AN ANALYSIS OF BRAZILIAN SCIENTIFIC STUDIES ON STORAGE OF MATERIALS AVAILABLE ON GOOGLE SCHOLAR IN 2023

Eliane Pereira Viana[A], Alexandre Lopes Martiniano[B], Gilbert Breves Martins[C], Daniel Nascimento-e-Silva[D]

ARTICLE INFO	ABSTRACT
	Purpose: This study aimed to analyze the scientific productions on storage in the Google Scholar database in 2023. **Theoretical Structure:** The study's theoretical structure focused on the conceptual and operational aspects of the storage process in its various dimensions and analytical categories, enabling the understanding of the main aspects of the national scientific production published in Brazilian journals, platforms, and repositories on storage. **Design/Methodology/Approach:** The conceptual bibliographic method was used in its four stages: the formulation of research questions, with exclusion criteria and appropriate response standards, data collection in scientific databases, organization of data in figures and other diagrammatic schemes where the responses generated can be visualized, and presentation of the results in specific communication products for evaluation by the scientific community. **Findings:** The results showed that a) the most frequently discussed topics in the publications were storage, storage, and specific aspects of stored materials, b) theoretical-empirical studies were predominant, c) several different methods were used to generate the findings, with the experimental method prevailing, d) most of the studies aimed to apply the knowledge generated, e) only one-third of these publications were in journals and proceedings of scientific events. **Research, Practical, and Social Implications:** The findings show that Brazilian journals and scientific communities prioritize theoretical-empirical studies, especially those that have the potential to be transformed into techniques and technologies. The implications are much more impactful if the production is geared towards agribusiness. **Originality/Value:** The study shows the theoretical-empirical trend of research on storage, mainly because it is primarily carried out by engineering areas, which seek to solve problems that the agribusiness industry has faced in its challenges of increasing the efficiency of its production process combined with the increasing quality of its products. Doi: https://doi.org/10.26668/businessreview/2024.v9i8.4886

[A] *Technologist in Logistics. Instituto Federal de Educação, Ciência e Tecnologia do Amazonas. Manaus, Amazonas, Brazil. E-mail: elianeviana2017@gmail.com Orcid: https://orcid.org/0009-0000-0850-1414*

[B] *Master in Electrical Engineering. Instituto Federal de Educação, Ciência e Tecnologia do Amazonas. Manaus, Amazonas, Brazil. E-mail: alexandre.martiniano@ifam.edu.br Orcid: https://orcid.org/0009-0004-8304-2982*

[C] *PhD in Computer Science. Instituto Federal de Educação, Ciência e Tecnologia do Amazonas. Manaus, Amazonas, Brazil. E-mail: gilbert.martins@ifam.edu.br Orcid: https://orcid.org/0009-0004-8844-2651*

[D] *PhD in Production Engineering. Instituto Federal de Educação, Ciência e Tecnologia do Amazonas. Manaus, Amazonas, Brazil. E-mail: danielnss@gmail.com Orcid: https://orcid.org/0000-0001-9770-575X*

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UMA ANÁLISE DOS ESTUDOS CIENTÍFICOS BRASILEIROS SOBRE ARMAZENAGEM DE MATERIAIS DISPONÍVEIS NO GOOGLE ACADÊMICO NO ANO DE 2023

RESUMO

Propósito: Este estudo teve como objetivo analisar as produções científicas sobre armazenagem contidas na base de dados Google Acadêmico no ano de 2023.

Estrutura Teórica: A estrutura teórica do estudo se concentrou nos aspectos conceituais e operacionais do processo de armazenagem em suas diversas dimensões e categorias analíticas, para que se pudesse compreender os principais aspectos da produção científica nacional publicada em periódicos, plataformas e repositórios brasileiros sobre armazenagem.

Desenho/Metodologia/Abordagem: Foi utilizado o método bibliográfico conceitual nas suas quatro etapas: a formulação das questões de pesquisas, com os critérios de exclusão e os devidos padrões de respostas, a coleta de dados em bases científicas, a organização dos dados em figuras e outros esquemas diagramáticos onde se possa visualizar as respostas geradas e a apresentação dos resultados em produtos comunicacionais específicos para avaliação da comunidade científica.

Descobertas: Os resultados mostraram que a) os assuntos mais tratados nas publicações foram armazenagem, armazenamento e aspectos específicos dos materiais armazenados, b) os estudos teórico-empíricos foram os predominantes, c) foram utilizados vários métodos diferentes para gerar as descobertas, com prevalência do método experimental, d) a maior parte dos estudos teve como objetivo a aplicação dos conhecimentos gerados, e) com apenas um terço dessa publicação feita em periódicos e anais de eventos científicos

Pesquisa, Implicações Práticas e Sociais: As descobertas mostram que os periódicos e as comunidades científicas brasileiras privilegiam estudos teórico-empíricos, especialmente os que têm potencial para serem transformados em técnicas e tecnologias. Se a produção estiver de alguma forma voltada para o agronegócio, as implicações tendem a ser muito mais impactantes.

Originalidade/Valor: O estudo mostra a tendência teórico-empírica das pesquisas sobre armazenagem, principalmente porque é feita, em grande parte, por áreas da engenharia, que buscam a solução de problemas que a indústria do agronegócio tem enfrentado em seus desafios de aumento de eficiência de seu processo produtivo aliada à qualidade crescente de seus produtos.

Palavras-chave: Armazenagem de Materiais, Estudos Científicos, Google Acadêmico, Pesquisa Bibliográfica, Armazenagem.

