Fruit Freeze-drying Process with Antioxidants

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Abstract

The objective of this article is to collect information on the process of freeze-drying fruits with antioxidants with the application in the food industry and its commercialization, as well as to describe its antioxidant capacities and health benefits. Through the search for theses, scientific articles, university repositories with the respective criteria that allows establishing the results of various authors, where they also talk about freeze-drying to prolong the useful life of fruits. Since it is a process that allows to preserve all the nutrients and the phenolic compounds and the antioxidants mainly. The export of fruits is a growth of the national market destined for Dubai and freeze-drying meets high quality standards so that it is supplied to the market frequently and permanently. It is concluded that freeze-drying is a very complete method to preserve nutritional properties, which results in obtaining products with similar characteristics to the initial raw material.

Keywords: *Freeze drying, Antioxidants, Nutrients, Export.*

Introduction

New trends in food consumption show that the population seeks healthier options with less invasive preservation treatments for their nutrients, however, fresh foods such as fruits and vegetables have a limited shelf life and the application of technological processes is necessary to reduce the physicochemical properties of deterioration. Ecuador is a country rich in flora and fauna, so it has large varieties of fruits, vegetables, flowers and other vegetables that, despite being grown all year round, present problems, in some cases due to the lack of post-harvest management. Fruits are valuable that contribute to a healthy and varied diet of the population. Currently in greater quantities we find fresh fruits for short periods of time. The shelf life of the blackberry is only 3 to 5 days, since it has a high water content, which makes it very fragile to handling and susceptible to the post-harvest storage period.(FAO, 2015)(Cruz Bojórquez, Gonzáles Gallego, & Sanchéz Collado, 2013)(Valenzuela, Ayala, & Bohórquez, 2015)(Valenzuela, Ayala, & Bohórquez, 2015)

Fruits and vegetables rich in bioactive components, in addition to having an appreciable antioxidant capacity, which brings great health benefits to their consumers; In addition to being very attractive to the food industry. Fruits are an important source of water, fiber, vitamins, minerals, among other compounds that make them an essential component to achieve a balanced diet and thus, a proper functioning of the body and prevention of chronic diseases.(Zhao, et al., 2017)(Zhao, et al., 2017)

Fruits with antioxidant action are necessary to maintain a good physiological function, since with a greater number of oxidants it could cause oxidative damage that triggers critical diseases that can lead to death.

Preservation methods have constantly been studied to ensure that the bioactive compounds present in food are maintained or modified minimally, thus preserving their nutritional and nutraceutical value, one of the most used being dehydration, in which food is placed in mechanical dryers of different types: based on hot air, Gas ovens, microwaves and freeze dryers that control climatic and sanitary conditions, so that good quality, hygienic and toxic substance-free products are obtained.(Rubio, 2014)

Antioxidants

Fruits that can be considered daily consumption contain antioxidants.

Substances that prevent the production of tissue damage caused by free radicals, which is carried out by reducing or eliminating them; In addition, antioxidants favor the reduction of the risk of cardiovascular, inflammatory, neurodegenerative diseases (Parkinson's and Alzheimer's), liver diseases (cirrhosis), type 2 diabetes and even cancer.(Coronado, Vega y León, Gutiérrez, Vázquez, & Radilla, 2015) (Fonseca-García, Calderón-Jaimes, & Rivera, 2014)

Antioxidants are substances that stabilize the oxide-reducing mechanisms that occur naturally in the body, and are present in foods such as: fruits, vegetables and some grains.(Percival, 1998) (Bartosz, 2014) (Cruz Bojórquez, Gonzáles Gallego, & Sanchéz Collado, 2013)

A dietary antioxidant is a substance that is part of everyday food consumption and can prevent the adverse effects of reactive species on the normal physiological functions of humans.(Patthamakanokporn, Puwastien, Nitithamyong, & P., 2008)

Origin of fruits with antioxidants

In the Andean area, many fruits little known in other regions are grown, such as tree tomato or sacha tomate, aguaymanto, prickly pear and papaya de monte. These fruits are mainly consumed naturally without major degree of processing; There is also not much information about its chemical composition. The revaluation of native fruits, little known or unknown outside their regions of origin. Among these native fruits there are important sources of vitamins, sugars, gelling materials (pectins), antioxidant materials, acids, aromas and flavors that await their identification and subsequent exploitation by the industry to develop innovative and competitive products in the market.(Carrasco & Encina, 2008) (Carrasco & Encina, 2008)

Studies have been conducted on the fruits of Ecuador for their important antioxidant capacity. In past studies, 17 fruits were analyzed in Ecuador, among which are bananas, capulí, passion fruit, etc. resulting in significant variability in phenolic content, as

well as antioxidant activity.(Vasco, Ruales, & Kamal-Eldin, 2008)

