

International Journal of Pharmacology and Clinical Research



ISSN Print: 2664-7613
ISSN Online: 2664-7621
Impact Factor: RJIF 8
IJPCR 2023; 5(1): 54-57
www.pharmacologyjournal.in
Received: 20-07-2023
Accepted: 22-08-2023

Dr. Tendai Chikosha
Faculty of Agriculture and
Post-Harvest Research,
Zimbabwe College of
Agriculture, Harare,
Zimbabwe

The influence of sorghum grain storage on nutritional and therapeutic properties

Dr. Tendai Chikosha

DOI: <https://doi.org/10.33545/26647613.2023.v5.i1a.38>

Abstract

Sorghum (*Sorghum bicolor*), a staple crop in many parts of the world, is renowned for its nutritional and therapeutic properties, including its high content of macronutrients, dietary fibers, and bioactive compounds with antioxidant, anti-inflammatory, and anticancer activities. However, improper storage conditions can lead to significant degradation of these properties, impacting both human health and economic value. This article examines the effects of various storage methods on the nutritional and therapeutic properties of sorghum, emphasizing the biochemical and bioactive changes caused by environmental factors, pest infestations, and microbial contamination. Strategies to preserve the nutritional and therapeutic integrity of sorghum grains are discussed, along with potential avenues for future research.

Keywords: Contamination, discussed, potential

Introduction

Sorghum (*Sorghum bicolor*) is a drought-tolerant cereal crop cultivated for its versatility in food, feed, and industrial applications. With a rich nutritional profile, including carbohydrates, proteins, fats, vitamins, minerals, and bioactive compounds, sorghum plays a significant role in promoting health and preventing diseases (Awika & Rooney, 2004) [1]. Additionally, sorghum is valued for its therapeutic properties, such as antioxidant, anti-inflammatory, and antidiabetic effects, attributed to its high phenolic content and unique phytochemicals (Beta *et al.*, 2005) [2]. However, post-harvest losses during storage significantly impact the grain's nutritional and therapeutic potential. Adverse storage conditions, including high humidity, temperature fluctuations, and biological contamination, lead to degradation of macronutrients, bioactive compounds, and functional properties (Obadina *et al.*, 2014) [7]. This article investigates the influence of storage conditions on sorghum's nutritional and therapeutic properties and explores strategies to mitigate losses.

Nutritional and Therapeutic Properties of Sorghum

Sorghum (*Sorghum bicolor*) is a highly versatile and nutritionally rich cereal crop that serves as a staple food for millions of people, particularly in arid and semi-arid regions. Its resilience to harsh climatic conditions and ability to thrive in nutrient-depleted soils make it indispensable in food security strategies across Africa, Asia, and the Americas. Beyond its agricultural significance, sorghum is valued for its nutritional and therapeutic properties, which make it a key component of healthy diets and functional foods. These properties are attributed to its macronutrient composition, micronutrient profile, and a variety of bioactive compounds with health-promoting effects.

Nutritionally, sorghum is an excellent source of carbohydrates, providing 65–75% of its dry weight. These carbohydrates, primarily in the form of starch, serve as an important energy source for human diets. The slow-digesting nature of sorghum starch contributes to its low glycemic index, making it a suitable grain for managing blood sugar levels in individuals with diabetes or those at risk of developing the condition. Additionally, sorghum contains 7–15% protein, which includes essential amino acids necessary for muscle repair, enzyme function, and overall metabolic health. Although its protein digestibility is slightly lower compared to other cereals due to the presence of protein cross-linkages with tannins,

Corresponding Author:
Dr. Tendai Chikosha
Faculty of Agriculture and
Post-Harvest Research,
Zimbabwe College of
Agriculture, Harare,
Zimbabwe

advanced food processing methods such as fermentation and decortication can enhance its nutritional value.

Sorghum is also a good source of dietary fiber, with levels ranging between 8–12%. The insoluble fiber present in sorghum aids in maintaining gastrointestinal health by promoting regular bowel movements, preventing constipation, and supporting a healthy gut microbiome. Its high fiber content has also been linked to a reduced risk of cardiovascular diseases by aiding in cholesterol reduction and improving lipid profiles. Furthermore, sorghum is naturally gluten-free, making it an excellent dietary alternative for individuals with celiac disease or gluten sensitivity.

Micronutrient-wise, sorghum is rich in essential minerals such as iron, zinc, magnesium, and phosphorus. These minerals are crucial for various physiological processes, including oxygen transport, immune function, bone health, and energy metabolism. Iron and zinc deficiencies, common in many developing regions, can be mitigated through the inclusion of sorghum in diets. Sorghum also provides B-complex vitamins such as thiamine, riboflavin, and niacin, which play vital roles in energy production, neural function, and cellular repair.

