



(REVIEW ARTICLE)



## Convection freeze-drying on squid: Principles, advantages and disadvantages

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### Abstract

Currently, many different drying methods applied to seafood composed of squid. Different methods have other advantages and disadvantages, in which the convection freeze-drying method is commonly found in coastal communities on squid. Therefore. This article focuses on the principles, advantages and disadvantages of the convection freeze-drying method on squid as a foundation for the widespread application of this method in industrial production. The results are presented based on research documents on convection freeze-drying on squid and production practices.

**Keywords:** Advantages; Convection; Disadvantages; Freeze-Drying; Squid; Principles

### 1. Introduction

Drying is the removal of water from materials such as food, wood, or chemical products to increase durability, reduce weight, and prevent the growth of bacteria and mold. Here are some popular drying methods:

- Air drying;
- Natural drying (Uses peripheral air to remove water from the material. This process happens naturally, often taking time).
- Forced drying is use a fan or ventilation system to enhance the air drying process;
- Steam drying: Direct steam drying mean that steam is directly applied to the material to evaporate water. Indirect steam drying is transferred heat using steam through an insulation before coming into contact with the material to be dried;
- Vacuum drying: Room vacuum drying use a vacuum to reduce pressure, helping water evaporate at a lower temperature. Continuous vacuum drying uses a continuously vacuum system to reduce pressure and remove water from the material;
- Auroral ray drying.
- Infrared aurora drying (Uses infrared aurora rays to heat and evaporate water from materials);
- Micro wave drying (Microwave drying is using microwaves to heat evaporating water from inside the material);
- Cold-drying;
- Freeze drying (Uses cold air to freeze water, then removes it from the material);
- Drying with ultraviolet rays (Using ultraviolet rays to heat and evaporate water from materials).

Drying methods are chosen depending on the type of material to be dried, the desired moisture level, and specific technical requirements [1-10]. According to VASEP “In the first 8 months of 2022, Vietnam squid and octopus exports

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reached \$489 million, up 36% over the same period in 2021. In which, squid exports accounted for 56.4%, reaching \$276 million, up 47%; octopus exports accounted for 43.6%, reaching \$213 million, up 24%" [11]. Therefore, the study focused on principles, advantages and disadvantages of convection freeze-drying on squid.

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## 2. Material and methods

Documents in the press, television and mass media on convection freeze-drying, convection freeze-drying on squid, experience of experts in convection freeze-drying of squid, analysis of experimental drying data Squid convection was carried out in this study.

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## 3. Results and discussion

### 3.1. Principles and structure of convection freeze-drying

Convection freeze drying is a new air drying method in the seafood industry, used to preserve and process aquatic products such as fish, shrimp, squid, and other seafood. Drying process does not require high temperatures, helping to maintain product quality and minimize nutrient loss compared to traditional drying methods. For operating principle: Freeze drying is the drying of a product by cooling the air around it, causing the water in the product to freeze and then turn to water vapor. Convection is the heat exchange process between cold air and hot air takes place effectively, helping quickly water vapor from aquatic products. Some advantages are preserving product quality and energy saving. Convection freeze-drying retains flavor, color, and nutrients without changing sensory properties of seafood. Convection freeze drying consumes less energy than traditional drying methods. Freeze drying is applied usually in processing salmon, shrimp, squid, and other seafood, suitable for dried aquatic products such as fish balls, shrimp, and squid. Main equipment composed of drying system and conveyor belt or product shelf. Drying system includes drying chambers, fans, and refrigeration systems to create cold air. Product shelf used to place products to be dried and move them through the drying process. Process management includes control of humidity, temperature, and drying time is necessary to ensure final product quality. In summary, convection freeze-drying in seafood is an effective method to preserve product quality during processing and storage, especially when it is required to maintain the sensory structure and nutrients of the seafood product.

The convection freeze drying model in the seafood industry includes many components to perform the drying process effectively. Below is an overview model of the convection freeze drying system.

- Drying chamber: Is a place to store aquatic products that need to be dried. Design so that cold air can circulate and come into contact with the product;
- Fan: Used to create cold air quality in the drying chamber. Supports the convection processing between cold air and moist air from aquatic products;
- Cooling system: Function to generate cold air, usually using a refrigeration compressor or liquid refrigeration system. Causes the water in the product to freeze and then turn into steam;
- Heat exchange system: Heat exchanges can be included at various points in the drying process to optimize energy efficiency. Supports convection and air cooling;
- Control system: Includes humidity and temperature sensors to ensure drying occurs in a controlled manner. The controller automatically adjusts mainly parameters such as humidity and temperature. (6) Conveyor belt or product storage shelf: Used to move the product through the drying chamber, helping the drying process uniform evenly. Can be designed to adjust travel speed depending on product type and drying requirements;
- Steam water collection system: To capture water vapor from dried products, preventing them from returning to the drying chamber;
- Control and monitoring system: Includes control panels so the operator can monitor and control the drying process.

