Grains as Functional Food Link to Diabetic Disease: A Bibliometric Review

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ABSTRACT

Research related to grains and legumes has been widely conducted and scientifically proven to inhibit certain diseases. However, no studies or articles combine and review the relationship of grains to diabetes bibliographically. This article aims to link and identify grain and legume components to diabetic disease. This study obtained a database from ScienceDirect of 1,025 articles published between 2014 and 2024 that were processed bibliometric ally using the VOS viewer application. Visualization data showed diagrams of networks with 125 items, 7 clusters, and a total link strength of 3.046, with 'diabetes' makes up the largest cluster. Grain as a functional food for diabetes is linked to its active components and associations with biopeptides, prebiotics, and diabetic complications, which have become a trend in food research. This information can be utilized for functional food product development to decrease risk of diabetes disease.

Keywords: grain, diabetes, research trend, bioactive, functional food

INTRODUCTION

Diabetes mellitus is being accelerated by lifestyle choices such as unhealthy food, insufficient exercise, smoking, and excessive alcohol intake (Arifah et al., 2023). A chronic metabolic disease called diabetes is typified by hyperglycemia, brought on by inefficient insulin synthesis or activity. The emergence of macrovascular and microvascular problems would result from uncontrolled glucose metabolism. (Devi et al, 2023 and Patra et al, 2023). The International Diabetes Federation noted in 2021 that 537 million adults with diabetes worldwide, or 1 in 10 people. Diabetes also causes 6.7 million deaths, or 1 in 5 seconds (IDF, 2021).

There is an urgent need for improved management options due to the rising prevalence of type 2 diabetes. While sulphonylureas (metformin), biguanides, and alpha-glucosidase inhibitors are oral anti-diabetic medications, There is an urgent need for improved management options due to the rising prevalence of type 2 diabetes. Even though biguanides, sulphonylu reas (metformin), and alpha-glucosidase inhibitors (acarbose and voglibose) are often used as oral anti-diabetic medications, they can have unfavourable side effects. Along with gastrointestinal side effects such as nausea, vomiting, and diarrhoea, these drugs may cause weight gain. People's knowledge of the connection between nutrition and health has significantly increased in recent years. Ever-discerning customers are beginning to recognize the importance of diet and its traditional role in the human body. Beyond simply meeting the body's need for satisfaction, food is essential in maintaining the proper balance between health and illness. Therefore, research into natural materials with anti-diabetic properties is becoming increasingly popular as a substitute strategy (Elam et al., 2021; Jeong et al., 2024).

Diet occupies the foremost part in the management of diabetes, especially consumption of whole grain products, as it possesses amusing content of dietary fibre, phytochemicals, minerals, and vitamins (Devi et al., 2023). Grains and legumes, such as rice, oats *(Avena sativa)*, sorghum *(Sorghum bicolor)*, foxtail millet *(Setaria italica)*, proso millet *(Panicum millaceum)*, adzuki bean *(Vigna angularis)*, and black soybean

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(Glycine max), are recognized as valuable and nutrient-rich natural resources due to their bioactive compounds. Due to their status as strong metal chelators and radical scavengers, phenolic acid and flavonoids lessen the oxidation load. These crops have been reported to exhibit various health benefits, including antioxidant, anti-cancer, anti-obesity, and anti-diabetic effects. Previous studies on their anti-diabetic effects have primarily focused on whole grains, highlighting the role of dietary fibre in reducing blood glucose levels by slowing down the emptying of the digestive tract (Jeong et al., 2024; Ademosun et al., 2023; Ontawong et al., 2023).

There is a large amount of research examining the functional and nutraceutical qualities of grain as a diet and several studies on grain and its effects on health. Notably, an increasing body of research indicates that whole grains are effective in preventing and treating type 2 diabetes (T2D), and it is advised to consume more whole grains (Ren et al., 2024). However, no bibliometric research has been done on this subject. Bibliometric analysis is an effective tool for objectively studying the status quo and reflecting the development of a scientific field. Quantitative analysis was conducted based on the information in posted records, including journal, publication date, author, institution, affiliated country, and keywords (Xiao et al., 2024). Therefore, to understand the scope of prior research and determine the future direction of research, a bibliometric study must be conducted on grains as functional foods linked to diabetes disease.