UN ANÁLISIS DE ESTUDIOS CIENTÍFICOS BRASILEÑOS SOBRE ALMACENAMIENTO DE MATERIALES DISPONIBLES EN GOOGLE ACADEMIC EN EL AÑO 2023

RESUMEN

Propósito: Este estudio tuvo como objetivo analizar las producciones científicas sobre almacenamiento contenidas en la base de datos Google Scholar en el año 2023.

Estructura Teórica: La estructura teórica del estudio se centró en los aspectos conceptuales y operativos del proceso de almacenamiento en sus diversas dimensiones y categorías analíticas, de modo que fue posible comprender los principales aspectos de la producción científica nacional publicada en revistas, plataformas y repositorios brasileños. en almacenamiento.

Diseño/Metodología/Enfoque: Se utilizó el método bibliográfico conceptual en sus cuatro etapas: formulación de preguntas de investigación, con criterios de exclusión y estándares de respuesta adecuados, recolección de datos sobre bases científicas, organización de datos en figuras y otros esquemas esquemáticos donde se muestran las respuestas generadas. pueden visualizarse y los resultados presentarse en productos de comunicación específicos para su evaluación por la comunidad científica.

Hallazgos: Los resultados mostraron que a) los temas más discutidos en las publicaciones fueron el almacenamiento, almacenamiento y aspectos específicos de los materiales almacenados, b) predominaron los estudios teórico-empíricos, c) se utilizaron varios métodos diferentes para generar los descubrimientos, con predominio del método experimental, d) la mayoría de los estudios apuntaron a aplicar el conocimiento generado, e) solo un tercio de esta publicación se realizó en revistas y anales de eventos científicos

Implicaciones de Investigación, Prácticas y Sociales: Los hallazgos muestran que las revistas y las comunidades científicas brasileñas favorecen los estudios teórico-empíricos, especialmente aquellos que tienen el potencial de transformarse en técnicas y tecnologías. Si la producción se centra de alguna manera en la agroindustria, las implicaciones tienden a ser mucho más impactantes.

Originalidad/Valor: El estudio muestra la tendencia teórico-empírica de la investigación sobre almacenamiento, principalmente porque es realizada, en gran parte, por áreas de ingeniería, que buscan resolver problemas que ha

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enfrentado la industria agroindustrial en sus desafíos de aumentar la eficiencia de su proceso de producción combinado con la creciente calidad de sus productos.

Palabras clave: Almacenamiento de Materiales, Estudios Científicos, Google Scholar, Investigación Bibliográfica, Almacenamiento.

1 INTRODUCTION

Storage is one of the structural bases of logistics activities. It is present from the extraction of natural raw materials through the various production systems until reaching the organizations that will distribute the products to the end consumers. Each organization receives and stores raw materials and their finished products at some point, in the same way that it stores them for transportation so that the dynamics of the logistics are based on the production-storage-production or operation-storage-operation scheme (in the case of service provision). More recently, this logistical component has expanded its frontiers and importance, encompassing data storage for information and communication technologies (Heo et al., 2024; Goswami et al., 2024; Alghushairy & Ma, 2022), genomics (Yu et al., 2024; Wang et al., 2024; Akash et al., 2024), and energy (Jamal et al., 2024; Ali et al., 2024; Yang et al., 2024), among countless other areas.

This growing and cumulative importance is also present in the generation of knowledge. A survey in the Google Scholar database in June 2024 showed approximately 7.6 million studies available. Considering only those published and made available in that database between 2020 and 2024, the number is approximately 1.69 million. In 2024 alone, approximately 78,700 studies were published and made available. These are fabulous numbers and prove how warehousing is a phenomenon that challenges the innovation capabilities of organizational managers so that they can increase the efficiency of their logistics operations, both externally and internally. This ongoing search for efficiency has drawn scientists' attention to deepening their knowledge, allowing for a greater understanding of the factors that affect warehousing performance and specific aspects of the stored materials.

Given this enormous amount of knowledge produced and made available in the Google Scholar database, one question resonates in the ears and minds of Brazilian logistics researchers and their members: What has been the contribution of Brazilian science to the stock of knowledge on warehousing? In this sense, this study aimed to analyze the scientific productions on warehousing contained in the Google Scholar database in 2023 to understand which are the most studied subjects, the types of studies carried out, the most common methods applied, the

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intended objectives and the types of publications that are made. The aim was to provide an overview of the Brazilian contribution to science on the storage phenomenon. The method used was the conceptual bibliographic method developed by Nascimento-e-Silva (2012; 2020; 2021a), which consists of formulating a research question, followed by collecting data from scientific databases, proceeding with the organization of the data and ending with the generation of the desired answer. In addition to this introduction, this document includes a review of the literature on storage, details of the method used, the results achieved, the conclusion, and the list of works cited throughout the text.

2 STORAGE: APPROACHES AND ATTRIBUTES

The literature review showed that the phenomenon of material storage does not have a consensual definition. The most common perception found is that storage is the same as a generic name, as can be found in the studies by Aristides et al. (2015), Kluck (2017), and Bastos (2021). Name refers to any naming, which is the act of naming things. For example, when it is said that a cat will be named Mario Bros., this act of naming the cat is said to be a generic name because any name could be chosen to name it. In this sense, it is said that storage is a general name that involves a whole series of activities divided into two groups: storage and distribution of materials. This means that this name, although generic, only applies to the activities of storing materials and the activities of distributing these same stored materials. In other words, storage of materials is storage and distribution. If it only involves storage and not distribution, it cannot be considered storage. Likewise, it cannot be classified as storage if it is only distributed and not stored.

