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Checklist for Submitted Manuscripts

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COVER: Figure 1. Bacteria of the genus *Enterobacter* sp. (left) and *Clostridium* (right). Biohydrogen Production from Effluents Using Anaerobic Bacteria: A Bibliometric Review by Gisele Beatriz Teles Goes et al. J Bioeng. Tech. Health 2024;7(2):206.

Challenges in the Development Process of Lipid Nanoemulsions for Parenteral Nutrition

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Lipid emulsions (ELP) used in parenteral nutrition represent a complex pharmaceutical formulation. These emulsions serve as vital sources of energy, essential fatty acids, and fat-soluble vitamins in nutritional therapy regimens. Therefore, following a systematic approach in the development process is crucial to ensure the safety of ELP. With this objective in mind, our study aimed to survey the stages involved in the development process of lipid nanoemulsions applied in parenteral nutrition and to identify the primary needs and challenges encountered throughout this process. Consequently, our analysis revealed 10 stages in the Product Development Process (PDP) and identified 20 specific needs that characterize the development of lipid nanoemulsions for parenteral nutrition. These identified needs offer valuable insights for future research endeavors to enhance the development of parenteral diets.
Keywords: Product Development. Parenteral Lipid Emulsions. Parenteral Nutrition. Quality Function Deployment (QFD).

Parenteral Nutrition (PN) involves the intravenous infusion of nutrients, comprising a solution or emulsion containing macronutrients and micronutrients. The primary goal of PN is to synthesize or maintain tissues, organs, and systems [1]. Within PN, fatty acids (FA) are delivered through parenteral lipid emulsions (ELP). These emulsions consist of essential fatty acids (AGE), phospholipids, and fat-soluble vitamins and employ a complex nanotechnological delivery system. Additionally, ELP is a high-density energy source and varies in the quantity, type, and source of fatty acids [2,3].

PN is designed to fulfill patients' nutritional and metabolic requirements. Consequently, ELP plays a crucial role in patient prognosis due to its significant impact on the immune and inflammatory systems. While PN represents a costly therapeutic approach, when appropriately indicated and administered, ELP can mitigate complications, reduce hospitalization duration, and decrease overall medical care costs [4].

ELP is configured as a pharmaceutical product, necessitating adherence to a meticulous development process to ensure its safety. Given the complexity of the ELP development process, characterized by the vast amount of information involved, careful navigation is crucial. Notably, many design tools are applicable in the early stages of development. The selection of methodologies and technologies employed in ELP development is paramount, as they dictate the characteristics of the final product [5,6]. Therefore, this study aims to survey the stages involved in executing the ELP development process, specifically focusing on lipid nanoemulsions applied in parenteral nutrition, and to identify the primary needs and challenges encountered.

Materials and Methods

This study employs a quantitative approach to explore scientific and technological aspects. The methodology follows an applied framework, adhering to the stages of lipid nanoemulsion development for parenteral nutrition as proposed by De Paula (2004) [7]. De Paula's model integrates management principles and product development techniques [6]. A schematic representation of the methodological process and techniques employed (Figure 1).

Figure 1. Research process and techniques.
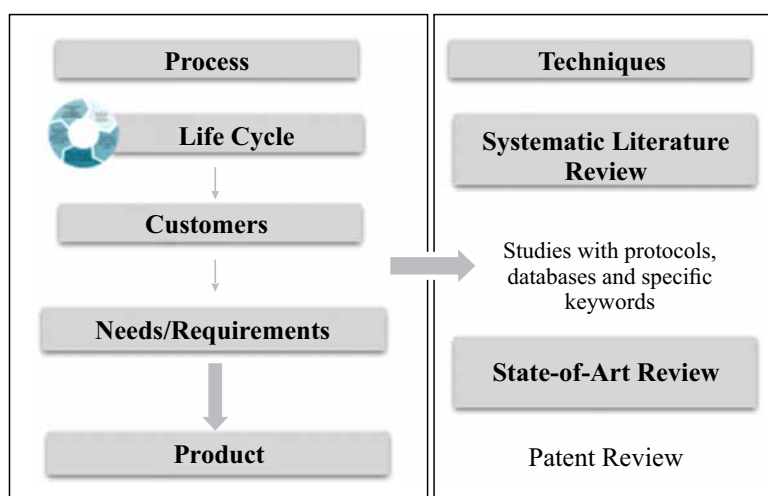
Initially, a comprehensive analysis was conducted to map current and future processes and the needs and contextual factors pertinent to the development of lipid nanoemulsions for parenteral nutrition therapy. It involved identifying and systematizing the stages and processes throughout the life cycle and articulating the discerned needs.

Results and Discussion

The steps in the development process were identified by adapting Yugue's (2009) drug development processes [8]. A detailed review mapped out 20 distinct needs that characterize the process of developing lipid nanoemulsions for parenteral nutrition (Table 1).

Amaral and colleagues (2017) [6] emphasize the significance of identifying needs in product development, as products should be designed based on these needs. This approach provides a comprehensive understanding of the design objectives.

Parenteral lipid emulsions play a crucial role in clinical practice and patient prognosis [9], and they are becoming an increasingly important area of research. The process of developing lipid nanoemulsions for parenteral nutrition follows well-defined steps. It is worth noting that inadequate adherence to any of these stages may compromise the Product Development Process (PDP) outcomes. Regarding challenges, it is pertinent to highlight the necessity of importing inputs/raw materials for the production process and the absence of domestic companies manufacturing these products in Brazil. Brazil has limited influence in this technology and lacks significant knowledge appropriation in this sector, leading to external dependence and substantial costs for the country.

However, the absence of domestic companies specializing in developing lipid nanoemulsions for parenteral nutrition could present an opportunity. Nonetheless, realizing this potential requires proactive economic measures to stimulate technical, scientific, and technological advancements in this field.

Conclusion

The identified needs are essential for developing lipid nanoemulsions applied in parenteral nutrition. Moreover, these needs can serve as valuable contributions to studies to formulate parenteral diets in future research endeavors. Other researchers should undertake the development of a reference model for designing and developing parenteral diets, which could provide support for both future research and industry applications.

Table 1. Steps and needs in developing lipid nanoemulsions applied in parenteral nutrition.

Stages	Stages of PDP	Requisites
1	Concept study	Medical viability
		Regulatory viability
		Development feasibility
		Manufacturing feasibility
		Low production cost
		Commercial feasibility
2	Pre-clinical study	Complying with published literature
3	Method development (raw material)	Viable raw material cost
4	Method validation (raw material)	Potential raw material
5	Pre-formulation study	Chemical stable raw material/inputs
		Inputs with low degradation capacity
6	Product/formulation development	Production feasibility
7	Development of analytical method (finished product)	Precise, consistent, and reliable data
8	Stability study	Accelerated stability
		Long-term stability
9	Clinical study	Be safe
		Complying with ANVISA requirements
10	Product registration dossier/report	Meeting published scientific needs
		Be viable for regulatory approval
		Complying with criteria for product approval and price officialization

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Calculation of Vascular Impedance for Modeling the Arterial System in Patients with Cardiovascular Diseases

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The process of detecting pathologies in the human cardiovascular system remains challenging despite advancements in current technologies. It is imperative to devise new methods to aid in diagnosing the diseases. This study focuses on an approach employed in Cardiovascular Engineering, wherein the systemic arterial circulation is modeled using equivalent electrical circuits known as "Windkessel Models". The parameter values of these models are obtained through system identification techniques. This work covers two methods: Method 1 utilizes the tools available in the MATLAB software toolbox, while Method 2 involves expanding the Fourier series to calculate vascular impedance. Consequently, 2-element (2WK) and 3-element (3WK) models were developed with an accuracy of up to 83%. These models accurately represent arterial behavior and can serve as potential tools to aid in identifying cardiovascular diseases in patients.
Keywords: Windkessel Model. System Identification. Cardiovascular Engineering. MATLAB.

Cardiovascular diseases accounted for 31% of recorded deaths in 2016. Despite technological advancements, these fatalities persist due to late or sudden diagnoses. This statistic underscores the vital role of the Human Cardiovascular System (CHS) in supplying nutrients to sustain the body's organs. The CHS functions as a periodic pumping system, characterized by two distinct phases, systole, and diastole, driven by the heart's pumping action and observable throughout the circulatory system [1].

Understanding the CHS is paramount for effective diagnosis, and one method to achieve this is through mathematical modeling. For instance, a lumped parameter model can represent the hemodynamic behavior of a specific point in the circulatory system using an analogous electrical circuit known as the Windkessel circuit [2].

However, to develop this model and simulate the arterial physiological behavior of a patient, calculating cardiovascular impedance is imperative. Cardiovascular impedance represents the input-output relationship between pulsatile blood flow and pulsatile blood pressure in an artery, depicted by the transfer function Z_{in}, (Figure 1). The parameters of this function can be calculated using system identification methods [3,4].

Therefore, this research aims to calculate the parameters of the Windkessel models of the SCH of an adult patient, which can help in obtaining faster diagnoses of certain cardiac conditions, thus enabling the initiation of preventive treatments as soon as possible.

Materials and Methods

Using a lumped parameter model, we describe a fluidic system through an equivalent electrical circuit, which is the systemic arterial circulation in this study, given a uniform distribution of the fundamental variables (flow, pressure, and volume). This circuit model is called "Windkessel Model", which can be 2 elements (2WK), 3 elements (3WK) or 4 elements (4WK), in which each component represents a characteristic of the artery (Figure 2). The resulting transfer functions for each of these circuits are described in Equations (1), (2), and (3), respectively.

Two different methods were employed and subsequently compared to obtain this transfer function. Method 1 utilizes pre-existing computational system identification tools to determine a transfer function that depicts the

Figure 1. A block diagram illustrating vascular impedance [6].
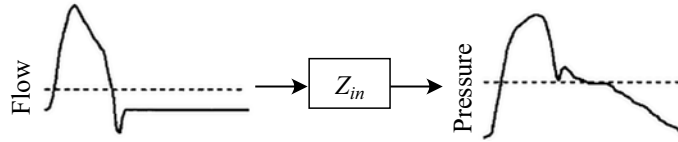
Figure 2. Relationship between Windkessel circuits and arterial behavior [2].

$$H_{2WK}(s) = \frac{P(s)}{Q(s)} = \frac{Rp}{sCRp + 1} \tag{1}$$

$$H_{3WK}(s) = \frac{P(s)}{Q(s)} = \frac{sCRpZc + Rp + Zc}{sCRp + 1} \tag{2}$$

$$H_{4WK}(s) = \frac{P(s)}{Q(s)} = \frac{s^2RpCLZc + sLRp + sLZc + RpZc}{s^2RpLC + sL + sRpCZc + Zc} \tag{3}$$
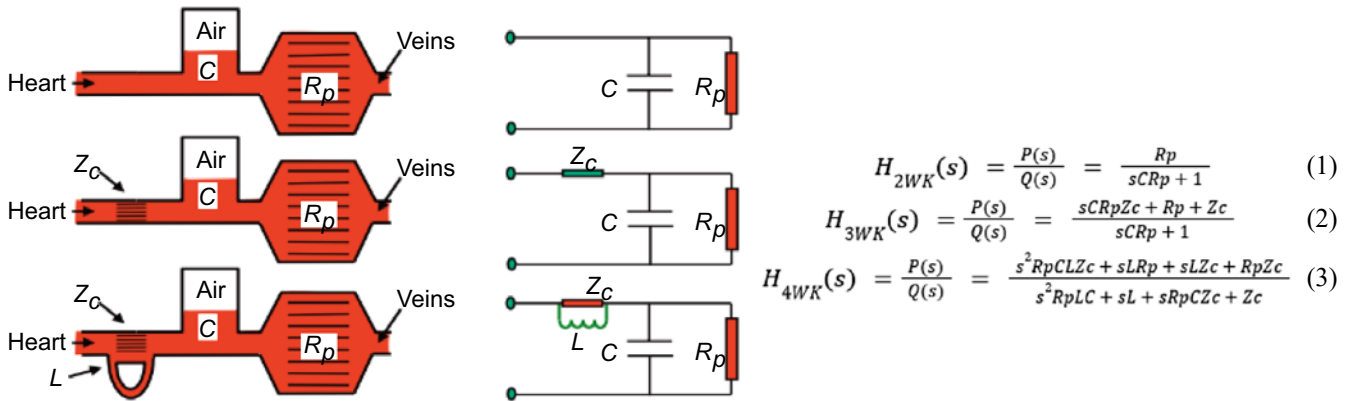
system represented by vascular impedance. This method considers the input and output data of the system (flow and pressure, respectively), sourced from a database derived from a study conducted by Harana and colleagues [5]. The database, generated virtually, aims to emulate the cardiovascular system of elderly individuals. The dataset pertaining to the ascending aorta, through which blood initially exits the heart, was selected to mitigate noise.

Method 2 involves constructing the graph of vascular impedance modulus and phase, as specified in Equation (4), to derive the parameters that characterize the desired circuit. Fourier Analysis represent the flow and pressure signals as the sum of sines and cosines, as depicted in equations (5) and (6).

The calculated impedance values make it possible to determine the parameter values for each type of Windkessel model. Subsequently, computer simulations can be conducted, enabling various analyses to derive a patient diagnosis.

Results and Discussion

An algorithm was developed using MATLAB software to compute impedance. This algorithm

facilitated the calculation of vascular impedance based on data from a database. Subsequently, by employing the functions estimated by the algorithm, parameter values could be obtained by comparing the transfer function of the Windkessel circuit with that obtained via the software.

The desired resistance and capacitance values for the 2- and 3-element circuits can be extracted with the calculated vascular impedance. Table 1 presents the resulting values from both simulations.

Furthermore, Method 1, utilizing the MATLAB system identification toolbox, allowed for examining the model's response curve compared to the natural curve. Figure 3 displays the blood pressure data output obtained given a blood flow data input. It is evident that the more complex the represented system, the closer the output curve aligns with the natural curve.

Conclusion

Through this study on cardiovascular impedance, we could simulate a patient's systemic arterial circulation using concepts from equivalent electrical circuits. Such an approach holds promise for expediting and refining the diagnosis

$$|Z_n|\angle_z = \frac{|P_n|\angle\varphi_p}{|Q_n|\angle\varphi_q} \tag{1}$$

$$p(n) = P_0 + \sum_0^\infty Q_n cos(\omega_n t)+ \varphi_p \quad \therefore \quad p_n = P_n cos(\omega_n t + \varphi_p) = |p_n|\angle\varphi_p \tag{2}$$

$$q(n) = Q_0 + \sum_0^\infty Q_n cos(\omega_n t + \varphi_q) \quad \therefore \quad qQ = {}_n cos(\omega_n t + \varphi_q) = |q_n|\angle\varphi_q \tag{3}$$

Table 1. Fluidic values obtained from the methods.

Circuit Parameter	Mathematical Model		
	Method 1: 2WK	Method 1: 3WK	Method 2
Capacitance (mL*mmHg^-1)	0.87	1.032	1.16114
Impedance (mmHg*mL^-1*s)	2.092	1.973	1.755
Characteristic Impedance (mmHg*mL^-1*s)	-	0.02394	0.02395

Figure 3. Response curves obtained for the Windkessel models.

Measured (mydata) and simulated model output
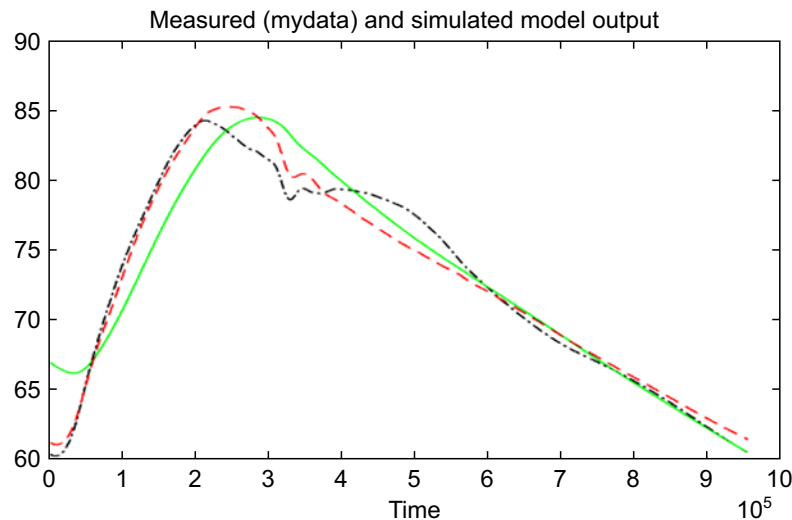
The curve with black lines and dots represents the real pressure curve; the continuous green curve depicts the two-element Windkessel model; and the dashed red curve illustrates the three-element model. (2WK Accuracy: 51.34%; 3WK Accuracy: 83.32%).

of cardiovascular diseases, as variations in parameter values serve as indicators of potential pathologies.

However, our analysis only encompasses the arterial circulation of the cardiovascular system. Further insights could be gained by extending this modeling to encompass the entire Human Cardiovascular System (HCS), rendering the model more comprehensive and detailed. This expansion would enable a broader range of analyses and facilitate more accurate diagnoses.

One current challenge in implementing this project is the limited availability of technologies capable of measuring blood flow without

invasive methods that disrupt circulation. With the advancement of technologies capable of indirectly and painlessly measuring blood flow, models such as this could become more widely applicable, thereby streamlining the identification of cardiovascular pathologies.

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Machine Learning-Based Cardiac Arrhythmia Detection in Electrocardiogram Signals

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The cardiovascular system is vital for human physiology, regulating blood circulation. Cardiovascular Diseases (CVDs), including cardiac arrhythmias, can disrupt the heartbeat rhythm, impacting blood circulation. Black-box computational modeling of this system can facilitate the development of novel methods and devices to assist in diagnosing and treating CVDs. Artificial Neural Networks (ANNs) represent an effective black-box approach. Implementation involves selecting a database, separating training and test sets, and defining the model structure. The MIT-BIH database is commonly utilized to train computational models to detect cardiac arrhythmias. However, preliminary results with the ANN model trained using MIT-BIH data failed to meet the expected objectives, presenting numerous challenges. Nonetheless, given its nascent stage, there remains potential for optimizations, rendering it a prospective tool for diagnosing cardiac arrhythmias.
Keywords: Electrocardiogram. Cardiac Arrhythmias. Artificial Intelligence. Machine Learning.

The cardiovascular system plays a pivotal role in human physiology, orchestrating blood circulation throughout the body. Its proper functioning is paramount for maintaining optimal blood pressure and flow and the effective distribution of oxygen and nutrients essential for sustaining physiological well-being. However, deviations in cardiovascular function, often precipitated by cardiovascular diseases (CVDs), can significantly compromise these vital processes. CVDs stand as a leading cause of mortality globally, contributing to approximately 17.9 million deaths annually, accounting for 31% of all global deaths [1].

The heart's electrical activity, crucial for regulating cardiac function, can be comprehensively represented through an electrocardiogram (ECG) (Figure 1). The ECG waveform encapsulates essential information about the various electrical waves governing the cardiac cycle. Within the spectrum of CVDs, cardiac arrhythmias emerge as electrical aberrations that disrupt the temporal intervals between QRS complexes in the ECG signal.

These disturbances manifest as irregular heartbeat rhythms, thereby perturbing the harmonious functioning of the cardiovascular system [2].

Computational modeling of the human cardiovascular system offers insights into heart physiology and facilitates the development of diagnostic and therapeutic methods for cardiovascular diseases. However, like many physical phenomena, the cardiovascular system is characterized by Non-Linear and Time-Varying Systems (NLVT), posing challenges for classical analytical modeling and control methods. Black box modeling, a system identification method, circumvents this challenge by heuristically deriving an approximate mathematical model based on input-output relationships without explicitly modeling the system's physical behavior. Artificial Intelligence (AI), particularly Machine Learning (ML), has emerged as a powerful tool for implementing black box modeling solutions. ML, a subarea of AI, enables the creation of artificial neural networks (ANNs), computational models trained using datasets to perform desired functions

In this context, this research aims to develop an ANN model capable of accurately identifying the location of R peaks in electrocardiogram (ECG) signals. This model aims to evaluate the patient's heart rhythm and aid in diagnosing cardiac arrhythmias [3].

Figure 1. Capture of a typical ECG signal.
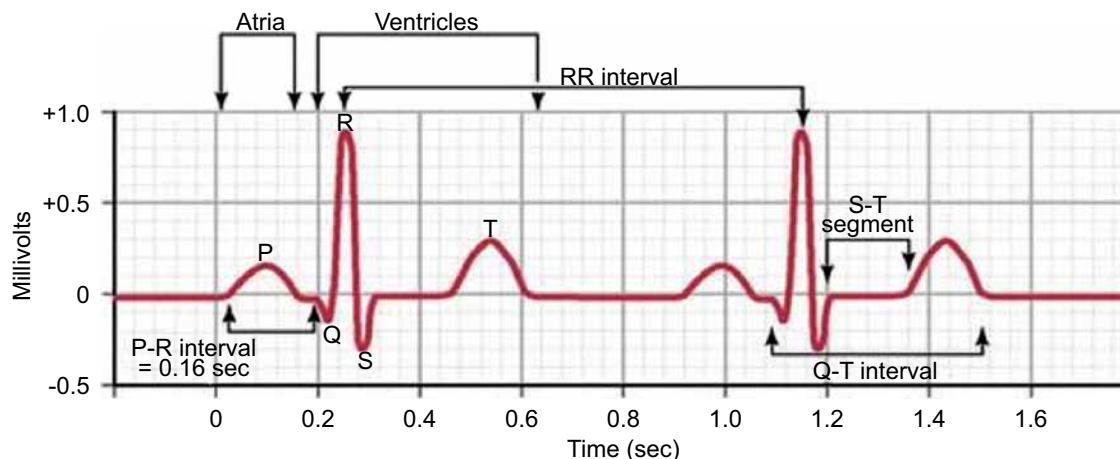
Source: Guyton (2011) [2].

Materials and Methods

Figure 2 illustrates the typical process of training mathematical models using machine learning (ML) neural network architectures. Following this process, the electrocardiogram (ECG) database selected for this study was the MIT-BIH database [4], renowned as one of the most frequently utilized databases in the scientific literature [5]. The chosen artificial neural network (ANN) architecture was the multilayer perceptron (MLP) classifier. The configuration of the MLP, as depicted in Figure 2, was established with three layers: the input layer comprising 20 neurons, employing the rectified linear unit (ReLU) activation function, is connected to the hidden layer, which consists of 10 neurons, also activated by the ReLU function. Subsequently, the hidden layer is linked to the output layer utilizing the sigmoid activation function, generating the desired outcome. The MLP classifier will be implemented within the TensorFlow and sci-kit-learn libraries within the Python programming language development environment.

The training and validation steps of the computational model involve utilizing a subset of records from the database [4] for training purposes and a separate subset for testing and validating the model. Initially, a unitary set containing record 100 was utilized for training, selected due to its high signal quality and sinus rhythm falling within the expected range for a healthy heart [4]. For the test set, six records were randomly chosen. This approach assesses the model's efficacy in recognizing patterns across various records, regardless of their previously known condition. Averages of Precision (PRC), Recall (RC), F1 Score

Figure 2. Block diagram of computer-aided arrhythmia classification systems.
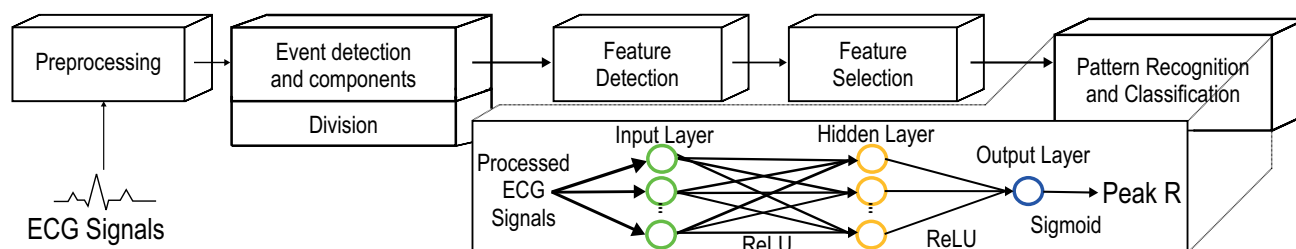
Adapted from Hammad and colleagues (2021) [3].

(F1), and Accuracy (ACC) metrics were computed to evaluate the performance of the model. These metrics were derived from True Positive (Tp), True Negative (Vn), False Positive (Fp), and False Negative (Tn) values, as outlined in the literature [6].

Results and Discussion

Figure 3 depicted the results of the predictions generated by the trained artificial neural network (ANN) model. The outcomes reveal three distinct behaviors: Accurate identification of a single peak per R wave, as illustrated in Figure 3(a) Multiple markings on the same peak within a single R wave, exemplified in Figure 3(b) The absence of any markings denoting R peaks, as illustrated in Figure 3(c).

The results presented in Table 1 indicate that the model predictions exhibit a low rate of False Positive (Fp) values but a high rate of False Negative (Fn) values. Consequently, the model demonstrates high precision but low recall, as precision measures the proportion of true positive predictions among all positive predictions. In contrast, recall measures the proportion of true positive predictions among all actual positive instances. On a scale from 0 to 1, the average F1 score suggests that the model's performance is moderate, considering the significant disparity in recall values. Notably, the trained model proves ineffective for record 114, as no detected R peak corresponds to a True Positive (Tp), resulting in accuracy being the only relevant metric.

Overall, the model exhibits high accuracy, primarily because this metric accounts for all

Figure 3. Temporal template for predicting R peaks: (a) correct marking; (b) multiple markings on the same peak; (c) absence of marking.
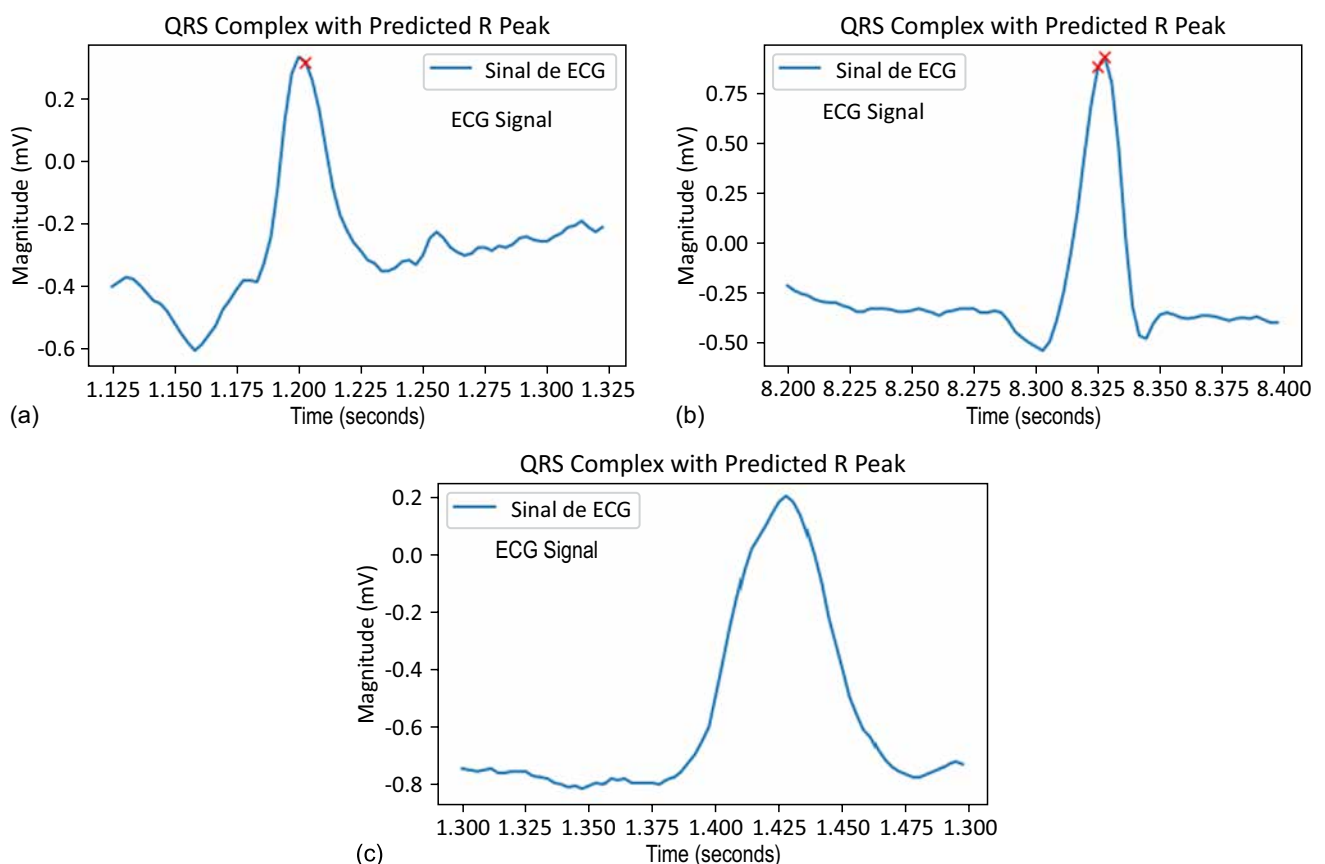
Table 1. Metrics adopted for evaluating the performance of the trained ANN model.

Test Recorder	$PRC = \dfrac{Tp}{Tp+Fp}$	$RC = \dfrac{Tp}{Tp+Fn}$	$F1 = \dfrac{2*PRC*RC}{PRC+RC}$	$ACC = \dfrac{Tp+Tn}{Tp+Tn+Fp+Fn}$
105	0.83	0.66	0.73	0.99
114	0	0	0	0.99
121	0.89	$4.26*10^{-3}$	$8.48*10^{-3}$	0.99
200	0.90	0.38	0.53	0.99
215	0.93	0.67	0.77	0.99
228	0.78	0.36	0.49	0.99
Median	0.72	0.35	0.42	0.99

outcomes and the inherent imbalance between R-peaks classes and non-R-peaks. Notably, R-peak signals are inherently more challenging to detect, contributing to the model's observed performance.

A contributing factor to these results may be utilizing only one record for training the model, leading to an inadequately sized database. Other factors potentially influencing performance include noise in the ECG signal and the accuracy of R peak annotations used during training. These challenges pertain to the ECG signal's pre-processing and event and wave detection stages. To address these issues, Hammad and colleagues and Xiao and colleagues, in their systematic literature reviews, suggest employing traditional and wavelet filters for noise reduction and algorithms such as the Pan-Tompkins algorithm and the Savitzky filter-Golay.

Conclusion

This study proposed a system for identifying cardiac arrhythmias using artificial neural networks (ANNs) to aid medical diagnoses. The ANN model developed within the Python development environment demonstrated proficiency in identifying R peaks from the ECG signal. While the achieved results have yet to meet the desired research objectives fully, it is essential to note that the model's development is in its nascent stage, with numerous optimization opportunities awaiting exploration. Furthermore, several more advanced ANN architectures could be investigated in future studies, including Convolutional Neural Networks, Long Short-Term Memory networks, and hybrid architectures.

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Optical Characterization of Oximeters and Development Kits for Photoplethysmography

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Photoplethysmography (PPG) is a non-invasive method used to diagnose parameters associated with optical blood analysis. Equipment such as an oximeter utilizes this method to diagnose oxygen saturation. The present work aims to analyze and characterize devices for PPG and understand their operating principles through quantitative experimental tests. The conclusion of this study is expected to obtain information about the technical and constructive aspects of the optical system of some PPG devices.
Keywords: Photoplethysmography. Optics. Characterization. Devices.

Photoplethysmography (PPG) stands as a non-invasive technique utilized to discern variations in capillary and arterial blood volume by exploiting the interaction of light with human tissue, as highlighted in studies by Rochmanto and colleagues (2017) [1], and Tamura and colleagues (2014) [2]. The typical PPG signal comprises an alternating current (AC) component and a direct current (DC) component, from which vital information such as oxygen saturation and hemoglobin levels can be extracted. Total hemoglobin consists of four components: oxyhemoglobin, deoxyhemoglobin, methemoglobin, and carboxyhemoglobin, with their spectral curves well-defined and referenced in the works of Yoon and Jeon (2005) [3] for hematological component analysis.

An oximeter is a non-invasive sensor that employs the PPG method to measure oxygen saturation. This device relies on optical transmission principles, wherein the emitting source and the signal acquisition sensor are positioned on opposite surfaces. Light-emitting diodes (LEDs) in the red and infrared range typically serve as the emitting source. At the same time, the signal acquisition sensor is commonly a photodiode sensitive to the same wavelength range as the transmitted light.

Currently, pulse oximeters employ optical reflection techniques, where both the emitting source and the signal acquisition sensor are situated on the same surface. The acquisition sensor typically consists of a photodiode similar to those utilized in transmission oximeters. In addition to utilizing LEDs emitting in the red and infrared ranges, these pulse oximeters may incorporate a green LED.

Moreover, for studying purposes without a need for medical validation, development-kits can be used to analyze PPG signals. These kits generally employ reflection-based devices with optical configurations like pulse oximeters. The ensuing tests aim to analyze and characterize several PPG devices while comprehending their operational principles. For this purpose, two development kits were selected for testing: one manufactured by AMS and the other by Analog Devices, alongside a pulse oximeter produced by Multilaser.

Materials and Methods

The optical characterization of the devices involved conducting two quantitative experimental tests: acquiring the spectral curve of the LEDs and surveying the optical emission signal over time.
The devices under characterization included the development kits AS7057_EVK_UG001039

from AMS and the EVAL-ADPD4100Z-PPG from Analog Devices, which utilize the reflection principle, and the HC261 oximeter from Multilaser, which operates on the transmission principle. Figure 1 illustrates an enlarged image of the optical components of these devices. For the first test, the experimental setup comprised an optical fiber from Ocean Optics, an AvaSpec-2048 spectrometer from Avantes, and the AvaSoft8 acquisition software. The light sources analyzed were the LEDs integrated into the devices.

The experimental setup for the second test consisted of employing an Ocean Optics optical fiber connected to a Thorlabs SM05PD2A silicon photodiode, a Thorlabs AMP 120 trans-impedance amplifier, and a Tektronix oscilloscope, model TDS1001B. Figure 2 depicts the experimental acquisition system for the first and second tests.

Results and Discussion

Figure 3 depicts a graph illustrating one of the spectral curve measurements acquired for the infrared LED from the AMS development kit. This graph facilitates the determination of the wavelength of the emission peak. Table 1 summarizes the measured peaks across the devices for each LED (green, red, or infrared).

Figure 4 is the PPG optical signal from the AMS development kit analyzed on the oscilloscope. It is possible to extract information such as pulse width and emission frequency of the light signal through this signal. This information was not found in the datasheets of these components. Table 2 describes the results obtained for all devices analyzed in this study.

Figure 1. Enlarged image of the LED and sensor area of the AS7057_EVK_UG001039 kit (A) and, the EVAL-ADPD4100Z-PPG Kit (B) and the HC261 Oximeter (C).
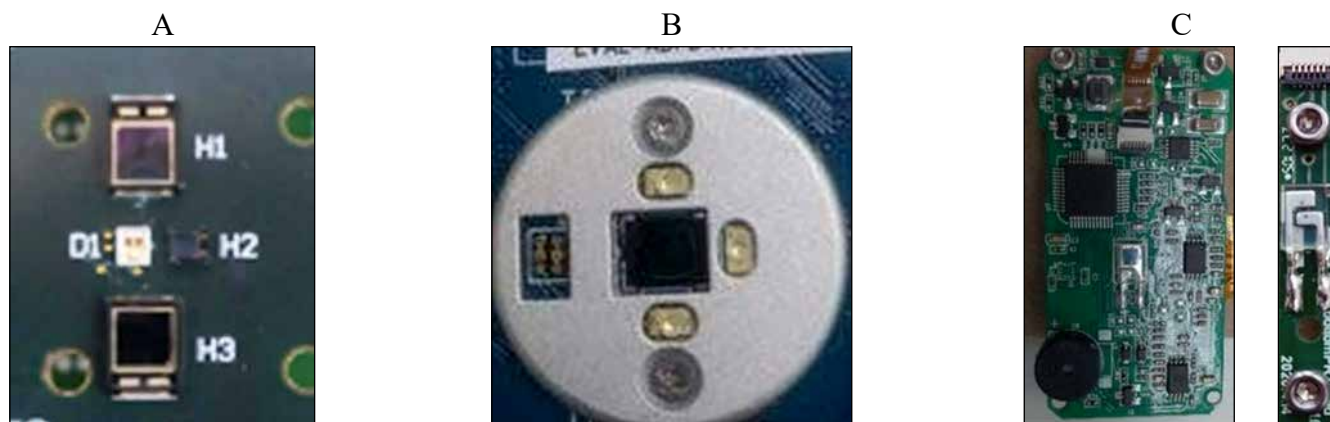
Figure 2. Experimental acquisition systems for spectral curve acquisition tests (A) and signal analysis optical (B).
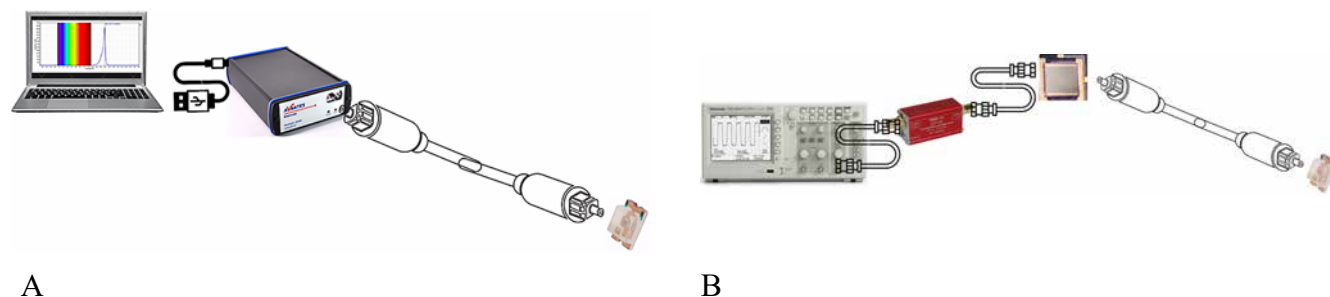
Figure 3. Spectral curve of the infrared LED.
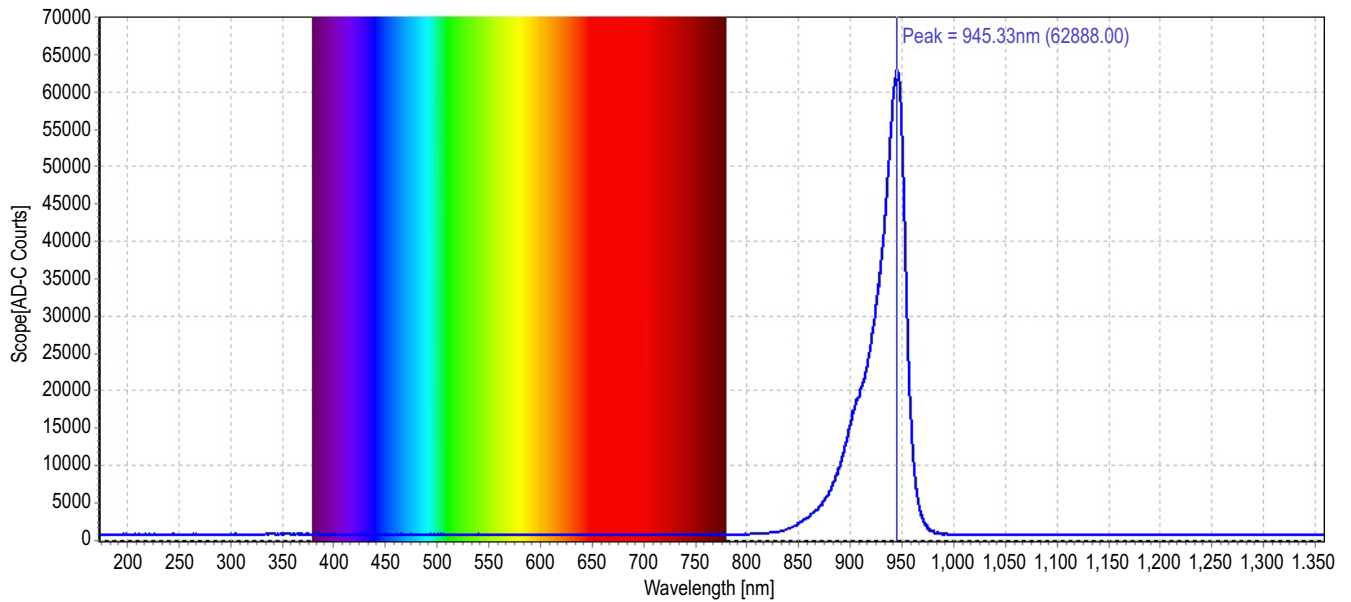
Table 1. Peak emission values of LEDs.

Device	Green LED		Red LED		Infrared LED	
	Measured	**Datasheet**	**Measured**	**Datasheet**	**Measured**	**Datasheet**
AS7057_EVK_UG001039	521 nm	526 nm	657nm	660nm	945nm	950nm
EVAL-ADPD4100Z-PPG	515 nm	520nm	660nm	640nm	938nm	940nm
Oximeter	x	x	659 nm	660 nm	889 nm	880 nm

Figure 4. PPG optical signal read on the oscilloscope.
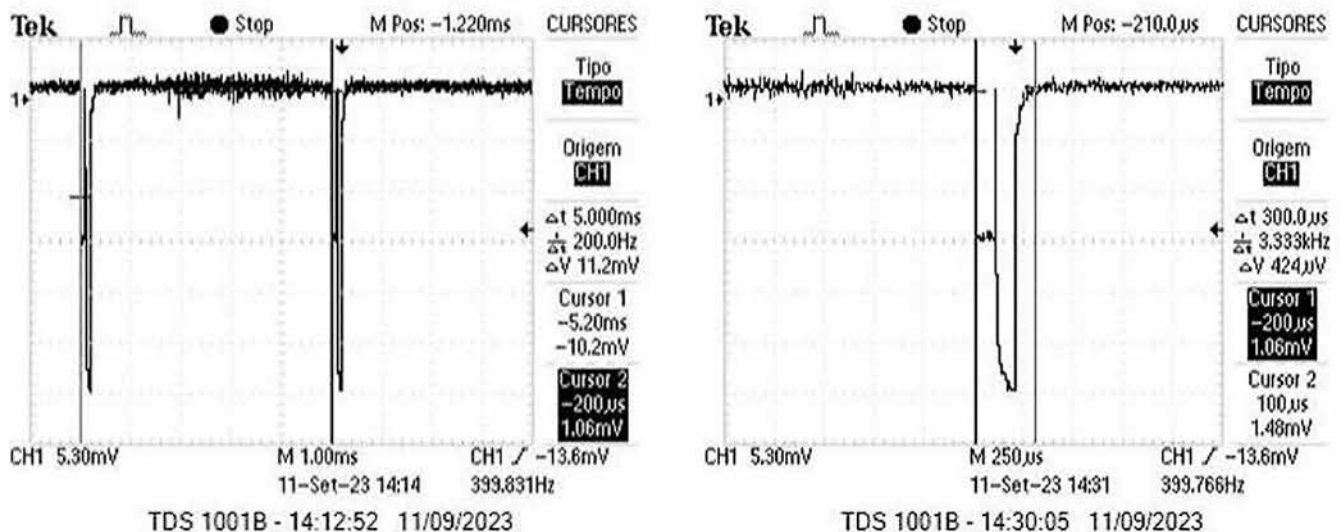
Table 2. Emission frequency and pulse width values of the device LEDs.

