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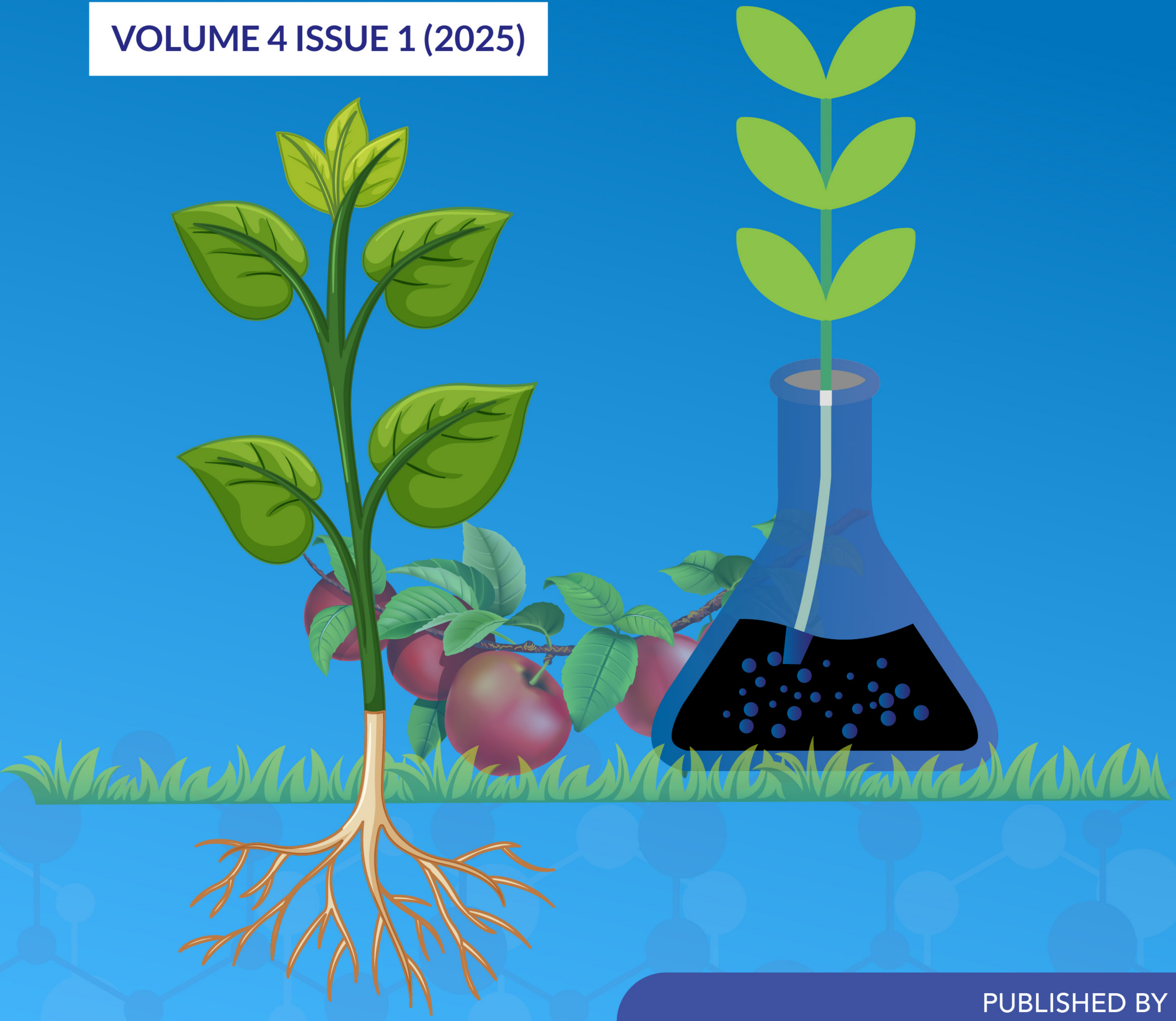

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Effect of Pre-treatments on the Osmotic Dehydration and Mass Transfer Behaviour of Sweet Potatoes (*Ipomoea batatas Lam.*)

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ABSTRACT

Food security is increasingly threatened by rapid population growth, climate change, and resource constraints, necessitating efficient preservation techniques to minimize post-harvest losses. This study investigates the osmotic dehydration process of two sweet potato (Ipomoea batatas Lam.) varieties, Local Sada and Kamala Sundari, under varying sugar concentrations (40%, 50%, 60%), temperatures (30°C, 40°C, 50°C, and 60°C), slice thickness (3 mm or 5 mm), and pre-treatment conditions (blanched or unblanched). The research problem addresses the high perishability of sweet potatoes post-harvest, leading to significant food losses, and the lack of optimized osmotic dehydration parameters tailored to specific sweet potato varieties. The novelty of this study lies in its comprehensive examination of multiple processing parameters simultaneously within a single experimental framework, allowing for an in-depth understanding of mass transfer mechanisms and varietal differences. Results indicate that increased sugar concentrations and temperatures enhance dehydration rates, with blanching further accelerating mass transfer by increasing cell permeability. However, varietal differences were significant: Kamala Sundari exhibited slower yet more controlled dehydration, maintaining better structural integrity, while Local Sada dehydrated faster but showed higher susceptibility to structural collapse. Slice thickness also played a crucial role, as thinner slices (3 mm) dehydrated more quickly but were prone to texture loss compared to thicker slices (5 mm). Unblanched samples, despite slower dehydration rates, retained better textural attributes. These findings have strong industrial relevance, providing a framework for optimizing osmotic dehydration conditions tailored to different sweet potato varieties, ensuring improved product quality and reduced post-harvest losses in food processing industries.

INTRODUCTION

Food security worldwide is increasingly threatened by rapid population growth, climate change and an overburdened set of resources (Sarker *et al.,* 2023). Protecting nutrient-rich crops through processing is vital. Sweet potatoes (Ipomoea batatas L) have become an important crop in developing nations due to their high calorific yield, nutritional profile, and ability to adapt to marginal growing conditions (Otálora *et al.,* 2024). Food production is vital in providing essential nutrients and increasing food security, and it is critical to economic and public health stability (Peng & Berry, 2018). Tropical and sub-tropical regions rely heavily on tuber crops such as sweet potatoes for caloric intake (Rinaldo, 2020). However, the high amount of moisture makes it highly perishable following harvest and usually results in food loss (Nath & Sil, 2008). Osmotic dehydration is a widely used method in the food industry to preserve fruit and vegetables by reducing the amount of water they contain while conserving their nutritional and sensory quality. To do this, food items are submerged into an osmotic solution composed of salt or sugar, which creates an osmotic pressure gradient to remove water from food structures while permitting solvent diffusion (Silva *et al.,* 2014; Cheng *et al.,* 2023; Osae *et al.,* 2024). Sweet potatoes (*Ipomoea batatas* L.) are particularly well known for their rich nutrient content; therefore, sweet potato dehydration produces intermediate moisture products, which improve shelf life and flavor profiles (Malakar *et al.,* 2021).

