Osmotic Dehydration with Low-Calorie Sweeteners: Fruit Preservation for Generation Z

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Abstract

Osmotic dehydration, a method for preserving fruits, relies on osmosis to extract excess moisture while preserving nutritional and sensory qualities. This study explores the use of low-calorie sweeteners as osmotic agents in fruit dehydration, addressing implications for both food processing and health-conscious consumers. Key factors influencing osmotic dehydration success include osmotic solution composition, concentration, and process conditions. The choice of osmotic agent, such as sucrose, erythritol, xylitol, or sorbitol, impacts water loss and solid gain during the process. The consumers today opt for low calorie or no-sugar added preserved foods. In this context, rise in research and industry interest in low calorie osmo-dehydrated fruits segment is increasing. Temperature and osmotic duration significantly affect dehydration kinetics, with higher temperatures accelerating water loss. Various techniques, including osmo-canning and high-pressure pre-treatment are used to optimize osmotic dehydration. However, differing morphological and anatomical characteristics of each fruit required modification for the pre-treatments and processes involved. Challenges arise in selecting appropriate osmotic agents and conditions for specific fruits. Despite these challenges, osmotic dehydration remains a valuable tool for preserving fruits, offering high-quality, nutritious, and flavourful products, along with health-conscious benefits from low-calorie sweeteners. Understanding key variables is crucial for successful fruit preservation using osmotic dehydration.

Introduction

Osmotic dehydration has gained significant popularity in recent times as an emerging technology. Osmotic agents hold a crucial role in the drying kinetics of fruits. By employing a semipermeable membrane, it becomes possible to extract moisture from a region with lower solute concentration and transfer it to an area with a higher concentration, achieving equilibrium on both sides. This process is commonly referred to as osmotic dehydration (Tiwari 2005). The calorific values of foods are indicative of the energy that the human body can derive during its metabolism and are typically expressed as kJ / 100 g of food or 100 ml of beverage. Food calorific values are usually denoted in kcal. In recent years, the osmotic dehydration process has emerged as a key pre-treatment technique for dehydrating fruits. Notably, one of the lesser-known benefits of osmotic dehydration is its utilization of low-calorie sweeteners as osmotic agents, ultimately promoting health benefits. This study briefly explores the use of low-calorie sweeteners in the dehydration of fruits, shedding light on the positive implications this approach has for both food processing and health-conscious consumers.

Snacks for Generation Z

Osmodehydrated is embarking on a venture dedicated to crafting nutritious snacks specifically tailored for Generation Z. This innovative food preservation technique has garnered popularity within the snack industry for its ability to create healthy, convenient, and flavorful snacks by preserving the nutritional value of fruits, vegetables, and other food items. In today's health-conscious climate, where traditional single-form nutrition like fresh fruits or salads is no longer favored, Osmodehydrated aims to address this shift by introducing a diverse range of snacks that promote the consumption of wholesome foods among the younger generation. The demand for these osmodehydrated snacks is fuelled by the growing awareness of health and wellness, especially among millennials and Generation Z. These snacks are designed to provide high nutritional value in a compact and convenient format, meeting the specific preferences and requirements of this generation. Unlike conventional snacks, which often contain preservatives and artificial additives, osmodehydrated snacks offer a healthier alternative, preserving the natural nutrients of the ingredients. In today's fast-paced world, especially for Generation Z, there is a strong need for on-the-go snack options that are both healthy and easy to consume. Osmodehydrated snacks address this need by being lightweight, portable, and having a prolonged shelf life, catering to the busy lifestyles of consumers who seek nutritious choices without compromising on taste or quality.

The market for these healthy osmodehydrated snacks is experiencing robust growth, driven by the increasing health consciousness among consumers. Convenience also plays a pivotal role, as consumers are drawn to snacks that offer both nutrition and ease of consumption. Additionally, the market benefits from the rising preference for natural and organic products. Consumers are increasingly leaning towards snacks made from natural ingredients, devoid of artificial flavors and chemicals. Osmodehydrated snacks align perfectly with this trend, preserving the natural goodness of fruits and vegetables without the need for synthetic additives, making them a preferred choice for health-conscious individuals. Furthermore, the accessibility of osmodehydrated snacks through online platforms enhances the market's growth, providing consumers with the convenience of browsing and purchasing these snacks from the comfort of their homes. This convenience factor further propels the market for healthy osmodehydrated snacks, making them an attractive option for consumers seeking nutritious and delicious snack choices.

Fig. 1 Various Osmodehydrated Fruits

Osmotic dehydration Principle and Process

Osmotic dehydration, a cost-effective technique, is crucial for preserving the nutritional richness, flavour, and colour of food products by extracting excess water. The process gains efficacy when materials are pre-treated with an osmotic solution containing lower solute concentrations, enhancing rehydration characteristics. The primary goal of osmotic dehydration is to elevate the nutritive, sensory, and functional attributes of food items by lowering water activity (a_w), effectively hindering microbial growth within the food matrix. As a result, osmotic dehydration is widely utilized as a preliminary step in drying processes, reducing harshness and enabling more efficient drying. In a distinctive approach, fruits undergo partial water removal through immersion in a hypertonic solution, increasing their soluble solid content. This "dewatering impregnation soaking process" (DISP) is influenced by critical factors such as solute concentration, temperature, and contact time.

