Drying of food

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Food Preservation by Drying:
Food Preservation by Drying 1 Prof. P. A. Pawar , Department of chemical Technology, Sant Gadge Baba Amravati university, Amravati, Maharashtra State, India

PowerPoint Presentation:
Food Preservation Food preservation involves the action taken to maintain foods with the desired properties or nature for as long as possible. A number of new preservation techniques are being developed therefore understanding the effects of each preservation method on food has become critical. Preservation methods start with the complete analysis and understanding of the whole food chain, including growing, harvesting, processing, packaging, and distribution. It is important to identify the properties or characteristics of food that need to be preserved.

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Why to Preserve Foods ? To maintain product quality. To overcome inappropriate planning in agriculture, produce value-added products, and provide variation in diet . Value-added food products can give better-quality foods in terms of improved nutritional, functional, convenience, and sensory properties. Eating should be pleasurable to the consumer. Variation in the diet is important to reduce reliance on a specific type of grain.

PowerPoint Presentation:
Food Preservation Methods

INTRODUCTION:
INTRODUCTION Drying is a method of food preservation that works by removing water from the food, which prevents the growth of microorganisms and decay. Drying food using the sun and wind to prevent spoilage has been known since ancient times. Water is usually removed by evaporation (air drying, sun drying, smoking or wind drying) but, in the case of freeze-drying, food is first frozen and then water is removed by sublimation. 5

Drying using Heated air:
Drying using Heated air Fig: A schematic diagram of a hot air dryer. 6

Properties of Air–Water Vapor Mixture in Drying:
Properties of Air–Water Vapor Mixture in Drying Use of a Psychrometric Chart Fig: Heating and Drying process presented in Psychrometric Chart 7

Equilibrium Moisture Content:
Equilibrium Moisture Content Fig :Drying curves of the same food as influenced by two equilibrium moisture contents 8

Water Activity:
Water Activity Fig : Hysteresis shown by the difference between the isotherm of a food for desorption and for adsorption. 9 a w = P w / P ws The water activity can be given by :

Heat and Mass Transfer in Drying:
Heat and Mass Transfer in Drying Fig : Typical drying rate curves: (a) drying rate versus drying time, (b) drying rate versus water content. 10

PowerPoint Presentation:
(a) and (b) Drying curves. The temperature and humidity of the drying air are constant and all heat is supplied to the food surface by convection.

DRYING SYSTEMS:
DRYING SYSTEMS Drying processes can be broadly classified, based on the water-removing method applied, as (A) Thermal drying (i) Air drying, (ii) Low air environment drying, and (iii) Modified atmosphere drying. (B) Osmotic dehydration (C) Mechanical dewatering 13

Thermal drying:
Thermal drying Heated Air Drying Sun drying Solar drying Puffing drying Spray drying Spouted bed drying Fluidized bed drying Centrifugal Fluidized-Bed Drying Drum drying 14

Heated Air Drying:
Heated Air Drying In the case of air drying, atmosphere is used as the drying medium and heat as different modes could be applied in the process. This is the simplest drying technique, which takes place in an enclosed and heated chamber. Air circulation can be horizontal or vertical to the layer or bed. The structure and composition, such as fat content, of a product affects the drying rate. Fig : Cactus membrane air dryer (for low pressure air drying technique). 15

PowerPoint Presentation:
16 Fig: Tunnel Dryers Fig : various types of air dryers Fig: Conveyor (or Belt) Dryers

Sun & solar drying:
Sun & solar drying Solar drying is an extension of sun drying that uses radiation energy from the sun. Solar drying is a non-polluting process and uses renewable energy. Moreover, solar energy is an abundant energy source that cannot be monopolized. However, solar drying has several drawbacks that limit its use in large-scale production. 17 Fig : shows typical solar drying process

Disadvantages in Sun &Solar drying:
Disadvantages in Sun &Solar drying The main disadvantages of this type of drying are (i) Contaminations from the environment, (ii) Product losses and contaminations by insects and birds, (iii) Floor space requirements, (iv) Difficulty in controlling the process, and (v) Bad odour, etc. 18

