Post Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

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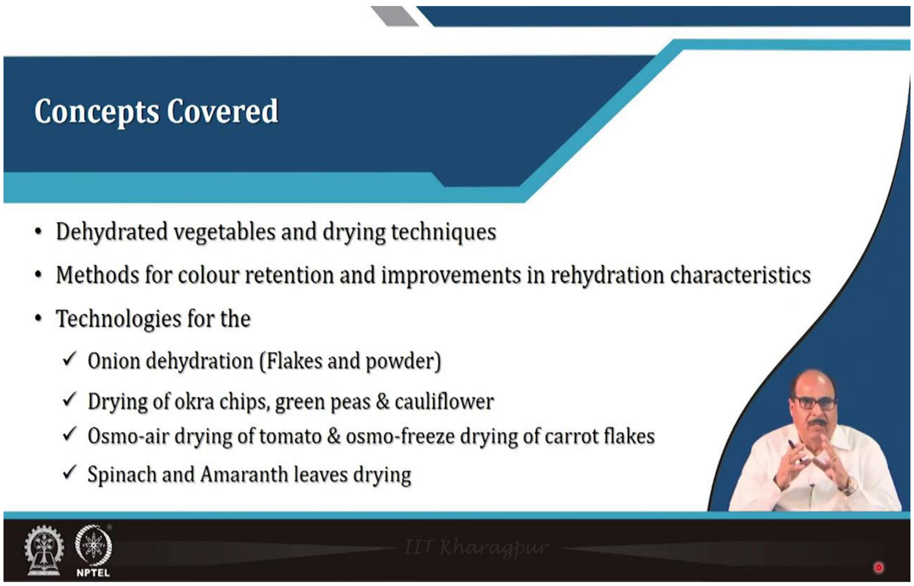
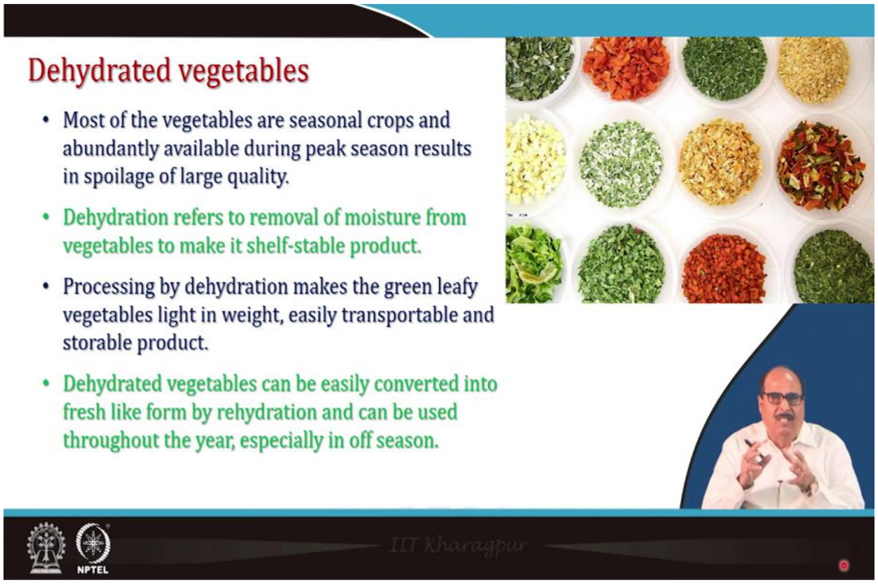
Lecture 35
Dehydrated and Instant Cooking Vegetables

Hello everybody, Namaskar.

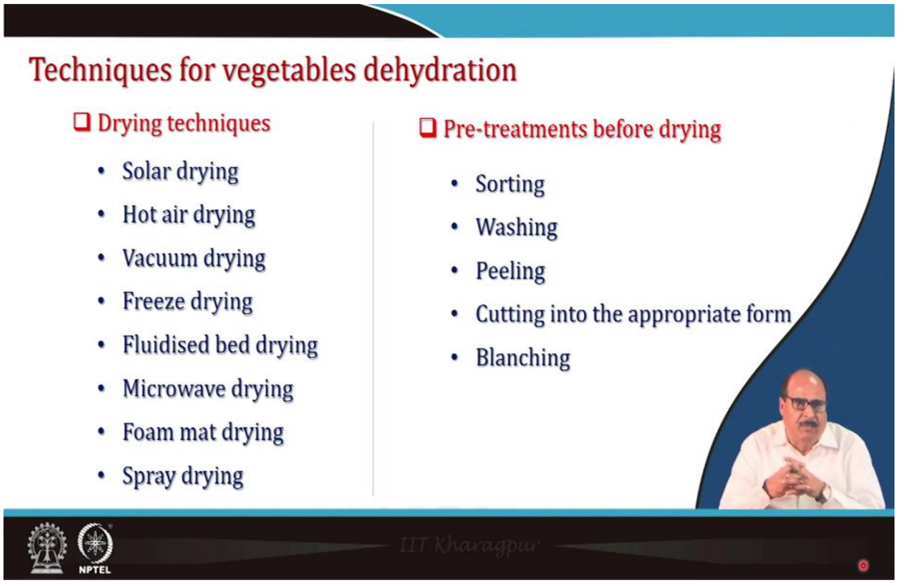


In this lecture, we will see what are dehydrated vegetables and drying techniques, methods for colour retention and improvements in rehydration characteristics, technologies for onion dehydration (Flakes and powder), drying of okra chips, green peas & cauliflower, osmo-air drying of tomato & osmo-freeze drying of carrot flakes, and spinach and amaranth leaves drying.

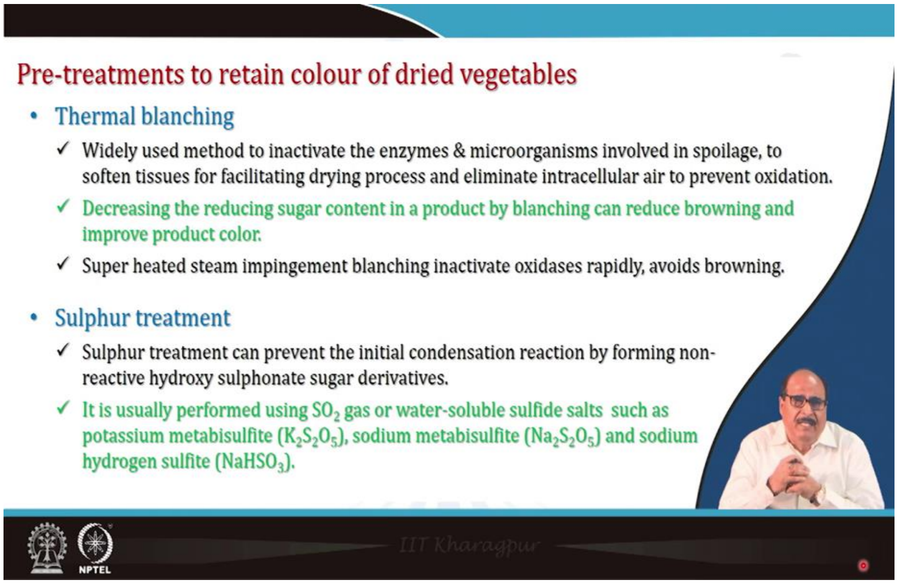


Dehydrated vegetables

Most of the vegetables are seasonal crops and abundantly available during peak season results in spoilage of large quality. Dehydration refers to removal of moisture from vegetables to make it shelf-stable product. Processing by dehydration makes the green leafy vegetables light in weight, easily transportable and storable product. Dehydrated vegetables can be easily converted into fresh like form by rehydration and can be used throughout the year, especially in off season.



Various techniques used for dehydrating vegetables are solar drying, hot air drying, vacuum drying, freeze drying, fluidized bed drying, microwave drying, foam mat drying, spray drying, depending upon the type of the end product required. The pretreatment methods are very important operation before the dehydration of vegetables. Some of the pre-treatment methods are sorting, washing, peeling, cutting into the appropriate form and blanching.