Another way of understanding storage is as a set, as found in the studies by Silva and Martins (2020) and Caixeta Filho et al. (2005). A set is any grouping of things with some characteristic in common. The group of students in a classroom has a common characteristic of being students of that classroom. Storage is also seen as a set because it groups activities to properly maintain an organization's materials (Silva & Martins, 2020). The study by Caixeta Filho et al. (2005) shows that it is not enough to store these materials but to preserve them under certain conditions that do not alter their quality or quantity.

Another term found in the literature, equivalent to storage, was guard (Domingues, 2016). The idea of storage derives from people's and organizations' efforts to care for, look after, protect, and preserve something. Storage is a form of storage because it involves taking

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care of the materials under its responsibility so that they can be used as soon as needed. What characterizes storage as storage is its temporary nature, so long-term or permanent storage cannot be considered. Table 1 summarizes these findings from the literature.

Table 1

Approaches to material storage

References	Approaches
Aristides et al. (2015); Kluck (2017); Bastos (2021)	Generic name
Silva & Martins (2020); Caixeta Filho et al. (2005)	Set of activities
Oliveira et al. (2015)	Storage
Domingues (2016)	Process
Phu; Cho (2014)	Provision
Nascimento et al. (2018)	Maintenance
Santos et al. (2022)	Management

Source: Data collected by the authors.

The study by Domingues (2016) considers storage as equivalent to a process. A process is the logical sequence of steps in which a particular product or service must be materialized when the last one is completed. Storage is a process because it consists of three logically ordered steps: receiving materials, arranging the materials in appropriate places, and collecting the generated products for new disposal until they are transported to the customers. This process involves two steps of materials: the inputs or raw materials for production and a step of products, which are the production results.

Provision was another term in the literature equivalent to storage (Phu & Cho, 2014). The idea of provision arises from two concerns in materials management. The first is the provision of materials that will be required by the organization to supply its production system; the second is the result of the first, as the provision of materials so that they are in ideal conditions for use until the time of the orders. This means that provision is only synonymous with storage when it supplies the organization with production inputs and makes them available internally. Supply is a relationship with the external environment, while provision is a relationship with the internal environment.

According to the study by Nascimento et al. (2018), storage can also be considered a form of maintenance. Maintenance focuses on preserving two aspects of materials: their functionality and physical integrity. From this point of view, storage is the synthesis of the second stage of provision, which is the guarantee that the availability of materials meets the production requirements, which is one of the challenges of storing these inputs, materialized from a set of procedures typical of materials management. For this to happen, maintenance

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must account for the location of spaces reserved for materials, lighting, air conditioning, handling, and numerous other technical aspects of transportation and movement of materials within the warehouse, both of materials as inputs and of products that are available for dispatch to customers.

Santos et al. (2022) consider storage as a type of management. More specifically, economic management of storage space. Since management is the process of planning, organizing, directing, and controlling resources to achieve organizational objectives, all processes specifically involving resources intended for production are the responsibility of storage as management. Moreover, since it involves the management of physical space, everything related to location, area size, layout, inventory maintenance, dock and bay specifications, and warehouse reorganization are also under the scope of responsibility of this type of management.

The terms of equivalence represent the first part of scientific concepts. They are also commonly called approaches, an aspect of reality contemplated in scientific studies. The other part is called attributes. The attributes represent the main aspects the approaches contemplate in their explanations of reality. The attributes also signal what science has already mapped and can explain. Thus, the conceptual scope already known to science is obtained when the equivalence terms are combined with the attributes. Table 2 presents the main storage attributes according to the scientific literature. To facilitate understanding, groupings of attributes related to the same aspect were created, as is the case of storage activities, highlighted in the studies by Aristides et al. (2015), Kluck (2017), Bastos (2021), Silva and Martins (2020) and Caixeta Filho et al. (2005), but in a very generic way. Other studies specified these activities as storage of materials (Domingues, 2016), inventory maintenance (Silva & Martins, 2016), reception of materials (Domingues, 2016), protection of materials (Phu & Cho, 2014), control of materials (Phu & Cho, 2014) and adequacy of storage (Silva & Martins, 2020). These activities are, therefore, the most common ones found in the literature that attest to the responsibility of the storage phenomenon.

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Table 2

Storage attributes

References	Attributes	Semantic groups
Aristides et al. (2015); Kluck (2017); Bastos (2021); Silva & Martins (2020); Caixeta Filho et al. (2005)	Activities	Storage activities
Domingues (2016)	Material storage	
Silva; Martins (2020)	Stock maintenance	
Domingues (2016)	Material reception	
Phu & Cho (2014)	Material protection	
Phu & Cho (2014)	Material control	
Silva & Martins (2020)	Storage suitability	
Caixeta Filho et al. (2005)	Quality conditions	Storage challenges
Caixeta Filho et al. (2005)	Product conservation	
Oliveira et al. (2015)	Products	Storage focus
Nascimento et al. (2018)	Stock	
Santos et al. (2022)	Materials	
Aristides et al. (2015); Oliveira et al. (2015); Domingues (2016); Kluck (2017); Bastos (2021)	Material distribution	Distribution of materials
Oliveira et al. (2015); Domingues (2016); Nascimento et al. (2018)	Time (short)	Nature of storage
Aristides et al. (2015); Caixeta Filho et al. (2005); Kluck (2017); Bastos (2021)	Temporary storage	
Aristides et al. (2015); Kluck (2017); Bastos (2021)	Destination point	Storage locus
Phu & Cho (2014); Santos et al. (2022)	Physical space	

Source: Data collected by the authors.