Puffing drying:
Puffing drying It is a process for puffing-drying fruit & vegetable foods at normal temperature. The process includes removing the free water from fruits and vegetables which have been washed, then put the fruits and vegetables into a reaction vessel, and vacuumizing the reaction vessel to 0.08-0.1 MPa, injecting carbon dioxide to 1.5-10.5 MPa, maintaining 30 seconds to 60 minutes, depressurizing to atmospheric pressure over 0.5-4 minutes so as to puff-dry the materials. Explosive puffing is designed to give small particles a porous structure ,By using a combination of high temperature and high pressure, and a sudden release of the pressure i.e. Explosion. 19

Spray drying :
Spray drying Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with a hot gas. Spray dryers can dry a product very quickly compared to other methods of drying. 20 Fig: Schematic diagram of a spray drying system. (Courtesy of APV Crepaco, Inc., Dryer Division, Attleboro Falls, MA.)

Spouted bed drying:
Spouted bed drying A spouted bed is normally a cylindrical vessel, with a conical base, loaded with particles. The cone is truncated to form a nozzle where warm air is fed in. The air feed flow rate should be enough to spout the particles. In a spouted bed dryer, a jet of heated gas enters the chamber at the centre of a conical base. The food particles are rapidly dispersed in the gas, and drying occurs in an operation similar to flash drying. A smaller flow rate would end the spout and an undesirable fixed bed operation would be started. 21

Fluidized bed drying:
Fluidized bed drying A fluidized bed is formed when a quantity of a solid particulate substance (usually present in a holding vessel) is placed under appropriate conditions to cause the solid/fluid mixture to behave as a fluid. This is usually achieved by the introduction of pressurized fluid through the particulate medium. 22

Centrifugal Fluidized-Bed Drying:
Centrifugal Fluidized-Bed Drying Fig: Schematic diagram of a centrifugal fluidized-bed dryer. 23 The centrifugal fluidized-bed dryer works on the same principle as the conventional fluidized-bed dryer except that a rotating chamber is used. In a spouted-bed dryer, the heated gas enters the chamber at the center of a conical base as a jet Another variation is the spin flash dryer. Hot air is introduced into the bottom of the chamber, which is rotated at relatively high speed .

Drum drying:
Drum drying Drum drying is one of the most energy-efficient drying methods and is particularly effective for drying high viscous liquid or pureed foods, such as baby foods, pureed vegetable, mashed potatoes, cooked starch, and spent yeast. Rotary drum dryers are cylindrical shells 1–5 m in diameter, 10–40 m in length, and rotating at 1–8 rpm with a circumferential speed of approximately 0.2–0.4 m/s. The energy consumption in a typical drum dryer ranges between 1.2 and 1.5kg steam per kg of evaporated water, corresponding to energy efficiencies of about 70–90%. Under ideal conditions, the maximum evaporation capacity of a drum dryer can be as high as 80kg H 2 O/hm 2 . 24 Fig: double drum dryer.

LOW AIR ENVIRONMENT DRYING:
LOW AIR ENVIRONMENT DRYING Freeze Drying Ball Drying Vacuum drying Heat pump drying Supercritical drying Smoking 25

Freeze Drying :
Freeze Drying The freeze-drying process There are three stages in the complete drying process: (i) Freezing, (ii) Primary drying, and (iii) Secondary drying. Properties of freeze-dried products Applications of freeze-drying in food Industry Freeze-drying equipment (i) Rotary evaporators, (ii) Manifold freeze-dryers, and (iii) Tray freeze-dryer 26

Ball Drying:
Ball Drying Fig: a typical Ball Drying process 27

Vacuum drying:
Vacuum drying Vacuum drying of food involves subjecting the food to a low pressure and a heating source. The vacuum allows the water to vaporize at a lower temperature than at atmospheric conditions, thus foods can be dried without exposure to high temperature. In addition, the low level of oxygen in the atmosphere diminishes oxidation reactions during drying. In general, color, texture, and flavour of vacuum-dried products are improved compared with air-dried products. Two of the special advantages of vacuum drying is that the process is more efficient at removing water from a food product, and it takes place more quickly than air drying. for example, the drying time of a fish fillet was reduced from about 16 hours by air drying to 6 hours as a result of vacuum drying. 28