Dehydration by osmotic is highly dependent on various variables, including the amount of osmotic solution applied, processing temperature, sample thickness, pretreatment methods (blanching) used as well as sweet potato variety differences that influence cell structure, moisture content and chemical composition that ultimately impact dehydration rates as well as final product characteristics (de Souza Silva *et al.,* 2011). Osmotic dehydration depends on many variables, including the quantity and temperature of osmotic solutions used, sample thickness, method of pretreatment (blanching) utilized and sweet potato varieties whose cells alter cell structures, moisture content and chemical composition to influence rate of dehydration as well as final characteristics (Lagnika *et al.,* 2021). Sweet potatoes degrade rapidly due to their high moisture levels, leading to significant post-harvest losses (Sarker *et al.,* 2023; Araújo & Pena, 2023). However, the effect of key processing parameters such as sugar concentration, temperature, slice thickness, and pretreatment (blanching, etc.) on sweet potato degradation remains uncertain (Kadir *et al.,* 2024; Dermesonlouoglou *et al.,* 2025). Unblended on the kinetics of osmotic dehydration has not been sufficiently researched, nor

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has the significance of varietal differences such as Sada vs Kamala Sundari in dehydration behavior been recognized fully. This study addresses these gaps by investigating how processing variables affect water loss and solids gains during osmotic dehydration, in combination with varietal characteristics to optimize dehydration processes for product quality and effectiveness.

This study aims to investigate the effects of sugar concentration in the solution (40%, 50% and 60%) as well as the temperature, the thickness of slices (3 and 3 millimeters), and the pre-treatment method (blanched or. non-blanched) on the dehydration behavior of two varieties of sweet potato such as Local Sada as well as Kamala Sundari. The research focuses on studying the mechanisms of water loss and gain of solids during the process of osmotic dehydration in order to improve processes to ensure efficient removal of moisture while preserving the desirable structural and sensory characteristics (Lagnika *et al.,* 2021; Pandiselvam *et al.,* 2022). The uniqueness of this research is the holistic method of analysis. In contrast to previous studies that looked at individual parameters on their own the research we are conducting simultaneously examines various critical variables, including slice geometry, pretreatment and differences between varietals within a single experimental framework (Antonio *et al.,* 2008; Corrêa *et al.,* 2017; Wu *et al.,* 2020; Wang *et al.,* 2025). This integrated analysis will provide extensive insight into the mechanisms of mass transfer in osmotic dehydration. The report will also offer practical recommendations for the development of specialized methods to preserve sweet potatoes. The findings will aid in the reduction of postharvest losses as well as increasing the shelf-life of this vital crop, with a substantial impact on industry and food security.

MATERIALS AND METHODS

Raw Materials and Identification

Two kinds of sweet potatoes, Local Sada and Kamala Sundari, were purchased from a local market in Mymensingh, Bangladesh. A plant pathologist at Bangladesh Agricultural University verified the variety's identity using morphological traits. Only fresh tubers with no defects were used in the tests.

Preparation of Raw Materials

Tubers were cleaned under running tap water to eliminate soil, cleansed with a food-grade product, rinsed with distilled water, and dried by air. They were then peeled with a stainless-steel peeler to reduce the loss of flesh and cut into 5 and 3 mm pieces using an automated slicer to ensure uniformity across the samples (Kwaw *et al.,* 2023; Šovljanski *et al.,* 2024).

Pre-Treatment (Blanching vs. Unblanching)

Slices were split in two parts. To blanch slices, they were soaked in water at a temperature of 90°C for 3 minutes before being chilled in ice water for 2 minutes in order to stop the cooking. The samples that were not blanched were processed with no heating treatment (Osae *et al.,* 2024).

Osmotic Dehydration Process

Analytical-grade sucrose solutions were made at 40, 40%, 50%, and 60% (w/v) after dissolving the necessary amount of sucrose in the distilled water. Slices of sweet potato (both blanched and unblanched with a thickness of 3 mm and 5 mm) were immersed in a solution of sugar at a fruit-to-solution ratio of 1:10. Dehydration was conducted in a temperature-controlled water bath at 30°C, 40°C, 50°C, or 60°C for 6 hours, with a peristaltic pump circulating the solution at 500 ml/min (tube bore size: 8.0 mm). The samples were taken at predetermined intervals (30, 60, 120, 180, 240, 300, and 360 minutes) to determine the amount of mass transferred (Antonio *et al.,* 2008; Pang *et al.,* 2021; Rastogi, 2023).

Total Solids Determination

The quantity of total solids in those sweet potato pieces was measured using gravimetric analysis by drying in a vacuum oven at 70°C for 24 hours according to the procedure explained in the work of AOAC (Association of the Official Analytical Chemistry). Sweet potato slices were then transferred to aluminum dishes pre-weighed to ensure that all dishes' weights were precisely recorded (Tayyab Rashid *et al.,* 2020; Osae *et al.,* 2024; Rindang *et al.,* 2024). The dishes and the slices were then put in a vacuum oven set at 70°C for a drying time lasting 24 hours (Balladin & Headley, 1999). After drying, the samples were allowed to cool down to room temperature with a desiccator to avoid moisture absorption from the surroundings. The aluminum dishes that held dried samples were weighed to determine the weight (Pang *et al.,* 2021). The content of total solids (TS) was calculated by using the following equation (Equation 1):

$$\text{Total Solid (TS)},\% = (W3-W1)/(W2-W1) \qquad (1)$$

Where, W1 = Weight of aluminum dish, W2 = Weight of dish and sample, W3 = Weight of dish and the vacuum dried samples

Determination of Mass Transfer

The mass transfer during the osmotic dehydration process of sweet potato slices was assessed by measuring two key parameters: Water Loss (WL) and Solid Gain (SG).

Water Loss (WL)

To determine the loss of water during dehydration osmotically of slices of sweet potatoes, we estimated their decrease in weight after dehydration by capturing their mass at the beginning (Mi) prior to observing how dehydrated each slice was at various intervals of sampling (30, 60, 120, 180, 240, and 360 mins) by using Genina-Soto *et al.*'s (2001) equation that is described below (Equation 2):

$$\text{Water loss (WL)},\% = (Mi-Mo)/Mi \qquad (2)$$

Where, Mi is the initial mass of the sweet potato slice, and Mo is the mass of the osmotically dehydrated slice at a specific time interval.

Solid Gain (SG)

Solid gain was assessed by measuring the growth in the solids content of the sweet potato slices because of the absorption of sugar in the Osmotic solution. The total solids of both the original slices (TSi) and the dehydrated osmotically soaked cut (TSo) were determined by gravimetric analysis by using a vacuum oven to dry at 70°C for a period of 24 hours (Pang *et al.,* 2021). The gain in solids was calculated by using the following equation (Equation 3):

Solid Gain (SG),% =(TSo-TSi)/Mi (3)

Where, TSo = Total solids of the sample after osmotic dehydration, TSi = Initial total solids of the sample before dehydration, and Mi = Initial mass of the sweet potato sample.

This part should contain adequate detail to reproduce reported data. It can be divided into subsections to demonstrate data type and collection, and also if several methods are described. Methods already published should be indicated by a reference; only relevant modifications should be described. The methodology should be written concisely in detail by maintaining the continuity of the texts.

RESULTS AND DISCUSSION

This research set out to assess the effects of sugar solution concentration on the dehydration of osmotic fluids by analyzing various parameters, including concentration (40%, 50% or 60%), temperature (30°C, 40°C, 50°C, 60°C), sample preparation method (blanched versus non-blanched), and sample size (3mm thick samples for uniformity during the experiment). Key findings and conclusions can all be drawn based on the experiment's results.

