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A REVIEW ON FORMULATION AND PROCESSING TECHNOLOGIES ON POWDER JUICE

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• **ABSTRACT**

Powdered foods are easy to store and transport, with a longer shelf life that minimizes potential waste, contributing to sustainable development. Each food category has a unique composition, responsible for its chemical and physical attributes, which directly influences the stability of powdered products. The drying method used is essential to obtain the desired characteristics of the powdered food, and the choice of each technology can provide unique morphological properties regarding size, shape, and density, among other factors. Furthermore, rehydration properties must also be investigated, as they play a fundamental role in the reconstitution of powdered foods, influencing the dispersion and dissolution of the powder in liquids. Therefore, this review provides a comprehensive overview of the powdered food manufacturing process and its advantages.

• **KEYWORDS:** Powdered Product, Drying Process, Rehydration Properties, Food Microstructure.

1. INTRODUCTION

Demand for instant powdered fruit and vegetable juices has grown rapidly because powders offer longer shelf-life, lower transportation cost, easy storage and convenient reconstitution while concentrating nutrients and flavours for food, nutraceutical and beverage applications. Transforming liquid juices into stable powders presents technical challenges: many valuable phytochemicals and aromas are heat-sensitive, juices are sticky and hygroscopic and powder reconstitution and sensory quality must be preserved.[1]

To meet these constraints, a range of dehydration and microencapsulation technologies have been developed and refined from conventional spray-drying and freeze-drying to hybrid and emerging approaches such as spray-freeze-drying, refractance-window drying, foam-mat drying, microwave-assisted and vacuum drying, and encapsulation strategies using carriers. Recent reviews document how each method balances quality, energy use, throughput and cost, and how carrier systems and process optimisation are critical to retain bioactive stability and improve powder handling.[2,3]

2. DEFINATION

Powder Juice: Powder juice can be defined as a nutrient-rich functional beverage formulated from a blend of fruits, vegetables, herbs, and sometimes additional supplements, designed to provide instant energy, hydration, and enhanced nutritional benefits beyond basic nourishment.[4]

Powder juices are considered a part of the functional food and nutraceutical category, as they combine taste, nutrition, and health-promoting properties using advanced formulation technologies like spray drying, freeze drying, or microencapsulation to retain bioactive components and extend shelf life.[5]

3. CLASSIFICATION OF DIFFERENT TECHNIQUES OF POWDER JUICE FORMULATION

- **Drying Technologies**
  - Spray Drying
  - Freeze Drying
  - Drum Drying
  - Vacuum Drying
- **Encapsulation Technologies**
  - Microencapsulation
  - Nanoencapsulation

4. DIFFRTENT TECHNOLOGIES OF POWDER JUICE AND ITS PROFILE

4.1 DRYING TECHNOLOGIES

a. Spray Drying

- **Types of Spray Dryers**

1. Conventional Spray Dryer
2. Centrifugal Spray Dryer
3. Fluidized Bed Spray Dryer

• Principle

Spray drying is based on the principle of transforming a liquid feed into a dry powder by rapid evaporation of the solvent using a hot drying gas. It works on the concept of surface area enhancement by atomizing the liquid into fine droplets, a large surface area is created, allowing for instantaneous drying within a few seconds.[6]

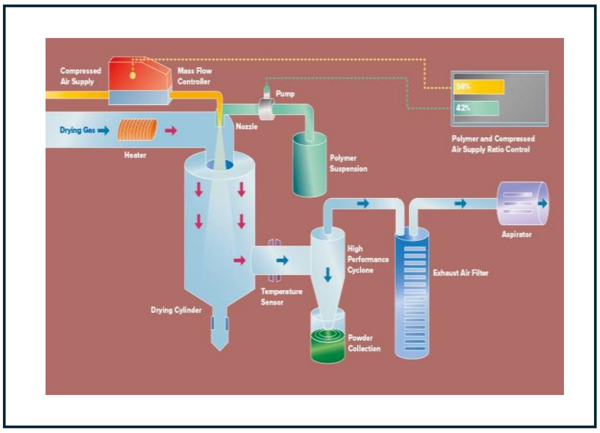

Figure 1: Spray Dryer.

• Advantages

- Produces uniform, fine, and free-flowing powders.
- Ideal for heat-sensitive materials
- Allows for large-scale continuous production

• Disadvantages

- Bulky and expensive to install.
- Challenging to clean after use.
- Low thermal efficiency with significant heat loss during operation.

b. Freeze Drying (Lyophilization)

• Principle

Freeze drying works on the principle of sublimation, direct conversion of ice to vapor without passing through the liquid phase. This is achieved by freezing the material and then reducing the surrounding pressure below the triple point of water, allowing the frozen solvent to sublimate. The removal of water or solvent from a frozen product by sublima.[7]

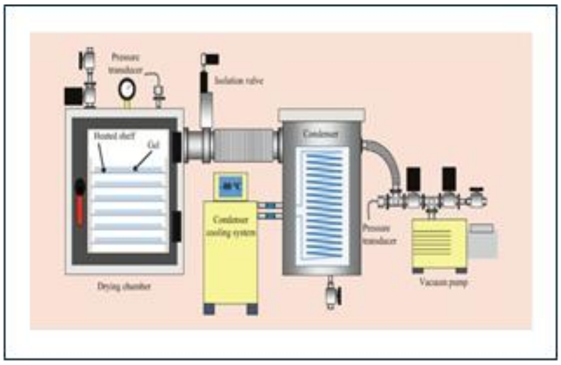

Figure 1: Freeze Dryer.