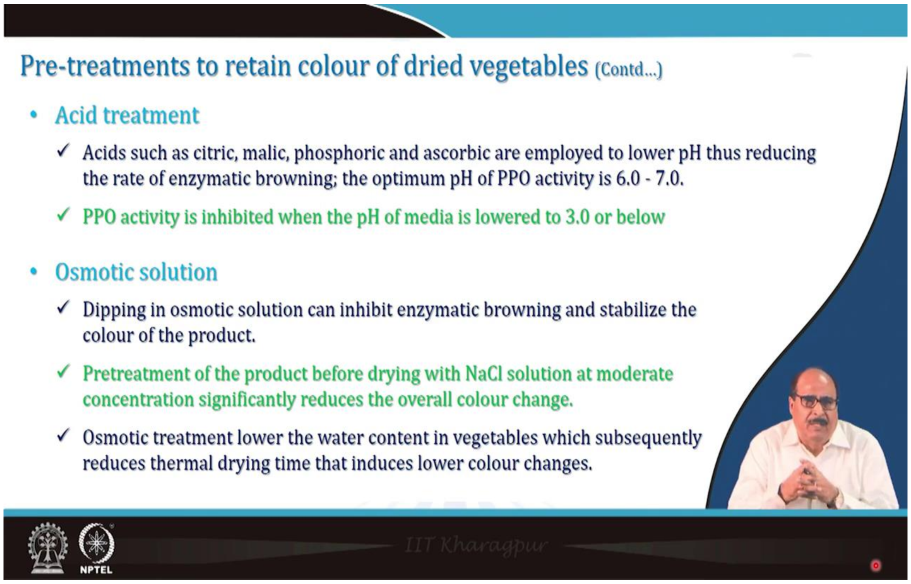
Pre-treatments to retain colour of dried vegetables:

Thermal blanching

Widely used method to inactivate the enzymes & microorganisms involved in spoilage, to soften tissues for facilitating drying process and eliminate intracellular air to prevent oxidation. Decreasing the reducing sugar content in a product by blanching can reduce browning and improve product color. Super heated steam impingement blanching inactivate oxidases rapidly, avoids browning.

Sulphur treatment

Sulphur treatment can prevent the initial condensation reaction by forming non-reactive hydroxy sulphonate sugar derivatives. It is usually performed using SO2 gas or water-soluble sulfide salts such as potassium metabisulfite (K2S2O5), sodium metabisulfite (Na2S2O5) and sodium hydrogen sulfite (NaHSO3).

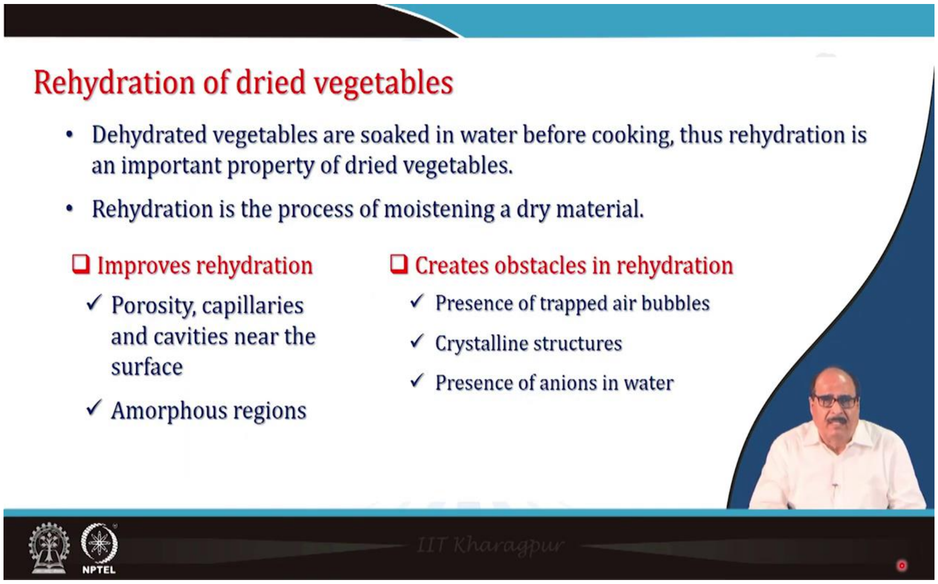


Acid treatment

Acids such as citric, malic, phosphoric and ascorbic are employed to lower pH thus reducing the rate of enzymatic browning; the optimum pH of PPO activity is 6.0 - 7.0. PPO activity is inhibited when the pH of media is lowered to 3.0 or below.

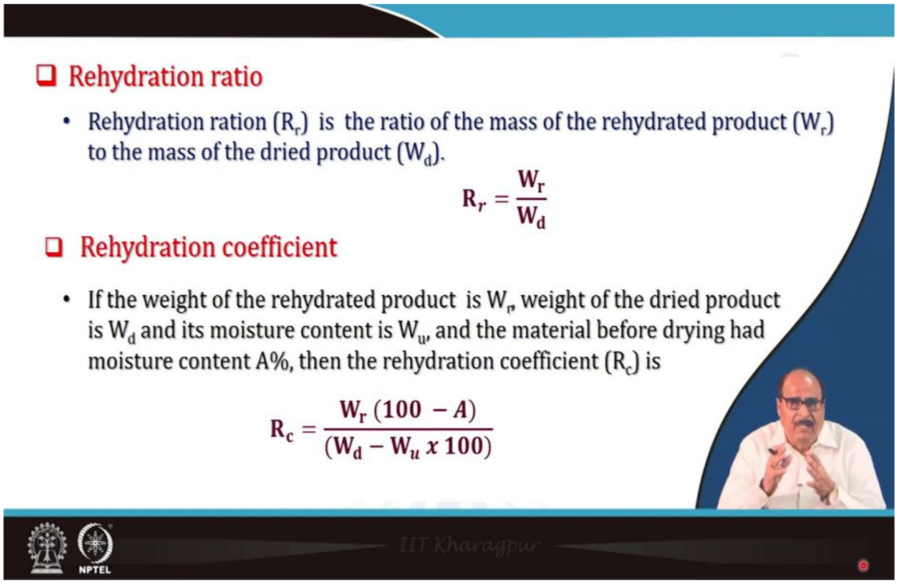
Osmotic solution

Dipping in osmotic solution can inhibit enzymatic browning and stabilize the colour of the product. Pretreatment of the product before drying with NaCl solution at moderate concentration significantly reduces the overall colour change. Osmotic treatment lowers the water content in vegetables which subsequently reduces thermal drying time that induces lower colour changes.



Rehydration of dried vegetables

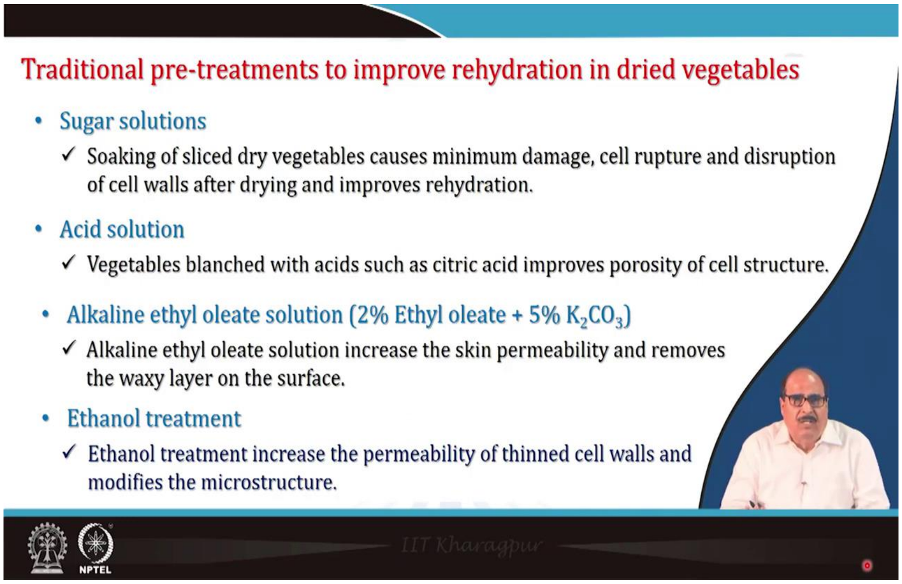
Dehydrated vegetables are soaked in water before cooking, thus rehydration is an important property of dried vegetables. Rehydration is the process of moistening a dry material. Factors improving rehydration are porosity, capillaries and cavities near the surface and amorphous regions whereas factors which create obstacles in rehydration are presence of trapped air bubbles, crystalline structures and presence of anions in water.