Osmotic Dehydration Behavior

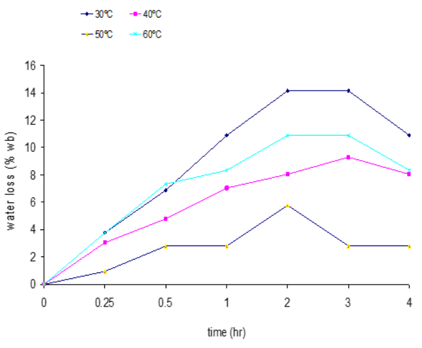
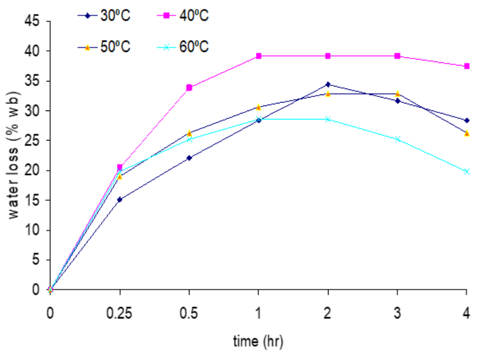
Effect of Pretreatment on the Dehydration Behavior of 3mm Thick Sweet Potato (var. Local Sada)

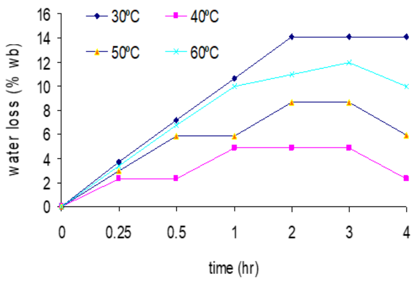
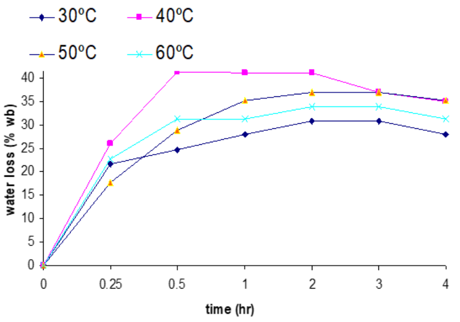
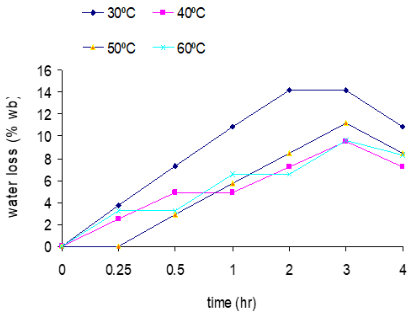
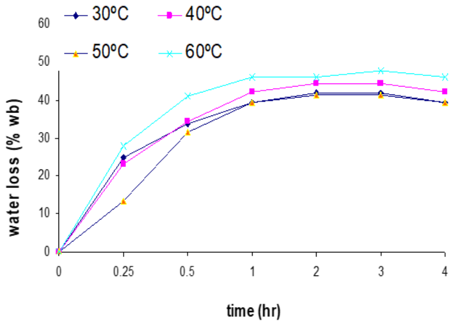
Results indicate that increasing sugar solution concentration between 40% and 60% increases the efficiency of osmotic dehydration significantly due to an increase in pressure gradient caused by an increase in concentration (Antonio *et al.,* 2008). Dehydration rates at 40% concentration were lower than at 50% and 60% concentration, suggesting a minimum concentration is necessary for effective moisture removal (these results align with established principles of osmosis (Table 1); an increase in concentration accelerates water molecules through a semipermeable membrane that surrounds food ingredients) (Jain & Chauhan, 2022).

Temperature was an integral component of osmotic hydration (Wang *et al.,* 2025). Rising from 30°C to 60°C would decrease viscosity in this sugar mixture and thus accelerate mass transfer (Lagnika *et al.,* 2021). Additionally, rising temperatures boost energy kinetics for water molecules, allowing easier escape from samples. However, extreme temperatures such as 60°C may cause changes to color, texture, nutritional quality, and other aspects. These extreme changes were especially prevalent with blanched samples due to increased thermal changes (Wang *et al.,* 2025).

Blanching, which involves brief exposure to hot water or steam, enhances permeability within a sample's cell structure, facilitating faster water removal during osmotic dehydration. This was particularly evident at higher sugar concentrations (50% and 60%) and temperatures between 50°C and 60°C. Unblanched samples exhibited slower dehydration rates due to their intact cell walls, which presented resistance against diffusion; blanching improved dehydration efficiency but may have led to some loss of soluble solids, as seen previously. Interactions among sugar concentration, temperature, and sample type (blanched vs. unblanched) revealed complex dynamics (Osae *et al.,* 2024). For instance, while a 60% sugar solution mixed with 60°C resulted in the highest dehydration rates, it might not be optimal in terms of sensory or nutritional attributes of samples; thus, a balance must be found between dehydration efficiency and product quality preservation. Furthermore, blanched samples benefitted more from increased temperatures than unblanched ones, emphasizing the necessity of tailoring processing conditions according to specific characteristics of the raw material used (Wu *et al.,* 2020; Pang *et al.,* 2021).

Table 1: Water loss over time at various temperatures and sugar solution concentrations for 3mm thick sweet potato slices (var. local sada)

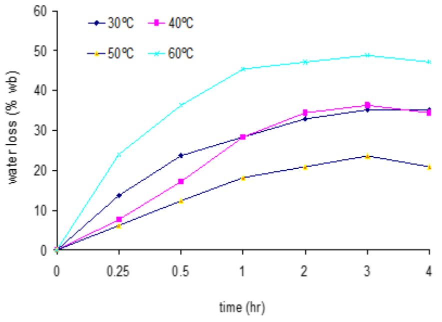
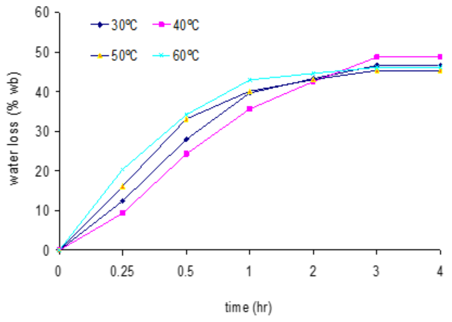
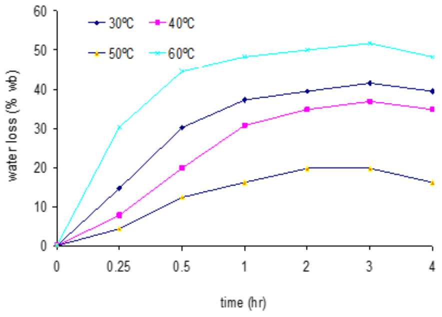
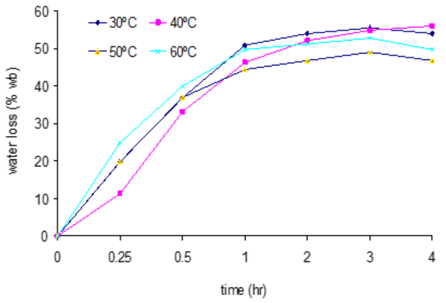
Sugar solution concentration	Blanched	Unblanched
40%		

