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Effect of drying on the microbial growth, nutritional value & antioxidant activities of various food: A Review

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Abstract
The importance of antioxidants and nutritional value in human nutrition has grown in popularity, notably as a result of the health benefits they have been linked to for a number of chronic diseases, such as cardiovascular disease and several forms of cancer. Fruits and vegetables must be kept fresh at all times because they are fragile. The different types of drying and their impact on the nutritional value, microbial growth, and antioxidant activities of diverse foods are discussed in this review article. It depends on the moisture level reached after drying how much the microbial activity in food is reduced. As a result of the drying process, the foods' water activity and moisture content are decreased, which substantially inhibits or delays the growth of germs. Low-aw foods shouldn't be thought of as being sterile though because they can become infected with fungi and other things while being dried in unsanitary settings. When dried foods are processed, the minimal value for the development of microorganisms can occasionally be attained if drying is not done to a sufficient degree of moisture during food processing and storage. While being stored, transported, and sold, various bacteria, yeast, and mould can continue to thrive in dry foods and cause deterioration. The food industry's most often used dehydration technique is air-drying. The water content of the food goods is dramatically reduced to an appropriate level by blowing hot air over their surface, maintaining microbiological safety.

Keywords: drying, microorganisms, food, dried fruits, vegetables, processing, bacterial & water activity

Introduction

The consumption of fruits and vegetables is rising in popularity as one of the most significant sources of necessary nutrients, such as various types of vitamins and fibre [1]. Phytochemicals found in fruits and vegetables have been found to have an impact on human health. Specifically, fruits and vegetables' health-protective effects are due to phytochemicals with antioxidant properties. In fact, antioxidants may reduce oxidative stress in illness [2]. By removing the moisture that germs, yeasts, and moulds require to survive, drying food maintains its nutrition and protects it. Despite the fact that some nutrients, such as vitamin C, are destroyed during drying, taking the water out of food concentrates the remaining nutrients, packing more calories, dietary fibre, and/or air-resistant vitamins and minerals into a tiny size. The primary goals of drying are to increase food shelf life and preserve food by reducing water activity and content, avoid the need for expensive refrigeration systems for storage and transport, reduce the amount of space needed for storage and transport, and increase the variety of foods available to consumers by providing a wide range of flavours and textures [3], [4]. Drying entails removing the water vapour from the meal's surface as well as using heat to evaporate the water that is already present in the food. As a result, it combines the mass and heat transfer processes, which require energy. To use hot air flowing over the food is the most common way of transferring heat to a drying material, being this process mainly by convection [5]

One of the earliest foods to be industrially dried dates to the seventeenth century and is dried fruits and vegetables. The drying business has improved with the emergence of warfare over time. The late 1800s and early 1900s saw a large increase in fruit drying in the USA, and natural drying systems were supplanted with artificial drying systems. Before World War II, milk and eggs were the items that were dried using roller and spray dryers the most. The recognition and acceptance of drying have been greatly aided by military application. In earlier times, just the sun was used for natural drying. However, it is no longer favoured due to sanitary reasons including the need for insecticide, pollination, wide areas, and long times, as well as the fact that sunlight is only useful during specific times of the year. Nowadays, thanks to technological advancements, drying procedures can be carried out using a variety of techniques [6].

Drying Methods

Sun drying, conventional dryers (tray, tunnel, drum), spray dryers, fluidized bed dryers, freeze, vacuum, or microwave drying are the drying techniques most frequently employed in the food business [7]. Other novel technologies used for high-quality dried food products include microwave-vacuum, microwave-freeze, puffing, instant controlled pressure drop (DIC), superheated steam (SSD), infrared radiation (IR), radiofrequency, electrohydrodynamic (EHD), ultrasonic, and supercritical CO2 drying [8, 9]. The drying process aids in preventing an enzymatic or non-enzymatic browning reaction as well as the growth of these bacteria that may contaminate food or be present naturally in fruits and vegetables and cause food deterioration [10]. Fruits and vegetables can be dried to reduce packaging requirements and shipping weight while also extending shelf life by reducing the viability of microorganisms [11].