Rehydration ratio (Rr): It is the ratio of the mass of the rehydrated product (Wr) to the mass of the dried product (Wd).

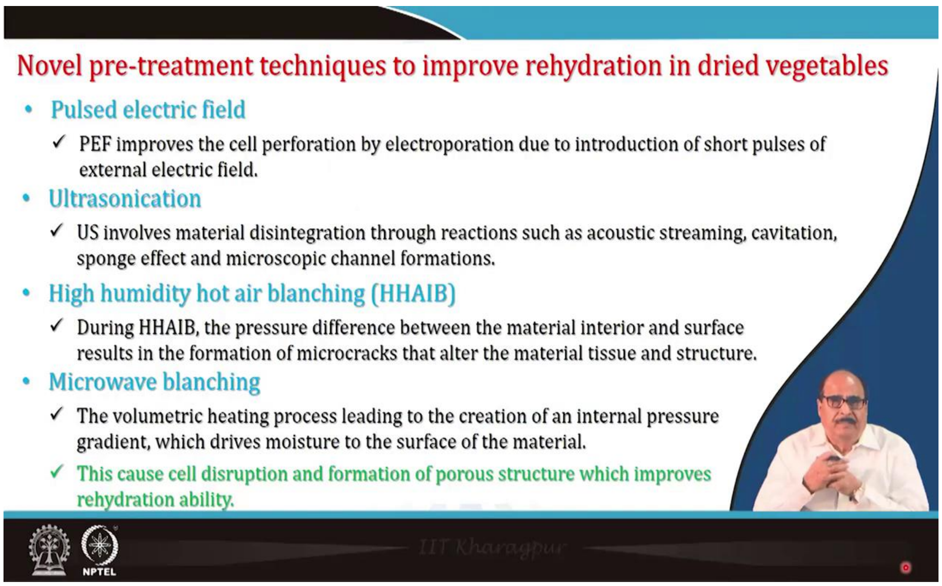
Rehydration coefficient (Rc): If the weight of the rehydrated product is Wr, weight of the dried product is Wd and its moisture content is Wu, and the material before drying had moisture content A%, then the rehydration coefficient (Rc) is

$$R_c = \frac{W_r\,(100\ - A)}{(W_d\ -\ W_u\ x\ 100)}$$



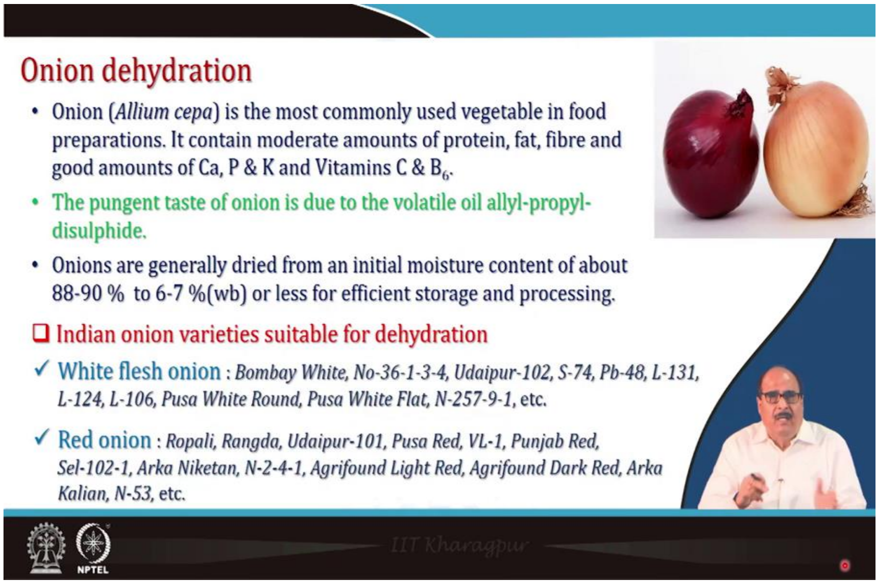
Traditional pre-treatments to improve rehydration in dried vegetables:

Sugar solutions: Soaking of sliced dry vegetables causes minimum damage, cell rupture and disruption of cell walls after drying and improves rehydration. **Acid solution:** Vegetables blanched with acids such as citric acid improves porosity of cell structure. **Alkaline ethyl oleate solution:** Alkaline ethyl oleate solution increases the skin permeability and removes the waxy layer on the surface. **Ethanol treatment:** Ethanol treatment increases the permeability of thinned cell walls and modifies the microstructure.



Novel pre-treatment techniques to improve rehydration in dried vegetables

Pulsed electric field: PEF improves the cell perforation by electroporation due to introduction of short pulses of external electric field. Ultrasonication: US involves material disintegration through reactions such as acoustic streaming, cavitation, sponge effect and microscopic channel formations. High humidity hot air blanching (HHAIB): During HHAIB, the pressure difference between the material interior and surface results in the formation of micro cracks that alter the material tissue and structure. Microwave-blanching: The volumetric heating process leading to the creation of an internal pressure gradient, which drives moisture to the surface of the material. This cause cell disruption and formation of porous structure which improves rehydration ability.



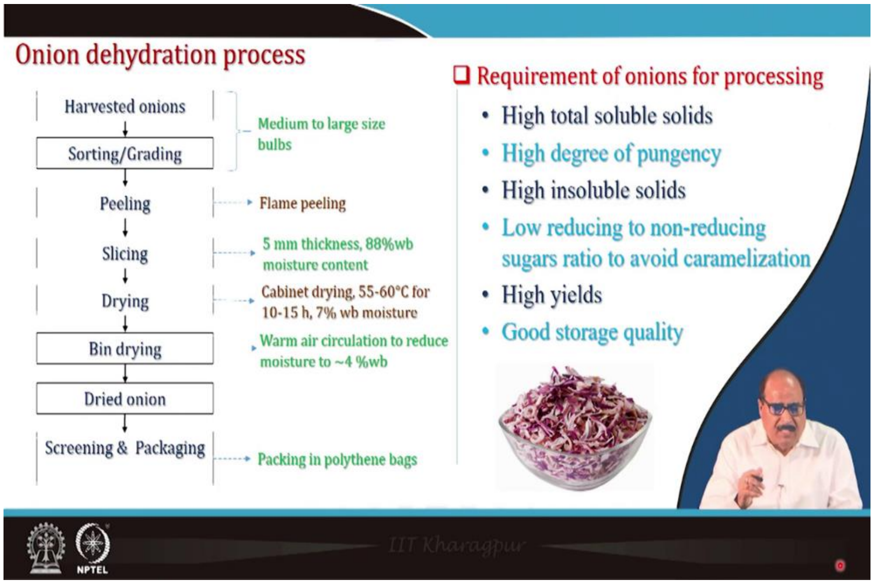
Onion dehydration

Onion (Allium cepa) is the most commonly used vegetable in food preparations. It contains moderate amounts of protein, fat, fibre and good amounts of Ca, P & K and Vitamins C & B6. The pungent taste of onion is due to the volatile oil allyl-propyl-disulphide. Onions are generally dried from an initial moisture content of about 88-90 % to 6-7 % (wb) or less for efficient storage and processing.