Another grouping formed was called storage challenges because they represent the central and constant concern of this part of materials management. It is composed of efforts to guarantee the quality conditions of products, materials, and all types of stock through conservation schemes and systems specific to the type of material or input, as seen from the study by Caixeta Filho et al. (2005). This semantic group focuses on products (Oliveira et al., 2015), stock (Nascimento et al., 2022), and materials (Santos et al., 2022), which represent the third semantic grouping of attributes constructed. Products are the results of production processes, which must be stored for delivery in ideal quality and conservation conditions to the organization's customers. Stocks are all types of inputs intended for the process of transformation into products. Materials are all physical goods, whether stocks, products, or other materials (such as cleaning and office supplies) that the organization and its organizational units will demand. Distribution is one of the fundamental differentiating characteristics of storage, as mentioned in the studies by Aristides et al. (2015), Oliveira et al. (2015), Domingues (2016), Kluck (2017), and Bastos (2021). Material distribution is the delivery of orders requested by organizational units or customers of an organization. For internal supply to occur, warehouses receive purchase orders from organizational units, acquire what was requested, and store it from the moment it arrives until delivery. In the case of product delivery, production is

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received, stored, and delivered upon request or order from other organizational units. However, activities are often not subject to uniformity or standardization (Wang & Yang, 2022; Wang et al., 2022). However, initiatives in this direction are necessary to add value to storage activities (Wo et al., 2022). If the distribution of materials is a differentiating attribute of storage, the other is temporality. More specifically, storage is always the search for keeping materials in the shortest possible time, as can be seen in the studies by Oliveira et al. (2015), Domingues (2016), Nascimento et al. (2018), Aristides et al. (2015), Caixeta Filho et al. (2005), Kluck (2017) and Bastos (2021). The name "nature of storage" was given to this grouping because brevity is part of this specialized area of materials management. Consequently, long-term or definitive storage is not part of its conceptual or operational scope. The idea of short, medium, and long-term aligns with the organization's production cycle. Food production has a much shorter cycle than the shipping industry, so materials also suffer the consequences of this temporality, significantly affecting their storage nature. Warehouses are the locus of storage, as predicted in the sixth and final semantic grouping constructed. The scientific literature cites the locus as a destination point (Aristides et al., 2015; Kluck, 2017; Bastos, 2021) and physical space (Phu & Cho, 2014; Santos et al., 2022), pure and simple. Destination points and physical spaces are covered by a series of focal points, when viewed from the storage perspective, which involves both physical infrastructure, such as temperature, size, lighting, and facilities (pallets, gondolas, shelves, etc.), and extraphysical infrastructure, such as the types and forms of operationalization of the services provided there. All six attribute groups are taken in unison and simultaneously execute storage activities.

For this study, storage will be considered as a process of temporary storage of materials, which begins with the reception of material orders and ends with their effective distribution to customers. It is important to emphasize that it is impossible to list all the activities that make up the storage process because they depend on numerous distinct characteristics of the organization, product, and relationships with customers and suppliers. For example, if the organization adopts a just-in-time system, the storage will have different storage activities than another that adopts push production. If the product is food, the steps will differ from fuel production. Finally, the steps will differ if production is carried out directly in the client organization.

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3 RESEARCH METHODOLOGY

This section presents the main aspects of the methodological strategy used to generate answers to the research question of this study. The main questions were divided into guiding research questions and specific focuses to guide data collection. The focus allowed us to choose the most appropriate way to generate the answers, guiding the creation of the data collection instrument, the collection of data, and the generation of the answers and their consequent interpretations. The section ends with a presentation of the limitations of the study.

3.1 GUIDING QUESTIONS

This study aimed to analyze Brazilian scientific productions on storage contained in the Google Scholar database in 2023. To this end, five guiding research questions were formulated: What were the most studied subjects, what were the types of studies carried out, what were the methods used, what were the intended objectives, and what were the types of publications carried out? The methodological design of the research was the conceptual bibliographic in its four stages: formulation of the guiding questions, data collection in databases, data organization, and generation of responses (Nascimento-e-Silva, 2020; 2021a; 2021b; 2021c; 2023).

3.2 STUDY DESIGN

The design of this research consisted of four stages, each executed from substages, as provided for by the conceptual bibliographic method (Nascimento-e-Silva, (2020; 2021a). Several studies have used this procedure, such as those by Craveiro et al. (2023), Simões and Nascimento-e-Silva (2020), Oliveira et al. (2023a), Oliveira et al. (2023b) and Bezerra et al. (2024). The first was the research planning. Here, the main research question and the guiding questions were defined. Immediately afterward, the field study protocol was prepared, containing the definitions of the restrictions to be made, and the response patterns were developed. The second stage aimed to collect data from the Google Scholar database. To this end, the data collection instrument was first created, which is a table with several columns called data mass, containing a column for each guiding question and other columns for information about the study; then, the instrument was tested and validated, and ended with the

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collection of data, in compliance with the research protocol developed in the previous stage. Figure 1 summarizes these procedures.