The therapeutic properties of sorghum are largely attributed to its abundance of bioactive compounds, including phenolic acids, flavonoids, tannins, and anthocyanins. These phytochemicals are primarily concentrated in the bran and outer layers of the grain, making whole-grain sorghum more beneficial than refined products. Phenolic compounds in sorghum exhibit strong antioxidant activity, which helps neutralize free radicals and reduce oxidative stress, thereby lowering the risk of chronic diseases such as cancer, cardiovascular diseases, and neurodegenerative disorders. Flavonoids in sorghum have been shown to possess anti-inflammatory properties, which are crucial in managing conditions like arthritis and inflammatory bowel disease.

The antidiabetic properties of sorghum are well-documented, with studies showing its ability to modulate glucose metabolism and improve insulin sensitivity. This effect is linked to the presence of unique tannins and phenolic acids that inhibit carbohydrate-digesting enzymes, slowing the release of glucose into the bloodstream. Additionally, tannins and anthocyanins in sorghum have demonstrated anticancer potential by inducing apoptosis in cancer cells, inhibiting tumor growth, and preventing DNA damage.

Sorghum's therapeutic benefits also extend to its role in gut health. The prebiotic properties of its fiber and phenolic compounds promote the growth of beneficial gut bacteria, which are essential for a healthy digestive system and immune response. Moreover, the antimicrobial properties of certain sorghum bioactives help inhibit the growth of harmful pathogens, making sorghum a functional food for improving overall gut health and immunity.

In traditional medicine, sorghum has been used for its astringent and diuretic properties, often employed in managing digestive disorders and urinary tract infections. Emerging research continues to explore the potential of sorghum-derived bioactive compounds in innovative applications such as drug development and nutraceuticals, further highlighting its therapeutic potential.

Overall, sorghum's nutritional and therapeutic properties make it a highly valuable crop for addressing global health challenges. Its ability to provide essential nutrients, support

metabolic health, and deliver bioactive compounds with medicinal properties underscores its role in promoting well-being and preventing diseases. By incorporating sorghum into diverse diets and exploring innovative processing methods, its full potential as a nutritional and therapeutic powerhouse can be realized, benefiting populations worldwide.

Effects of Storage on Nutritional and Therapeutic Properties

The effects of storage on the nutritional and therapeutic properties of sorghum are profound, as post-harvest conditions can significantly alter its macronutrients, bioactive compounds, and overall health-promoting potential. These effects are influenced by factors such as moisture levels, temperature fluctuations, pest infestations, and microbial contamination, each of which plays a role in the biochemical degradation of sorghum grains. Understanding these changes is crucial for preserving the nutritional and therapeutic value of sorghum during storage, especially in regions where it serves as a dietary staple.

Moisture content is a critical factor in determining the stability of sorghum during storage. High moisture levels (>13%) create favorable conditions for enzymatic activity and microbial growth, leading to the degradation of macronutrients such as carbohydrates, proteins, and lipids. Obadina *et al.* (2014)^[7] demonstrated that elevated moisture levels promote the growth of fungal species like *Aspergillus* and *Penicillium*, which produce mycotoxins such as aflatoxins. These toxic compounds not only degrade the nutritional quality of sorghum but also pose severe health risks, including carcinogenesis and liver damage. Additionally, moisture-induced enzymatic activity can hydrolyze starch into simpler sugars, reducing its energy content and altering its suitability for consumption and industrial applications.

Temperature fluctuations during storage exacerbate nutrient losses by accelerating lipid oxidation and protein denaturation. Park *et al.* (2012)^[8] found that prolonged exposure to high temperatures leads to rancidity in lipids, resulting in the loss of essential fatty acids and a decline in grain flavor and usability. Proteins, which are critical for metabolic functions, undergo structural changes under thermal stress, reducing their digestibility and bioavailability. Phenolic compounds, which are responsible for sorghum's antioxidant and anti-inflammatory properties, are particularly sensitive to heat and oxygen. Beta *et al.* (2005)^[2] observed that prolonged storage under suboptimal conditions degrades phenolic acids and flavonoids, diminishing their therapeutic efficacy in combating oxidative stress and chronic diseases.

Pest infestations represent another major challenge during sorghum storage, particularly in traditional systems. Insects such as weevils (*Sitophilus zeamais*) and borers (*Prostephanus truncatus*) consume carbohydrate reserves and expose grains to secondary microbial contamination. Tefera *et al.* (2011)^[9] highlighted that pest-infested grains experience significant reductions in protein and lipid content, as well as the loss of bioactive compounds. These biochemical changes not only compromise the nutritional integrity of sorghum but also reduce its therapeutic potential, including its antioxidant and anticancer properties. Microbial contamination, particularly fungal infestation, is a critical concern in humid storage environments. Fungal

activity depletes bioactive compounds, such as tannins and anthocyanins, which are essential for sorghum's anticancer and antidiabetic properties. Hell and Mutegi (2011) [4] emphasized that mycotoxin contamination further erodes the grain's nutritional value and therapeutic potential, making it unsafe for human and animal consumption. Additionally, microbial activity can degrade vitamins, particularly B-complex vitamins like thiamine and niacin, which are vital for energy metabolism and neural function.