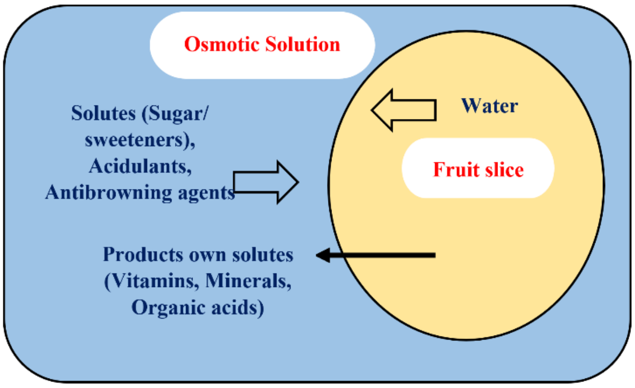
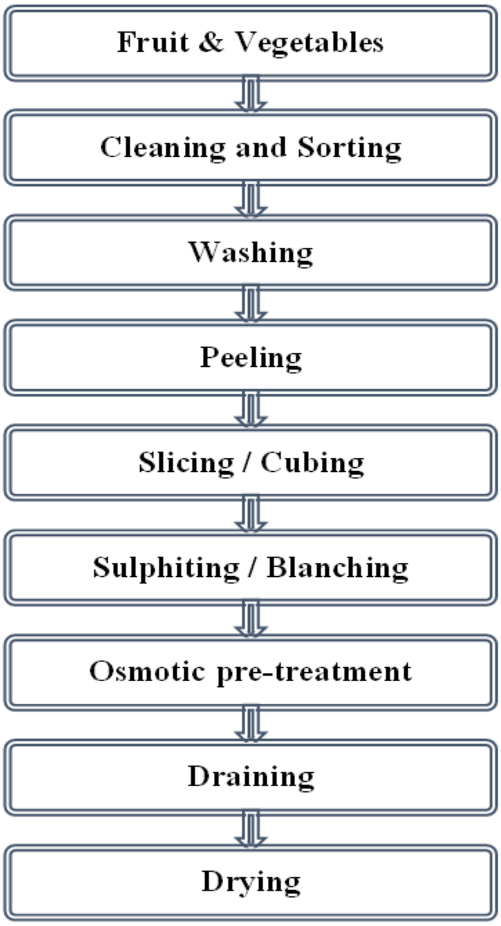


Fig. 2 Osmodehydration Process

During osmotic dehydration, two simultaneous counter-current flows take place: water migrates from the sample's interior into the osmotic solution, while osmotic agents diffuse in the opposite direction, moving from the solution into the product. An often-overlooked third flow involves substances like vitamins, organic acids, saccharides, and mineral salts, moving from the food into the osmotic solution. Although this flow doesn't significantly impact mass exchange, it profoundly influences the final nutritional values and sensory attributes of the food. Several parameters influence osmotic dehydration, including the osmotic agent, solute concentration, agitation, temperature, immersion time, ratio of sample to solution, as well as the shape, size, and tissue compactness of the material (Bashir *et al.*, 2020).

Fig. 3 Flowchart for Osmotic dehydration



Bellary & Rastogi (2012) underscore the primary advantage of osmotic dehydration: reducing the wat er activity of food materials to inhibit microbial growth. Given that many food materials have substantial water content, this method proves cost-effective for storage and transportation. Osmotic dehydration stands out as an energy-efficient partial dehydration process, as it doesn't require a phase change. Moreover, it enables possibilities such as food formulation by reducing water activity and fortification with compounds that modify structural, functional, and nutritional properties. Notably, this method is effective at room temperature, minimizing heat damage to colour, texture, flavour, volatile components, and oxidative changes (Hasanuzzaman *et al.*, 2014).

Osmotic agents

The choice of osmotic agents wields a considerable influence over the diffusion rate during osmotic dehydration processes. Notably, an array of popular osmotic agents exists, including salt, sugar, jaggery, honey, sucrose, glucose, fructose, sorbitol, glycerol, glucose syrup, corn syrup, maple syrup, starch, fructo-oligosaccharides, maltodextrin, and ethanol. These agents must possess specific attributes to be effective, such as being convenient, non-toxic, possessing a pleasant taste, and having the ability to readily dissolve into high-concentration solutions.

Safety and Regulatory Approvals

Polyols emerge as a superior alternative to other sweeteners due to their advantageous properties. These compounds provide fewer calories per gram and do not cause a significant increase in blood glucose response, making them a favourable option for health-conscious consumers. The appeal of polyols extends to their low-insulinemic, low-digestible, and osmotic qualities, making them a versatile choice in various food products. Additionally, polyols are non-cariogenic, meaning they do not contribute to tooth decay, enhancing their suitability for dental health. Recognizing their benefits, the Food and Drug Administration (FDA) has approved the use of eight different polyols, including erythritol, hydrogenated starch hydrolysates, isomalt, lactitol, maltitol, mannitol, sorbitol, and xylitol (Rice *et al.*, 2020). This approval underscores the safety and efficacy of polyols, solidifying their position as a preferred sweetener option in the food industry (Magda *et al.*, 2022). The safety of polyols like erythritol and xylitol has been extensively studied and approved by regulatory bodies such as the Joint Expert Commission on Food Additives (JECFA) and the U.S. Food and Drug Administration (FDA). These agencies have classified these compounds as safe for consumption, ensuring their widespread use in the food industry (Mazi *et al.*, 2003).