• Advantages

- Ideal for heat-sensitive materials.
- Produces lightweight, stable, and easily reconstitutable products.
- Minimizes chemical degradation and loss of volatile compounds.
- Enhances shelf-life and bioavailability.

• Disadvantages

- High cost
- Long processing time compared to spray or vacuum drying.

c. Drum Drying

• Principle

In drum drying, the juice concentrate or puree is applied as a thin film onto the surface of one or two heated metal drums. The drums are internally heated with steam (120 170°C). As the drum rotates, moisture evaporates rapidly. A doctor blade or scraper removes the dried film, which is then milled into powder form.[8]

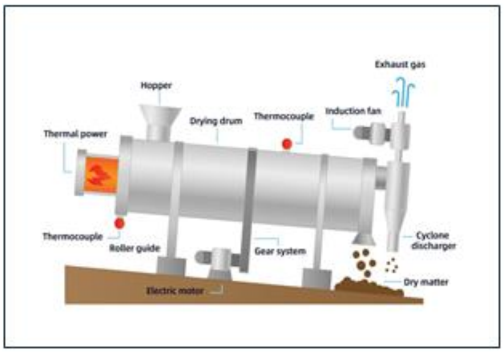

Figure 3: Drum Dryer.

• Advantages

- Rapid drying and good retention of nutrients
- Energy efficient compared to spray drying for viscous materials.

- Can handle high-viscosity juices that are difficult to spray dry.
- Compact equipment and relatively low maintenance cost.

• Disadvantages

- High drying temperature can cause flavor loss, browning, or vitamin degradation.
- Powder may have poor solubility compared to freeze- or spray-dried powders.
- Requires precise control of film thickness and drum speed.

d. Vacuum Drying

• Principle

Vacuum drying operates on the principle of lowering the pressure around the material to reduce the boiling point of water or solvent present in it. This allows drying to occur at lower temperatures, which is crucial for heat-sensitive materials like fruit juices that contain vitamins, antioxidants, and volatile flavor compounds. At reduced pressure, the vapor pressure of water equals the surrounding pressure at a lower temperature, causing moisture to evaporate without thermal degradation of the product.[9]

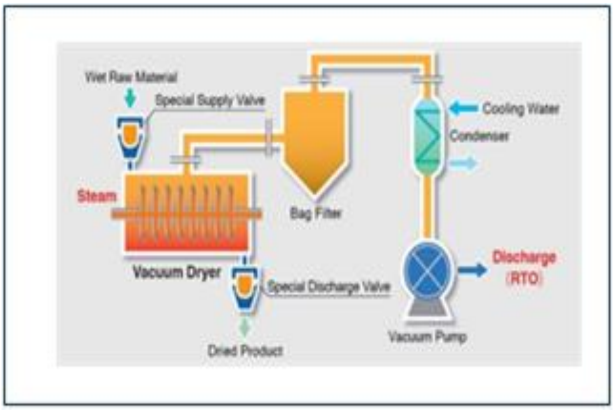

Figure 4: Vaccum Dryer.

• Advantages

- Low-temperature drying preserves nutrients, flavor, and color.
- Minimizes oxidation due to reduced oxygen levels.
- Produces high-quality, porous powders that are easy to reconstitute.

• Disadvantages

- Long drying time compared to spray drying.
- Higher equipment and operational cost due to vacuum generation.

4.2 ENCAPSULATION TECHNOLOGIES

a. Microencapsulation

• Definition

Microencapsulation is a process in which active components suchas juice concentrates, flavors, vitamins, or bioactive compounds are enclosed within a protective wall material. This technique is widely used in powdered juice production to protect sensitive ingredients from degradation during drying, storage, and reconstitution.[10]

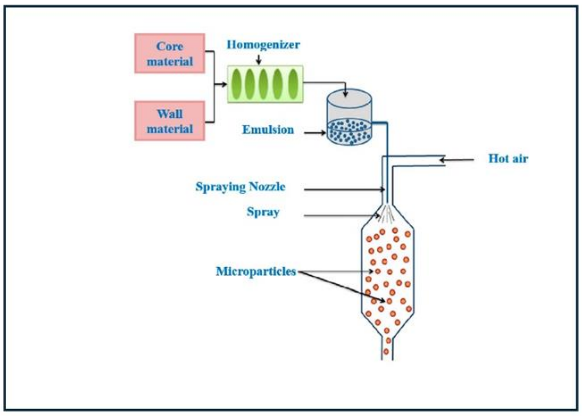

Figure 5: Microcapsulation.