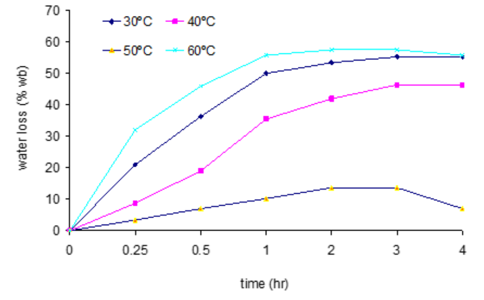
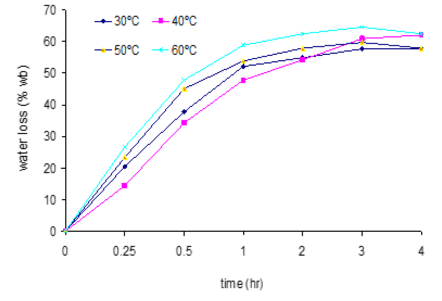
50%		
60%		

Effect of Pretreatment on the Dehydration Behavior of 3mm Thick Sweet Potato (var. Kamala Sundari)

This research studies the dehydration characteristics of sweet potato slices from two varieties, Local Sada and Kamala Sundari, under varying conditions of sugar solution concentration (40%, 50%, and 60%), temperature, and pretreatment methods (blanched or unblanched). Local Sada was tested with 3mm and 5mm slices, while Kamala Sundari only required 3mm slices for experiments (Table 2). Our findings indicate that higher sugar concentrations and elevated temperatures significantly accelerate both varieties' water loss and solid gain. However, varietal differences were evident; Kamala Sundari showed slower dehydration rates but superior structural integrity than Local Sada. Blanching enhanced dehydration efficiency in both cases, leading to greater softening with local Sada.

Table 2: Water loss over time at various temperatures and sugar solution concentrations for 3mm thick sweet potato slices (var. kamala sundari)

Sugar solution concentration	Blanched	Unblanched
40%		
50%		

60%		

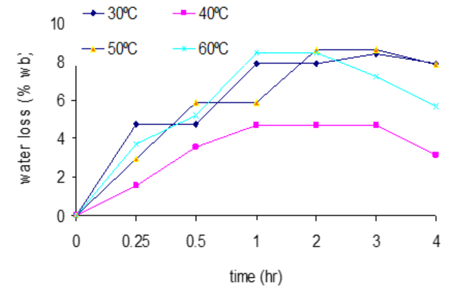
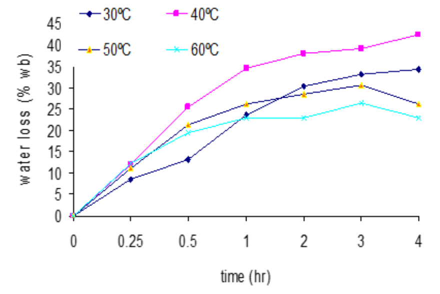
A comparison between these varieties underscores the role that thickness and cellular structure have on dehydration kinetics. Thinner slices (3 mm) dehydrated faster for local Sada than thicker (5 mm), emphasizing geometry's role in mass transfer. On the contrary, Kamala Sundari displayed more controlled dehydration conditions that preserved quality attributes more effectively than Local Sada; these insights highlight the necessity of customizing dehydration parameters to specific sweet potato varieties to optimize both efficiency and product quality; such tailored approaches can help achieve desired outcomes while mitigating adverse side effects like excessive shrinkage or nutrient loss (Rastogi, 2023).

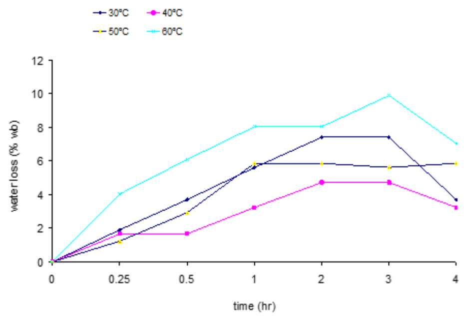
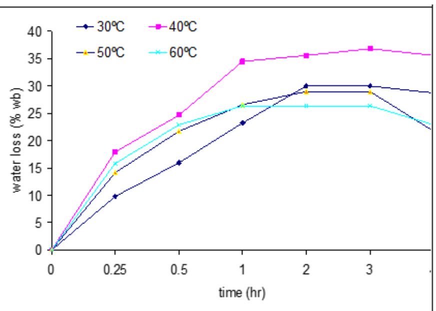
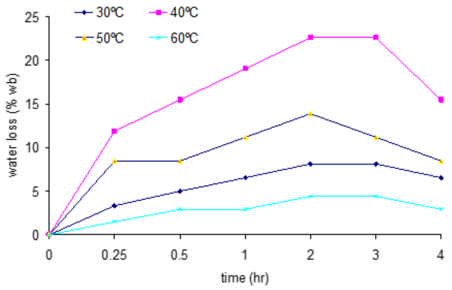
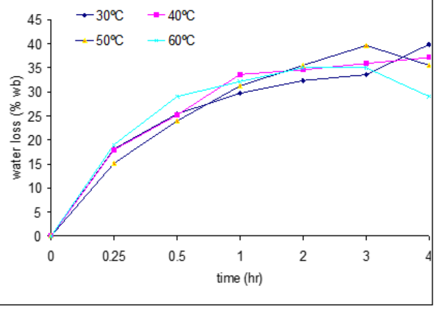
Effect of Sugar Solution Concentration, Temperature, Blanching on Dehydration Behavior of 5mm Thick Sweet Potato (var. Local Sada)

Results indicate that increasing sugar solution concentration dramatically accelerates osmotic dehydration. At 40% sugar concentration, dehydration rates were relatively lower than 50% and 60% sugar concentrations (Table 3). This can be explained by the higher osmotic pressure gradient created by more concentrated solutions, which drives water out more effectively (de Souza Silva *et al.,* 2011; Silva *et al.,* 2014). At every temperature condition, 60% sugar solutions demonstrated superior dehydration efficiency. These findings confirm the principles of osmosis, where an increased concentration gradient causes water molecules to migrate out from food materials into hypertonic solutions more quickly (Omar *et al.,* 2020). Reducing sugar intake could have unintended side effects such as excessive shrinkage or structural collapse of sweet potato slices; dehydration effectiveness must be balanced against high-quality products for best results. Temperature was an integral component in controlling osmotic hydration; higher temperatures between 30°C and 60°C resulted in greater degrees and rates of dehydration for all levels tested. As temperatures increased from 30°C to 60°C, dehydration efficiency improved across all sugar concentrations tested; at higher temperatures, the viscosity of sugar solutions was reduced, which improved mass transfer rates, while water molecules gained energy through friction, which assisted their migration away from sweet potato slices at elevated temperatures. 60°C was found to have the highest dehydration rates when combined with 50 and 60% sugar solutions. While higher temperatures may increase dehydration efficiency, they must still be used carefully to avoid adverse consequences (Jany *et al.,* 2016; Potatoes *et al.,* 2023).