Device	Emission Frequency	Pulse Width
AS7057_EVK_UG001039	200 Hz	0.3 ms
EVAL-ADPD4100Z-PPG	300 Hz	4 us
Oximeter	100 Hz	1 ms

Conclusion

In addition to the red and infrared LEDs in all three analyzed devices, the reflection-based devices also incorporate green LEDs. Despite its lower skin penetration power, the green wavelength can be leveraged in the reflection model to extract information from capillary blood vessels.

Based on the results of the second test, it was observed that the LEDs do not emit light continuously. Instead, they are sequentially activated and exhibit well-defined emission frequencies. These frequencies vary across devices, reflecting their distinct diagnostic functions; for instance, the oximeter focuses on oxygen saturation (SPO2), while the kits encompass PPG analysis and diagnosis functions. The insights from these tests contribute significantly to understanding the structural aspects of the optical systems employed in these photoplethysmography devices, thereby enhancing their optical characterization.

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Advanced Methacrylated Gelatin (GelMA) Hydrogel Scaffolds for Wound Care Applications

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Tissue engineering is an area of research that has been advancing with the implementation of new technologies to create scaffolds that can aid in regenerating damaged tissues. Among these technologies, bioprinting has gained prominence due to the diverse range of hydrogels that can be used as scaffolds and dressings for tissue regeneration. Gelatin methacrylate (GelMA) has been studied for its potential use as a dressing for skin regeneration. This study aimed to evaluate the properties of scaffolds with different concentrations of 3D-printed GelMA for application as wound dressings. The degradation rate and tensile strength of these scaffolds were assessed. Results showed that with increasing GelMA concentration, there was a decrease in the degradation rate and swelling while the maximum tensile stress increased. The next phase of this study will involve incorporating drugs to evaluate their influence on the properties of the scaffolds.
Keywords: Scaffolds. Gelatin. 3D Bioprinting. Wound Dressing.

Hydrogels are hydrophilic polymers whose chemical and mechanical properties vary based on the selected polymer and concentration. Several hydrogels are used in bioengineering to produce scaffolds for regenerative medicine, such as bandages. These structures serve as extracellular support to assist in cell proliferation, thereby accelerating tissue regeneration [1]. Various hydrogels, including hyaluronic acid, gelatin, alginate, and chondroitin sulfate, are studied for tissue regeneration due to their properties, such as water retention, porosity, and degradation [2]. This work aimed to produce and evaluate scaffolds' tensile properties and degradation rate based on methacrylate gelatin hydrogel (GelMA) for application as dressings to aid in the regeneration of skin injuries.

Materials and Methods

To produce GelMA, 10 grams of gelatin from pig skin was dissolved in 100 mL of ultrapure water using a magnetic stirrer for 1 hour. Then, 0.14 mL of methacrylate anhydride (MA) was added for each gram of gelatin dissolved, and the mixture was left under constant stirring for at least 2 hours. After this period, an additional 100 mL of ultrapure water was added to stop the reaction. The solution was then divided into Falcon tubes, with 25 mL of the solution in each tube, and subjected to centrifugation for 10 minutes at 5000 RPM at 25ºC to remove part of the byproducts. After centrifugation, the solution was transferred into membranes for dialysis with ultrapure water to remove the remaining MA. The water immersed in the membrane was changed daily for 5 days. After dialysis, the solution was removed from the membrane, frozen at -80ºC, and lyophilized to produce the hydrogel. The hydrogel was prepared in three concentrations (5%, 10%, and 15%) using lyophilized GelMA. To do that, 10 mL of phosphate-buffered saline (PBS) was added to the lyophilized GelMA on a magnetic stirrer at 40ºC to dissolve the gelatin completely. Lithium phenyl-2,4,6-trimethylbenzoylphosphinate (LAP) was added as a 1% photoinitiator to cure the scaffold after bioprinting. The bioprinted bandages, with dimensions of 15x80x1.5 mm, were printed using an Octopus model bioprinter from 3D Biotechnology Solutions at a speed of 300 mm/minute with 80% fill through a 1-millimeter diameter needle with a layer height of 0.7 mm.

After printing, the dressings were exposed to 375 nm UV light for 10 minutes and then subjected to testing and evaluation of their properties. The degradation test was conducted using portions of the bioprinted dressings, with each dressing separated into three samples for each concentration. These samples were weighed and placed in a 12-well plate filled with PBS. The plates were then incubated in an oven with agitation and air circulation at 37ºC. The samples were weighed every three days over a total of 15 days. During the first week, the PBS was not changed, while in the second week, the PBS was changed at each weighing to evaluate the swelling of the scaffolds. For mechanical analysis, the stress-strain behavior of each scaffold at different concentrations was analyzed using a Brookfield CT3 texturometer to evaluate how increasing the concentration of GelMA affects mechanical resistance. This test was conducted at a speed of 0.05 mm/s.

Results and Discussion

Figure 1 shows the stress-strain curves of the scaffolds. An increase in stress proportional to the concentration is observed, with strain varying between 20% and 60%. The scaffold with a concentration of 15% GelMA exhibited the highest tensile stress, approximately 980 KPa, almost 10 times greater than the maximum stress obtained by the scaffold with 5% GelMA.

Figure 2 shows the degradation curves of the scaffolds with different concentrations of GelMA over 15 days. A noticeable difference in the degradation rate of each scaffold is observed. For scaffolds with 5% GelMA, the weight loss was almost 50%, representing the highest degradation rate among the scaffolds. As the GelMA concentration increased, the degradation rate progressively decreased. From the sixth day onwards, the ability of PBS to degrade the scaffolds diminished significantly, leading to absorption and, consequently, a mass gain. Lower concentrations of GelMA absorbed more PBS than higher concentrations due to their greater affinity with the solution.

Discussion

The behaviors observed in Figures 1 and 2 can be explained by the concentration of GelMA in each scaffold. According to the study by Xu and colleagues (2023) [3], increasing the concentration of GelMA enhances mechanical properties and decreases the scaffolds' degradation and swelling rate. Additionally, lower concentrations of GelMA demonstrate higher rates of degradation and swelling and lower tensile values, corroborating the results of this study.

Figure 1. Stress x Deformation curves of the GelMA dressing at 5%, 10% and 15%.
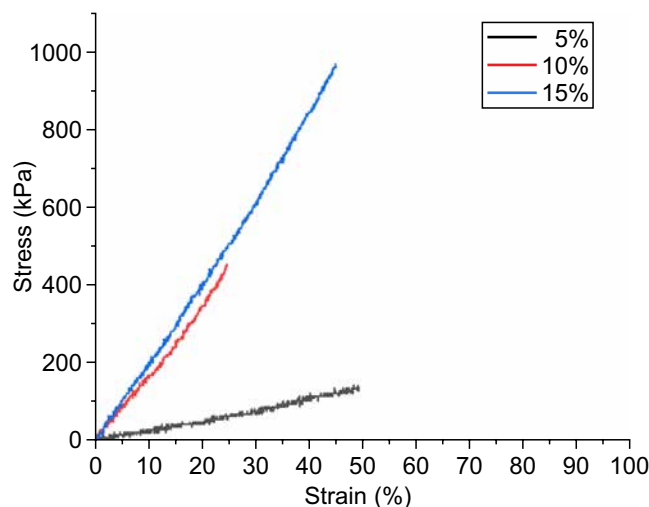
Figure 2. Degradation curve of 5%, 10% and 15% GelMA dressings.
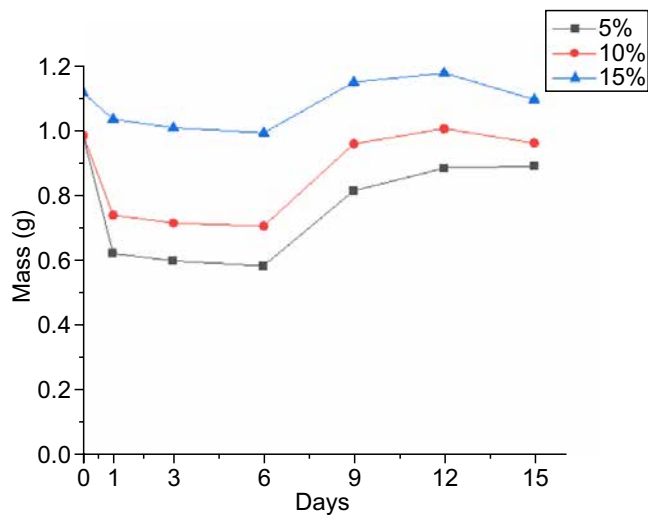
Conclusion

The results of the tensile and degradation tests were promising for the subsequent stage of drug incorporation, aimed at improving tissue regeneration capacity. Cell viability tests must be conducted to enhance this study to verify cytotoxicity. The tensile test results are crucial for determining the optimal GelMA concentration.

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Production and Characterization of Valhalla Craft Beer in Style Porter Added with Rapadura and Mate Herb

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Craft beer production involves several critical phases, including mashing, boiling, fermentation, and carbonation. The increasing popularity of craft beer in recent decades has revolutionized the global beverage market. This article delves into the history, production methods, and physical-chemical analyses essential for ensuring product quality. Each stage described in this article is based on specific literature, and rigorous laboratory analysis is employed to certify the excellence of the final product. An outstanding characteristic of artisanal beer is its emphasis on quality, authentic flavor, and traditional production techniques. Analyses indicate that craft beers establish a more intimate connection with local cultures and brewing traditions besides offering diversified and complex flavors. This trend suggests a promising future for artisan producers, highlighting the importance of sustainability and innovation in the sector. Keywords: Drinks. Fermentation. Processes.

Craft beers stand out from their industrial counterparts due to their meticulous brewing process. The smaller scale of production allows for the use of higher-quality raw materials and the inclusion of regional ingredients, resulting in a drink with an intense and unique flavor profile. Unlike industrial beers, craft beer production follows a longer process, ensuring that fermentation and maturation periods are fully respected without using accelerants.

A significant distinction between craft and industrial beers lies in the malt composition. While industrial beers typically contain 60% malt and 40% other cereals to reduce production costs, craft beers prioritize a higher proportion of malt. This emphasis on malt enhances the beer's flavor and aroma complexities, catering to the preferences of a discerning consumer base [1].

Porter is renowned for its deep, dark color and originates in 18th-century Britain. Interestingly, its name stems from the English port workers who, seeking a richer and more robust beverage, blended various types of beers. However, as manufacturing techniques evolved and roasted malt was introduced, this blending practice gradually fell out of favor. Its medium body, well-balanced bitterness, and low foaming properties characterize Porter. It is distinguished by aromas reminiscent of coffee and chocolate, attributed to its malt composition. The histories of Porter and Stout are closely intertwined; in 19th-century England, more robust and drier beers began to be labeled as stouts. Although initially distinct, the differences between Porter and Stout have become more subtle over time. Nevertheless, the Porter style has experienced a revival. It has branched out into contemporary variations such as Imperial Porter (the standard version), Baltic Porter (a more prosperous and creamier variant), American Porter (noted for its higher hop content), and robust Imperial Porter, featuring a more pronounced alcohol profile and prominent hops [2].

Materials and Methods

The formulation of craft beer containing yerba mate and rapadura was defined using the BeerSmith® software for assistance. The production process followed a specific protocol visually represented in Figure 1 for better understanding. Essential ingredients such as malts, yeasts, and hops were sourced from a reliable supplier, Bahia Malte,

in Salvador/BA. Specifically, the 1st generation Safale American yeast was utilized, with a 50.28 cells/mL concentration. According to Sleiman and colleagues (2010), first-generation yeasts are those used for the first time, meaning they have not yet been utilized in the wort fermentation process. These yeasts can be reused for this purpose up to six consecutive times.

Local ingredients were procured for the Porter-type craft beer, including yerba mate (Ilex paraguariensis) from Salvador/BA and rapadura from Barreiras/BA. The selected hop variety was Northern Brewer, renowned for its aromatic properties and moderate bitterness potential. However, it is worth noting that it can be substituted with another hop variety, Perle, originally from Germany and introduced in 1934. Perle has a high content of alpha acids and Cohumulone, which are responsible for the bitterness and aroma in beer, with the latter ranging from 27 to 32%. Hops were added during the final wort-boil stage to impart the beer's distinctive aroma.

The malts chosen for this production were Swaen©Ale, GoldSwaer©Red, GoldSwaen©Munich Dark, and BlackSwaen© Chocolate B, all obtained from Bahia Malte, a reputable supplier of inputs for craft brewers in Salvador/BA.

Cleaning of Equipment

Equipment cleaning is a crucial step before starting the brewing process to ensure product quality and minimize the risk of contamination. The equipment was meticulously cleaned using a specific protocol. Initially, it was washed with water at 75°C and detergent to remove dirt or residues. This was followed by cleaning with a 70% alcohol solution to disinfect the surfaces and kill any remaining microbes.

As illustrated in Figure 2, specialized cleaning agents were employed for the heat exchanger. These included detergent, sodium bicarbonate, and a hydrochloric acid solution to thoroughly clean and sanitize the heat exchanger. These cleaning agents help remove stubborn residues, mineral deposits, and microbial contaminants that can affect the quality and safety of the final product. It is important to note that thorough equipment cleaning is essential in the brewing industry to maintain hygiene standards, prevent cross-contamination, and ensure the consistency and quality of the brewed beer [3].

Used Equipment

Figure 3 illustrates the equipment used to produce Valhalla beer: a cauldron for boiling the malt, pipes for transporting fluids, a pump, and a heat exchanger.

Preparation of Craft Beer Added with Yerba Mate and Rapadura

During the production of Valhalla beer, the process begins with grinding the malt and infusing it into 15 liters of mineral water. This step, known

Figure 1. Simulation in BeerSmith® Software.

Amt kg	Name	Type	#	%/IBU
2.50 kg	Swaen©Ale (7.1 EBC)	Grain	2	73.5 %
1.0 pkg	Safale American (DCL/Fermentis #US-05) [50.28 mL]	Yeast	7	-
15.50 g	Northern Brewer [8.50 %] - Boil 35.0 min	Hop	6	22.9 IBUs
0.70 kg	GoldSwaen©Red (50.0 EBC)	Grain	3	20.6 %
0.10 kg	GoldSwaen©Munich Dark (145.2 EBC)	Grain	5	2.9 %
10.50 l	Dias D'Avila	Water	1	-
0.10 kg	BlackSwaen©Chocolate B (900.3 EBC)	Grain	4	2.9 %

Figure 2. Team members cleaning the heat exchanger.

as malting, involves converting barley into malted barley, typically at a temperature of 70°C. To efficiently extract sugar from the malt, the grains are washed repeatedly using 3 liters of water. Subsequently, the malt is removed, and the wort is boiled for an hour with the addition of hops. After 45 minutes of boiling, yerba mate and brown sugar, previously diluted in 1 liter of water, are added to the wort. Once the boil is complete, it is crucial to cool the wort rapidly. This is achieved using a heat exchanger (Figure 4), to bring the wort to the

Figure 3. Enlarged image of the production process.

ideal fermentation temperature range of 16-22°C. Elevated temperatures can compromise the yeast's viability, making cooling essential. After cooling, the wort is filtered to remove residual solids, and yeast is added to initiate fermentation. This fermentation process involves complex chemical and biochemical reactions and requires precise control. Upon completion of maturation and fermentation, the beer is ready for bottling. For every 600 mL of beer, 5 g of sugar is added before bottling to induce carbonation. In total, 45 bottles of 350 mL were

Figure 4. Valhalla beer production process flowchart.
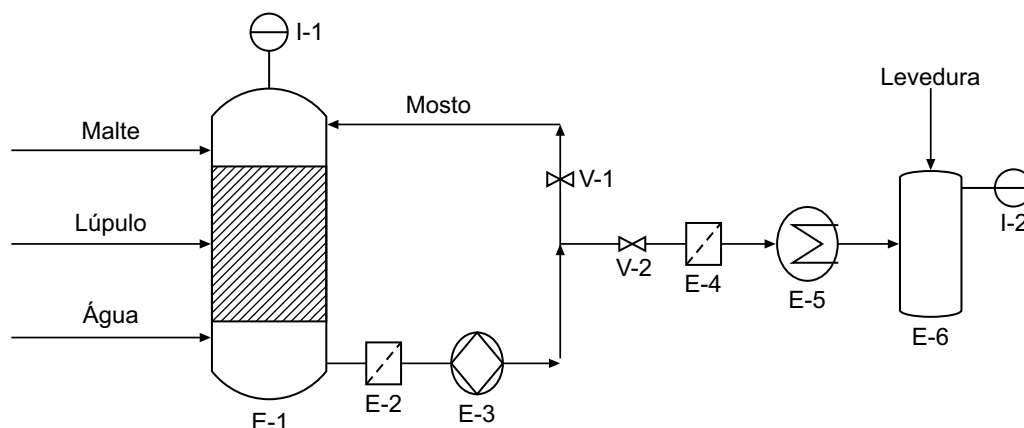
Caption - Flowchart for the production of Valhalla Beer		
Equipments	**Name**	**Descriptive**
E-1	Reactor	Performing stages of mashing and wort boiling
E-2	Filter	Filtration of the wort for reflux with the pump
E-3	Pump	Conveying the wort to the reflux system or the heat exchanger
E-4	Filter	Filtration of the wort for the fermentation stage
E-5	Heat exchanger	Cooling the wort for the fermentation stage
E-6	Tank	storage tank
I-1	Temperature indicator	Indicator to maintain temperature
I-2	Temperature indicator	Indicator to maintain temperature
V-1	Valves	Valve for wort reflux in the reactor
V-2	Valves	Valve for cooling the wort in the geat exchaner

produced, resulting in 16 liters of beer. The process outlined here serves as the basis for the industrial-scale production of Valhalla beer, adapted from the steps used in experimental production.

Results and Discussion

The craft beer's processing yield was within expected parameters, reaching 84.3%. However, a 15.7% loss was attributed to residual sludge at the bottom of the fermenter and maturator, typically discarded during the process. The recipe's initial volume was 19 liters, but after preparation, it was reduced to 16.017 liters. In the experimental production of beer with yerba mate and brown sugar, the initial wort showed 19.8° Brix, a density of 1.077, and a pH of 5.68. After boiling, the final extract had 24.0° Brix, a density of 1.093, and a pH of 4.54.

Carbonation was found to be satisfactory, as

indicated by carbon dioxide microbubbles. This characteristic enhanced the yerba mate's pungency, complementing the hops' balance. The Northern Brewer hops contributed a distinct aroma and bitterness to the product.

The 24° Brix value signifies the concentration of sugars in the must, which is crucial for fermentation and conversion into alcohol, heat, and carbon dioxide until all fermentable substrates are consumed. It is typical to observe a reduction in Brix value as fermentation progresses (Table 1) [4].

During the boiling process, where starch is extracted from the malt until complete fermentation, the Brix value is reduced from 24° Bx to 12.1 °Bx. This reduction is due to yeast consuming sugars and converting them into alcohol.

Figure 5 presents the pH and density analysis from the start of the manufacturing process to the conclusion of fermentation. The initial pH, recorded as 4.02, complies with the recommended

Table 1. Brix degree values during the process.

Process	Degress Brix (ºBx)
Mashing	19.8 ºBx
Boiling	19.2 ºBx
Boiling/Adding of hops	19.8 ºBx
Boiling addition of malt and molasses	24.0 ºBx
Fermentation/Beginning	15.2 ºBx
Fermentation/Complete	12.1 ºBx

Figure 5. Monitoring of pH and density analyses.
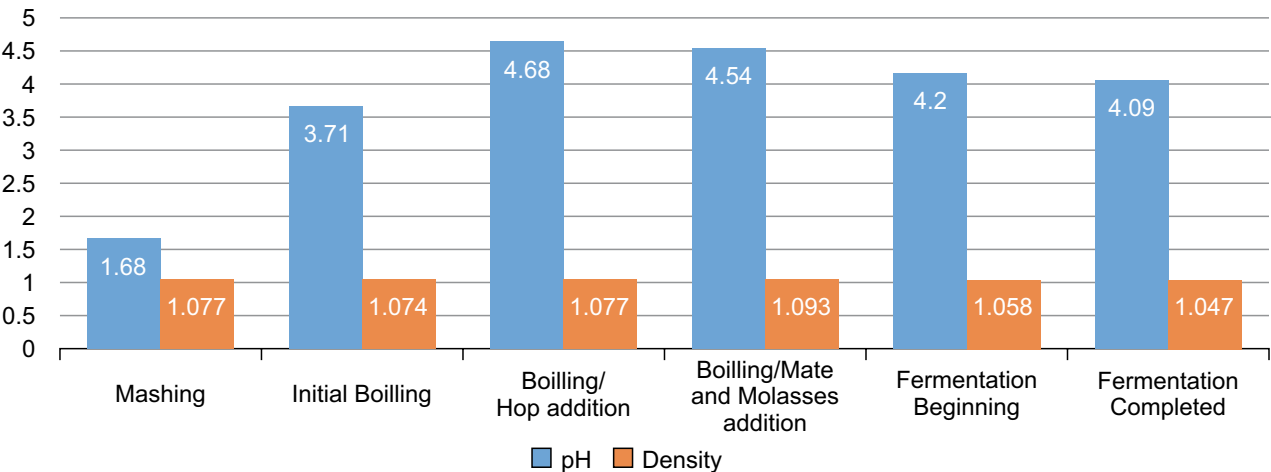
values in the literature for this beer style [5]. Due to biochemical reactions during fermentation, the pH decreased to 0.007. Borzani and colleagues (1983) note that this reduction correlates with the formation of 44 organic acids, including acetic acid, succinic acid, and lactic acid [5]. This value meets the established standards for the beverage [6].

The alcohol content is a crucial characteristic of beer influenced by fermentation. It is during this process that the alcohol level is determined. Therefore, categorizing beer based on its alcohol content is essential (Table 2). The final alcohol content of the beer produced was 8.3% (v/v), which is considered high but consistent with expectations for Porter-type beers. According to Brazilian legislation, beers can contain up to 45% adjuncts relative to their malt content [7]. Thus, all samples are classified as beers regarding adjunct and alcohol content.

The increase in °Bx (Table 3) at the end of the carbonation process, where our final product is obtained, is due to adding an average of 5 g of sugar

Table 2. Analysis of Brix, pH, and Density in the last stages.

	Brix Degree (°Bx)	pH	Density
Maturation	11.9°	4.16	1.044
Final Product	13.6°	4.16	1.042

Table 3. Colorimetric assessment.

	L*	a*	b*
Color	20.86 + -0.01	3.50 + -0.02	3.79 + 0.06
Coefficient of Variation	0.05%	0.44%	1.68%
Confidence Interval	20.86 + -0.02	3.50 + -0.05	3.79 + 0.15

L* represents luminosity, ranging from 0 (completely black) to 100 (completely white). The result falls between 20.84 and 20.88, indicating low luminosity, characteristic of dark beer, specifically Porter-type beer. The positive a* value enhances the coloring from the rapadura additive, which is reddish in an aqueous medium. Additionally, the positive b* value indicates a yellowish color, resulting from the chromatic mixture of red and yellow, resembling dark orange or caramel, consistent with the color of our beer (Figure 6).

Figure 6. Beer coloring.

per 600 mL of beer during bottling. This addition enables the production of CO_2, as the yeast produces CO_2 retained in the bottle. Statistical calculations were performed for each variable, including mean, standard deviation, coefficient of variation, and a 95% confidence interval (Table 3).

Conclusion

Hence, the history of beer is intertwined with human evolution and has always been associated with pleasure, gatherings, celebrations, and more. It is noteworthy that the global market remains predominantly controlled by significant corporations. However, the surging demand for craft beers is exponential, driven by their enhanced palatability and the opportunity for unique recipe additions that complement the chosen beer style. Valhalla beer, infused with mate tea and brown sugar, epitomizes a typical craft beer that aligns with the theoretical Porter style, validated through laboratory-based physical-chemical analyses that substantiated the initial hypothesis. Despite a relatively high yield (84.3%), minor losses during the fermentation process did not impact the final outcome. This underscores that artisanal production does not equate to compromised quality.

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Regulatory Aspects of Additives in Brazilian Gelatin Desserts

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Gelatin desserts are a standard part of many people's daily lives due to their practicality and affordable price. In this study, compliance with ANVISA regulatory standards related to the use of additives in the production of these desserts was analyzed. Eighteen products of various brands and flavors were collected and classified into standard and diet categories. Inconsistencies in the use of some additives were observed: lack of regulation for the additive's use in this type of dessert, incorrect classification, and labeling, and the absence of information about the additive's classification on the label (artificial, natural, or synthetic identical to natural). Therefore, based on the analysis of the obtained samples, we concluded that some brands of gelatin desserts still need to comply with the legislation regulating this product fully.
Keywords: Gelatin. Legislation. Additives.

Since ancient times, there have been records of recipes to obtain jelly or solidified broth from fish and meat by boiling fish heads, leftover meat, bones, and cattle hooves. Over time, this type of food gained popularity and became one of the primary protein sources for the poorest communities. Eventually, it began to be widely produced and sold as a food product known as gelatin [1].

Gelatin is a protein obtained through the partial hydrolysis of collagen from animal bones, skin, and cartilage. There are two main types of gelatin: type A, which is extracted using acids, and type B, which is extracted using alkaline means [2].

Gelatin is used in various food and non-food products, including crafts and artistic products. Before it reaches the familiar form, the raw material undergoes several processing steps in industries to extract collagen [1].

The first time powdered gelatin was intended for dessert production was in 1845, as evidenced by a US patent. Fifty years later, Jell-O popularized gelatin as a dessert worldwide [3].

The gelatins commonly sold in supermarkets for consumption are referred to as "gelatin desserts"

because, in addition to the main ingredient, gelatin itself, several other ingredients are added to create the final product consumed as a dessert. Some of the ingredients used in the production of this food are intended to enhance its characteristics; these ingredients are called additives. According to the Ministry of Health (2023):

> "A food additive is defined as any ingredient intentionally added to food, without the purpose of nutrition, to modify the physical, chemical, biological, or sensory characteristics during manufacturing, processing, preparation, treatment, packaging, packaging, storage, transport, or handling of food."

They are present in practically all industrialized food products to improve their appearance and shelf life. In gelatin desserts, additives play a crucial role by adding flavor, stabilizing the texture, intensifying the color, and more, ultimately promoting a more attractive product for consumers.

Like other food products, the manufacture of gelatin is regulated by stringent federal legislation that undergoes regular review. Gelatin is classified as a meat product according to decree No. 9,013, dated March 29, 2017, which governs all aspects of its manufacturing [4]. Furthermore, Ordinance No. 384, issued on August 25, 2021, approves the Technical Regulations establishing the identity and quality standards for gelatin, hydrolyzed gelatin, and edible collagen [5].In addition to traditional gelatin of animal origin, a vegan option is available in supermarkets called "vegan gelatin," a plant-

based dessert made from seaweed agar. This type of food is categorized as a dessert or dessert powder in category 19 and subcategory 2 ("other desserts with or without gelatin, with or without starch, with or without gelling agents") according to the Brazilian food categorization system established by the National Health Surveillance Agency - Anvisa (Guide nº 43/2020 – version 1, p 26, 2020).

Regarding additives, they are regulated by Resolution - RDC No. 778, dated March 1, 2023, which outlines the functions and usage of food additives [6], and by Normative Instruction - IN No. 211, dated March 1, 2023 [7], which sets forth conditions and limits for the use of food additives. This study aims to analyze whether the use of food additives in gelatin desserts aligns with their intended functions and complies with the corresponding legislation regulating the production and marketing of such desserts.

Materials and Methods

Eighteen food products with various flavors were analyzed, covering almost all consumption possibilities within the dessert category, including ready-to-consume and preparation-required desserts. These products were classified into two categories: standard and diet (sugar-free). The analysis encompassed products from 12 brands falling under subcategories such as gelatin desserts or other desserts. Labeling information was gathered from retail supermarkets in Salvador, Bahia, and online sources.

The obtained results were compared with relevant legislation, including Normative Instruction - IN N° 211, dated March 1, 2023, for desserts; RDC nº 725, 2022, and RDC Nº 722 for flavorings; and RDC nº 239, dated July 26, 2018, for sweeteners.

Results and Discussion

Out of the total products evaluated (n = 18), 7 fall under the standard classification, while 11 are categorized as diet desserts (Table 1). This indicates a notable increase in the production of diet gelatins,

reflecting companies' efforts to cater to a broader consumer base, including those unable or unwilling to consume sugar. This trend also extends to desserts incorporating natural additives such as coloring, flavoring, and sweeteners. Additionally, Table 1 shows that 14 gelatin products are of animal origin, while 4 are of vegetable origin, highlighting the diversity of options available in the Brazilian market.

It is evident that gelatin desserts dominate the market, a trend driven by consumer demand and production costs, which subsequently influence purchasing power.

Figure 1 shows all additives found on product labels with their respective technological functions. Figure 2 shows these same additives according to their technological function, but they are found by normative instruction No. 211 for the category of desserts.

Acidity Regulators

According to Normative Instruction (IN) No. 211, acidity regulators are characterized by altering or controlling the acidity or alkalinity of foods. Therefore, according to Table 2, it is possible to observe all the additives that appeared in some products and how often they were present. It was observed that all additives present are according to the normative instruction mentioned above and by their category for all products found.

Acidulants

According to Normative Instruction No. 211, acidulants are substances that increase acidity or give food an acidic flavor. Moreover, according to Table 3, which presents all the acidifiers used in these products and their frequency, only 2 additives comply with IN No. 211 corresponding to the food category in which they are used. However, the additive fumaric acid was not regulated for use in this type of food, even though, according to the International Food Additive Numbering System (INS), it is considered an acidulant [8].

Table 1. Information on the collected dessert products (n = 18).

Flavor	Rating	Brand	Origin	Presentation
Açaí with Banana	Standard	Dr. Oetker	Animal	Powder
Pineapple	Standard*	Dr. Oetker	Animal	Powder
Blackberry	Diet	Dr. Oetker	Animal	Powder
Pineapple, mint, ginger	Diet*	Dr. Oetker	Animal	Em pó
Cherry	Standard	Royal	Animal	Powder
Passion Fruit	Diet	Royal	Animal	Powder
Strawberry	Standard	Sol	Animal	Powder
Strawberry	Standard	Apti	Animal	Powder
Lemon	Diet	Apti	Animal	Powder
Tangerin	Diet	Linea	Animal	Powder
Raspberry	Diet	Lowçucar	Animal	Powder
Mango	Diet *	Lowçucar	Animal	Powder
Blueberry	Standard	Neilar	Animal	Powder
Lemon	Diet	Magro	Animal	Powder
Orange	Standard	Gelialgas	Vegan	Hydrated
Strawberry	Diet	Vegan	Vegan	Powder
Red Fruits	Diet	Dolce Vita	Vegan	Hydrated
Açaí with guarana	Diet	Vigor e Saúde	Vegan	Hydrated

* Contains other additives even though they are the same type and brand.

Figure 1. Frequency of types of additives found in products according to their labeling.
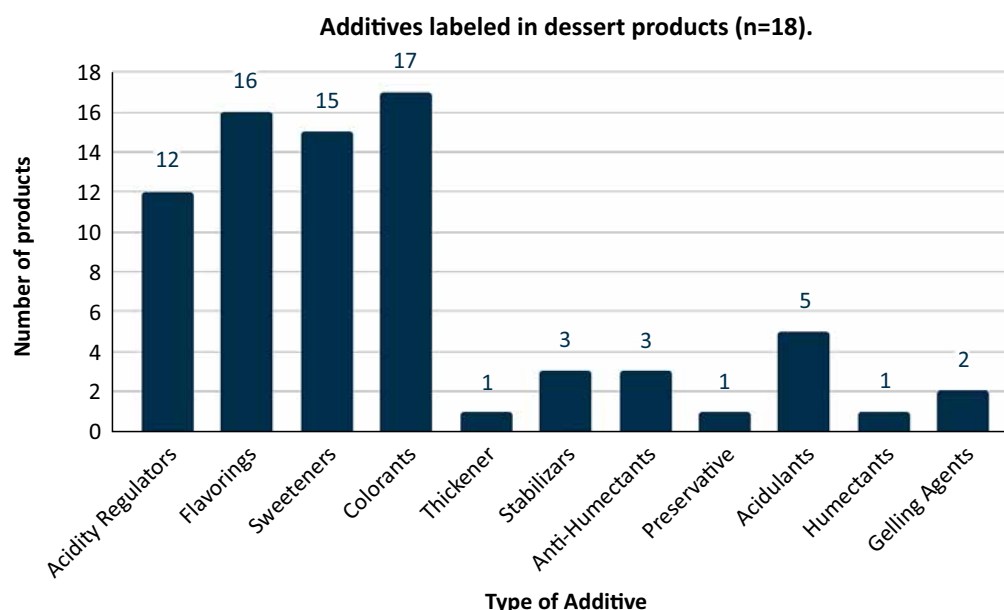
Figure 2. Frequency of types of additives found in products according to the analysis carried out.
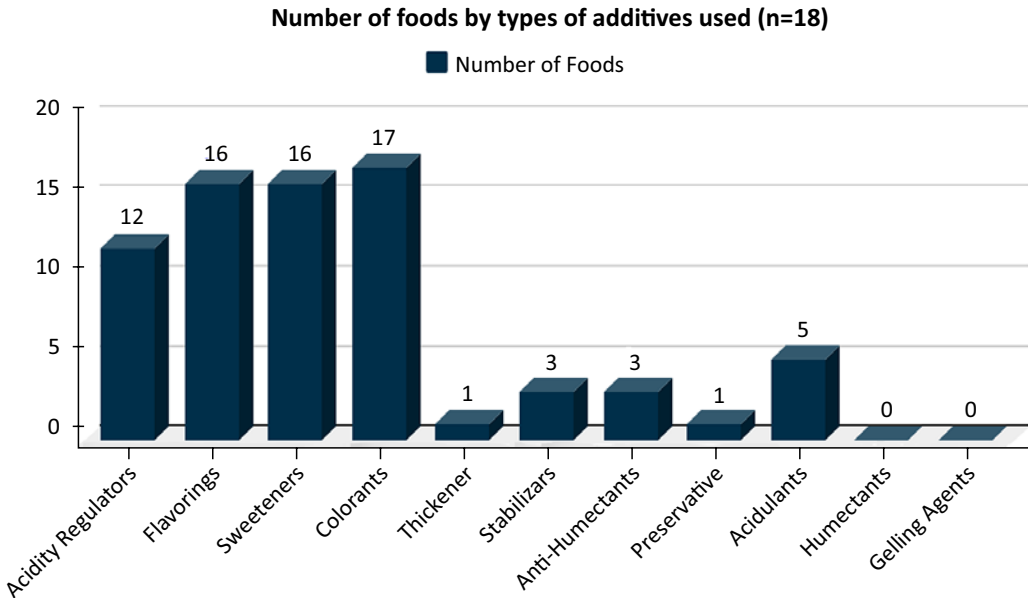
Table 2. Acidity regulating additives (n = 12).

INS	Name	Frequency in products	Maximum limit (mg/kg ou mg/L)	Category of dessert that can be used
297	Fumaric acid	10	Quantum satis	19.1 and 19.2
331(iii)	Sodium citrate	11	Quantum satis	19.1 and 19.2
330	Citric acid	1	Quantum satis	19.1 and 19.2
296	Malic acid (DL-)	1	Quantum satis	19.1 and 19.2

Table 3. Acidifying additives (n = 5).

INS	Name	Frequency in products	Maximum limit (mg/kg ou mg/L)	Category of dessert that can be used
297	Fumaric acid	3	-	-
355	Adipic acid	1	Quantum satis	19.1 and 19.2
330	Citric acid	2	Quantum satis	19.1 and 19.2

Preservatives, Stabilizers, and Thickeners

Table 4 outlines three additives, each corresponding to its specific function. Notably, it does not include other additives in products with similar functions. As per Normative Instruction No. 211, the definitions of these functions are as follows:
- Preservative: Prevents or delays food alteration caused by microorganisms or enzymes.
- Stabilizer: Maintains a uniform dispersion of two or more immiscible substances in food.
- Thickener: Increases the viscosity of food.

All food additives in the table comply with IN No. 211 for desserts. Notably, potassium sorbate, categorized as a preservative, includes a note specifying its usage limit expressed in terms of sorbic acid, individually and in combination. Potassium sorbate and sodium carboxymethyl

cellulose are the sole ingredients used in products falling under category 19.2.1, corresponding to ready-to-eat desserts.

Antihumectants

As per Normative Instruction No. 211, antihumectants are additives characterized by their ability to reduce the hygroscopic properties (moisture absorption from the air) of foods and prevent individual particles from sticking together. Table 5 lists the two additives in some food products, specifically gelatin desserts, that exhibit antihumectant properties. Both additives comply with IN No. 211, with two reservations outlined:

Firstly, both additives are restricted to post-preparation desserts.

Secondly, for tricalcium phosphate, the limit specified in Table 5 applies to the ready-to-consume product.

Flavors

According to Normative Instruction No. 211, flavoring is a substance or mixture with aromatic or flavorful properties that can impart or enhance the aroma or flavor of food. However, none of the analyzed products lists the additives used due to Article 12 of RDC No. 722 §3º. The declaration must indicate the technological function without specifying the individual additives for flavoring additives. This information is authorized by RDC No. 725, 2022. The resolution provides definitions for different types of flavorings found in products:

Artificial Flavoring: A chemical compound obtained by synthesis that has yet to be identified in products of animal, vegetable, or microbial origin, used either in its primary state or prepared for human consumption.

Flavoring Identical to Natural: A chemically defined substance obtained by synthesis, isolated from raw materials of animal, vegetable, or microbial origin, with a chemical structure identical to substances in natural raw materials.

Synthetic Flavoring: A chemically defined compound obtained by chemical processes, comprising flavoring identical to natural and artificial flavoring.

Table 4. Preservative, stabilizing, and thickening additives.

Function	INS	Name	Frequency in products	Maximum limit (mg/kg ou mg/L)	Category of dessert that can be used
Preservative	202	Potassium Sorbate	1	500	19.2
Stabilizer	331(iii)	Sodium citrate	3	Quantum satis	19.2
Thickener	466	Sodium carboxymethyl-cellulose (cellulose gum)	1	Quantum satis	19.2

Table 5. Antihumectant additives (n = 3).

INS	Name	Frequency in products	Maximum limit (mg/kg ou mg/L)	Category of dessert that can be used
341iii	Tricalcium Phosphate	2	25,000	19.1 and 19.2
551	Silicon Dioxide	3	Quantum satis	19.1 and 19.2
330	Citric acid	2	Quantum satis	19.1 and 19.2

Flavors and Labeling

RDC No. 725, 2022, Article 10 §1 explains that for flavorings exclusively intended for industrial use, the declaration of ingredients and usage instructions can be alternatively made in commercial documents, except when there are restrictions on the limit of use for specific components in food. Figure 3 illustrates the types of flavorings found according to the label, where 3 are artificial, 5 are synthetic, identical to natural, and 8 have only the flavoring name on the packaging label. However, this last type of labeling does not comply with RDC No. 725, 2022, Article 6, IV, which requires the classification of natural or synthetic flavors based on the nature of their raw materials or production processes.

Despite the lack of classification on the label for these 8 flavorings, they provide information in small letters on the front packaging about the flavorings used. Figure 4 categorizes the products analyzed into 4 artificial flavorings and 12 synthetic identical to natural flavorings. Comparing images 3 and 4, it is evident that out of the 8 flavorings without classification, 1 is artificial, and 7 are identical to natural. This highlights the need for consumers to make a more significant effort to obtain information about the products they consume.

Gelificants

According to Normative Instruction No. 211, a gelling additive is a substance that provides texture through gel formation. Therefore, of the 4 vegan gelatins analyzed, only 3 products used algae extract or agar-agar as the main product to constitute the dessert. Furthermore, 2 products present agar-agar as a gelling additive (Table 6). According to Normative Instruction No. 211, it is not presented as a gelling additive in the dessert category 19.2, only as a thickener, stabilizer, and emulsifier.

Dyes

As per Normative Instruction No. 211, a dye is a substance that imparts, intensifies, or restores the color of a food. Decree No. 55,871, dated March 26, 1965, provides definitions for different types of dyes found in products:

Natural Coloring: Harmless pigment or dye extracted from a vegetable or animal substance.

Artificial Coloring: Substance, an artificial coloring agent with a defined chemical composition, obtained through a synthetic process.

Table 7 outlines all the dyes used in these products and their frequency and type (natural or artificial). Only one dye, beetroot powder, appears to deviate from compliance with IN No. 211 for the corresponding food category. However, this discrepancy is due to the name under which it is presented, as it contains the additive betanin (also known as beet red), a water-soluble dye predominantly found in beetroot (*Beta vulgaris*). Betanin is categorized in the International Food Additive Numbering System (INS) as number 162 and aligns with IN No. 211 for categories 19.1 and 19.2, with its usage limit defined as quantum satis.

Sweeteners

According to Normative Instruction No. 211, a sweetener is a substance that imparts a sweet flavor to food, distinct from sugars. Table 8 displays all the additives found in some products and their frequency and type (natural or artificial). While IN-211 does not specify which sweeteners should be used in the dessert food category, all additives listed in Table 8 are recognized in the international numbering system for food additives as sweeteners and are permitted for use in foods by RDC No. 239, dated July 26, 2018.

However, RDC No. 239, dated July 26, 2018, stipulates that sweeteners can only be used to partially or wholly replace sugars in specific categories:

- Foods and beverages for weight control, by Ordinance SVS/MS No. 30, dated January 13, 1998.

Figure 3. Frequency of flavorings according to their classification on the label.

Figure 4. Frequency of flavorings according to their classification on the packaging.