Classification

The following can be determined:

Antioxidant oxygen receptors

- Ascorbic acid and ascorbates
- Erythrophobic acid (isoascorbic acid)

Chelating agents

- Polifosfatos
- Tartaric acid
- Citric acid
- Lecithin

Eventual antioxidants

- Amino acids
- Spice extracts
- Vitamin A

Properties of antioxidants

The actions of antioxidants have an important interest in food science for the formulation of functional foods.(Škrovanková, Sumczynski, Mlček, Juříková, & Sochor, 2015)

Antioxidant properties should not only be studied for their chemical-biological interactions, but for their role in oxidative deterioration affecting food. Associated with the antioxidant function is considered the process of oxide-reduction that refers to two basic moments: a) oxidation that implies loss of hydrogen electrons with the gain of oxygen in the molecule, b) reduction that means gain of hydrogen electrons with the loss of oxygen. Thus the oxidant is reduced by reacting with that molecule that oxidizes. This process is daily in the human organism and represents the well-known oxide-reducing pair or redox balance. (Pastene, 2009)(Quintanar & Calderón, 2009)

Health benefits.

Around 100 diseases have been studied and their relationship with the imbalance of the oxidative system, among others: cardiovascular, cancer, gastric, respiratory, neurological and endocrine system. Among these, those of the cardiovascular type have ample evidence. The oxidation of LDL (low-density lipoprotein) cholesterol seems to represent the "master key" in the development of atherosclerosis, as they can be cytotoxic to endothelial cells and lower the motility of macrophagic tissue. It is proposed that vitamin E that is transported by LDL cholesterol can reduce oxidation processes. (Stanner, Hughes, Kelly, & Buttriss, 2004)

As in any health topic, diagnosis, treatment or prevention requires years of study and various tools for analysis, especially today that every day new technologies arise for experimental work. Solid foundations are required to support studies of this scientific field and its transfer to the general population.(Coronado, Vega, Gutierrez, Vazquez, & Radilla, 2015)

Among the products with antioxidants, most consumed, are those with: vitamin E: avocado, olive oil, brown rice, dried fruits; with vitamin C: chard, tomatoes (lycopene), all citrus fruits (lemon, orange, tangerine), plus kiwi, strawberry, guava; with β-carotene: carrot, spinach, mango, melon; With flavonoids: green tea, wine, apple, or pears. , A high-consumption antioxidant food is guava (Psidium guajava L.) which contains vitamins A, C and polyphenols. When studying the fresh fruit, the skin, the pulp and the entire outer layer (hull), a higher content of polyphenols (wet base) is observed in the skin of the fruit and then in the pulp and

hull.(Reyes, Galicia, & Carrillo, 2011)(Palomino, Guija, & Lozano, 2009)

Freeze-drying

It is a technique in which various foods can be preserved by means of the sublimation of water, this mechanism consists of "freezing the product and then removing the ice by sublimation, applying heat in vacuum conditions. In this way, the passage to the liquid phase of the water contained in the food is avoided". (Parzanese, 2000)

Phases of freeze-drying

There are three important phases that influence the drying speed as a function of time.

They are distinguished in:

Phase 1: Conductive. Where it starts by heating the sample at a rate that grows rapidly until it reaches a peak. The stipulated time in this phase is relatively short, between 10 and 15% of the time that the entire freeze-drying process takes.

Phase 2: Diffusive. It is the lowering of the rate of sublimation as a porous layer of a dry material is formed that is resistant to heat and steam in the drying process.

These first two phases correspond to a primary drying that fulfill the function of removing all the possible amount of liquid from the product.

Phase 3: Diffusive. Its sublimation speed decreases until it reaches zero.

As shown by means of a graph the process of lyophilization by stages.(Orrego, 2008)

Figure 1 Freeze-drying process phases

The freezing curve graphically represents the typical course of the food freezing process. The diagram varies according to the influence of the following factors: freezing method, size, shape, chemical composition and physical properties of the product, and type of packaging (or lack thereof).(Hiccup, 2021)

Stages of freeze-drying

Lyophilization is carried out at temperatures below the total solidification temperature, that is, the product must be frozen at temperatures between 10 and 15 °C below its eutectic temperature to avoid the formation of H2O clots that do not solidify(Cruz & Tomas, 2018). Pretreatment and freezing.

