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THE PHYSICS OF DRYING METHODS AND IT'S INFLUENCE ON THE NUTRIENT RETENTION IN MORINGA OLEIFERA LEAVES- A SURVEY

[1]ROMANUS I. O, [2]SUNDAY AYIGUN & [3]MARIA DINGARI

[1&2]Department of Physics with Electronics Federal Polytechnic, Mubi [3]Department of Science Laboratory Technology Federal Polytechnic Mubi.

ABSTRACT

This review highlights the importance of selecting appropriate drying methods to preserve the nutrient content of Moringa oleifera leaves, a highly nutritious plant often called the "drumstick tree" or "miracle tree." The leaves are rich in essential nutrients,

Introduction

Moringa oleifera, often referred to as the "drumstick tree" or "miracle tree," is a versatile and highly nutritious plant that has gained significant attention in recent years due to its potential health benefits (Justina, 2023). The leaves of Moringa oleifera are particularly rich in essential nutrients, making them a valuable dietary source in many parts of the world. However, the preservation of these nutrients during the drying

making them valuable for dietary purposes, but maintaining their nutritional value during drying is critical. The review explores the physics behind various drying techniques and their impact on nutrient retention. Drying Moringa leaves is crucial for extending their shelf life and ensuring their availability throughout the year. The review discusses different drying methods, such as sun drying, oven drying, freeze drying, and microwave drying, and how they affect nutrient content. It emphasizes the role of physics principles like heat and mass transfer, phase changes, and thermodynamics in these drying processes. Traditional sun drying, while cost-effective, is shown to lead to nutrient losses due to heat sensitivity. In contrast, low-temperature methods like freeze drying and air drying are more effective at preserving nutrients. The need for temperature control and understanding enzymatic reactions and oxidation processes in nutrient preservation is underscored. It highlights the impact of drying methods on sensory qualities, emphasizing the potential benefits of freeze drying and vacuum drying. Additionally, it addresses the importance of obtaining reliable data on nutrient composition and the hygiene concerns associated with traditional drying methods and makes recommendations.

Key Words: Moringa, heat, phase, nutrient, mass and temperature.

process is a critical concern, and understanding the physics behind various drying methods is essential in optimizing the nutrient content of dried Moringa leaves. (Jaiswal, et.,al 2012).

The drying of Moringa leaves is a crucial step in their preservation, as it extends their shelf life and makes them more accessible for consumption, especially in regions where fresh leaves are not readily available year-round. Various drying methods, such as sun drying, oven drying, freeze drying, and microwave drying, can be employed to remove the moisture from the leaves. Each of these methods has its own unique impact on the nutrient content of the leaves, which can be explained through the lens of physics.

Physics plays a fundamental role in the drying process of Moringa leaves. The key principles of heat and mass transfer, as well as the understanding of phase changes, are essential in comprehending how different drying methods affect the nutrient content. Different drying methods rely on the transfer of heat to remove moisture from the leaves. Sun drying, for example, utilizes natural solar radiation to heat the leaves, whereas oven drying uses forced convection to circulate hot air (Moyo, *et al.,* 2011). Understanding the principles of heat transfer helps determine the rate of moisture removal and its impact on nutrient retention.

Moisture removal is achieved through mass transfer, typically involving the movement of water from the interior of the leaves to the surface where it evaporates. Physics principles help assess the efficiency of moisture removal and its influence on nutrient degradation (Paliwal, *et al*., 2011).

Phase Changes, as water evaporates from the leaves, it undergoes a phase change from liquid to vapor. The energy required for this phase change affects the temperature of the leaves and can influence nutrient stability.

The laws of thermodynamics play a role in understanding the energy exchanges during drying. Nutrients within the leaves can migrate during drying, impacting their distribution and concentration.

Understanding diffusion mechanisms can shed light on how nutrients are redistributed within the leaves.

Drying as a form of processing ensures the availability of perishable products all year round (Habou *et al.*, 2003). Drying method is used in Nigeria for preserving leafy vegetable and example of such vegetables is leaf of *Moringa oleifera*. Drying leafy vegetable increase their shelf life upon storage (Eklou *et al.*, 2006). The need for a well-established data on the nutrients composition of food is of great importance in identifying and solving nutritional problem in the society. Drying agricultural produce by sun drying is widely used in most of the developing countries of the tropical region. However, solar drying is an elaboration of sun drying and was the most hygienic method of drying (Bala and Woods, 1994). The leaves of *Moringa oleifera* are preserved traditionally using sun drying (open air) and this is associated with possible contamination by microorganisms, infestation by insects and rodents. Their quality can be diminished and even become inedible (Diamante and Munro, 1993).

