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Various techniques for dehydration of fruit juices: A review

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Abstract
Fruits and vegetable juices are dried and dehydrated to increase their usable lifetime, storage stability and minimize processing requirements and enhance transportability. Traditionally preservation techniques of juices were mostly based on drying through thermal processes, causing quality degradation and product contamination. Energy utilization and nature of dried product are basic parameters in the choice of drying process. An ideal drying system for the arrangement of value dried out items shortens the drying time and makes least contamination the item. To minimize the energy use and total cost new measurements came up in drying procedures. This paper represents basic review on juice drying techniques along with their merits and demerits regarding the quality of dried product and the process performance are evaluated.
Keywords: *Dehydration, vacuum, pasteurization, evaporation, freeze.*

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I. Introduction

Fruit and vegetable juices are watery mixture containing lots of water content. It contains about 8 – 20% of solid solute and 80 – 92% water. The solid solute in such juices are usually volatile and unstable. It is difficult to store, pack, handle and transport liquid juices. Hence, it is desired to remove some or all parts of water from it. By removing part of water from the liquid, a fruit juice concentrate is produced with is also used as semi finished product in manufacturing fruit juice beverage and fruit juice powder.

Drying is an oldest method for dehydration of food material. History shows that sun wind and smoky fire had been used to dry and preserve food materials. The nutritive value of fruits and vegetables are minimally affected due to drying. Vitamin C in citrus fruit are destroyed due to heat hence such juices either need pretreatment or low dehydration methods. Some methods of juice dehydration that has proven effective for fruit juice dehydration are freeze vacuum dehydration, foam mat dehydration, spray drying, etc. These methods do not show markable flavor change as they do not incorporate adverse operating conditions.

Dehydrated juice powder often tends to form cake and lumps at certain storage temperature. Caking causes the rehydration of dehydrated product quite difficult. It is also necessary to protect the dehydrated product from oxidation.

II. Conventional dehydration and preservation techniques

Thermal Processing (pasteurization)

Pasteurization is defined as the use of temperature about 100°C to destruct the spoilage organism. The acidic nature of most juices make it fit for pasteurization. According to intensity of applied heat treatment, there are four groups of conventional pasteurization:

- High-temperature long time (HTLT): Pasteurization at 80 – 100°C for more than 30 seconds.
- High-temperature short time (HTST): Pasteurization at 80°C for lesser than 30 seconds.
- Mild temperature-long time (MTLT): Pasteurization at less than 80°C for more than 30 sec.
- Mild temperature-short time (MTST): Pasteurization at less than 80°C for less than 30 sec.

Sun drying

This method is quite risky because the weather is uncontrollable and it also takes very long time. To dry in sun hot, dry and breezy days are best. Humidity below 60% is best for sun drying. The cool dry air condenses and can add moisture back to the food. This method is not very effective for handling liquid juices. It requires lot of precautions. The material being sun dried needs to be brought under shelter during the night time. It needs very keen selection of material of construction of the dryer. Copper is to be avoided as it destroys vitamin C and increases oxidation.

Thermal evaporation under vacuum

This method is used for partial dehydration of fruit and vegetable juices considering it to be most economical method of fruit juice concentration. Use of high vacuum (i.e. 29 in Hg) helps in evaporating water from fruit juice at much lower (i.e. 58-60°C) than its boiling temperature with steam economy too. Types of evaporator used for juice concentration:

Table 1: Types of evaporator used for juice concentration

Concentration methods	Specific type
Vacuum pan	Climbing film & falling film
Recirculation	Single stage and one pass Five stages and one pass
Plate	Three stages and single pass
Agitated film	Single stage
Centrifugal	Single stage

Solar drying

Solar drying is a reliable approach to food preservation for the future. But, there are food safety challenges that make the process difficult to control. One challenge is the direct contact between the product and the surrounding air since the air may be contaminated with microorganisms. In order to reduce the probability of contamination by solar drying, fruit juices can be dried with membrane pouches that provide a hygienic barrier between the product and the surrounding air. It is suitable for juicy, citrus fruits that are difficult to preserve with traditional solar drying practices. The pouches can be used to concentrate juices into marmalades in tropical countries where established infrastructure is not available.

III. Modern preservation and drying techniques

Freeze concentration

Freeze concentration (FC) is concentration procedure, in which two distinctive steps namely, ice crystallization and ice separation from the concentrate phase are involved.

a) First stage

Fruit juice is supercooled below its freezing point to allow water to separate as ice crystals, using either direct or indirect contact type crystallizer.

b) Second stage

The ice crystals are separated from the concentrated fruit juices using presses, centrifuges or combination of these.

Membrane processing

Membrane technology is used to clarify the juice by means of ultrafiltration and microfiltration and to concentrate it by means of nanofiltration and reverse osmosis.