MATERIALS AND METHOD

Data Sources

The data was reviewed through ScienceDirect and Pubmed databases. However, ScienceDirect was chosen as the primary source compared to the two databases because the keywords related to the desired topic were few in the PubMed sources. The selected research data use keywords namely "diabetic," "anti-diabetic," "grain," "functional food," "neutraceutical," and "food product." The data taken in this bibliometric analysis starts from 2014-2024, with only research and review articles. Data is taken in RIS form and processed using VOS viewer.

Data Extraction and Analysis

In order to extract and analyze data, information from the body of scientific literature is gathered, including pertinent article titles, abstracts, keywords, and articles. After the data extraction, analysis is done to comprehend and examine the information gathered. The ". RIS" format is used to hold the collected material. Vos viewer version 1.6.19 is then used to export the data for additional bibliometric analysis (van Eck & Waltman, 2020). Examining contributing publishers, publication trends, keyword co-occurrence networks, and overlay are some parameters employed to produce the results.

Sample articles downloaded in RIS format will then be processed using the VOS viewer version 1.6.19 application to export data for bibliometric analysis. The data extraction steps to attach visualizations and term maps are as follows.

- Open the VOS viewer version 1.6.19 application and select the Create section on the left bar.

- Choose the type of data by selecting the create a map based on bibliographic data, next

- Choose data sources by selecting the read data from reference manager files that support data types RIS, End Note, and RefWorks, next

- Select files that have been downloaded, choose type of analysis and counting method, type of analysis: co-occurrence; unit of analysis: keywords; counting method: full counting, next

- Choose threshold: minimum number of occurrences of a keyword; in this article, using five keyword occurrences, then choose the number of keywords to be selected, next

- Verify selected keywords by removing keywords that are not in the form of words and meanings other than those desired, finish> run the algorithmic layout.

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Term Map

A program called VOS viewer is used to examine and display bibliometric data from databases that take the form of words that show up in the keywords, abstracts, and titles of particular works of literature. After running the layout algorithmic program, it will display network visualization, overlay visualization, and density visualization, which differ based on their purpose. A bubble map is used to visualize the data, with each bubble representing a word or phrase that appears in the literature. The bubbles' colour shows the number of citations per publication that contain that word. The separation between two bubbles represents the frequency with which those two terms occur. (Yeung et al., 2018; Arifah et al., 2022).

RESULTS AND DISCUSSION

Publication Trends

The most recent study data was gathered on May 17, 2024, and is available on Science Direct. According to the data retrieval date, the most recent publication was released in May of 2024. We offer the network and overlay visualization, both filtered by terms from the 1.025 references.