Figure 3. Frequency of flavorings according to their classification on the label.
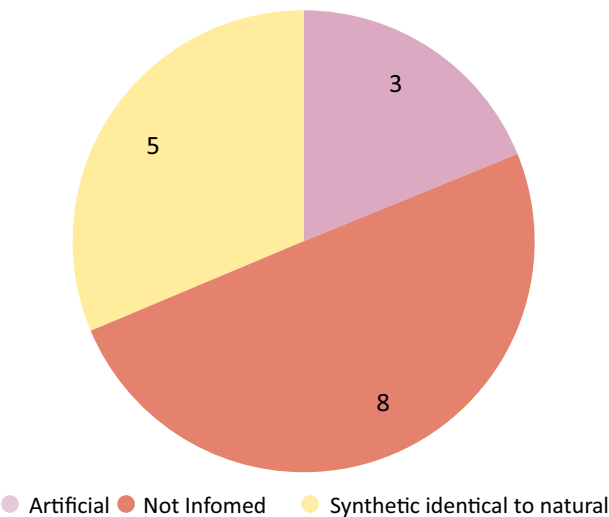
Figure 4. Frequency of flavorings according to their classification on the packaging.
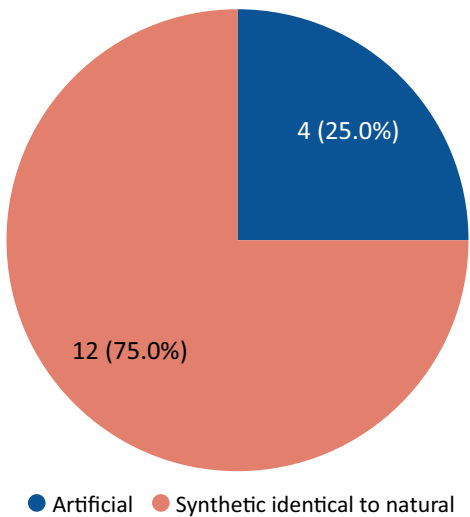
Table 6. Gelling additives (n = 2).

INS	Name	Quantity
406	Agar-agar	2

Table 7. Coloring additives (n = 17).

INS	Name	Quantity	Natural	Maximum limit (mg/kg ou mg/L)	Category of dessert that can be used
100(i)	Turmeric	2	Yes	150	19.1 and 19.2
160b	Urucum	1	Yes	10	19.1 and 19.2
140i	Chlorophyll	1	Yes	Quantum satis	19.1 and 19.2
160a(ii)	Beta-carotene	1	Yes	Quantum satis	19.1 and 19.2
-	Beetroot powder	1	Yes		
123	Bordeaux S/Amaranto	7	No	100	19.1 and 19.2
110	Twilight Yellow FCF	9	No	100	19.1 and 19.2
133	Bright blue FCF	5	No	150	19.1 and 19.2
129	Red 40/ Allura Red AC	2	No	150	19.1 and 19.2
102	Tartrazine	5	No	150	19.1 and 19.2
171	Titanium Dioxide (Inorganic)	1	No	Quantum satis	19.1 and 19.2
132	Indigotine blue	1	No	Quantum satis	19.1 and 19.2

Table 8. Sweetener Additives (n = 16).

INS	Type	Quantity	Natural
951	Aspartame	9	No
952(iv)	Sodium cyclamate	4	No
950	Acesulfame potassium	11	No
954(iv)	Sodium saccharin	4	No
955	Sucralose	4	No
960	Steviol Glycosides	2	Yes
967	Xylitol 1	1	Yes

- Food for restricted sugars diets, as per items 4.1.1.1, 4.1.1.2, and 4.1.1.3 of SVS/MS Ordinance No. 29, dated January 13, 1998.
- Foods and drinks for diets with controlled sugar intake, according to item 4.2.4 of Ordinance SVS/MS No. 29, dated 1998.
- Formulas for enteral nutrition, by Resolution of the Collegiate Board of Directors - RDC No. 21, dated May 13, 2015.
- Foods and drinks with complementary nutritional information for attributes like "contains no sugar," "no added sugar," "low in sugar," or "reduced in sugar." This includes references to attributes like "low in energy value" or "reduced in energy value" when sugar is partially or entirely replaced, as per RDC No. 54.
- Supplements by Resolution of the Collegiate Board that regulates food supplements - RDC No. 243, dated July 26, 2018, which outlines the health requirements for food supplements.

Notably, 5 out of the 7 standard products with higher quantities of sugar as an ingredient utilize sweeteners, which contrasts with the resolution. However, products targeted for diet purposes remain compliant with the resolution.

Conclusion

The study highlights notable differences in the classification, function, and quantity of additives used in gelatin desserts across standard, diet, and vegan options. Vegan variants typically feature fewer additives, with most being of natural origin. Diet variants lacking sucrose utilize sweeteners to impart sweetness. Analysis of the additives in gelatin desserts reveals inconsistencies in adherence to applicable legislation among brands. Some additives are not even explicitly regulated for this food category.

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Applying Swot Analysis Adapted to Public Management: An Action Research

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This initiative aimed to adapt the SWOT analysis to the public management context. The adapted technique was applied in a case study of a Brazilian organization focused on Science, Technology, and innovation in the healthcare sector. Data was gathered through questionnaires from 67 participants involved in the institution's strategic planning and analyzed using mixed methods with the assistance of Iramuteq software. Similarity analysis identified four distinct classes, one of which was a novel category termed "management," which seemingly contradicts traditional SWOT theory. However, this classification resolves the planning dilemma by shifting the focus to management rather than solely emphasizing finalistic areas. Consequently, these findings contribute to enhancing the quality of public management.
Keywords: Public Management. Strategic Planning. SWOT. Innovation. Improvement. Iramuteq.

The Unified Health System (SUS) was established for universalization by Brazil's Federal Constitution in 1988, highlighting health as a pivotal area for instigating structural changes and holding the potential to mitigate inequalities [1]. However, increasing globalization amplifies economic and political disparities among countries [2]. Consequently, the centrality of Science, Technology, and Innovation (ST&I) in addressing health challenges and the significance of this domain as a catalyst for economic, social, and environmental development emphasize the necessity for concentrated efforts directed toward productive transformation and technological innovation, as well as novel forms of scientific production. These efforts should expand access to essential rights, as demonstrated during the COVID-19 pandemic [2].

In this context and in response to diverse challenges, health ST&I institutions must strive for continual improvement and the integration of organizational learning, which can foster innovation in management processes and enhance performance and sustainability. Thus, it is imperative to cultivate a culture that esteems learning, thereby facilitating the commitment and concerted action of all individuals within an organization [3,4].

In pursuing process enhancement, public Science, Technology, and Innovation (ST&I) organizations, aligned with the principles of new Public Management, frequently endeavor to integrate practices from the private sector. The private sector, driven by the imperative to navigate constant market pressures and technological advancements, demonstrates agility in implementing novel solutions. However, a significant challenge arises in adapting these practices while respecting the distinctive characteristics of public administration [5].

The SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) is one of the most utilized internal and external analysis techniques within strategic planning processes [6]. It aids in identifying organizational strengths, weaknesses, opportunities, and threats through a comparative assessment of competitors [7,8]. However, the emphasis on competitive analysis is more relevant in private organizations, necessitating adjustments for its application in public administration to account for its unique characteristics and context. Proposed adaptations have culminated in a prototype that

injects innovation, albeit incrementally, into the SWOT framework [9]. Nonetheless, there is a risk that altering a tool grounded in theoretical and empirical foundations may yield unsatisfactory outcomes.

Hence, this study aims to showcase the outcomes of employing the adapted SWOT Matrix within a Brazilian public health ST&I institution affiliated with the Ministry of Health. Doing so contributes to improving management practices in public administration while integrating lessons learned and innovative approaches.

Materials and Methods

The method adopted for this study encompasses a specific aspect of the strategic planning process, focusing solely on the context analysis conducted using the adapted SWOT framework. Several studies have proposed adaptations of this tool, with the primary adjustment involving a shift in the comparative analysis from competitors to organizational identity, comprising the mission, vision, and organizational values [10,11]. While some authors include organizational identity as a stage in the planning process, they continue to center the analysis on competitors.

Variables were identified to guide the analysis and categorized into the internal and external environment of the organization. While some studies relate SWOT to another technique called PESTAL [12,13], our adjustment extends beyond macroeconomic variables. Additionally, variables guiding the internal analysis, such as organizational functions and managerial roles [14,15], and microeconomics, utilizing the adapted five competitive forces model, are included.

Furthermore, the adapted SWOT is employed to generate generic strategies and indicate the organization's positioning, a well-established aspect in the literature [16,17]. Each quadrant of the resulting matrix, derived from the intersection of strengths and weaknesses with threats and opportunities, yields a generic strategy [18,19]. Following the analysis of these variables, the

dominant strategy or the institution's predominant positioning in a particular quadrant is identified, guiding the formulation of objectives in the subsequent planning phase.

The adapted SWOT Matrix underwent testing through an action research project conducted in a teaching/educational unit responsible for training staff for the Unified Health System (SUS). This unit operates within a health Science, Technology, and Innovation (ST&I) institution, encompassing care, teaching, research, communication, and scientific dissemination. The sample for this study comprised 100 planning participants out of a total of 570 workers, conducted in July 2022. This research was conducted as part of a project approved by the SENAI/CIMATEC Research Ethics Committee under Certificate of Submission for Ethical Appraisal No. 59519522.5.0000.9287.

Data collection was facilitated through an anonymous questionnaire distributed via email. The questionnaire was structured with closed and mandatory questions and open and optional questions, encompassing 25 variables related to the internal and external environment. Closed questions were categorized according to a Likert scale [21] and analyzed quantitatively, utilizing descriptive statistics to generate mean values and standard deviations. On the other hand, open questions were qualitatively analyzed using the Iramuteq 0.7 software [22]. This software was utilized to identify similarities among the analyzed text segments and to classify these segments arranged in a descending hierarchy [23]. Finally, a comparison was drawn between the quantitative and qualitative data analysis results to assign names to the emerged classes identified by the software.

Results and Discussion

<u>Closed Questions Results</u>

The analysis of closed questions from the questionnaires completed during the planning process yielded 67 responses out of 100 participants (67% response rate). The variables were arranged

in ascending order based on a Likert scale ranging from -4 to 4, with the average responses calculated to identify the primary strengths, weaknesses, opportunities, and threats related to the organizational identity of the surveyed institution. The standard deviation (SD) was also determined.

Table 1 presents the initial results of the 12 variables about the internal environment, encompassing final services and management, which were analyzed to discern strengths and weaknesses. The table illustrates the outcomes of the analysis of 13 external environment variables, encompassing both micro and macroeconomic factors, yielding values for opportunities and threats.

Based on the analysis of the proposed variables, it is possible to discern the organization's strategic positioning per the TOWS Matrix quadrants. Each quadrant suggests a strategic scenario based on the current context, ranging from the most optimistic (where strengths predominate and opportunities abound) to the most pessimistic (which combines weaknesses and threats) [16,17]. The institution falls within the quadrant where strengths prevail in addressing threats. In this quadrant, the most appropriate generic strategy is maintenance [24],

which involves creating short--, medium---, and long-term objectives to preserve identified strengths or address threats [25].

Results of Open-Ended Questions

Each variable included an open-ended question, which was analyzed using Iramuteq. The 67 participants generated 59 texts, segmented into 780 text fragments, of which the software successfully analyzed 709, encompassing 90.9% of the produced texts. We identified classes using the descending hierarchical classification method (Figure 1).
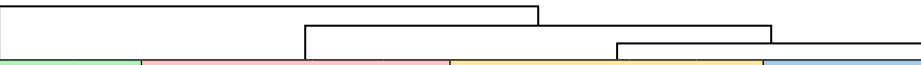
The dendrogram (Figure 1) illustrates a hierarchy among the classes derived from the analysis. These classes consist of text segments (STs), lemmas (words without prefixes or suffixes), and themes (25 pre-defined variables). Lemmas were incorporated into suggested classes based on similarity, determined by their chi-square size (x^2). The most significant class was Class 3, comprising 191 out of the 709 STs, thus contributing the most to the textual corpus, with 26.94% of the total.

Class 1, representing 25.5% of the corpus, is the least interconnected with others. It is characterized by the most prominent lemmas ($p < 0.0001$) and the

Table 1. Results of the analysis of internal and external environment variables survey data.

Internal Variables	Mean	PD(+-)	Internal Variables	Mean	PD(+-)
Teaching	2.3	1.8	Financiers	2.7	1.2
Research	1.6	2.1	Technologies	2.3	1.7
Workers	1.2	2	Partners	0.8	0.4
Leadership	1.1	1.8	Society	0.6	2.2
Health services	0.8	2	Citizen-user	0.6	0.7
Organizational culture	0.7	1.9	Environment	0	2.2
Unit organization	0.5	1.7	Suppliers	0	1.2
Planning	0.3	1.7	Competition	-0.4	2
Communication	0.1	2.3	Legislation	-0.6	1.9
Internal control	0	1.7	Health	-0.7	2.2
Infrastructure	-1	1.9	Education	-1.1	2.3
Budget	-1	1.9	Politics	-2.8	1.8
			Economy	-3	1.4

Figure 1. Dendrogram of the class suggested by Iramuteq.

		Class 1 25.5% - 181 ST		Class 4 21.0% - 149 ST		Class 3 27.0% - 191 ST		Class 2 25.5% - 181 ST	
		f	x2	f	x2	f	x2	f	x2
Mottos	Public	68	70	Organization 83	63	Infrastructure 86	54	Research 57	82
	Health	52	59	Planning 75	51	Sector 72	27	Program 100	58
	Threats	83	52	Identity 83	38	Condition 81	25	Teaching 53	52
	Law	90	48	Decision 92	27	Adequate 77	22	Teaching 100	38
	Economic	93	37	Achievement 100	22	Fundamental 74	22	Funding 81	36
	Panorama	100	33	Leadership 72	20	Area 58	20	Encourage 100	34
	Country	68	30	Community 100	20	Room 79	19	Public Notice 100	34
	Country	70	30	Team 89	18	Service 49	18	Group 85	32
	State	100	29	Culture 68	18	Service 89	18	Researcher 65	32
	Politics	72	27	Importance 71	17	Budget 88	15	Funding 75	29
Themas	Politics	81	35	Planning 77	40	Infrastructure 76	55	Teaching 58	43
	Economic	73	27	Control 92	32	Budget 44	4	REsearche 51	41

highest chi-squared value for this class, including terms such as "public" ($x^2 = 70$), "health" ($x^2 = 59$), and "threat" ($x^2 = 52$). Besides these lemmas, the themes most influential in shaping this class were "politics" ($x^2 = 35$), "health" ($x^2 = 37$), and "economics" ($x^2 = 24$). Notably, the themes of economics and politics emerged as primary threats in the quantitative analysis of closed questions. Consequently, Class 1 was labeled "Threats to public health," with representative text segments reflecting this classification: "The current political landscape poses a significant threat, as the federal government's stance against science and public health..." "The country is facing an economic crisis due to various factors, exacerbated by the federal government's adoption of neoliberal policies undermining public investment, including in public health and ST&I."

Class 2 primarily comprised the lemmas "research" ($x^2 = 82$), "program" ($x^2 = 58$), and "teaching" ($x^2 = 52$), along with the themes "research" ($x^2 = 43$) and "teaching" ($x^2 = 41$). The quantitative survey and thematic analysis indicated that participants regarded these slogans and themes as the school's primary strengths. Therefore, this class is aptly named "Strengths," encompassing 149 STs or 21% of the corpus. The following text segment encapsulates the essence of this

class, emphasizing the imperative of integrating research with teaching and education: "Fostering collaboration between teaching and research, fostering greater synergy between undergraduate and graduate programs, training faculty in active teaching methodologies, and engaging students in addressing real-world public health challenges."

Class 3, comprising 191 text segments, represents 26.94% of the total corpus. It is characterized by the lemmas "infrastructure" ($x^2 = 54$), "sector" ($x^2 = 27$), and "conditions" ($x^2 = 25$), along with the thematic variable "infrastructure" ($x^2 = 55$). Compared with the quantitative analysis results, it aligns with the institution's main weaknesses, particularly in infrastructure and budgetary resources. Although budget-related slogans and themes are present, they are not the most significant. Notably, this class is linked to Class 2 through budgetary concerns, as illustrated by the following text segment: "We need to establish programs to stimulate and facilitate the internationalization of our research groups and our extensive and selective programs, with special attention to overcoming the financial constraints that currently serve as the primary obstacle to this internationalization." Hence, Class 3 is aptly named "Weaknesses," underscored by the following significant text segments: "The healthcare facilities

are currently experiencing significant disruptions to their regular operations due to lack of maintenance ..., resulting in considerable wear and tear on these facilities, delays, and service interruptions." "The pandemic has presented challenges, such as adapting classroom layouts. The arrangement of workspaces... needs to be reassessed."

Class 4 comprises 188 text segments, constituting 26.5% of the total corpus. It is characterized by the lemmas "organization" ($x^2 = 63$), "planning" ($x^2 = 51$), and "leadership" ($x^2 = 20$), alongside the thematic variables "planning" ($x^2 = 40$), "control" ($x^2 = 32$), "culture" ($x^2 = 23$), and "leadership" ($x^2 = 15$). Representative text segments for this class include: "Planning holds significant importance for organizational identity as it serves as a guiding element, defining the vision of the future and organizational objectives, thereby facilitating the achievement of desired institutional social outcomes, while also aiding in the evaluation process of these outcomes." "Leadership is a crucial aspect for the organization and its identity." "Internal control is indispensable for ensuring organizational transparency...".

These text segments underscore the significance of managerial functions, initially outlined by Fayol in the early twentieth century [15]. While the classes might have been anticipated to align with SWOT theory and address opportunities, this was not the case. Consequently, this class was labeled "Management," despite not strictly adhering to the SWOT Matrix theory, exhibits closer ties to Classes 2 and 3 than Class 1. This proximity in relationship could be attributed to classes 2 and 3 addressing the internal environment. The empirical findings indicate a tendency to concentrate analysis on management, although such evidence cannot be universally applied. Class 4 underscores the innovation of introducing variables exclusively dedicated to management, thereby allowing other variables to focus on issues about the organization's core functions without the risk of diverting planning focus solely towards administrative concerns, such as personnel shortages, budget constraints, systems, or infrastructure inadequacies.

Conclusion

The empirical research has yielded a significant finding in class 4, which delves into management functions. It may initially be a deviation from the theoretical precepts of SWOT, which has emerged as a solution to the observed inclination towards prioritizing management at the expense of analyzing core areas. Thus, the initial concept of delineating themes for both management and core areas is further validated. The application of SWOT, adapted for public management through action research, has successfully yielded the intended outcomes. It facilitated identifying and analyzing strengths, weaknesses, opportunities, and threats while indicating strategic positioning based on the predominant quadrant. Consequently, it has generated insights that can enhance public management quality by introducing a new class.

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Sensitization for Solid Waste Disposal: Cosmetic Packaging Collection Initiative at a Public University

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This study endeavors to promote the responsible disposal of solid waste within a student environment, addressing concerns regarding the sustainability of our planet. The level of sensitivity and awareness among the academic community regarding proper waste disposal practices was assessed. As an intervention strategy, a collection point was established at a center within UFRB. While most respondents exhibited knowledge of the subject, over 80% highlighted the lack of access to collection points. Furthermore, 84% of respondents believe that initiatives like this one foster proper waste disposal habits, yet only 37% reported utilizing the installed collection point. Consequently, the campaign raises awareness within the community, but more effective measures are necessary to ensure widespread participation.
Keywords: Solid Waste. Proper Disposal. National Solid Waste Policy. Reverse Logistics. Public University.

Understanding the repercussions of climate change on Earth's ecosystems has emerged as a paramount concern. In response, the United Nations established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to advocate awareness and research. Compelling evidence indicates that human activities have contributed to global warming, profoundly impacting the cryosphere, biosphere, oceans, and atmosphere [1].

Examining various emission scenarios outlined in the AR6 climate change report reveals a consistent projection: surface temperatures will continue to escalate until mid-century. Drastic reductions in greenhouse gas emissions are imperative to curtail global warming within the range of 1.5° to 2°C of pre-industrial levels [2]. Implementing changes across multiple domains is essential to mitigate CO_2 emissions and address greenhouse gases, aligning with the UN's Sustainable Development Goals (SDG 13).

Forecasts from the Organization for Economic Cooperation and Development (OECD) anticipate a significant rise in the consumer class with disposable income, from 1.8 billion in 2010 to nearly 5 billion by 2030. Concurrently, the World Economic Forum predicts a global population of approximately 9 billion by 2030, adding 3 billion new middle-class consumers [3].

In Brazil, discussions surrounding this topic have gained momentum since 2010 with the enactment of the PNRS (National Policy on Solid Waste) Law No. 12,305. This legislation reinforces the prohibition of improper solid waste disposal. Consequently, reverse logistics emerges as a potential competitive advantage for organizations, fostering intellectual growth centered on sustainability [4]. Despite PNRS regulations, approximately 1,657 municipalities in Brazil still rely on landfills, contravening legal mandates [5].

As highlighted by Fernandes and colleagues [6], reverse logistics continually evolves and encompasses returning products to manufacturers, extending material lifespan, and promoting recycling. Post-consumer reverse logistics should be prioritized by organizations, forming a strategic plan to enhance their reputation, reduce costs, bolster market acceptance, and reaffirm environmental commitment [7].

It is crucial to raise awareness among residents regarding their role in managing solid waste, as emphasized by Lima and colleagues [7]. Individuals are primary waste producers, underscoring their responsibility for waste disposal [8].

This study aims to provide a comprehensive theoretical overview of proper solid waste disposal topics. Additionally, it seeks to assess community engagement within a university setting concerning adopting collection points conducive to appropriate disposal, with the potential for subsequent material selection and recycling initiatives.

Reverse Logistics

Logistics entails the strategic planning, execution, and oversight of the efficient and cost-effective flow and storage of raw materials, in-process inventory, finished products, and associated information from the point of origin to the point of consumption, all aimed at meeting customer demands. However, within this framework lies reverse logistics, which manages the flow from the point of consumption back to the point of origin [4].

Reverse logistics encompasses various facets, including reduction, resource conservation, recycling, replacement, and disposal, mirroring traditional procurement logistics activities such as sourcing, transportation, storage, and packaging [4]. This process involves retrieving products or materials from consumers or end-users, aiming to reintroduce them into the production cycle or ensure proper disposal [6].

National Solid Waste Policy

The National Solid Waste Plan (PNRS) underscores the escalating challenge of waste generation, exacerbated by urbanization, population growth, and consumerist trends. This surge in waste production has emerged as a significant concern for governmental authorities and the global community, given the inherent difficulties in managing and disposing of such vast quantities of waste compounded by their complex chemical compositions. Improper disposal poses grave environmental and human health threats [9].

The PNRS advocates for proactive measures aimed at curbing waste generation and fostering shared responsibility among all stakeholders involved in waste generation, including manufacturers, importers, distributors, retailers, and consumers. Consequently, a growing impetus exists to expand individual and collective accountability in waste management practices. It is no longer sufficient for manufacturers to address waste generated within their production processes merely; they are now obligated to oversee the product's lifecycle until its eventual disposal [4].

Circular Economy

The notion of a circular economy emerged as a response to the detrimental impacts of linear manufacturing methods, as elucidated in "The Limits of Growth," a seminal publication by the Club of Rome in 1972. This pioneering work highlighted the adverse consequences of resource extraction on terrestrial ecosystems and climate patterns. Linear manufacturing, characterized by material extraction, production, and consumption followed by disposal, perpetuates resource depletion and environmental degradation [10].

In contrast, the circular economy represents a paradigm shift towards sustainability, wherein waste is eliminated, and resources are conserved through continuous reuse, recycling, and regeneration. This approach fosters a symbiotic relationship between economic activities and the biosphere, ensuring minimal ecological footprint. The circular economy embodies a holistic vision of economic development that prioritizes environmental stewardship and resource efficiency (Figure 1).

In the circular economy, processes, services, and products are engineered to prioritize repairability, durability, and upgradability. This contrasts with the linear economy model [11], where products are typically designed with a short lifespan and limited potential for reuse or recycling. The fundamental distinction lies in the circular economy's emphasis on creating a closed-loop system, where materials and resources are continually cycled back into production processes.

From the design phase onwards, there is a concerted effort to ensure that products and services

Figure 1. Circular Economy.
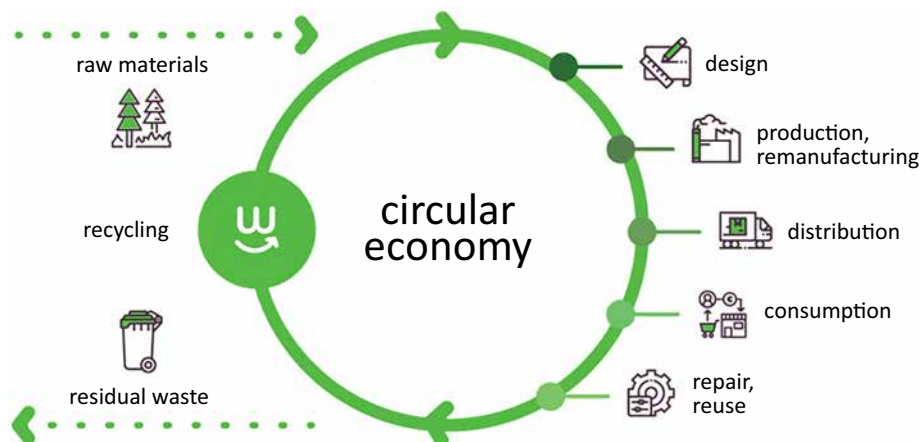
retain their value at the end of their lifecycle [12], serving as productive resources for other industries through remanufacturing and recycling. However, it is essential to maintain the quality of materials throughout the recycling process to ensure their suitability for reuse.

Transitioning to a circular economy requires collaboration across economic sectors involving companies, consumers, and policymakers [13]. This collaborative approach is crucial for achieving resource efficiency and waste reduction outcomes.

Projects designed with a "cradle to cradle" perspective exemplify this approach, aiming to create industrial products and systems that sustain their quality and productivity across multiple life cycles. This philosophy emphasizes the importance of considering the entire lifecycle of products, from raw material extraction to end-of-life disposal, in the design process.

Ultimately, embracing the circular economy requires a shift in both consumer and producer behaviors and changes in education and values. This transformation involves rethinking traditional consumption patterns and adopting more sustainable practices to promote long-term environmental and economic sustainability.

Materials and Methods

The study employed a survey methodology incorporating both quantitative and qualitative approaches. It was conducted at the Federal University of Recôncavo da Bahia (UFRB), specifically at the Center for Technology in Energy and Sustainability (CETENS), to assess the academic community's engagement regarding proper solid waste disposal.

An online form was created using the Google Forms tool to gauge the community's behavior and understanding regarding solid waste disposal. This form was distributed to the academic community through WhatsApp groups at the center, comprising approximately 250 individuals. Additionally, a QR code was provided on the collection box placed within the center, allowing all nearby individuals to access the form. The form included questions addressing various aspects of solid waste disposal, including understanding, habits, and disposal practices related to post-consumer materials. A total of 64 responses were obtained through the survey, which did not include any demographic or qualification data.

The project extended beyond merely quantifying waste disposal and aimed to encourage future sustainable practices among the community members. A collection box was placed in a high-traffic area within the university campus to facilitate waste collection. The box was constructed using recycled cardboard and metro paper, aligning with the project's sustainability objectives. A booklet containing disposal instructions and information about the ongoing research was placed on the box's surface.

The collection box remained accessible on the university campus for ten days, allowing ample time for community members to dispose of their waste. The sequence of activities carried out throughout the study is depicted in Figure 2, providing a visual representation of the procedures undertaken for better understanding and visualization.

Results and Discussion

The following section will present the survey results for reverse logistics and proper disposal of solid waste collected through a form made available to the academic community of CETENS (Center for Energy and Sustainability) of UFRB, Federal University of Recôncavo da Bahia. In order to carry out the necessary analyses based on data collected from faculty and students on campus, we collected a total of 64 responses.

Analyzing the survey responses provides valuable insights into the community's awareness and engagement regarding the proper disposal of solid waste.

Firstly, the data indicates that a significant portion of the research collaborators (71.9%) are familiar with the term "conscious disposition," with 17.2% having heard of it a few times and 10.9% having never encountered it before (Question 1). This suggests a baseline level of awareness among the community members. However, approximately 18 individuals are unfamiliar with the concept, which may warrant further attention, especially considering the center's focus on Energy and Sustainability.

Secondly, regarding the community's awareness and engagement with proper waste disposal, a majority (84.4%) indicated some level of concern, with 57.8% sometimes worrying and 26.6% constantly worrying about the issue. However, a notable percentage (15.6%) of respondents rarely or never express concern, highlighting a need to address barriers to engagement (Question 2).

When examining the main limiting factors for community engagement, lack of access to appropriate disposal destinations emerged as the primary concern, cited by 81.3% of respondents (Question 3). This underscores the importance of initiatives such as the project in providing accessible disposal options. However, it is noteworthy that despite the initiative, no packaging was available

Figure 2. Study framework.
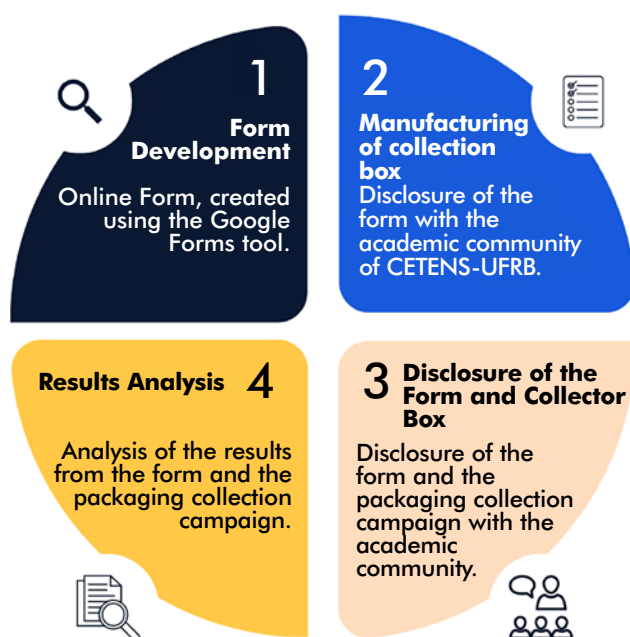
Figure 3. Results of the questionnaire.

Question 1
Have you ever heard about conscious disposition?
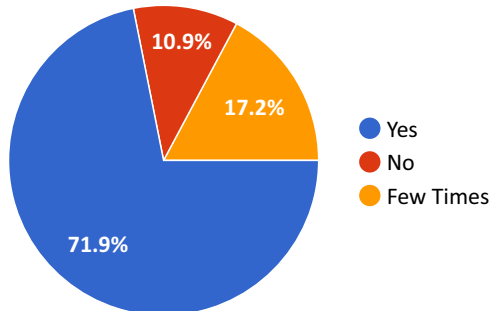
Question 4
Do you know what means reverse logistic?
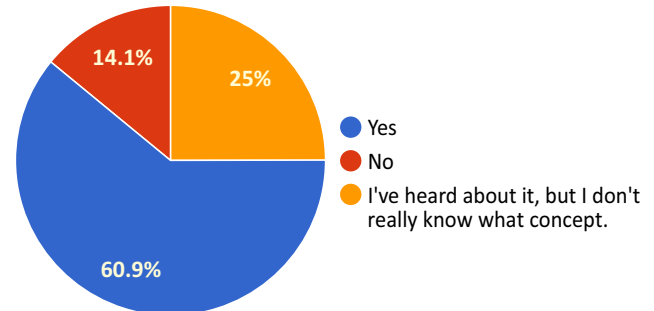
Question 2
Do you usually worry about the proper disposal of waste produced/consumed?
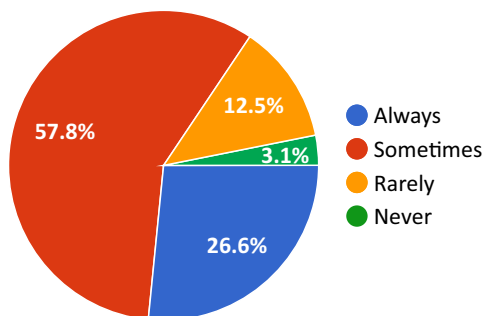
Question 5
Do you believe that the project will encourage you to property dispose of packaging through easy access to the destination location?
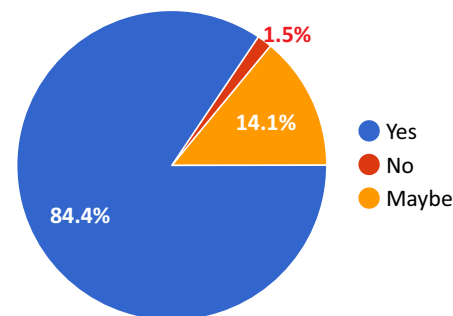
Question 3
What are the main factors responsible for making proper disposal difficult?
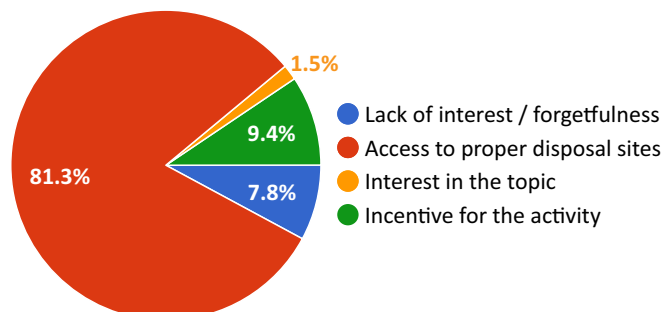
Question 6
Are you able to make any disposition of material?
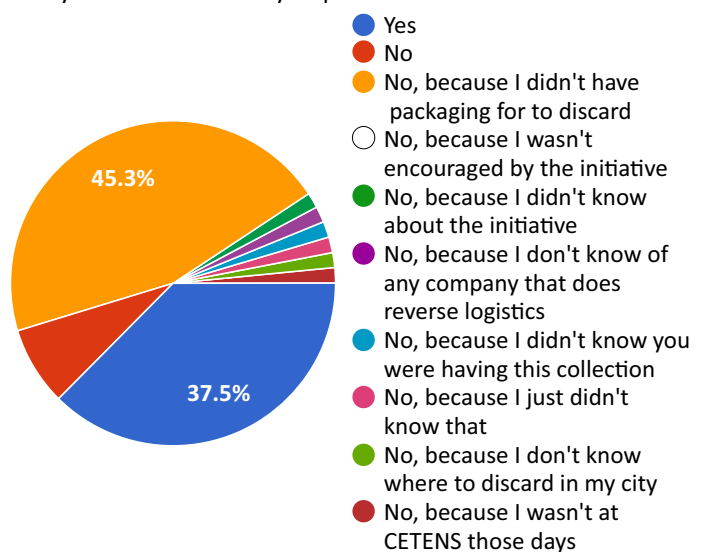
at the designated disposal point, suggesting a discrepancy between community needs and project implementation.

Additionally, while factors such as lack of information (7.8%) and lack of incentive (9.4%) were less frequently cited, they still represent barriers to community engagement. Only a tiny percentage (1.5%) reported a lack of interest in the topic, indicating that awareness and publicity efforts may play a crucial role in fostering community participation (Question 3).

In summary, the survey results emphasize the importance of addressing barriers to engagement and ensuring alignment between community needs and project initiatives to effectively promote proper waste disposal practices. Continued awareness-raising efforts and improvements in project implementation can contribute to increased community involvement and adherence to sustainable waste management practices.

The survey responses shed light on the academic community's awareness of reverse logistics and their perceptions of the project's effectiveness in promoting proper waste disposal.

Firstly, most respondents (60.9%) indicated familiarity with reverse logistics, demonstrating a level of understanding of companies' responsibilities regarding material production and disposal. However, it is notable that a significant portion (25%) have heard of the term but do not fully understand the concept, suggesting a need for further education and awareness-raising efforts (Question 4).

Regarding the project's potential to encourage proper waste disposal, an overwhelming majority (84.4%) expressed confidence that it would incentivize them to dispose of packaging appropriately (Question 5). This positive response indicates strong support for the initiative and suggests that easy access to disposal locations is critical in promoting community engagement.

However, the responses revealed some discrepancies when asked about their disposal behavior. While a substantial number (37.5%) reported having disposed of materials, primarily

due to the lack of packaging, this contradicted the observation that no packaging was provided at the designated disposal location on the CETENS Campus. This inconsistency suggests respondents' potential misunderstanding or misinterpretation of the question, highlighting the importance of clear communication and instructions in future surveys or initiatives (Question 6).

Additionally, some respondents cited forgetfulness (7.8%) as a reason for non-disposal, while a small percentage (1.5%) expressed disinterest or lack of awareness of the initiative (Question 3). These responses underscore the need for ongoing engagement and reminders to encourage consistent participation in waste disposal initiatives.

Overall, while the survey results indicate positive attitudes towards the project and a willingness to engage in proper waste disposal practices, there are opportunities for improvement in communication, education, and implementation to ensure the project's effectiveness and maximize community involvement.

Conclusion

The conclusions drawn from the study highlight the importance of initiatives aimed at proper waste disposal and sustainability within academic communities. While the data indicates a strong interest and willingness to engage in such initiatives, there is a need for increased awareness and ongoing efforts to promote sustainable practices.

One key recommendation is to enhance education and awareness-raising efforts on waste management and sustainability topics. This could involve incorporating these topics into academic curricula, organizing workshops, seminars, and awareness campaigns, and providing regular updates and reminders to the community about the importance of proper waste disposal.

Moreover, the study suggests the development of projects and activities specifically targeted at promoting sustainability within the academic community. These projects could include

implementing additional waste collection points, collaborating with public bodies and organizations to facilitate recycling and waste management, and the organization of debates and discussions on environmental issues.

Notably, the support of the university administration and stakeholders is crucial for the success of these initiatives. By providing resources, funding, and institutional support, the university can drive positive change and foster a culture of sustainability on campus.

Overall, the study underscores the potential for universities to lead by example and serve as catalysts for environmental stewardship and sustainable practices. Through collective efforts and collaboration, academic communities can contribute to addressing environmental challenges and promoting a more sustainable future for all.

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Validation of Analytical Methodology for Determining Polycyclic Aromatic Hydrocarbons (PAHs) in Fine Particulate Matter Emitted by Diesel Engines

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Studies on determining toxic pollutants in particulate matter emitted by diesel engines are crucial for developing strategies to mitigate atmospheric pollution. However, the low levels of analytes and the complexity of the matrix pose significant challenges from an analytical chemistry perspective. This work aimed to evaluate the analytical parameters of a procedure for determining polycyclic aromatic hydrocarbons (PAHs) in delicate particulate matter emitted by diesel engines. The validation parameters indicated good linearity, with coefficients of determination (R^2) ranging from 0.9959 to 0.9995. The limits of detection and quantification were between 0.24 to 0.60 ng/mL and 0.78 to 2.0 ng/mL, respectively. Recoveries ranged from 66.1% to 121%, with relative standard deviations (RSD%) of less than 20%. Applying this method to determine PAHs in PM1.0 and PM2.5 samples revealed high levels of these compounds in S10 diesel samples.
Keywords: Atmospheric Pollution. Chromatography. Mass Spectrometry.

The growing concern about emissions of toxic compounds into the atmosphere, such as polycyclic aromatic hydrocarbons (PAHs), has generated renewed interest in researching more sustainable alternatives, such as biofuels. PAHs are products of incomplete combustion of organic matter, with fossil fuels being the primary sources of these emissions [1-3]. However, the low concentrations of these compounds in the samples (a few µg/g) combined with the high complexity of the particulate matter matrix present challenging conditions for most existing analytical methods [4].

Using gas chromatography coupled with mass spectrometry (GC-MS) offers a robust analytical approach for identifying and quantifying these compounds, allowing an assessment of the potential environmental impacts associated with using various fuels. Efficient sample preparation methods are often necessary to achieve adequate quantification limits for these determinations. This study aimed to evaluate the main analytical parameters for the validation stage of an analytical procedure for determining PAHs in particulate matter (PM) samples emitted by diesel engines.

Materials and Methods

We employed the analytical parameters reported by Santos and colleagues (2016) [4] and Paim and colleagues (2023) [3] to determine PAHs. The separation and identification of the compounds were performed using a gas chromatograph coupled with a mass spectrometer, model QP2010 SE (Shimadzu, Kyoto, Japan), equipped with a DB-5MS capillary column (30 m x 0.25 mm ID x 0.25 µm film thickness). Data acquisition was conducted in SIM (single ion monitoring) mode. To validate the method, the following analytical parameters were evaluated: selectivity, linear range and linearity, limit of detection (LD), limit of quantification (LQ), precision, and accuracy, using urban dust reference material (NIST Urban Dust 1649b).

Results and Discussion

Validation of the Analytical Method

Table 1. presents the analytical parameters evaluated in the method validation. The coefficients of determination (R^2) ranged from 0.9959 for acenaphthylene-d10 to 0.9995 for naphthalene, indicating excellent linearity.

The detection and quantification limits ranged from 0.24 to 0.60 ng mL⁻¹ and 0.78 to 2.0 ng mL⁻¹, respectively, demonstrating suitability for quantifying these compounds in the analyzed samples. The method's accuracy was assessed by analyzing urban dust's certified reference material (SRM) (Urban Dust 1649a, NIST). The recoveries obtained from the SRM analysis ranged from 66.1% for phenanthrene to 121% for naphthalene, with relative standard deviation (RSD%, n=3) values below 20%, within the recommended range for trace-level analysis [4,5].

After establishing the analytical parameters, the validated procedure was applied to determine PAHs in samples of $PM_{1.0}$ (aerodynamic diameter of up to 1.0 µm) and $PM_{2.5}$ (aerodynamic diameter of up to 2.5 µm) collected during studies with emissions from diesel engines mounted on a bench dynamometer, using different mixtures of biofuels with S10 diesel.

Figure 1 shows the chromatogram (GC-MS/SIM) obtained from the injection of an extract of a $PM_{2.5}$ sample from the combustion of S10 diesel.

The concentrations of PAHs quantified in the samples were reported as the sum of low molecular weight PAHs (LMWPAH) and high molecular weight PAHs (HMWPAH). The final concentration was expressed as the mass of the analyte per mass of PM (µg g⁻¹). In general, the total concentrations of HMWPAH in the analyzed samples were higher than the concentrations of LMWPAH. This was expected, as HMWPAH are predominantly emitted by pyrogenic sources, which involve the combustion of organic matter.

Table 1. Analytical parameters of the method used in the analyses.