Figure 1

Study design.
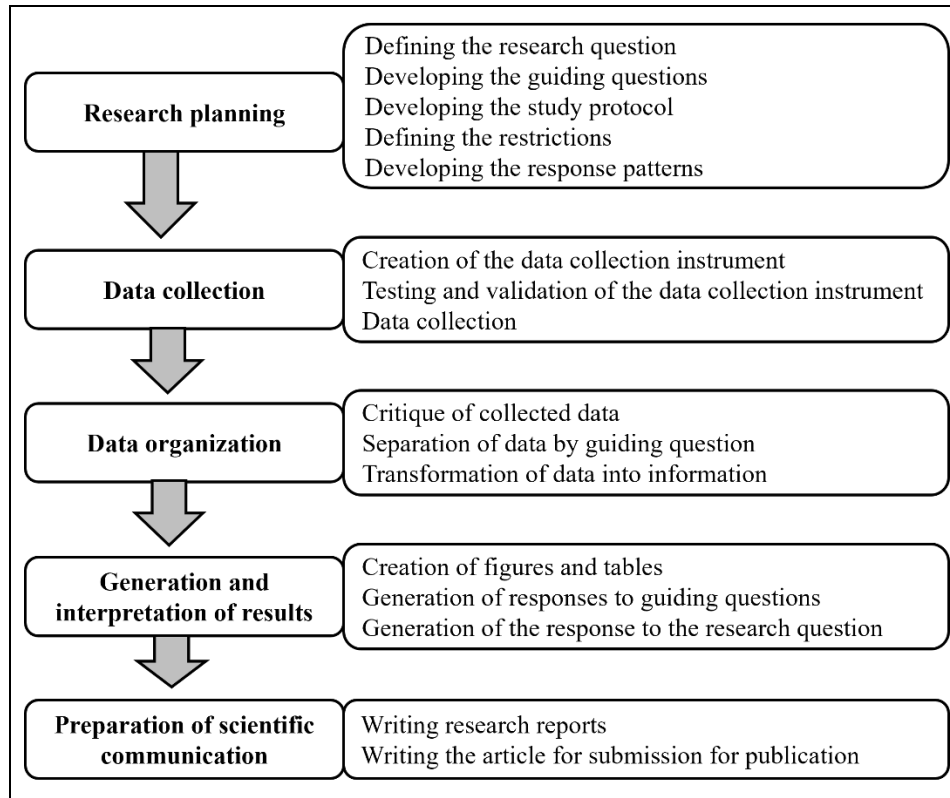
Source: Prepared by the authors.

The third stage involved organizing the data. It began with a critique of the collected data to ensure that they followed the restrictions and response standards in the research protocol and continued with the analysis of each collected data piece. Each data set was separated from the mass of data so that they could be handled separately and transformed into a figure that showed the answer sought. The fourth stage began with the creation of figures summarizing the responses, continued with the writing of the response based on the behavior of the data, and ended with the writing of the comparison of the behavior found with the theoretical framework of reference of the study. The fifth and final stage sought to transform the research reports into scientific communication for publication. To this end, the reports were completed by adding the literature review, applied methodology, conclusion, and study introduction. The article for submission and publication was written by adapting the study's final report to the journal's editorial scope.

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3.3 POPULATION AND SAMPLE

The population of this study consisted of all scientific publications in the Google Scholar database made available during the year 2023 that contained the term "storage" in their title or subtitle. The survey of publications was carried out in April 2024 and revealed a total of 40 texts with this criterion. Of this total, eight documents were unavailable for download, eight were procedure manuals, and four did not contain enough information to be referenced. Therefore, 20 studies remained, which constituted the sample from which the results of this research were generated. It is worth mentioning that similar behavior was already expected since the platform allows all types of documents to be allocated, with different forms of access, some free and others more restricted.

3.4 INSTRUMENTS AND TECHNIQUES FOR DATA COLLECTION, ANALYSIS, AND ORGANIZATION

The data set was used as a data collection instrument, as recommended by the studies by Nascimento-e-Silva (2023), which is an electronic table with columns intended for collecting responses from bibliographic documents. Unlike the studies carried out by Craveiro et al. (2023), Simões and Nascimento-e-Silva (2020), Oliveira et al. (2023a), Oliveira et al. (2023b), Cardoso and Nascimento-e-Silva (2024), and Bezerra et al. (2024), among others, which used a two-column data set, ours had information about the study consulted, as well as the subjects covered, types of studies carried out, methods applied, intended objectives and types of publications carried out, constituting a total of six columns. Only documents in Portuguese were consulted.

The technique used for data collection consisted of the following steps. First, we identified studies with the term "storage" in their title and subtitle and then downloaded them all (eight were not accessed because the platforms did not allow it). Then, each one was opened so that we could analyze its content to see if it met the requirements contained in the field research protocol, which excluded documents that were not considered scientific, such as technical documents in manual format, normative instructions, etc. Twenty complete studies remained, and 12 others did not meet the protocol requirements were discarded.

The data analysis was done simultaneously with its organization, separating each column of data from the others. The data on the subjects covered in the studies were collected in five columns: the number of keywords that generally appear in articles and other scientific

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productions. They were gathered in a single column so they could be placed in alphabetical order, and thus, we had a map of how many there were and which ones were most repeated, an essential procedure for creating the subject cloud. This organization allowed us to visualize and understand the answer obtained for the first guiding question. The other data were analyzed similarly, with the difference that they were organized in tables, in which the first column indicates the sources (references) and the second column shows the answers obtained for each guiding question.