The Impact of Osmotic Agents on Osmodehydrated Fruits

Osmotic Solution Concentration: The concentration of the osmotic solution is a critical variable affecting mass transfer kinetics during osmotic dehydration. In many cases, a syrup intensity of 60 to 70°B has been found to be optimal. Higher concentrations generally result in faster osmosis rates. However, it's noted that for extended osmotic treatments beyond 50% weight loss, the benefits of using higher concentrations may diminish. Studies on apricot and apple osmotic dehydration have shown that higher sucrose concentrations lead to greater water loss and solid gain during the process.

Osmotic Length and Temperature: Increasing the osmotic length leads to increased weight loss during osmotic dehydration of fruits like mango and pineapple, but the rate of weight loss tends to decrease. Additionally, temperature plays a crucial role in osmotic dehydration. Higher temperatures lead to increased water loss, while solid gain is less affected. However, temperatures above 50°C can result in enzymatic browning and flavour degradation.

Osmotic Dehydration Techniques: Various techniques have been employed for osmotic dehydration. For instance, osmo-canning of apple rings involves soaking them in a 70% sugar solution before canning, resulting in improved texture and consistency. Papaya slices have been osmotically dehydrated using a soak solution containing sucrose, citric acid, and potassium sorbate. Similarly, Cavendish banana slices were soaked in sugar solutions, resulting in reduced moisture content and increased TSS.

High-Pressure Treatment: High-pressure treatment before osmotic dehydration has been explored as well. Studies have shown that high-pressure pre-treatment can enhance the mass transfer rate during osmotic dehydration.

Effect of Different Osmotic Agents: Various osmotic agents have been employed, including sorbitol, erythritol, xylitol, isomaltulose, tagatose, oligofructose, and stevia. The choice of osmotic agent can impact water loss and solid gain during osmotic dehydration. For example, erythritol and xylitol have been found to be more effective than sucrose in some cases due to their lower molecular weights (Rizzolo *et al.*, 2007). Isomaltulose resulted in the highest mass loss in osmodehydrated lemon slices compared to tagatose (Brochier *et al.*, 2015). Glycerol, sorbitol, and polydextrose showed significant water loss at the beginning of the process, which decreased over time (Assis *et al.*, 2016).

Impact of Solute Molecular Weight: The molecular weight of the osmotic agent can also affect the rate of water loss and solids gain. For instance, glucose solutions tend to yield higher water loss and solid gain compared to sucrose solutions, attributed to differences in molecular weight.

Challenges in Osmotic Dehydration: Despite the benefits of osmotic dehydration, some fruits exhibit a low aptitude for this process due to their morphology and anatomy. Additionally, processing conditions and the choice of osmotic agents can impact the success of osmotic dehydration.

Conclusion

Osmotic dehydration is recognized as a clean and efficient pre-treatment method for fruit products. It offers a means to enhance the quality of value-added products while minimizing time requirements and maximizing resource utilization. This technique is versatile and holds great potential for fruit preservation. However, its success hinges on several critical factors, including the concentration of the osmotic solution, operating temperature, the choice of osmotic agents, and specific processing techniques. To achieve optimal results in osmotic dehydration, a comprehensive understanding of these variables is essential, particularly when dealing with various types of fruits. This knowledge allows for the fine-tuning of osmotic dehydration processes to meet specific product requirements and quality standards, making it a valuable tool in the realm of fruit preservation and value addition.

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Table: 1 Different type of osmotic agents

Sweetener	Type	Caloric Value (kcal/g)	Sweetness Compared to Sucrose	Applications
Sucrose	Disaccharide	4.0	100%	Osmotic dehydration, murabbas, candies, cakes, pastries, jams, stabilizer, preservative, thickener
Erythritol	Polyol	0.2	70-80%	Candies, chocolates
Xylitol	Polyol	2.4	100%	Chewing gums, various food products
Sorbitol	Polyol	2.4-2.6 (EU:2.4)	50%	Low-calorie sweeteners, humectants, texturizers, softeners
Mannitol	Polyol	~2.0	50%	Various applications
Isomaltulose	Reducing Disaccharide	~4.0	42%	Substitute for sucrose in most sweet foods
Oligofructose	Soluble DietaryFiber	~1.5	Not applicable	Prebiotic properties, dietary fiber
Stevia	Plant-Derived	0	1500%	Various food and medicinal uses; 15 times sweetener than sucrose
Tagatose	Fructose Isomer	~2.4	92%	Confectionery products, chocolate, candies, fudges, caramels, ice cream, soft drinks, cereals

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