Blanching significantly improved the osmotic dehydration process. Blanched samples exhibited higher water loss and solid gain than unblanched ones across all sugar concentrations and temperatures. Blanching disrupts the cellular structure, increasing membrane permeability and facilitating faster water diffusion and solute absorption. Neutralizing enzymes responsible for browning dehydrated products were particularly successful at neutralizing enzymes responsible for browning at higher sugar concentrations and temperatures (50, 60, and 80%) with temperatures reaching 50°C and 60°C. Unblanched samples experienced slower dehydration rates due to

Table 3: Water loss over time at various temperatures and sugar solution concentrations for 5mm thick sweet potato slices (var. local sada)

Sugar solution concentration	Blanched	Unblanched
40%		

50%		
60%		

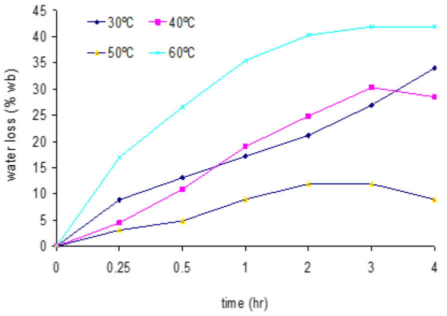
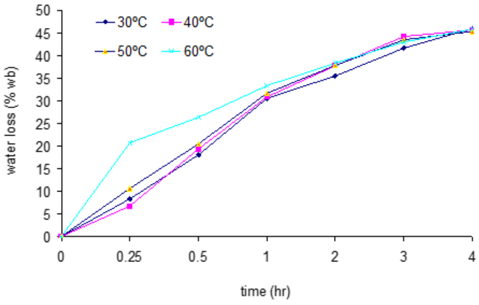
wall-like cells offering resistance against water diffusion (Rastogi, 2023). However, cell membranes in samples that were not blanched acted as barriers, slowing the dehydration process. A mixture of 60% sugar solution at 60°C and blanched samples resulted in maximum water loss, demonstrating its effectiveness as an efficient dehydration method. Unblanched samples treated with 40 % sugar solution at 30°C experienced minimal water loss due to reduced osmotic pressure variation and temperature-driven diffusion. These findings highlight the importance of an efficient strategy for optimizing osmotic dehydration processes that prioritize effectiveness and quality products (Rashid *et al.,* 2020).

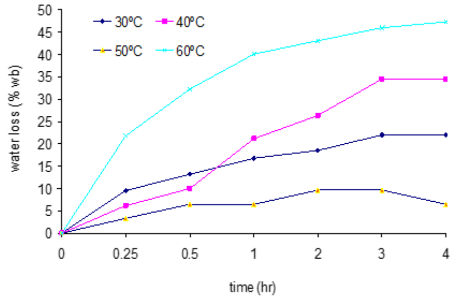
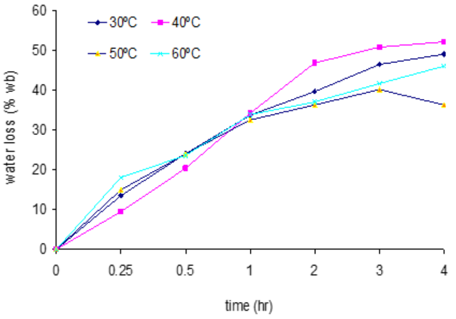
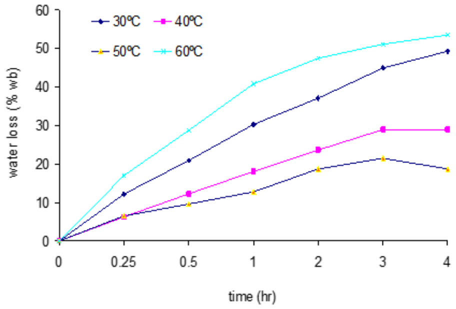
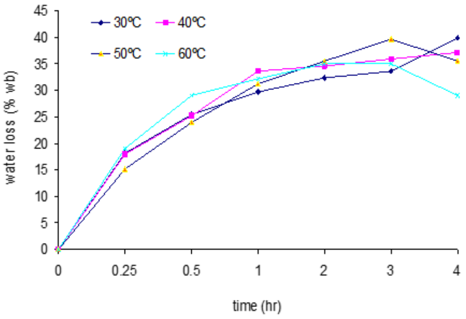
Effect of Sugar Solution Concentration, Temperature, and Blanching on Dehydration Behavior of 5 mm Sweet Potato (var. Kamala Sundari)

Sada and Kamala Sundari varieties were investigated for dehydration behavior when subjected to various sugar concentrations (40 %, 50%, 60% and 60 %), temperatures, and pretreatment conditions (blanched and non-blanched). Both varieties displayed that higher sugar concentrations and temperatures increased water loss through dehydration by osmosis; however, each variety showed different rates and amounts of dehydration. Kamala Sundari displayed slower dehydration rates than Local Sada because of its larger cells, which could aid in resisting the diffusion of moisture more efficiently. Blanching aided in dehydration for both kinds, but Kamala Sundari showed greater structural strength, while local Sada was more susceptible to collapse and shrinkage (Table 4).

Comparative analyses of two varieties show how their distinct characteristics affect dehydration. Despite similar processing conditions, Kamala Sundari was better at preventing dehydration while maintaining its unique characteristics than Sada from the local farm. Kamala Sundari varieties with skins that were not blanched showed slower but more even dehydration that preserved the sensory and texture throughout dehydration, highlighting

Table 4: Water loss over time at various temperatures and sugar solution concentrations for 5mm thick sweet potato slices (var. kamala sundari)

Sugar solution concentration	**Blanched**	**Unblanched**
40%		

50%		
60%		

the importance of adjusting dehydration parameters to specific types of sweet potatoes. By tailoring the conditions for the specific variety, it is possible to get optimal results for dehydration without suffering adverse side effects like excessive shrinkage and loss of nutrients, which ultimately enhance sweet potato's use in food services (Corrêa *et al.,* 2017).

Mass Transfer Behavior

Kinetics of Solid Gain in 3mm Thick Sweet Potato Slices (var. Local Sada) During Osmotic Dehydration

The study aimed to determine the impact of sugar concentration, temperature, and the pre-treatment of the sample (blanched as opposed to. not blanched) on the behavior of mass transfer in 3mm-thick slices of sweet potato (var. Local Sada) in the course of the dehydration process, which took place over a 4-hour duration (Table 5). The study was carried out with 40, 50%, and 60% sugar solutions and temperatures ranging between 40°C and 60°C. The process of osmotic dehydration is intrinsically time-dependent. Understanding the dynamics of time in the loss of water and gain of solids is essential for determining the optimal treatment parameters (Mari *et al.,* 2024).

The results show an increase in sugar solution concentration had a significant impact on the mass transfer rate, specifically in terms of loss of water and gain. The water removal rate was quite low with a sugar concentration of 40 in the sample compared to 50 and 60 %. This could be due to the greater Osmotic pressure gradient produced from the concentrated solution, which draws water out of sweet potato slices more efficiently. In particular, that solution with 60% sugar showed the highest water loss in all temperatures. However, it is important to remember that higher sugar concentrations led to a higher gain in solids (sugar uptake) through sweet potato slices. This is to be expected because the force for the diffusion of solutes into food items is increased with sugar concentration. While this can improve the sweetness and preservation potential of the food item, the excessive gain in solids could negatively impact sensory qualities like texture and taste (Silva *et al.,* 2014).