3.5 GENERATION AND INTERPRETATION OF RESULTS

The results were generated using semantic analysis. This technique was applied to the questions regarding the topics covered in the studies analyzed to determine the most frequent. Semantic analysis identified the topics based on the number of times they appeared in the keywords of the articles and scientific productions. The other results were generated similarly, counting the frequency of the responses obtained. However, instead of creating a column in the tables to record the number of times they appeared, it was decided to replace the numbers with the sources so that the more studies appear in the reference table, the greater the frequency of that category. To find out how many times, for example, these appear as a type of publication, count how many authors were cited in that part of the table. The interpretation of the results sought to find out "what those results mean" by the guidelines of Nascimento-e-Silva (2020b; 2021d), who consider interpretations as the results of comparisons of empirical evidence with a theoretical framework of reference. The application of this system compared the responses that appear in the word cloud and tables with the review of the study's literature, showing fundamental aspects that also appear in recent scientific studies, especially in international literature. This procedure allows knowledge already mapped by science to be confirmed or refuted and fill gaps.

3.6 LIMITATIONS OF THE STUDY

Two significant limitations can be seen in this study. The first concerns the period of the data collected, which was restricted to the scientific production made available on the Google Scholar platform in 2023, configuring it as a cross-sectional study. It would be interesting to expand the collection of productions to at least five years, converting it into a

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longitudinal study. However, longitudinal studies are concerned with indicating the evolution of the behavior of a given phenomenon over time, which was not the intention of this study, which focused precisely on knowing what and how the scientific production on storage happened in that year, creating a snapshot of this logistical reality, rather than a film. The second was restricting the collection to studies published in Portuguese and only in Brazilian platforms and journals. Expanding the collection to include Brazilian production in other languages, journals, and platforms would be very interesting. Once again, the purpose of the study comes into play, which is to learn about Brazilian production published in Brazilian media (journals, platforms, and repositories). This information allows us to understand, for example, what is produced and what the journals value, what interests they have in which subjects and types of research, in addition to other aspects considered necessary.

4 RESULTS AND DISCUSSION

This section is organized according to the guiding research questions to facilitate understanding of this study's findings. In this sense, the results related to the most studied subjects in the Brazilian literature on storage will be presented first, followed by the types of studies, most common methods used, intended objectives, and types of publication.

4.1 MOST STUDIED SUBJECTS: KEYWORDS

The survey of the keywords used in studies on storage shows the predominance of the terms storage and warehousing, as shown in Figure 2. In second place appear terms related to the types of stored materials, such as grains and metal alloys, and logistics as a set of activities aimed at both supplying organizations and distributing to customers what the organizations produce. Next appear the specific terms for stored materials, such as hydrides, hydrogen, and metals, as well as those that portray the aspects of storage that were analyzed in the studies, such as losses, safety, conservation, and cost reduction.

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Figure 2

Most studied subjects
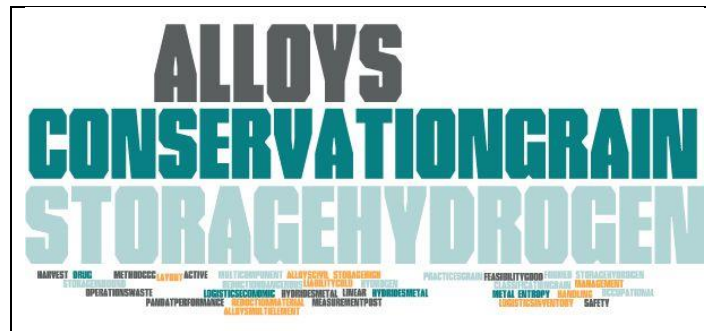
Source: Data collected by the authors.

These results indicate that studies on warehousing focus on three major interrelated fields: materials, logistics, and storage. The field related to materials is close to the scientific conception of management as planning, execution, and control of supplies and distribution, as seen in the studies by Rajyaguru (2023) and Olanrewaju et al. (2021), to obtain economic and financial advantages for the organization, as in the study by Mžavanadze (2024). The field of logistics is divided into external and internal (Reikin, 2024; Haini et al., 2024). The first concerns external supply efforts, the means through which organizations meet their needs and distribution, the purpose of which is to bring their products to their customers. In addition, there is internal logistics, in which materials are transported and stored to supply production lines and operations. Storage, in turn, is the temporary arrangement of materials in a given place, either for transportation to other modes and organizations or for feeding internal production lines (Kedebe, 2016).

4.2 TYPES OF STUDIES

Table 3 presents the results related to the types of studies on storage found in the literature. Theoretical-empirical studies predominate, such as the studies by Amaral (2023), Aranda (2023), Barbosa et al. (2023), Bohrer et al. (2023), Correa (2023), Fatorelli (2023), Kunh et al. (2023), Menezes (2023), Normando et al. (2023), Rodrigues (2023), Santos et al. (2023), Silva (2023), Silva et al. (2023), Simão et al. (2023), Starlino (2023), Stoco (2023) and Vicente (2023). Only one study of the theoretical essay type was found. Theoretical-empirical studies are characterized by efforts to generate scientific knowledge from constructing empirically tested theoretical architectures (Nascimento-e-Silva et al., 2023; Cappellari et al., 2022). Theoretical essays, in turn, are manipulations of the stock of scientific knowledge to

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build theoretical architectures (Nascimento-e-Silva et al., 2023; Cembranel et al., 2022). It can even be said that a theoretical essay is a theoretical architecture that has not yet been tested.