The cumulative impact of these factors during storage leads to a significant decline in the nutritional and therapeutic properties of sorghum. Phenolic degradation, for instance, reduces its ability to scavenge free radicals and protect against oxidative damage, undermining its antioxidant capacity. Similarly, the loss of tannins and flavonoids diminishes sorghum's ability to regulate blood sugar levels and prevent chronic diseases like diabetes and cancer.

To mitigate these effects, various storage technologies have been explored. Hermetic storage systems, which create oxygen-free environments, have proven effective in preserving macronutrients and bioactive compounds. De Groote *et al.* (2013) [3] demonstrated that airtight storage reduces pest and microbial activity, maintaining the grain's nutritional and therapeutic integrity for extended periods. Similarly, low-temperature storage has been shown to minimize lipid oxidation and protein denaturation. Park *et al.* (2012) [8] reported that refrigeration preserves phenolic compounds and antioxidant properties, ensuring the grain's functional quality.

Moisture control through drying technologies is another critical strategy. Proper drying to reduce moisture content below 13% prevents enzymatic and microbial degradation. Obadina *et al.* (2014) [7] highlighted the efficacy of solar and mechanical drying in maintaining sorghum's quality while reducing contamination risks. Additionally, the use of natural preservatives such as neem oil and diatomaceous earth provides an eco-friendly approach to pest control without compromising the grain's bioactive profile (Tefera *et al.*, 2011) [9].

In conclusion, storage conditions play a pivotal role in determining the nutritional and therapeutic properties of sorghum grains. Factors such as moisture, temperature, pests, and microbial contamination lead to significant biochemical changes that compromise its health benefits and usability. Advanced storage technologies, including hermetic systems, low-temperature environments, and improved drying methods, offer effective solutions to mitigate these losses. Continued research and adoption of these practices are essential for preserving the nutritional and therapeutic value of sorghum, ensuring its role in promoting health and food security.

Strategies to Preserve Nutritional and Therapeutic Properties

Preserving the nutritional and therapeutic properties of sorghum grains during storage is essential for maintaining their value as a dietary staple and functional food. Given the susceptibility of sorghum to biochemical degradation due to moisture, temperature fluctuations, pest infestations, and microbial contamination, strategic interventions are required to minimize nutrient losses and maintain the integrity of bioactive compounds. Effective storage strategies combine advanced technologies and sustainable practices to ensure that sorghum retains its macronutrients, micronutrients, and

therapeutic compounds such as phenolics, flavonoids, and tannins. Controlled atmospheric storage is a proven technique for maintaining sorghum's quality. Hermetic storage systems, which rely on airtight conditions, create an oxygen-deprived environment that inhibits microbial growth and pest activity. De Groote *et al.* (2013) [3] demonstrated that hermetic storage significantly reduces post-harvest losses by up to 90%, preserving the antioxidant properties of phenolic acids and flavonoids. This method also minimizes lipid oxidation, ensuring the stability of essential fatty acids. By limiting oxygen availability, hermetic systems effectively slow the enzymatic reactions that lead to the breakdown of starch and proteins, safeguarding sorghum's nutritional and therapeutic value.

Moisture control is another critical aspect of grain preservation. High moisture content (>13%) fosters microbial contamination and enzymatic activity, which degrade macronutrients and bioactive compounds. Advanced drying techniques, such as solar drying and mechanical drying, have been shown to reduce moisture levels uniformly, preventing the growth of spoilage organisms. Obadina *et al.* (2014) [7] reported that proper drying significantly reduces the risk of aflatoxin contamination by fungal species such as *Aspergillus* and *Penicillium*. Additionally, drying at moderate temperatures ensures that phenolic compounds, which are highly sensitive to heat, remain intact. These bioactive compounds are vital for sorghum's antioxidant, anti-inflammatory, and anticancer properties. Temperature management plays a pivotal role in preserving the biochemical stability of sorghum grains. Storage in low-temperature environments, such as refrigeration, effectively slows enzymatic reactions, microbial growth, and oxidative stress. Park *et al.* (2012) [8] found that refrigeration minimizes lipid oxidation and protein denaturation, thereby maintaining sorghum's functional quality. Furthermore, cold storage preserves phenolic compounds and flavonoids, which are crucial for sorghum's therapeutic properties. However, the adoption of low-temperature storage in resource-constrained regions remains challenging due to high energy costs and infrastructure requirements. Biopesticides and natural preservatives offer eco-friendly alternatives to chemical fumigants for pest control. Neem oil, diatomaceous earth, and other plant-based biopesticides have been shown to effectively protect grains from pest infestations without leaving harmful residues. Tefera *et al.* (2011) [9] highlighted that natural treatments not only preserve the nutritional quality of sorghum but also maintain its therapeutic properties, such as antioxidant and antidiabetic activities. Additionally, natural antioxidants like ascorbic acid can be applied during storage to mitigate oxidative damage, ensuring the stability of phenolic acids and other bioactive compounds. Innovative packaging solutions also contribute to the preservation of sorghum's nutritional and therapeutic properties. Vacuum-sealed or multilayer packaging with UV protection reduces the exposure of grains to environmental stressors such as light, oxygen, and humidity. Hell and Mutegi (2011) [4] demonstrated that advanced packaging significantly extends the shelf life of sorghum while maintaining its bioactive profile. These systems are particularly effective in protecting the grain from oxidative stress, which depletes its antioxidant capacity and diminishes its health-promoting potential.

