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Review

Progress and Trends in Forage Cactus Silage Research: A Bibliometric Perspective

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Abstract: *Opuntia* spp. (forage cactus or spineless cactus) is a plant native to Mexico that is commonly used as alternative nutrient-rich fodder in semi-arid regions. Due to its resistance to drought, forage cactus has become an important least-cost ingredient for formulating balanced rations for ruminants during times of scarcity. In addition, ensiling, an anaerobic fermentation process, is also a strategy used to allow a supply of bulky food all year round, since it conserves forage and maintains its nutritional value. In this sense, using the Scopus database and the visualization tool VOSviewer, the present work proposes a bibliometric analysis of forage cactus silage to track and map the evolution and main issues in the research field, current trends, and future directions. The results revealed that the first publication was in 2013; and since 2020, the number of publications has been growing. Brazil was highlighted, by far, as the most relevant country on the topic, and the top institutions were from northeast Brazil, which has been working on co-authored articles. The current hot research topics are focusing on the mixed silage of forage cactus and other forages such as gliricidia, maniçoba, and sorghum biomass, as well as evaluating the fermentative performance and chemical characteristics for improving ruminal diets, especially for goats and sheep. This study provides important information for researchers to identify gaps and direct their studies to better use the whole potential of forage cactus as an alternative roughage source.

Keywords: cactus; *Opuntia*; silage; bibliometrics

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1. Introduction

The *Opuntia* spp. (forage cactus or spineless cactus), native to Mexico [1], is a drought-tolerant and water-efficient (xerophytes) genus of plants that can be grown as a fodder crop in degraded and marginal drylands. Due to their morphophysiological features of resilience to poor soil conditions and high biomass yield, these species have become a highly viable alternative fodder for animal nutrition in arid and semi-arid areas. The use of cactus has been reported, for example, in silage for lamb feed [2], as supplementation for dairy cows [3], and also in the maintenance of equine diets [4].

The inherent properties of semi-arid, constant, and severe drought and low and uneven rainfall have a massive impact on the production of sufficient fodder for animals, making livestock activity challenging in these regions [5]. According to Silva et al. [6], the Brazilian semi-arid region, for example, is characterized by high insolation levels, average annual temperatures of 23 to 27 °C, and irregular rainfall in which precipitation

is generally concentrated over a short period of 3 to 4 months per year, which makes agricultural activities difficult. Because of the low availability of pastures, in terms of intensity and distribution, farmers, especially smallholders, need to appeal to high-price and not readily available energy-concentrated crops to feed their herds, which implies increasing production costs [7].

In this scenario, native forage, such as forage cactus, emerges as a crucial alternative to ensure animals' nutrition and improve productivity during the summer and long periods of climatic cultivation restriction. Costa et al. [8] highlighted the benefit of including spineless cactus (*Opuntia ficus-indica* L. *Miller*) in lactating dairy goats' diets to fulfill water requirements and reinforced its importance as feed in areas where water is a severe limiting factor for agriculture and animal husbandry. Forage cactus also has excellent palatability and high metabolizable energy and is considered a cost-effective and rich source of non-fibrous carbohydrates (NFC; 500 g·kg^{-1} DM), water-soluble carbohydrates (WSC; 150 g·kg^{-1} DM), minerals, and micronutrients [9–11].

Nonetheless, the use of forage cactus as the sole roughage in animals' diets may be restricted due to the low content of dry matter (DM; 100 g·kg^{-1} DM), crude protein (CP; 60 g·kg^{-1} DM), and neutral detergent fiber (NDF 280 g·kg^{-1} DM) [9]. These nutrients are indispensable to provide a balanced meal, and thus cactus must be combined with other ingredients to meet nutritional requirements and prevent metabolic disorders such as rumen acidosis [11]. In the ruminant diet, forage cactus species have been explored in the total or partial replacement of traditional roughages (Tifton hay, corn, or sorghum silage), commonly used in silage form. The ensiling process is an efficient technique for storing and preserving forage worldwide [12]. The process occurs through the combination of anaerobic conditions with the natural fermentation of plant sugars by lactic acid bacteria, which creates an environment that controls microbial activity detrimental to the silage and rumen microorganisms [13,14].

Therefore, given the relevance of *Opuntia* species as an alternative ingredient in animal meals in areas with severe climate fluctuations, this study aims to present a bibliometric study using the Scopus database, with no time restrictions, addressing the scientific research on cactus silage. Bibliometry is defined by Mao et al. [15] as a methodology that uses math and statistics to provide a systematic evaluation of trends on a specific subject. It allows for mapping the literature in a research field and describing the distribution patterns of identified articles, such as central theme, area of study, institute, and country [16]. In this view, the proposed work will access relevant publications regarding forage cactus silage, and the findings will be useful to understand the historical and current status of the evaluated field, as well as future trends in it.

2. Materials and Methods

2.1. Data Source and Search Strategy

To track the trends and evaluate the characteristics of the published literature over time [16–18], a bibliometric search was conducted using the Scopus database, known for its vast indexed references and high-quality research data [19]. The search was performed in January 2024 to retrieve articles mentioning forage cactus silage or related terms in the title, abstract, and keywords, limited to original scientific papers published up to 2023. The query was defined to ensure a strategic association of keywords, Boolean operators, and the "*" character to capture all possible suffixes of the different terms. The search query was as follows: TITLE-ABS-KEY ((nopalea OR *Opuntia* OR "spineless cactus") AND (forage* OR silage* OR roughage* OR fodder* OR ferment* OR aerobic* OR anaerobic*)).

2.2. Screening Strategy

At first, the query resulted in 706 articles, which were carefully and comprehensively analyzed to remove all papers unrelated to the study's scope. The main criteria used for inclusion of articles were those of original research related to the use of silage of forage cactus (*Opuntia ficus-indica* Mill and *Nopalea cochenillifera* Salm Dyck), wherein articles either

based on the silage of another plant (without mixing with forage cactus) or the use of forage cactus in other forms were excluded. The selection was made by screening the titles and abstracts of all articles and the main text when necessary. Therefore, 676 of 706 were excluded, and the 30 remaining articles were exported in CSV format for the bibliometric analysis using VOSViewer software (version 1.6.20). The flow diagram for the searching and screening process is shown in Figure 1.

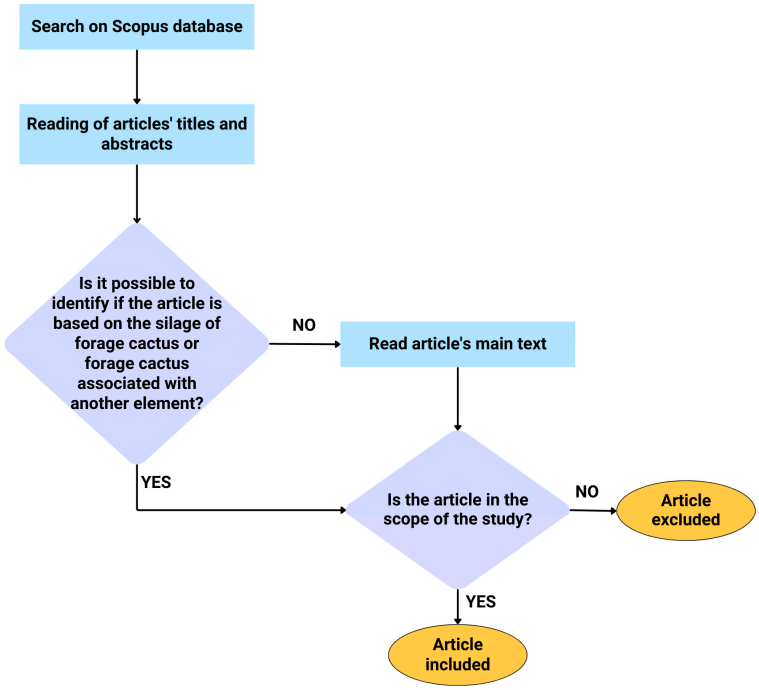

Figure 1. Flow diagram of the screening process.

2.3. Bibliometric Maps and Statistical Analyses

The bibliometric analysis of the 30 retrieved articles was carried out in VOSviewer to combine activity-yielding and relationship indicators analyses considering the following variables: publication year, knowledge area, keywords, citations, authors, country, journals, and institutions. The selected VOSviewer tool for performing bibliometric analysis is free software that enables the construction and graphical representation of easy-to-interpret bibliometric maps. It can generate maps of authors or journals based on co-citation data or maps of keywords based on co-occurrence data [20].

In VOSviewer, the terms were filtered based on all keywords defined by the author, editors, and reviewers. By selecting and analyzing the terms filtered by the author keywords, a map was constructed with the network of keywords with the highest occurrence and the co-occurrences between them. The geographic distribution and publications affiliations were also analyzed, and a map was constructed to represent co-authorship collaborations between the institutions with the largest number of publications on cactus silage. The top most productive countries, journals, and research institutions were ranked according to the functions in VOSviewer. The bibliometric indicators CiteScore, SCImago Journal Rank (SJR), Source Normalized Impact per Paper (SNIP), and impact factor (IF) for 2022 were also analyzed for classification purposes.

3. Results and Discussion

As reported in Section 2.1, the first search of the Scopus database resulted in 706 articles encompassing several research areas.

In the filtering step, wherein all articles were carefully examined concerning the main content, it was possible to verify that most of them were not related to "forage cactus silages" and were being selected because of some of the terms used in the search query.

Due to the terms *Opuntia*, forage*, and silage*, the search included articles related to the use of fresh cactus combined with silages from other forage crops, as in the study carried out by Siqueira et al. [21], who evaluated the effect of fresh cactus forage (*Nopalea* and *Opuntia*) mixed with sugarcane bagasse, urea, Tifton hay, corn silage, and sorghum silage in relation to nutrient intake and digestibility, as well as ruminal dynamics.

Using the terms *Opuntia* and ferment*, some works on in vitro fermentability testing of cactus pear were retrieved. Oliveira et al. [22], through an in vitro fermentation test, focused on apparent organic matter digestibility, gas methane, and short-chain fatty acid production, evaluating *Opuntia* and other plants from the Brazilian Caatinga biome for methanogenic potential in ruminant nutrition. In other research areas, these terms included studies using cactus in biofuel production, such as the study by Alencar et al. [23], who analyzed parameters of cactus pear as a potential biomass for bioethanol production.