- Air Drying: The food industry's most widely used dehydration technique is air drying. The water content of the food goods is dramatically reduced to an appropriate level by blowing hot air over their surface, maintaining microbiological safety.

- Freeze Drying: Another dehydration technique that food manufacturers typically use to prepare high-moisture food goods is freeze-drying. The best method for drying processes, it is typically regarded as. The food products are kept frozen throughout the process when a vacuum is applied beneath a freezing temperature, and the water content is continuously reduced through sublimation.

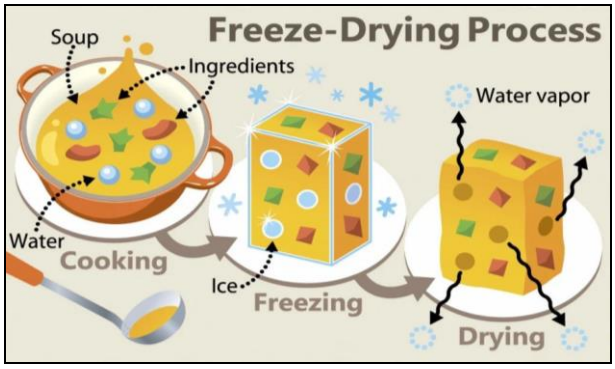

Fig 1: Process of Freeze Drying
https://www.scienceabc.com/wp-content/uploads/2015/09/freeze-drying-process.jpg

- Radiant Energy Vacuum (REV) dehydration: One type of cutting-edge, low-temperature drying technique is Radiant Energy Vacuum (REV) dehydration. The moisture in the food products absorbs the microwave radiation when the REV is used on them, creating a significant internal vapour pressure differential between the inside and exterior of the object. The vapour inside the food is continuously moved to the surface when it is vacuumed, where it is anticipated that the pressure will be significantly lower than inside the food products.
- High hydrostatic pressure (HHP) application: This non-heat technology is used to treat a variety of foods, including jams, juices, guacamole, sauces, oysters, and packaged cured ham, in order to decrease the amount of microorganisms and lengthen shelf life.
- Ultraviolet (UV) irradiation: Aspergillus niger and Bacillus subtilis are two moulds that can be used to decontaminate dried fig fruits and break down aflatoxin using ultraviolet (UV) irradiation and infrared (IR) heat, respectively [13-14]. These moulds have great heat resistance. The killing efficacy of bacteria was significantly increased when IR heating and UV light were combined [15]. The use of irradiation technology is a reliable way to sterilise food while maintaining its nutritional value and extending shelf life [16].
- Food decontamination using cold plasma treatment (CPT) is a promising nonthermal processing alternative [17]. Cold plasma is produced by applying an electrically charged or electromagnetic radiation to specific gases (O2, He, Ar, H2, etc.) in a vacuum at room temperature. Additionally, radiofrequency, microwave, UV, and X-ray can be used to produce cold plasma [18, 19]. Pulsed electric field (PEF) treatment is the application of an electric field to fluid foods positioned between two electrodes in a batch or continuous flow system. It is used to preserve food without significantly altering flavour, colour, or nutritional content while inactivating bacteria, lowering enzyme activity, and prolonging life span [20-21].

Impact of Drying on Microbial Growth, Nutritional Value & Antioxidant Activities

Food drying is a traditional method for keeping food fresh after its natural shelf life has passed. The method began with meals being exposed to the sun in order to remove a significant amount of water from them and help with their conservation. Nowadays, more advanced technologies are used instead of the traditional solar dying method, which had a number of drawbacks. These technologies include hot air drying, spray drying, lyophilization, infrared, microwave, or radiofrequency drying, as well as osmotic dehydration or various mixed procedures. However, compared to their fresh counterparts, dried versions of many foods considerably lose their organoleptic and nutritional properties. Dry heat is less effective than wet heat in inactivating microorganisms because microbial cell viability is more persistent in a dry state [53, 54]. In actuality, the structure of the microbe undergoes a number of modifications during the drying process. For instance, the absence of water causes protein denaturation and damage to cell walls [55, 56].