PAHs	Linear Range (ng mL⁻¹)	R²	LD (ng mL⁻¹)	LQ (ng mL⁻¹)	Recovery (mean±RSD) SRM Nist 1649b
Naphthalene	0.78-40	0.9995	0.24	0.78	121±3
Acenaphthylene	1.18-400	0.9991	0.36	1.18	112±1
Acenaphthylene-d10*	0.5-400	0.9959	-	-	-
Acenaphthene	1.19-40	0.9991	0.36	1.19	86.1±7.2
Fluorene	2.00-60	0.9988	0.60	2.0	96.1±5.4
Phenanthrene	1.77-60	0.9988	0.53	1.77	66.1±10.9
Phenanthrene-d10*	0.5-400	0.9981	-	-	-
Anthracene	1.09-40	0.9990	0.33	1.09	99.7±12.4
Fluoranthene	1.09-40	0.9990	0.33	1.09	91.0±12.3
Pyrene	1.89-60	0.9986	0.57	1.89	91.4±11.7
Benzo[a]anthracene	1.24-40	0.9987	0.37	1.24	87.3±13.6
Chrysene	1.28-40	0.9986	0.38	1.28	99.6±6.4
Benzo[b]fluorene	1.32-40	0.9985	0.4	1.32	116.4±15
Benzo[a]pyrene	1.22-40	0.9988	0.37	1.22	80.7±13.6
Benzo[e]pyrene	1.22-40	0.9988	0.37	1.22	75.1±6.8
Perylene	1.30-40	0.9986	0.39	1.3	81.0±13.1
Indeno[1,2,3-*cd*]pyrene	0.82-40	0.9990	0.25	0.82	94.0 ± 14.9
Dibenzo[*a,h*]anthracene	1.14-40	0.9990	0.34	1.14	84.9±7.8
Benzo[*ghi*]perylene	1.43-40	0.9987	0.43	1.43	80.5±9.0
Coronene	1.07-400	0.9991	0.32	1.07	96.7±13.7

LD: limit of detection; LQ: limit of quantification; R²: coefficient of determination. *Internal standard.

Figure 1. GC-MS/SIM chromatogram obtained from the analysis of a PM2.5 sample from the combustion of S10 diesel.
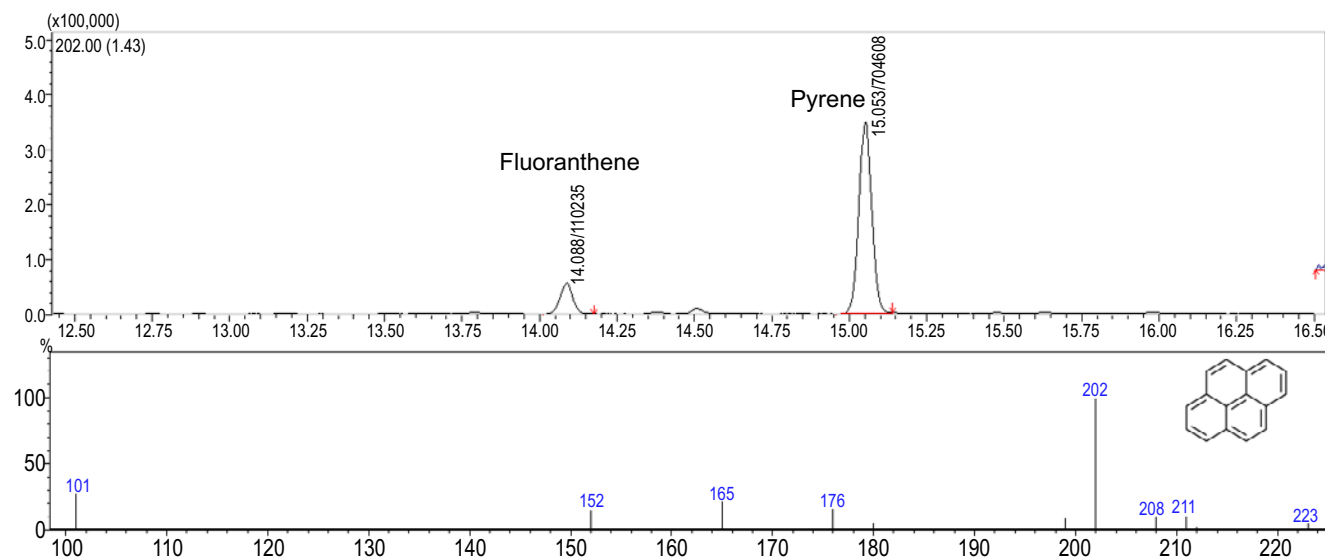
The PAHs with high molar mass fluoranthene and pyrene (M+ m/z 202) were the compounds with the highest concentrations. The mass spectrum of pyrene obtained in SIM mode is also shown.

Despite all fuel mixtures undergoing combustion in the engine (dynamometer) under controlled conditions, higher concentrations of both LMWPAH and HMWPAH were observed in the $PM_{2.5}$ samples obtained from the combustion of pure S10 diesel and a mixture of S10 diesel with second-generation ethanol. In contrast, LMWPAH concentrations were lower than those observed for HMWPAH. Unlike HMWPAH, LMWPAH is characteristic of petrogenic sources, such as petroleum and by-products from fuel refining [1,2].

Conclusion

The results obtained from the validation of the analytical procedure were satisfactory, demonstrating good linearity, precision, accuracy, and low LD and LQ values. The analysis of PM2.5 and PM1.0 samples from the combustion of different diesel mixtures with biodiesel indicated that the highest concentrations of PAHs were observed in the S10 diesel sample, particularly PAHs with high molar mass. Conversely, the concentrations of these PAHs were reduced in mixtures of diesel with first-generation ethanol.

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Modeling Evapotranspiration and Temperature in the Amazon Basin Using the WRF Model

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The Amazon rainforest has been significantly impacted by increased deforestation and a temperature rise of 2.2°C. These factors and climate change disrupt the natural interaction cycle between the forest and the climate, affecting the global moisture flow. In this context, the present study aims to simulate meteorological variables, specifically evapotranspiration and temperature, in the Amazon Basin using the WRF (Weather Research and Forecasting) mesoscale model. The simulation covered the year 2021 with a spatial resolution of 9 km. This allowed for an evaluation of the spatial distribution of temperature and evapotranspiration throughout the year, providing insights into the behavior of these variables in the region. The simulations were satisfactory, underscoring the model's potential to support environmental studies and analyses on the Amazon Basin. It was found that April, October, and November exhibited the highest temperature values, averaging between 36-42 °C. In contrast, the lowest temperatures were recorded in June and July, with average values ranging from 6-18 °C.
Keywords: Amazon Basin. Land Use and Occupation. Climate Change. WRF.

Globally, extreme meteorological phenomena such as heat waves, droughts, and intense rains have become more frequent over the past 20 years [1,2]. Alongside the Pacific Ocean, the Amazon rainforest is a significant source of moisture in the global atmosphere, playing a crucial role in regulating the global climate system.

However, increased deforestation has significantly impacted the Amazon, with 19% of the area now deforested [3]. Other issues include land grabbing, agricultural expansion, fires, forest degradation, and a temperature rise of 2.2 °C [4].

These factors, coupled with climate change, disrupt the natural interaction cycle between the forest and the climate, affecting the global flow of moisture [5,6]. Given this scenario, the pursuit of sustainability in the Amazon has driven the development of systemic studies across various knowledge domains and at different spatial and temporal scales. To address these challenges, high-resolution atmospheric-hydrological models are emerging as a promising approach to understanding the dynamics of a river basin. The primary model of this type, the

Weather Research and Forecasting (WRF) model [7], has been extensively studied and optimized to provide an improved numerical tool for global water resource planning and assessing the impacts of climate change on regional hydrology. In this context, the present study aims to simulate meteorological variables, specifically evapotranspiration and temperature, in the Amazon Basin for the year 2021 using the WRF mesoscale model with a spatial resolution of 9 km, incorporating land cover and use data from MapBiomas.

Materials and Methods

The study area for this work corresponds to the Amazon Basin (Figure 1). The simulations were conducted using land use and occupation data from Collection 7 of the MapBiomas Project (https://MapBiomas.org/), which was processed using the Raster calculator of QGIS 3.26 software for 2021 and 1985. The analysis of this data is crucial as it allows the model to integrate changes in land use and occupation over time accurately. The simulations were carried out using WRF version 4.2.0, initialized at 0000 UTC and extending to 1800 UTC from January to December 2021 for the region under study. The initial and boundary conditions used in the simulations were sourced from the global atmospheric model GFS (Global Forecast System) from NCEP (National Center

Figure 1. Changes in land use and occupation in the Amazon Basin in the years 1985 and 2021.
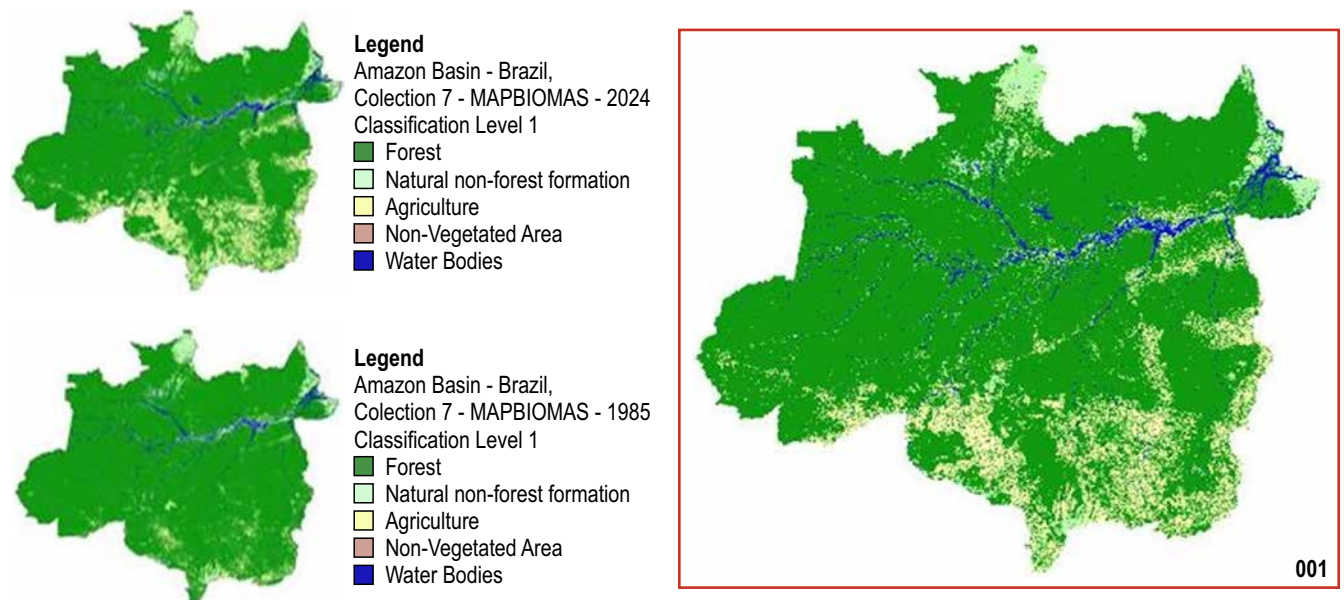
for Environmental Prediction), with a horizontal resolution of 0.25° x 0.25° and a temporal resolution of 6 hours. The model was configured with a grid resolution of 9 km (336x285) and 50 vertical levels encompassing the Amazon Basin [5] (Figure 1).

The physics options adopted and left unchanged for all simulations were as follows:

- Microphysics: WRF Single-Moment 6-class scheme
- Cumulus: Grell-Freitas scheme Boundary Layer Parameterization: Mellor-Yamada Nakanishi and Niino Level 2.5 PBL.
- Radiation: RRTMG for both shortwave and longwave radiation.
- Land-Surface Model: Noah Aerosol Interactions with Radiation: Parameterized following Ruiz-Arias and Thompson's water/ice-friendly approach.

By incorporating detailed land use and occupation data, the WRF model can more accurately reflect the environmental dynamics of the Amazon Basin. This allows for a more precise simulation of meteorological variables, providing valuable insights for environmental studies and policy-making.

Results and Discussion

Figure 2 presents temperature and evapotranspiration (ET) maps generated from numerical modeling for 2021. Due to the vast expanse of the Amazon Basin, there are pronounced spatial gradients of hydrometeorological variables, resulting in significant spatial variations in temperature and ET.

The temperature maps reveal that April, October, and November experienced the highest temperature values, with averages ranging between 36-42 °C, which were more evenly distributed across the region. In contrast, the lowest temperatures occurred in June and July, with average values ranging from 6-18 °C. Notably, the highest temperatures were consistently recorded in the basin's southern part throughout most of the year.

Regarding ET, the monthly averages are well-distributed across the basin. The increase in ET is primarily related to increases in solar radiation and temperature, the two main variables influencing ET variability in the Amazon region. This relationship is evident when comparing the monthly average ET values with the monthly average temperature values during the simulated period. Similar results for the estimation of ET

Figure 2. Map of monthly average temperature (on the left) and evapotranspiration (on the right).
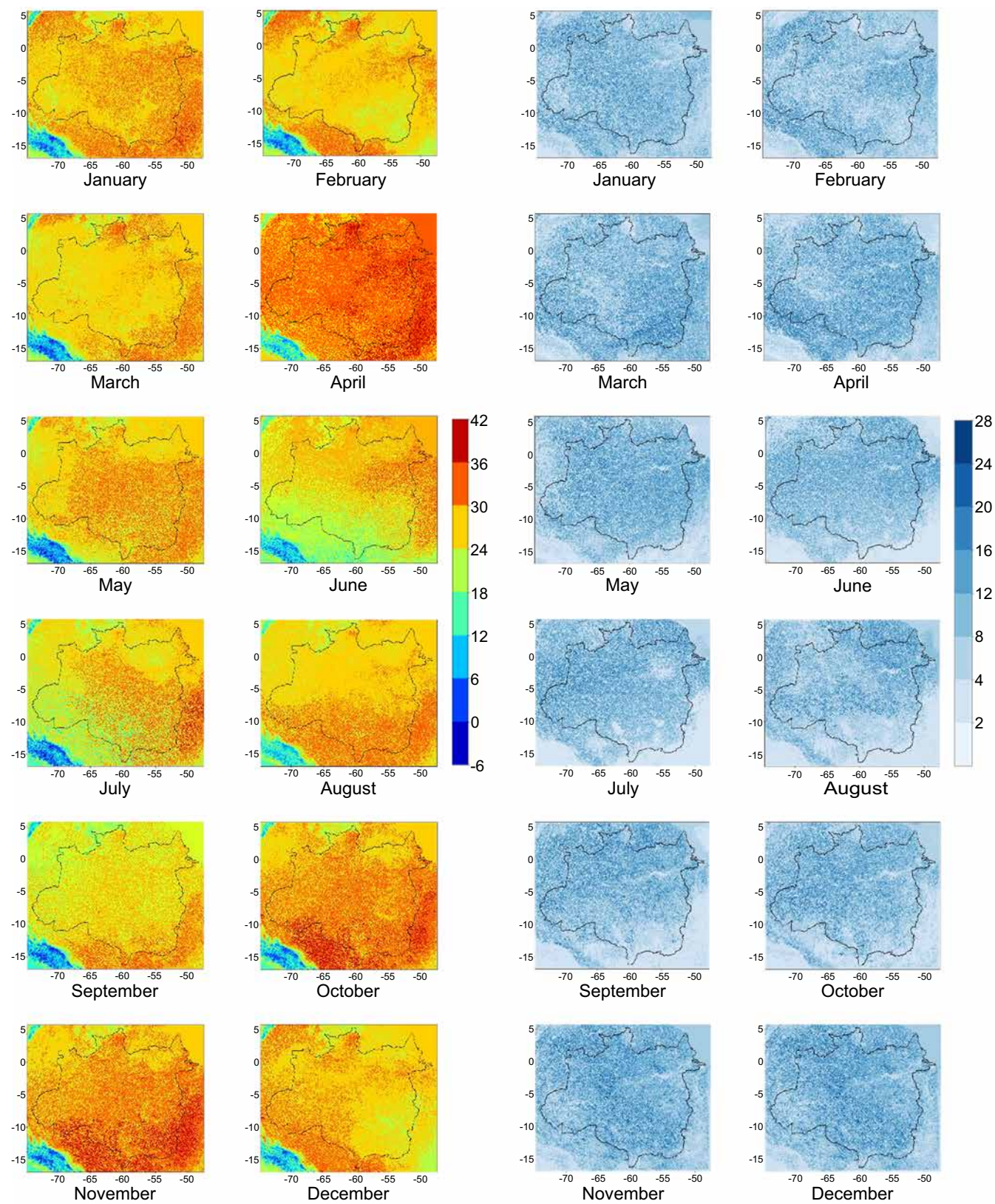
and temperature variables in the region have been reported in previous studies [6-10].

The spatial distribution and variability of temperature and ET across the Amazon Basin underscore the region's complex climatic dynamics. The findings highlight the importance of using high-resolution models to capture these variations accurately, which is crucial for environmental studies and climate impact assessments.

Conclusion

This initial study aimed to analyze the spatial distribution of temperature and evapotranspiration (ET) in the Amazon Basin, highlighting the potential of the WRF model to support environmental studies and analyses focused on the region. Additionally, the work sought to address the current dynamics of land use and occupation in the Amazon, offering a contemporary perspective on these changes and their impacts. Future research will be dedicated to exploring potential correlations between deforestation and ET patterns and other meteorological variables, focusing on areas that have undergone intense changes in land occupation. Furthermore, a detailed hydrological analysis will be conducted in the Manaus region using the hydrological module of the WRF model to understand local water dynamics better. Additionally, changes in land use and occupation between 1985 and 2021 will be analyzed through simulations to identify environmental impacts in the Amazon Basin during this period of significant change. This study underscores the importance of using advanced modeling techniques to understand the complex interactions between land use, climate, and hydrological processes in the Amazon Basin. Continued research will provide valuable insights for sustainable management and conservation efforts in this critical region.

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Proposal of an Automated Monitoring System of Aquamarine Water Quality in Coral Reef Regions

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Coral reefs play a crucial role in marine ecosystems, providing habitat and sustenance for diverse marine species. However, they face rapid degradation due to human activities, posing a significant threat to their ecological balance. Monitoring the water quality near these reefs is essential to their preservation, ensuring that critical factors such as temperature, oxygen levels, and salinity remain within appropriate ranges. Traditional monitoring methods are often slow and labor-intensive, requiring field agents to collect data manually. Therefore, there is a pressing need to develop autonomous monitoring devices capable of transmitting real-time data from specific locations to researchers and environmental preservation teams. Doing so can improve our understanding of reef health and respond more effectively to threats. This project aims to contribute to preserving coral reefs by providing timely and accurate data for conservation efforts. By harnessing technology to monitor and protect these vital ecosystems, we can work towards ensuring their long-term survival.
Keywords: Coral Reefs. Monitoring. Automation.

The theoretical foundation of this document resides within the domains of marine conservation and environmental monitoring. Extensive research has underscored the critical importance of coral reefs as ecosystems that provide habitat and sustenance for numerous marine species [1,2].

However, human activities and climate changes have led to the rapid degradation of these systems, posing a significant threat to their ecological balance. According to recent studies [3,4], one of the most effective strategies to preserve these reefs is by continuously monitoring water quality in their vicinity, ensuring that factors such as temperature, oxygen levels, and salinity are maintained at appropriate levels.

Conventional approaches to water quality monitoring typically involve manual data collection, a time-consuming and costly process. It often

results in delayed responses to environmental changes and can have long-term adverse effects on the ecosystem. Researchers have recognized the need for automated monitoring systems to collect and analyze real-time data, facilitating swift and effective responses to environmental fluctuations [5].

The efficacy of traditional monitoring approaches for marine ecosystems has been scrutinized in recent literature [6], underscoring the necessity for efficient and precise automated systems. Furthermore, authors have identified key challenges that impede effective monitoring, such as high long-term maintenance costs, inadequate utilization of equipment, and insufficient investment in monitoring initiatives for these environments [7]. To address these challenges, there has been growing interest in leveraging emerging Artificial Intelligence-based technologies, which have the potential to enhance precision, immediacy, and automation in data collection processes.

Indeed, automation offers a promising avenue for real-time monitoring and data collection in marine environments [8]. However, the implementation of such systems remains cost-prohibitive and demands substantial investment. An alternative

approach involves the utilization of decentralized biosensors capable of remotely sharing information and providing real-time data about their installation locations [9].

Given the critical state of coral reefs, immediate action is imperative. Human activities and climate change present formidable threats to these ecosystems, underscoring the importance of societal responsibility in their preservation. Monitoring water quality is one of the most effective strategies for safeguarding reefs. While traditional methods are labor-intensive and financially burdensome, automated systems and sensors present viable solutions, albeit requiring significant investment.

Against this backdrop, this study aims to explore recent advancements in automated marine monitoring to develop a solution that automates the assessment of water temperature, oxygen levels, and salinity in coral reef regions. By doing so, this research endeavors to contribute to the preservation of these vital ecosystems.

Materials and Methods

This research adopts a descriptive-qualitative methodology, utilizing articles, journals, and pertinent publications in the coral reef monitoring domain, encompassing both automated and non-automated approaches. This exhaustive review of the state-of-the-art literature enhances comprehension while delineating the evolutionary trajectory of the field.

Understanding the current landscape of coral monitoring systems is paramount, necessitating an examination of prevailing constraints, challenges, and promising breakthroughs. Moreover, identifying cost-effective equipment capable of autonomous monitoring is pivotal, laying the groundwork for developing a Meteoceanographic Buoy prototype engineered for minimal human intervention.

Prototyping the Buoy demands meticulous consideration of cost-effectiveness, longevity, self-sufficiency, and seamless integration with extant networks. Essential components include sensors for salinity, temperature, and oxygen levels, complemented by an integrated battery system.

The project initiates with a laboratory testing phase, wherein components are assembled and integrated. Here, the functionality of salinity, temperature, and oxygen sensors is scrutinized, alongside their interfacing with the data-sharing electronic platform.

Subsequently, the prototype undergoes field testing to evaluate its performance under real-world marine conditions. This stage is pivotal for assessing durability against wave impact and seawater corrosion. Additionally, field tests facilitate the collection of authentic data to validate the sensors' accuracy and reliability.

Results and Discussion

The proposed device consists of a floating buoy composed of sturdy and lightweight materials capable of withstanding marine conditions such as wave impact and corrosion caused by seawater. The Buoy should be equipped with strategically positioned sensors, including a salinity sensor, a temperature sensor, and an oxygen sensor (Figure 1).

The submerged section of the buoy houses all the essential sensors, enabling the monitoring of various parameters near coral reefs. An Arduino (ATmega328) is the electronic prototyping platform atop the Buoy, complemented by a GSM module (sim900a) for internet-enabled data transmission.

Instead of a galvanic sensor, an optic sensor (DOG-209FYD) is employed for monitoring dissolved oxygen, owing to its enhanced reliability and non-toxic properties. Salinity measurements are facilitated by an electrical conductivity sensor (RK500-13), renowned for its seamless integration and low power consumption. Meanwhile, temperature monitoring is entrusted to the DS18B20 sensor, which is esteemed for its affordability and dependable performance. Figure 2 presents these sensors.

Near the Buoy's apex, a compact solar panel links to a base-mounted battery, forming an energy storage system vital for continuous operation. This

Figure 1. Meteoceanographic buoy and Sensor tray.

a)   b)
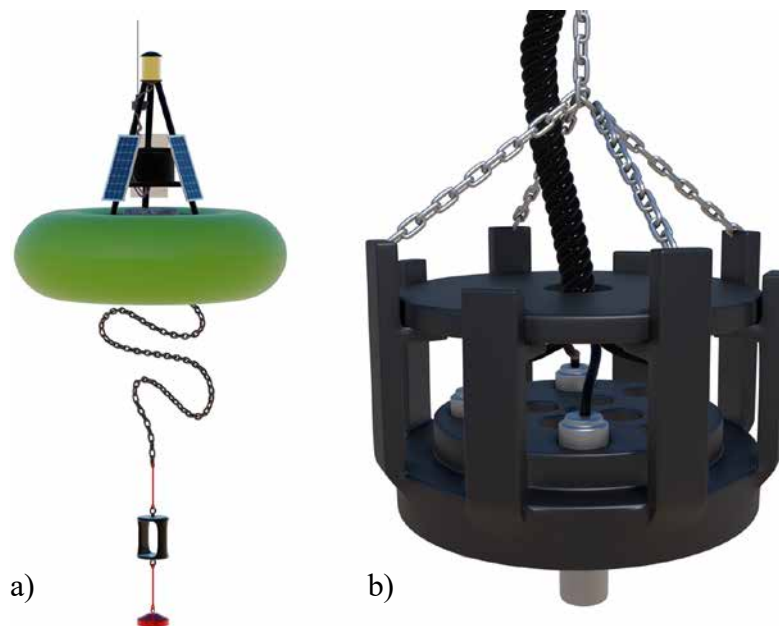
Figure 2. Respectively: RK500-13, DS18B20, DOG-209FYD.

setup harnesses solar energy during daylight for subsequent use during diminished solar exposure and nighttime periods.

It is securely housed within a sealed enclosure to safeguard the battery from external elements such as water, sunlight, and wind. Data transmission occurs at short intervals, approximately every 10 minutes when internet-connected, with immediate transmission triggered by significant environmental shifts. This strategy conserves battery power, mitigating depletion risks arising from constant connectivity and computation and minimizing the potential for data loss during periods of inactivity.

The Buoy's rounded base offers stability against ocean currents, while its elongated top features a small antenna, indicating the sensor's internet connectivity and data transmission functions.

At the Buoy's core lies a sealed compartment housing the battery. Submerged beneath the surface, a 3-meter cable connects the structure to a protective "cage" shielding the sensors from direct marine animal contact, housing all submerged sensors as illustrated in Figure 1.

This robust design ensures the Buoy's resilience in marine environments, facilitating the acquisition and transmission of critical water quality data from the coral reef vicinity, thus bolstering ecosystem preservation efforts.

The sensors are tethered by a chain beneath the Buoy, with wiring routed through it, bolstering their

security and stability. This configuration ensures their connectivity to the Buoy and maintains their positioning within the data collection radius, minimizing deviations caused by water currents. Consequently, this setup enhances data accuracy and diminishes the risk of buoy dislodgement, fortifying the system's reliability. Thus, the chain and wiring amalgamation is indispensable in sensor safety and performance.

Conclusion

Various challenges associated with establishing an automated monitoring system and marine preservation have been elucidated through the research and conceptualization phases. A primary challenge lies in determining the optimal sensor placement on the Buoy to ensure accurate monitoring of water parameters near coral reefs.

Integrating the battery into the system is critical, necessitating meticulous isolation from environmental elements due to its susceptibility to damage.

Concerning automated monitoring, careful consideration must be given to defining the frequency and data size for transmission, typically around 10 Kb per transfer, equivalent to approximately 10,000 characters. This decision balances energy consumption, data usage, and information accuracy.

Ultimately, the automated monitoring system facilitates continuous data collection on water quality parameters near coral reefs, enabling real-time analysis. This capability can significantly contribute to coral preservation efforts by facilitating prompt responses to environmental threats.

Moreover, the incorporation of solar energy and optimization of data transmission enhance the system's efficiency, reliability, and autonomy, bolstering its effectiveness in marine conservation endeavors.

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Influence of Chemical Structure on the Thermal and Mechanical Properties of Structural Adhesives

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This study aims to evaluate the influence of the chemical structure of acrylic and epoxy structural adhesives on their thermal and mechanical properties. Differential scanning calorimetry (DSC) and uniaxial tensile strength tests were conducted to assess the characteristic transition temperatures and mechanical properties. The DSC results indicated that the acrylic adhesives have higher glass transition temperatures than the epoxy-based adhesives. Regarding mechanical properties, the epoxy adhesives exhibited greater maximum resistance and lower deformation at break than the acrylic adhesives. The findings revealed that the chemical structure of adhesives significantly influences their thermal and mechanical properties, necessitating careful selection based on the specific application requirements across a wide range of products being developed and commercialized. Keywords: Structural Adhesive. Chemical Structure. Thermal Properties. Mechanical Properties.

Adhesives are materials applied to surfaces to join items through adhesive bonding [1] permanently. They are responsible for wetting surfaces by spreading at a contact angle close to zero and must harden into a solid, cohesive, and strong material [2] through the curing process. To join high-strength adherents, structural adhesives are increasingly used as an alternative to traditional mechanical joining methods such as rivets, screws, and welding.

Structural adhesives offer several advantages, including application at room temperature, combining bonding and sealing in a single operation, and providing thermal and electrical insulation. They also ensure even stress distribution, a smooth surface appearance, and enhanced resistance to fatigue, vibration, and acoustic damping [3]. Additionally, it is cost-efficient process that allows for a homogeneous distribution of stresses between bonded surfaces under load [4].

A structural adhesive is a substance that joins elements to produce high-modulus, high-strength permanent bonds capable of transmitting structural stresses without losing integrity within design limits [5]. Structural adhesives are widely used in various fields such as aerospace, automotive, electronics, semiconductors, construction, footwear, clothing, and emerging areas like biology and medicine [6].

The main classes of adhesives, categorized by their chemical nature, include epoxy, polyurethane, acrylic, cyanoacrylate (superglue), anaerobic, and high-temperature adhesives [3,4]. Epoxies are the most versatile family of adhesives, known for their excellent adhesion to many substrates and varied properties such as high-temperature resistance, durability, resistance to extreme environments, relatively low curing temperatures (for two-component formulations), ease of use, and low-cost [4,7].

Acrylic adhesives are characterized by their polymerization with acrylate and methacrylate monomers. These adhesives are classified as single component (including anaerobic adhesives, cyanoacrylates, and UV-cured adhesives) or two-component (reactive acrylics). Some notable properties of acrylic adhesives include design flexibility, high strength, fast curing, and tolerating less prepared surfaces [3,4]. They

exhibit excellent adhesion to various substrates, including aluminum, brass, copper, stainless steel, carbon steel, most plastics, wood, glass, asbestos-cement boards, and hardboard [1].

Studies are being conducted to evaluate structural adhesives' thermal and mechanical properties, including acrylic and epoxy-based adhesives. These studies have observed that the adhesive formulation, including its chemical base and hardener, can significantly influence its properties [8-10]. Considering the differences in adhesive properties according to the chemical structure and the presence of additives in the formulation, as noted in the literature, the present study aims to evaluate the influence of the chemical structure of acrylic and epoxy structural adhesives on their thermal and mechanical properties.

Materials and Methods

In this study, the following adhesives were used: Methacrylate: 1 - Adekit A310 from Sika (A1), and 2 - Araldite® F362 from Huntsman (A2); Epoxy: 1 - Betamate™ 2096 from DuPont (E1), and 2 - Scotch-Weld™ DP420 from 3M (E2).

Tensile strength tests were carried out by ASTM D638, using five Type IV test specimens for each adhesive, produced using a poly(tetrafluoroethylene) (PTFE) mold on an aluminum base. The adhesive components were mixed manually and then placed inside the mold. A vibrating system (shaker sieve with a vibration amplitude of 3.5) was used to reduce the number of bubbles when applying the adhesive to the mold. After 24 hours (for acrylics) and 168 hours (for epoxy), the molded specimens were tested on an Emic universal testing machine, Model DL 2000, with Tesc 2000 data processing software and a 10 kN load cell, at a speed of 5 mm/min. DSC analysis was performed using a TA Q10 V9.9 Build 303 device. For all compositions, samples of approximately 7 mg were heated at 10 °C/min from 20 to 150 °C and then cooled to 20 °C to eliminate the initial thermal history.

After that, the samples were heated again from 20 to 150 °C at the same heating rate to determine the glass transition temperature. The analysis was conducted under a 50 mL/min nitrogen gas flow, used as purge and protection gas.

Results and Discussion

Figure 1a shows the curves of the second heating of the adhesives at 10 °C/min, revealing a deviation from the linear baseline corresponding to the glass transition temperature range (Tg). The DSC curves indicate a slight deviation at average temperatures of approximately 99 °C, 108.1 °C, 47 °C, and 76 °C for adhesives A1, A2, E1, and E2, respectively, indicating the glass transition.

Figure 1b shows that, among the adhesives studied, those with an epoxy chemical base exhibited a lower Tg than the acrylic ones. This may be associated with bulky functional groups in the chemical structure of epoxy adhesives. Functional groups that may be present in the structure of epoxy adhesives cured with the reaction of an epoxy resin composed of bisphenol A diglycidyl ether (DGEBA) and 4,4'-diaminodiphenyl sulfone (DDS) include hydroxy, benzene-ether, alkyl, epoxy rings, benzene-NH2, and benzene-amine groups [11]. Bulky side groups limit the proximity of the polymer chains, and the greater the distance between them, the more quickly they can move, increasing the free volume and consequently decreasing the Tg [12].

The two acrylic adhesives studied have similar Tg values. This similarity can be attributed to both adhesives containing a methyl group on the same carbon as the methacrylate group, which increases the rigidity of the polymer chain, thereby increasing Tg [13,14]. Epoxy adhesives, on the other hand, exhibited different Tg values, suggesting that factors beyond chemical composition, such as the use of different hardeners or the presence of additives, can alter the properties of the adhesives. Additionally, Azúa and colleagues noted that an excess of epoxy groups can undergo a homopolymerization reaction initiated by tertiary

Figure 1. a. DSC curves related to the second heating of the adhesives at 10 °C/min; b. Glass transition temperature of the studied adhesives.

(a)　　　　　　　　　　　　　　　　　　　　　　　(b)
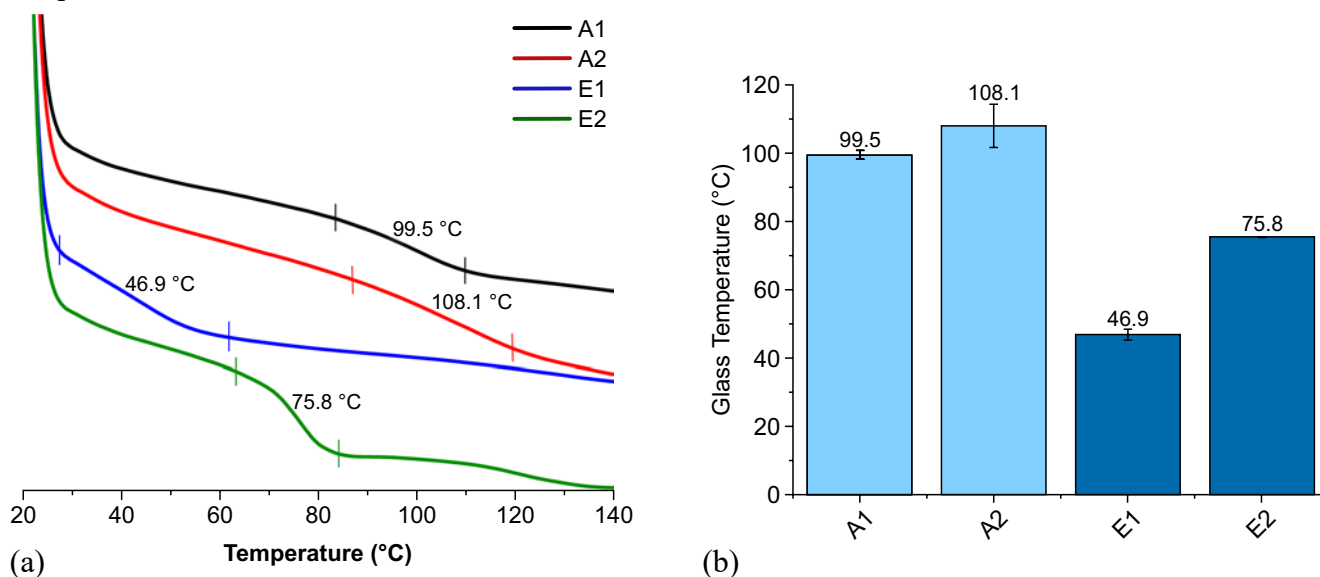
Figure 2. a. Stress x strain curves of the studied adhesives; b. Maximum tensile strength of the studied adhesives.

(a)　　　　　　　　　　　　　　　　　　　　　　　(b)
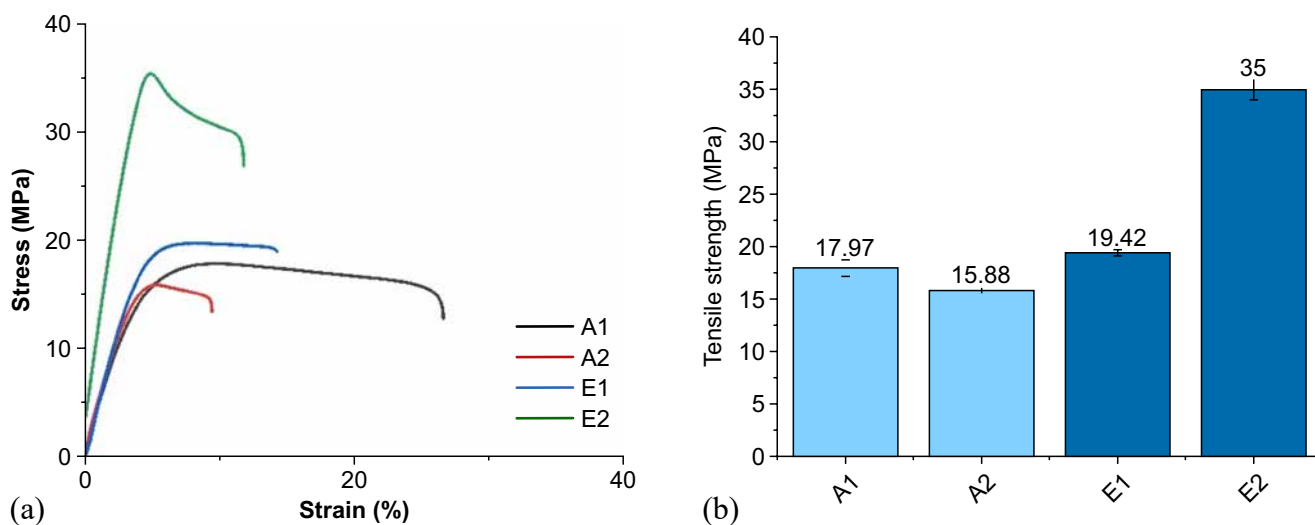
amines at high temperatures, leading to an increase in Tg [14].

Figure 2 shows the curves of (a) stress *versus* strain and (b) the maximum tensile strength of structural adhesives. The maximum tensile strength values of epoxy adhesives were higher than those observed for acrylic adhesives. As noted with the glass transition temperature, the two acrylic adhesives exhibited similar maximum tensile strength values, around 18 MPa and 16

MPa for adhesives A1 and A2, respectively. Since both acrylic adhesives are based on methacrylate, similar thermal and mechanical behavior is expected. If one of the adhesives were an acrylic with an acrylate group, the results would likely be more significant variation. According to Betz [12], the restricted movement of the methyl group provides methacrylate polymers with higher tensile strength and lower elongation percentages compared to acrylate polymers.

Epoxy adhesives, in turn, presented different maximum resistance values, highlighting that the presence of additives and different compositions in the adhesive formulation can also interfere with the properties, with different thermal and mechanical behavior being observed, even for adhesives with the same chemical base.

Conclusion

This study evaluated the influence of the chemical structure on the thermal (glass transition temperature) and mechanical properties (maximum tensile strength and deformation until rupture) of epoxy and acrylic structural adhesives. The results demonstrate that, in addition to the chemical structure, the presence of different additives and hardeners significantly affects the properties of structural adhesives.

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Comparative Study of Analytical and Numerical Methods for Stress Analysis in Screw Thread Fillets

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In structures joined by bolted connections, bolts are the most critical components of the assembly, with thread tearing being one of the most significant failure modes. This work presents an analytical and numerical modeling of the stresses in screw threads using finite element analysis. The results show consistency between the two methods, although simplifications were adopted in this study.
Keywords: Stress in Screw Threads. Numerical Modeling. Finite Elements. Screws.

Screws are vital machine elements used for fastening and connecting mechanical components [1]. Their disassembling ability makes them a preferred choice over welding in many applications. However, screws are often the most vulnerable components in bolted connections [2,3], with thread tearing being one of the most critical failure modes [4]. Therefore, ensuring the reliability of analytical methods for designing bolted joints and calculating the associated stresses is crucial.

According to Norton [5], shear stress (τ) is responsible for thread tearing in screws and can be calculated using the Equation 1. In this Equation, F represents the force applied to the screw, d_r is the internal diameter, p is the thread pitch, and w_i is a factor equal to 0.8 if the screw meets the ISO standard [5].

$$\tau = \frac{F}{\pi d_r w_i \, p} \qquad \text{Eq 1}$$

Budynas and Nisbett [6] proposed that thread tension is composed of normal stresses in two axes, due to screw traction and thread bending, in addition to screw torsion. The bending stress (σ_f) and tensile stress (σ_t) of the screw can be calculated

using Equations 2 and 3, respectively, where n_t is the number of engaged threads.

$$\sigma_f = \frac{6F}{\pi d_r n_t p} \qquad \text{Eq 2}$$

$$\sigma_t - = \frac{4F}{\pi d_r^2} \qquad \text{Eq 3}$$

According to Budynas and Nisbett [6], the stresses in the fillets are distributed in different ways. Experimental tests have shown that the first fillet supports 38% of the load F, the second supports 25%, and the third supports 18%, with the values becoming negligible after the seventh fillet. When using 0.38F as the axial force and considering only one engaged thread, the stress level for the thread-nut combination is at its highest. It is essential to account for these values when calculating the shear stress (Equation 1).

Subsequently, the stresses are transformed into equivalent stress using the Von Mises method, as represented by Equation 4, where σ_1 and σ_2 are usually stresses and τ is the shear stress.

This work presents a comparison between the stress results in screw threads obtained using analytical models, as described by the equations above, and numerical models via finite element analysis.

$$\sigma_{eq} = \sqrt{\sigma_f^2 + \sigma_f \sigma_t + \sigma_t^2 + \tau^2} \qquad \text{Eq 4}$$

Materials and Methods

The analytical and numerical model of the thread stresses of an M16 and a pitch of 2mm with those of a nut were compared. The same material was used for both components. In all models, a traction force of 5000 N was applied. Stress calculations were performed using the methods described by Budynas and Nisbett [6] and Norton [5]. The Von Mises stress was then calculated for each model, considering the load distribution percentages presented by Budynas and Nisbett [6]. Figure 1 represents a finite element analysis, assuming the nut was fixed on the upper face. Structural steel was used, with an elastic modulus of 200 GPa and a Poisson's ratio of 0.3. For the 2D analysis, quadrilateral elements with a size of 0.1 mm were used in the regions of the thread fillets, and the contacts between the threads were defined without friction. Figure 1 illustrates the mesh, the loading, the restriction imposed on the nut, and the path for calculating the average stresses at the root of the fillet. Due to the axisymmetric nature of the analysis, torsional effects were not considered in the model.