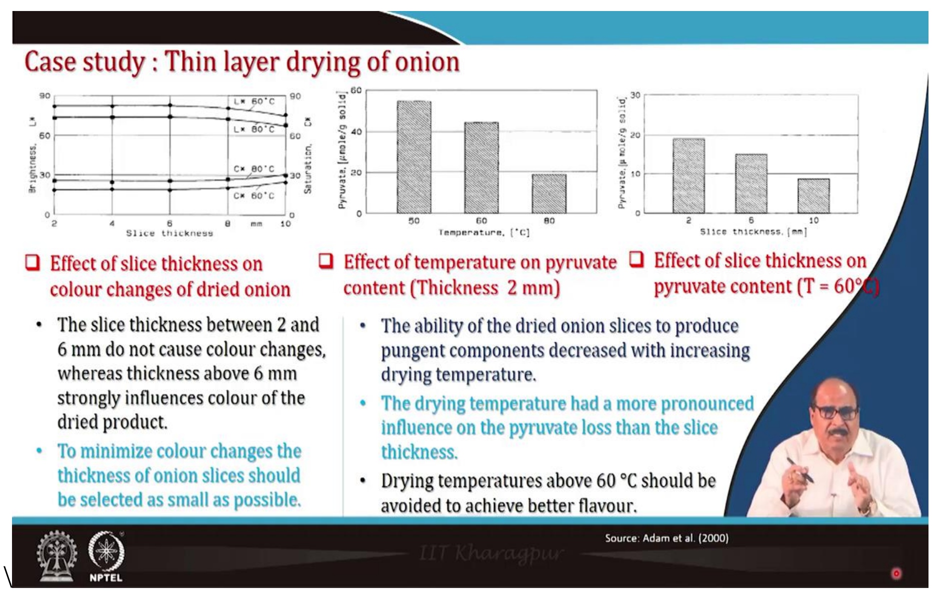
Indian onion varieties suitable for dehydration

White flesh onion: Bombay White, No-36-1-3-4, Udaipur-102, S-74, Pb-48, L-131, L-124, L-106, Pusa White Round, Pusa White Flat, N-257-9-1, etc.

Red onion: Ropali, Rangda, Udaipur-101, Pusa Red, VL-1, Punjab Red, Sel-102-1, Arka Niketan, N-2-4-1, Agrifound Light Red, Agrifound Dark Red, Arka Kalian, N-53, etc.



Onion drying process include harvesting and sorting/grading of medium to large size bulbs, peeling (flame peeling), slicing (5 mm thickness, 88%wb moisture content), drying (Cabinet drying, 55-60°C for 10-15 h, 7% wb moisture), bin drying (Warm air circulation to reduce moisture to ~4 %wb), screening and packaging of dried onions (Packing in polythene bags). Requirement of onions for processing are High total soluble solids high degree of pungency, high insoluble solids, low reducing to non-reducing sugars ratio to avoid caramelization, high yields and good storage quality.



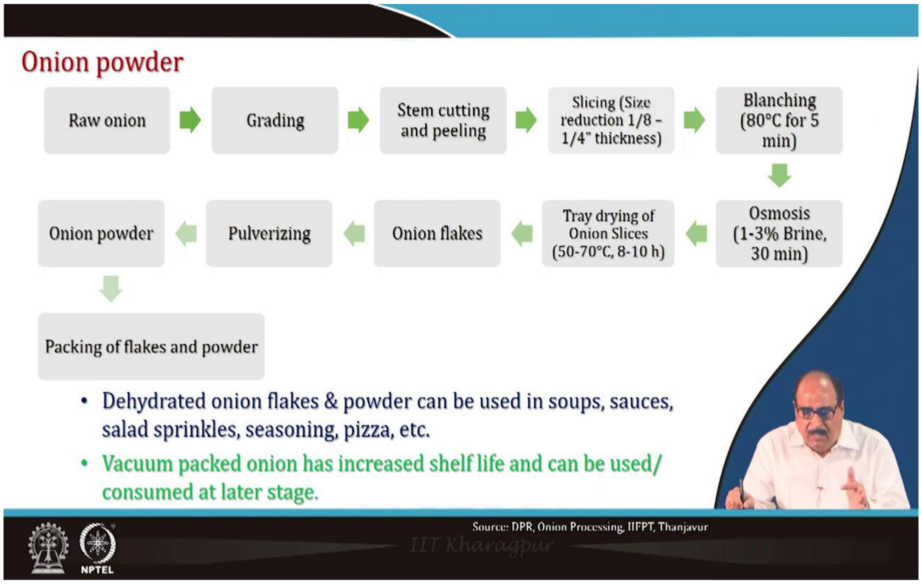
Case study: Thin layer drying of onion

Effect of slice thickness on colour changes of dried onion

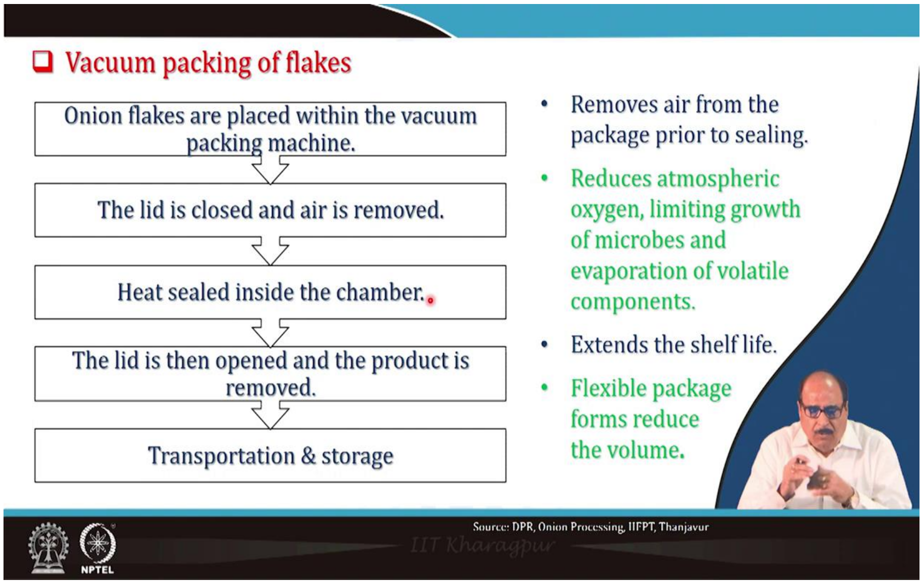
The slice thickness between 2 and 6 mm do not cause colour changes, whereas thickness above 6 mm strongly influences colour of the dried product. To minimize colour changes the thickness of onion slices should be selected as small as possible.

Effect of temperature on pyruvate content (Thickness 2 mm)

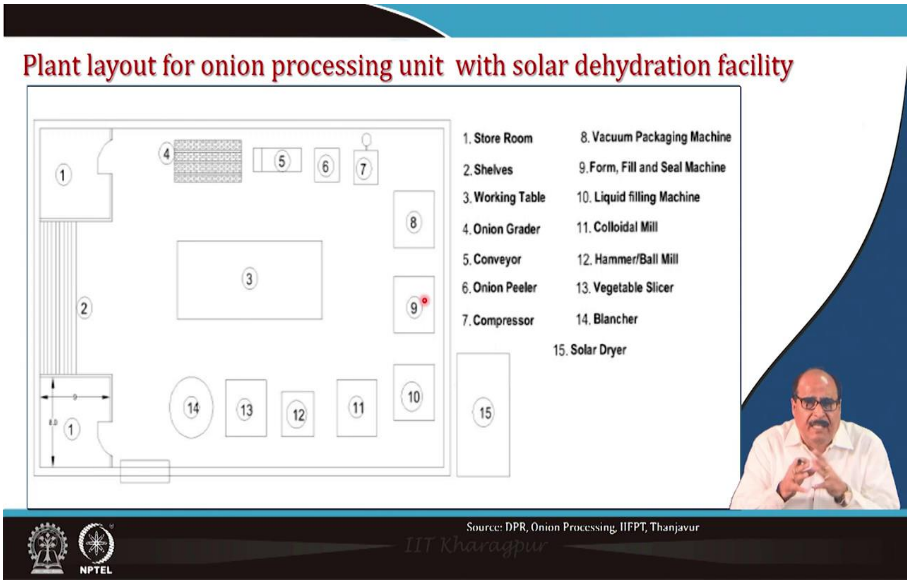
The ability of the dried onion slices to produce pungent components decreased with increasing drying temperature. The drying temperature had a more pronounced influence on the pyruvate loss than the slice thickness. Drying temperatures above 60 °C should be avoided to achieve better flavour.