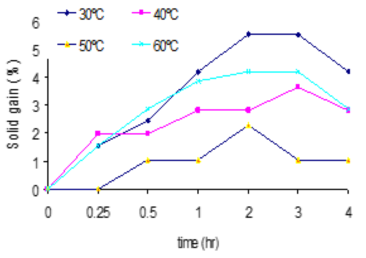
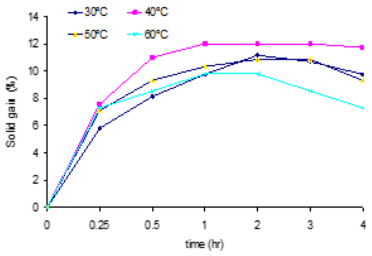
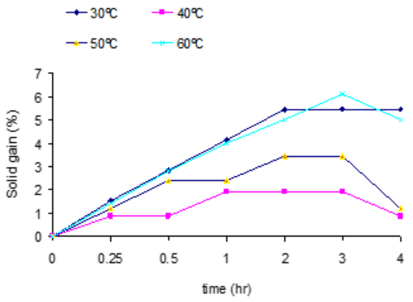
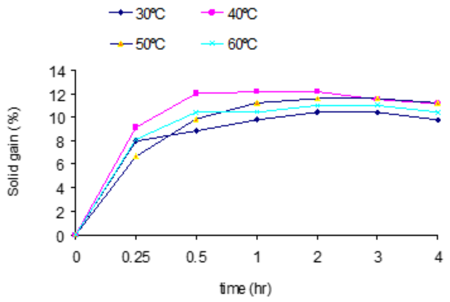
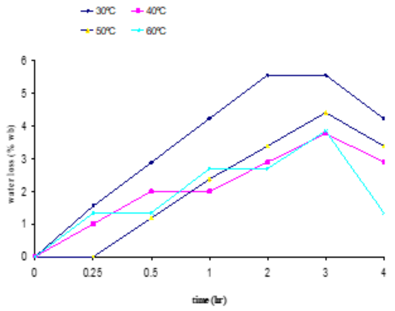
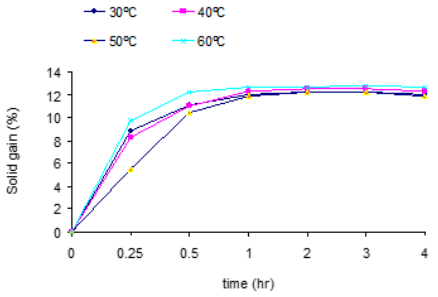
In the initial stages of the osmotic dehydration process (approximately 60-90 minutes), the loss of water and gain in solids occurred rapidly. This can be explained by the pronounced concentration gradient between slices of sweet potato and the supertonic sugar solution that causes water dispersal from the samples and the influx of solutes. When sugar concentrations were higher (50 % and 60 %) and higher temperature (50°C or 60°C) this initial phase was more evident as blanched samples showed greater mass transfer rates compared to the unblanched samples. The temperature played an important role in determining the speed and amount of mass loss during Osmotic dehydration. As temperatures increased from 40°C up to 60°C, both water loss and solid gain accelerated in all sugar concentrations. This is explained by two primary reasons: higher temperatures reduce the viscosity of sugar solution, increasing the mass transfer rate. The higher temperatures enhance the energy of the kinetic energy of solute and water molecules, making it easier for them to move through the cell membranes of slices of sweet potato (Pang *et al.,* 2021; Rastogi, 2023; Mari *et al.,* 2024).

Notably, the highest levels of loss of water and solid gain were seen at temperatures of 60°C, specifically when combined with 50% or 60% sugar solutions. However, exposure for a long time to extreme temperatures can cause undesirable consequences like over-shortening, collapse of the structure, or degrading of heat-sensitive nutrients. So, even though increased temperatures improve the efficiency of mass transfer, however, they should be monitored to avoid negative consequences on the quality of the product (Mari *et al.,* 2024; Aćimović, 2024).

The study revealed distinct variations in mass transfer behavior between unblanched and blanched samples. Blanching, a pre-treatment involving short exposure to steam or hot water, appears to improve the permeability of sweet potato's cell structure, permitting faster water removal and more solid gain when dehydration occurs via osmosis. This effect was especially evident when sugar concentrations were higher (50 % and 60 %) and at higher temperatures (50°C or 60°C). The unblanched samples had a lower rate of loss of water and solid gain, possibly because their cell walls were intact, which were more resistant to mass transport. While blanching increased the efficiency of dehydration, it could have caused some loss of soluble solids during the pre-treatment process, as was observed in earlier studies. This is a trade-off between dehydration speed and the retention of nutrients, which should be considered when selecting the pretreatment methods (Peng & Berry, 2018).

The interaction between sugar content and temperature and sample types (blanched instead of unblanched) showed complex dynamics. Combining 60% sugar solution and a temperature of 60°C produced the highest % ages of water loss and solid gain. However, this is not ideal for preserving sweet potato slices' nutritional and sensory qualities. The blanched samples benefited more at higher temperatures than non-blanched ones, highlighting the necessity of tailoring the processing conditions to the unique nature of raw materials. These findings indicate the necessity of a comprehensive approach to maximizing osmotic dehydration processes, considering both the effectiveness and quality of the product (Osae *et al.,* 2024).

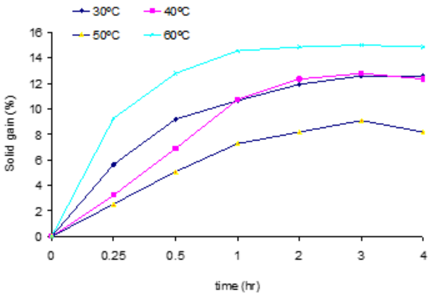
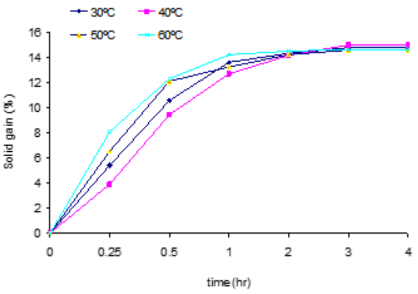
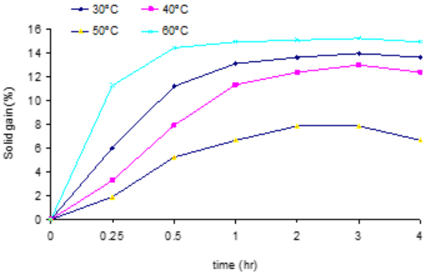
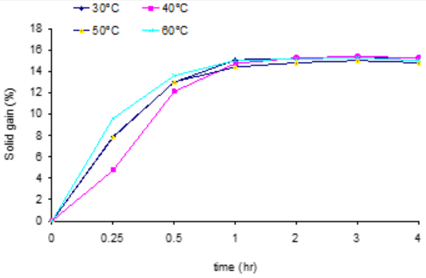
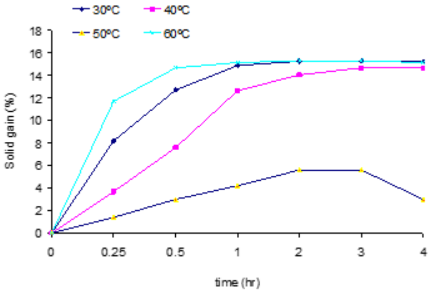
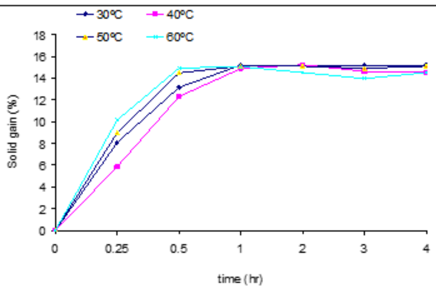
Table 5: Solid gain dynamics in 3mm thick sweet potato slices (var. local sada)