The thrust of this review is to provide an overview of relevant studies that investigated the impact of different drying methods on the nutrient content of Moringa oleifera leaves and to consolidate the existing body of knowledge regarding the physics of the effect of drying methods on the nutrient content of Moringa oleifera leaves through a comprehensive analysis of relevant scientific literatures.

DRYING METHODS

Sun Drying

Drying Moringa leaves through the traditional and cost-effective method of sun drying involves exposing them to direct sunlight to reduce moisture content. However, this approach has been found to cause significant nutrient losses, particularly in vitamins such as vitamin C and thiamine, due to the heat sensitivity of these nutrients (Singh et al., 2017). Various drying methods significantly affect the nutrient content of Moringa oleifera leaves. Sun drying, although commonly practiced, has been shown to lead to substantial nutrient losses, especially heat-sensitive compounds like vitamin C and certain B vitamins. On the other hand, low-temperature drying methods like freeze drying and air drying are more effective at preserving the nutrient content, resulting in higher retention of vitamins and minerals. Likewise, Jaiswal et al. (2012) observed decreased retention of phenolic compounds and antioxidant activity in sun-dried leaves.

Several studies have compared different drying methods for Moringa oleifera leaves, including sun drying, oven drying, and microwave drying. The consistent finding is that sun drying negatively affects nutrient content, particularly heat-sensitive compounds like vitamin C and certain B vitamins. Microwave drying, although faster, can also lead to nutrient losses due to high temperatures. Oven drying at lower temperatures has been identified as a suitable compromise, preserving a greater proportion of nutrients.

Traditional drying methods like sun drying and air drying have been widely used for Moringa oleifera leaves due to their simplicity and affordability. However, these methods often result in substantial nutrient losses. Vacuum drying and freeze drying have gained attention as alternatives that can better preserve the nutritional value of the leaves, though they might require specialized equipment and higher initial investments. The choice of drying method for Moringa oleifera leaves can impact not only the nutrient content but also the sensory qualities of the dried product. While sun drying may result in a more intense color, it often leads to undesirable changes in flavor and texture due to nutrient degradation. Techniques such as freeze drying and vacuum drying have shown potential in maintaining both nutrient levels and sensory attributes. Enzymatic reactions and oxidation processes are major contributors to nutrient loss during the drying of Moringa oleifera leaves. Studies suggest that quick drying methods, such as microwave drying, can help minimize these reactions and retain more nutrients. However, a balance must be struck, as excessively high temperatures in microwave drying can also lead to nutrient degradation.

Air drying

This involves the removal of moisture through exposure to natural air currents, is another commonly employed method for drying Moringa leaves. While gentler than sun drying, air drying can still impact nutrient retention. Studies by Rahman et al. (2018) indicated that air drying led to a decrease in vitamin C and polyphenol content, contributing to overall nutrient degradation. However, it was noted that air drying resulted in better nutrient preservation compared to sun drying.

Oven drying

Oven drying utilizes controlled heat, is a faster drying method. However, higher temperatures in ovens can lead to nutrient losses. Rahman et al. (2016) demonstrated that oven drying at elevated temperatures caused reductions in vitamin C, carotenoids, and chlorophyll content in Moringa leaves. The study highlighted the importance of temperature control to mitigate nutrient degradation.

Freeze drying

This is a more advanced method involving freezing the leaves and then sublimating ice to remove moisture, has shown promise in preserving the nutrient content of Moringa leaves. Studies by Ghasemzadeh et al. (2010) found that freeze drying resulted in higher retention of phenolic compounds and antioxidant activity compared to other drying methods. Similarly, Siddhuraju and Becker (2003) reported that freeze-dried Moringa leaves exhibited better retention of essential amino acids. A comparative study by Oliveira et al. (2015) compared different drying methods and found that freeze drying resulted in the highest retention of ascorbic acid and total phenolic compounds, followed by air drying, oven drying, and sun drying. The study highlighted the potential of freeze drying for nutrient preservation. Gupta et al. (2018) investigated the effect of various drying methods on protein content in Moringa leaves and reported that freeze drying maintained higher protein levels compared to sun and shade drying. A study by Chauhan et al. (2014) evaluated the impact of drying methods on mineral content and revealed that freeze-dried samples retained higher levels of minerals like iron and calcium.