Freeze-drying in the food industry

For the lyophilization of any product begins with freezing from low temperatures (-30 ° C to -40 ° C) where the size of the ice crystals is normally regulated with freezing rates, since a slow rate promotes the formation of large crystals, favoring lyophilization, but affecting the integrity of cell membranes, while a high rate produces microcrystals minimizing damage to cell membranes; However, it simultaneously increases the presence of unfrozen water trapped in the vitreous area that is difficult to remove during drying. (Orrego, 2008) Through lyophilization, dehydrated

products such as fruits, vegetables, coffee, beverages, etc. have been obtained. Technological advances have taken this process beyond consumer expectations.

The applications of freeze-drying are different, especially in the field of food since here its main contribution is to extend the shelf life and facilitate the transportation of these.

Freeze-drying conditions

In this mechanism the fruit in its fresh state, spoil in a short time but its shelf life can be extended by reducing its moisture content by means of lyophilization, that is, by drying applying heat to the vacuum.

The production of these fruits is a great challenge for the food industry, since some drying processes can damage the antioxidant effects of plants (Lutz, Hernández, & Henríquez, 2015).

The results obtained by lyophilization are considerably affected by the speed with which they freeze:

Rapid or long-lasting freezing is a process through which the temperature of food drops approximately -20°C in 30 minutes. Slow freezing is a process in which the desired temperature is reached between 3 and 72 hours, just as it happens in domestic refrigeration appliances.(Hiccup, 2021)

Freeze-dried fruits

The freeze-dried fruit is characterized by having a great similarity with the dehydrated one; However, there are small differences between the two, from their production to their texture. These fruits can be considered as the perfect accompaniment to a diet: they are low in calories, high in fiber, allows to control anxiety, possess antioxidants and nutrients and maintains their flavor (Arias, Fonseca, & Vélez, 2018).

For several decades the technique of eliminating water in food has been used, which is usually applied in coffee, but today it is being used in other types of foods such as fruits, since it allows to preserve the aroma and flavor; They can even last up to twelve months inside the right packaging. The lyophilization technique is the best method to get dried fruit since during the process the fruit does not lose its natural nutrients or flavor, in addition to not adding any chemicals or preservatives, causing the demand for this product to grow thanks to the acceptance of consumers.(Innovative Cooking, 2017)(Lopez, 2016)

Thanks to the geographical position and climate that Ecuador has, it is possible to grow a wide variety of products (vegetables or fruits) considered non-traditional such as pineapple, papaya, mango, guava, among others, which make up a percentage of the exportable supply that the country has. (Arias, Fonseca, & Vélez, 2018)

The blackberry (Rubus glaucus) is a fruit that due to its properties can also be freeze-dried.

The Castile blackberry Rubus glaucus was discovered by Hartw and described by Benth, is native to the tropical Andean zone mainly in Colombia, Ecuador, Panama, Guatemala, Honduras, Mexico and Salvador (Arboleda, Marin, Marin, Guevara, & Rivera, 2019).

Blackberries are fruits of low caloric value due to their low contribution in carbohydrates; However, what really characterizes them is the presence of abundant natural pigments (anthocyanins and carotenoids), with antioxidant action. Anthocyanins give them their characteristic color. Blackberries are very rich in vitamin C and E, they also have high

pectin content, these fruits are rich in assimilable iron so its use against anemia is recommended.(Valenzuela, Ayala, & Bohórquez, 2015)

Nutritional properties

(Asqui, 2019), mentions some nutritional properties such as:

- It has antioxidants that are important for heart and artery health to prevent fat gain.
- The vitamins that are present in the blackberry such as; A, C, E, K and folic acid. Vitamin A helps eye health, ascorbic acid or vitamin C improves immunity, vitamin E acts as an antioxidant, phylloquinone helps calcium absorption and blood clotting.
- It improves appetite and helps fight anemia due to its iron content.
- It helps detoxify the body.

Fruits that contain vitamin C are very important as it is the largest source of antioxidants that are generated.

Listed below is a variety of fruits with their vitamin C content and water percentage.

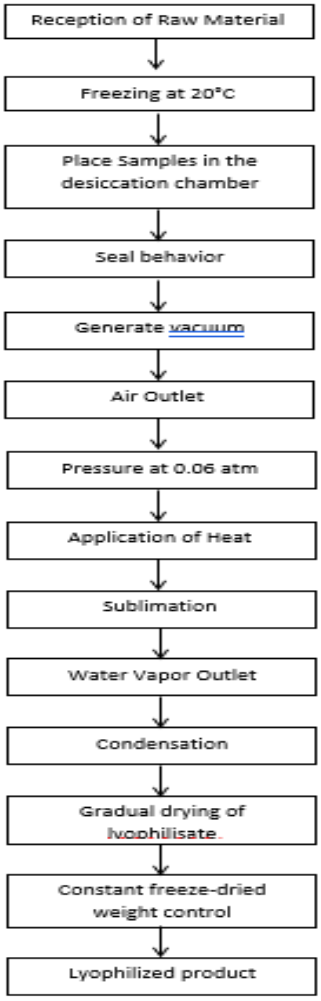
(INCAP, 2019)

Table 1 Vitamin C content and water percentage.

