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ANALYSIS AND PERSPECTIVES OF FRUIT AND VEGETABLE DRYING PROCESS METHODS

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Abstract: Drying fruits and vegetables are a method that has been employed for centuries to preserve the nutritional content of produce, extend shelf life, and reduce waste. This process involves removing the moisture content from fruits and vegetables to prevent spoilage and enable long-term storage. Various drying methods exist, each offering unique advantages and considerations in terms of efficiency, final product quality, and energy consumption.

Key words: Long-term storage, drying methods, a cost-effective method, technology advances, color, nutritional content.

Introduction. One of the traditional methods of drying fruits and vegetables is sun drying. This approach involves spreading the produce out in the sun to naturally dehydrate them. While sun drying is a cost-effective method and can enhance the flavor of certain fruits, it is highly dependent on weather conditions and can be time-consuming. Factors such as temperature, humidity, and sanitation also play crucial roles in the success of sun drying. Whichever drying method you choose-sun drying, solar drying, oven drying or dehydrator drying-be sure to place the fruit in a single layer on the drying trays. The pieces should not touch or overlap. Follow the directions for the drying method you choose and dry until the food tests dry. Heat flows from the medium (hot air) to the food surface, which re- sults in moisture being driven out from inside the food material to the surface and finally evaporating to the medium. Heat must be transferred to equal the heat of vaporization. Dried fruit is made of fresh fruits and processed by peeling, coring, sugar water boiling, soaking, drying and packing. Dried fruits have under 20% water content, with dry surface and slight stickiness. Fruits and vegetables are processed by various methods like low temperature, thermal treatment, concentration, freezing and irradiation. But prior to subjecting fruits and vegetables to such treatments, all fruits and vegetables undergo some preliminary operations. Aside from some volatile nutrients, properly dehydrated vegetables and fruits can retain their nutritional content, cost less to ship and are shelf-stable almost indefinitely. Temperature matters in the dehydration process and foods dried at lower temperatures tend to retain more of their nutritional content. Low humidity, low heat and good air circulation are critical for successful drying. You can use a dehydrator, oven, microwave or even air-dry some foods. Start with good quality foods. During these years of working on food dehydration and drying, one simple fact has become increasingly obvious.

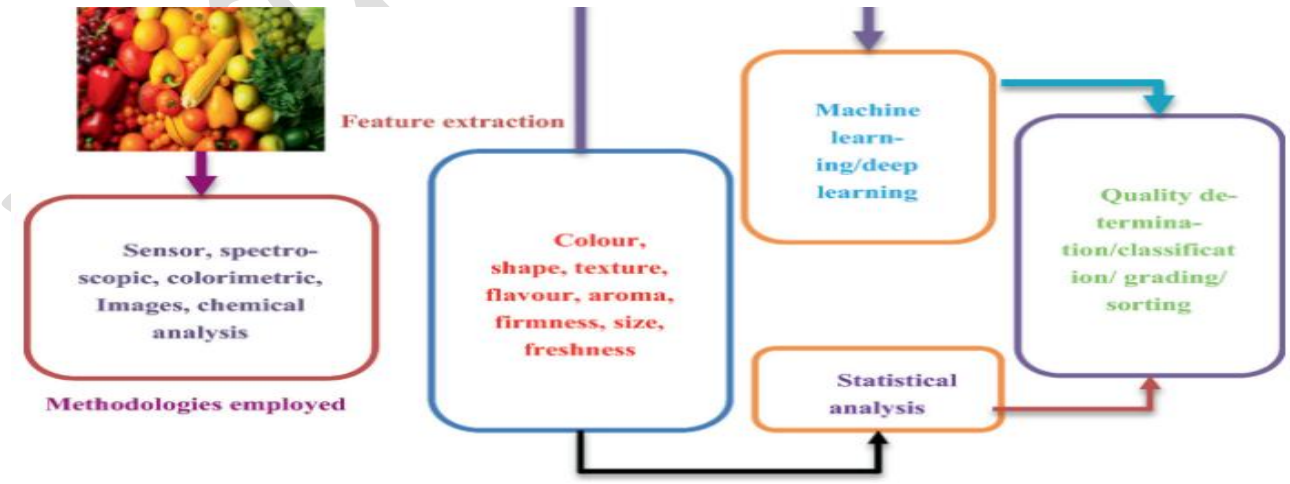

Figure 1. Review on quality determination for fruits and vegetables

It seems that drying is viewed as something that can be easily done with little or no training; and often without a basic understanding of the concepts involved. Frequently, difficulties are encountered in the drying process due to incorrect methods being used. Poor quality product may be obtained that can pose potential risks to the consumer, or which can cause spoilage during storage. The purpose of this work is to provide those interested in drying fruits and vegetables with an introduction to what is really a very diverse topic. It is my preference to write in an informal narrative style using examples based on personal experiences, without the inclusion of academic citations. Mathematics has a key role in understanding food drying. It is the basis for expressing a variety of aspects associated with drying from the rate at which moisture is removed from a product, to assessing the performance of a dryer. Every effort has been taken to provide detailed examples of the calculations that may be encountered. It should be noted that most of these are not especially complicated, but they may be somewhat intimidating to those with a fundamental fear of mathematics [1]. There are various strategies to reduce postharvest losses for economic benefit. Low-cost options are better suited in an African environment where resources are limited. At the farm level, adequate harvesting time, simple pre-treatment, cold chain, and appropriate packaging are well known to extend the shelf life of fresh fruits, vegetables, and root crops. Additional extension of shelf life requires processing; for example, dehydration or canning. Fruits, vegetables, and root crops that can be rehydrated or milled into flour are attractive alternatives for long-term storage. The flour can also be used as porridge or as raw materials in further processing, for example, extrusion to produce ready-to-eat snacks. Drying is one of the oldest food preservation techniques. It removes the water from food products, thus drastically reducing water activity, and generally can produce food materials close to or below the glass transition temperature.