Ultrafiltration (UF)

These membrane processes can also perform clarification and fractionation other than concentrating. It Produces juice of desirable quality at low cost of operation and with greater speed. In one step, it performs juice clarification and increased flavor and aroma retention.

Reverse osmosis (RO)

It is basically a concentration process. A pressure that is greater than its osmotic pressure is applied to fruit juice. This pressure forces the water out of the juice. It gives Considerable amount of aroma retention at a cost competitive with evaporation, without undue loss of solids.

Spray drying

Spray drying technique is use to produce fruit or vegetable powders from juices. Dry powders can be directly used as important constituents of dry soups, yogurt, etc. The drying is achieved by spraying of the slurry into an airstream at a temperature of 138 ^{0}C to 150 ^{0}C and introducing cold dry air either into the outlet end of the dryer or to the dryer walls to cool them to 38 ^{0}C - 50 ^{0}C. The most commonly used atomizers are rotary wheel and single-fluid pressure nozzle. A wide range of fruit and vegetable powders can be dried, agglomerated, and instantized in spray drying units, specially equipped with an internal static fluidized bed, integral filter, or external vibrofluidizer. Bananas, peaches, apricots, and to a lesser extent citrus powders are examples of products dried by such techniques. Spray drying of soluble fruit powders and convective drying of fruit and vegetables reduces the thermo-plasticity of particles and product hygroscopicity. They also eliminate the need for adding stabilizers which may adversely affect the sensory properties of the final product.

Freeze drying

There are two main stages in the freeze drying process: (a) freezing of the food, when most of the water is converted into ice, and (b) sublimation, when the bulk or all of the ice is transferred into vapor under very low pressure or high vacuum. In some cases, additional final drying, in the same or other equipment, is necessary. Cabinet or tunnel batch-type dryers are typically used with pressures in the range 13.5-270 Pa. Bananas, oranges, strawberries, peaches, plums, tomato, fruit juices and flavors, asparagus, beans, cabbage, cauliflower, celery, mushrooms, onions, peas, parsley and chives are processed by freeze drying.

IV. Measures to avoid lump formation and caking in dehydrated juice powder

Caking can be avoided in the dehydrated fruit juice product by centrifuging the freshly prepared fruit juice, then removing part of the supernatant portion of the centrifuged fruit juice before dehydration of the sediment portion alone or together with a portion of the supernatant liquid. The sediment portion is then dehydrated and a portion of the dehydrated supernatant liquid product may be mixed with the dehydrated sediment portion after each has been reduced to powdered granules of a suitable size. Any loss in flavor and sweetness of the fruit juice may be overcome by adding citric acid and a non-reducing sugar, such as sucrose, to the dehydrated fruit juice product at the time of packaging or rehydration or at any other suitable time.

The percent removal of supernatant portion depends upon the storage temperature and storage time of the final product.

V. Comparison of dehydration methods

Foam drying

Dehydration equipment varies in form with different juices and includes tunnel driers, kiln driers, cabinet driers, vacuum driers, and other forms. Foam mat and foam spray drying are two foam drying methods. Foam dried fruit or vegetable powders have fewer heat-induced changes in color and flavor than conventional spray dried products. They yield product with lower density than that of a conventional dryer.

Freeze drying

The advantage of freeze drying over other methods is the superior quality of the product. Very little or no shrinkage occurs. The dry product has color and flavor almost as fresh as that of the raw material. The only disadvantage of this process is the high equipment and operational cost. Freeze-drying includes fluidized bed processes, spray-drying, continuous processes, foam drying processes, slush freezing and the thermal shock processes