Heat pump drying:
The heat pump dryer is a further extension of the conventional convection air dryer with an inbuilt refrigeration system. The use of the heat pump dryer offers several advantages over conventional hot air dryers for drying food products, including higher energy efficiency, better product quality, the ability to operate independent of outside ambient weather conditions, and zero environmental impact. The advantages of heat pump drying are Heat pumps offer levels of efficiency unattainable by boilers and electric heating; Heat pump reduces CO 2 emission and is recommended by various authorities. Table: General Comparison of Heat Pump Dryer with Vacuum and Hot-Air Drying 29 Heat pump drying Parameter Hot-Air Drying Vacuum Drying Heat Pump Drying SMER (kg water/kWh) 0.12–1.28 0.72–1.2 1.0–4.0 Drying efficiency (%) 35–40 > 70 95 Operating temperature range (°C) 40–90 30–60 10–65 Operating % RH range Variable Low 10–65 Capital cost Low High Moderate Running cost High Very high Low

Smoking:
Smoking Smoking is the process of flavoring, cooking, or preserving food by exposing it to the smoke from burning or smoldering plant materials, most often wood. Types of smoking Hot smoking Smoke-roasting Cold smoking Preservation - In the past, smoking was a useful preservation tool, in combination with other techniques, most commonly salt-curing or drying. 30

MODIFIED AND CONTROLLED ATMOSPHERE DRYING:
MODIFIED AND CONTROLLED ATMOSPHERE DRYING This is a new concept of drying foods using heat pump dryers, which uses modified atmospheres such as nitrogen and carbon dioxide, for better quality and preservation of constituents of foods, prone to oxidation also called as Modified atmosphere heat pump dehumidifier MAHPD drying. It was found that apple tissues dried by MAHPD had lighter color, lower bulk density values, porous (noncollapsed) structure, and better rehydration properties compared with those dried by most other common drying methods. Studies have shown that Fruits dried by MAHPD retained the highest levels of nutrients, such as vitamin C, and flavour compounds 31

OTHER DRYING METHODS:
OTHER DRYING METHODS Refractance Window TM Drying Method Microwave Drying and Radio Frequency Drying Microwave-Augmented Freeze Drying 32

Refractance WindowTM Drying Method:
Refractance Window TM Drying Method The Refractance WindowTM drying system is a novel drying method developed by MCD Technologies, Inc. (Tacoma, WA). It utilizes circulating water at 95–97 0 C as a means to carry thermal energy to materials to be dehydrated. Pureed products are spread on a transparent plastic conveyer belt that moves over circulating water in a shallow trough. The unused heat in the circulating water is recycled. The dried products are then moved over a cold water trough to enable easy separation of the product from the belt by the scraper device. Products on the moving belt dry rapidly. It is effective in drying pureed vegetables, algae, fruits, and liquid eggs. In particular, it can be used to dry pureed fruits with high sugar contents with no need of a carrier (such as maltodextrin). The energy efficiency of an RW system can be as high as 70%, and the system can result in over 6 log reduction of vegetative bacterial cells. 33

Microwave Drying and Radio Frequency Drying:
Microwave Drying and Radio Frequency Drying Microwave drying uses the electromagnetic radiation in the microwave frequency range (300– 3,000MHz) as a form of energy to dry food products. Microwave drying systems take advantage of

the fact that microwaves directly interact with polar molecules, especially water, in moist foods to generate heat for moisture evaporation. Research has demonstrated that microwave heating in combination with a fluidized bed can be very effective in increasing drying rates of particulate products during the falling rate periods while maintaining a relatively low product temperature to retain product quality Microwave drying is currently used commercially to finish dry pasta products. Electromagnetic energy in the radio frequency range 1–100MHz has also been extensively used to finish dry crackers and cookies as well as some cereal products. 34

Microwave-Augmented Freeze Drying:
Microwave-Augmented Freeze Drying Conventional freeze-drying can be speeded up by using a volumetric heating mode, such as microwaves This dryer is basically a conventional freeze dryer that has the added capability of allowing microwaves to be introduced within the drying chamber. In all cases the drying time was reduced to between one third and One half the times required without the use of the microwaves. 35 Fig: Schematic diagram of a microwave-augmented freeze-dryer.