This is the process flow chart for the onion powder production. Raw onion is taken for grading, stem cutting and peeling, slicing (Size reduction 1/8 – 1/4" thickness), blanching (80°C for 5 min), osmosis (1-3% Brine, 30 min), tray drying of onion slices (50-70°C, 8-10 h) to prepare the onion flakes, pulverizing is done to produce onion powder and Packing of flakes and powder is done in the final step. Dehydrated onion flakes & powder can be used in soups, sauces, salad sprinkles, seasoning, pizza, etc. Vacuum packed onion has increased shelf life and can be used/ consumed at later stage.



For vacuum packaging of onion flakes onion flakes are placed within the vacuum packing machine. The lid is closed and air is removed. Heat sealed inside the chamber. The lid is then opened and the product is removed. Finally Transportation & storage is done. Vacuum packaging removes air from the package prior to sealing, reduces atmospheric oxygen, limiting growth of microbes and evaporation of volatile components, extends the shelf life, Flexible packaging forms reduce the volume.

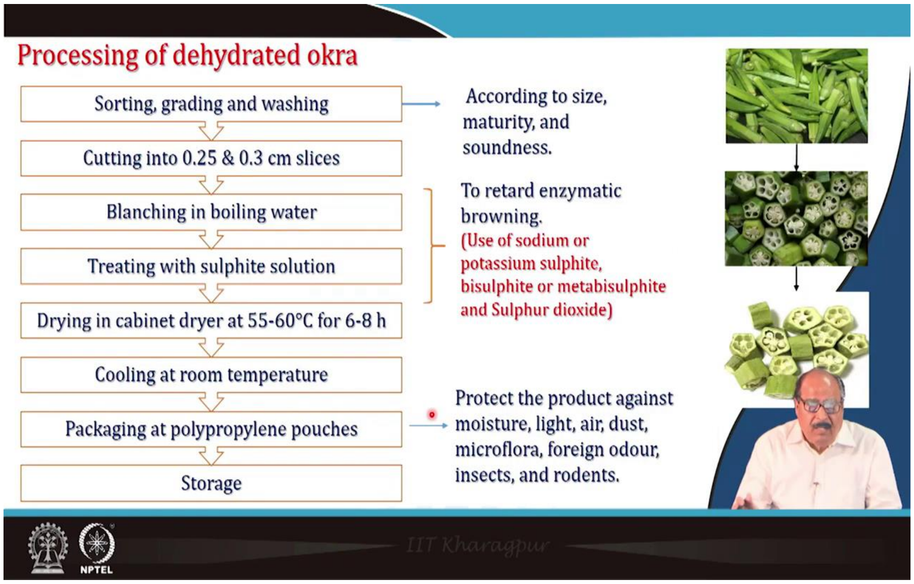


Plant layout for onion processing unit with solar dehydration facility

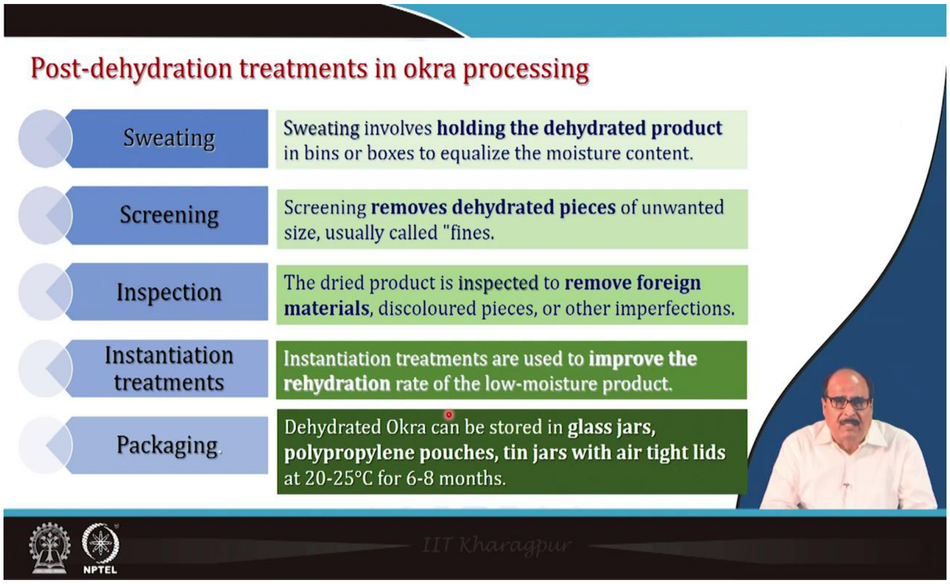
The plant layout in the figure includes 1- Store room, 2-Shelves, 3-working table, 4-onion grader, 5-coveyor, 6-onion peeler, 7-compressor, 8-vacuum packaging machine, 10-liquid filling machine, 11-colloidal mill, 12-hammer mill/ball mill, 13-vegetable slicer, 14-blancher and 15-solar dryer.

Dehydrated okra

Okra chips are a dehydrated version of okra. It can be consumed as a low-calorie snack. Salt, spices and vegetable oils are added to boost its flavour & lengthen shelf life. Okra's suitability for drying is fair to good. Okra chips are a good source of potassium, magnesium, Vitamin A, calcium and folate.



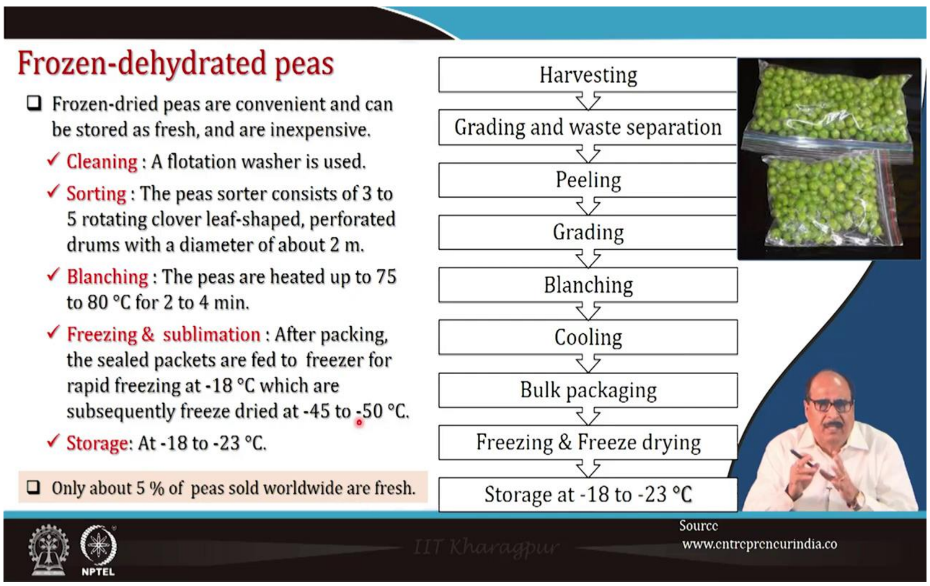
Processing of dehydrated okra include sorting, grading and washing according to size, maturity, and soundness, cutting into 0.25 & 0.3 cm slices, blanching in boiling water and treating with sulphite solution (use of sodium or potassium sulphite, bisulphite or metabisulphite and Sulphur dioxide) to retard enzymatic browning, drying in cabinet dryer at 55-60°C for 6-8 h, cooling at room temperature, packaging at polypropylene pouches and storage in order to protect the product against moisture, light, air, dust, microflora, foreign odour, insects, and rodents.