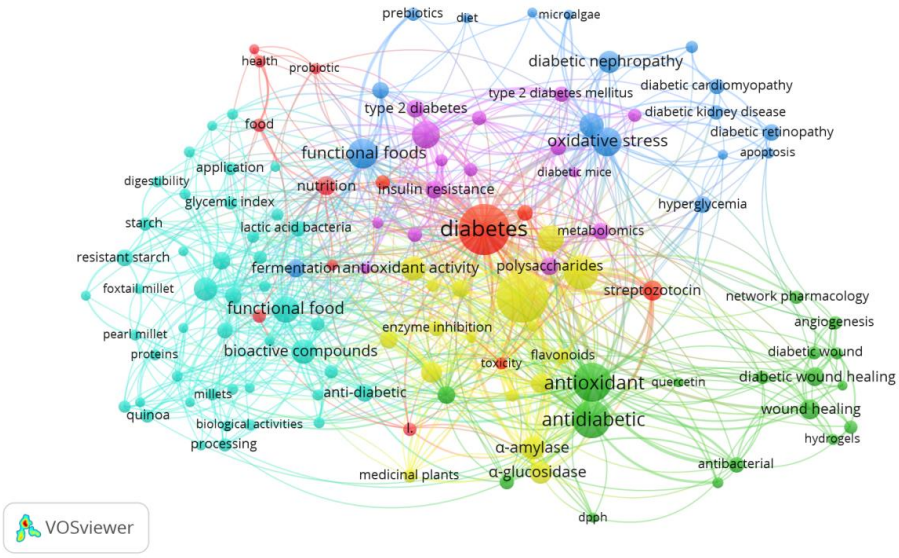

Fig 1. Network Visualization

In this work, Fig. 2 presents the findings of the bibliographical analysis. Network visualization and overlay visualization are the two visuals we give, filtered by terms from the references. Diagrams of Networks With 125 items, 7 clusters, and a total link strength of 3.046—Figure 2 shows the network visualization of the references using VOS viewer. Accordingly, the number of citations and similarity level are shown by the size of the circles and the spacing between them. The co-citation network analysis identified seven unique clusters, each representing a different research topic. The colors orange, yellow, blue, tosca, purple, and green are displayed.

Diabetes makes up the largest cluster (orange). This visualization is split into seven clusters based on the VOS viewer visualization results. The initial group comprises Amaranth, antocyanins, anti-diabetic, anti-nutritional factors, antidiabetic potential, application, applications, bioactive components, bioactive compounds, bioactive peptides, bioactivity, bioavailability, biological activities, buckwheat, dietary fibre, digestibility, encapsulation, food processing, food safety, food security, foxtail millet, functional food, functional properties, glycaemic index, glycemic index, lactid acid bacteria, millets, molecular mechanism, nutraceuticals, nutrients, nutritional value, pearl millet, physicochemical properties, processing, processing technique, protein, proteins, quinoa, resistant starch, sorghum, starch, sustainability, and whole grains are included in Cluster 1. Cluster 2 comprises the following 18 items: angiogenesis, DPPH, hydrogel, hydrogels, quercetin, wound healing, anti-

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inflammation, anti-inflammatory, antibacterial, anticancer, antidiabetic, antioxidant, antioxidants, chitosan, diabetic wound, diabetic wound healing, diabetic wounds. Apoptosis, diabetic cardiomyopathy, diabetic kidney disease, diabetic neuropathy, diabetic nephropathy, diabetic retinopathy, hyperglycemia, inflammation, microalgae, oxidative stress, prebiotics, prevention, probiotics, and type 1 diabetes are then included in Cluster 3 (17 items). A-amylase, a-glucosidase, a-glucosidase inhibitor, flavonoids, glycation, medicinal plants, molecular docking, phenolic compounds, phytochemicals, polyphenols, antioxidant activity, cytotoxicity, diabetes mellitus, and enzyme inhibition are all included in Cluster 4 (17 items). The fifteen elements that comprise Cluster 5 are bio accessibility, blood glucose, insulin resistance, hypoglycemia, gut microbiota, metformin, metabolomics, polysaccharides, polysaccharides, type 2 diabetes, and type 2 diabetes mellitus. Bioactive, biological activity, food, health, nutrition, nutritional composition, and probiotics comprise Cluster 6 (8 items). Diabetes, insulin, obesity, streptozocin, and toxicity make up Cluster 7 (5 items).