Results and Discussion

The finite element simulation results indicated that the stress value successively decreased from the first fillet to the subsequent ones (Figure 2). A path created at the base of the thread (Figure 1) revealed that the first thread fillet had an average stress of 45.513 MPa at its root. This value is consistent with the analytical methods, particularly with the results found using Norton's methodology [5]. Table 1 compares the values obtained by each method. From Table 1, it is evident that the values show low deviations from each other. However, it is essential to note that the simplifications used in this study, such as the absence of friction between the screw and nut threads, can affect the results. While friction was ignored in the present work, some analyses use friction coefficient values between 0.05 and 0.2 [4].

In Figure 2, points of stress concentration are observed due to geometric discontinuities in the modeling of the fillets, leading to a significant increase in stress in these regions. Additionally, using a sufficiently ductile material allowed for stress distribution among the threads, which would

Figure 1. Finite element model.
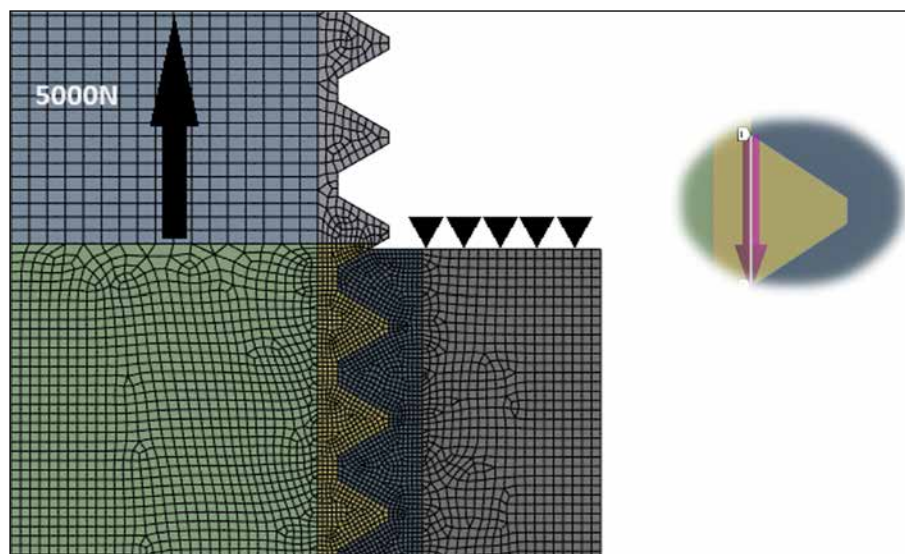
Figure 2. Von-Mises stress field - Scale 230:1.
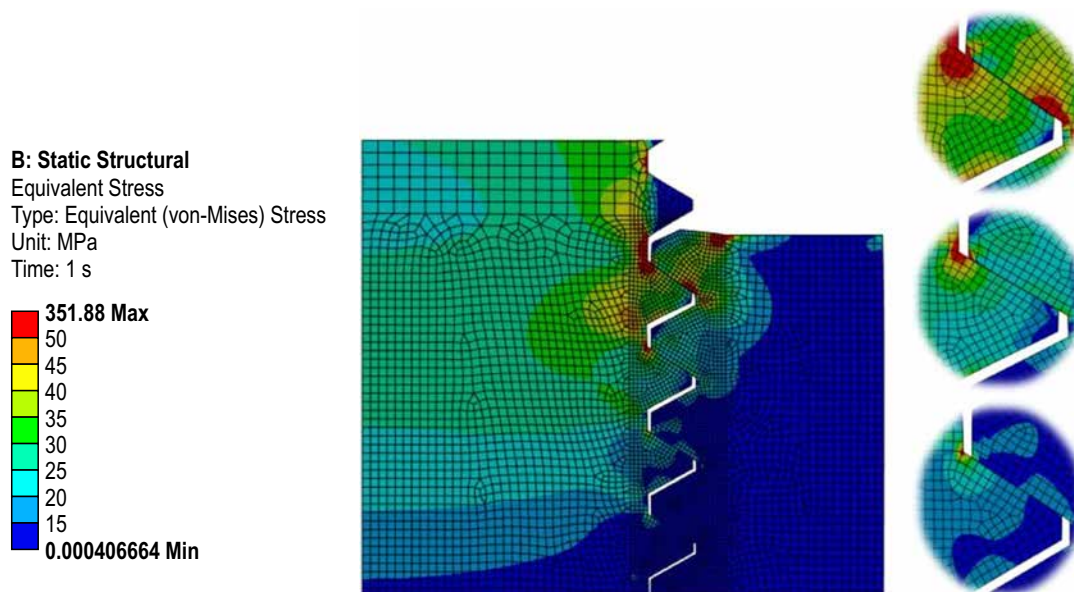
Table 1. Average Von-Mises stress results in the first three fillets.

Method	First Fillet Stress (MPa)	Second Fillet Stress (MPa)	Third Fillet Stress (MPa)
Finite elements	45.513	31.402	19.872
Budynas & Nisbett [6]	51.239	33.7096	24.2709
Norton [5]	47.3393	31.1443	22.4239

not be possible with a brittle material. According to Norton [5], if the material of the nut or screw is very rigid, the stress tends to concentrate on the first thread, while more ductile materials tend to distribute the stress among the threads. The numerical results allowed us to verify the load percentages supported by each fillet by dividing the total contact force by the applied force. The results showed that the first fillet supported 37.4% of the load, the second supported 27.5%, and the third supported 16.8%, consistent with Budynas and Nisbett's findings [6].

Conclusion

The analytical and numerical models used for comparison in this work showed good agreement. However, some simplifications, such as the absence of friction between the threads and geometric discontinuities in the model, affected the results. Using a malleable material allowed the stresses to be distributed across the threads without overloading the first thread fillet. For future work, the effect of friction should be included in the analysis, and small radii should be used at the sharp corners of the thread fillets to alleviate the stress concentrations more accurately.

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Robotic Arm-Aided Non-Destructive Testing Using Eletromagnetic Acoustic Transducers for Thickness Measurement in Industrial Applications

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In the oil and gas industry, expediting inspections of critical components is imperative. Overcoming Nondestructive Testing (NDT) challenges is crucial for forecasting future demand, particularly in difficult-to-reach areas. Within the realm of robot manipulators, modern robots possess desirable qualities for constructing automated NDT systems capable of meeting the demanding specifications of the oil and gas sector. This study introduces an autonomous inspection using a robotic arm with 5 degrees of freedom to assess the effectiveness of nondestructive inspection via an electromagnetic acoustic transducer in plate metal thickness measurement. The enhanced inspection speed and anticipated operational limits for conducting the scan enhance the visualization of various thicknesses.
Keywords: Robotic Arm. Ultrasonic Evaluation. Signal Processing.

The passage elucidates the functionality and significance of robotic arms equipped with 5 Degrees of Freedom (DoF), elucidating their capability to maneuver in diverse directions through interconnected joints. It delineates the utility of 5 DoF robotic arms in conducting nondestructive testing (NDT) via ultrasonic immersion inspection to identify flaws and defects in materials and structures.

Furthermore, it underscores the advancement of industrial robots in manipulating probes with heightened speed and precision compared to alternative NDT techniques. However, it emphasizes the necessity to optimize robotic trajectory to minimize inspection duration and investigates factors influencing the efficiency of robotic scanning motion, including those often overlooked in current methods. In NDT applications utilizing industrial robots, the conventional setup involves securing the specimen while the robot handles the ultrasonic probe and executes operations [1,2].

The article delves into integrating a robotic arm with nondestructive testing utilizing electromagnetic acoustic transducers (EMAT) for thickness measurement in industrial contexts. It delves into the benefits of leveraging a robotic arm for NDT with EMAT technology, enabling non-contact and nondestructive inspection of materials.

Materials and Methods

EMAT Theory and Automated Inspection

In an EMAT setup, a coil generates dynamic electromagnetic fields on the surface of a conductive material, while permanent magnets or electromagnets establish a biasing magnetic field [3,4]. The EMAT operates based on the interactions between these electromagnetic fields within the material, the resulting forces on the body due to the interactions between the electromagnetic and elastic fields, and the computation of the acoustic fields arising from these forces on the component [5-7]. Figure 1 illustrates the behavior of longitudinal and shear ultrasonic waves [3].

The Lorentz force directly impacts the ions within the material, inducing mechanical vibration and potentially generating an ultrasonic wave. When an external magnetic field is applied to a ferromagnetic material, a dimensional change occurs depending on the magnitude and direction

Figure 1. EMAT longitudinal (L-wave) and shear (S-wave) propagation [3].
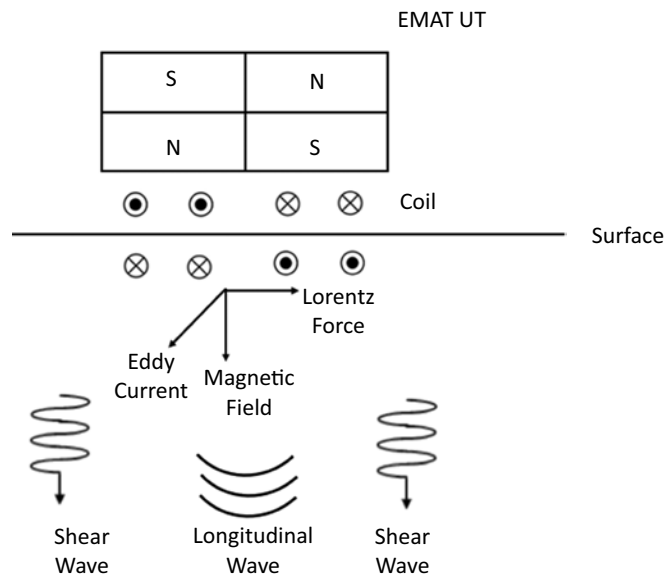
of the field [6,7]. Magnetostriction, the property of ferromagnetic materials to deform in the presence of an external magnetic field, contributes to higher energy conversion efficiency in EMATs based on magnetostriction compared to those based on the Lorentz force [10,11].

The advantage of EMATs lies in their non-contact nature, allowing for continuous operation at high temperatures without requiring physical coupling, sample preparation, or active cooling of the transducer [12-14]. When measuring metal plate thickness, EMATs assess the time interval of the echo signal to determine the plate's thickness. Traditionally, the transit time between two consecutive echoes in an ultrasonic waveform is used as the time-interval value, with signal amplitude and signal-to-noise ratio (SNR) serving as critical indicators of measurement accuracy.

Inspecting defects in specimens with complex surface shapes using traditional manual ultrasonic testing (UT) methods is challenging due to the difficulty in manipulating the probe [15].

However, robotic scanning technology has garnered significant interest due to its enhanced repeatability and accuracy. Robot arms offer the advantage of accessing areas and inspecting geometries impractical for manual methods [16].

Hamidreza and colleagues [17] developed and evaluated a flexible robotic gripper incorporating embedded EMATs within a versatile lizard-inspired tube inspector (LTI) robot. The gripper affixed to a robotic manipulator, was assessed on pipes of varying outer diameters. The system effectively captured transmitted and received signals in the time domain, observing signal amplitude amplification with increased sample diameter.

Furthermore, EMATs were integrated into the robotic ultrasonic system to generate Lamb waves with satisfactory SNR for inspecting tubular components. The system's effectiveness in detecting cracks and corrosion was evaluated through experimental measurements of artificially induced defects.

Experimental Setup

The schematic depicted in Figure 2 illustrates the setup utilized for the nondestructive testing process. The Reach Robotics© Alpha 5 manipulator served as the platform for conducting the tests, employing two types of EMAT transducers from SONEMAT in its end effector: an S-wave 5 MHz center frequency HWS2225GC

Figure 2. Arrangement experimental.

and an L-wave 5 MHz center frequency LW155T. To accommodate each EMAT transducer, a custom gripper was designed with dimensions tailored to the specific requirements of the L-wave and S-wave transducers. The movement of the gripper was controlled using the master arm of the Alpha 5 manipulator.

The EMAT PR500 pulse generator system delivers a 400 V pulse adjusted at a 100 kHz Pulse Repetition Frequency (PRF) to the selected EMAT transducer. Subsequently, the output signal collected by the transducer is digitized by the Tektronix© TDS1102C oscilloscope, which boasts a sampling rate of 4 MS/s and a data length of 20000 samples. To minimize the influence of noise, the received signal undergoes 256-time averaging by the oscilloscope. Ultrasonic signals are collected via a laptop connected to the oscilloscope's USB port, utilizing a data acquisition system for waveform analysis with the designed EMAT. Additionally, the laptop facilitates communication with the robotic arm via the RS232 port of the master arm, allowing control over the position, speed, acceleration, and torque of the Alpha 5 manipulator.

To evaluate the inspection capacity of the EMAT transducer using the Alpha 5 manipulator, an aluminum testing plate measuring 100 x 100 x 10 mm is selected. A comparative analysis will be conducted between the results obtained from the manually performed experiment and those obtained through the described robotic arm experiment.

Figure 3 depicts the analysis flowchart outlining the utilization of EMAT with the robotic manipulator. In this setup, the liftoff distance varies from 0 to 1 mm, aiming to assess the ability to measure thickness without a signal amplifier in the pulser receiver system. One hundred thickness measurements are conducted using this experimental scheme to cover various regions of the aluminum specimen. Mean values and standard deviations are computed to evaluate material thickness.

Results and Discussion

Figure 4 displays the typical received signals of EMATs for L-Wave and S-Wave, respectively. The reflection peaks of the testing block, which will be utilized for thickness measurement, are distinctly visible. These peaks indicate thickness variation in the block and provide crucial information for inspection. Comparatively, when employing the robotic arm inspection technique, the amplitude intensity of the received signals is compatible with manually collected signals.

The utilization of the Alpha 5 robotic arm offers significant advantages in terms of signal intensity and reliability. The robotic arm ensures consistent

Figure 3. Fluxogram to perform EMAT analysis.
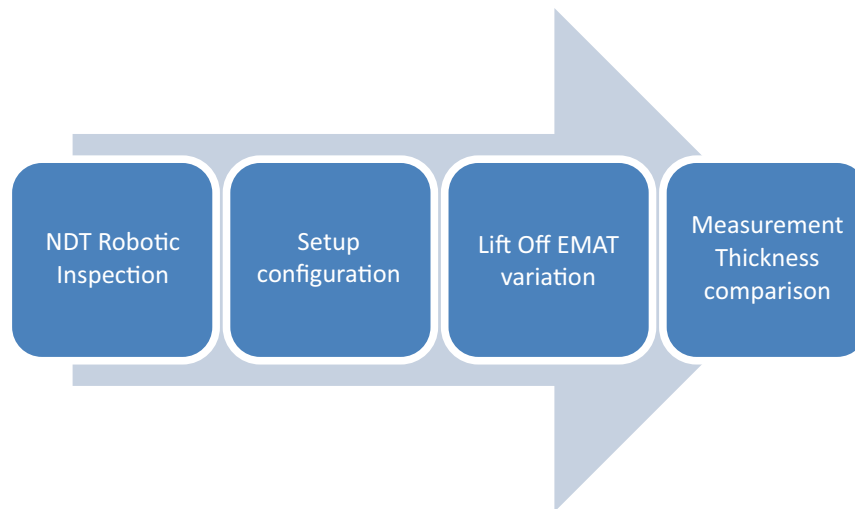
Figure 4. Signal collected comparison for Longitudinal and Shear Waves.
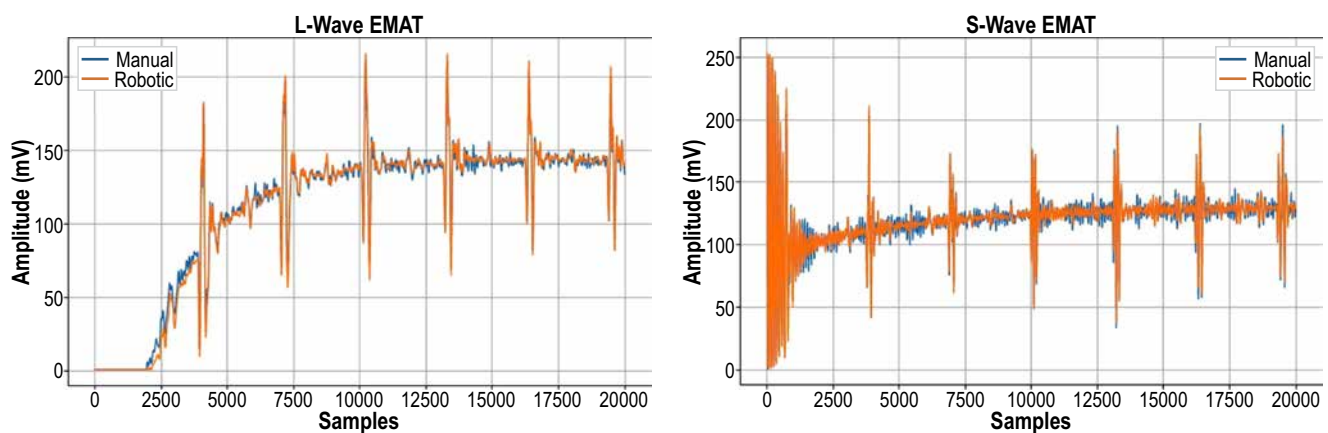
and precise application to the EMAT transducer, producing more robust and pronounced ultrasound signals. These higher signal amplitudes facilitate easier detection and analysis of reflection peaks, enabling more precise thickness measurements. Furthermore, robotic arm inspection with the Alpha 5 diminishes the likelihood of signal distortion or noise interference, leading to more reliable inspection results.

As a result, robotic measurement of plate thickness using EMAT has the potential to yield more accurate results than measurements performed by an operator using identical transducers. Figure 5 depicts a comparative boxplot of the actual thickness values, those

obtained through manual measurements, and those achieved using Alpha 5. The boxplot illustrates that the robotic measurements are more tightly clustered around the actual thickness values, indicating higher accuracy.

The boxplot analysis, employing zero liftoff techniques, provides valuable insights into the suitability of the robotic signals for measuring the thickness of aluminum using nondestructive inspection techniques with EMAT transducers. It allows for observation of the average values and dispersion of the signals, offering crucial information about their effectiveness and reliability.

When examining the average values, we can assess whether they align with the desired

Figure 5. Boxplot for all thickness measurement experiments.
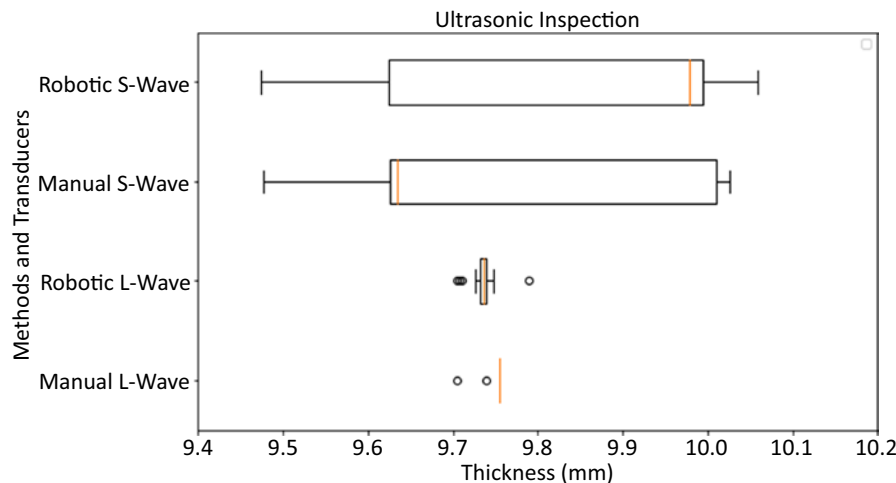
measurement accuracy for aluminum thickness. The boxplot analysis confirms that the average values obtained from the robotic signals fulfill this purpose. The robotic arm demonstrates excellent efficiency and successfully meets the high-speed inspection requirements to capture and measure the thickness of aluminum with the desired precision.

Furthermore, the dispersion of the signals, as depicted in the boxplot, provides an understanding of the variability or spread in the measurements. In the case of the robotic signals, the dispersion is also deemed appropriate for the proposed task, and this implies that the measurements obtained from the robotic arm inspection exhibit consistent and reliable results, as the dispersion falls within an acceptable range.

The analysis of thickness calculation and the corresponding error margin, expressed as a percentage, is presented in Table 1.

The Table 1 offers valuable insights into the thickness measurements obtained using the manual EMAT and robotic approaches. A notable observation is that the manual EMAT technique exhibits a higher error margin than the robotic approach, as evidenced by the error margins in the table. This difference is primarily attributed to the considerable variation in pressure applied during manual EMAT scanning.

Conclusion

This study utilized a 5-degree-of-freedom robot arm to conduct robotic ultrasonic inspection on an aluminum test plate. The outcomes of the robotic inspection were compared against those of manual and passive compliance-based inspection.

Table 1. Margin error % measurement.

Inspection Arrangement		0mm Liftoff		1mm Liftoff	
		Thickness ($\bar{X} \pm \sigma$)	Error margin	Thickness ($\bar{X} \pm \sigma$)	Error margin
Manual	L-Wave	9.57 ± 0.01	-4.3%	10.71 ± 3.33	+7.1%
	S-Wave	9.79 ± 0.70	-2.1%	10.31 ± 0.51	+3.1%
Robotic	L-Wave	9.77 ± 0.01	-2.3%	9.55 ± 0.01	-4.5%
	S-Wave	9.89 ± 0.70	-1.1%	9.79 ± 0.71	-2.1%

The versatility of the robot arm's movements enabled the inspection of complex geometries, while ultrasonic waves facilitated the detection of surface and subsurface discontinuities.

The experimental findings demonstrated satisfactory precision with real-time data collection using a sufficiently high sampling rate, and this facilitated thickness measurement using EMAT in the aluminum test plate. The advancement of path planning software tailored for NDT inspections is anticipated. Moreover, implementing automated metrology solutions is poised to enhance the accuracy of these inspections. The evaluation of integrating a soft robotic gripper end effector will also be a focus of this study.

Furthermore, a mechanism will be developed to ensure the synchronous acquisition of real-time positional data from the robot controller for discrete points with the corresponding ultrasonic flaw echo signals. This mechanism will ensure precise alignment and correlation between positional information and ultrasonic data during inspections.

Acknowledgments

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Market Analysis for Implementing Good Laboratory Practices at the SENAI Institute of Innovation in Advanced Health Systems (ISI-SAS) of SENAI CIMATEC

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Good Laboratory Practices (GLP) comprise a quality system encompassing organizational processes and conditions under which non-clinical safety studies for human health and the environment are planned, developed, monitored, recorded, archived, and reported. The objective of this work was to analyze the market to guide decision-making regarding the implementation of GLP at CIMATEC's ISI-SAS, following NIT-Dicla-035, with a focus on achieving Conformity with the Principles of Good Laboratory Practices recognized by Cgcre of Inmetro. This study showed that the prevalence of Test Facilities in Brazil's South and Southeast regions became evident. Most companies that responded to the questionnaire expressed interest in GLP studies, particularly cytotoxicity. By comparing the requirements of NIT-Dilca-035 with the structure of ISI-SAS, it was determined that implementing GLP in this sector is feasible, leading to the initiation of Good Laboratory Practices implementation in this area.
Keywords: Good Laboratory Practices. Quality. Health. Environment.

The Principles of Good Laboratory Practice (GLP) constitute a quality system encompassing the organizational processes and conditions under which non-clinical studies on human health and environmental safety are planned, developed, monitored, recorded, archived, and reported. Tests conducted by these principles are typically mandated by regulatory bodies for evaluating and registering products such as pharmaceuticals, cosmetics, and genetically modified organisms, among others. GLP principles also benefit research endeavors by ensuring quality, credibility, and relevance in health research, enhancing result reliability, and promoting result efficiency and reproducibility.

In Brazil, the National Institute of Metrology, Quality, and Technology – INMETRO, under the General Accreditation Coordination (Cgcre), is the official entity responsible for overseeing compliance with Good Laboratory Practice Principles (GLP) [1]. Implementing GLP is a crucial strategy to guarantee the quality, reliability, and integrity of data generated in studies or tests. Brazil's

comprehensive adherence through Inmetro's Cgcre to the Organization for Economic Co-operation and Development (OECD) Acts related to Mutual Acceptance of Data (MAD) by GLP Principles encompasses various test item categories, including pharmaceuticals and cosmetics. These categories align with the profile of products developed and tested at the SENAI Institute of Advanced Health Systems (ISI-SAS/SENAI CIMATEC).

ISI-SAS serves as a research, development, and innovation center with a mission to become a leader in developing new health technologies to directly contribute to the technological and scientific advancement of the national industry. Alongside its goal of providing excellent services, combined with the scarcity of recognized laboratories offering services in compliance with GLP standards in Brazil's north and northeast regions, achieving GLP recognition is a priority in ISI-SAS's quest to deliver quality and excellence in its analyses. Therefore, this study aimed to survey service demands requiring GLP recognition and define which tests should be prioritized for initial implementation within ISI-SAS facilities.

Materials and Methods

The method employed for this study consisted of three main phases:

Survey of Recognized Testing Institutions for GLP in Brazil

The survey of test installations was conducted using data from the Inmetro website [2]. Quantitative data were gathered, including percentages by status (Active or Inactive), region, and state in Brazil.

Analysis of Inmetro Standards Associated with GLP

The standards analysis was performed directly on the Inmetro website. Base documents for implementing Good Laboratory Practices (GLP) [1] and documents focusing on the Study Specialty Area designated for implementation were scrutinized. In total, 33 documents were analyzed to define the necessary documents and action plan for GLP implementation.

Market Research for Feasibility Assessment

Market research was carried out through a questionnaire titled "Research on Priority Areas for Recognition in Good Laboratory Practices (GLP)," generated in Forms. The questionnaire was distributed to customers to identify demands for GLP-recognized testing, aimed at boosting production and commercialization of products within the local industry, particularly in sectors such as Pharmaceuticals, Cosmetics, Personal Care Products, Medical Devices, and Biotechnology. Sindusfarma provided publicity support. The results were categorized by area of study specialty: Toxicological Studies, Cytotoxicity Studies, Studies with GMOs, and Others. Each group was further subclassified based on the type of study, and these data were presented descriptively, reporting quantity and percentage.

Results and Discussion

As of March 2024, Brazil boasts 51 recognized test facilities for Good Laboratory Practices (GLP), with 47 of them (92.2%) currently holding active recognition [2]. Geographically, there is a notable concentration of GLP-recognized Test Facilities in the Southeast region of Brazil, accounting for 35 facilities (68.6%) (Figure 1). Specifically, the State of São Paulo stands out within this region with 31 recognized facilities (60.8%) (Figure 2).

Regarding the Specialty Area, it is evident that a significant portion of recognized companies in Brazil (59%) are focused on Waste Studies related to "Pesticides, their components, and similar substances" (Figure 3). This highlights a specific emphasis within the GLP framework on environmental and toxicological studies, particularly in pesticide-related research.

The concentration of GLP-recognized Test Facilities in the Southeast, particularly in São Paulo, aligns with the region's prominence in scientific research and industrial development. It also reflects the strategic positioning of these facilities to cater to the demand for GLP-compliant testing services, especially in areas related to environmental and public health concerns.

Figure 1. Test facilities recognized for GLP by the Brazilian Region.
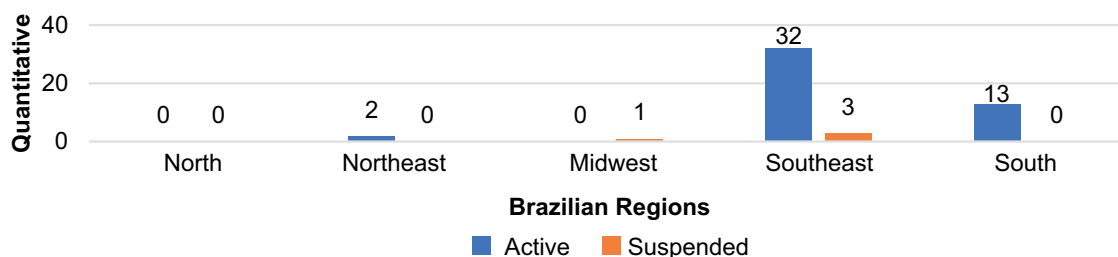
Figure 2. Test facilities are recognized for GLP by the Brazilian state.
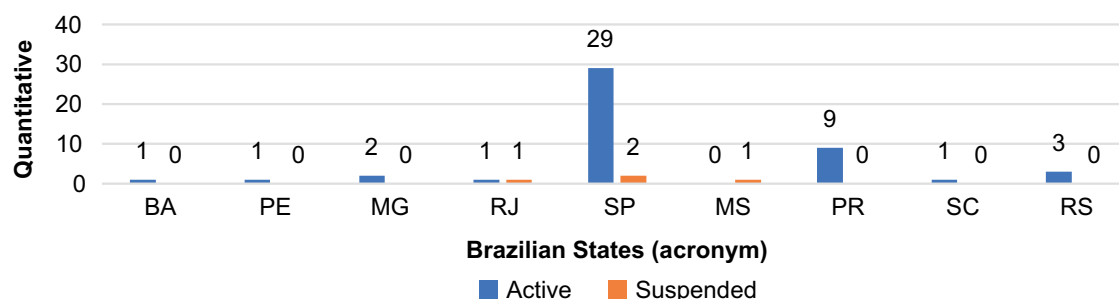
Figure 3. Test facilities are recognized for GLP by the specialty area.
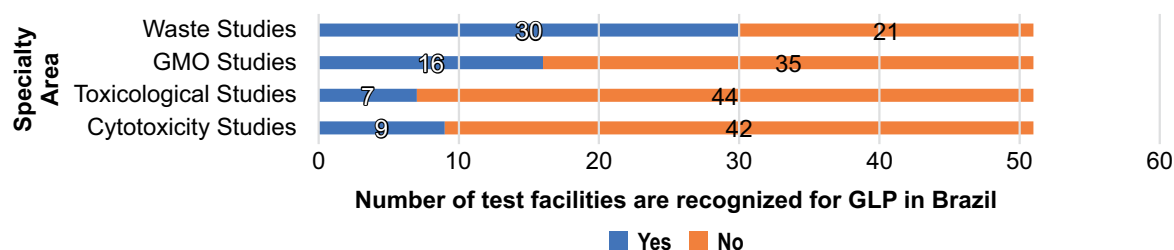
These findings underscore the importance of regional distribution and specialization within the GLP framework, providing insights into the landscape of GLP-compliant testing services in Brazil and guiding strategic decisions for GLP implementation and service prioritization at institutions like ISI-SAS.

Figures 1 and 2 highlight a notable scarcity of recognized Good Laboratory Practices (GLP) services in the North (0%) and Northeast (3.8%) regions of Brazil. Specifically, the Northeast region houses only 2 facilities, both recognized in the "Waste Studies" specialty area for "Pesticides, their components, and similar substances." This indicates a regional disparity in GLP service availability, with a concentration of recognized facilities primarily in the Southeast region. ISI-SAS's strategic specialty areas that align best with its portfolio include Toxicological Studies, Cytotoxicity Studies, and Studies with Genetically Modified Organisms (GMOs). These areas correspond to the core

activities and expertise of ISI-SAS, suggesting a natural fit for GLP implementation and service provision within these domains. Between August and November 2024, responses were collected from twenty customers regarding their GLP demands. Interestingly, most respondents indicated that their primary GLP demands lie outside Toxicological Studies, Cytotoxicity Studies, and GMO Studies—three strategic areas within ISI-SAS's scope. Among these alternative areas, Cytotoxicity Studies emerged as the most recommended (Figure 4). These findings underscore the importance of strategic alignment between GLP service offerings and organizational expertise. Additionally, they highlight the potential for expanding GLP services beyond traditional areas to cater to evolving market demands and capitalize on specialized capabilities within institutions like ISI-SAS.

The second-largest demand identified was for Toxicological Studies (Figure 4). However, it is

Figure 4. Number of partner companies that require GLP testing by recognition area.
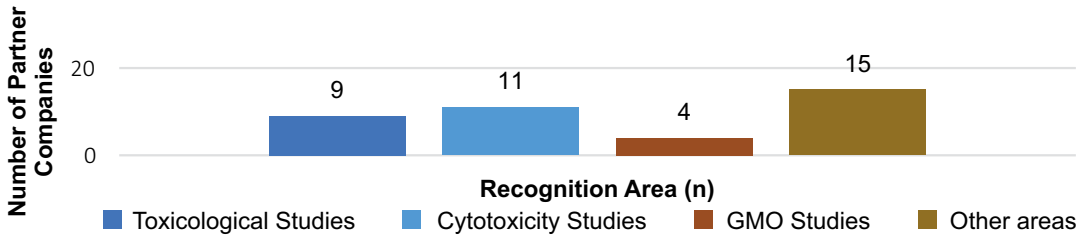
noteworthy that the most selected test within this area, the Assessment of pyrogenic contamination, necessitates REBLAS accreditation. Consequently, it was determined that the implementation of cytotoxicity studies at ISI-SAS of SENAI CIMATEC is justified, driven by both customer demand and the scarcity of this service in the local market.

Following these assessments and a thorough analysis of normative documents related to Good Laboratory Practices (GLP), particularly referencing NIT-Dicla-035 [3], it was confirmed that ISI-SAS possesses the requisite infrastructure and qualified personnel necessary for implementing GLP for Cytotoxicity Studies in this sector. This includes ensuring the maintenance, calibration, and qualification of critical equipment and the preparation, review, and publication of documents to uphold the quality and adherence to GLP principles throughout the study lifecycle, from defining the study plan to disposing of inputs. An action plan has been structured and is currently in progress, with submission for recognition anticipated from mid-2024. However, several challenges have been identified, including the volume of documents to be prepared or reviewed relative to the number of capable employees, adapting shared spaces to GLP principles, instilling a culture centered on quality assurance, and managing the time required to procure inputs and equipment maintenance services. The action plan has achieved 50% completion and is expected to conclude in second half-year 2024.

Conclusion

The analysis conducted in this study revealed a significant need for recognized Good Laboratory Practices (GLP) services in the North and Northeast regions of Brazil, particularly evident in the absence of registered services for Cytotoxicity Studies within these regions. Conversely, there was a notable predominance of GLP-recognized services in São Paulo, accounting for 60% of such services. In light of these findings, the comprehensive analysis undertaken herein has substantiated and underscored the feasibility of implementing Cytotoxicity Studies at ISI-SAS. This strategic decision aligns with market demands, addresses regional service gaps, and leverages ISI-SAS's existing infrastructure and qualified personnel. We extend our gratitude to CNPq for the grant awarded and to Centro Universitário SENAI CIMATEC for their unwavering support in facilitating the implementation of Good Laboratory Practices (GLP) at ISI-SAS, SENAI CIMATEC.

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Hybrid Renewable Energy Systems: An Analysis from the State-of-the-Art Review

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This state-of-the-art review investigates the literature on Hybrid Renewable Energy Systems (HRES) in response to growing global energy demands and climate change concerns. Solar photovoltaic (PV) and wind turbine (WT) systems are pivotal components of HRES, which, when complemented by Battery Energy Storage Systems (BESS), enhance system efficiency by storing and dispatching surplus energy during low-generation periods. An analysis of literature trends reveals a notable surge in HRES research publications, peaking in 2022. Researchers primarily focus on optimizing hybrid systems, emphasizing modeling, sizing, and feasibility assessments. The dominance of Asian countries in HRES research highlights potential applications in off-grid settings within densely populated, remote, and isolated regions. A review of the ten most cited articles from 2019 to 2023 reveals that these publications predominantly discuss the state-of-the-art in HRES. The analysis identifies knowledge gaps, emphasizing the importance of research addressing control strategies, simulation tools, and the feasibility of large-scale hybrid power plants across diverse geographies, particularly in areas with high solar and wind generation potential. This review not only highlights the rapid growth and global relevance of HRES but also serves as an incentive for ongoing exploration, innovation, and collaboration in areas concerning the future of energy.
Keywords: HRES. Hybrid Renewable Energy Systems. Literature Review.

The worldwide energy demand has expanded in recent decades, a trend attributed to socio-economic developments. Energy generation is pivotal in ensuring electricity accessibility and availability to meet this growing demand [1].

Conversely, sustainability concerns have sparked discussions about reducing fossil fuel use for energy generation. Climate change has been a significant driver in adopting renewable energy sources (RES) as the most suitable solution for meeting energy requirements [2].

In 2020, renewable energy accounted for one-third of total power generation worldwide. Notably, RES were the only energy resources that experienced increased demand during the pandemic period [3]

Annual renewable capacity additions increased by 45%, reaching almost 280 GW in 2020. This high-capacity growth became the norm in 2021

and 2022, with RES representing 90% of new power capacity expansion globally [4]. Renewable energies account for approximately 80% of the national energy matrix in Brazil, reflecting the country's significant hydropower, solar, and wind potential [5].

Solar photovoltaic (PV) and wind turbine (WT) systems stand out as the primary RES for practical implementation. These technologies continuously improve for higher efficiency and can be assumed for large-scale applications [6]. Thus, the combined utilization of PV and WT systems represents an up-and-coming option among RES for meeting the growing load demand.

Additionally, the complementary energy generation profiles exhibited by PV, WT, and other RES allow for the construction of Hybrid Renewable Energy Systems (HRES). HRES involves the integration of two or more generation units, offering a solution to the intermittent power supply challenge and thereby increasing power system reliability, resilience, and stability [7].

Battery Energy Storage Systems (BESS) applied in Hybrid Power Plants (HPPs) complement the hybrid arrangement and maximize the energy generated. When the power generated by the

sources exceeds the demand, the excess energy can be stored in BESS and then dispatched into the grid during periods of low generation [3]. Despite the increasing discussion around this configuration, models outside Brazil are the primary references for installing HPPs. European countries, Australia, the United States, China, and India, are highlighted as the primary market players. Table 1 show cases the main projects involving the hybridization of energy sources worldwide [6].

For example, the Kennedy Energy Park in Flinders Shire, Australia, stands as one of the pioneering large-scale hybrid power plants globally. Construction commenced in 2017, and it successfully became operational in 2019. It has an installed capacity of over 60 MW, with 43.5 MW from wind, 15 MW from solar, and 4 MWh of lithium-ion storage.

Drawing on the innovative advances of projects like the Kennedy Energy Park, which has demonstrated the capabilities of large-scale hybrid power plants, this work aims to present a state-of-the-art review of HRES research issues, emphasizing the following aspects:

- Literature publications about HRES: perspective over time;
- The main themes regarding hybrid systems presented in the literature;
- Geographical perspective on scientific content regarding HRES;
- Literature review of principal works on the feasibility assessment of HRES.

Materials and Methods

A state-of-the-art review was chosen to clarify, group, and synthesize the most relevant current knowledge about HRES. Figure 1 summarizes the schematic of the methodology approach used in this study. A framework is proposed for the state-of-the-art review, and the respective findings are presented below.

- Scoping Step: The research strategy was based on the selection of keywords and the use of Boolean operators "AND" and "OR," detailed as follows: ("HRES") AND ("HYBRID RENEWABLE ENERGY SYSTEMS") AND ("HYBRID POWER PLANT" OR "HYBRID

Table 1. Some of the main examples of hybrid power plants in the world.

Location (City - Country)	Wind Power (MW)	Solar Power (MW)	Storage (MW/MWh)	Wind/Solar PV Proportion (%/%)	Company
Parc Cynog - Wales	3.60	4.99	-	42 / 58	Vattenfal
Haringvliet - Netherlands	21.00	31.00	12 / 12	40 / 60	Vattenfall
Kavital - India	50.00	28.80	-	63 / 37	Hero Futures Enery & Siemens Gamesa
Flinders Shire - Australia	43.00	15.00	2 / 4	74 / 26	Wind Lab & Eurus Energy
Pelica Rapids (MN) - United States	5.00	0.50	-	90 / 10	Juhl Energy
Ollague - Chile	0.30	0.21	0.3 / 0.8	59 / 41	Enel Green Power
Tilos - Greece	0.80	0.16	0.8 / 2.4	83 / 17	H2020 Research Consortium
Graciosa - Portugal	4.50	1.00	6.0 / 3.2	81 / 19	Younicos
La Muela - Spain	0.85	0.25	0.4 / 0.5	78 / 22	Siemens Gamesa

Figure 1. Method approach (Adapted from Babatunde and colleagues [1])
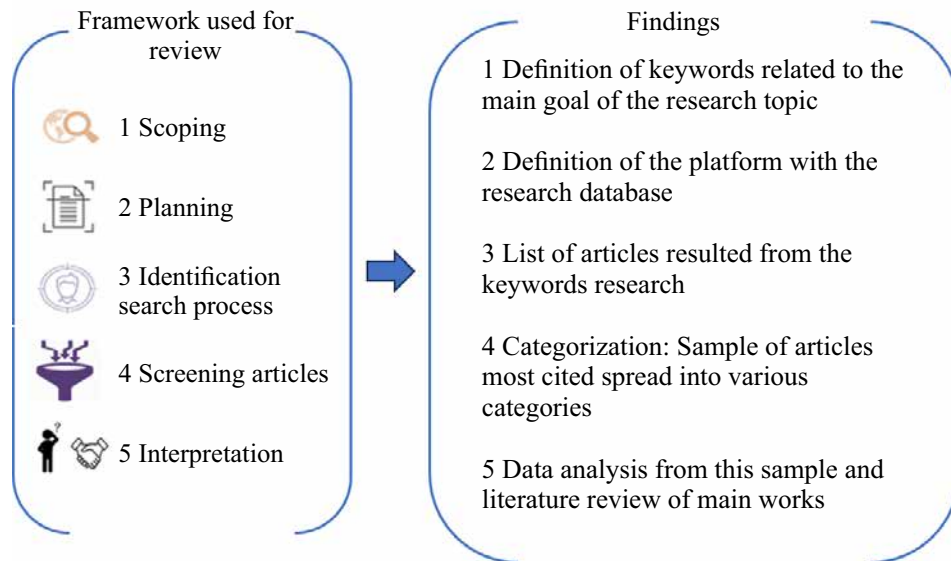
POWER SYSTEMS"). This research aimed to identify the main general works on the theme from various nonrestrictive perspectives, such as control, modeling, simulation, feasibility, and others.

- Planning Step: Dimensions AI was chosen as the research database platform. Dimensions is an artificial intelligence platform that provides a search tool for linked research databases covering publications, grants, patents, datasets, policy documents, and technical reports [7].

- Identification Step: The number of works resulting from the keyword search was accounted for. The platform returned a list of publications that could be ordered, analyzed, and downloaded to compose a literature review on the research topic.

- Screening Articles Step: The chosen platform allowed the download of 500 works organized by ranking based on the number of citations. Therefore, this study considers the first 500 articles from the research results.

