp. (2):1–8. doi:10.61185/SMIJ.2022.11101 .

[22] Md, Z. A., N. A., N. Hakimi, M. Ahmad, G. Al-Sharqi, F. Al-Quran, A. M., A. (2024). A DEMATEL Analysis of the Complex Barriers Hindering Digitalization Technology Adoption in the Malaysia Agriculture Sector. Journal of Journal of Intelligent Systems and Internet of Things, 13(1), 21-30.

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