Another popular drying method is dehydration using conventional air-drying techniques, such as using electric dehydrators or oven drying [2]. Electric dehydrators provide a more controlled environment for drying fruits and vegetables compared to sun drying, allowing for precise temperature and airflow regulation. Oven drying, on the other hand, offers a quick and efficient way to remove moisture but may require careful monitoring to avoid overheating the produce. Freeze drying is a modern technique that involves freezing the fruits and vegetables and then subjecting them to a vacuum environment to remove the ice through sublimation. This method preserves the shape, color, and nutritional content of the produce exceptionally well, resulting in high-quality dried products. However, freeze drying is a more expensive and energy-intensive process compared to traditional drying methods. Microwave drying is another innovative approach that uses microwave radiation to remove moisture from fruits and vegetables rapidly. This method can significantly reduce drying times and preserve the nutritional qualities of the produce due to the short exposure to heat [3]. However, microwave drying may lead to uneven drying and affect the texture of the final product if not carefully monitored. Infrared drying is a method that utilizes infrared radiations to dehydrate fruits and vegetables efficiently. This technique offers uniform drying and shorter processing times compared to conventional drying methods. Infrared drying also helps in maintaining the color, flavor, and nutritional value of the produce. The technology should also apply to small and medium enterprises. Moreover, adaptable technologies at the household/subsistence farm level are also of importance. The choice of technology is also determined by the end use of the product, desired characteristics, and available infrastructure to preserve the product. Solar drying is a preferable technology used for the shelf-life extension of fresh produce when the use of energy-consuming technologies is not feasible or accessible. However, the nutritional and food quality after solar drying is less than for other drying technologies. This is related to drying time and temperature were heat sensitive and enzymatic/oxidative degradation of vitamins and other nutrients can occur. The mechanisms of dehydration in terms of moisture loss resulted in lower quality products especially those related to rehydration [4]. Thus, research on solar dehydration should target the pretreatment of raw materials to avoid lower-quality products. Although, solar drying is a cost-effective technology; dependence on weather is a major limiting factor in the use of this technology. Thus, the use of solar panels and concentrators that can store energy for use during the night is an important consideration. There is limited literature on novel drying technologies, especially RF. Moreover, data on

the drying of indigenous crops for example amaranth, cassava, and plantain banana are limited. Most research and application of the novel technologies have used sliced fruits, vegetables, and root crops. It is also imperative to consider the dehydration of whole fruits, for example, marula and wild medlar, by the novel processing technologies. The novel technologies discussed in this paper can promote the production of high-quality shelf-stable dried fruit, vegetables, and root crops [5]. This will enable whole year-round access to the dried fruits for food and nutrition security. The dried fruits, vegetables, and fruit as flours can also be used as ingredients in various food products and even food for food fortification for micronutrients and dietary fiber. Whichever drying method you choose-sun drying, solar drying, oven drying or dehydrator drying-be sure to place the fruit in a single layer on the drying trays. The pieces should not touch or overlap. Follow the directions for the drying method you choose and dry until the food tests dry. Heat flows from the medium (hot air) to the food surface, which re- salts in moisture being driven out from inside the food material to the surface and finally evaporating to the medium. Heat must be transferred to equal the heat of vaporization. Dried fruit is made of fresh fruits and processed by peeling, coring, sugar water boiling, soaking, drying and packing. Dried fruits have under 20% water content, with dry surface and slight stickiness. Fruits and vegetables are processed by various methods like low temperature, thermal treatment, concentration, freezing and irradiation. But prior to subjecting fruits and vegetables to such treatments, all fruits and vegetables undergo some preliminary operations. Aside from some volatile nutrients, properly dehydrated vegetables and fruits can retain their nutritional content, cost less to ship and are shelf-stable almost indefinitely [6]. Temperature matters in the dehydration process and foods dried at lower temperatures tend to retain more of their nutritional content. Low humidity, low heat and good air circulation are critical for successful drying. You can use a dehydrator, oven, microwave or even air-dry some foods. Start with good quality foods. This process preserves food for much longer than its ordinary shelf life. Dehydrated foods can be a healthier alternative to many snacks, and you can add them to salads, oatmeal, baked goods, and smoothies. Because they rehydrate in liquid, they're also easy to use in recipes.

Overall, the choice of fruit and vegetable drying method depends on various factors such as the desired quality of the final product, available resources, cost considerations, and energy efficiency. Exploring different drying techniques and understanding their advantages and limitations can help producers and consumers make informed decisions regarding the preservation and utilization of fruits and vegetables. As technology advances, new drying methods may emerge, providing even more efficient and sustainable ways to dry fruits and vegetables while retaining their nutritional value and flavor profiles. It is essential to continue analyzing and innovating in the field of fruit and vegetable drying to meet the increasing demand for healthy, convenient, and long-lasting food products in a sustainable manner.

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