Post-dehydration treatments in okra processing

Sweating: Sweating involves the holding the dehydrated product in bins or boxes to equalize the moisture content. **Screening:** Screening removes dehydrated pieces of unwanted size, usually called fines. **Inspection:** The dried product is inspected to remove foreign materials, discoloured pieces, or other imperfections. **Instantiation treatments:** Instantiation treatments are used to improve the rehydration rate of the low-moisture product. **Packaging:** Dehydrated Okra can be stored in glass jars, polypropylene pouches, tin jars with air tight lids at 20-25°C for 6-8 months.

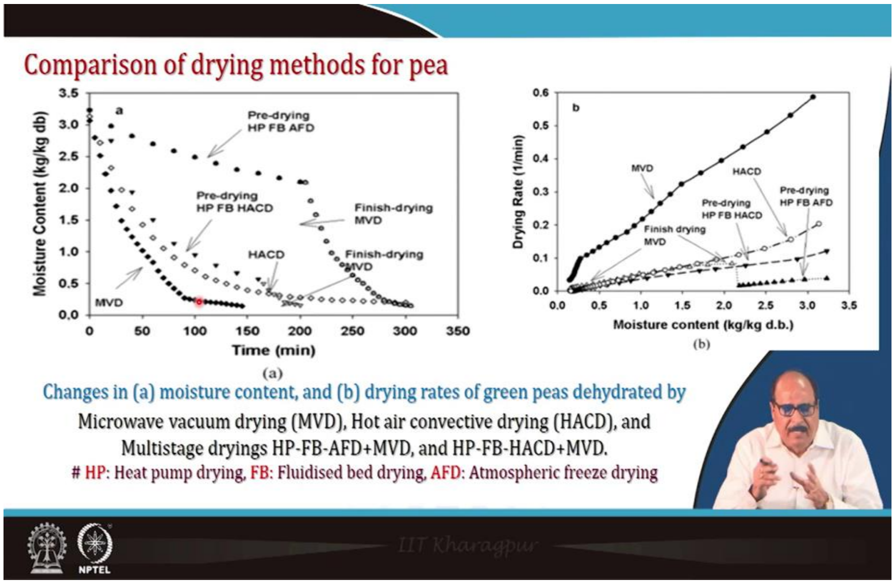
The machineries involved for processing of okra are Roller brush washer, Universal slicer, Blanching tank, Vacuum packaging machine, Impulse heat sealer electric power and Tray dryer.



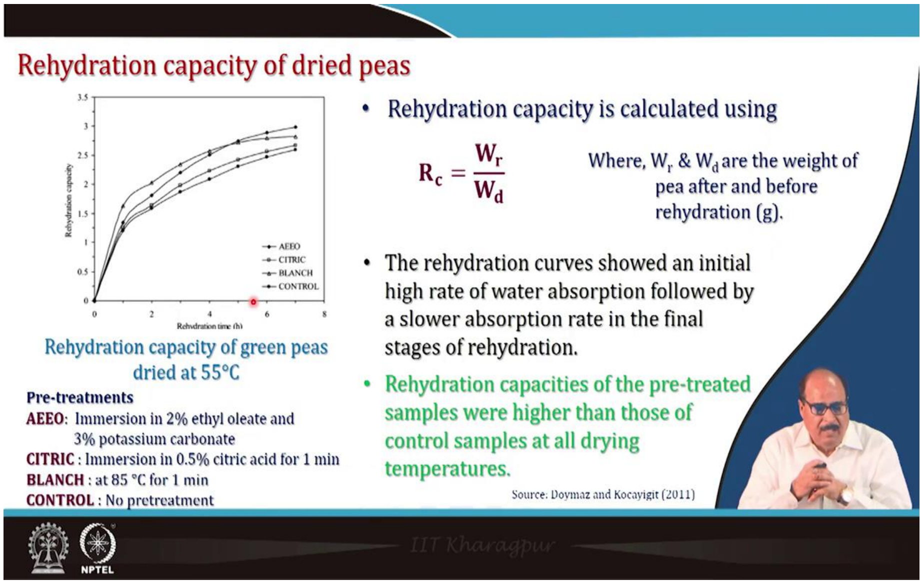
Frozen-dehydrated peas

Frozen-dried peas are convenient and can be stored as fresh, and are inexpensive. Cleaning: A flotation washer is used. Sorting: The peas sorter consists of 3 to 5 rotating clover leaf-shaped, perforated drums with a diameter of about 2 m. Blanching: The peas are heated up to 75 to 80 °C for 2 to 4 min. Freezing & sublimation: After packing, the sealed packets are fed to freezer for rapid freezing at -18 °C which are subsequently freeze dried at -45 to -50 °C. Storage: At -18 to -23 °C. Only about 5 % of peas sold worldwide are fresh. The processing steps involve harvesting, grading and waste separation, peeling, grading, blanching, cooling, bulk packaging, freezing and freeze drying, and Storage at -18 to -23 °C.

The equipments used in freeze drying of peas are Bubble cleaning machine, Pea sheller, Screw blancher, Packaging machine, and Freeze dryer.

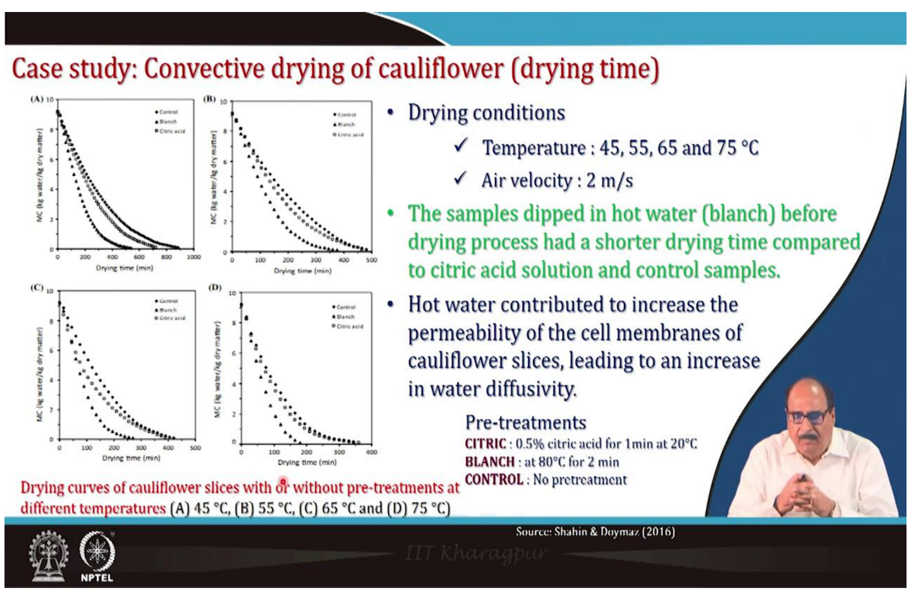


Here is the comparison of drying methods of pea. There are two graphs, one is moisture content versus time and other is drying rate versus moisture content. Different drying methods such as Microwave vacuum drying (MVD), Hot air convective drying (HACD), and Multistage dryings HP-FB-AFD+MVD, and HP-FB-HACD+MVD have been plotted and shown in the graphs. All these processes were applied in combination and permutations to know the affecting parameters. The microwave vacuum drying is found better among all the processes.