Carotenoids are essential pigments with nutritional significance. Kalyani et al. (2013) found that freeze drying was effective in preserving carotenoid content in Moringa leaves.

The antioxidant capacity of Moringa leaves was assessed by Rajasekaran et al. (2016), who reported that freeze-dried samples exhibited superior antioxidant activity compared to other drying methods. A study by Kour et al. (2020) investigated the impact of drying methods on flavor compounds in Moringa leaves and indicated that freeze drying resulted in better preservation of aromatic compounds.

Jaiwal, et., al. (2021) discussed various drying methods for Moringa oleifera leaves and their impact on nutrient content and functional properties. It highlights the importance of physics principles in understanding these effects.

Moyo, et.,al (2015), provided an insights into the physics-based approach to the effect of drying methods on the nutritional composition of Moringa oleifera leaves. It covers a range of drying techniques and their implications for nutrient retention.
Anwar, et., al. (2017) explores how various drying methods affect the phytochemical profiles of Moringa oleifera leaves. It discusses the physics behind these changes and their implications for health benefits. Kibar, & Özcan, (2011), investigated the physics-based changes in nutrient content during convective drying of Moringa oleifera leaves. It includes a detailed analysis of heat and mass transfer processes. Kumar, & Singh (2007) employed mathematical modeling to understand the drying kinetics and nutritional changes during hot air drying of Moringa oleifera leaves, emphasizing the physics principles involved in the process.

CONCLUSION

The drying of Moringa oleifera leaves is a critical step in their preservation, with different drying methods having varying effects on the nutrient content of these highly nutritious leaves. The physics behind drying processes, including heat and mass transfer, phase changes, thermodynamics, and diffusion mechanisms, play a fundamental role in understanding how these methods impact nutrient retention. Sun drying, a traditional and cost-effective method, is commonly practiced but has been shown to cause substantial nutrient losses, especially for heat-sensitive compounds like vitamin C and certain B vitamins. On the other hand, low-temperature drying methods like freeze drying and air drying are more effective at preserving the nutrient content, resulting in higher retention of vitamins and minerals. Oven drying at lower temperatures has been identified as a suitable compromise, preserving a greater proportion of nutrients compared to sun drying. Vacuum drying and freeze drying are alternative methods that can better preserve the nutritional value of Moringa leaves, although they may require specialized equipment and higher initial investments. These methods have shown potential in maintaining both nutrient levels and sensory attributes, making them valuable options for producing high-quality dried Moringa products. Enzymatic reactions and oxidation processes are major contributors to nutrient loss during drying, and quick drying methods like microwave drying can help minimize these reactions. However, it is essential to strike a balance, as excessively high temperatures in microwave drying can also lead to nutrient degradation. Carotenoids, proteins, minerals, antioxidant capacity, flavor compounds, and essential amino acids are among the nutrients that can be better retained through freeze drying compared to other drying methods.

RECOMMENDATIONS

1. Based on the existing research, freeze drying appears to be one of the most effective methods for preserving the nutrient content of Moringa oleifera leaves. Consider investing in freeze-drying equipment if possible, especially for commercial production, to maximize nutrient retention.
2. For oven drying and microwave drying, temperature control is crucial to mitigate nutrient degradation. Implement precise temperature monitoring and control systems to ensure optimal drying conditions.
3. Depending on the specific needs and resources available, consider diversifying drying methods to optimize nutrient preservation. For example, freeze drying can be reserved for high-value products, while oven drying at lower temperatures can be used for less sensitive applications.

4. Continuously monitor and test the nutrient content of dried Moringa products to ensure they meet nutritional standards. This will help in quality control and ensuring that the chosen drying method is effectively preserving nutrients.
5. Educate Moringa leaf producers and consumers about the importance of choosing drying methods that best preserve nutrients. Encourage the adoption of more effective drying techniques, even at the small-scale production level.
6. Support further research into innovative drying methods and technologies that can enhance nutrient retention in Moringa leaves. Collaboration between researchers, agricultural experts, and food scientists can lead to advancements in this field.

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