In addition, the terms *Opuntia*, ferment*, and silage* embraced studies that evaluated cactus fruits or the by-products of cactus fruits. The paper by Vastolo et al. [24] verified the effectiveness of silage in preserving prickly pear by-products while comparing different levels of wheat straw inclusion.

3.1. Trends in Publications

To attain the purpose of this study regarding unveiling the scientific literature on forage cactus silage, all the subsequent analyses were performed considering only the 30 articles identified as within the domain of the studied field.

From the outputs of publication per year as shown in Figure 2, it is possible to observe that the first article was published about one decade ago, in 2013, and that there was a turning point in 2020, when the number of publications increased significantly. This sudden increase in the number of articles published in 2020 and 2023 can be related to the drought in the semi-arid lands of Northeast Brazil, as most of the retrieved articles on silage cactus were from northeast Brazilian institutions. According to Marengo et al. [25] and Vieira et al. [26], this region experienced exceptional drought events and vegetation stress during 2012–2018 and 2021, which aggravated the situation of limited resources for human and animal feed. This scenario may have influenced the development of strategies for mitigating problems in animal production, such as the silage of forage cactus, which would have resulted in the publication of such articles in the following years.

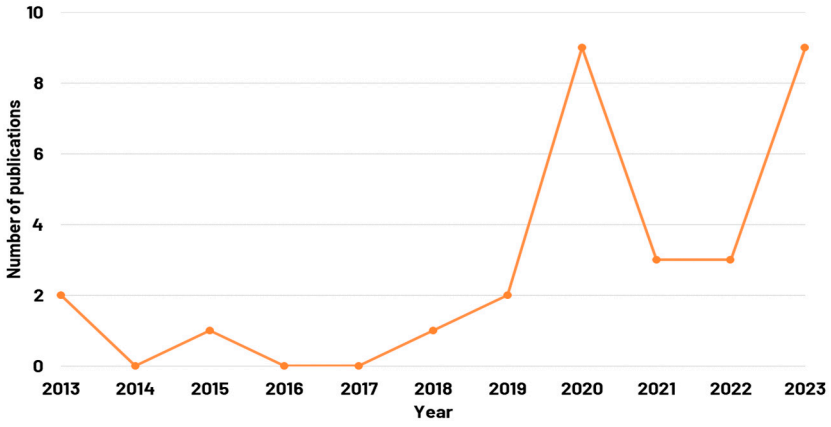

Figure 2. Number of scientific articles on cactus silage published up to 2023 (Scopus database).

3.2. Keyword Analysis

As affirmed by Uddin and Khan [27], keywords represent important information that can guide researchers in identifying relevant scientific articles according to the area of interest. In addition to author keywords, it is also common to find in the database additional keywords indexed by editors and reviewers based on the subject text in the publication. Analysis of the occurrence of keywords extracted 241 keywords, out of which the authors assigned 104 and 160 were indexed on Scopus. In this study, only the authors' keywords

were considered, and in order to simplify the analysis, before exporting to VOSviewer, association of keyword variant forms as singular/plural and synonyms was performed.

Table 1 presents the list of the most used keywords; *Opuntia* and silage appear sharing the first position, with ten occurrences each. That was expected, as these keywords are directly related to the terms used in the query. "Semi-arid" appears with six occurrences, which refers to the region where cactus is a disseminated plant and has been historically used as strategic and alternative roughage for ruminants' diets. "Lactic acid bacteria" and "fermentation profile" relate to the silage process that preserves raw plant materials by converting sugar into lactic acid under anaerobic conditions. The occurrence of "Manihot" is justified because it is a plant native to the Brazilian semi-arid region that is often mixed with forage to contribute to the protein and fiber intake in animal feed.

Table 1. Most frequently used author keywords in articles published on cactus silage up to 2023 (Scopus database).

Keyword	Occurrences
Opuntia	10
silage	10
semi-arid	6
lactic acid bacteria	5
Nopalea	5
Manihot	4
cactus	4
digestibility	4
fermentation profile	4

Limiting the minimum number of author keyword occurrence to two, VOSviewer returned 23 keywords, which were grouped into four clusters, color-coded red, green, blue, and yellow. In the network visualization map of author keywords shown in Figure 3, the size of the nodes represents the number of occurrences of the keyword, and the thickness of the line is proportional to the intensity of co-occurrence between two keywords.

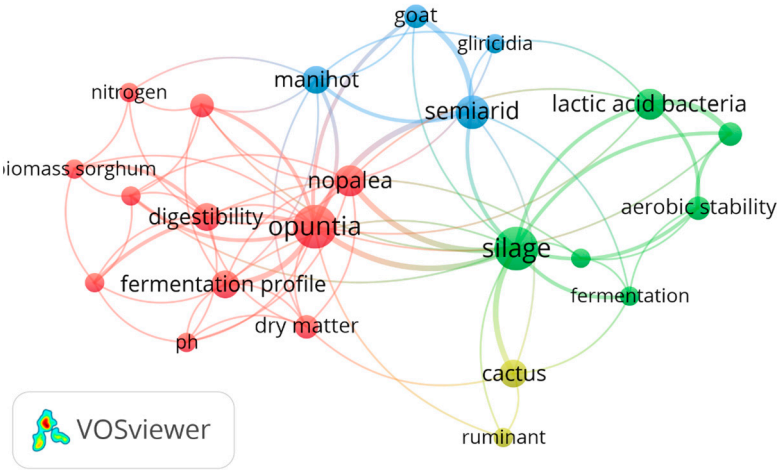

Figure 3. Cluster map for the most used author keywords in articles on cactus silage (Scopus database). Each color represents the cluster to which the keyword belongs.

3.3. Most Cited Articles

Table 2 lists, in descending order, the top ten most cited articles on forage cactus silage and their respective FWCI (field-weighted citation impact) values. FWCI is a metric provided by Scopus that refers to the ratio between the number of citations received by a paper and the expected number of citations over the previous three years for all Scopus

publications of the same age, document type, and field. It measures how well cited a publication is compared to similar publications.

Cited 26 times since its publication, "*Effect of feeding cactus-legume silages on nitrogen retention, digestibility and microbial protein synthesis in goats*" written by Gusha et al. [28] and published in the journal Animal Feed Science and Technology is the most cited article.

The other papers highlighted in Table 2 are "*Intake, nutrient digestibility, nitrogen balance, and microbial protein synthesis in sheep fed spineless-cactus silage and fresh spineless cactus*" published in the journal Small Ruminant Research by Pereira et al. [29] and "Water intake and ingestive behavior of sheep fed diets based on silages of cactus pear and tropical forages" published in the Tropical Animal Health and Production by Silva et al. [30], which showed the highest FWCI values of 2.16 and 2.59, respectively. A FWCI value > 1 means those works were cited more than the average citations of papers in the same fields.

From this analysis, it can be observed that the most relevant articles, according to the citation metrics, focused on studying the effect of forage cactus silage on animal nutrition, mainly to evaluate the use of this plant as an alternative resource to traditional forage crops.

Table 2. List of main publications on cactus silage based on total citations (Scopus database).

Document Title	Authors	Year	Journal	TC [1]/FWCI	Ref.
Effect of feeding cactus-legume silages on nitrogen retention, digestibility and microbial protein synthesis in goats	Gusha, J., Halimani, T.E., Ngongoni, N.T., Ncube, S.	2015	Anim. Feed Sci. Technol.	26/1.12	[28]
Mixed silages of cactus pear and gliricidia: chemical composition, fermentation characteristics, microbial population and aerobic stability	da Silva Brito, G.S.M., Santos, E.M., de Araújo, G.G.L., (. . .), de Oliveira Lima, A.G.V., Cavalcanti, H.S.	2020	Scientific Reports	24/0.88	[31]
Silages in the form of diet based on spineless cactus and buffelgrass	Macêdo, A.J.D.S., Santos, E.M., de Araújo, G.G.L., (. . .), Sá, W.C.C.S., Pereira, D.M.	2018	Afr J Range Forage Sci	19/1.43	[32]
Carcass traits and meat quality of lambs fed with cactus (*Opuntia fícus-indica Mill*) silage and subjected to an intermittent water supply	do Nascimento Souza, A.F., de Araújo, G.G.L., Santos, E.M., (. . .), Pinho, R.M.A., de Moura Zanine, A.	2020	PLoS ONE	18/0.75	[2]
Isolation and identification of lactic acid bacteria in fresh plants and in silage from *Opuntia* and their effects on the fermentation and aerobic stability of silage	Pereira, G.A., Santos, E.M., Araújo, G.G.L., (. . .), Neto, J.M.C., Nascimento, T.V.C.	2019	Journal of Agricultural Science	16/1.21	[33]
Performance, body water balance, ingestive behavior and blood metabolites in goats fed with cactus pear (*Opuntia ficus-indica* L. *Miller*) silage subjected to an intermittent water supply	Albuquerque, I., Araújo, G., Santos, F., (. . .), Silva-Filho, E., Oliveira, R.	2020	Sustainability (Switzerland)	14/1.13	[34]
Water intake and ingestive behavior of sheep fed diets based on silages of cactus pear and tropical forages	Silva, T.S., de Araujo, G.G.L., Santos, E.M., (. . .), Ribeiro, O.L., Turco, S.H.N.	2021	Tropical Animal Health and Production	12/2.59	[30]
Fermentation profile and nutritional quality of silages composed of cactus pear and maniçoba for goat feeding	Matias, A.G.S., Araujo, G.G.L., Campos, F.S., (. . .), Emerenciano Neto, J.V., Voltolini, T.V.	2020	Journal of Agricultural Science	10/1.07	[35]
Intake, nutrient digestibility, nitrogen balance, and microbial protein synthesis in sheep fed spineless-cactus silage and fresh spineless cactus	Pereira, G.A., Santos, E.M., Oliveira, J.S.D., (. . .), Cruz, G.F.D.L., Leite, G.M.	2021	Small Ruminant Research	9/2.16	[29]
Silage composed of *Opuntia ficus-indica f. inermis* cladodes, olive cake and wheat bran as alternative feed for barbarine lamb	Abidi, S., Ben Salem, H., Nefzaoui, A., Vasta, V., Priolo, A.	2013	Acta Horticulturae	9/-	[36]

[1] Total citations.