PRETREATMENTS BEFORE DRYING:
PRETREATMENTS BEFORE DRYING Sulphur dioxide treatments Blanching Salting or curing Salt Sugar Nitrates and nitrites Cooking Dipping Pretreatments 36

Dipping Pretreatments:
Dipping Pretreatments 37 Type Compounds Chemicals Esters Methyl oleate, ethyl oleate, butyl oleate Salts Potassium carbonate, sodium carbonate, sodium chloride, potassium sorbate , sodium polymetaphosphate Organic acids Oleic acid, steric acid, caprillic acid, tartaric acid, oleanolic acid Oils Olive oil Alkali Sodium hydroxide Wetting agents Pectin, tween, nacconol Others Sugar, liquid pectin Surfactants Nonionic Monoglycerides , diglycerides , alkylated aryl polyester alcohol, polyoxyethylene sorbitan monostearate , sorbitan monostearate , D- sorbitol , Anionic Sodium oleate, steric acid, sorbitan heptadecanyl sulfate , Esters Methyl oleate, ethyl oleate, butyl oleate Salts Potassium carbonate, sodium carbonate, sodium chloride, potassium sorbate , sodium polymetaphosphate Organic acids Oleic acid, steric acid, caprillic acid, tartaric acid, oleanolic acid Oils Olive oil Alkali Sodium hydroxide Wetting agents Pectin, tween , nacconol Others Sugar, liquid pectin

Selection of New Drying Systems:
Selection of New Drying Systems 38 Technique Suitability/current usage Advantages Disadvantages Microwave drying and radio frequency, drying High value-added products, pasta, cookies Good for finishing, drying, low temperature, batch or continuous operation, good quality May be expensive Microwave-augmented freeze-drying High value-added products Low temperature rapid, good quality Expensive Centrifugal fluidized bed drying Small particles, vegetable pieces, powders Rapid, easy to control Loss of product integrity, noisy Ball drying Small particles, vegetable pieces Relatively low temperature, rapid, continuous Loss of product integrity, difficult to control Ultrasonic drying Liquids Rapid Requires low-fat solutions

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Technique Suitability/current usage Advantages Disadvantages Smoking Meat, fish Added flavors Difficult to control, slow Cabinet tray dryer or tunnel dryer Fruit, vegetables, meat and fish Batch or semi continuous (for tunnel dryer), flexible Relatively small throughputs, poor control of quality Conveyor dryer Diced vegetables and fruit Continuous, large throughputs, consistent quality large floor space required; some thermal degradation Drum drying Liquids, pureed fruit and vegetable Continuous, high energy efficiency May require modification of liquid to allow good adhesion to the drum wall Spray drying Liquids, instant tea, coffee Spherical product Some quality loss Fluidized-bed drying Small uniform particles, small vegetable Usually batch operation, uniform drying, rapid Restriction on particle size Freeze-drying High value products, fruit pieces, instant coffee, vegetables, dairy products, meats Can be used in continuous operation, no restriction on particle size, excellent retention of product sensory, physical, and Nutritive characteristics Slow, expensive, fragile product, need good package material to prevent oxidation Explosive puffing Gives small particles Good rehydratability, rapid High heat, loss of product integrity Osmotic drying Sugar-infused fruit High quality Multiple-step process Refractance Window Pureed products High quality Continuous, still in perfection stage 39

Conclusion:
Conclusion Drying is one of the most energy and economically efficient preservation process. When different preservation techniques applied with drying it gives better product. Each drying method may be particularly suited for a specific group of products so while applying the methods detailed study of the product and method should be done. 40