Sugar solution concentration	**Blanched**	**Unblanched**
40%		
50%		
60%		

Kinetics of Solid Gain in 3mm Sweet Potato Slices (var. Kamala Sundari) During Osmotic Dehydration

Dehydration characteristics of sweet potato slices from two varieties, Sada and Kamala Sundari, were studied under different sugar concentrations (40%, 50%, and 60%), temperatures, and pre-treatment methods (blanched and unblanched). Higher sugar concentrations and temperatures significantly increased both types' water loss and solids gain. There were slight variations between their rates and intensities of dehydration; Kamala Sundari showed significantly slower dehydration rates due to its cell structure and retention characteristics compared with Local Sada. Blanching increased dehydration efficiency for both types, yet Kamala Sundari had greater structural integrity, while Local Sada was more susceptible to swelling and collapse. Even though processing conditions were similar, Kamala Sundari displayed more precise dehydration methods that preserved texture and quality than local Sada. Kamala Sundari samples that had not been blanched showed slower yet more stable dehydration while maintaining taste quality, indicating the need to adjust osmotic dehydration parameters for specific varieties of sweet potatoes (Table 6). Utilizing optimal conditions based on a variety of characteristics can assist in reaching desired dehydration outcomes without unintended side effects such as excessive shrinkage or loss of nutrients, expanding sweet potato's food-related applications (Rastogi, 2023).

Table 6: Solid gain dynamics in 3mm thick sweet potato slices (var. kamala sundari)

Sugar solution concentration	**Blanched**	**Unblanched**
40%		
50%		
60%		

Kinetics of Solid Gain in 5mm Thick Sweet Potato Slices (var. Local Sada) During Osmotic Dehydration

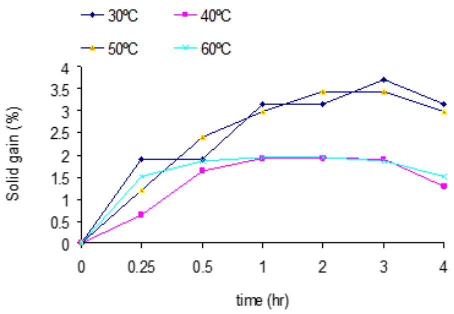
Results demonstrate that increasing sugar solution concentration significantly alters mass transfer behavior, particularly regarding water loss and solid gain. At 40% sugar concentration there was less water removed compared to 50% and 60% concentrations due to higher osmotic pressure gradients created by more concentrated solutions creating an effective gradient to draw moisture away from sweet potato slices more effectively (Table 7). Of all temperature conditions studied, 60% sugar solution demonstrated the greatest water loss. However, it should be noted that higher sugar concentrations also led to an increase in solid gain (sugar uptake) by sweet potato slices, expected as solute diffusion increases with sugar concentration. Although increasing solid gain may enhance the sweetness and preservation potential of the product, excessive solid accumulation may have adverse impacts on sensory qualities such as texture and flavor (Antonio *et al.,* 2008; Sarker *et al.,* 2023).

Temperature was an essential component in determining the rate and extent of mass transfer during osmotic dehydration, with both water loss and solid gain increasing exponentially between 40°C and 60°C for all sugar concentrations. Higher temperatures decrease viscosity of sugar solution and improve mass transfer rates, while increasing water and solute molecules' kinetic energies to assist them in passing across sweet potato slices' cell membranes more freely. At 60°C, the highest water loss and solid gain rates were observed, especially when combined with 50% and 60% sugar solutions. More prolonged exposure to higher temperatures can produce adverse side effects, including excessive shrinkage or structural collapse and degradation of heat-sensitive nutrients. While higher temperatures improve mass transfer efficiency, they must also be managed carefully to avoid adverse consequences on product quality (Wu *et al.,* 2020).

Experiments have revealed significant variations in mass transfer behavior between blanched and unblanched samples. Blanching, which involves short exposures to hot water or steam, appears to increase the cell structure permeability of sweet potatoes, leading to faster water removal and higher solid gain during osmotic dehydration. This effect was particularly visible at higher sugar concentrations (50% and 60%) and temperatures between 50°C and 60°C, where unblanched samples showed slower rates of water loss and solid gain due to their intact cell walls' more excellent resistance to mass transference. Blanching may increase dehydration efficiency yet can result in the loss of some soluble solids during pre-treatment, according to previous studies (Rashid *et al.,* 2020; Wu *et al.,* 2020; Kwaw *et al.,* 2023; Rastogi, 2023; Ahmad & Zaidi, 2023).

Interactions among sugar concentration, temperature, and sample type (blanched vs. unblanched) revealed intricate dynamics. At 60% sugar solution and 60°C, water loss was highest while solid gain was greatest; however, this combination may not be optimal in preserving sensory and nutritional attributes of sweet potato slices. Blanched samples showed greater benefit from higher temperatures than unblanched samples, emphasizing the significance of adapting processing conditions according to each material's specific properties. These interactions underscore the necessity of taking a holistic approach when optimizing osmotic dehydration processes, taking both efficiency and product quality into consideration (Lagnika *et al.,* 2021). For applications requiring rapid dehydration and increased sweetness, such as fruit

Table 7: Solid gain dynamics in 5mm thick sweet potato slices (var. kamala sundari)

<table>
<tr><th>Sugar solution concentration</th><th>Blanched</th><th>Unblanched</th></tr>
<tr><td>40%</td><td>


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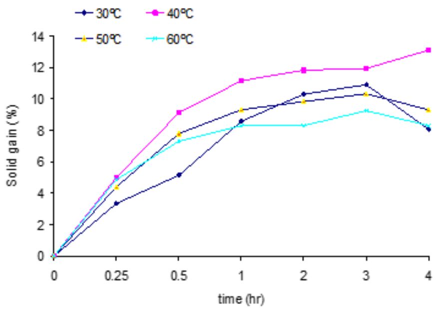
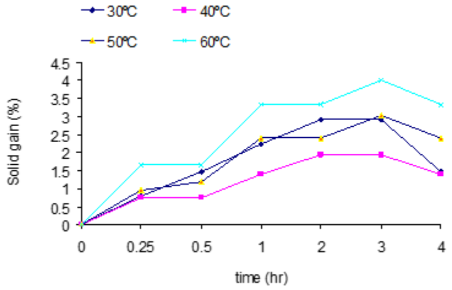


</td></tr>
<tr><td>50%</td><td>


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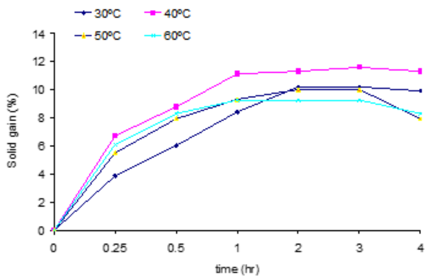
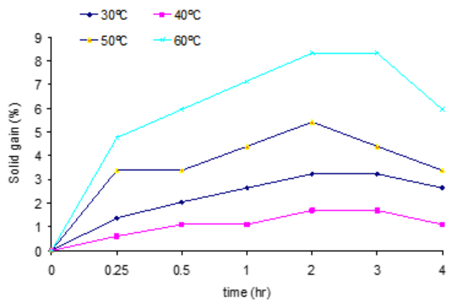