3.4. Analysis of Journal Productivity

Publication of the 30 articles was found to be distributed among 19 journals. Table 3 shows the most productive journals, which account for 18 publications, or 60% of total publications. Considering the low number of published articles in the field, other metrics were used to analyze the journals' performance better. The metrics considered were Cite Score, SJR, SNIP, and IF, and are represented in Figure 4.

Table 3. Main journals on cactus silage based on the number of published articles up to 2023 (Scopus database).

Journal	Number of Documents
Journal of Agricultural Science	4
African Journal of Range and Forage Science	3
Tropical Animal Health and Production	3
Acta Horticulturae	2
J. Prof. Assoc. Cactus Dev.	2
Scientific Reports	2
Small Ruminant Research	2

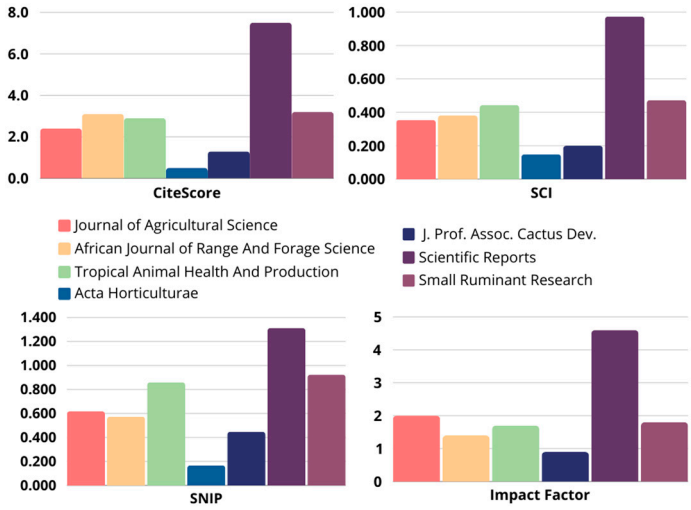

Figure 4. CiteScore, SJR, SNIP, and IF index values of most relevant journals on cactus silage publication (Scopus database).

Acta Horticulturae is among the journals with the highest number of publications (Table 3), but it has the lowest CiteScore, SJR, and SNIP values and does not have an IF value. Although *Acta Horticulturae* published one of the articles with the highest number of citations, as shown in Table 2, the paper does not have a FWCI value or an IF. In addition, the low value of other metrics indicates that articles published in this journal are not cited frequently.

3.5. Geographical Distribution and Affiliations

The analysis of the authors' and co-authors' countries showed that the articles' origins were dispersed along eight countries, all classified as tropical or temperate climate regions, where arid and semi-arid areas are located.

Brazil was highlighted as the country with the highest number of publications in the field, accounting for 83.3% of the total publications, with 25 articles (Table 4). Meanwhile, the other countries in the list have only one publication each. Further, when analyzing countries' interactions, it was observed that the only pairs of countries that presented co-authorship for publication were Italy–Tunisia and Brazil–Chile, with each interaction

resulting in one published article. This lack of interaction indicates that it is not common for authors from different countries to collaborate in publications on the evaluated topic.

Table 4. Most relevant countries by number of scientific publications on cactus silage up to 2023 (Scopus database).

Country	Number of Documents	Percentage (%)
Brazil	25	83.3%
Chile	1	3.3%
Iran	1	3.3%
Italy	1	3.3%
Mexico	1	3.3%
South Africa	1	3.3%
Tunisia	1	3.3%
Zimbabwe	1	3.3%

Regarding the authors' and co-authors' affiliations, 40 institutions were identified, where those with the most publications on forage cactus silage were from the northeast of Brazil, a region that concentrate most of the Brazilian semi-arid areas [6] and is estimated to contain about 500 thousand hectares of cultivated forage cactus [37]. The institutions' names and their respective number of publications are presented in Table 5. The top three institutions, accounting for 63.3% of publications (19 articles), were EMBRAPA (Brazilian Agricultural Research Corporation) Semiárido, Federal University of Paraiba, and Federal University of Maranhão.

Table 5. Most relevant affiliations on cactus silage based on the number of published articles up to 2023 (Scopus database).

Affiliation	Country	Documents
EMPRAPA Semiárido	Brazil	16
Federal University of Paraíba	Brazil	15
Federal University of Maranhão	Brazil	13
Federal University of the São Francisco Valley	Brazil	7
Federal University of Piauí	Brazil	6
Federal University of Agreste of Pernambuco	Brazil	6
Federal University of Tocantins	Brazil	3
State University of Montes Claros	Brazil	3

The collaboration network displayed in Figure 5 evidenced a frequent collaboration between the most productive institutions. EMBRAPA Semiárido, the Federal University of Paraíba, and the Federal University of Maranhão, published nine articles in collaboration, and EMBRAPA Semiárido and the Federal University of Paraíba published 13 articles in co-authorship on the topic presented. The geographical proximity of these institutions and the relevant cultivation of cactus pear in these areas justify the common interest in cooperating for the valorization and development of studies on cactus silage.

The leading role of Brazil and its institutions in the research is related to the relevance of forage cactus in the semi-arid area of the country. As explained in the Section 1, the semi-arid areas of Brazil (located in the central northeast region in the states of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia, and in the north of Minas Gerais, a state that belongs to the southeast region [6]) is characterized by long periods of drought, wherein forage cactus is an important food source for animals due to its high moisture and carbohydrate content. Forage cactus can supply a significant proportion of livestock water and energy necessities.

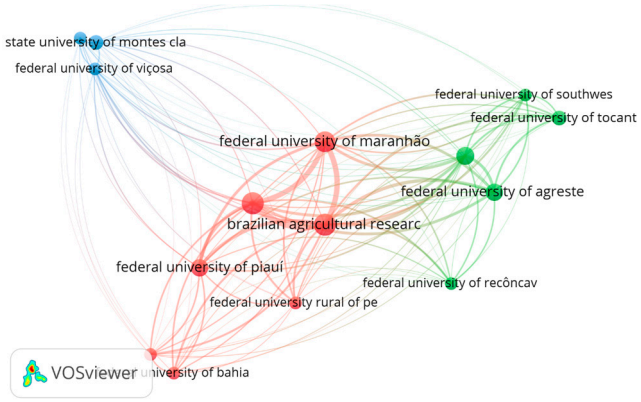

Figure 5. Collaboration visualization map of the most productive institutions. Each color represents the cluster to which the item belongs.

3.6. Areas of Scientific Knowledge

In the Scopus database, the articles were found belonging to nine areas of scientific knowledge (Table 6), showing a multidisciplinary collaboration between different areas on the topic. It must be mentioned that each article can be simultaneously classified in more than one area.

The number of documents of each area and the share of contribution is present in Table 6 and illustrated in Figure 6, where it is observed that the greatest contribution is from Agricultural and Biological Sciences (51% of the total), followed by Veterinary (16.32%) and Biochemistry, Genetics, and Molecular Biology (10.02%). Meanwhile, the other remaining areas represent 22.44% of the total. This trend is expected, since silage of forage cactus is a strategy used in animal feed.

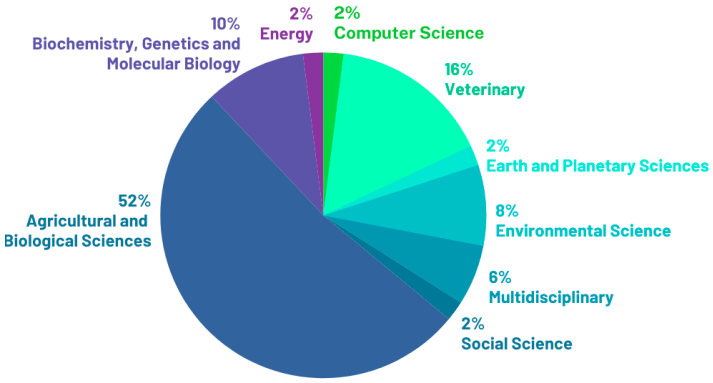

Figure 6. Percentage contribution of each subject area in the preliminary results on cactus silage (Scopus database).

Table 6. Number of scientific articles on cactus silage by research area (Scopus database).

Subject Area	Documents
Agricultural and Biological Sciences	25
Veterinary	8
Biochemistry, Genetics, and Molecular Biology	5
Environmental Science	4
Multidisciplinary	3
Computer Science	1
Earth and Planetary Sciences	1
Energy	1
Social Sciences	1

3.7. Analysis of Selected Articles

Subsequently, to perform the bibliometric analysis, the articles were grouped according to (A) the composition of the studied silages and (B) if experiments included silages in animals' diets; some documents were classified in more than one category. The five groups were: (i) forage cactus silage, (ii) cactus silage with other forages, (iii) forage cactus silage with industrial by-products, (iv) forage cactus silage in the sheep diet, (v) forage cactus silage in the goat diet, and (vi) forage cactus silage in the bovine diet. All articles and their respective category or categories are shown in Table 7.

Table 7. List of articles on cactus silage retrieved from the Scopus database and their respective categories according to the specific objective.