- Interpretation Step: The downloaded sample was analyzed from various perspectives: number of publications over time and by source titles, number of citations for each source, and geographical perspective of the most cited publications.

The research aimed to answer the question: What is the current literature discussing hybrid renewable systems? We proposed segregating the results into distinct categories to complement the analysis of our results (Table 2). The words related to each category were searched in the content of the title of each paper. A literature review was conducted, highlighting the ten most cited works from the last five years, from 2019 to 2023.

Results and Discussion

Applying this research strategy to Dimensions AI returned 1923 publications, including articles, thesis, dissertations, and technical reports, among others. As the first result of the analysis of HRES literature, Figure 2 illustrates the number of publications in each year from 2015 until 2023. This graph shows an expressive rise in the literature discussion about hybrid systems after 2019, reaching a peak in 2022. The results for 2024 are still non-expressive because these data were taken in January of this same year. In addition to understanding when the topic began to gain volume in publications, it is essential to understand the primary source titles discussing the theme. Figure 3 demonstrates the relationship

Table 2. List of categories chosen to represent the main themes regarding HRES.

Categories (CAT)							
1	2	3	4	5	6	7	8
Optimize	Sustainability	Assesment	Control	Sizing	Review	Simulation	Management
Optmization	Sustainable	Feasibility		Design	State-of-the-art		Operation
Optimization		Assessing		Size	Overview		
Optimal		Techno-economic		Model			
		HOMER					
		Cost analysis					
		Techno-economic					

Figure 2. Number of publications in each year within the scope of HRES [7].
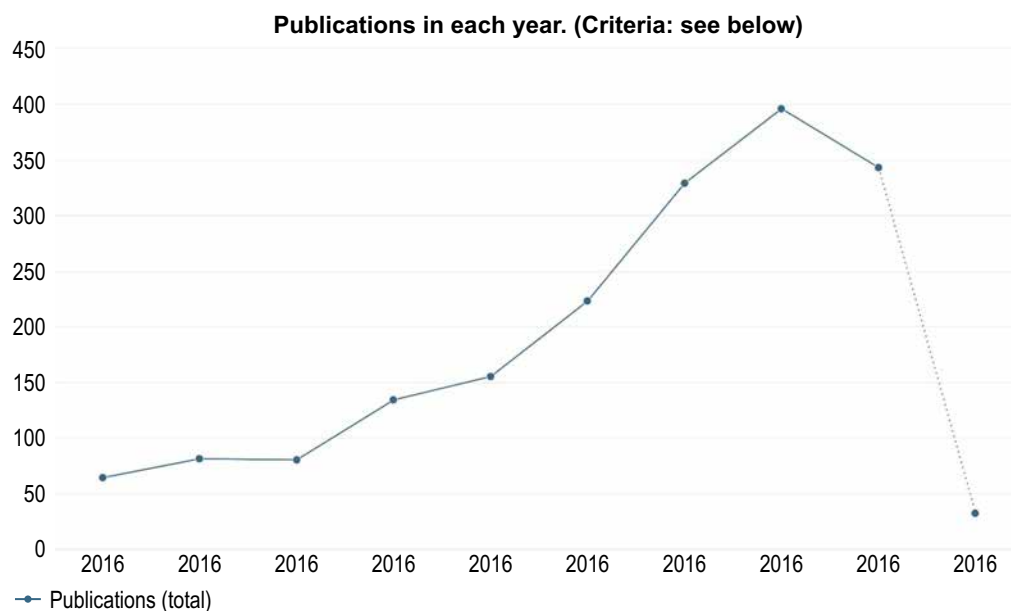
between source titles and citations about hybrid renewable energy systems. Publication citations are the number of times other publications in the database have cited a publication. Citing publications can be of any type, such as articles, chapters, preprints, or monographs. The results show that the journal Energies from MDPI has the most publications about HRES from the Dimensions database. However, the most cited journal regarding hybrid technologies and applications is the Renewable and Sustainable Energy Reviews from Elsevier. Moreover, from the total number of publications, the following analysis considered only the number of articles produced, which totaled 1,383 registers, excluding other types of scientific productions.

The sample of 500 works exported from Dimensions AI was categorized into different themes, presented in Table 2, returning the number of articles for each category, as shown in Table 3 for each category

Figure 3. Source titles and citations related to the top 10 journals obtained from the search.
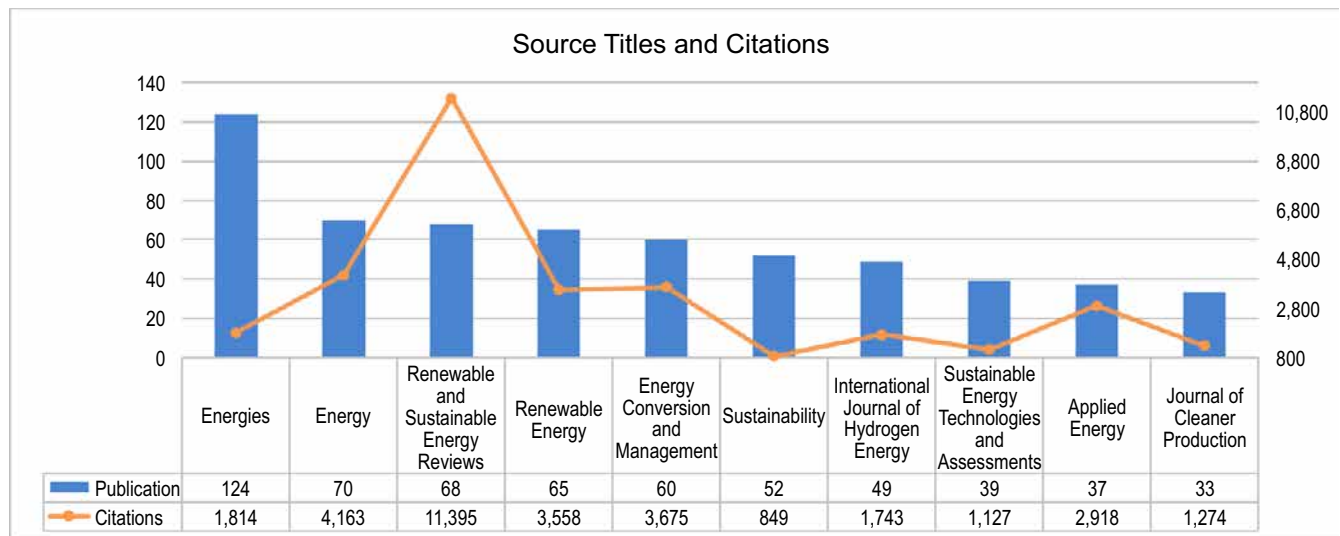
Table 3. Number of articles found about HRES.

Results by categories	
CAT 1	241
CAT 2	22
CAT 3	115
CAT 4	45
CAT 5	182
CAT 6	83
CAT 7	7
CAT 8	66

We concluded that researchers are prioritizing studies about the optimization of hybrid systems, followed by sizing and modeling the design of the plant and its equipment. The feasibility assessment is also an essential study in understanding the techno-economic aspects of the project. There is a lack of studies about simulation tools, and the results for control strategies suggest that this theme can be explored more. Although these works explore renewable energy sources, researchers do not associate the title of their works with sustainability. This shows that authors prioritize technical aspects over environmental approaches when discussing hybrid systems. Despite HRES being affordable for any country, especially the ones with high solar and wind potential, it is evident that Asian countries have more scientific production about the theme. Table 4 lists the ranking of the 10 countries with the most articles produced, of which the first 5 are from Asia.

The expressive participation from Asian countries can be explained by the fact that 60% of the world population is from Asia, and more than half of them live in rural and remote areas. In this case, HRES projects can be applied in an off-grid arrangement to supply the population's energy needs without the necessary infrastructure investment to connect the HPP to the electrical grid [8]. Understanding the financial resources applied to this type of project is fundamental to evaluating

Table 4. Number of publications about HRES for each country.

Country	Publications
India	79
China	58
Iran	37
Malaysia	31
Saudi Arabia	28
Spain	21
Egypt	18
Australia	17
Morocco	14
United States of America	14

the feasibility of the HPP implementation. When solar and wind generation are applied separately, it is usually necessary to increase the installation size when compared to using a hybrid combination of both to supply the same demand. Thus, the HRES can improve reliability and performance, and decrease generation fluctuation and investment costs [9].

To better understand the principal topics of study about HRES that contributed to the increase in publications after 2020, Table 5 presents a list of the 10 most cited articles of the last 5 years, from 2019 to 2023.

With the analysis of Table 5, it is possible to observe a certain balance among categories 1, 3, 5, and 6, with CAT6 containing four of the top five most cited articles. This is explained by the need for access to the literature review and state-of-the-art references in developing large projects involving various themes of HRES. Among these CAT6 articles within the top five, it is worth noting some that review methodologies for sizing and optimization of HRES, which are the main themes of CAT1 and CAT5, respectively.

For CAT3, different evaluations and case studies involving various software tools such as HOMER and MATLAB were conducted among the articles in the table. As for CAT1, different optimization methodologies (e.g., PSO, genetic algorithms) were applied and reviewed.

Conclusion

This state-of-the-art review has comprehensively explored the scientific scenario of HRES studies. Notably, 2020 represented a significant milestone, with renewable energy contributing one-third of total power generation worldwide. This rise in implemented generation projects is reflected in a substantial increase in HRES research publications, achieving a peak in 2022 until now.

Solar and wind technologies' complementary energy generation profiles make them an ideal pair within hybrid renewable systems. Integrating a BESS further enhances the efficiency and reliability of HRES, allowing for the storage and dispatch of excess energy during periods of low generation.

The analysis of literature trends shows that researchers predominantly focus on optimizing hybrid systems, followed by sizing and modeling, with feasibility assessments playing a crucial role in understanding the techno-economic aspects. The top countries contributing to HRES research are predominantly from Asia, emphasizing the potential for off-grid applications in populous regions.

The literature review of the ten most cited articles from 2019 to 2023 encompasses studies of state-of-the-art, the use of tools such as HOMER

Table 5. List of the 10 most cited articles from 2019 to 2023.

Title	Year	Authors	Keywords	Source	DOI	Study Type	Categories
A review on recent sizing methodologies of hybrid renewable energy systems [10]	2019	Lian, Jijian; Zhang, Yusheng; Ma, Chao; Yang, Yang; Chaima, Evance	Hybrid renewable energy system; Renewable energy source; Classification Evaluation indicator; Sizing methodology; Software tool	Energy Conversion and Management	10.1016/j.encomma n.2019.112027	Literature review; mathematical approach	CAT5, CAT6
Reliability, economic and environmental analysis of a microgrid system in the presence of renewable energy resources [11]	2019	Adefarati, T.; Banasal, R.C.	Economic; Emission; Environment; Microgrid; Reliability	Applied energy	10.1016/j.apenergy .2018.12.050	Literature review; Case Study; mathematical approach	CAT3
Uncertainty models for stochastic optimization in renewable energy applications [12]	2020	Zakaria, A.; Ismail, Firas B.; Lipu, M.S. Hossain; Hannan, M.A.	Stochastic optimizations; Uncertainty model; Scenario generations; Renewable energy applications	Renewable Energy	10.1016/j.renene.2 019.07.081	Literature Review; Optimization models for renewable energy applications	CAT1, CAT6
Solar and wind power generation systems with pumped hydro storage: Review and future perspectives [13]	2020	Javed, Muhammad Shahzad; Ma, Tao; Jurasz, Jakub; Amin, Muhammad Yasir	Pumped hydro storage; Solar-hydro energy storage; Wind-hydro energy storage; Hybrid renewable energy systems; Hybrid storage	Renewable Energy	10.2016/j.renene.2 019.11.157	Literature review; Future perspectives	CAT6
Battery energy-storage system: A review of techologies, optimization objectives, constraints, approaches, and outstanding issues [14]	2021	Hannan, M.A.; Wali, S.B.; Ker, P.J.; Rahman, M.S. Abd; Mansor, M.; Ramachandar amurthy, V.K.; Muttaqi, K.M.; Mahlia, T.M.I.; Dong, Z.Y.	Battery energy-storage system; Sizing; Optimization algorithm; Objective functions; Constraints	Journal of Energy Storage	10.1016/j.est.2021. 103023	Literature review; Optimization of BESS	CAT1, CAT6
Environmental and economic multi-objective optimization of a household level hybrid renewable energy system by genetic algorithm [15]	2020	Mayer, Martin János; Szilágyi, Artúr; Gróf, Gyula	Renewable energy production; Hybrid energy system; Life-cycle assessment; Multi-objective optimization; Genetic algorithm	Applied Energy	10.1016/j.apenergy .2020.115058	Optimization of HRES; MATLAB simulation; Literature review	CAT1, CAT6
Integrated sizing of hybrid PV-wind-battery system for remote island considering the saturation of each renewable energy resource [16]	2019	Ma, Tao; Javed, Muhammad Shahzad	Solar-wind-battery system; Renewable energy saturation; Cost of energy Energy balance; Net present cost; Hybrid Renewable system reliability	Energy Conversion and Management	10.2016/j.encomma n.2018.12.059	Case study; Mathematical approach	CAT3, CAT5
Techno-economic analysis of a hybrid renewable energy system for an energy poor rural community [17]	2019	Krishan, Om; Suhag, Sathans	Wind energy conversion system (WECS); Photovoltaic (PV) system; Battery energy storage system (BESS); Techno-economic analysis; Hybrid renewable energy system (HRES)	Journal of Energy Storage	10.2016/j.est.2019. 04.002	Case Study; Homer and MATLAB simulation;	CAT3
Feasibility analysis and techo-economic design of grid-isolated hybrid renewable energy system for electrification of agriculture and irrigation area: A case study in Dongola, Sudan [18]	2019	Elkadeem, M.R.; Wang, Shaorong; Sharshir, Swellam W.; Atia, Eman G.	Hybrid renewable energy; Techno-economic optimization; Carbon emissions; Net present cost; Sensitivity analysis; HOMER Pro®	Energy Conversion and Management	10.1016/j.encomma n.2019.06.085	Case Study; Literature review of existing HRES; HOMER simulation;	CAT3, CAT5
Potential, optimization and sensitivity analysis of photovoltaic-diesel-battery hybrid energy system for rural electrification in Algeria [19]	2019	Fodhil, F.; Hamidat, A.; Nadjemi, O.	Hybrid renewable energy system; Photovoltaic; Diesel; PSO optimization; Rural electrification	Energy	10.1016/j.energy-2 018.12.049	Case study; HOMER simulation; literature review of optimization methods	CAT1, CAT3, CAT5

to optimize strategies, and the relevance of sizing methodologies to implement hybrid systems. In this work, it is noteworthy that many literature reviews and state-of-the-art articles suggest the necessity of such materials for research and development involving HRES.

Furthermore, it is fundamental to recognize the global significance of HRES and bridge the knowledge gaps identified in this review. Future research investigations should explore control strategies and simulation tools and address the feasibility of large-scale hybrid power plants in diverse geographical contexts.

In essence, this review not only underscores the rapid growth and global relevance of HRES but also motivates continued exploration, innovation, and collaboration in pursuing a sustainable and resilient energy future.

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Using Motor Imaging and Deep Neural Networks for Knee Osteoarthritis (OA) Diagnosis: A State-of-the-Art Approach

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Knee osteoarthritis is a degenerative condition affecting the knee joints. It occurs when the cartilage covering the joint surfaces of the knee progressively wears away, leading to pain, swelling, stiffness, and loss of function in the affected knee. Cartilage, a smooth and tough tissue, is a shock absorber between bones and enables smooth joint movement. With time, factors such as aging, overuse, or prior injuries can contribute to cartilage deterioration, thus increasing the risk of knee osteoarthritis development. Accurately diagnosing knee osteoarthritis (OA) can be time-consuming, given that several other conditions share similar signs and symptoms. This study aims to expedite the diagnosis of knee OA by leveraging motor imagery patterns detected through electroencephalogram (EEG) analysis using deep learning techniques.
Keywords: Knee Osteoarthritis. Motor Imaging. Electroencephalogram (EEG). Deep Gearning.

The primary risk factors for developing knee osteoarthritis (OA) encompass aging, a family history of the disease, previous joint injuries, obesity, excessive or inadequate physical activity, and certain medical conditions like rheumatoid arthritis. Symptoms of knee osteoarthritis can vary, including pain exacerbated by physical activity, swelling, stiffness, crepitus (creaking or popping) during knee movement, muscle weakness, and limited range of motion. Over time, knee OA can significantly impact quality of life, impairing everyday activities such as walking and stair climbing. Diagnosis typically involves a comprehensive clinical examination, detailed medical history review, X-rays, and, occasionally, other imaging tests such as MRI [1].

The primary objective of this study is to explore, develop, and assess a diagnostic tool utilizing motor imagery and deep neural networks (deep learning) for knee OA diagnosis. Specific aims include digitizing, studying, and organizing EEG databases of individuals with and without OA pathology into a user-friendly format.

Subsequently, the study aims to create and simulate a model representing the system and, ultimately, to test, evaluate, refine, and assess the accuracy of the proposed model for OA diagnosis. Recent research suggests that electroencephalography (EEG) is emerging as a potential tool for chronic pain analysis, particularly in rheumatic diseases like osteoarthritis. Studies conducted by Pinheiro and colleagues (2016) [2] indicate that evaluating EEG characteristics during wakefulness, a period of complete rest, reveals EEG slowness associated with chronic neuropathic pain. Additionally, theta and alpha bands exhibit higher absolute density in patients with chronic pain than in healthy individuals, suggesting discernible patterns that can be used for diagnostic purposes.

Further investigations, such as the study by Luft & Andrade (2006) [3], delve into motor imagery, the mental visualization of movement without actual muscle activation, captured via EEG. Their findings demonstrate cortical activation in premotor and motor brain areas during motor imagery, offering a non-invasive means to diagnose severe pain in structures like skeletal muscles without inducing movements that could exacerbate the issue.

Building upon these studies, we propose the following hypothesis: Can artificial intelligence classification techniques identify patterns in EEG

signals of individuals with knee osteoarthritis solely through motor imagery of contraction and relaxation in the affected area?

Given the significance of technologies facilitating early disease diagnosis and the economic and social importance of studies in this field, this research aims to enable diagnosis through comparative analysis. Specifically, it seeks to establish a model to estimate the probability of knee osteoarthritis (OA) based on electroencephalogram (EEG) signal patterns and motor imagery in groups of individuals with and without the condition.

Materials and Methods

The electroencephalogram (EEG) records the brain's electrical activities over time. These activities generate low-intensity fields captured and recorded by electrodes placed on the scalp. Protocols have been developed to standardize electrode placement for EEG signal capture. In this study, the International 10-20 System protocol was employed. This protocol utilizes 20 points marked on the skull, dividing it into proportions of 10% or 20% of the distances between reference points: Nasion and Inion in the medial plane (Figure 1a) and pre-auricular points in the perpendicular plane to the skull (Figure 1b) [4].

The lobe beneath each electrode is identified by a nomenclature consisting of a maximum of two letters and a number or another letter to identify its hemispheric position [5]. Table 1 details each point of the electrodes.

The data has been digitized, processed, and formatted into spreadsheets at this research stage. Each file has been appropriately tagged for submission to the deep neural network (deep learning) CNN, which is currently under development. Regarding hardware and software, the research employs an I7 processor with 64 GB of RAM and an RTX 4070 TI graphics card (GPU) with 12 GB of RAM, utilizing a 7680 CUDA 192-bit GDDR X type. The software utilized includes Matlab, the Anaconda platform with Python, and its libraries, such as Tensorflow and Keras.

Theoretical Framework

To identify gaps in the intersection of knee osteoarthritis (OA) and deep learning, a comprehensive search was conducted on Google Scholar using keywords such as "Knee Osteoarthritis," "Deep Learning," and "Convolutional Neural Network." Initially, the search yielded 751 articles, and upon adding "motor imagery" to the search terms, no relevant results were found. From the initial search, three significant articles were selected as the basis for the research. Table 2 provides a summary of these critical articles.

Therefore, the decision was made to further explore the research on knee osteoarthritis (OA) through motor imagery, which emerged as a notable gap in this study.

Conclusion

We aim to present a model capable of diagnosing the pathology of osteoarthritis (OA) with a high level of probability using a patient's EEG data.

Acknowledgments

Table 1. Points in the 10-20 pattern.

Points	Represented Area
Fp	Frontal polar
F	Frontal
T	Temporal
C	Central
P	Parietal
O	Occipital
z	Midline
Numbers	Odd numbers on the left side of the midline, even numbers

Figure 1. Different perspectives of the international standard 10-20 for electrode positioning.
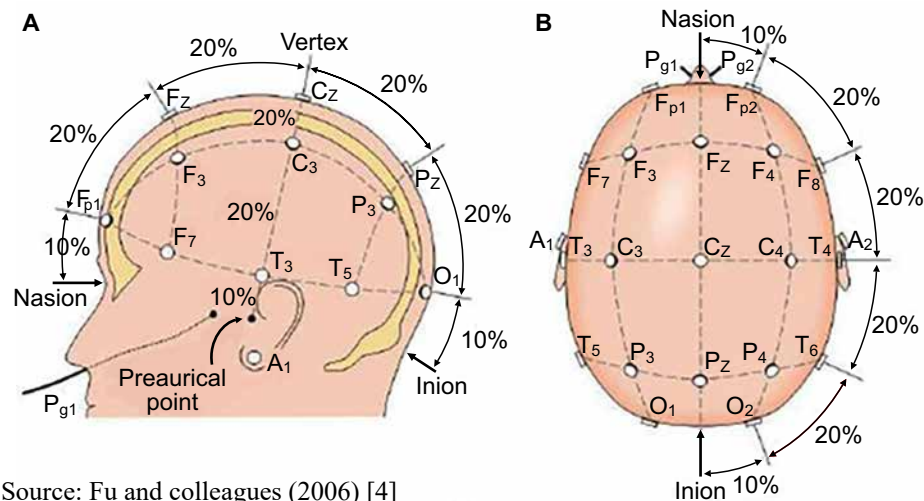
Source: Fu and colleagues (2006) [4]

Table 2. Relevant articles.

Publication	Year	Method
Knee osteoarthritis severity prediction using an attentive multi-scale deep convolutional neural network [6]	2024	X-ray analysis through CNN
Emergence of deep learning in knee osteoarthritis diagnosis [7]	2021	Using of 2D and 3D magnetic resonance imaging with DL
Imaging studies on OA research between January 2019 and April 2020: models of early knee OA, structure modification in established OA, deep learning approaches in image analysis [8]	2021	MRI, X-ray (plain radiography)

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Word Generation Interventions for Individuals with Aphasia: A Systematic Review

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Aphasia is a disorder that affects a person's ability to communicate, compromising their ability to understand or express themselves. Although aphasia rehabilitation aided by computerized tools already exists, there are gaps in this area. This study aims to conduct a literature review to understand the current state of technology supporting the treatment of aphasia and to identify areas that still need to be explored, focusing mainly on tools with game characteristics and those that stimulate word generation. The review was conducted using the Capes and Scopus databases, searching for articles published in the last 20 years. The analyzed studies reveal the effectiveness of computational support in treating aphasia; however, few studies address this subject for Portuguese-speaking individuals with aphasia.
Keywords: Aphasia. Rehabilitation. Word Generation. Gamification.

Aphasia is a disorder that compromises a person's ability to communicate. The primary causes are strokes and other brain traumas, but any abnormal condition affecting the brain areas related to language can cause aphasia [1]. The specific brain region affected determines the type of aphasia in the patient. Damage to the front part of the brain results in difficulty expressing oneself, associated with Broca's aphasia, while damage to the rear area impairs comprehension, associated with Wernicke's aphasia [1]. In response to the injury, language functions may be migrated to other brain areas [2].

A speech therapist typically monitors aphasia treatment and employs various tools to exercise the patient's brain functions. The intensity of the treatment is a crucial factor for its effectiveness, with a minimum of 8 hours per week being ideal. However, achieving this intensity in a hospital setting is often challenging [2]. To enhance treatment intensity, the use of computers and mobile technologies has become a well-accepted alternative, even among patients who were not previously familiar with such devices [2]. This study aims to analyze the current state of technology regarding computerized support for the rehabilitation of aphasic patients by conducting a systematic review of the available literature.

Materials and Methods

The systematic review was conducted from October to December 2023 using the Capes and Scopus databases. The search string was carefully assembled and refined to yield results aligned with the study's objectives, covering the last 20 years (2003 to 2023). The search string used was:

TITLE-ABS-KEY (((aphasia AND (rehabilitation OR {serious game} OR {word generation}))) AND app)) AND (EXCLUDE (SUBJAREA, "ARTS")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Portuguese")).

This search returned a total of 30 articles. Articles not available for full reading online and those not associating aphasia rehabilitation with the use of computer technologies were excluded. After this filtering process, 11 articles were selected for detailed reading and analysis.

Results and Discussion

From the literature review, the study developed by Elien de Cock stands out [3]. Conducted between September 2018 and December 2019, the study observed 25 aphasic patients from Ghent

University Hospital in Belgium using tablets containing STAPP, an online application for speech treatment in Dutch-speaking patients. The objective was to verify the application's viability and acceptability to support patient rehabilitation.

Among the patients, 36% reported having no prior experience with mobile devices, and 32% had no experience with computers. Despite this, the study revealed a high acceptance rate, with an average satisfaction rate of 91%. This high acceptance indicates that technological support in treatment is well-received among patients, even those unfamiliar with the devices. However, it is essential to investigate potential differences in acceptance among Brazilian patients, considering the cultural and technological differences between countries.

Positive results were also observed in the research by Karen Mallet [4], where 30 stroke patients, with an average age of 69, participated in tablet therapy aimed at better understanding their perspective on the treatment. The tablets were loaded with applications selected by the doctors based on each patient's needs. The patients in this study were more familiar with technology, with 43% reporting average knowledge of computers.

The results showed a positive response to tablet treatment despite difficulties in use. While 71.4% needed help using the tablet, 64.3% expressed interest in continuing to use the tablet even after being discharged from the hospital. In her study, Gail Ramsberger [5] followed three patients with different types of aphasia. One of the patients was a 33-year-old woman with severe speech and writing impairments due to aphasia. During the evaluation period, she used an application to convert speech to text for writing messages. The patient would then correct errors in the message using her speech until she was satisfied with the results. In just two sessions, the patient achieved a basic level of competence in communication and could produce an email. This study demonstrated the effectiveness of non-specific mobile applications for treating aphasia in helping aphasic individuals improve their communication skills.

Conclusion

The analysis of the articles reveals that computers and mobile applications are viable tools for supporting the traditional treatment of aphasia when accompanied by a professional. There is also a gap in the use of these technologies in Portuguese, which is crucial when dealing with a language disorder. Based on the results of this review, a support base for the development of interactive technology is expected to be generated that aids in the training of word generation for aphasic individuals. For instance, gamified applications could introduce a playful aspect to the treatment, enhancing patient engagement and effectiveness.

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Technologies for Monitoring Fatigue in Workers:
A Human-Centered Approach in the Construction Industry Context

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The article delves into the imperative of adopting a human-centered approach to safeguard the well-being and performance of workers, with a particular focus on civil construction—an industry emblematic of conditions necessitating heightened attention to occupational health and safety. In this context, the study advocates for a systematic review leveraging the optimized BiLi method (Bibliographic and Literary Review Method) to scrutinize the monitoring and diagnosis of fatigue—a pervasive concern impacting worker welfare and productivity. Through meticulous execution of the BiLi method, the research culminated in identifying 10 pertinent articles predominantly elucidating physical fatigue alongside insights into factors contributing to mental fatigue. The study underscores the pivotal role of heart rate monitoring facilitated by wearables in expediting the early detection of fatigue—a pivotal metric for preemptive intervention and mitigation strategies. Furthermore, the review underscores the salience of gauging brain electrical activity and assessing sleep quality as pivotal indicators, offering comprehensive insights into the multifaceted dimensions of fatigue management in occupational settings. By synthesizing these findings, the study contributes substantively to the discourse on worker well-being. It underscores the urgency of adopting proactive measures to mitigate the deleterious effects of fatigue in the workplace, thereby fostering an environment conducive to optimal performance and sustained occupational health.
Keywords: Construction Worker. Fatigue. BiLi Method. Heart Rate.

The human-centered approach has emerged as a pivotal discourse in discussions surrounding the future of manufacturing systems [1]. By fostering collaboration between technology and workers, this approach endeavors to augment technical capabilities while cultivating safer, more inclusive, and healthier working environments. Traditionally, worker behavior within industrial settings has been perceived as static, primarily focusing on physical interactions and often overlooking emotional and physiological factors [2]. However, there is a growing imperative to recognize humans as dynamic elements within industrial systems, particularly in light of the burgeoning concept of Industry 5.0. This paradigm shift signifies a transition toward sustainable societies prioritizing human-centered actions and resilient production systems [3]. Within the construction industry—a sector renowned for its representative role in catalyzing a paradigm shift concerning workers—the challenges are particularly pronounced. Construction workers frequently contend with occupational hazards, enduring high levels of physical and mental strain during task execution, jeopardizing their well-being, safety, and overall performance [4].

Fatigue emerges as a critical concern among workers, characterized by a decline in mental and/or physical performance attributed to cognitive overload, physical exertion, sleep deprivation, or illness. This condition significantly undermines worker safety, health, and performance, ultimately impacting the productivity and quality of their output [5].

Accurately monitoring and diagnosing fatigue, especially within the construction industry, are imperative to cultivating safe, efficient, and productive work environments [6]. This paper underscores the significance of adopting a human-centered approach and prioritizing worker well-being on the shop floor. Through a systematic

review focusing on monitoring and diagnosing fatigue in construction workers, this study evaluates the technologies and metrics employed to assess workers' performance and health, drawing upon available scientific evidence.

Materials and Methods

The systematic review was conducted using the BiLi method (Bibliographic and Literary Review Method), pioneered by researchers from SENAI CIMATEC. This method offers a streamlined approach to sourcing publications relevant to a specific topic, leveraging appropriate tools for optimal results [7].

Central to the BiLi method are several tools developed within the R programming language, including Bibliometrix, Litsearch, and RevTools [7]. These tools facilitate efficient literature search, bibliometric analysis, and review process management. Additionally, the method recommends employing CmapTools to construct concept maps, aiding in visualizing key themes and relationships within the literature. Furthermore, Mendeley is proposed as a valuable tool for organizing and annotating articles during the reading and analysis phase, enhancing workflow efficiency and data management.

Figure 1 summarizes the BiLi method, which is composed of four stages: (1) naive cycle, (2) optimized cycle, (3) impact cycle, and (4)

production cycle. Throughout the steps, the method helps the researcher to filter and select the keywords with the most significant impact, refining the search until reaching the most significant publications for their study.

In the naive cycle (Step 1), an initial search was conducted in the Scopus database using broad yet representative keywords: "fatigue" and "construction worker," spanning from 2017 to 2023. This yielded 140 publications. To ensure the relevance and consistency of the results, key indicators such as co-citation networks, annual scientific production, publication history, and word clouds were analyzed using Bibliometrix.

Utilizing the litsearchr tool, an automated metadata analysis of the initial search results was performed to suggest keywords for refining the search string. This led to a new search query: (fatigue AND ("construction worker" OR "construction industry") AND ("heart rate" OR wearable OR sensor)), resulting in 59 publications.

In the optimized cycle (Step 2), the 59 publications were meticulously evaluated and filtered based on graphical indicators in Bibliometrix and by reviewing the titles and abstracts. This rigorous filtering process yielded 30 selected publications.

Moving to the impact cycle (Step 3), the focus shifted to identifying the five most cited authors and their respective articles for further examination. From the pool of 30 publications, 10 highly relevant articles in the study area were identified.

Figure 1. BiLi method.
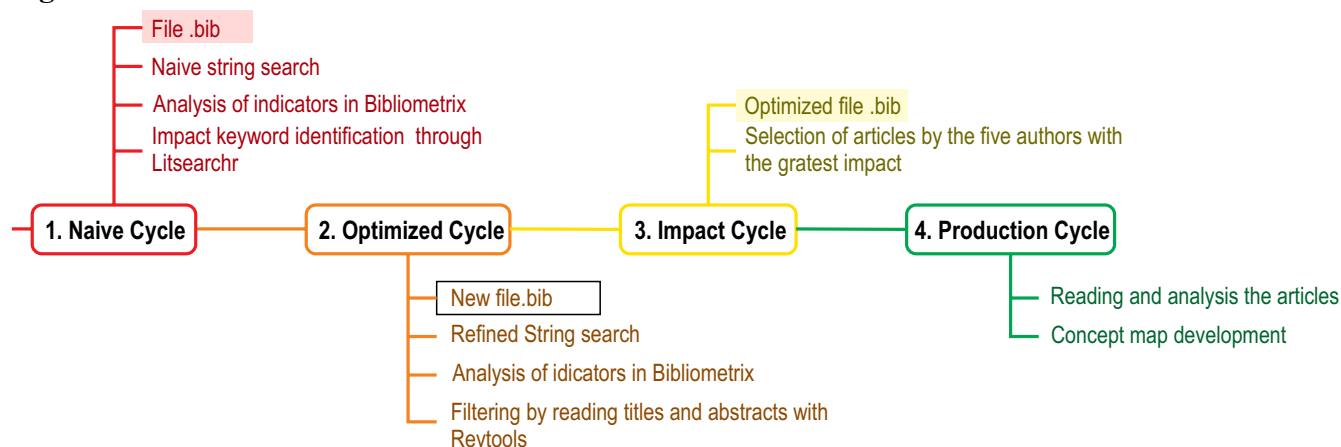
Source: Adapted from Reis and Vale [7].

As per the method's recommendation, the ranking was extended to include the first seven most cited authors to broaden the scope of analysis. Table 1 presents the authors with the highest impact and their pertinent information.

As a summary of the application of the BiLi method for the chosen systematic search, Figure 2 illustrates the number of publications related to the diagnosis of fatigue in workers in the construction sector for each of the steps.

Results and Discussion

The application of the BiLi method yielded 10 articles, as outlined in Table 2. Notably, the majority of the researchers and publications originated from China. Given the niche nature of the topic, centered on the civil construction segment, the volume of publications obtained was relatively modest compared to more generalized applications. Nonetheless, these findings were deemed adequate to fulfill the defined objectives and offer valuable insights for researchers exploring this specific context further.

Although all the selected articles focus on fatigue as their primary subject, it is essential to recognize the two distinct categories within this condition: physical fatigue and mental fatigue. Mental fatigue pertains to diminished cognitive performance resulting from prolonged periods of intellectual activity [8-10], while physical fatigue arises from strenuous physical exertion.

Table 1. Ranking of top authors listed on Impact Cycle.

Ranking	Author	Citations	Country
1	Heng Li	254	China
2	Ali Ghahramani	180	United States of America
3	Ashrant Aryal	180	United States of America
4	Burcin Becerik-Gerber	180	United States of America
5	Xiaochun Luo	171	China
6	Jue Li	154	China
7	Xuejiao Xing	154	China

Figure 2. Summary of the application of the BILI method.
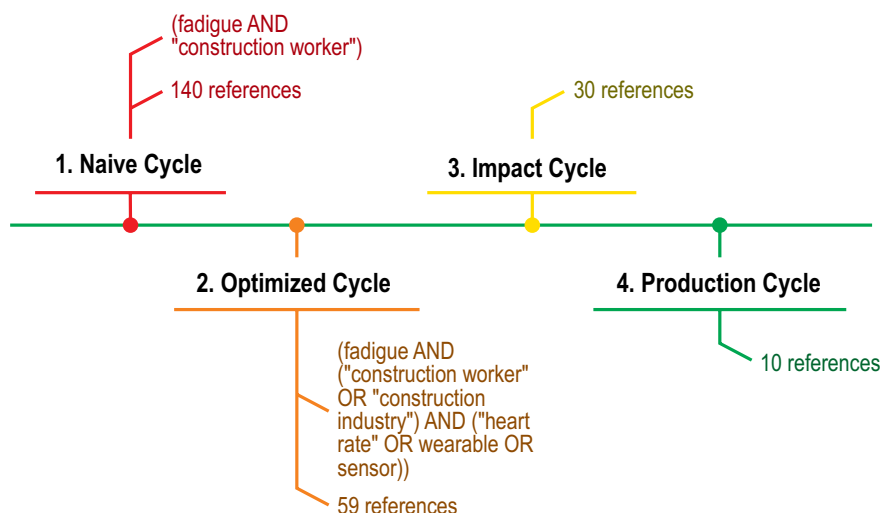
Notably, only 30% of the chosen articles address research centered on mental fatigue, indicating a concentration of studies on physical conditions and a gap in effective methods for measuring mental fatigue [9].

While some studies investigate physical and mental fatigue separately, a pilot study delved into the effects of physical fatigue in inducing mental fatigue among construction workers. Xing and colleagues' (2020) research utilized cognitive tasks to induce varying degrees of mental fatigue under different levels of physical exertion. The findings demonstrated a significant increase in mental fatigue, suggesting a decline in cognitive performance influenced by heightened physical exertion [10].

Table 2. Top 10 articles obtained on the production cycle.

Authors	Title	Year	Journal	Countries
Aryal A and colleagues	Monitoring fatigue in construction workers using physiological measurements	2017	Automation in Construction	United States of America
Li H and colleagues	Pre-service fatigue screening for construction workers through wearable EEG-based signal spectral analysis	2019	Automation in Construction	China
Yu Y and colleagues	An automatic and non-invasive physical fatigue assessment method for construction workers	2019	Automation in Construction	China
Xing X and colleagues	Effects of physical fatigue on the induction of mental fatigue of construction workers: A pilot study based on a neurophysiological approach	2020	Automation in Construction	China, Australia, United Kingdom
Anwer S and colleagues	Cardiorespiratory and thermoregulatory parameters are good surrogates for measuring physical fatigue during a simulated construction task	2020	International Hounal of Environmental Research an Public Health	
Li J and colleagues	Identification and classification of construction equipment operators' mental fatigue using wearable eye-tracking technology	2020	Automation in Construction	China, Saudi Arabia
Anwer S and colleagues	Test-retest reliability, validity, and responsiveness of a textile-based wearable sensor for real-time assessment of physical fatigue in construction bar-benders	2021	Journal of Building Engineering	China, United Kingdom, Saudi Arabia, Canada.
Anwer S and colleagues	Evaluation of Physiological metrics as a real-time measurement of physical fatigue in construction workers: State-of-the-Art Reviews	2021	Journal of Construction Engineering and Management	China, United Kingdom, Saudi Arabia.
Anwer S and colleagues	Identification and classification of physical fatigue in construction workers using linear and nonlinear heart rate variability measurements	2023	Journal of Construction Engineering and Management	China,United Kingdom, Canada

Various non-intrusive methods for identifying and categorizing physical fatigue has been proposed. Conventional subjective approaches like questionnaires are discouraged due to their inability to provide dynamic and continuous analysis of worker behavior [4]. An innovative approach involves analyzing 3D movement images of workers coupled with biomechanical calculations to estimate joint torques. Algorithms can then discern physical fatigue based on current joint loads and historical data [4].

For assessing perceived physical exertion (PEER), the Borg Scale or Table is commonly employed. This numerical scale ranges from 1, "No exertion," to 10, "Maximal exertion" [6], adapted from the original scale that ranged from 6 to 20 [11,12]. This method gauges sensory perceptions of physical work and individual effort, stress, or distress experienced during physical activity. It has proven reliable for classifying physical fatigue [6,11,12].

The utilization of wearable devices is gaining traction in studies, primarily due to technological advancements and compatibility with the construction environment's demands. These wearables are often washable, reusable, and capable of continuous use over extended periods. They are valuable tools for acquiring real-time physiological data essential for diagnosing physical and mental fatigue. Examples cited in the selected articles include smartwatches [6,12], wearable eye-tracking devices [9], multisensory textiles [13,15], and wearable EEG devices [8]. Heart rate is a predominant metric for diagnosing and predicting fatigue across most studies [6,10-15]. Table 3 provides a comprehensive overview of all cited metrics, their respective references, and the conditions they relate to.

Conclusion

The human-centered approach is paramount for fostering a safe, inclusive, and healthy work environment within the construction industry, particularly concerning the prompt diagnosis and prevention of physical and mental fatigue. The systematic review undertaken in this article has illuminated pertinent studies delving into emerging technologies and metrics for data analysis, alongside strategies for identifying and categorizing fatigue within this domain. Despite advancements, early detection of fatigue remains a formidable challenge for organizations. It is hoped that insights gleaned from these strategies will pave the way for implementing appropriate preventive and interventional measures, thereby mitigating the risks associated with physical and mental exhaustion.

Nevertheless, it is crucial to acknowledge that the review was constrained by the availability

Table 3. Main metrics used for fatigue analysis.

Metric	Reference	Condition
Joint torque	[4]	Physical fatigue
Heart rate	[13,14,12,11,10,15]	Physical and mental fatigue
Electroencephalography (EEG)	[8,11,10]	Mental fatigue
Eye movement	[9]	Mental fatigue
Respiratory rate	[13,12]	Physical fatigue
Skin temperature	[13,12,14,11]	Physical fatigue
Electrodermal activity	[12]	Physical and mental fatigue
Electrical activity of muscles	[14]	Physical fatigue
Sweat	[16]	Physical fatigue

of specialized publications on the subject matter and its application. In future endeavors, we aim to explore a broader spectrum of technologies and metrics employed across diverse industrial sectors, which could also be applicable within the construction context.

Furthermore, there is a pressing need for empirical studies evaluating the efficacy of these interventions in real-world settings. Such endeavors would furnish more robust evidence supporting adopting these approaches within the construction industry.

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Development of a Data Manager for Analyzing the Global Distribution of COVID-19 Vaccines Using Data from 'Our World in Data'

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The COVID-19 pandemic has triggered a global race for vaccination as a crucial preventive measure. Considering socioeconomic disparities and public policies, this study investigated the number and proportion of vaccinations in different countries. Using data from the "Our World in Data" platform, we collected vaccination information since December 2020, including population estimates. We selected the top 10 countries regarding vaccination and stratified them by income. SQL Server and PHPStorm were used to manage the data. The results demonstrated the evolution of vaccination up until March 2023. Easy access to this data allows us to investigate the effectiveness of government interventions in public health, using comprehensive datasets better to understand the progress and impact of vaccination efforts.
Keywords: COVID-19. Vaccination. Database. Public Policy.

The COVID-19 pandemic not only represented an unprecedented public health challenge but also triggered a global race towards vaccination, which is a crucial measure for preventing the severity of the disease and death and for controlling its transmission (WHO, 2020) [1]. The multifaceted impact of COVID-19 necessitated different approaches from local health authorities in various countries concerning the vaccination schedules adopted and the outcomes of these measures [2]. To analyze these approaches, obtaining vaccination data from reliable sources such as public health organizations, government agencies, and academic institutions is essential.