</td></tr>
<tr><td>60%</td><td>


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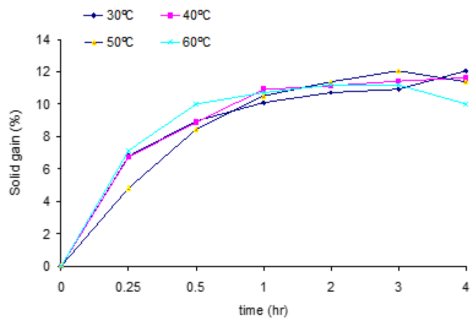

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</table>

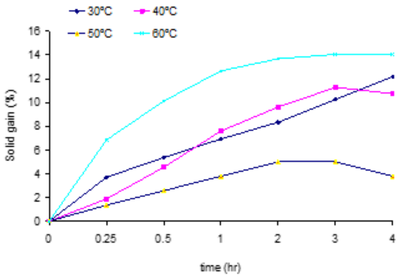
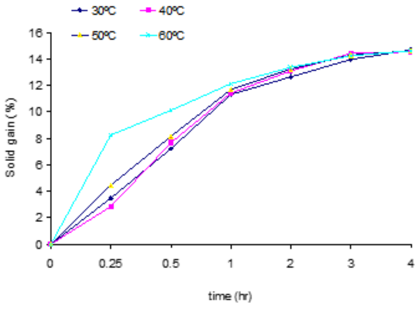
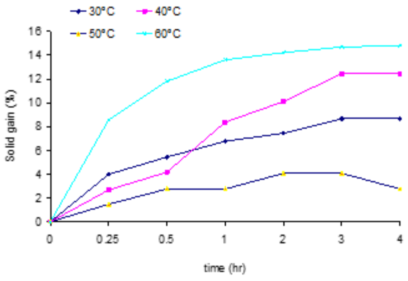
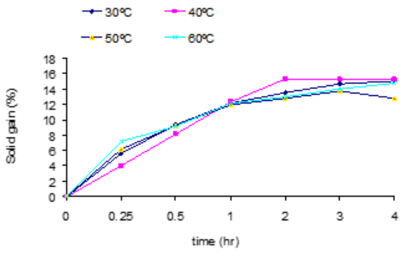
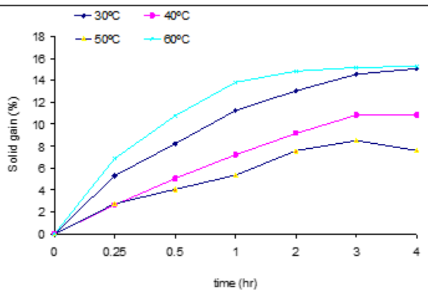
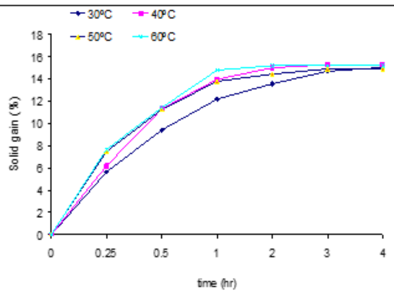
preservation or intermediate moisture food production, using a 60% sugar solution at 50°C-60°C with blanched samples would be most efficient. On the other hand, milder conditions (e.g., 40%-50% sugar solution at 40°C-50°C with unblanched samples) may be preferable.

Kinetics of Solid Gain in 5mm Thick Sweet Potato Slices (var. Kamala Sundari) During Osmotic Dehydration

Dehydration behavior of 5mm Sweet Potato slices from Local Sada was evaluated using different sugar solution concentrations (40%, 50% and 60%), temperatures and pre-treatment conditions (blanched vs unblanched). Higher sugar concentrations and elevated temperatures significantly accelerated water loss through osmotic dehydration; thicker 5mm slices showed slower dehydration rates due to longer diffusion paths for moisture removal (Table 8). Blanching improved dehydration efficiency by increasing cell permeability but led to greater softening and structural collapse than unblanched samples which retained better texture even at slower dehydration rates (Mari *et al.,* 2024).

Comparison between blanched and unblanched 5mm slices illustrates the trade-offs between dehydration speed and product quality. Blanching may speed mass transfer more rapidly, yet its use compromises the structural integrity of slices that are more easily prone to breakage. Unblanched slices showed a more gradual and controlled dehydration process, which better protected their physical properties than that of blanching did - as reported by Neri *et al.* (2011). These results highlight the significance of optimizing processing conditions based on slice thickness and pretreatment to strike an equilibrium between efficiency and quality, increasing sweet potato applications such as intermediate moisture foods or fruit preservation while maintaining their desirable sensory attributes (Rindang *et al.,* 2024).

Table 8: Solid gain dynamics in 5mm thick sweet potato slices (var. kamala sundari)

Sugar solution concentration	**Blanched**	**Unblanched**
40%		
50%		
60%		

Practical Implications and Industrial Relevance

This study's results have far-reaching ramifications for food processing industries worldwide. By studying the effects of sugar concentration, temperature, slice thickness, and pre-treatment on osmotic dehydration kinetics, our findings provide a solid framework for process optimization in industrial settings. Specifically, designed dehydration systems could maximize efficiency while protecting quality sweet potato products.

Examples of optimal conditions identified (using a 60%

sugar solution at 50-60°C for blanched 3 mm slices, for instance) can be scaled up using continuous processing systems equipped with temperature-controlled baths and high-efficiency peristaltic pumps; such systems will ensure consistent product quality, reduce energy consumption, and reduce postharvest losses while simultaneously minimizing postharvest losses. Additionally, this method could serve as a model for dehydrating other moisture crops while broadening industrial applications. Future efforts should focus on conducting small-scale experiments and economic feasibility analyses to test the scalability of optimized conditions; additionally, integrating modern control systems for process management can further increase efficiency while maintaining quality throughout commercial operations.

CONCLUSIONS

The study provides a thorough understanding of the osmotic degradation behavior of slices of sweet potato focused on two kinds (local Sada as well as Kamala Sundari) and various parameters like sugar concentration in the solution (40, 50 60, 80%) as well as temperatures and slices' thickness (3 mm or 5 mm) and the pre-treatment conditions (blanched as opposed to. non-blanched). The results highlight the crucial importance of these variables in determining the effectiveness of dehydration and solid gain as well as the quality of the product. The higher sugar levels and the elevated temperatures generally increased water loss and solid gain in all tests. However, differences between the different species were apparent in Kamala Sundari, which showed slower but controlled dehydration than Local Sada, which demonstrated higher removal of moisture but higher vulnerability to the collapse of the structure. Slice thickness had a significant impact as thin slices (3 mm) dehydrated faster than those with thicker slices (5mm); however, the latter exhibited better structural integrity throughout processing. Blanching has been found to accelerate dehydration through increasing cell permeability, but it also weakened texture, particularly in smaller slices and the Local Sada type. Although less prone to drying, the samples that were not blanched maintained more physical characteristics, making them suitable for use in applications where texture is essential. These findings highlight the importance of adjusting the dehydration parameters, including the sugar content, temperatures, and pre-treatment, to the unique features of sweet potato varieties and the desired characteristics of the product.

The study provides valuable insights for the food processing industry by optimizing osmotic dehydration conditions for specific sweet potato varieties, reducing post-harvest losses, and enhancing product quality. These findings also apply to other high-moisture crops, broadening food preservation strategies. Future research should explore alternative osmotic agents, integrate advanced drying techniques, and assess the economic feasibility of industrial-scale implementation. This study advances food dehydration science, offering practical guidance for both research and industry applications.

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