Document Title	Category	Reference
Carcass traits and meat quality of goats fed with cactus pear (*Opuntia ficus-indica Mill*) silage subjected to an intermittent water supply	i, v	Cruz et al. [38]
Total Mixed Ration Silages Based on Forage Cactus and Xerophile Legumes as Alternatives for Ruminants	ii	Rodrigues et al. [39]
Tropical grass silages with spineless cactus in diets of Holstein × Zebu heifers in the semi-arid region of Brazil	vi	Cordeiro et al. [9]
Mixed sorghum and forage cactus silage: composition, digestibility, fermentation, and losses	ii	Oliveira et al. [22]
Intake, digestibility, nitrogen balance and performance in lamb fed spineless cactus silage associated with forages adapted to the semi-arid environment Spineless cactus silages in diets for lambs	i, ii, iv	Silva et al. [40]
Fermentation profile, chemical composition, and aerobic stability of cassava shoots silages with cactus pear	ii	Araújo et al. [41]
Quality of mixed silages of sorghum, BRS Capiaçu grass, and cactus pear in a semi-arid region of Brazil	ii	Alencar et al. [23]
Qualitative evaluation of total mixed ration silage containing forage cactus and guinea grass as a nutritional alternative for feedlot-finished sheep	i, ii, iv	Sá et al. [42]
Nutritional properties and in vitro gas production in cactus pear (*Opuntia stricta*) and cassava (*Manihot esculenta*) shoot silages	ii	Araújo et al. [43]
Cactus-alfalfa blend silage as an alternative feedstuff for Saanen dairy goats: Effect on feed intake, milk yield and components, blood and rumen parameters	ii, v	Ravari et al. [44]
The inclusion of cactus pear changes the fermentation process, chemical composition and aerobic stability of arboreal cotton silages	ii	Melo et al. [45]
Effects of browse legume species addition on nutritional composition, fermentation characteristics and aerobic stability of *Opuntia* cladodes silage	ii	Matlabe et al. [46]
Spineless cactus use management on microbiological quality, performance, and nutritional disorders in sheep	i, iv	Paulino et al. [47]
Water intake and ingestive behavior of sheep fed diets based on silages of cactus pear and tropical forages	ii, iv	Silva et al. [30]
Intake, nutrient digestibility, nitrogen balance, and microbial protein synthesis in sheep fed spineless-cactus silage and fresh spineless cactus	i, iv	Pereira et al. [29]
Mixed silages of cactus pear and gliricidia: chemical composition, fermentation characteristics, microbial population and aerobic stability	i, ii	Brito et al. [31]
Fermentative characteristics and chemical composition of cochineal nopal cactus silage containing chemical and microbial additives	i	Sá et al. [48]

Table 7. *Cont.*

Document Title	Category	Reference
Fermentation profile, microbial populations, taxonomic diversity and aerobic stability of total mixed ration silages based on Cactus and Gliricidia	ii	D. Santos et al. [49]
Methods of storing cactus pear genotypes for animal feeding	i	Carvalho et al. [50]
Fermentation profile and nutritional quality of silages composed of cactus pear and maniçoba for goat feeding	i, ii, v	Matias et al. [35]
Performance, body water balance, ingestive behavior and blood metabolites in goats fed with cactus pear (*Opuntia ficus-indica* L. *Miller)* silage subjected to an intermittent water supply	i, v	Albuquerque et al. [34]
Nutritional value of BRS capiacu grass (*Pennisetum purpureum*) silage associated with cactus pear	ii	Monção et al. [51]
Fermentation losses of cactus silages with elephant grass	ii	R. S. Santos et al. [52]
Carcass traits and meat quality of lambs fed with cactus (*Opuntia fícus-indica Mill*) silage and subjected to an intermittent water supply	i, iv	Souza et al. [2]
Isolation and identification of lactic acid bacteria in fresh plants and in silage from *Opuntia* and their effects on the fermentation and aerobic stability of silage	i	Pereira et al. [33]
Feed Alternatives with Cactus Forage Silage for Animal Nutrition	i	Nogueira et al. [53]
Silages in the form of diet based on spineless cactus and buffelgrass	ii	Macêdo et al. [32]
Effect of feeding cactus-legume silages on nitrogen retention, digestibility and microbial protein synthesis in goats	ii, v	Gusha et al. [28]
In vitro digestibility of prickly pear cactus (*Opuntia* spp.) additioned with brewery by-products	i, iii	Fuentes-Rodriguez et al. [54]
Silage composed of *Opuntia ficus-indica f. inermis* cladodes, olive cake and wheat bran as alternative feed for barbarine lamb	iii, iv	Abidi et al. [36]

Not all articles reported in the main text the details of the production of forage cactus silage studied. However, based on a general analysis of the works, some common sets of conditions and trends in the production of silages could be identified. Palms used in silages had been planted or regrown for 6 to 24 months, except for the work by Albuquerque et al. [34], who used palms older than 4 years. The cactus cladodes were crushed or chopped into particles with dimensions ranging from 0.5 cm to 5 cm. The majority of silos were made of polyvinyl chloride (PVC), and in some studies, such as that of Melo et al. [45], the silos were equipped with a Bunsen valve at the top to eliminate the gases formed inside, and a layer of sand was added to the bottom to drain the effluents. The maximum periods between ensiling and opening the silos varied from 34 to 200 days. The following subtopics present a detailed analysis of the content present in the selected articles according to the categories mentioned.

3.7.1. Forage Cactus Silage

Concerning the methods for storing forage cactus, Carvalho et al. [50] used indicators of feed quality for ruminants (chemical composition, mineral composition, and fermentative profile) and compared silage within the natural form of three forage cactus genotypes: Doce and Baiana (*Nopalea cochenillifera*) and Orelha de Elefante Mexicana (OEM) (*Opuntia tuna*). The natural form was evaluated for 0 days, 30 days, and 60 days of storage, and silage for 60 days of storage. The authors noted a significant difference in the chemical and mineral composition of the ensiled mass under different treatments. The Doce genotype had the highest values of DM, OM, TC, NFC, OEM genotype of CP, NDF, and ADF, and the Baiana genotype had the highest values of EE and MM. Regarding the processing form, silage increased MM and decreased OM, TC, NDF, NFC, and ADF. The authors observed a significant effect of genotype and processing form on pH, NH_3-N (recommended to

be below 10%), and buffer capacity, which were, respectively, 4.3, 2.8% of total N, and 23.6 mEq/100 g DM for the natural form, and 4.0, 2.5% of total N, and 78.9 mEq/100 g DM for silage. However, regardless of the forage cactus genotype and storage method, all were in the required ranges for ruminant feeding. They outlined that forage cactus can be stored as silage and in natural form for up to 60 days after harvest without compromising the quality of the feed for ruminants, but that natural storage would be preferable for small properties where machines and silage equipment are unavailable.

Pereira et al. [33] isolated lactic acid bacteria (LAB) from spineless cactus and spineless cactus silage and estimated their effects on improving the fermentation pattern and increasing the aerobic stability of cactus silage. They observed the predominance of LAB from the genus Weissella in the plant and the genus Lactobacillus in silage and confirmed that ensiling *Opuntia* with inoculants triggered lactic fermentation and minimized fermentation losses while ensuring no aerobic deterioration and high recovery of DM.

Some additives can be used in the ensiling process, and in this regard Nogueira et al. [53] observed that *Opuntia* silage BC decreased with urea and wheat bran inclusion from 22.65 to 7.69 mEq/100 g DM, and that DM increased with wheat bran (114.8 to 265 g/kg) and decreased with urea (114.8 to 108.2 g/kg). Adding urea and wheat bran had a decreasing effect in gas losses and LA, AA, and PA concentrations but had little effect in LAB, mold, and yeast (main silage-degrading microorganisms) populations. The supplementation of urea and Lactobacillus buchneri by Sá et al. [48] improved the fermentative profile of silage without compromising the chemical composition or affecting the aerobic stability of cochineal nopal cactus silage.

In the study by Pereira et al. [29], the authors compared fresh forage cactus with forage cactus ensiled with and without a microbial inoculant. They concluded that, regardless of the inoculation, forage cactus ensiling reduced the amount of pathogenic enterobacteria and improved the intake and digestibility of some nutrients by sheep. Silva et al. [50] compared spineless cactus silage with corn silage and mixed silages of spineless cactus and forage plants also found in semi-arid regions (gliricidia, pornunça, and buffelgrass). Diets based on cactus silage provided an overall higher intake of DM, OM, CP, NFC, and total digestible nutrients, improved digestibility of DM, OM, CO, and NDF, and a higher body weight gain than corn silages.

According to Albuquerque et al. [34], the inclusion of forage cactus silage in goats' diets improves eating, ruminating efficiency rate, and body water retention, and according to Souza et al. [2] the use of forage cactus silage in lambs' diets resulted in positive effects on feed conversion, average daily gain, carcass yield, and meat quality. Thus, forage cactus silage is highly recommended in animals fed in semi-arid and arid regions, since it reduces water demand without affecting their performance or health.

In the study carried out by Paulino et al. [47], lambs were subjected to diets of spineless cactus crushed and immediately supplied to the animals or crushed 8 h before supply and silage of spineless cactus. In terms of exposure time, chopping the spineless cactus to particles of 2 cm^2 or less and exposing them to oxygen for more than 7 h accelerates the microbial colony's proliferation; thus, cutting the spineless cactus into larger particles and feeding them immediately to the animals is recommended. Nonetheless, considering all treatments, spineless cactus in silage was the best in improving degradability and accelerating digestion in the rumen, allowing a higher DM intake and reducing the amount of bacteria ingested by the animals.

Studies were also carried out to evaluate quality parameters such as chemical composition, fermentation characteristics, microbial population, and the aerobic stability of forage cactus silages and to compare them with silages composed of forage cactus and different levels (0%, 25%, 50%, 75%, and 100%) of gliricidia [31], maniçoba [35], or Guinea grass (0,10, 20, 25 and 30%) [43]. The inclusion of maniçoba, gliricidia, or guinea grass increased nutrient intake (DM, EE, CP, NDF, and ADF), water intake, and aerobic stability. As a function of opening times (1, 7, 15, 30, 60, and 90 days) a reduction in NFC and TC content was observed due to the fermentation of sugars and the maximum production of acid acetic,

protic acid, NH-NH_3, and lactic acid at 30–60 days. For evaluation of the ensiling method, Fuentes-Rodriguez et al. [54] determined the in vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of fresh and ensiled forage cactus combined with brewery by-products (BBs) and molasses. Contrary to other studies, fresh biomass showed better overall digestibility than ensiled cactus.

3.7.2. Mixed Silages of Forage Cactus and Other Forages

In the work by Brito et al. [31] the authors tested the inclusion of 25, 50, 75, and 100% gliricidia. All tested silage showed efficiency in terms of fermentative profile, chemical composition, and silage losses. The presence of gliricidia increased pH and increased the BC to 57.4, 65.8, 96.4, and 86.3%, respectively, and led to minimum gas losses with the addition of 50 and 75% gliricidia. Ensiling benefited the development of LAB and reduced the count of molds and yeasts from 60 days of silage, where the lowest number of LAB was in the forage cactus before silage (5.98 log CFU). The authors concluded that adding at least 25% gliricidia is recommended to ensure the aerobic stability necessary for improving the quality of forage cactus silage and the nutritional value of animal feed. Santos et al. [49] investigated the forage cactus level in the total mixed ratio of forage cactus and gliricidia silage. Gliciridia inclusion increased LA and N-NH_3 and caused a slight decreased in AA, PP, pH (4.46 to 4.11), CP, and LAB count (6.3 to 6.0). However, all silages presented similar results for the propagation of lactic acid bacteria, and the acetic acid values (>0.17 g/kg DM) corroborate the limit established to keep the yeast content controlled and maintain high aerobic stability of the silage. Thus, when added to diets up to 60%, forage cactus fulfilled its function of provoking lactic and acetic fermentation, leading to better fermentative patterns and the presence of taxonomic communities that preserve ensiled mass.