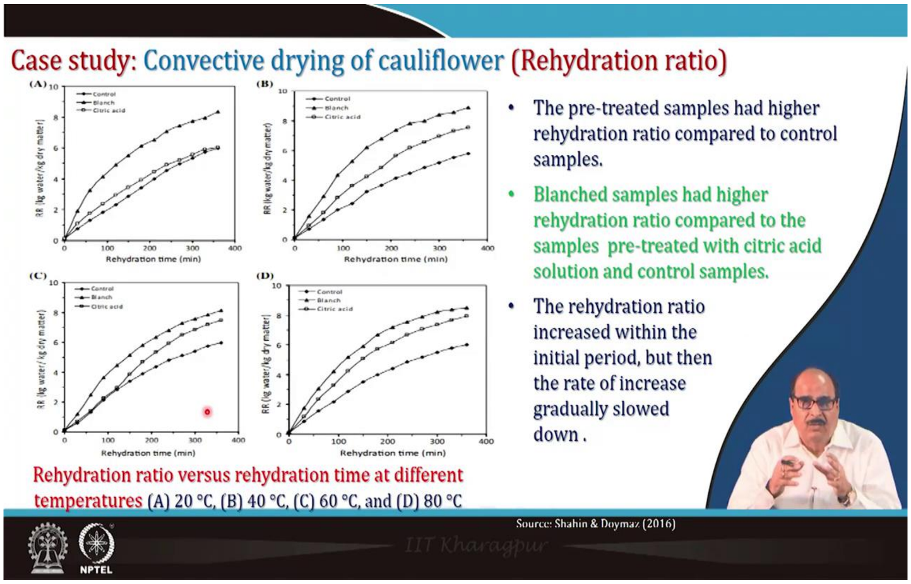
Rehydration capacity of dried peas

Rehydration capacity is the ratio of W_r & W_d Where, W_r & W_d are the weight of pea after and before rehydration (g). The rehydration curves showed an initial high rate of water absorption followed by a slower absorption rate in the final stages of rehydration. Rehydration capacities of the pre-treated samples were higher than those of control samples at all drying temperatures. Rehydration capacity of green peas dried at 55°C employing different pre-treatments such as AEEO: Immersion in 2% ethyl oleate and 3% potassium carbonate, CITRIC : Immersion in 0.5% citric acid for 1 min, BLANCH : at 85 °C for 1 min, CONTROL : No pretreatment have been shown in the plot.



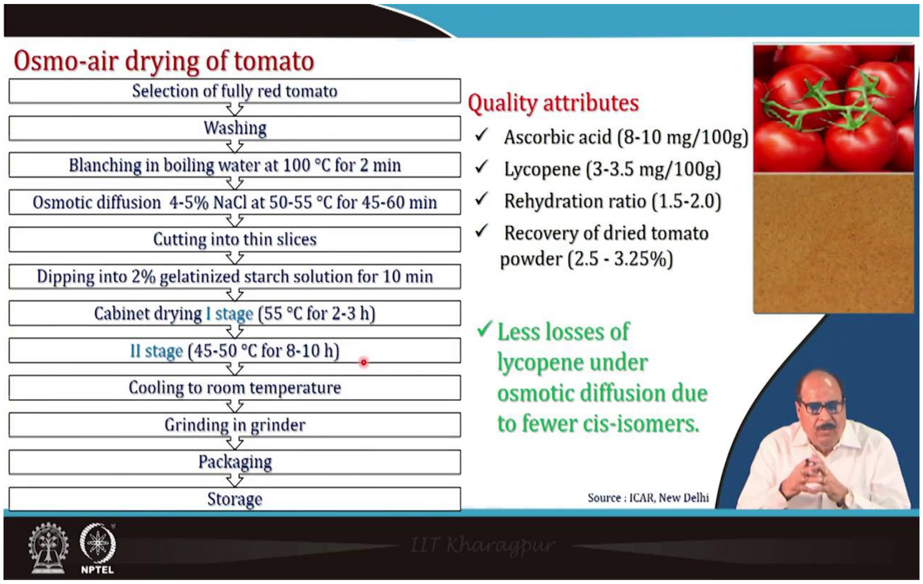
Case study: Convective drying of cauliflower (drying time)

Drying conditions were temperature: 45, 55, 65 and 75 °C and air velocity: 2 m/s. The samples dipped in hot water (blanch) before drying process had a shorter drying time compared to citric acid solution and control samples. Hot water contributed to increase the permeability of the cell membranes of cauliflower slices, leading to an increase in water diffusivity. Pre-treatments used were CITRIC: 0.5% citric acid for 1min at 20°C, BLANCH: at 80°C for 2 min and CONTROL: No pretreatment. Drying curves of cauliflower slices with or without pre-treatments at different temperatures (A) 45 °C, (B) 55 °C, (C) 65 °C and (D) 75 °C) have been shown in the drying rate plots.



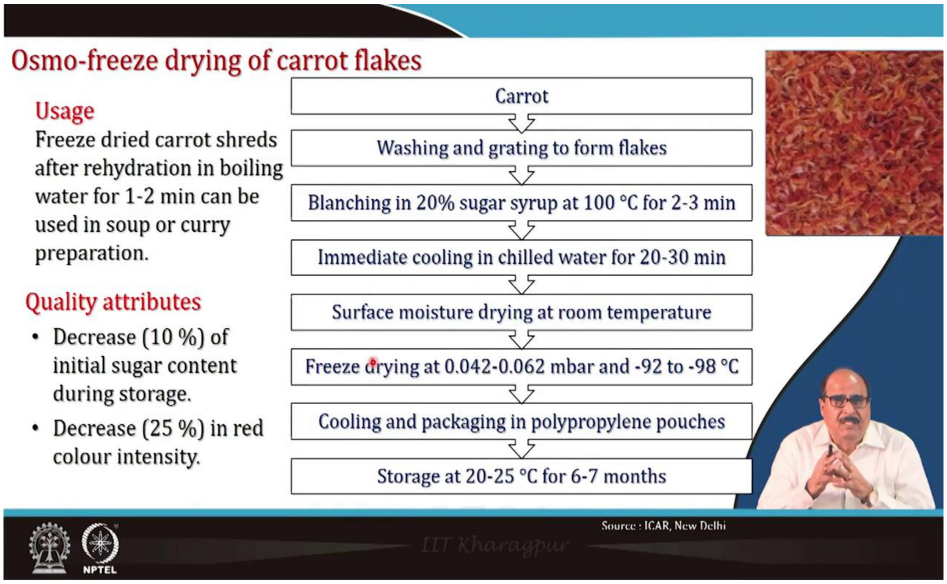
Case study: Convective drying of cauliflower (Rehydration ratio)

The pre-treated samples had higher rehydration ratio compared to control samples. Blanched samples had higher rehydration ratio compared to the samples pre-treated with citric acid solution and control samples. The rehydration ratio increased within the initial period, but then the rate of increase gradually slowed down. Rehydration ratio versus rehydration time at different temperatures (A) 20 °C, (B) 40 °C, (C) 60 °C, and (D) 80 °C have been plotted.