Overlay Visualization Using VOS viewer

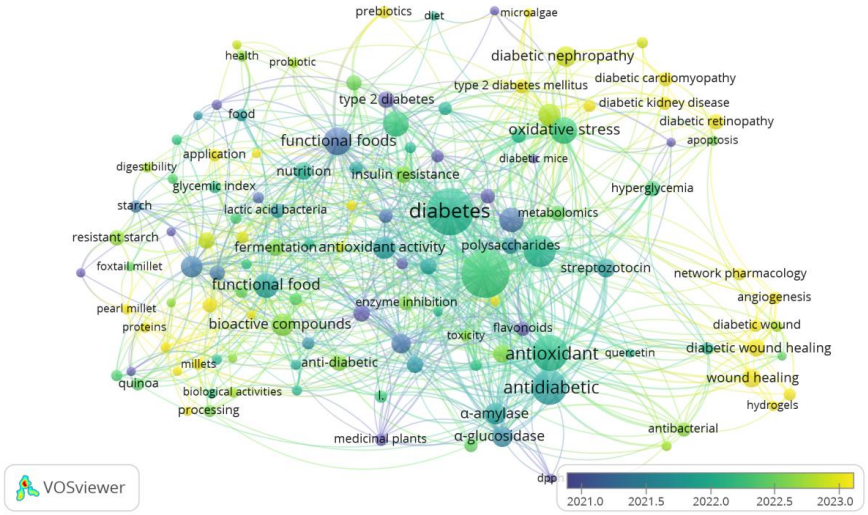

Fig 2. Overlay Visualization

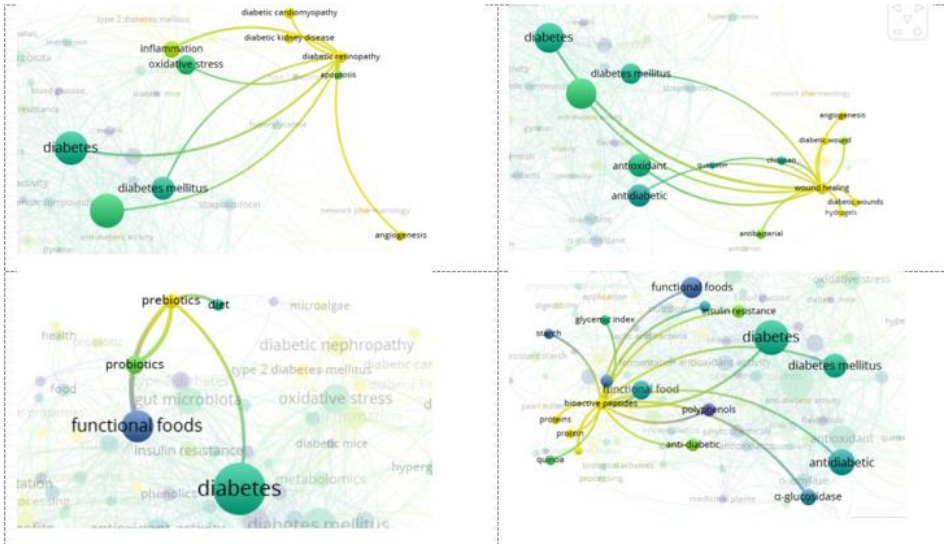

Fig 3. Trends research between 2023-2024

In Figure 3, the novelty of the articles is visually depicted, with brighter nodes indicating more recent publications. The yellow-colored nodes represent research and review articles published between 2022 and 2024, covering diabetic cardiomyopathy, diabetic kidney disease, diabetic neurophathy, diabetic nephropathy, diabetic retinopathy, prebiotics, and biopeptides. These recent articles reflect the latest advancements and investigations in the field of diabetes. On the other hand, the purple-colored nodes indicate articles published

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in older years, specifically from 2021 and earlier. These older publications might lay the foundation for diabetes research but could be considered less current regarding their relevance to current knowledge. The green nodes represent articles published in the intermediate period, around 2021 to 2022.

These articles likely contributed to bridging the gap between earlier research and more recent findings. From a close examination of Figure 3, we can infer that most research on functional food for diabetes primarily focuses on understanding its various components and their functional roles. This suggests that researchers have been interested in exploring grain's biochemical constituents and potential applications as a functional food for diabetes. Furthermore, the visual representation in Figure 3 reveals that some of these components have undergone significant development and processing, leading to the creation of diverse products. This indicates that diabetes research has progressed beyond basic understanding and has entered the realm of practical applications and innovations.

Data table containing article information related to grains as functional food link to diabetic disease can be seen in table1 below.