Table 3

Types of studies

References	Types of studies
Amaral (2023); Aranda (2023); Barbosa et al. (2023); Bohrer et al. (2023); Correa, (2023); Fatorelli (2023); Kunh et al. (2023); Menezes (2023); Normando et al. (2023); Rodrigues (2023); Santos et al. (2023); Silva (2023); Silva et al. (2023); Simão et al. (2023); Starlino (2023); Stoco (2023); Vicente (2023)	Theoretical-empirical
Colla (2023)	Theoretical essay

Source: Data collected by the authors.

These results are interesting because they demonstrate that studies on storage are focused on understanding empirical reality based on the guidance of available scientific knowledge. This type of procedure contributes significantly to the advancement of science because it represents the practice of a planetary effort to understand objective reality, which allows, among other developments, the generation of technologies, as is the case of the study by Zhao et al. (2022) and practical understanding of the behavior of reality, as in the research by Landim et al. (2023) and Sant´Anna et al. (2021). Consequently, it is likely that logistics, in general, and more specifically, the storage area, have undergone considerable socioeconomic development.

4.3 METHODS USED

Storage studies used a wide variety of methods to generate their results. Experimental studies configured the majority of procedures (Aranda, 2023; Normando et al., 2023; Silva, 2023; Starlino, 2023; Vicente, 2023), including the use of modeling as a strategy, as was the case in the studies by Kunh et al. (2023), Rodrigues (2023), Fatorelli (2023) and Stoco (2023). Case studies were the second most used procedure (Barbosa et al., 2023; Simão et al., 2023; Silva et al., 2023). The survey was the method used in the studies by Bohrer et al. (2023), Correa (2023), and Menezes (2023) to generate inferences for an entire population from an adequately selected sample. The bibliographic method was used in the study by Colla (2023), and the combination of several methods was used in the research by Santos et al. (2023). It was impossible to identify the procedure used in the study by Amaral (2023).

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Table 4

Methods used in the studies

References	Methods used
Colla (2023)	Bibliographic
Barbosa et al. (2023); Simão et al. (2023)	Case study
Silva et al. (2023)	Single case study
Aranda (2023); Normando et al. (2023); Silva (2023); Starlino (2023); Vicente (2023)	Experimental
Kunh et al. (2023); Rodrigues (2023)	Experimental (model)
Fatorelli (2023); Stoco (2023)	Experimental (simulation)
Amaral (2023)	Undefined
Bohrer et al. (2023); Correa, (2023); Menezes (2023)	Survey
Santos et al. (2023).	Multimethods

Source: Data collected by the authors.

The results regarding the methods used to generate the results of the studies in the literature are in line with the discovered typology, in which the theoretical-empirical type predominates. Experimental methods aim to understand the cause-effect relationship between certain phenomena (Khoiron et al., 2024; Sitorus et al., 2024; Mansour et al., 2024), whose intention, in most cases, is to manipulate what is being tested. The case study method often has a very similar interest, in which scientists seek to understand how certain phenomena occur based on the conjunction of several sources of evidence (Hermawan et al., 2024; Seiawan, 2023). The survey method has the challenge of understanding a part of reality that is very similar to the whole so that the result of that part corresponds to the explanation of the whole (Hapsari et al., 2024; Warumu, 2024). The multi-method strategy is a current trend to reduce the limitations that the adoption of a single method usually presents, as applied in the studies by Liying and Mengying (2024) and Sugandini et al. (2024). These methods allow the structuring of knowledge with several developments, both for science and for generating techniques and technologies.

4.4 GOALS OF THE STUDIES

Table 5 summarizes the results achieved for the guiding question that sought to know the goals of the studies with storage as their object. These results could be divided into two large blocks. The block of studies marked in gray could be called applied since they intended to understand a particular aspect of storage so that a course of action or some artifact could be generated. For example, Amaral's (2023) study aimed to create a company that could explore storage and logistics services, Kunh's (2023) intended to develop a risk management model for

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workers who perform grain storage and drying operations, while Menezes aimed to create a digital game that would allow engineering students to gain knowledge about the phenomenon of storage. This first block constituted most studies found in the literature.

Table 5

Goals of the studies.

References	Goals of the studies
Amaral (2023)	Create a storage and logistics company
Kunh (2023)	Develop and apply a model for managing occupational risks during grain storage and drying.
Menezes (2023)	Develop a digital game applying storage engineering concepts
Rodrigues (2023)	Apply predictive machine learning models to monitor quality and predict losses early in corn grains' transportation, drying, and storage stages.
Vicente (2023)	Optimize the composition, microstructural characterization, and hydrogen storage properties of a HEA (high entropy alloy)
Silva et al. (2023)	Optimize costs for moving containers in a road transport logistics operation and customs storage in maritime import operations from the port of Santos.
Stoco (2023)	Integrate the CALPAHD method with the Python programming language, aiming at the selection of multi-element alloys for hydrogen storage.
Aranda (2023)	Produce, characterize, and evaluate the hydrogen storage properties
Santos et al. (2023)	Propose an ergonomic solution for the storage of manufactured parts
Bohrer et al. (2023)	Design the storage structure for production materials "Pellets."
Starlino (2023)	Analyze the behavior of cold-formed profile columns with rack sections and perforations, considering the locking of the cross-section opening positioned intermittently along the column.
Simão et al. (2023)	Analyze the implementation of the SSBI tool in managing inbound and outbound logistics processes of a distribution center in the food and pet care sector.
Colla (2023)	Analyze the legal aspects of issues related to the demurrage judgment in connection with the services provided by container storage terminals.
Barbosa et al. (2023)	Analyze and adapt the storage environment so that there are no financial impacts for the company and damage to the environment.
Silva (2023)	Investigate the hydrogen storage properties of multicomponent CCC alloys of the Ti-V-Nb-M system (M = Cr, Co and Ni) and perform the design of alloys through computational thermodynamics methods/models.
Fatorelli (2023)	Understand the factors that affect the NPV of an economic feasibility project for implementing a grain storage unit on a rural property.
Correa (2023)	Diagnose the storage capacity of a wheat cooperative
Normando et al. (2023)	Evaluate the effect of the combination of protective insecticides and the separation of grains by density in maintaining the quality of corn grains during storage.