In a similar approach, some authors combined forage cactus with forage adapted to semi-arid areas, such as buffelgrass (*Cenchrus ciliares* L.), gliricidia (*Gliricidia sepium*), *Leucaena leucocephala*, *Senna obtusifolia*, and pornunça (*Manihot* sp.). As a result, Rodrigues et al. [39] reported that all silages exhibited satisfactory acid lactic bacteria propagation (5.0 to 6.3 log CFU/g), DM contents near 30% as recommended, final pH 4.0–4.2, N-NH_3 (2.21 to 0.85% of total N) within the adequate range, higher usage potential of the fibrous fraction by the ruminal microbiota, and high aerobic stability. Based on the fermentative pattern and nutritional value, the authors concluded that forage cactus silage associated with 34.1% *G. sepium* or 42.14% *S. obtusifolia* can be recommended for ruminants. Silva et al. [30] found that a diet containing 70% cactus and 30% gliricidia stood out for meeting part of the animals' water requirement and with higher efficiency, demanding less energy to meet their nutritional needs. Silva et al. [30] evaluated experimental diets for lambs by comparing spineless cactus silage with corn silage and mixed silages of cactus and gliricidia, pornunça, or buffelgrass in a ratio of 70% cactus to 30% forage. Except for cactus combined with buffelgrass, all diets based on spineless cactus silage improved animal body weight gains compared to corn silage. Regarding the different forages, gliricidia inclusion provided the more marked changes in silage, with the highest increase in the intake of CP, EE, NDF, and total digestible nutrients, digestibility of DM and OM, and intake in g/kg $BW^{0.75}$ of NDF and DM.

By evaluating *Opuntia*–browse legume (*Senegalia mellifera*, *Searsia lancea*, *Prosopis velutina*, *Grewia flava*, and *Leucaena leucocephala* leaves) mixed silages, Matlabe et al. [46] concluded that adding legumes increases the nutritive value, fermentation characteristics, and aerobic stability of forage cactus silage. Especially the combination of *Opuntia–G. flava* and *Opuntia–L. leucocephala* stood out as good quality alternatives to be used by small-scale farmers for ruminant livestock during periods of drought. Gusha et al. [28] co-ensiled *Opuntia ficus* indica with dry forage legumes and observed an improvement in DM, OM, digestibility of OM, and overall N content when compared to silage made from cereals. According to the authors, forage cactus can link legume forage and hays by supplying a degradable source of organic matter, producing silage with fewer laxative effects and moderate ruminal degradability.

In the study carried out by Macêdo et al. [32], they evaluated five diets based on spineless cactus and buffelgrass (0, 14.94, 25.20, 30.21, and 35.77% of inclusion). They observed differences in DM content and DM degradability decreased with the proportion of buffelgrass in the diets. Overall, all diets showed values within the ideal range for feeding animals and based on the fermentation profile, nutrient losses, and chemical composition; diets with higher proportions of spineless cactus were suggested for silages. Monção et al. [51] indicated that the inclusion of up to 5% of forage cactus in silage of Brazil seeds capiaçu grass allows to obtain DM content in the ideal recommended range and leads to an increase of digestible NDF content, improving the fermentation characteristics and the nutritional value of the silage.

Santos et al. [52] and de Sá et al. [42] evaluated the treatment of cactus silage with increasing levels of elephant grass (*Pennisetum purpureum Schum*) (10, 20, 30, and 40% on a fresh-weight basis) and Guinea grass (0,10, 20, 25, and 30% on a dry-matter basis), respectively. Elephant grass did not affect pH, effluent losses, or DM recovery but increased dry matter content and decreased gas losses and moisture. Overall, adding up to 40% of elephant grass improved the fermentation profile of forage cactus silage for animal feed. In silage containing guinea grass, lactic acid bacteria are predominant, and the inclusion of 30% GG resulted in an increase in pH compared to other diets. Including 10% and 20% of guinea grass resulted in aerobic deterioration after 48 h of exposure to air, but enterobacteria were not detected during the 96 h evaluation. Thus, guinea grass can be added in forage cactus silage up to a level of 30% without compromising the chemical composition, silage losses, or fermentative profile.

Alencar et al. [23] and Silva Cordeiro et al. [9] studied the impact of mixed silages of biomass sorghum and BRS capiaçu (*Pennisetum purpureum Schum*) with 40% of spineless cactus on the fermentative profile and nutritional value. Silages based on BRS Capiaçu grass exhibited lower dry matter intake, higher pH values, and higher moisture content when combined with cactus, which may have influenced lactic acid synthesis. Biomass sorghum with forage cactus exhibited lower losses, higher DMR, and higher lactic acid concentration than conventional sorghum silage. The inclusion of forage cactus pear in biomass sorghum silage enhanced the degradation rate of potentially degradable insoluble fraction of DM and the effective degradability of DM and NDF and improved the concentrations of desirable volatile organic acids and the nutritional profile.

Oliveira et al. [22] included 0, 10, 20, 30, and 40% of forage cactus in sorghum silage to examine the effect on chemical-bromatological composition, losses, in vitro digestibility, and fermentative profile. The inclusion of forage cactus negatively influenced the contents of DM, EE, NDF, ADF, and cellulose of sorghum silage and linearly increased the digestibility in vitro and the total digestible nutrients. There was also noticed a linear increase in pH, N-NH_3, acetic acid, and butyric acid, reaching values indicative of the limitation of the fermentation process from the level of 20%. Overall, adding forage cactus affects sorghum silage without influencing losses during silage. However, high levels of forage cactus would provide DM in a concentration less suitable for the fermentation process. Thus, the authors recommend the inclusion of up to 10% forage cactus to ensure an adequate silage fermentation process.

Maniçoba (*Manihot pseudoglaziovii*) addition also improved the fermentative characteristics and nutritional value of forage cactus silage when included at 25, 50, or 75%, showing adequate values of pH, DM, moisture, and low buffering power that enhance the fermentation pattern [35]. Including fiber ingredients in forage cactus silage is a determining factor for the normal functioning of rumination, ruminal movement, and homogenization of ruminal content and salivary secretion, as it promotes a positive balance of physically effective NDF and NFC and nitrogen.

Araújo et al. [41] ensiled shoots of cassava (*Manihot esculenta*) with forage cactus at 15%, 30%, or 45% on a fresh-matter basis and reported a decrease in gas production, CP, non-protein nitrogen, and NFC and an increase in soluble sugars (NFC and TC) and fractions of rapidly degraded true protein with forage cactus inclusion. They recommended

the combination of 45% forage cactus with 55% of the aerial part of cassava in mixed silages for the proper ruminal level of synchronism between the degradation of carbohydrates and proteins during microbial protein synthesis.

Ravari et al. [44] examined the effect of forage cactus–alfalfa blend silage (CABS) on the feed intake, milk production and composition, blood parameters, rumen fermentation parameters, and feeding behavior of dairy goats. The replacement of corn silage by CABS did not affect DM intake, milk yield, blood metabolites, or feeding behavior. Therefore, CABS was considered a suitable alternative for ruminants during periods of forage shortage in semi-arid regions.

Melo et al. [45] evaluate the fermentation process, nutritional quality, and aerobic stability of mixed silages of arboreal cotton and forage cactus at 0, 15, 30, 45, and 60% inclusion levels. The addition of cactus decreased the DM, EE, OM, and CP contents and increased mineral matter content, NDF, TC, and fermentation losses. The authors concluded that the inclusion of forage cactus up to 60% in arboreal cotton silages alters the fermentation profile and causes nutritional reduction, but still presents characteristics of good quality silage and showed aerobic stability results similar to corn silage.

3.7.3. Forage Cactus Silage with Industrial By-Products

For the effect of including brewery by-products (yeast and/or wet brewers grains) plus 10% molasses, Fuentes-Rodriguez et al. [54] verified that the in vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) of silages increased with BB inclusion and incubation times (0, 12, 24, 48, 72, and 96 h).

Abidi et al. [36] evaluated the nutritive value of lamb diets based on common oaten hay and concentrate (control), silage with concentrate or half control with half silage, where silage was a mixture of olive cake (40%), chopped cladodes of spineless cactus (*Opuntia ficus-indica f. inermis*) (35%), and wheat bran (25%) ensiled for 75 days; the concentrate was composed of barley grains (75%) and soybean meal (25%). It was observed that the nitrogen balance was similar among treatments, and that replacement of hay by silage did not affect total intake and OM or CP digestibility but decreased NDF. The control-silage diet presented higher DM intake and lower OM, CP, and NDF digestibility compared to control and silage diets.

3.7.4. Forage Cactus Silage in the Sheep Diet

Paulino et al. [47] examined the proliferation of enterobacteria and their association with diarrhea in fifteen lambs fed for 31 days with spineless cactus chopped (fresh and stored) and in silage form. There was an evident interaction effect among particle size, time of exposure, and the processing method of cactus for bacterial load. Crushing forage cactus hours before supplying it to animals stimulates the growth of pathogens that trigger digestive disorders and increase contamination. Meanwhile, the animals fed with spineless cactus silage had the highest NFC and TDN intake and lowest bacterial count, demonstrating a good fermentation profile. Ensiling mass is highlighted as a strategy to control enterobacteria and diarrhea when feeding small ruminants.

Pereira et al. [29] fed twenty sheep at 6 months of age for 31 days to investigate how the high levels of NFC and moisture in spineless cactus affect fermentation and the proliferation of bacteria that cause diarrhea in ruminants, while comparing the effect of spineless cactus in fresh and silage form (with and without a microbial inoculant) in the diet of sheep. Ensiled biomass improved intake and higher digestibility coefficients of DM, OM, NDF, EE, NFC, and total digestible nutrients, resulting in lower counts of fecal enterobacteria. In conclusion, the main benefit of ensiled forage cactus is that it lowers the number of potential pathogens that can affect animals' ruminal balance and health.