• Advantages

- Protects heat- and oxygen-sensitive nutrients .
- Improves flowability and solubility of the powder.
- Enhances storage stability and shelf life.
- Masks undesirable tastes or odors.
- Enables controlled release during rehydration.

• Disadvantages

- High Processing Cost
- Limited Encapsulation Efficiency.

b. Nanoencapsulation

• Principle

The principle of nanocapsulation is based on forming core shell structures at the nanometer scale, where the core is surrounded by a protective wall made of biopolymers or lipids. These nanocarriers act as barriers that shield the core from environmental stress and control its release during rehydration or digestion.The small size of nanoparticles increases the surface area, allowing better absorption, dispersion, and stability of juice bioactives in the powder form.[11]

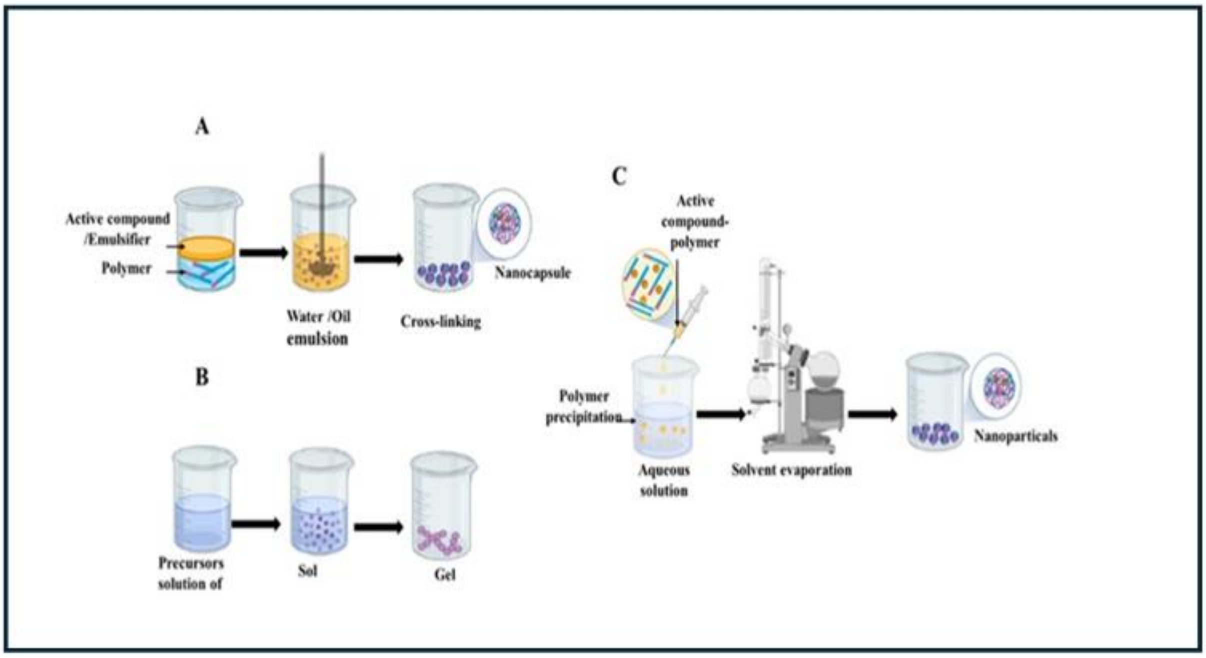

Figure 6: Nanocapsulation.

• Advantages

- Protects sensitive nutrients.
- Enhances solubility and reconstitution ability of juice powder.
- Improves nutrient retention during storage.

• Disadvantages

- High Production Cost.
- Complex Process OptimizatioPossible o Nutrient Loss During Drying.

5. CONCLUSION

The formulation and processing of powdered juice represent a vital approach to transforming perishable liquid juices into stable, convenient, and nutrient-rich products. Various drying technologies such as spray drying, freeze drying, drum drying, vacuum drying, microencapsulation, and nanocapsulation have been developed and optimized to retain the nutritional, functional, and sensory qualities of fresh juices. Each technique offers distinct advantages and limitations: spray drying is cost-effective and scalable; freeze drying preserves sensitive bioactives; vacuum drying minimizes oxidation; and encapsulation methods provide enhanced protection and controlled release of nutrients. The selection of suitable formulation parameters including carrier agents, core-to-wall ratios, inlet temperature, and feed concentration is crucial to achieving high powder quality with good solubility, flowability, and color stability.

Overall, advancements in assisted and hybrid drying systems, combined with encapsulation technologies, have significantly improved the shelf life, bioavailability, and consumer acceptability of juice powders. Future research should focus on eco-friendly, energy-efficient, and nutrient-preserving techniques to develop sustainable powdered juice products that meet the growing global demand for functional and convenient beverages.

Powder juice technologies have evolved significantly, offering efficient methods to transform liquid fruit and vegetable juices into stable, lightweight, and easy-to-use powdered products. Advances in drying and encapsulation techniques.

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