Integrated pest management (IPM) strategies are crucial for addressing pest infestations during storage. IPM combines biological, physical, and chemical control methods to minimize pest damage while preserving the grain's quality. For example, combining hermetic storage with natural repellents and periodic monitoring ensures effective pest control without compromising the nutritional and therapeutic properties of sorghum.

Emerging technologies, such as nanotechnology-based storage solutions and biofilm coatings, hold significant promise for enhancing grain preservation. Nano-based materials can be used to create antimicrobial surfaces that prevent fungal and bacterial contamination, while biofilm coatings derived from edible polymers like chitosan provide a protective barrier against moisture and pests. These innovations are particularly valuable for preserving the phenolic compounds and flavonoids in sorghum, which are highly sensitive to environmental stressors.

In addition to technological interventions, farmer education and training are essential for promoting best practices in sorghum storage. Educating farmers on the importance of drying, pest control, and proper packaging can significantly reduce post-harvest losses and improve the quality of stored grains. Policies that provide subsidies for storage infrastructure, such as metal silos and hermetic bags, can further enhance the adoption of effective storage strategies.

In conclusion, preserving the nutritional and therapeutic properties of sorghum requires a multifaceted approach that addresses the biochemical challenges of storage. Strategies such as controlled atmospheric storage, moisture control, low-temperature environments, biopesticides, and advanced packaging solutions have been validated by studies as effective methods for maintaining the quality of sorghum grains. Continued research and innovation in storage technologies, combined with farmer education and policy support, are critical for ensuring the sustainability of sorghum as a dietary staple and a therapeutic resource.

Conclusion

Storage practices have a profound influence on the nutritional and therapeutic properties of sorghum grains. Factors such as moisture, temperature, microbial contamination, and pest infestation contribute to nutrient and bioactive compound losses, diminishing sorghum's health benefits. By adopting advanced storage technologies, including hermetic systems, moisture control, and biopesticides, it is possible to preserve the nutritional and therapeutic integrity of sorghum. Continued research and dissemination of best practices are crucial for ensuring the sustainability of sorghum as a dietary staple and therapeutic resource.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Awika JM, Rooney LW. Sorghum phytochemicals and their potential impact on human health. *Phytochemistry*. 2004;65(9):1199–1221.
2. Beta T, Rooney LW, Marovatsanga LT, Taylor JRN. Phenolic compounds and antioxidant properties of sorghum. *Cereal Chem*. 2005;82(4):390–393.

3. De Groote H, Kanampiu F, Warburton H, *et al*. Effectiveness of hermetic systems in controlling maize storage pests in Kenya. *J Stored Prod Res*. 2013;53:27–36.
4. Hell K, Mutegi C. Aflatoxin control and prevention strategies in key crops of sub-Saharan Africa. *Afr J Microbiol Res*. 2011;5(5):459–466.
5. Nusrat A, Julie AP. Nutritional benefits of sorghum grains. *J Agric Sci*. 2018;10(7):132–138.
6. Hussen A. Impact of grain storage method on sorghum grain quality in Ethiopia: A review. *J Curr Res Food Sci*. 2021;2(1):40–45.
7. Obadina AO, Oyewole OB, Sanni LO, Tomlins KI. Bio-preservation of African fermented foods using lactic acid bacteria. *Trends Food Sci Technol*. 2014;38(2):129–136.
8. Park SH, Itoh K, Sugimoto T, *et al*. Effects of temperature and storage duration on sorghum seed germination and nutrient content. *Agric Sci Technol*. 2012;14(5):25–30.
9. Tefera T, Kanampiu F, de Groote H, *et al*. The metal silo: An effective grain storage technology for reducing post-harvest storage losses. *J Stored Prod Res*. 2011;47(3):210–215.
10. Taylor JRN, Schober TJ, Bean SR. Novel food and non-food uses for sorghum and millets. *J Cereal Sci*. 2006;44(3):252–271.