Souza et al. [2] evaluated the effect of forage cactus silage and an intermittent water supply for lambs on carcass traits and meat quality by feeding thirty-six lambs with diets containing forage cactus silage (0.21, and 42% based on dry matter). There was no significant effect of intermittent water supply in any of the parameters. Adding forage

cactus silage as a substitute for Tifton hay at 42% positively affected carcass yields, non-carcass constituents, and commercial cuts, in addition to increasing the meat quality of the lambs. Forage cactus silage was recommended during water scarcity without harming lamb production and meat quality.

Silva et al. [30] examined the water intake and ingestive behavior of forty male lambs of 7 months of age fed with formulated diets of forage cactus silages combined with tropical forage (described in Section 3.7.2). The mix of forage cactus–gliricidia was considered the most efficient diet due to the higher intakes of DM and water intakes via food, metabolic water, water excreted via urine, and total water excretion, in addition to offering great performance in terms of times for ruminations and the number of cuds per day. Nonetheless, from a broad view, all silages based on cactus stood out as a better alternative than traditional corn silage in the water supply via food for sheep in drylands.

Evaluating the meat quality of lambs receiving a common or silage-containing diet, as described in Section 3.7.3, Abidi et al. [36] fed three groups of eight male lambs, weighed them every 15 days for 60 days, and analyzed the carcasses after slaughter. They reported that the lambs grew similarly for all treatments, and they did not observe effective differences in the proportion of saturated/polyunsaturated fatty acids and omega 6/omega 3; otherwise, replacing hay with silage increased carcass yield. Then, it was concluded that the ensiled mixture could totally or partially replace oaten hay without harming lamb performance or meat quality.

Testing diets for lambs based on mixed silage of spineless cactus, as previously described in Sections 3.7.1 and 3.7.2 , Silva et al. [40] reported that spineless cactus with a roughage base in a 70:30 ratio, associated with a concentrated source in a 60:40 ratio, is efficient in feeding sheep with gains of over 200 g/day, which is similar or superior to corn silage-based diets.

3.7.5. Forage Cactus Silage in the Goats' Diet

Albuquerque et al. [34] fed thirty-six goats using three levels of forage cactus silage (0.21 and 42% DM total) combined with Tifton-85 hay and concentrate of corn bran, soybean meal, wheat bran, and a mineral part, while supplying intermittent daily offers of water or water restriction every 24 or 48 h for 75 days. The nutritional profile was positively influenced by the inclusion of forage cactus silage, where diets with 42% forage cactus provided greater NFC and TDN content, DM and TDN digestibility, and Ca:P ratio than diets with 0% forage cactus and was similar levels compared with diets with 21% forage cactus. Forage cactus inclusion also affected drinking water intake and ingestive behavior. Although goats fed with any level of cactus were observed to have a reduction in drinking water ingestion, a positive water balance was obtained, with total water intake greater than water excretion. Forage cactus improved eating efficiency and ruminating, as goats that did not receive cactus pear silage in their diets spent more time eating and ruminating. The authors concluded that forage cactus silage of up to 42% is recommended for improving eating and ruminant efficiency without affecting the performance or health of the animal.

Matias et al. [35] fed twenty-four confined male goats with diets based on silage of forage cactus combined with maniçoba (25, 50, 75, and 100%) as sources of fiber. They demonstrated the potential of complementarity between the two fodders for microbial fermentation to occur appropriately. The presence of maniçoba was important to maintain the levels of effective fiber and CP, EE, NDF, and ADF, which improved the development of ruminal flora and the fermentation process, and forage cactus silage provided readily degradable NFC for energy supply and protein synchrony in goat feeding.

In their article, Ravari et al. [44] indicated that CABS had benefits in increasing milk protein content and in the reduction of somatic cell count (SCC), suggesting a positive effect of CABS on improving mammary gland functionality, as a higher level of SCC is an indicator of intramammary infections and poor quality of milk. Authors recommend replacing up to 30% of corn silage with the proposed silage to formulate low-cost diets for dairy goats.

Gusha et al. [28] demonstrated that forage cactus–browse silages led to higher microbial protein synthesis, increasing amino acid supply for animal tissue maintenance, growth, and production. Therefore, silages are suitable as feed to improve goat performance in periods of feed scarcity. However, the authors suggested long-term feeding trials to evaluate growth, reproduction, and overall performance to confirm these findings.

Cruz et al. [38] used thirty-six crossbred goats to evaluate the effect of replacing Tifton 85 grass hay with forage cactus at 0.21 and 42% total DM and intermittent water supply (IWS) on carcass traits, meat quality, fatty acid profile, and nutraceutical parameters. Forage cactus inclusion did not affect the rib eye area, carcass weight, or physical-chemical characteristics but reduced some branched-chain fatty acids. The authors concluded that cactus pear silage is adequate to replace Tifton hay up to 42% in the diet of goats in confinement to reduce production costs without negatively affecting carcass traits, meat quality, and the product to be marketed.

3.7.6. Forage Cactus Silage in the Bovine Diets

Only one study among the 30 articles reported an experiment based on forage cactus silage for feeding ruminants that are not goats or sheep. In their work, Silva Cordeiro et al. [9] examined the effect of BRS 716 biomass sorghum silage and BRS capiaçu grass silage with spineless cactus for feeding ten crossbred heifers. The authors showed that BRS 716 and BRS capiaçu grass silage with spineless cactus increased the non-fibrous carbohydrate intake, protein digestibility, and microbial production, and cactus inclusion did not interfere with the nitrogen utilization efficiency, final body weight, or average daily gain of crossbred heifers. Therefore, a diet based on biomass sorghum and forage cactus would be recommended for feeding these animals in the in-growing phase.

3.8. Overview and Future Prospects

Some observations could be highlighted based on the detailed analysis of the 30 selected articles. Considering the categories in which the articles were grouped, studies on cactus silage with industrial by-products were restricted to 2013, the first year with publications on cactus silage. In 2020, one of the years with the largest number of publications on the topic (nine articles), it was possible to identify a common focus. Otherwise, in the last two years of the period evaluated in this study (2022 and 2023), experiments were found to be focused on evaluating the characteristics and effects of forage cactus silage combined with other forage crops, especially species also adapted to arid and semi-arid regions.

For all evaluated categories, the results obtained from studies on forage cactus silage have been promising. However, the authors suggest more in-depth experiments to confirm and expand their findings, especially related to in vivo tests in animal diets. Gusha et al. [28] suggested carrying out long-term experiments in feeding goats with forage cactus-based silages, and Brito et al. [31] suggested studying more precisely variables such as consumption, digestibility, and performance of animals fed mixed silages. Pereira et al. [33] reported the importance of more research to examine the effect of different strains of lactic acid bacteria in ensiling, as there are only a few studies in this field.

From a general perspective, considering the scope of the analyzed articles and the growth of publication, it can be seen that studies on forage cactus silage tend to become a hot spot in the field of animal nutrition. The published articles have shown the relevance of forage cactus associated with the ensiling process to provide low-cost feed resource solutions for minimizing the scarcity of feed sources, especially in drylands. Nonetheless, the quantity of studies on this field is still low, and most were published in recent years. To improve the potential of animal diet based on cactus silage, it is necessary to keep the development of other studies on this topic.

Future research should be focused on evaluating the effect of forage cactus silage on the performance and nutritional profile of different animals over a broader range of time and parameters; studying the dynamics of forage cactus silage associated with other plants (silage or raw); improving the parameters of fermentation; evaluating the difference

between forage cactus varieties; and providing a more in-depth economic analysis for replacing traditional forage. Also, research on this topic must be explored in other countries located in semi-arid areas.

4. Conclusions

The importance and increasing interest in cactus silage as an alternative forage could be noticed by examining articles published in the field and available in scientific databases. The performed bibliometric analysis highlighted Agricultural and Biological Sciences; Veterinary; and Biochemistry, Genetics, and Molecular Biology as the areas with the highest percentage of publications on cactus silage. Regarding countries' relevance in the field, Brazil stands out for its significant contribution, with the largest number of publications and the most productive institutions.

The experiments reported in the selected articles were developed to analyze the characteristics of forage cactus silages, forage cactus silages with other forages, and forage cactus silages with industrial by-products. The most recent publications had been performed focusing on improving or testing silages composed of forage cactus combined with different levels of other forages, e.g., maniçoba, gliricidia, and elephant grass, and on the influence of cactus silage or mixed forage cactus silage on small ruminants, e.g., sheep and goat diets. In a broad view, the results of the evaluated studies have proved forage cactus silage as a promising alternative, although further experiments should be conducted to provide more solid information.

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References

1. Anaya-Pérez, M.A. History of the Use of Opuntia as Forage in Mexico. *FAO Plant Prod. Prot. Pap.* **2001**, *169*, 5–12.
2. do Nascimento Souza, A.F.; Leal de Araújo, G.G.; Santos, E.M.; Sérgio de Azevedo, P.; Silva de Oliveira, J.; Perazzo, A.F.; Pinho, R.M.A.; de Moura Zanine, A. Carcass Traits and Meat Quality of Lambs Fed with Cactus (*Opuntia ficus-indica* Mill) Silage and Subjected to an Intermittent Water Supply. *PLoS ONE* **2020**, *15*, e0231191. [CrossRef] [PubMed]
3. De Ferreira, M.; Da Silva, F.M.; Bispo, S.V.; Azevedo, M.D. Strategies for the Supplementation of Dairy Cows in the Brazilian Semi-Arid. *Rev. Bras. Zootec.* **2009**, *38*, 322–329. [CrossRef]
4. Rodrigues, P.G.; Garcez, D.S.M.; Silva, C.M.; Santana, C.C.S.; Santana, J.C.S.; Lopes, C.D.C.; Muniz, E.N.; de Oliveira Júnior, G.M.; Silva de Moura, R.; de Souza, J.C. Use of Palm Bran (*Nopalea cochenillifera* (L.) Salm-Dyck) in Partial Replacement of Concentrate in Maintenance Equine Diets—A Pilot Study. *Arch. Anim. Breed.* **2021**, *64*, 273–282. [CrossRef] [PubMed]