The control panel can provide information about humidity, temperature, and other relationship parameters. The convection freeze-drying process in this model helps maintain the quality of seafood products by reducing temperature levels and drying times, which is necessary to retain the flavor, color and nutrients of the seafood product.

### 3.2. Conditions need to be controlled in convection freeze drying

For convective freeze-drying of squid, drying conditions are grave to ensure high product quality. Here are some chief conditions to consider:

- Humidity: Keep the humidity in the drying chamber low to optimize the drying process, that helps absorb water quickly from the ink without changing its structure or quality. Humidity control can be better through a low humidity cold air supply system;
- Temperature: Usually maintained at low levels to avoid damaging the squid structure and retain the sensory quality of the product. This can be controlled using the refrigeration system and control panel to regulate the temperature;
- Drying time: Drying time is necessary controlled to ensure for the squid drying to the desired dryness without changing its color or flavor. This is usually installed and controlled using an automated system;
- Fan and convection system: Convection between cold air and hot air helps increase drying efficiency. The fan provides air quality circulation and ensures that the cold air comes into contact with the squid effectively.
- Monitoring and control system: This system provides continuous information about humidity, temperature, and other parameters related to the drying process. Sensors and control panels help adjust drying conditions for the best results.
- Preserving sensory and nutritional quality: The convection drying process should be adjusted like that the squid does not lose color and flavor and retains grave nutrients.

By maintaining these conditions, convection freeze-drying for squid can be performed effectively and retain the quality of the final product.

### 3.3. Economic benefits

Convection freeze-drying on seafood raw materials can bring many economic benefits, depending on the production scale, type of product, and specific business conditions. Below are some economy benefits that convection freeze drying can bring:

- Energy saving: Compared to traditional drying methods using high temperatures, convection freeze drying usually consumes less energy. The can lead to reduced energy-related costs, helping to increase the energy efficiency of the manufacturing process;
- Preserving product quality: Convection freeze drying retains the sensory and nutritional quality of seafood well, helps add value to the product and can expand the consumption market;
- Reduce product loss: The freeze-drying process quickly reduces the moisture in the product, thereby reducing the loss of weight and size of the seafood. The can help increase efficiency and reduce material waste;
- Increase applicability: Convection freeze-drying allows rapid processing and maintenance of quality of many different types of seafood. The can increase the application of the drying process and expand the range of products that can be processed; (5) Reduce storage costs: Dried seafood is more stable and can be preserved time more without freezing or other preservation measures. The storage costs is significantly reduced;
- Brand enhancement: The high quality of seafood products after convection freeze-drying can create a positive brand image, helping to increase customer trust and create marketing opportunities.
- Compliance with food safety regulations: Convection freeze drying often retains more food safety than other processing methods, helping businesses comply with food safety regulations and industry standards. However, to achieve high economic efficiency, businesses need to begin investment in a convection freeze drying system and ensure the operating process is carefully managed to optimize performance.

The thing may require engineering controls, personnel training, and continuous monitoring to guarantee stable and efficient production.

### 3.4. Calculating the economic efficiency

Calculating the economic efficiency of convection freeze-drying on squid requires analysis of many factors, including initial investment costs, operating costs, energy savings, and other related benefits regarding product quality. Here are some mainly steps to calculate economic efficiency.

- Initial investment cost: Determine the investment cost to purchase a convection dryer, including machine price, transportation, installation, and other related costs price. If necessary, include investment costs for infrastructure improvements.
- Operating costs: Determine operating costs, including energy, maintenance, and other costs associated with the drying process. Calculate annual operating costs based on product quantity and specific operating conditions;
- Energy saving: Compare the energy consumption of convection freeze drying with traditional drying methods. Calculate energy savings over time and consider energy costs in calculating operating costs;

- Production Efficiency: Evaluate the production efficiency of convection freeze drying by comparing drying time and yield to other methods;
- Product quality: Evaluate product quality retention after drying and compare with other methods. Consider the added value of the product due to retained quality;
- Add value and expand market field of vision: Determine whether additional value can be added to the product due to high quality after drying. Consider the possibility of expanding market field of vision or accessing new markets thanks to product quality;
- Capital recovery time: Calculate the time required to recoup the initial investment based on the operating costs of energy savings and added value;
- Risk assessment and other incurred costs: Consider other risk factors and additional costs that may affect the calculation of economic efficiency.

Calculating economic efficiency requires detail and assessment of all factors to make accurate decisions. It should be connect closely to specific business, market field of vision, product conditions, and influence this calculation.

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#### 4. Conclusion

The article has presented the structure of convection freeze drying equipment with basic principles in convection freeze drying. The advantages and disadvantages of the method when using squid drying compared to other drying methods are also analyzed and presented. Calculating the economic efficiency of the convection freeze-drying method on squid compared to other drying methods has also been shown. The necessary control conditions in convection freeze-drying of squid are specifically presented in the study.

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#### Compliance with ethical standards

##### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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