The "Our World in Data" platform (OWD, 2024) [3] offers a comprehensive compilation of vaccination data from around the world since December 2020 and continues to update it. Therefore, this work aimed to organize and develop queries that can extract and facilitate research and analysis of the "Our World in Data" database, allowing for an in-depth examination of the

distribution of vaccines administered in different countries from the onset of vaccinations to the present.

Materials and Methods

Data was collected on the online platform "Our World in Data", which combines official vaccination numbers since December 2020 with more recent data from government health agencies worldwide. This platform also provides population estimates for per capita metrics based on the United Nations World Population Prospects and categorizes population groups by income using the World Bank classification. To manage and organize the raw data spreadsheet from the "Our World in Data" platform, we utilized the software "SQL Server Management Studio" (Microsoft). The following SQL queries were created to facilitate the development and debugging of the code:

1. Total number of vaccinations per country.
2. The proportion of vaccinations with an initial and complete schedule.
3. Division of data by income group.

These queries were designed to extract relevant information for a comprehensive analysis of global

vaccination distribution, considering various socioeconomic factors and public health policies.

Results and Discussion

Data collection on the "Our World in Data" platform was conducted on March 12, 2023.

This effort produced a comprehensive table containing vaccination data from December 2020 to the collection date, encompassing 243 countries, counties, and delimited territories. The dataset also included population estimates, income group classifications, and death counts, resulting in 12,816,911 entries or raw data points. Due to the substantial volume of data, analysis could not be performed directly in the Excel spreadsheet where the data was initially downloaded.

Consequently, it was necessary to employ a more robust tool capable of efficiently selecting data according to the parameters set for evaluation. Using SQL Server Management Studio, we significantly enhanced data processing efficiency. The generated SQL code was designed to handle large datasets, enabling rapid and effective data operations such as filtering, cleaning, transformation, and analysis.

This approach allowed us to extract and analyze the necessary information with greater accuracy and speed, providing valuable insights into the global distribution of COVID-19 vaccines. The processed data highlighted vital trends and disparities in vaccination rates across different countries and income groups, facilitating a better understanding of the impact of socioeconomic factors and public health policies on vaccination efforts.

The Excel spreadsheet was converted into a database using SQL Server Management Studio (Microsoft) to provide integrated data validation. This integration included all the spreadsheet information into a database table, facilitating efficient management of the high volume of data. The database table contained selected data entries such as the number of vaccinations per country, the number of people with initial and complete vaccination schedules, income groups, population numbers, and dates.

For the development of the code, selected SQL queries were added. These queries included commands to retrieve, modify, or manipulate specific data such as the total number of vaccinations per country, the proportion of vaccinations with initial and complete schedules, and divisions by income group[4].

After stratifying the data, they select the top 10 countries regarding the number and proportion of vaccinations [(#vaccines/population) × 100] with initial and complete schedules as possible. Additionally, the data was stratified by income group, covering the period from December 2020 to the latest consultation on March 12, 2023 (Figure 1). This approach allows for ongoing updates; the same code can generate updated analyses if the spreadsheet is updated with more recent data.

This method enabled us to handle the large dataset efficiently, ensuring accurate and timely data analysis. The processed data provided valuable insights into the global distribution of COVID-19 vaccines, highlighting key trends and disparities across different countries and income groups. This facilitated a deeper understanding of the impact of socioeconomic factors and public health policies on vaccination efforts, contributing to more informed decision-making in public health management.

All this analysis enabled efficient data extraction on a vast scale. Another significant advantage was the feasibility of data manipulation and the potential for integrating automation into the process. Once processed, the data could be easily exported for later presentation in tables. This step was crucial for preparing the collected data for subsequent analysis of the vaccination situation in different countries. The generated tables may aid future studies in comparing public policy adoption for vaccination and the resulting vaccination rates. Additionally, they serve as tools for visualizing the progression of vaccination about the implementation or lack of public policies promoting vaccine availability and uptake. Furthermore, new queries can be added to the code to complement the study.

Figure 1. Data stratified by income group (December 2020 to March 12, 2023).
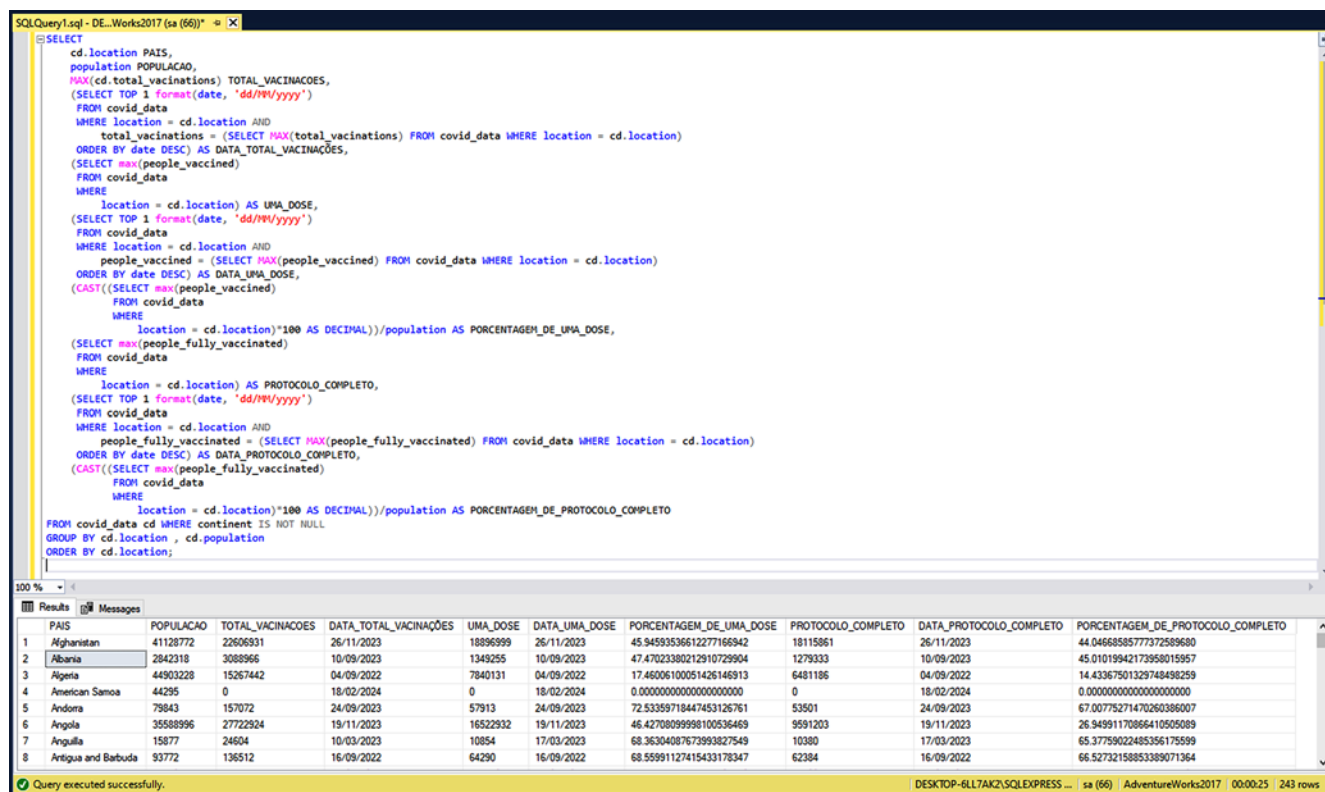
Conclusion

Data stratification facilitated easier access, enabling the following analysis stage concerning vaccination coverage and political responses in different sociopolitical contexts. By leveraging comprehensive datasets from "Our World in Data" containing epidemiological metrics and vaccination progress, future work can continue to link policy interventions and elucidate the differential impacts of government strategies on public health outcomes.

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Biohydrogen Production from Effluents Using Anaerobic Bacteria: A Bibliometric Review

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This study investigates biohydrogen production from effluents using anaerobic bacteria through a bibliometric review supported by VOSviewer software. The potential of biohydrogen as a sustainable energy alternative is highlighted, as evidenced by growing academic interest. The analysis, focused on documents published between 2019 and 2024, reveals 141 publications that show trends, technical and economic challenges, and opportunities for process optimization and technological integration. Continued research is recommended to overcome barriers and promote biohydrogen's viability, also considering its large-scale production's environmental and social impacts.
Keywords: Biohydrogen. Anaerobic Bacteria. VOSviewer. Bibliometric Review.

Biohydrogen represents a promising frontier in the search for renewable energy sources, utilizing biological processes to convert organic compound-rich raw materials, such as biodiesel effluents, into clean energy. Recognized by ANEEL as biomass due to its organic origin and potential for energy generation through conversion processes, these residues offer a sustainable alternative to traditional fossil fuels [1]. By transforming wastewater into biohydrogen, we aim to significantly reduce CO_2 emissions and replace resources such as methane with more environmentally friendly solutions like biomethane or ethanol [2].

Hydrogen-producing bacteria, which inhabit water, soil, and sewage, play a crucial role in this biotechnological process, providing a less polluting route for energy production.

Fermentation, in particular, stands out as a practical and environmentally friendly approach for hydrogen production, promising efficiency and affordability with continued research progress in this area [3].

Among the bacteria studied for biohydrogen production, *Clostridium* and *Enterobacter* species are notable as strict anaerobes. These bacteria can synthesize and produce hydrogen due to the presence of hydrogenase enzymes, which catalyze the reversible oxidation of hydrogen, as shown in Equation 1 [4].

$$(2H^+ + 2e^- \rightarrow H_2 \cdot) \qquad \text{Eq 1}$$
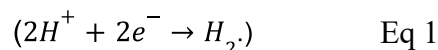
This study aims to conduct a comprehensive bibliometric analysis of recent technologies, methods, and innovations in effluents, focusing on glycerol for biohydrogen production through anaerobic fermentation. The investigation seeks to contribute to advancing knowledge and developing more sustainable and efficient techniques for biohydrogen production, aligning with global sustainability goals and objectives for reducing environmental impact.

Materials and Methods

The study methodology centered on conducting a bibliometric analysis concerning hydrogen generation from industrial effluents. The research

Figure 1. Bacteria of the genus *Enterobacter* sp. (left) and *Clostridium* (right).
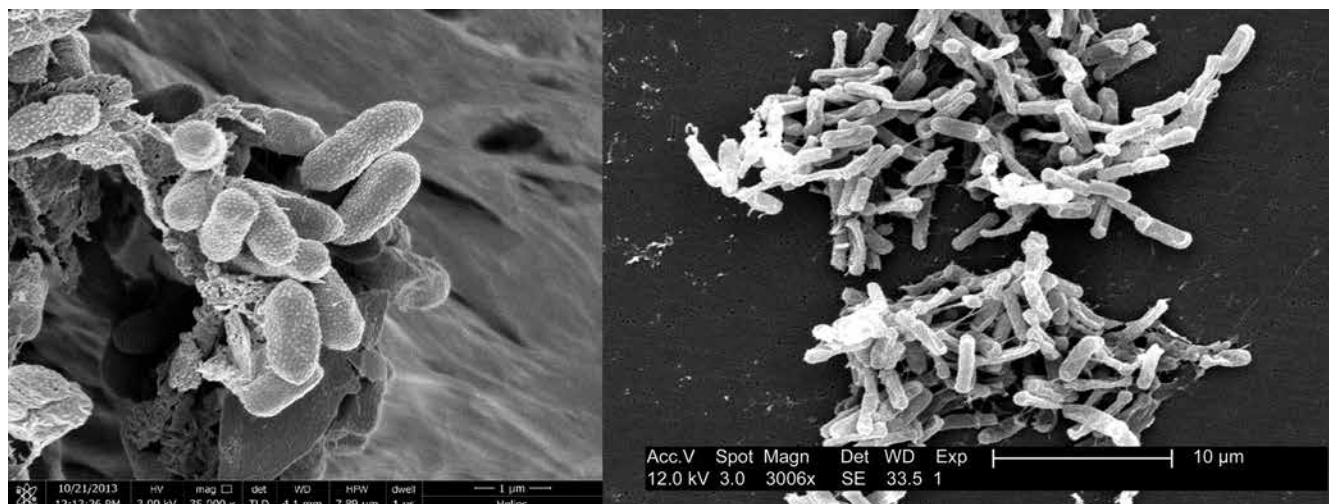
Source: Tang (2014) [4].

involved searching for pertinent patents and articles and analyzing documents utilizing Web of Science, Derwent World Patents Index™ (DWPI), and Lens® along with the VOSviewer analysis tool. VOSviewer software played a crucial role in performing a detailed and visual analysis of the gathered data, facilitating the identification of trends and patterns in research through graphs and tables. This tool was instrumental in interpreting bibliographic results and examining patents and articles based on critical indicators such as Biohydrogen, Wastewater, Energy production, Fermentation, Glycerol, Reuse, and Anaerobic processes.

The selection process focused on documents published from 2019 to 2024, filtering out inactive or irrelevant patents and prioritizing recent articles. The rigorous bibliometric analysis concentrated on articles within the same timeframe, delving into prevalent themes and related keywords to evaluate advancements and trends in biohydrogen production from effluents.

Results and Discussion

The bibliometric analysis yielded results from approximately 171 documents analyzed and published between 2019 and 2024, focusing on keywords such as Biohydrogen, Wastewater, Energy production, Fermentation, Glycerol, Reuse, and Anaerobic processes (Figure 2). The analysis of these articles revealed a predominant theme, indicating a notable interest in research within this domain. Consequently, it became feasible to identify the primary trends and inquiries associated with biohydrogen production during the specified period.

By analyzing the articles selected as the foundation of the VOSviewer tool, we can discern the primary structural dynamics within the research field. Notably, 44 articles mentioned keywords like "Glycerol" and "Crude-Glycerol," indicating a substantial interest in this area. The keyword "Fermentation" also appeared in 44 articles, underscoring the enthusiasm for utilizing this fundamental process in biohydrogen production. These keywords serve as foundational pillars for the field, depicted by thicker lines that signify a robust correlation between the keywords and their frequency of occurrence in searches.

Connections between different clusters, as illustrated in Figure 3, such as "Anaerobic Digestion" and "Biodiesel Treatment," underscore the significance of interdisciplinary collaboration and how diverse processes contribute to the progress of biohydrogen technology. This

Figure 2. Annual scientific production.
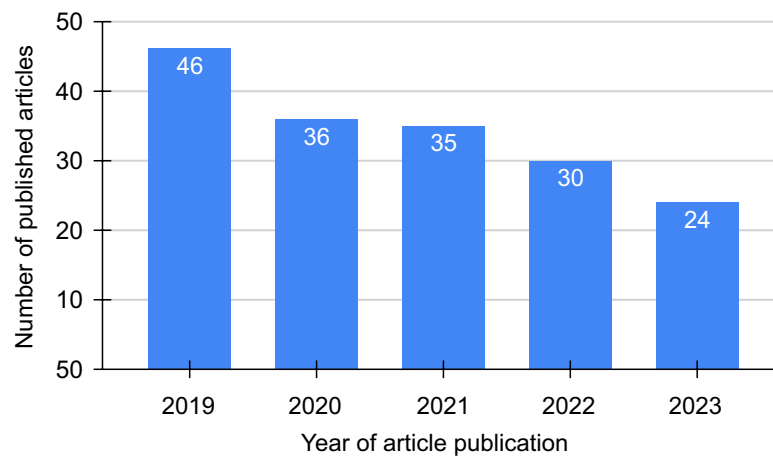
Figure 3. VOSviewer network map for related keywords.
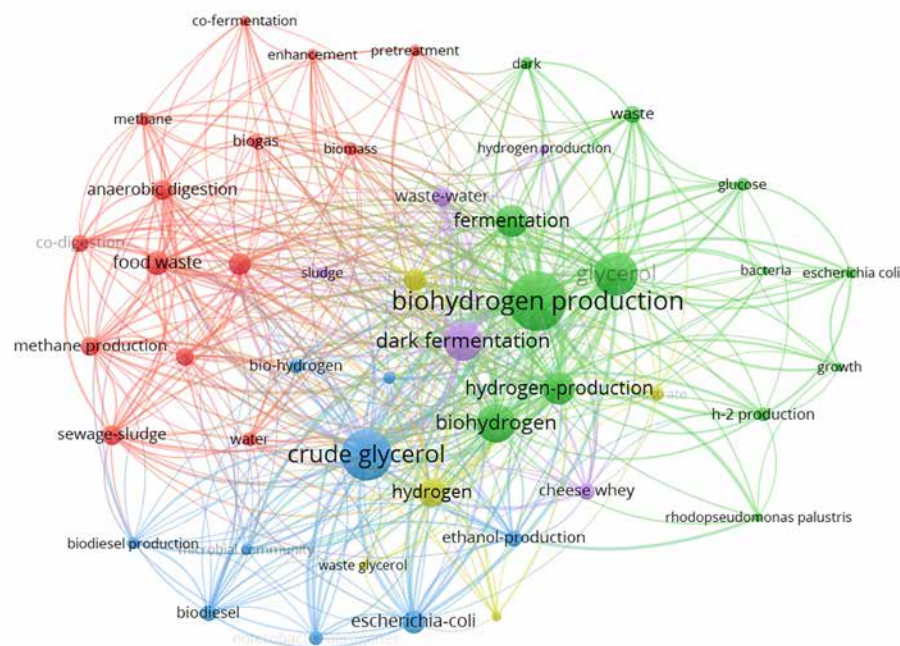
emphasizes the substantial integration between waste treatment and renewable energy production, representing a promising domain for enhancing environmental sustainability and energy efficiency. At the map's periphery, terms like "*Escherichia coli*" and "*Rhodopseudomonas palustris*" denote specific niches within the field or emerging research frontiers. While these terms are less interconnected, they are crucial indicators of potential innovation and the direction of future investigations. Among the prominent studies conducted, the article by Adeknbi and colleagues (2023) reviewed advancements in biohydrogen production from wastewater, focusing on production techniques, technical challenges, and economic considerations. It explores various hydrogen production pathways,

including biophotolysis (direct and indirect), dark fermentation, and photofermentation. Additionally, the article delves into bioreactor design and the technical hurdles associated with utilizing biohydrogen from wastewater. It also provides an economic assessment of biohydrogen production from wastewater. It discusses the potential of this approach to address energy and environmental issues concurrently, particularly in developing regions such as Africa.

Conclusion

This study underscores the increasing relevance of biohydrogen as a sustainable energy alternative, as evidenced by the bibliometric analysis conducted. Although much of the research remains in the laboratory phase, as indicated by the significant number of scientific articles, it reflects a rapidly evolving field and holds considerable potential. Despite the existing technical and economic challenges, such as the need to enhance the implementation of hydrogen plants, the future of biohydrogen appears promising. For future research endeavors, exploring new optimization techniques, developing more efficient fermentation systems, and investigating strategies for integrating this technology into existing value chains is recommended. Additionally, assessing the environmental and social impacts of biohydrogen production on a large scale will be crucial to ensure its sustainability and garner public acceptance.

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Production of Agave's Bioproducts: A Short Review

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The energy transition has become one of the most widely discussed topics in the past decade, driven by the adverse effects of fossil fuel usage. In this context, various biomasses have been under study to produce biofuels and other substances serving as synthetic platforms for more complex molecules. Among these biomasses, Agave, a species known for its high resistance to environmental factors typical of Brazil and intriguing characteristics for generating bioproducts, has emerged as a prominent candidate. This brief review aims to explore the potential of Agave as a significant platform for generating higher value-added products and to highlight the potential socio-economic impacts in Brazil, particularly in the Northeast region.
Keywords: Agave. Biofuels. Bioproducts.

In the past decade, considerable discussion has concerned the imperative to shift the composition of the world's energy matrix. Currently dominated by non-renewable fuels, these processes are directly linked to the generation of greenhouse gases (GHGs), resulting in various environmental and health hazards. Research centers and some chemical processing companies have advocated for using various types of biomass as an alternative to fossil fuels [1]. Biomass, classified as a group of energy products and renewable raw materials originating from organic matter formed through biological processes, provides energy and offers a range of high-value bioproducts [2].

Using biomass as a raw material, exemplified by Agave, sugarcane, and corn, holds promise in facilitating the world's energy transition. For perspective, biomass can be replenished at almost 100 billion tons annually, equivalent to 515 billion barrels of oil equivalents [3]. In Brazil, biofuel production is a prominent global player, ranking the country as the second-largest ethanol producer, primarily utilizing sugarcane as its raw material. Brazil consumed approximately 20 billion liters of ethanol in 2018, with production expected to increase by 5.5% by 2025 [4]. However, challenges associated with the use of sugarcane, such as competition with the food industry, water resource requirements, negative impacts from fertilizer use [5], and the necessity for agriculturally valuable lands, underscore the importance of considering investments in other biomass species.

In this context, the utilization of Agave in established or innovative processes holds significant potential, potentially emerging as a protagonist in the realm of biofuels and various bioproducts in the country. The Agave genus comprises over 300 species distributed across the globe, predominantly found in arid and semi-arid regions, constituting 12% of the Brazilian territory [6]. These regions are characterized by high temperatures, scarce rainfall, and water deficit [7,8]. Agave, with its high sugar content, which is crucial for biofuel production, its ability to thrive in extreme environments, and the abundance of available cultivation areas without competing as food, presents promising potential in the energy transition.

Additionally, Agave exhibits potential for producing other bioproducts applicable in pharmaceuticals, composites, fibers, and various materials, thus expanding its applications. Intermediate products derived from Agave processing, such as flavonoids, saponins, and terpenes, can be an intermediate platform for producing higher-value molecules in various chemical processes [9,10].

Thus, this work provides a concise review of studies focusing on the utilization of Agave species in generating high-value bioproducts.

Materials and Methods

The brief review presented in this study was conducted in two stages. The first stage involved utilizing platforms such as Science Direct, Google Scholar, Elsevier, and Scopus to search for academic articles using the keywords "*AGAVE*" AND "BIOREFINERY," "*AGAVE*" AND "PHARMACEUTICAL," and "*AGAVE*" AND "BIOPRODUCTS." The search prioritized articles published from 2013 onwards.

Upon identifying papers in the first stage, the second stage commenced. This subsequent stage entailed examining the references to identify any documents of interest using keyword searches and operators. After selecting the articles, brief descriptions of their contributions regarding the utilization of Agave were provided.

Results and Discussion

Most selected articles were published in the last decade, highlighting the conversion of various types of Agave into higher-value products using different methodologies. Some methodologies have already been established from a technical-

economic perspective, while others are still in the developmental stage. Among these studies, a significant focus was placed on the production of biofuels. However, substantial research has also been dedicated to obtaining bioproducts serving as synthetic platforms for other higher-value substances. Table 1 presents key results related to the generation of intermediate bioproducts, while Table 2 summarizes the main biofuels produced, along with their respective production methodologies.

Several research studies have delved into utilizing different Agave species across various sectors, including healthcare, cosmetics, and recycling. Mestre and colleagues utilized *Agave sisalana* to produce high-quality nanoporous carbohydrates for pharmaceutical product removal [11]. The raw material underwent a digestion and polycondensation process with sulfuric acid at a temperature below 100°C and ambient pressure, followed by chemical activation with potassium hydroxide or carbonate. The authors employed the resulting product to remove ibuprofen and iopamidol from aqueous solutions. The findings revealed that acid concentration influenced the structure and density of the intermediate product, with activation using KOH proving twice as efficient in pollutant removal compared to the commercially available material for this purpose, activated gold charcoal.

Table 1. Intermediate bioproducts, main processes, and raw materials.

Product class	Agave type	Applied method	Product	Reference
Bioproducts	*Agave sisalana*	Digestion and policondensation with H_2SO_4, chemical activation with KOH or K_2CO_3	Nanoporous carbohydrates	[11]
	Agave sisalana	*In vitro* and *in vivo* tests	Skin anti-oxidative and anti-aging products	[12]
	Agave tequilana	Injection molding with compatibilizer	Agave fiber-reinforced polymeric composite	[13]
	Agave lechuguilla	Fibers pre-treated with NaOH	Epoxy composites	[14]

Tabela 2. Biofuels, main processes, and raw materials.

Product class	Agave Species	Applied Method	Product	Reference
Biofuels	*Agave tequilana*	Two-stage acid and enzymatic hydrolysis	Hydrogen and methane	[15]
	Agave tequilana	Auto-hydrolysis, hydrolysis with cellulose cocktail, and fermentation with *Saccharomyces cerevisiae*		[16]
	Agave tequilana and *Agave Salmiana*	Pre-treatment using ammonia fiber expansion and fermentation	Ethanol	[17]
	Agave lechuguilla	Pre-treatment with sulfuric acid, saccharification, and fermentation with co-fermented *Escherichia coli* MM160	Ethanol	[18]
	Agave sisalana	Acid-base pre-treatment, followed by hydrolysis and fermentation with *Saccharomyces cerevisiae*	Ethanol	[19]
	Agave tequilana	Pre-treatment with ionic liquid and anaerobic digestion	Methane	[20]
	Agave tequilana	Enzymatic saccharification without detoxification and fermentation	Ethanol	[21]

On the other hand, Barreto and colleagues evaluated the utilization of residues from the same Agave to generate products combating oxidative stress and skin aging [12]. The authors assessed antioxidant activity in vitro and *in vivo* using the Caenorhabditis elegans organism model. The results demonstrated antioxidant activity in all *in vitro* tests, and vivo a reduction in free radicals was observed. Thus, the Agave residue exhibited promising results as an antioxidant agent.

Iftekhar and colleagues investigated the properties of a compound prepared by injection molding from a mixture of linear low-density polyethylene, polypropylene, and 25% by weight of fibers derived from *Agave tequilana* waste, with a compatibilizer content ranging from 1% to 3% [13]. The authors synthesized a compatibilizer in the laboratory and concluded that the adhesion of the plastic to the Agave fiber improved compared to a specific industrial compatibilizer. Furthermore, the results demonstrated that using 2% of the synthesized compatibilizer enhanced tensile strength by approximately 24% and flexural strength by 14% compared to non-compatibilized composites.

Majhi and colleagues utilized *Agave lechuguilla* fibers to reinforce epoxy composites to enhance the material's mechanical strengths [14]. Initially, the authors treated the fibers with 5%, 10%, and 15% NaOH concentrations and analyzed tensile strength and interfacial shear strength, with the 5% concentration yielding the best results. Subsequently, the authors discussed using the 5% NaOH-treated fiber and untreated fiber as reinforcement material, with concentrations ranging from 10% to 40%. The treated fiber exhibited approximately 8% better results in tensile and flexural strength than the untreated fiber.

Various research groups have explored processes for obtaining biofuels, mainly focusing on

proposing new routes for ethanol, hydrogen, and methanol, among others. Vargas et al. conducted a comparative study of single-phase and two-phase anaerobic digestion to produce hydrogen and methane from the acid or enzymatic hydrolysis of *Agave tequilana* bagasse [15]. The experiments were performed in batch reactors, with hydrolysate concentrations ranging from 20% to 100%. The results indicated that a high concentration of hydrogen could be achieved with enzymatic hydrolysis at 40% and a high methane concentration for hydrolysates at 20%. Thus, the two-stage process proved approximately three times more efficient than the single-stage process.

González and colleagues employed *Agave tequilana* bagasse for biofuel production [16]. The authors subjected the bagasse to auto-hydrolysis, hydrolysis using a cellulase cocktail, and fermentation with Saccharomyces cerevisiae. The process was conducted in a high-pressure Parr reactor, with a solid-liquid ratio of 1:6 and agitation at 200 rpm. The result obtained after a 10-hour fermentation period showed a 98.4% ethanol conversion rate relative to the theoretical value.

Gómez and colleagues utilized residues from *Agave tequilana and Agave salmiana* for bioethanol production [17]. The raw material underwent a chemical pre-treatment with ammonia under optimized conditions at temperatures between 100-120°C. The results demonstrated about 85% selectivity to sugars during pre-treatment and metabolic ethanol concentrations above 90% during fermentation. *Agave salmiana* exhibited a high content of converted sugars; however, it could not be fermented with high solid content due to the presence of inhibitory agents.

Blanco and colleagues utilized *Agave lechuguilla* as a raw material for ethanol production through pre-treatment with dilute sulfuric acid [18]. The study involved varying temperatures between 160°C and 200°C and acid concentrations between 0.5% and 1.5% (w/v), expressed as a combined severity factor. Optimal pre-treatment conditions were 180°C and 1.24% (w/v) sulfuric acid.

Following the pre-treatment process, the product underwent saccharification and co-fermentation with Escherichia coli MM160, producing an ethanol yield of 73.3%.

Ethanol production was also investigated by Veloso and colleagues using *Agave sisalana* bagasse [19]. Initially, the material underwent pre-treatment with sulfuric acid and sodium hydroxide, followed by enzymatic hydrolysis and fermentation with Saccharomyces cerevisiae yeast. The results revealed a glucose-to-ethanol conversion factor of 0.47, corresponding to a conversion efficiency of 92%, and a volumetric ethanol productivity equal to 1.2 g/L.

Biomethane production via anaerobic digestion was studied by Pimienta and colleagues using pre-treatment of *Agave tequilana* bagasse with the ionic liquid choline lysine [20]. The authors evaluated the optimized pre-treatment conditions, which were 124°C, 205 minutes, and 20% solid load. The results demonstrated the possibility of obtaining 12.5 kg of methane per 100 kg of untreated raw material, approximately 86% of the theoretical value.

Gaxiola and Gaxiola conducted a study on ethanol production from *Agave tequilana* leaves [21]. The authors utilized powdered species leaves and performed two processes of enzymatic saccharification without detoxification, followed by fermentation using Saccharomyces cerevisiae. Results were evaluated for different fermentation times, ranging from 0 to 40 hours, with 18 hours being the optimal time, resulting in ethanol production with a yield of 81% of the theoretical value.

This study highlights Agave as a promising raw material for generating various bioproducts, biofuels, and pharmaceutical products using diverse methods. Agave holds significant potential to positively impact Brazil's semi-arid areas, such as the northeast. Its innovative utilization can stimulate community economies by fostering development, job creation, and other socio-economic benefits. According to the Digital Agro 2022 Report by Mizokami, 3.3 million hectares of Agave in the Brazilian semi-arid region can produce 30 billion

liters of biofuels, equivalent to that produced using 4.5 million hectares of sugarcane. Furthermore, there is already a willingness to utilize Agave in semi-arid regions, with plans to allocate 2 million hectares for biofuel production from this raw material [22].

Conclusion

The literature studies reviewed reveal diverse methodologies for utilizing Agave in producing various bioproducts, mainly focusing on fuels and other substances with inherent high-added value, as well as serving as synthetic intermediate platforms for obtaining commercially valuable molecules across diverse industries. These research findings underscore the significant potential of Agave in generating such products. When combined with its characteristics of ample cultivable land, resilience to extreme conditions, and capacity to stimulate local economies, this potential becomes even more pronounced.

Brazil's semi-arid region offers ample opportunities for cultivating Agave species. Research endeavors targeting the utilization of *Agave sisalana* from this region, exploring the cultivation of new Agave species, and investing in biomass utilization represent promising avenues for energy transition and economic development in the northeastern part of Brazil.

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Exploring Cocoa Honey-Based Drinks: A Technical-Scientific Mapping Perspective

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Products rich in cocoa are highly energetic and offer various health benefits, including anti-inflammatory, antioxidant, analgesic, and vasodilatory properties. Cocoa production generates several by-products, including cocoa honey, a nutritious liquid extracted from the pulp of cocoa seeds. This by-product has the potential to develop functional beverages, catering to the growing demand for healthy foods. A search combining keywords and the Cooperative Patent Classification (CPC) code was performed in the Espacenet and Derwent (DWPI) databases. The scientific study investigated cocoa honey's composition, nutritional properties, and health effects, while the patent analysis sought to identify innovations related to its use. The goal was to provide insights into new functional and innovative products. The study revealed a need for more specific patents on cocoa honey, particularly at the national level.
Keywords: Cocoa. Cocoa Honey. Functional Drink. Patents.

Cocoa (*Theobroma cacao L.*) is a fruit of American origin belonging to the *Sterculiaceae botanical* family, typically found in tropical regions. Its planting is best done during the rainy season, which provides the necessary shade for optimal development [1]. *Theobroma cacao L.* is a dicotyledonous, neotropical tree with three genetic varieties [2,3]. The variability in cocoa characteristics can be influenced by the region in which it is cultivated, impacting the final product's traits [4].

Brazil is unique in having a complete production chain, being both a producer of cocoa and an industrial processor of cocoa beans, as well as a manufacturer of chocolate [5,6].

During the production process, particularly in the post-harvest phase, a significant amount of waste is generated, including cocoa shells, pulp, and cocoa honey. Approximately 80% of the fruit is considered waste, making it feasible to redirect this by-product for industrial use [7]. Cocoa honey, a thick liquid obtained during pulp extraction, is a by-product characterized by high perishability. It can be consumed fresh or undergo further processing, such as thermal pasteurization [8].

Despite its significant nutritional value, its utilization is limited, and its commercial use is at most 1% of the available quantity.

Cocoa-rich foods are renowned for their health benefits, which include anti-inflammatory, antioxidant, antimicrobial, analgesic, and vasodilatory properties [9]. Cocoa honey is an exceptionally nutritious product with an average pH of 2.76, imparting a naturally acidic flavor that limits the development of contaminating microorganisms [5,6]. Notably, it contains vitamin C, ranging from 7.64% to 10.9%.

With the growing demand for functional foods and beverages, there is a significant trend towards developing new products with beneficial health effects. In this context, cocoa-based drinks, such as those containing cocoa honey, have considerable growth potential due to their high nutritional value [8].

Therefore, minimizing waste generated by the cocoa industry and adding value to by-products is imperative for the sustainability of food processing. This study aims to investigate the potential for developing new functional fermented drinks containing cocoa honey through a bibliographic and patent analysis.

Materials and Methods

Two specific Cooperative Patent Classification (CPC) codes were used to ensure a broad scope of the research. According to the search strategy, these codes were linked to English keywords: 'Cocoa honey' and 'food' and 'beverage,' with codes A23G1/00 and A23L21/25, respectively (Table 1).

The research was conducted from August to November 2023. Patents associated with cocoa honey drinks were individually reviewed to map information about protected technologies relevant to the proposed investigation. It is important to note that certain patents may not appear in search results due to the eighteen-month confidentiality period. The search used Espacenet and Derwent World Patents Index (DII) to build a comprehensive table comparing patents registered in 90 countries, including Brazil. Graphs were generated using the Derwent platform, considering the main CPCs, year of highest patent publication, and countries of publication.

Results and Discussion

Approximately four patents were associated with cocoa honey-based drinks with functional properties based on the selection of the primary patents related to the keyword "cocoa honey and food and beverage" (Table 2). Among these, only two specifically focused on using cocoa honey in producing a functional drink; the others used cocoa honey as a sweetener or additive.

Among the companies and institutions holding patents for fermented drinks with functional effects, The Princeton Group Inc. stands out with five linked patents, followed by Nestlé with four patents (Figure 1). Additionally, the Federal University of Bahia holds two patents, all related to fermented drinks based on cocoa honey, which is the focus of this study. Functional foods are gaining popularity worldwide due to their metabolic and health-promoting effects and essential nutritional functions. Despite identifying several patents using the keywords, cocoa honey still needs to be explored

Table1. Description of Cooperative Patent Classification (CPC) codes.

CPC Code	Meanings
A23G1/00	Cocoa; cocoa products, e.g. chocolate; and substitutes
A23L21/25	Food or foodstuffs; non-alcoholic drinks; its preparation, e.g. cooking, nutritional quality modification; Honey; honey substitutes

Table 2. Keyword scheme.

Keywords	Individual Documents ESPACENET	Derwent Innovation
Honey cocoa	87	154
Honeu cocoa and food	58	108
Honey cocoa and Beverage	18	30
Honey cocoa and food and beverage	34	24
Honey cocoa and A23L21/25	8	9
Honey cocoa and A23G1/00	7	10

Figure 1. Leading companies and institutions holding patents.
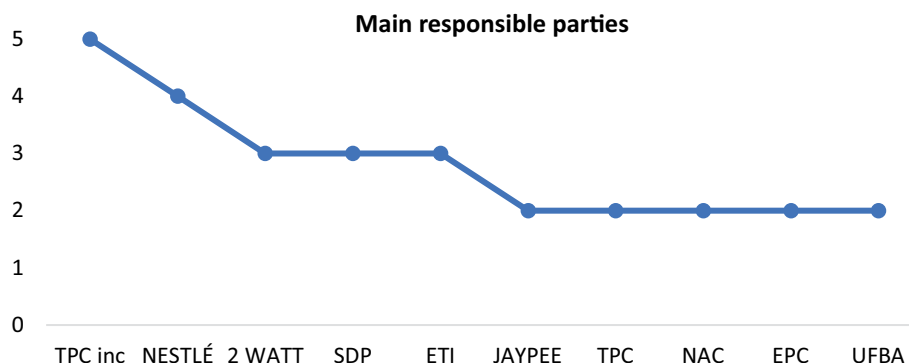
in innovative scientific circles, mainly due to the scarcity of studies on its conservation and technological improvement. However, utilizing cocoa honey can add value to the by-products generated in the cocoa processing chain and bring benefits through innovative products. Although the highest concentration of patents regarding functional drinks is in Asian countries and outside South America, there is limited foreign literature on cocoa honey-based drinks, with only national patents observed. This is due to several factors, such as cocoa honey being a by-product of the cocoa harvest and its rapid degradation. There is limited knowledge on how to preserve cocoa honey long-term without freezing.

Conclusion

Through this mapping, it is possible to design a product based on the results of the patents and market analysis, focusing on cocoa honey-based drinks. Furthermore, we aim to facilitate future research on using this by-product, considering one of the challenges faced: the scarcity of literature, especially in English, that comprehensively addresses cocoa honey.

Although the Asian continent has a significantly greater number of patents related to beverages and functional foods, the patents for beverages made from cocoa honey are exclusive to Brazil. This initiative aims to reduce waste generated in chocolate production, promoting a more conscious and sustainable industrial approach while also seeking to optimize the efficiency of the process.

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Biology-Inspired Innovations in Soft Robotics for Efficient Locomotion

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Inspired by nature, soft robotics promises to overcome traditional robots' limitations by using the flexibility and adaptability of living organisms to navigate complex environments. This field aims to replicate natural movements, such as the peristaltic motion of earthworms, applying them to robots to enhance locomotion and manipulation capabilities. Research focuses on developing prototypes inspired by biological mechanisms, with significant advances in design, actuation, and control, highlighting applications in challenging environments. Studies include the development of mobile robots with pneumatic actuation and models that mimic earthworm locomotion and exploring the use of friction for efficient movement. Soft robotics points to a future with more adaptable and efficient robots, promising innovations in inspection, exploration, and medicine, thanks to integrating new materials, actuators, and control algorithms.
Keywords: Robots. Soft Robotics. Bio-Inspired.

Inspired by the principles and mechanisms found in nature, soft robotics emerges as a promising field to overcome the limitations of traditional, rigid robotic systems [1,2]. This biomimetic approach seeks to replicate living organisms' adaptability, flexibility, and resilience, allowing the development of robots capable of performing complex tasks in varied and challenging environments [3].

By imitating biological structures, such as the peristaltic movements of earthworms and the deformation capacity of certain invertebrates, soft robotics offers innovative solutions for problems of locomotion, manipulation, and interaction with the physical world.

This expanded summary explores recent advances in this field, highlighting the main innovations in the design, performance, and control of soft robots and discussing their potential applications and impact on future robotic technology [4].

Materials and Methods

A search for articles focused on mobile soft robots was conducted using the IEEE Xplore and

Scopus databases. The search targeted mechanical models of mobile soft robots that could be reproduced or inspire other prototypes.

Of the twenty-five articles found, nine addressed the development of robots that fit the specified descriptions, focusing on the mechanical development of mobile robots, whether actuated via cables or pneumatics. These models will be briefly described throughout the article.

Results and Discussion

Research in soft robotics has advanced significantly, drawing inspiration from biology to develop robotic systems capable of efficient and adaptable locomotion in different environments. This section highlights recent innovations in soft robotics, focusing on locomotion mechanisms inspired by organisms such as earthworms and other invertebrates, which demonstrate peristaltic movements and deformation capabilities.

Earthworm-Inspired Locomotion

The locomotion of the earthworm (Figure 1) demonstrates peristaltic movement through a harmonic sequence of muscle contractions and relaxations in its segmented body. The contraction of the circular muscles, followed by the relaxation

Figure 1. Mechanism of locomotion of an earthworm.
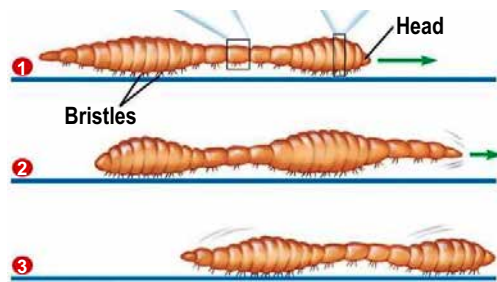
of the longitudinal muscles in alternating segments, drives the worm forward, creating an effective wave-like movement. This mechanism has been used as inspiration for soft robots with diverse applications.

Meshworm: A Soft Peristaltic Robot

The Meshworm robot [6] uses peristaltic locomotion, inspired by the movement of earthworms, through the sequential contraction and relaxation of antagonistic actuators made of nickel-titanium (NiTi) coils. A proprioceptive design with potentiometers allows closed-loop control, offering precise feedback about the robot's position. This approach enables Meshworm to navigate challenging environments while maintaining flexibility and resistance to significant external impacts.

Pneumatic Actuation Systems

A soft pneumatic robot designed for efficient locomotion in tubes features a structure composed of extendable pneumatic actuators and flexible feet [7]. This design optimizes the locomotion cycle, reducing the steps required to move. The phenomenological modeling of the robot, based on mathematical expressions, facilitates simulation and manufacturing, providing an accurate representation of its behavior.

Integrated Rotary Propeller Drive Mechanism with Capability for Smooth Peristaltic Movement

The article focuses on the design method of a Wave Wheel robot [8], which can generate continuous and smooth peristalsis driven by a clustered rotating propeller drive mechanism. When a single motor turns the propellers, the wheel generates peristaltic waves. The proposed mechanism has unique features: It can generate smooth peristalsis with a simple structure, be driven by a single motor, and propagate waves at high speed due to the infinite rotation of the shaft. Its structure is circular in the transverse plane and can be used as an omnidirectional drive wheel. The prototype, with a diameter of 57 mm, reached a maximum peristaltic locomotion speed of 43 mm/s when the angular speed of the propeller was 60 rad/s.