Nombre	Vit. C (mg)	% Agua
Banano maduro	9	74,91
Carambola	34	91,38
Coco	3	46,99
Fresa o frutilla	59	90,95
Guanábana	21	81,16
Kiwi	93	83,07
Mango maduro	53	83,50
Mango verde	128	87,60
Manzana	8	84,70
Mora	21	88,15
Papaya lechosa	63	88,83
Piña fruta dulce	56	65,66
Sandia	8	91,45

Flowchart for freeze-drying fruits.

Its mission is to remove the last traces of water vapor, evaporating the unfrozen water bound to the product. It is carried out at a temperature lower than that of denaturation of the product and a final humidity is achieved up to values below 1(Hiccup, 2021)%.



(Ñaupa, 2010)

Current regulations for freeze-drying

Freeze-drying quality standards

The Ecuadorian technical standard aseptic processing of health products. Part 3: Freeze-drying (ISO 13408-3:2006, IDT), specifies requirements and provides recommendations

on equipment, processes, programs and procedures for the control and validation of freeze-drying as an aseptic process. It does not contemplate the physical/chemical objectives of a freeze-drying process(INEN, 2014) .

And the term lyophilization is a physical-chemical drying process designed to remove solvents from both aqueous and non-aqueous systems, by sublimation and desorption (INEN, 2014).

Marketing of freeze-dried fruits.

Ecuador has a plan to export freeze-dried tropical fruits, specifically pineapple and bananas in the province of Guayas, destined for the United Arab Emirates – Dubai market.

Table 2 Political- administrative organization of the United Arab Emirates

ASPECTO	DESCRIPCIÓN
Emiratos que lo conforman	Abu Dhabi, Dubai, Sharjah, Ajman, Ras Al Khaimah, Sarjah y Umm Quwain. Abau
Capital	Abu Dhabi
Emiratos más representativos	Abu Dhabi (centro de la industria del petróleo y del gas) Dubái (turismo, construcción, servicios y el de más crecimiento).
Población Total	9.269.612
Población de los principales emiratos	Dubái (2.173.344) Abu Dabi (1.031.875) Al Ain (435.994)
Densidad	111 habitantes/km^2
Lengua Oficial	Árabe

(United Arab Emirates Business Guide, 2014) Mentioned the administrative level that maintains with United Arab Emirates.

Table 3 Administration of the United Arab Emirates

ADMINISTRACIÓN	DESCRIPCIÓN
Consejo Supremo Federal o Consejo Supremo	Máximo órgano de decisión política. Está conformado por un integrante de cada emirato, posee el poder ejecutivo y legislativo.
Consejo de Ministros	Es el poder ejecutivo de los EAU, da seguimiento a la política general, propone políticas federales.
Consejo Nacional Federal	Órgano Consultivo y de deliberación. Conformado por 40 miembros representando a los siete emiratos.
Consejo Superior de Seguridad Nacional	Cumple la función de discutir las políticas de seguridad de la Federación.
Corte Federal de Justicia	Conformada por sistemas federales y locales.
Ministerios Relevantes	Ministerio de Comercio Exterior
	Ministerio de Economía

(United Arab Emirates Business Guide, 2014)

There are four factors that consumers are currently looking for when purchasing a new food product: convenience, health, sensory enjoyment and pleasure. This trend is taken as an indicator to determine the degree of acceptance that will have the freeze-dried pineapple and banana that is intended to export to the UAE (Clementz & Delmoro, 2011)(Arias, Fonseca, & Vélez, 2018).

Import interest of freeze-dried fruits.

It is possible to observe the interest that the current importers of Dubai have for freeze-dried fruit, where 50% of these importers are quite interested in importing dried fruit from Ecuador, 25% are somewhat interested in importing the fruit and the other 25% are indifferent to the import of said fruit before the offer of other products from different countries (Arias, Fonseca, & Vélez, 2018).

Conclusions

The lyophilization of fruits is considered a method of dehydration in order to maintain the functional, nutritional and organoleptic properties, without forgetting the extension of the shelf life of the product. The

characterization of fruits is very important because of their high humidity, nutri contentinteas and antioxidants must obtain an optimal result and suitable for consumption. It should be noted that this process can alter the content of antioxidants but lyophilization is a basically mild method that would not change the predominance and composition of these compounds and that therefore lyophilization is feasible in fruits for industrialization, and commercialization.

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