5. Maia, S.M.F.; de Oliveira Galvão, C.; Abbruzzini, T.F.; Campo, J.; Orsini, J.A.M.; Cerri, C.E.P.; de Oliveira, T.S. 7 Managing Drought Stress in Agro-Ecosystems of Latin America and the Caribbean Region. *Soil Drought Basic Process.* **2023**, *20*, 24.
6. Silva, P.C.G.d.; Moura, M.S.B.d.; Kiill, L.H.P.; Brito, L.T.d.L.; Pereira, L.A.; Sá, I.B.; Correia, R.C.; Teixeira, A.H.d.C.; Cunha, T.J.F.; Guimarães Filho, C. Caracterização Do Semiárido Brasileiro: Fatores Naturais e Humanos. In *Semiárido Brasileiro: Pesquisa, Desenvolvimento e Inovação*; Embrapa Semiárido: Petrolina, Brazil, 2010.
7. Nobre, I.d.S.; Araújo, G.G.L.d.; Santos, E.M.; Carvalho, G.G.P.d.; de Albuquerque, I.R.R.; Oliveira, J.S.d.; Ribeiro, O.L.; Turco, S.H.N.; Gois, G.C.; Silva, T.G.F.d.; et al. actus Pear Silage to Mitigate the Effects of an Intermittent Water Supply for Feedlot Lambs: Intake, Digestibility, Water Balance and Growth Performance. *Ruminants* **2023**, *3*, 121–132. [CrossRef]
8. Costa, R.G.; Beltrão Filho, E.M.; de Medeiros, A.N.; Givisiez, P.E.N.; do Egypto, R.d.C.R.; Melo, A.A.S. Effects of Increasing Levels of Cactus Pear (*Opuntia ficus-indica* L. Miller) in the Diet of Dairy Goats and its Contribution as a Source of Water. *Small Rumin. Res.* **2009**, *82*, 62–65. [CrossRef]
9. Cordeiro, M.W.S.; Júnior, V.R.R.; Monção, F.P.; Palma, M.N.N.; Rigueira, J.P.S.; da Cunha Siqueira Carvalho, C.; da Costa, M.D.; D'Angelo, M.F.S.V.; Costa, N.M.; de Oliveira, L.I.S. Tropical Grass Silages with Spineless Cactus in Diets of Holstein× Zebu heifers in the Semiarid Region of Brazil. *Trop. Anim. Health Prod.* **2023**, *55*, 89. [CrossRef]
10. Gebremariam, T.; Melaku, S.; Yami, A. Effect of Different Levels of Cactus (*Opuntia ficus-indica*) Inclusion on Feed Intake, Digestibility and Body Weight Gain in Tef (*Eragrostis tef*) Straw-Based Feeding of Sheep. *Anim. Feed Sci. Technol.* **2006**, *131*, 43–52. [CrossRef]
11. Sobral, G.d.C.; de Oliveira, J.S.; Santos, E.M.; de Araújo, G.G.L.; de Sousa Santos, F.N.; Campos, F.S.; Cavalcanti, H.S.; de Souza Vieira, D.; Leite, G.M.; Coelho, D.F.O.; et al. Optimizing Silage Quality in Drylands: Corn Stover and Forage Cactus Mixture on Nutritive Value, Microbial Activity, and Aerobic Stability. *J. Arid Environ.* **2024**, *220*, 105123. [CrossRef]
12. Ramos, J.P.F.; Santos, E.M.; Santos, A.P.M.; de Souza, W.H.; Oliveira, J.S. Ensiling of Forage Crops in Semiarid Regions. In *Advances in Silage Production and Utilization*; IntechOpen: London, UK, 2016; Volume 65.
13. Rodrigues, A.M.; Pitacas, F.I.; Reis, C.; Blasco, M. Nutritional Value of *Opuntia ficus-indica* Cladodes from Portuguese Ecotypes. *Bulg. J. Agric. Sci.* **2016**, *22*, 40–45.
14. Dunière, L.; Sindou, J.; Chaucheyras-Durand, F.; Chevallier, I.; Thévenot-Sergentet, D. Silage Processing and Strategies to Prevent Persistence of Undesirable Microorganisms. *Anim. Feed Sci. Technol.* **2013**, *182*, 1–15. [CrossRef]
15. Mao, G.; Huang, N.; Chen, L.; Wang, H. Research on Biomass Energy and Environment from the Past to the Future: A Bibliometric Analysis. *Sci. Total Environ.* **2018**, *635*, 1081–1090. [CrossRef] [PubMed]
16. Vieira, F.; Santana, H.E.P.; Silva, D.P.; Ruzene, D.S. A Bibliometric Description of Organosolv Pretreatment for Coconut Waste Valorization. *BioEnergy Res.* **2023**, *16*, 2115–2130. [CrossRef]
17. Tang, R.; Zhang, S.; Ding, C.; Zhu, M.; Gao, Y. Artificial Intelligence in Intensive Care Medicine: Bibliometric Analysis. *J. Med. Internet Res.* **2022**, *24*, e42185. [CrossRef]
18. Teles, M.N.O.; Santos, B.L.P.; Silva, D.P.; Teixeira, J.A.; Ruzene, D.S. A Bibliometric Description of Lignin Applicability for the Removal of Chemical Pollutants in Effluents. *Water Air Soil Pollut.* **2020**, *231*, 1–14. [CrossRef]
19. *Scopus Content Coverage Guide*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 1–24.
20. Van Eck, N.; Waltman, L. Software Survey: VOSviewer, a Computer Program for Bibliometric Mapping. *Scientometrics* **2010**, *84*, 523–538. [CrossRef]
21. Siqueira, M.; Chagas, J.; Monnerat, J.P.; Monteiro, C.; Mora-Luna, R.; Dubeux, J.; Dilorenzo, N.; Ruiz-Moreno, M.; Ferreira, M. Nutritive value, in Vitro Fermentation, and Methane Production of Cactus Cladodes, Sugarcane Bagasse, and Urea. *Animals* **2021**, *11*, 1266. [CrossRef]
22. de Oliveira, P.V.C.; de Araújo, T.L.A.C.; Pinedo, L.A.; de Lima Júnior, D.M.; Cortes, L.C.D.S.L.; Firmino, S.S.; Pereira, M.W.F.; de Oliveira Lima, P. Mixed Sorghum and Forage Cactus Silage: Composition, Digestibility, Fermentation, and Losses Silagem Mista de Sorgo e Palma Forrageira: Composição, Digestibilidade, Fermentação e Perdas. *Semin. Agrar.* **2023**, *44*, 929–936. [CrossRef]
23. Alencar, A.M.S.; Júnior, V.R.R.; Monção, F.P.; Cordeiro, M.W.S.; Santos, A.d.; Caldeira, L.A.; de Oliveira, L.; Ananias, J.V.A.; da Costa, M.; de Souza, A.; et al. Quality of Mixed Silages of Sorghum, BRS Capiaçu Grass, and Cactus Pear in a Semiarid Region of Brazil. *J. Appl. Anim. Res.* **2023**, *51*, 719–728. [CrossRef]
24. Vastolo, A.; Calabrò, S.; Cutrignelli, M.I.; Raso, G.; Todaro, M. Silage of Prickly Pears (*Opuntia* spp.) Juice by-Products. *Animals* **2020**, *10*, 1716. [CrossRef] [PubMed]
25. Marengo, J.A.; Cunha, A.P.M.A.; Nobre, C.A.; Ribeiro Neto, G.G.; Magalhaes, A.R.; Torres, R.R.; Sampaio, G.; Alexandre, F.; Alves, L.M.; Cuartas, L.A. Assessing Drought in the Drylands of Northeast Brazil under Regional Warming Exceeding 4 C. *Nat. Hazards* **2020**, *103*, 2589–2611. [CrossRef]
26. Vieira, R.M.d.S.P.; Tomasella, J.; Cunha, A.P.M.d.A.; Barbosa, A.A.; Pompeu, J.; Ferreira, Y.; Santos, F.C.; Alves, L.M.; Ometto, J. Socio-Environmental Vulnerability to Drought Conditions and Land Degradation: An Assessment in two Northeastern Brazilian River Basins. *Sustainability* **2023**, *15*, 8029. [CrossRef]
27. Uddin, S.; Khan, A. The Impact of Author-Selected Keywords on Citation Counts. *J. Informetr.* **2016**, *10*, 1166–1177. [CrossRef]
28. Gusha, J.; Halimani, T.E.; Ngongoni, N.T.; Ncube, S. Effect of Feeding Cactus-Legume Silages on Nitrogen Retention, Digestibility and Microbial Protein Synthesis in Goats. *Anim. Feed Sci. Technol.* **2015**, *206*, 1–7. [CrossRef]