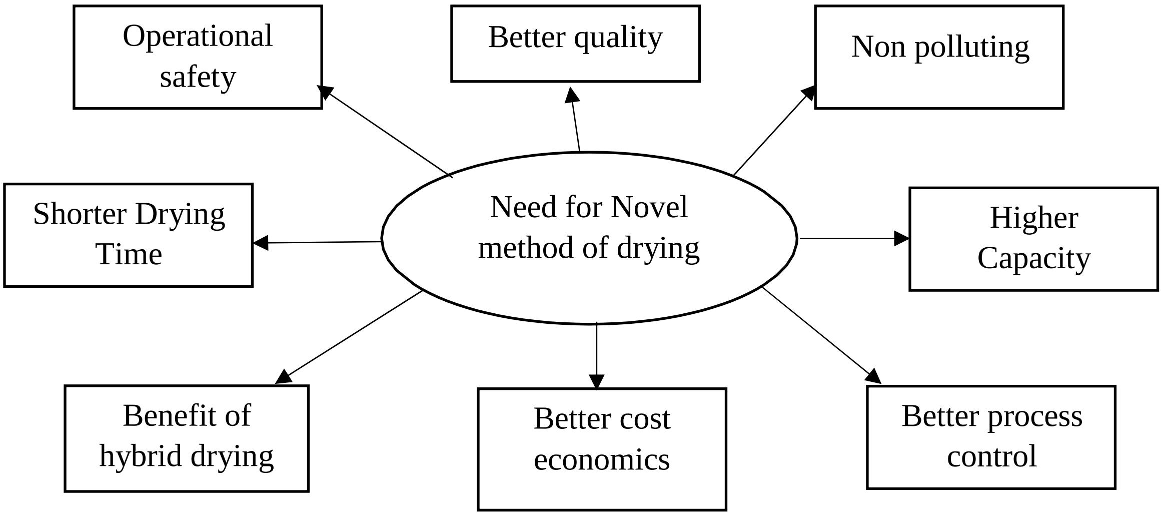

Figure 1: Need of novel drying method

Freeze concentration

The energy needed to freeze a unit of water that is the requirement of process is much less. The low process temperature prevents undesirable chemical reactions (minimum color change and vitamin losses). As vacuum is not involved in the process, the losses of low-boiling flavor and aromatic component are completely avoided. The flavor profile is much better. Major problem with freeze concentration is the loss of soluble solids of the juice in the separated ice. The final concentration of the concentrated juice is 40-55% dry matter, due to steep increase in the viscosity of ice-concentrated mixture.

Membrane processes

Ultra filtration produces juice of desirable quality at low cost of operation and with greater speed. In a single step, it performs clarification and fining both, lower energy consumption, increased flavor and aroma retention is characteristic of ultra-filtration. Considerable amount of aroma retention at a cost competitive with evaporation, without undue loss of solids is the main advantage of reverse osmosis plant. Concentration without phase change or thermal damage is achieved. It limits the upper concentration level of juice at about 28°Brix.

VI. Discussion

Various drying techniques are available for use on the industrial scale. The most successful and preferred methods for fruit juice powder production are freeze drying, foam mat drying and spray drying. Spray drying is the most economic technique maintaining quality by rapid dehydration but sometimes addition of additives is the essential requirement of the process.

Spray drying provides a large surface area of fine liquid droplets in the drying chamber, and leads to the production of regular and spherical shaped powder particles. Freeze drying is most efficient in nutrients preservation in powdered products, but its industrial-scale application is ignored by the high expenditures of the instrumentation and high energy consumption, as well as by a low throughput. The quality of the final dehydrated product depends on the conditions of drying processes, namely feed concentration, inlet and outlet air temperature, feed and compressor air flow rate, drying air flow rate, speed of atomizer, etc. The most important requirements on the powdered product are higher bulk density and low moisture content. Because a high bulk density reduces packaging and shipping costs and increases flowability and low moisture content ($<$ 5%) enhances product stability during packaging and storage. Literature shows that the drying temperature and carrier agent affects the physical properties of the powdered product, i.e. moisture content, bulk density and particle size significantly. Recently, due to multiple benefits of the application of these products in varieties of food formulations, the demand on fruit and vegetable juice powders has increased considerably. Hence, it is important to know how the drying technique and its other processing factors influence the powder properties and also how to optimize the suitable ranges of processing factors. Lots of studies have been performed on spray drying of fruits and vegetables juices. Only a few literature reviews on these studies are however available, in which the principles and complications of spray drying, and the effect of spray drying factors on the properties of fruit and vegetable powders are discussed. Especially recent research updates about the advances of spray drying of fruit and vegetable juices are missing which may be useful to perform further research. In order to obtain certain quality in powdered product, it is also required to find out the optimum conditions of spray drying factors. Therefore, more research is needed on optimization of drying of fruit and vegetable juices in order to understand the suitable optimum conditions for specific kinds of samples. Combinations with other techniques, such as ultrasound assisted spray drying, vacuum spray drying, ultrasound assisted vacuum spray drying, and dehumidified air spray drying have been shown to possess advantages over the conventional spray drying. Therefore, this review integrates advances in drying of fruit and vegetable juices and new trends of drying to overcome the limitations of conventional drying, which might be more beneficial for further research in the field of drying of fruit and vegetable liquid products.

VII. Conclusion

Numerous new techniques came up in drying innovation to diminish the operating cost and obtain high product quality. Among the advances techniques like vacuum drying, freeze drying, microwave drying, shower drying, modern spray drying are providing new dimensions to best quality dried items and powders. An ideal drying framework for the protection of juices is shorter drying time with least harm to the item. Recently, researchers and other stockholders are focusing on hybrid dryers which contribute to superior quality and cost effectiveness. Advanced novel techniques are gaining popularity day-by-day. However, several critical factors such as quality of product, reduction in drying time, energy efficiency, and overall cost effectiveness must be taken into consideration while developing future drying technologies.

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