Source: Data collected by the authors.

The second block of studies can be classified as analytical. Analyses are a form of scientific strategy that analyzes a part of the phenomenon, breaking it down into parts and transforming them into data so that its logic can be understood from a reverse scheme of the composition of the whole. The "broken" parts generate data, which are transformed into information that, in turn, allows the understanding of the behavior of that phenomenon or two or more of them in a relational way, as can be seen from studies such as those by Mekuri-Ndimele and Afebo (2023) and Casey and Cucurull (2022). In this sense, the study by

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Normando et al. (2023) evaluated the effect of the combination of factors on the quality of corn grains to determine whether there is any change during storage; Correa (2023) diagnosed the wheat grain storage capacity of a cooperative, and Fatorelli (2023) sought to understand the factors that affect the net present value of a project for a grain storage unit. An exciting aspect of these results, arising from the intended objectives, concerns the types of materials on which the studies were carried out. A highly significant amount was on grains, as shown in the studies by Kunh (2023), Rodrigues (2023), Fatorelli (2023), Corrêa (2023), and Normando et al. (2023), which represents almost a third of the sample obtained.

4.5 TYPES OF PUBLICATION

Table 6 shows the results obtained for the guiding question that sought to know where the findings of the studies on storage were published. The results showed a predominance of course completion panels, with undergraduate monographs appearing in the first place (Correa, 2023; Menezes, 2023; Vicente, 2023; Stoco, 2023; Barbosa et al., 2023), with master's dissertations (Fatorelli, 2023; Starlino, 2023; Aranda, 2023) and theses (Silva, 2023; Rodrigues, 2023; Kunh et al., 2023) tied for second place. Academic papers represent almost two-thirds of the total sample. Two studies were published in the form of papers presented at scientific events (Amaral, 2023; Normando et al., 2023), and five were published in scientific journals (Simão et al., 2023; Silva et al., 2023; Bohrer et al., 2023; Colla, 2023; Santos et al., 2023), accounting for just over a third of the total sample collected.

Table 6

Types of publication

References	Types of publication
Amaral (2023); Normando et al. (2023)	Paper (proceedings)
Simão et al. (2023); Silva et al. (2023); Bohrer et al. (2023); Colla (2023); Santos et al. (2023)	Paper (journals)
Correa, (2023); Menezes (2023); Vicente (2023); Stoco (2023); Barbosa et al. (2023)	Monography bachelor
Fatorelli (2023); Starlino (2023); Aranda (2023)	Master dissertation
Silva (2023); Rodrigues (2023); Kunh et al. (2023)	PhD Thesis

Source: Data collected by the authors.

These results show that most knowledge production on storage is concentrated and restricted to the academic environment. This means that scientific production on storage has not yet managed to leave academia and successfully undergo evaluation by the various scientific communities that comprise it. The evaluation by the members of these communities

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confers the validity and reliability of what is published, thus increasing the possibility that the knowledge generated can be used to support new discoveries and produce new technologies. Notably, this production originates from logistics and several fields, mainly engineering (Kunh, 2023; Menezes, 2023; Correa, 2023; Silva, 2023; Rodrigues, 2023).

5 CONCLUSION

This study analyzed five aspects of Brazilian scientific studies on material storage made available in 2023. The results showed that a) the most discussed topics were storage, storage, and specific aspects of stored materials, b) theoretical-empirical studies were predominant, c) several different methods were used to generate the findings, with the experimental method prevailing, d) most of the studies aimed to apply the knowledge generated, e) with only one-third of these publications made in journals and annals of scientific events. These findings provide an overview of Brazilian researchers' scientific production efforts on storage.

The scientific production studied has high technical-scientific quality. This is measured using the experimental method to test hypotheses and answer research questions of great interest to the scientific community. However, strangely, these discoveries were restricted to the examining boards because they are configured in course completion works, from technical to doctoral level. This does not mean, however, that studies published in journals and conference proceedings are not of the same quality. However, it is essential to point out that these discoveries need to be communicated to the scientific community so that they can support new studies and, above all, generate new techniques and technologies.

Another dimension of this panorama is the significant participation of studies focused on agribusiness. This detection may be due to the expansion of this economic sector into several others, such as finance and information technology so that the production of knowledge about storage and other aspects of the logistics chains is just an unfolding of their expansion needs. This means that agribusiness has contributed to scientific production in several fields, including storing materials. This is confirmed by the fact that several engineering departments have generated knowledge about storage based on the stock of knowledge in their areas.

Finally, this panorama is completed by the increase in Brazil's participation in international trade, whether as a supplier or as a consumer of raw materials and finished products. Since storage can be considered a link between transportation methods, as they expand and consolidate, the need to store materials, especially temporarily, also expands and

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consolidates in the same proportion. As a result, the quality of studies on storage may ultimately reflect the increase in Brazil's importance in the global economic scenario.

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