Table 1. Related articles to grains, legumes, and diabetic disease

Discussions	References
Treatment with meals enriched with almond drupes and seeds significantly corrected these effects in diabetic mice. This study found that almond-supplemented diets improved certain crucial biomarkers related to erections in diabetic mice.	Adebayo et al, 2019
Glutinous rice has been proven to have a variety of health benefits, including antioxidant activity, bioactive substances, anti-cancer characteristics, anti-inflammatory effects, diabetic potential, and cholesterol-lowering effects.	Ali et al, 2024
The nutritional composition of the lotus seed and the bioactivities of lotus seed extracts has anti-cancer, anti-proliferation, anti-diabetic, anti-inflammatory, neuroprotective, antioxidant, and immunomodulatory properties.	Bangar et al, 2022
Finger millet has distinguished health benefit features, such as anti-diabetic (type 2 diabetes mellitus), anti-diarrheal, antiulcer, anti-inflammatory, antitumorogenic (K562 chronic myeloid leukemia), atherosclerogenic effects, antibacterial and antioxidant properties.	Chandra et al, 2016
Black rice has shown promise in treating constipation, carcinogenesis, tumors, coronary heart disease, atherosclerosis, inflammations, nephrological disorders, type 2 diabetes, anemia, hyperglycemia, hypertension, and obesity.	Das et al, 2023
The study found that fermented finger millet-horse gram-based dosa can help regulate degenerative disorders caused by free radicals.	Devi et al, 2023
Plant protein peptides have bioactivities such as antihypertensive, hypocholesterolemic, immunomodulatory, antioxidant, antibacterial, anti-diabetic, opiate, and hepatoprotective effects, which are being recognized for their potential health benefits.	Fan et al, 2022
Amaranth and quinoa, small-seeded grains with high nutritional and phytochemical profiles, provide significant health benefits and protect against chronic illnesses such as hypertension, diabetes, cancer, and cardiovascular problems.	Jan et al, 2023
Flaxseed intake is increasing due to its capacity to reduce the risk of many degenerative (diabetes, obesity) and chronic disorders (cardiovascular disease, cancer).	Kause et al, 2024
Amaranth caudatus contain biologically active chemicals with anti-diabetic, anti-	Lopez et al,

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hyperlipidemic, and anti-cholesterolemic actions, as well as antioxidant and antibacterial properties.	2020
Sorghum grain has a high protein, amino acid content, and antioxidant properties may be helpful in the treatment of a variety of medical ailments.	Meena et al, 2022
Cereal contains inulin has been used to boost the nutritional and healthful features of the product as a sweetener and alternative for lipids and carbs, improving the nutritional value and lowering the glycemic index.	Melilli et al, 2024
Cereal polyphenols promote overall health through antioxidant, anti-inflammatory, antidiabetic, and anti-obesity activities.	Nguyen et al, 2024
A diet high in phytochemicals from nuts, legumes, and whole grains has been associated to reduced risk of lipid peroxidation, cardiovascular problems, cancer, and other diseases.	Pawase et al, 2024
Whole grains include bioactive compounds that can prevent or regulate diseases such as cardiovascular risk, cancer, type-2 diabetes, hypertension, and high blood pressure. They also improve gastrointestinal health.	Rawat et ak, 2023
Pigmented rice cultivars have more antioxidants, including phenolic compounds, flavonoids, and anthocyanins, making them more useful.	Veena et al, 2023
Fenugreek is a legume with therapeutic properties including antidiabetic, anticarcinogenic, hypocholesterolemic, antioxidant, and immunological activity.	Wani et al, 2016
The nutritional and bioactive properties of eight popular nuts (pecan, pine, hazelnuts, pistachio, almonds, cashew, walnuts, and macadamia) were studied in vitro for their anti-diabetic (pancreatic α-amylase and intestinal α-glucosidase), anti-obesity (pancreatic lipase), and anti-cholinergic (AChE and BuChE) inhibitory activity.	Wojdylo et al, 2022
Nutritional and anti-nutritional characteristics of mungbean varieties/cultivars, which are possible health factors and can be used to assess food quality in human healthcare.	Zafar et al, 2023

CONCLUSION

By employing bibliometric and study analysis and utilizing the VOS viewer software, we comprehensively examined the global trend of functional food for diabetes and its applications. During this analysis, we identified several terms that appeared multiple times and found that they held the same meaning. A total of 1.025 articles published between 2014 and 2024 were carefully selected for this investigation. Data from multiple sources were acquired from the ScienceDirect database between 2014 and 2024. According to the VOS viewer visualization results, the research trend on grain as a functional food seems to have increased, especially this year. Functional food interaction with diabetic disease is linked to the bioactive component benefits it delivers. Among the health benefits of grain as a functional food for diabetes is its link to its active components. Grain associations with biopeptides, prebiotics, and diabetic complications became a trend in food research.

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