29. Pereira, G.A.; Santos, E.M.; de Oliveira, J.S.; de Araújo, G.G.L.; de Sá Paulino, R.; Perazzo, A.F.; de Farias Ramos, J.P.; Neto, J.M.C.; de Lima Cruz, G.F.; Leite, G.M. Intake, Nutrient Digestibility, Nitrogen Balance, and Microbial Protein Synthesis in Sheep Fed Spineless-Cactus Silage and Fresh Spineless Cactus. *Small Rumin. Res.* **2021**, *194*, 106293. [CrossRef]
30. Silva, T.S.; de Araujo, G.G.L.; Santos, E.M.; de Oliveira, J.S.; Campos, F.S.; Godoi, P.F.A.; Gois, G.C.; Perazzo, A.F.; Ribeiro, O.L.; Turco, S.H.N. Water Intake and Ingestive Behavior of Sheep Fed Diets Based on Silages of Cactus Pear and Tropical Forages. *Trop. Anim. Health Prod.* **2021**, *53*, 1–7. [CrossRef]
31. da Brito, G.S.M.S.; Santos, E.M.; de Araújo, G.G.L.; de Oliveira, J.S.; Zanine, A.M.; Perazzo, A.F.; Campos, F.S.; de Lima, A.G.V.O.; Cavalcanti, H.S. Mixed Silages of Cactus Pear and Gliricidia: Chemical Composition, Fermentation Characteristics, Microbial Population and Aerobic Stability. *Sci. Rep.* **2020**, *10*, 6834. [CrossRef]
32. da Macêdo, A.J.S.; Santos, E.M.; de Araújo, G.G.L.; Edvan, R.L.; de Oliveira, J.S.; Perazzo, A.F.; dos Sá, W.C.C.S.; Pereira, D.M. Silages in the Form of Diet Based on Spineless Cactus and Buffelgrass. *Afr. J. Range Forage Sci.* **2018**, *35*, 121–129. [CrossRef]
33. Pereira, G.A.; Santos, E.M.; Araújo, G.G.L.; Oliveira, J.S.; Pinho, R.M.A.; de Zanine, A.M.; Souza, A.F.N.; Macedo, A.J.S.; Neto, J.M.C.; Nascimento, T.V.C. Isolation and Identification of Lactic Acid Bacteria in Fresh Plants and in Silage from Opuntia and Their Effects on the Fermentation and Aerobic Stability of Silage. *J. Agric. Sci.* **2019**, *157*, 684–692. [CrossRef]
34. Albuquerque, I.; Araújo, G.; Santos, F.; Carvalho, G.; Santos, E.; Nobre, I.; Bezerra, L.; Silva-Júnior, J.; Silva-Filho, E.; Oliveira, R. Performance, Body Water Balance, Ingestive Behavior and Blood Metabolites in Goats Fed with Cactus Pear (*Opuntia ficus-indica* L. Miller) Silage Subjected to an Intermittentwater Supply. *Sustainability* **2020**, *12*, 2881. [CrossRef]
35. Matias, A.G.S.; Araújo, G.G.L.; Campos, F.S.; Moraes, S.A.; Gois, G.C.; Silva, T.S.; Neto, J.V.E.; Voltolini, T.V. Fermentation Profile and Nutritional Quality of Silages Composed of Cactus Pear and Maniçoba for Goat Feeding. *J. Agric. Sci.* **2020**, *158*, 304–312. [CrossRef]
36. Abidi, S.; Ben Salem, H.; Nefzaoui, A.; Vasta, V.; Priolo, A. Silage Composed of *Opuntia ficus-indica* f. Inermis Cladodes, Olive Cakeand Wheat Bran as Alternative Feed for Barbarine Lamb. *Acta Hortic.* **2013**, *995*, 297–302. [CrossRef]
37. Santos, D.C.d.; Farias, I.; Lira, M.d.A.; Santos, M.V.F.d.; Arruda, G.P.d.; Coelho, R.S.B.; Dias, F.M.; de Melo, J.N. *Manejo e Utilização Da Palma Forrageira (Opuntia e Nopalea) em Pernambuco*; IPA: Recife, Brazil, 2006; 48p.
38. de Lima Cruz, G.F.; Santos, E.M.; de Araújo, G.G.L.; de Azevedo, P.S.; de Albuquerque, Í.R.R.; Panosso, N.M.; Perazzo, A.F.; de Moura Zanine, A.; de Jesus Ferreira, D.; de Oliveira Lima, A.G.V.; et al. Carcass Traits and Meat Quality of Goats Fed with Cactus Pear (*Opuntia ficus-indica* Mill) Silage Subjected to an Intermittent Water Supply. *Sci. Rep.* **2023**, *13*, 855. [CrossRef]
39. Rodrigues, R.; Lopes, R.; Santos, F.N.; Santos, E.M.; Perazzo, A.; Zanine, A.; Silva, R.; Silva, E.; Olivera-Viciedo, D.; Rocha, M.; et al. Total Mixed Ration Silages Based on Forage Cactus and Xerophile Legumes as Alternatives for Ruminants. *Agriculture* **2023**, *13*, 1759. [CrossRef]
40. Silva, T.S.; de Araújo, G.G.L.; Santos, E.M.; de Oliveira, J.S.; Godoi, P.F.A.; Gois, G.C.; Perazzo, A.F.; Ribeiro, O.L.; Turco, S.H.N.; Campos, F.S. Intake, Digestibility, Nitrogen Balance and Performance in Lamb Fed Spineless Cactus Silage Associated with Forages Adapted to the Semiarid Environment *Spineless cactus* Silages in Diets for Lambs. *Livest. Sci.* **2023**, *268*, 105168. [CrossRef]
41. Araújo, C.A.d.; de Oliveira, G.F.; Pinto, M.S.; Cunha, D.S.; Lima, R.S.; Costa, C.J.P.; Melo, D.A.d.S.; Campos, F.S.; Magalhães, A.L.R.; Gois, G.C. Fermentation Profile, Chemical Composition, and Aerobic Stability of Cassava Shoots Silages with Cactus pear. *Braz. J. Vet. Res. Anim. Sci.* **2023**, *60*, e212257. [CrossRef]
42. Sá, W.C.C.d.S.; Santos, E.M.; Oliveira, J.S.d.; Araújo, G.G.d.; Perazzo, A.F.; Pereira, D.M.; Santos, F.N.D.S.; Macêdo, A.J.D.S.; Cruz, G.F.D.L.; Corrêa, Y.R.; et al. Qualitative Evaluation of Total Mixed Ration Silage Containing Forage Cactus and Guinea Grass as a Nutritional Alternative for Feedlot-Finished Sheep. *N. Z. J. Agric. Res.* **2023**. [CrossRef]
43. de Araújo, C.A.; de Pinto, M.S.; de Oliveira, G.F.; da Silva Rodrigues, J.M.D.C.; de Cunha, D.S.; de Costa, C.J.P.; de Melo, D.A.S.; Magalhães, A.L.R.; de Araújo, G.G.L.; Campos, F.S.; et al. Nutritional Properties and in vitro Gas Production in Cactus Pear (*Opuntia stricta*) and Cassava (*Manihot esculenta*) Shoot Silages. *Afr. J. Range Forage Sci.* **2023**, *40*, 392–400. [CrossRef]
44. Ravari, F.N.; Tahmasbi, R.; Dayani, O.; Khezri, A. Cactus-Alfalfa Blend Silage as an Alternative Feedstuff for Saanen Dairy Goats: Effect on Feed Intake, Milk Yield and Components, Blood and Rumen Parameters. *Small Rumin. Res.* **2022**, *216*, 106811. [CrossRef]
45. de Melo, D.A.S.; Leite, A.C.S.P.; da Lima, R.S.; da Rodrigues, J.C.S.; de Araújo, C.A.; de Cunha, D.S.; Costa, P.; de Jesus, C.; de Sá, N.; Kelly, M. The Inclusion of *Cactus pear* Changes the Fermentation Process, Chemical Composition and Aerobic Stability of Arboreal Cotton Silages. *J. Prof. Assoc. Cactus Dev.* **2022**, *24*. [CrossRef]
46. Matlabe, G.; Mokoboki, H.K.; Sebola, A.N.; Lebopa, C.K.; Ravhuhali, K.E.; Hawu, O. Effects of Browse Legume Species Addition on Nutritional Composition, Fermentation Characteristics and Aerobic Stability of *Opuntia cladodes* Silage. *S. Afr. J. Sci.* **2022**, *118*, 1–6. [CrossRef] [PubMed]
47. de Paulino, R.S.; de Oliveira, J.S.; Santos, E.M.; Pereira, G.A.; de Ramos, J.P.F.; César Neto, J.M.; de Cruz, G.F.L.; Leite, G.M.; Satake, F.; da Silva, A.L. Spineless Cactus Use Management on Microbiological Quality, Performance, and Nutritional Disorders in Sheep. *Trop. Anim. Health Prod.* **2021**, *53*, 1–14. [CrossRef] [PubMed]
48. Sá, W.; Santos, E.M.; de Oliveira, J.S.; de Araujo, G.G.L.; Perazzo, A.F.; da Silva, A.L.; Pereira, D.M.; Neto, J.M.C.; Santos, F.N.S.; Leite, G.M. Fermentative Characteristics and Chemical Composition of Cochineal Nopal Cactus Silage Containing Chemical and Microbial Additives. *J. Agric. Sci.* **2020**, *158*, 574–582. [CrossRef]
49. Santos, F.N.S.; Santos, E.M.; Oliveira, J.S.; Medeiros, G.R.; Zanine, A.M.; Araújo, G.G.L.; Perazzo, A.F.; Lemos, M.L.P.; Pereira, D.M.; Cruz, G.F.L. Fermentation Profile, Microbial Populations, Taxonomic Diversity and Aerobic Stability of Total Mixed Ration Silages Based on Cactus and Gliricidia. *J. Agric. Sci.* **2020**, *158*, 396–405. [CrossRef]

50. de Carvalho, C.B.M.; Loiola Edvan, R.; dos Nascimento, K.S.; do Nascimento, R.R.; Bezerra, L.R.; de Jácome, D.L.S.; dos Santos, V.L.F.; de Santana Júnior, H.A. Methods of Storing Cactus Pear Genotypes for Animal Feeding. *African J. Range Forage Sci.* **2020**, *37*, 173–179. [CrossRef]
51. Monção, F.P.; Rocha Júnior, V.R.; Silva, J.T.; De Jesus, N.G.; Marques, O.F.C.; Rigueira, J.P.S.; Sales, E.C.J.; Silva Júnior, A.A.G.; Alves, D.D.; Carvalho, C.C.C. Nutritional Value of BRS Capiaçu Grass (*Pennisetum purpureum*) Silage Associated with Cactus Pear. *Iran. J. Appl. Anim. Sci.* **2020**, *10*, 25–29.
52. da Santos, R.S.; Emerenciano Neto, J.V.; de Souza Bonfim, B.R.; Fonseca dos Santos, U.L.; Rodrigues, A.C.; Lista, F.N.; dos Difante, G.S.; do Vale Bezerra, J.D. Fermentation Losses of Cactus Silages with Elephant Grass. *J. Prof. Assoc. cactus Dev.* **2020**, *22*, 72–78. [CrossRef]
53. de Nogueira, M.S.; de Araújo, G.G.L.; Santos, E.M.; Neto, S.G.; de Oliveira, J.S.; Perazzo, A.F.; de Zanine, A.M.; Pinho, R.M.A.; Corrêa, Y.R.; Pereira, D.M. Feed Alternatives with Cactus Forage Silage for Animal Nutrition. *Int. J. Agric. Biol.* **2019**, *22*, 1393–1398. [CrossRef]
54. Fuentes-Rodriguez, J.; Abrego-Garcia, A.; Ruiz-Zarate, F.; Montero-Almora, G.; Torres Hernandez, M.; Murillo Soto, M.E.; Garcia-Castillo, R.; Lopez-Gonzalez, J.J.; Ortiz de la Rosa, B. In vitro Digestibility of Prickly Pear Cactus (*Opuntia* spp.) Additioned with Brewery by-Products. In Proceedings of the VII International Congress on Cactus Pear and Cochineal 995, Agadir, Morocco, 17–22 October 2010; pp. 313–317.

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