While some dietary acids, such as acetic or ascorbic acid, may decrease the thermal stability of bacteria, they can enhance their capacity to survive under dehydration [57, 58]. In order to dry different strains like starter/pure cultures, such components as sugars, polypeptides, polyalcohols, and amino acids are used [59, 60]. Some foods containing these ingredients may also be referred to as low-acid foods. Acid-rich fruits have a pH that is low, which when paired with different techniques quickens the microorganism's demise. As a result, the structure of the meal may have an impact on how well bacteria survive after drying [58]. Food microbe development is mainly stopped or postponed by drying. The relative humidity in the storage space is crucial since dry goods are hygroscopic and their moisture content varies.

Vitamins can vary in their solubility in water. Some vitamins, like riboflavin, approach oversaturation as the drying process progresses and precipitate, resulting in lesser losses. Others, such as vitamin C, are kept dissolved up until the food's moisture content is extremely low before they begin to interact with the solutes more quickly as the process moves on. In addition to thiamine, which is extremely sensitive to heat, vitamin C is particularly affected by heat and oxidation. The liposoluble vitamins are more resistant to heat and oxidation (with losses of under 10%), but they could interact with the peroxides produced by lipid oxidation. [29] As a result of the liposoluble nutrients, such as essential fatty acids and vitamins A, D, E, and K, being mostly present in the dry matter of the food, there are losses during processing. The dietary minerals (copper and iron) are dissolved in the aqueous phase of the food and function as catalysts in oxidation processes of unsaturated lipids. As a result, when drying, water is removed and their reactivity decreases, improving the nutritional value preservation. The American Dietetic Association states that freeze dried fruits and vegetables have an equal quantity of antioxidants as their fresh counterparts. The phytochemicals and antioxidants in freeze-dried foods have been investigated for their potential role in the prevention and treatment of oesophageal and colon cancers by scientists at the American Institute of Cancer Research.

Proteins in most foods retain their biological value and are still digestible even after drying. Denaturation, however, can

happen in particular foods and in some operational environments [30]. In general, the retention of ascorbic acid is used to gauge the overall nutritional quality of processed foods. Because it is very water soluble, heat sensitive, and oxidation condition sensitive, this nutrient is very prone to deterioration (oxygen, pH, and metal ions). The USDA estimates that fresh broccoli will have 0.892 mg of ascorbic acid per gramme of fresh samples at an 89% moisture content, which is equivalent to 7.60 mg of ascorbic acid per gramme of dried samples at a 6% moisture content [22]. Thus, the total vitamin C content of fresh broccoli was reduced by about 50.2% as a result of the pre-treatment step of steam blanching [31]. The USDA estimates that fresh navel orange samples will have an ascorbic acid level of about 0.592 mg per gramme at an 81% moisture content, which is equal to 2.9 mg per gramme at a 6% moisture content in the dried sample [24]. This study's fresh and dried orange values are all higher than the suggested value, which could be attributed to the wide variety of orange genotypes, different harvesting locations, different levels of sunlight, and individual variances among the oranges [25].

Conclusion

Consumers often believe that dry foods are free of contamination and safe from microorganisms. Foodborne outbreaks may result from the infection of these items with foodborne bacteria, though. Aw is regulated both during drying and afterward to a level where microbes cannot thrive. The main sources of health hazards, however, include a variety of factors such inadequate dehumidification throughout the process, improper storage following the treatment, improper packing choice, and a high initial microbe load. A quick and sophisticated process of dehydrating fruits and vegetables like broccoli, oranges, and carrots is called REV-drying. When compared to the standard air-drying method, it can greatly cut processing time and better preserve nutritional benefits like vitamin C and -carotene. For the sake of human health, it is crucial to use caution when handling dried foods and take into account aspects like the production process and food quality during harvest. To ensure the safety of dried foods, it is important to take into account themes like human hygiene and contamination prevention in addition to the efficient application of procedures like HACCP and good manufacturing practises.

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