Friction-Based Locomotion

The significance of friction in facilitating the locomotion of soft robots has been underscored by the advancement of control systems that leverage friction to enable crawling movements [9]. Numerical simulations and real-time controllers based on friction feedback have been developed and implemented, showcasing the viability of this approach for achieving efficient locomotion.

Innovations in Actuation and Control

Various approaches have been investigated to improve soft robots' peristaltic locomotion [10] since specialized actuators produce peristaltic waves to lift structures inspired by scissor mechanisms and utilize electroactive polymeric materials [5]. These innovations aim to streamline mechanical design, minimize energy usage, and ensure effective motion efficiency in soft robots.

Conclusion

Advancements in soft robotics, drawing inspiration from biology, showcase considerable

potential for developing robots capable of navigating and operating in challenging environments. The mimicry of biological mechanisms offers insights into designing more adaptable and resilient robots and paves the way for innovative applications in inspection, exploration, and medicine. The integration of advanced materials, efficient actuators, and intelligent control algorithms remains a promising frontier in the field of soft robotics.

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Leveraging Artificial Intelligence in Contracting: A Digital Transformation for Public Institutions

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Digital transformation is increasingly essential for enhancing efficiency and data security. This study explores the impacts that Artificial Intelligence (AI) may have on the control of public procurement under the New Bidding Law. A systematic review of the literature on AI and public agencies was conducted. The findings indicate that the use of AI to oversee administrative activities and public procurement is already a reality. Further research is needed to identify additional factors where this technology can serve as an innovative tool to support the efficiency of public procurement.
Keywords: Digital Transformation. Public Procurement. Artificial Intelligence. Public Agencies.

Digital technologies have grown exponentially, becoming an integral part of daily life. The development and implementation of information and communication technologies have become crucial tools for achieving the 17 goals of the 2030 Agenda for Sustainable Development. Public organizations, driven by the desire to provide quality services to society, are increasingly adopting Artificial Intelligence (AI) tools [1].

In Brazil, the new bidding law [2] has introduced technological and digital innovation to the public procurement market, focusing on modernizing procedures through electronic administrative processes [3]. According to the sole paragraph of Article 11, senior management is responsible for procurement governance and implementing processes and structures that achieve established objectives, such as encouraging innovation. Senior management must promote an enabling environment and ensure that contracts align with these objectives, promoting efficiency, effectiveness, and efficacy [4].

In this scenario of digital transformation within public administration, AI presents a challenge,

given its submission to the legal regime of public law. Adopting new technologies requires careful planning and adaptation of the administrative structure to absorb technology's benefits effectively [3]. These strategies necessitate organizational changes within institutions to establish a digital culture and foster intense cross-sector collaboration [5].

There is limited literature on implementing AI in public procurement processes as a prerequisite for digital transformation. However, more research focuses on AI implementation in controlling public procurement and the judicial sector within public organizations [6].

Given the recent changes in the regulatory framework for public procurement (new competition law no. 14.133 published in April 2021 with a deadline for application until 12/31/23), the public sector faces a significant challenge in implementing digital processes. Considering that not all countries adopt the same procurement strategies, this article investigates the impacts AI may have on controlling Brazilian public procurement based on the New Bidding Law through an integrative literature review. This becomes an even more significant challenge in the post-pandemic world.

Materials and Methods

The methodological approach used in this study was a literature review, which facilitated

the presentation of the current state of the art on using AI to control public procurement. This approach contributes to identifying opportunities for improvement in the area and the development of new theories.

The literature review protocol was designed to achieve two main objectives: Reflect on the strategies and impacts of AI in the hiring processes of Brazilian public institutions. Map the strategies institutions adopt to navigate the new legal framework for public procurement. The search method employed a combination of topic-based searches, truncation, and Boolean operators. The keywords used in the research included "public governance," "public procurement," "government procurement," and "artificial intelligence."

Six articles relevant to the scope of this research were selected from the search. A qualitative analysis was then performed, focusing on change management and governance in public procurement.

The analysis of the identified works followed the phases defined in Figure 1, which outlines the structured approach for reviewing and synthesizing the literature.

Results and Discussion

The New Bidding Law (Law No. 14.133/2021) introduced significant innovations aligning with the digital public administration paradigm. Article 174 of this law established the National Public Procurement Portal (PNCP) as the primary official electronic site for centralized and mandatory disclosure of procurement activities by public bodies [9]. This portal represents a significant step forward in streamlining and modernizing bidding processes.

A notable innovation introduced by Law No. 14.133/2021 is the competitive dialogue bidding modality. This modality facilitates contracting works, services, and purchases by allowing the public administration to hold dialogues with bidders selected based on objective criteria. The aim is to develop one or more alternatives to meet public needs, after which the bidders submit final proposals [2].

In addition, Law No. 14.129/2021, known as the Digital Government Law, was enacted on March 29, 2021. This law aims to facilitate the digitalization of Brazilian public administration, enhancing the efficiency of administrative activities and providing

Figure 1. Search and selection method.

Google Scholar

Title / Abstract / Keyword:
("public governance" and "public procurement") or ("government procurement" and "artificial intelligence");
50 papers

Capes Periodical

Title / Abstract / Keyword:
("public governance" and "public procurement") or ("government procurement" and "artificial intelligence");
20 papers

Refinement of the 70 studies by Review Articles: → Excluded: 64 → **Final result: 10 papers**

public services. It aligns with the New Bidding Law by promoting digital processes in public procurement. SEGES/ME Ordinance No. 8.678/21 further supports governance in public procurement at the federal level, emphasizing the reduction of bureaucracy, encouragement of social participation, and the use of digital technologies [7]. Recent technological additions to the gov.br/purchasing portal include the Preliminary Technical Study, Risk Management Matrix, and Terms of Reference, all digitally linked to the Annual Procurement Plan (PGC). These functionalities aim to streamline procurement processes further. However, the digital transformation of public administration faces several barriers. Effective communication and experience-sharing between various societal sectors (public, academia, citizens, and companies) are crucial. The digital transformation process must comprehensively consider the organizational structure to benefit the public interest [8]. High-quality data is essential for artificial intelligence (AI) to function appropriately, necessitating access to comprehensive databases across all involved sectors. This requires strategic-level organization [9].

Public administrations face significant challenges in reconfiguring their internal and external activities to optimize the benefits of new technologies while ensuring sustainable and inclusive development. There is a risk of dehumanizing public administration if technology replaces human interaction entirely. For instance, valuable chatbots may not be accessible to illiterate users, potentially creating scenarios of discrimination and rights violations [5]. Electronic portals enhance technological tools for monitoring administrative activities, with AI supporting control agents in public bodies. Big data produced by the Brazilian public administration reinforces AI's instrumental role in fulfilling constitutional duties. The Federal Court of Auditors (TCU) exemplifies AI use in administrative control processes, with systems like Alice analyzing tenders and public notices to prevent fraud [6]. The New Bidding Law enhances transparency

and control in public procurement, prioritizing electronic procedures. This transition to digital formats will become the new norm for public procurement in Brazil, making public information more accessible and processable by AI.

To facilitate digital transformation and the adoption of complex technologies like AI, the Brazilian government has adopted strategic regulations. Vital elements of change management include stakeholder identification and involvement, leadership roles, effective communication of the shift to a digital mindset, and the allocation of resources (information, structure, and finances), as detailed in Table 1.

Although elements such as the importance of digitizing public institutions for society, identifying and engaging stakeholders, and providing necessary resources were mentioned, strategies for establishing a culture for digital transformation must be identified. BJERKE-BUSCH and colleagues suggest that leaders must gain change management skills to establish the necessary culture for digital transformation in institutions.

The COVID-19 pandemic has intensified the interaction between government and society through digital technologies. The use of AI will be increasingly discussed and evaluated in light of the challenges faced in Brazil and other countries regarding the regulatory framework and ethics in its application. However, Brazil is moving towards structuring public procurement to enable effective digital transformation by facilitating the use of AI in its processes.

Conclusion

The new bidding law includes a model for controlling public procurement to modernize these activities and make them more efficient and organized. It can be concluded that artificial intelligence, which requires electronic administrative processes, can support the work carried out by civil servants and units involved in public procurement control.

Table 1. Digital transformation public administration strategy and change management.

Strategies	Change Management Element
Brazilian Strategy for Digital Transformation - Decree No. 9.139, of March 21, 2018	Integration of all sectors of Brazilian society in favor of digital transformation, with the establishment of goals and dissemination of results
Digital Government Law - Law No. 14.129/2021, of March 29, 2021 - provides for the principles, rules and instruments for digital public administration and for increasing public efficiency.	Strengthening the role of the leadership of public institutions in driving the digital transformation process
New Bidding Law - Law No. 14.133/2021 (i) the preferential use of the electronic administrative process to carry out public procurement, in all its phases (internal, external and contractual) and (ii) the creation of the National Public Procurement Portal - PNCP	Induction of communication channels thus increasing the quality of communication between stakeholders.
New Bidding Law - Law No. 14.133/2021 (iii) the new bidding modality called competitive dialog.	Inducing the participation of one of the stakeholders (supplier companies) in the process of selecting the best solution for a given application of digital technologies.
Innovation Law (Law No. 10.973/2004) Legal Framework for Startups (Complementary Law No. 182/2021)	Participation of the societal sector as a provider of technological development and knowledge transfer. Provision of budgetary resource for innovation.

The electronic administrative process is the ideal and necessary path for administrative acts and a requirement for implementing the digital public administration model. Only through electronic processes can administrative activities leverage modern technologies, such as artificial intelligence, aligning with the technological advancements of the 21st century. From the perspective of change management for digital transformation in public procurement, institutions are legally supported to face arising difficulties. However, coordinated actions must be established between the sectors involved to ensure compliance with the Brazilian government's strategic planning.

Acknowledgments

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Fire Safety Performance of Wall Systems

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This article emphasizes the importance of proper performance of vertical sealing systems in building fire safety. It verifies the role of seals as elements to contain the spread of fire in buildings, based on the ABNT NBR 15575 - Part 4 Performance Standard. The research is grounded in analyses of the standard, PBQP-h, and academic literature in databases. Summary tables present criteria, evaluation methods, responsibilities, and necessary validations to ensure adequate performance. It is concluded that compliance with the Performance Standard is crucial to ensure the safety of occupants and the building's structure. The article highlights the importance of tests and project analyses in meeting the requirements of adequate performance.
Keywords: Fire Safety Walls. Performance. Fire Seals. Wall System.

Fires constantly threaten built environments, endangering human life, property, and the environment. In its relentless pursuit of innovation and efficiency, the construction industry has incorporated various materials and technologies. While these advancements offer numerous benefits, they also increase vulnerability to such disasters. Given this reality, understanding the factors contributing to the occurrence and spread of fires in buildings is crucial. It is also essential to explore prevention and control strategies to ensure occupants' safety and preserve built structures.

In Brazil, in 2022, there were 2,041 fire-related incidents in buildings. Commercial buildings accounted for 379 reports, followed by assembly locations, with 333 notifications for public meeting places and 306 for warehouses [1]. Figure 1 presents data on fires in commercial establishments, warehouses, and other categories.

Given the paramount importance of life and property preservation, the construction industry implements various fire containment and preservation strategies to ensure fire safety. In this context, fireproofing plays a fundamental role in safeguarding occupants and maintaining the integrity of buildings. Fireproofing is a compartmentalization element, a critical component restricting fire spread between different areas [2]. This limitation prevents rapid escalation, keeping evacuation routes accessible and safe.

Furthermore, fireproofing protects structural elements and equipment, thereby minimizing the damage caused by fire to the building and reducing the risk of collapse [3]. Therefore, fireproofing not only safeguards building occupants but also preserves the property.

NBR 15575 [4], also known as the Performance Standard, consolidates technical requirements to ensure building quality, safety, and comfort. In Part 4, this standard addresses the internal and external vertical sealing systems specifications, including a dedicated fire safety section. Various aspects are covered, such as fire resistance, smoke tightness, insulation, and flame propagation. These requirements ensure that the fireproofing used in buildings performs adequately in fire situations.

This article discuss the importance of fire protection in preventing and combating fires, emphasizing the criteria established by NBR 15575 - Part 4 and its relevance for the safety and protection of residential buildings. Through this discussion, we aim to contribute to a better understanding of this critical topic within the construction industry and to advocate for practices that ensure the safety of all stakeholders involved.

Figure 1. Incidence of structural fires by type of occupancy.
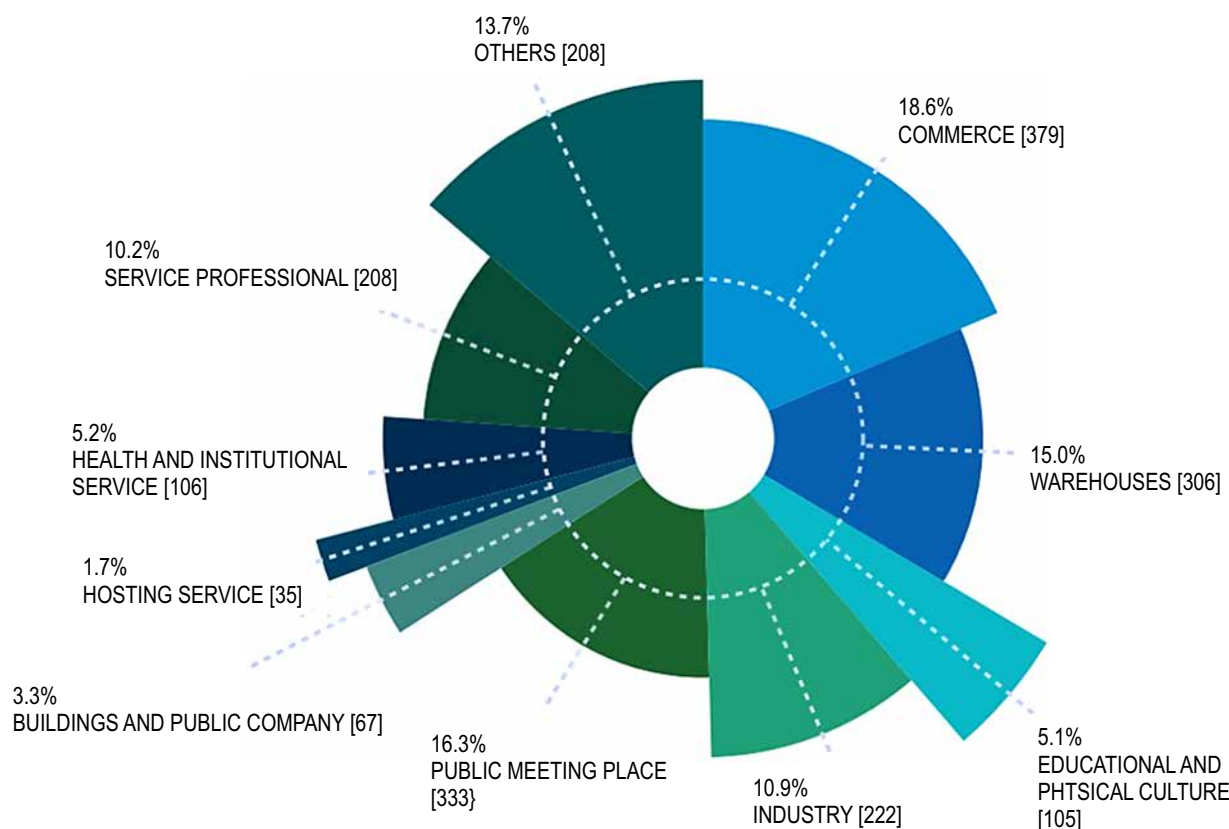
Materials and Metthods

This research delved into norms concerning fire safety sealing systems, focusing on the requirements outlined in NBR 15575 [5], as it sets the minimum criteria that seals must meet. The guidelines established by the National System of Technical Evaluations of Innovative Products and Conventional Systems were also examined. We created summary tables to streamline the topic based on the book "Analysis of Criteria for Meeting the Performance Standard" (Table 1), presenting the requirements, criteria, evaluation methods, responsible parties, and technical evidence for compliance with the standard above. Each aspect contributes to understanding the expected behavior of a sealing system.

The tables created aim to succinctly address the central questions regarding the performance standard. They indicate which criteria must be met to validate a wall system concerning fire safety. The first line of Table 1 presents the required requirements, followed by their respective criteria established in the standard. To enhance understanding, lengthy texts have been summarized and simplified. The technical standards necessary to meet the criteria are highlighted in the third line. The evaluation method determines compliance with the criteria and the system's performance level. Responsible parties are identified to facilitate inspection and project analysis, as they are responsible for providing evidence of performance. Therefore, information such as test reports, inspection reports, designers' statements, technical specifications, and design solutions can be used to demonstrate compliance with the expected performance.

Results and Discussion

Fire safety relies on the intricate details of a building, including materials, construction

Table 1. Summary table model used.

Requirement	Standard Item	Requirement Title	
Criterion	Standard Item	Criterion Title	Topics/Single Text
Standard	Standard to be met		
Evaluation Methods	Method to be used		
Responsibles	Process agent		
Evidencess	Document required for validation		

processes, structural systems, connections between elements, seals, ceilings, roofing, and coatings. All these aspects are significant and must be considered in the technical performance evaluation.

Compartmentalization Elements

Compartmentalization stands out as one of the most effective methods for fire protection. It involves dividing a building into sections containing flames, preventing horizontal and/or vertical fire spread. This protective measure is deemed passive, utilizing elements with diverse functions to shield the building from fire, thus avoiding additional energy consumption.

Compartmentalization elements are construction components endowed with fire-resistant properties that restrict flames' vertical and/or horizontal propagation [6]. Consequently, proof of fire resistance and adherence to fire reaction requirements are imperative. Within the context of seals, only internal horizontal compartmentalization and external facade compartmentalization are encompassed, exemplified by:

- Internal horizontal compartmentalizers: Following internal vertical compartmentalization, floors are established. Frequently, these floors possess extensive areas and necessitate further compartmentalization, employing horizontal elements to delineate spaces. As a result, internal walls that lack structural function yet possess fire-resistant properties are employed [6].
- External facade compartmentalizers: Analogous to floors requiring internal horizontal

compartmentalization, facades necessitate external vertical compartmentalization. This prerequisite precludes fire spread through the facade, preventing it from reaching the floor above immediately [6].

Performance Evaluation

Building performance evaluation can occur through prototypes, designs, and descriptive memoranda before construction. However, projects often entail uncertainties and lack details, particularly in innovative systems, necessitating additional evaluations. These assessments facilitate the development of constructive solutions, even in their nascent stages, underscoring their significance in advancing and refining construction systems.

According to the Technological Research Institute (IPT) [7], the initial evaluation stage entails analyzing the project to identify the interface's technical specifications and construction details. Standard specifications are pivotal in helping construction system developers enhance their projects. Thus, Table 2 addresses widespread inflammation in vertical seals, presenting pertinent classifications. Table 3 addresses fire spread in vertical seals, aiming to categorize dwelling facades to prevent excessive smoke production that could hinder occupants' escape. Table 4 addresses the fire spread while preserving the structural stability of the vertical seals. This norm item aims to resist inflammation for some time without losing its structural function.

The tests and their respective standards proposed by fire safety are listed in Table 5. These tests for fire reaction and resistance are intended to

Table 2. Occurrence of generalized inflammation according to NBR 15575-4.

Requirement	8.2 - PT 4	Make It Different for Gereralized Infflamation to Occur	
Criterion	8.2.1 - PT 4	Evaluation of the fire reaction of the internal face of vertical enclosures and their respective insulating cores.	The internal surfaces of external vertical enclosures (EVE) (facades) and both surfaces of internal vertical enclosures (IVE) must be classified as follows: a) I, II A, or III A when associated with kitchen spaces; b) I, II A, III A, or IV when associated with other indoor areas of the dwelling, except kitchens; c) I or II A when associated with common areas of the building or interior of stairwells, but with a maximum specific optical smoke density (Dm) lower than 100. NOTE: Materials used within the walls, whether internal or external, must be classified as I, II A, or III
Standard	NBR 9442		
Evaluation Methods	Test		
Responsibles	Constructor		
Evidences	Supplier report		

Table 3. Fire propagation with preservation of structural stability according to NBR 15575-4.

Requirement	8.3 - PT 4	Hard Fire Spread	
Criterion	8.3.1 - PT 4	Evaluation of the fire reaction of the external face of vertical enclosures of the facade.	The external surfaces of the VVEs (façades) must be classified I or II B.
Standard	NBR 9442, EN 13823.		
Evaluation Methods	Test		
Responsibles	Constructor		
Evidencess	Supplier report		

Table 4. Fire propagation with preservation of structural stability according to NBR 15575-4.

Requirement	8.4 - PT 4	Make the Fire Spread Difficult and Preserve the Structural Stability of the Building	
Criterion	8.4.1 - PT 4	Fire resistance of structural and subdivision elements	Structural walls must have fire resistance for a minimum period of 30 minutes, ensuring stability, watertightness, and thermal insulation.
Standard	NBR 14432 e NBR 5628		
Evaluation Methods	Test		
Responsibles	Builder and/or Structure Designer		
Evidencess	Supplier report and/or Project declaration		

Table 5. Fire reaction tests requested by NBR 15575-4.

Test	Standard
Incombustibility Test	ISO 1182
Flame Spread Test (Ip)	ABNT NBR 9442
Specific Optical Density of Smoke Test (Dm)	ASTM E662
SBI Test - Single Burning Item Test	ISO 13823
Ignitability Test	ISO 11925-2

evaluate two critical aspects of fire protection: the materials used and their behavior under fire. These tests are intended to comply with the requirements presented in the standard. They are necessary to assess whether the material used in constructing the walls of the environment will guarantee safety for the residents of the building.

Evaluations in Innovative Wall Systems

Next, we present innovative wall systems with a Technical Assessment Document (DATec) (Table 6), meeting SINAT guidelines (NBR 15575-4). Those presented in the table meet the requirements requested by the standard and have commercial validation.

Conclusion

The Performance Standard, ABNT NBR 15575 - Part 4, establishes crucial criteria for the construction industry, particularly regarding the sealing system. These criteria delineate various performance levels tailored to meet the demands of end consumers.

Given the many criteria, it became imperative to synthesize and organize this information into tables, streamlining the work involved in designing and constructing buildings. The significance of this endeavor lies in the systematic compilation of information from Part 4 of the Performance Standard and its application to innovative sealing systems, specifically concerning fire safety.

It is paramount for companies to ascertain their compliance with the standard and the level of performance they achieve through tests or other relevant analyses. Additionally, it is essential to delineate the responsibilities of the various stakeholders (developers, builders, suppliers, and designers) to ensure the attainment and maintenance of desired performance levels and to raise awareness of these responsibilities.

Fire safety is a critical aspect of the construction industry, and the Performance Standard is indispensable in fostering safer buildings concerning fires, ensuring that sealing systems meet requirements and effectively protect life and property.

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Table 6. DATecs and respective guidelines.

Sinat Guideline	DATec	Description	Control and evaluation measures	
Nº001 Rev.03	Nº 005-C	Lightweight concrete with polymer and fiberglass reinforcement protected with polyester	Use of non-combustible materials and controlled smoke emission	30 min RF with load application of 1,520 kgf/m
Nº002 Rev.02	Nº 008C	Panels of ceramic blocks and reinforced concrete ribs	Use of non-combustible materials with controlled smoke emission.	30-minute fire resistance with a load application of 9 kN/m (ground floor) and 18 kN/m (upper floor).
	Nº 012-E	Reinforced concrete panels and ceramic blocks.		60-minute fire resistance – both faces coated with gypsum (thickness=5mm).
Nº003 Rev.02	Nº 014C	SaintGobain dry construction system - Light Steel Frame.	Use of Class I and IIA materials in terms of smoke emission and flame propagation.	30-minute fire resistance with a load application of 600 kgf/m.
			Kitchen walls with gas equipment use 2 layers of ST gypsum boards on the inner face.	
	Nº 041	Tego Frame constructive system with prefabricated steel frame panels.	Use of Class I and IIA materials in terms of smoke emission and flame propagation.	30-minute fire resistance with a load application of 1,500 kgf/m.
Nº004 Rev.02	Nº 017A	Global Constructive System with PVC panels filled with concrete.	-	Fire reaction of PVC profiles: Ip=23 and Dm=405. 30-minute fire resistance with a load of 20 kN/m.
	Nº 037	Bazze PVC Constructive System with rigid PVC panels filled with concrete.	Use of PVC, Class IIA, in terms of smoke emission and flame propagation.	64-minute fire resistance with a load application of 1.6 tf/m.
Nº005 Rev.03	Nº 040	Immergrün constructive system with prefabricated wood frame panels.	Use of Class IIA materials in terms of smoke emission and flame propagation.	30-minute fire resistance with a load application of 1,400 kgf/m.
	Nº 020-D	Structured system with lightweight pieces of sawn solid wood.	Wooden pieces encapsulated with ST gypsum boards. Use of double layers of gypsum boards with staggered and treated joints.	Fire reaction for the inner face (gypsum board) and outer face (cement board).
				30-minute fire resistance with a load application of 20 kN/m.

Analysis of Equipments' Maintenance in a Production Line: Corrective and Preventive Approach: A Case Study in a Pharmaceuthical Industry

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This study aims to underscore the importance of effective maintenance management within the pharmaceutical industry. This is achieved by meticulously analyzing available data from a production filling line and leveraging real-world data from a public pharmaceutical facility. The research provides cogent recommendations to catalyze substantive improvements in maintenance management practices. The case study draws upon data from the service order management software employed in a specific filling line, employing the Failure Mode and Effect Analysis (FMEA) methodology to delineate critical components within the production process. Among the principal findings, it becomes evident that the prevailing preventive maintenance practice exhibits inadequacies in mitigating the incidence of corrective maintenance interventions. In light of these findings, the study advocates for adopting maintenance management protocols aligned with the ethos of Industry 4.0. By embracing contemporary practices inherent within Industry 4.0 frameworks, such as predictive maintenance and data-driven decision-making, pharmaceutical enterprises stand poised to optimize operational efficiencies and enhance overall maintenance efficacy. Keywords: Pharmaceutical Industry. Corrective Maintenance. Preventive Maintenance. Predictive Maintenance. Maintenance Techniques.

Since the advent of the Industry 4.0 paradigm, companies have leveraged technological advancements to bolster competitiveness, enhance quality, and minimize waste in production processes, ultimately bolstering net profits. The pharmaceutical sector has embraced these strategies, evolving its quality policies, adhering to good manufacturing practices, and enhancing regulatory compliance under the oversight of bodies such as the World Health Organization (WHO) and the National Health Surveillance Agency (ANVISA). This evolution aims to boost productivity while upholding product quality standards.

Maintenance is a crucial strategic function for achieving organizational objectives, as it plays a pivotal role in supporting management and addressing production challenges. According to statistics from the Brazilian Association of Maintenance and Asset Management (ABRAMAN), Brazil incurs a maintenance cost equivalent to 4.3% of its Gross Domestic Product (GDP), slightly higher than the global average of 4.1%. This translates to significant expenses, emphasizing the imperative for organizations to continuously improve their maintenance management practices by assimilating innovative knowledge and adopting best practices from leading industrial nations. Moreover, contemporary production and maintenance management models incorporate Cyber-Physical Systems, which advocate for integrated production and maintenance workflows utilizing AI programming. These systems leverage machine learning and data collected directly from equipment to facilitate predictive and prescriptive maintenance techniques.

Another pivotal aspect in contemporary production and maintenance management models is the integration of Cyber-Physical Systems [6]. These systems advocate for a cohesive approach to production and maintenance management, leveraging AI programming [7] rooted in machine learning and data collected directly from devices

and equipment within the production environment. This framework develops predictive [8] and prescriptive [9] maintenance techniques, enabling proactive problem-solving and optimization of maintenance activities.

This research endeavors to underscore the significance of effective maintenance management by analyzing available data to identify consistent indicators that can facilitate the adoption of a more efficient model within the pharmaceutical industry. Specifically, the study uses quantitative and qualitative methodologies to scrutinize machine stoppage data, critical process alarms, and data on corrective and preventive maintenance activities over a defined period. By evaluating the performance of current maintenance practices, this research sheds light on the absence of a systemic approach to assessing the effectiveness of maintenance management within the pharmaceutical sector.

Materials and Methods

This case study was carried out in a Fiocruz pharmaceutical laboratory (Oswaldo Cruz Foundation), founded in 1976, which currently has a total of 41,722 m² of built area. As this laboratory has an extensive portfolio in manufacturing vaccines, biopharmaceuticals, and reagents, the study will focus on a vaccine production line, specifically on the bottling process of a lyophilized product. The bottled product undergoes dehydration, is frozen under a vacuum, and then sublimated. This process is carried out to ensure a longer shelf life of the product. Figure 1 shows the vaccine production macro process and pictures of the filling line, composed of a bottle washer, deproteinization tunnel, filling machine, lyophilizer, and capping machine.

The factory maintenance manager software, customized for the pharmaceutical industry under the name ENGEMAN, was utilized for this study. This software facilitated the extraction, processing, and cataloging of fault messages and alarms from the equipment itself, with the primary objective of identifying and addressing the leading causes of downtime within the lyophilized filling line from 2015 to 2020.

To analyze failures in both corrective and preventive maintenance activities associated with the lyophilized filling line, the Failure Mode and Effect Analysis (FMEA) methodology will be

Figure 1. Macro process of a freeze-dried filling line.
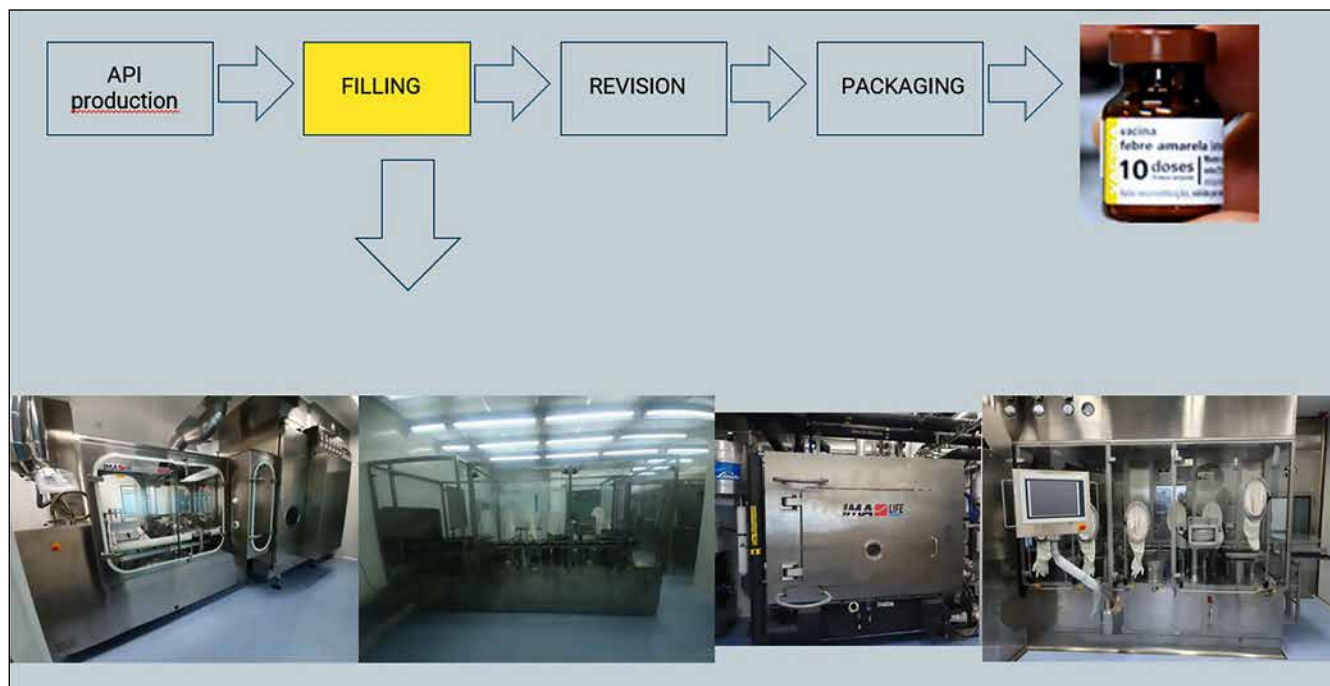
employed. FMEA is a systematic tool designed to identify and scrutinize the modes and root causes of failures occurring on the factory floor. By studying the consequences of these failures, FMEA aids in formulating and adopting appropriate maintenance measures. Through FMEA, it becomes feasible to pinpoint actions that could eliminate or mitigate the likelihood of future failures.

Furthermore, this study seeks to juxtapose the current maintenance techniques practiced within the factory with alternative approaches, such as predictive maintenance. Predictive maintenance involves real-time data acquisition from the factory floor, enabling proactive identification of potential issues before they escalate into critical failures. This comparative analysis aims to discern the efficacy and potential benefits of implementing predictive maintenance techniques within the pharmaceutical manufacturing environment.

Results and Discussion

The ENGEMAN factory maintenance manager software, tailored specifically for pharmaceutical industry applications, served as the primary tool for this study. It facilitated handling fault and alarm messages originating directly from equipment, aiming to export, process, and catalog the primary causes of stoppages within the production line spanning from 2015 to 2020. For the analysis of failures in both corrective and preventive maintenance activities associated with the lyophilized filling line, the Failure Mode and Effect Analysis (FMEA) methodology will be employed. FMEA is a systematic tool designed to identify and scrutinize the modes and root causes of failures occurring on the factory floor. By evaluating the consequences of these failures, FMEA assists in formulating and adopting appropriate maintenance measures. Through FMEA, it becomes feasible to pinpoint actions that could eliminate or mitigate the likelihood of future failures. Furthermore, this study intends to compare the current maintenance techniques practiced within the factory with alternative approaches, such as

predictive maintenance. Predictive maintenance involves real-time data acquisition from the factory floor, enabling proactive identification of potential issues before they escalate into critical failures. This comparative analysis aims to discern the efficacy and potential benefits of implementing predictive maintenance techniques within the pharmaceutical manufacturing environment. Preventive maintenance, as described in [12], primarily aims to reduce the likelihood of failures that may disrupt the production process, thereby minimizing the need for unscheduled corrective maintenance actions. Analyzing available data for the lyophilized filling line will evaluate and propose acceptable and reliable preventive maintenance activities performed [13], ensuring optimal operational efficiency and reliability. In possession of the reports issued by ENGEMAN of the records of the maintenance orders carried out on the filling line, it is necessary to filter the raw data since the field for the description of the fault that occurred is only sometimes easy to understand. Quantitative data refinement work was carried out (Figure 2):

In this case study, two classic types of maintenance models are employed: i) reactive or corrective maintenance, commonly referred to as "run to failure", wherein maintenance is performed only after equipment failure occurs without prior analysis, and ii) preventive maintenance, which involves scheduled interruptions of the operating system to address necessary corrections and replace parts according to predetermined expiration dates set by the manufacturer, irrespective of whether the machine exhibits faults [14]. Figure 2 depicts a quantitative analysis of the utilization of these two classic maintenance models. Surprisingly, implementing preventive maintenance did not decrease the number of corrective services; instead, it resulted in an increase (Figures 3 and 4).

From the results depicted in Figure 3, it becomes evident that the filling line encounters more issues related to the electrical part than the mechanical part. This observation can be attributed to this line's numerous parameters and electronic components

Figure 2. Number of filling line failures per year.
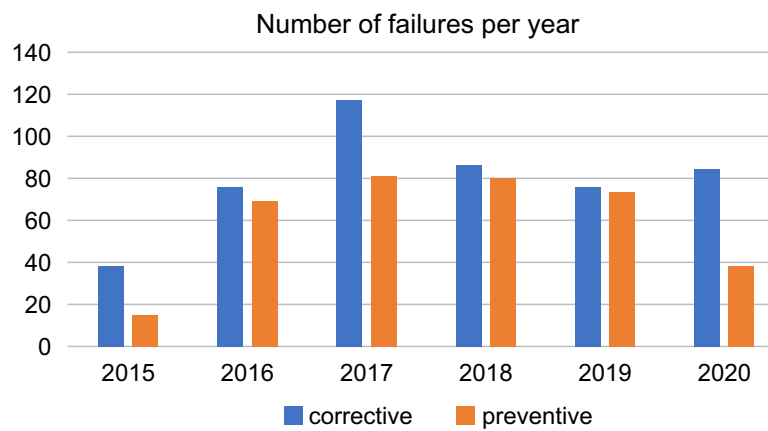
Figure 3. Number of mechanical *vs* electrical failures.
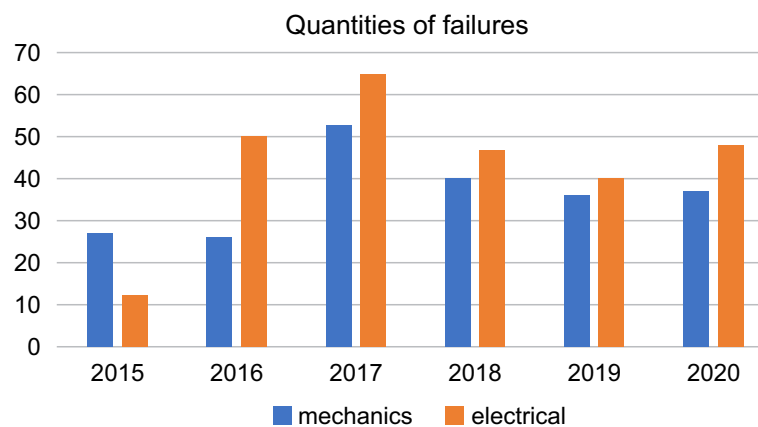
Figure 4. Types of intervention.
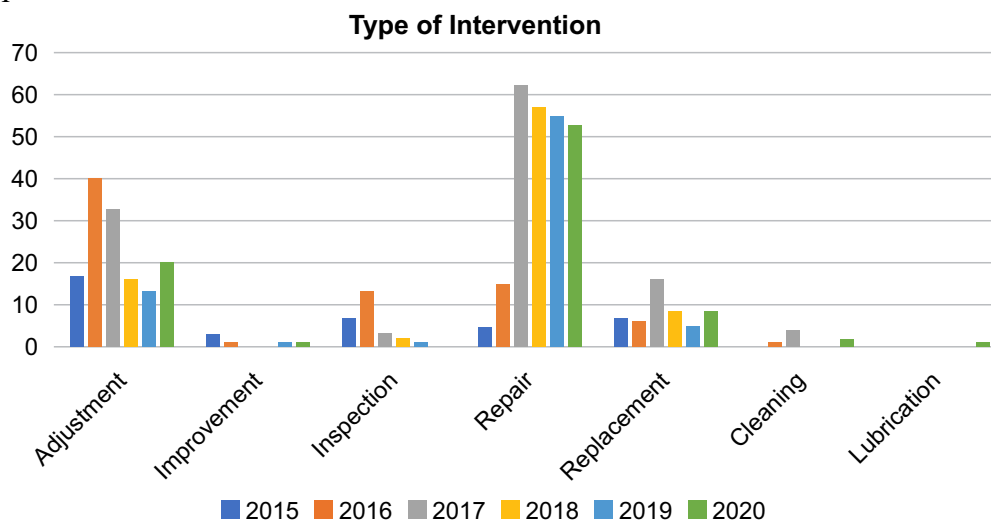
requiring adjustments. Additionally, it is imperative to assess the history of utilities within the building housing the filling line. Fluctuations in electrical power may necessitate using uninterruptible power supplies (UPS) or power generators to ensure the integrity of data recorded during the filling process. Interventions were categorized into broad groups to establish a standardized nomenclature for interpreting maintenance data, including adjustment, improvement, inspection, repair, exchange, cleaning, and lubrication. Figure 4 illustrates the significant adjustments and repairs carried out during interventions on this filling line. By examining the types of interventions, it becomes evident that enhanced training and collaboration between production and maintenance teams could effectively mitigate production downtime. Utilizing the Failure Mode and Effect Analysis (FMEA) tool to categorize critical points of the filling line qualitatively, it becomes feasible to identify components that have historically undergone exchange, adjustment, or repair, thereby enabling the proposition of alternative maintenance approaches.

Table 1 summarizes the significant components exhibiting this filling line's highest Risk Priority Number (RPN). The RPN is calculated as the product of severity, occurrence, and detection weights associated with component failure.

According to Table 1, the compressor and vacuum pump are the most critical components of the filling line and require special attention in maintenance because they are rotating machines, and wear occurs with greater incidence. Through this type of analysis, a more effective methodology can be proposed to maintain the critical components of the equipment through the proposed actions.

Conclusion

This case report article data about corrective and preventive maintenance activities spanning 5 years were meticulously analyzed within a filling line of the pharmaceutical industry. These data were sourced from the factory maintenance management software known as ENGEMAN. The outcomes of maintenance orders generated within this software were methodically cataloged, sorted, and identified using an Excel spreadsheet. Subsequently, the Failure Mode and Effect Analysis (FMEA) tool was employed to analyze and identify the primary critical components of the filling line. The application of preventive maintenance was then evaluated quantitatively and qualitatively compared to corrective measures. Based on the findings, the following conclusions can be drawn:

i) There is a need to review and refine preventive maintenance procedures based on historical failure data to establish a more reliable preventive maintenance regime.

Table 1. FMEA analysis identifying critical components.

Nº	Component	Failure Causes	Severity	Occurrence	Detection	RPN	Action
1	Compressor	Mechanical Wear	5	8	8	320	Implementation of predictive maintenance mode
2	Pump vacuum	Low Oil Level	6	10	5	300	Review the maintenance procedure and staff training
3	Condenser	Pipe Obstruction	7	5	8	280	Improve the quality of the equipment supply water
4	Piping	Crack in the Pipe	6	4	9	216	Piping repair
5	Pump vacuum	Contamination with Oil Moisture	5	8	5	200	Review the operation procedure and staff training

ii) Investing in operational and maintenance training initiatives to better mitigate identified failures and enhance overall maintenance efficacy is imperative.

iii) It is necessary to enhance the collection and filtering of maintenance data and integrate this database using advanced artificial intelligence (AI) techniques such as machine learning. This integration can facilitate more informed and assertive decision-making in maintenance management.

iv) Implementing predictive maintenance modalities should be prioritized to minimize downtime in the production process and ensure heightened reliability and quality in maintenance processes within the pharmaceutical industry.

By addressing these key conclusions, pharmaceutical companies can optimize maintenance practices, enhance operational efficiency, and bolster product quality and reliability.

Acknowledgments

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Number of Words – Title	120	90	95	85	70	60	120	90
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Font Size/Space-Abstracts/Key Words and Abbreviations	10; single space	10; single space	10; single space	10; single space	-	-	10; single space	10; single space
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References	20 (font size 10,single space	30(font size 10,single space	15 (font size 10,single space)	10 (font size 10,single space)	10 (font size 10,single space	5(font size 10,single space	20 (font size 10,single space	20

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