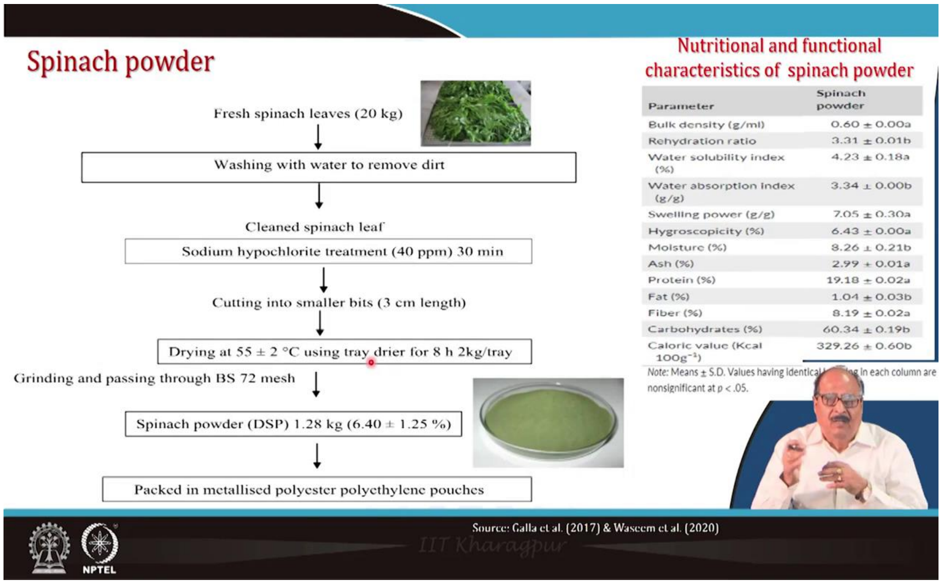
Osmo-air drying of tomato

- ✓ The processing involve selection of fully red tomato, washing, Blanching in boiling water at 100 °C for 2 min, Osmotic diffusion 4-5% NaCl at 50-55 °C for 45-60 min, Cutting into thin slices, Dipping into 2% gelatinized starch solution for 10 min, Cabinet drying I stage (55 °C for 2-3 h), II stage (45-50 °C for 8-10 h), Cooling to room temperature, Grinding in grinder, Packaging and Storage. Quality attributes are Ascorbic acid (8-10 mg/100g), Lycopene (3-3.5 mg/100g), Rehydration ratio (1.5-2.0), and Recovery of dried tomato powder (2.5 - 3.25%). There is less losses of lycopene under osmotic diffusion due to fewer cis-isomers.

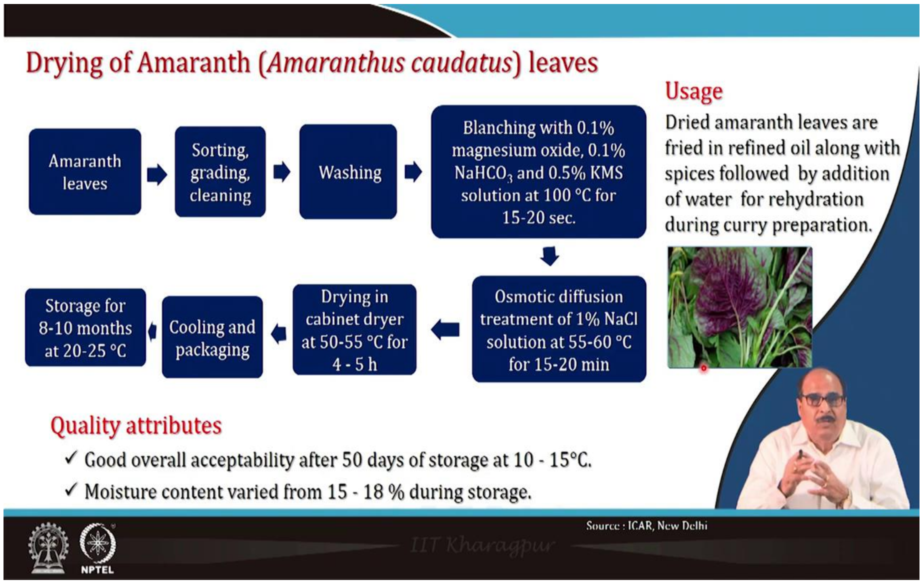


Osmo-freeze drying of carrot flakes

The process flow chart involve the selection of god carrots, Washing and grating to form flakes, Immediate cooling in chilled water for 20-30 min, Surface moisture drying at room temperature, Freeze drying at 0.042-0.062 mbar and -92 to -98 °C, Cooling and packaging in polypropylene pouches, Storage at 20-25 °C for 6-7 months. Freeze dried carrot shreds after rehydration in boiling water for 1-2 min can be used in soup or curry preparation. Changes in quality attributes include decrease (10 %) of initial sugar content during storage and decrease (25 %) in red colour intensity.

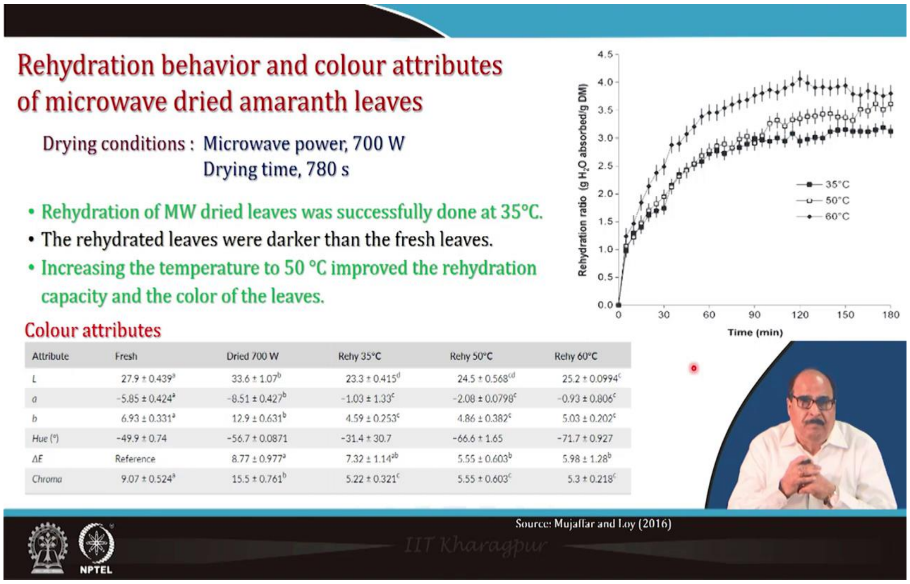


Process flow chart for spinach powder production include collection of fresh spinach leaves, washing with water to remove dirt, sodium hypochlorite treatment, cutting into smaller bits, drying using tray dryer, grinding and passing through 72 mesh, packaged in metalized polyester polyethylene pouches. Nutritional and functional characteristics of spinach powder are shown in the table.



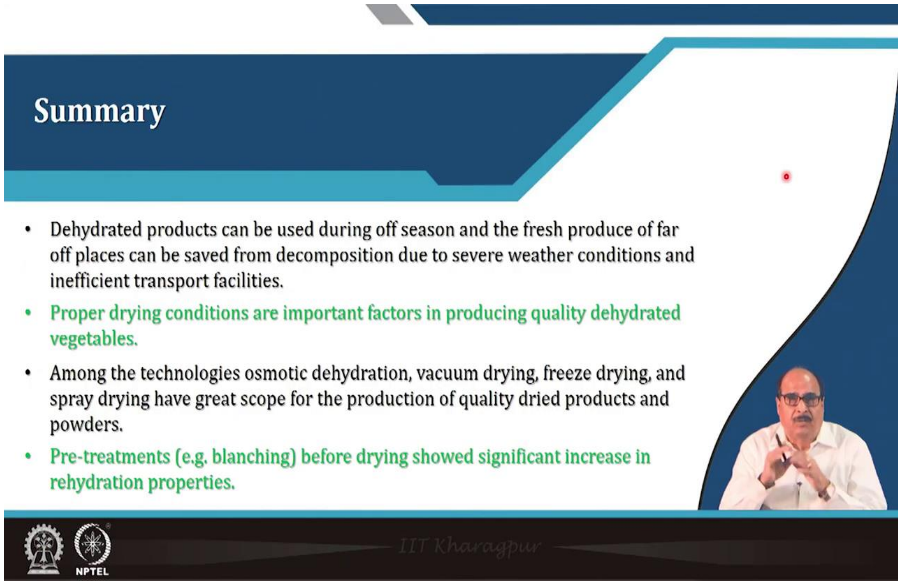
Drying of Amaranth (*Amaranthus caudatus*) leaves

Amaranth leaves are taken for Sorting, grading, cleaning, washing, Blanching with 0.1% magnesium oxide, 0.1% NaHCO3 and 0.5% KMS solution at 100 °C for 15-20 sec, Osmotic diffusion treatment of 1% NaCl solution at 55-60 °C for 15-20 min, Drying in cabinet dryer at 50-55 °C for 4 - 5 h, Cooling and packaging, and Storage for 8-10 months at 20-25 °C. Quality attributes include good overall acceptability after 50 days of storage at 10 - 15°C and moisture content varied from 15 - 18 % during storage. Dried amaranth leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

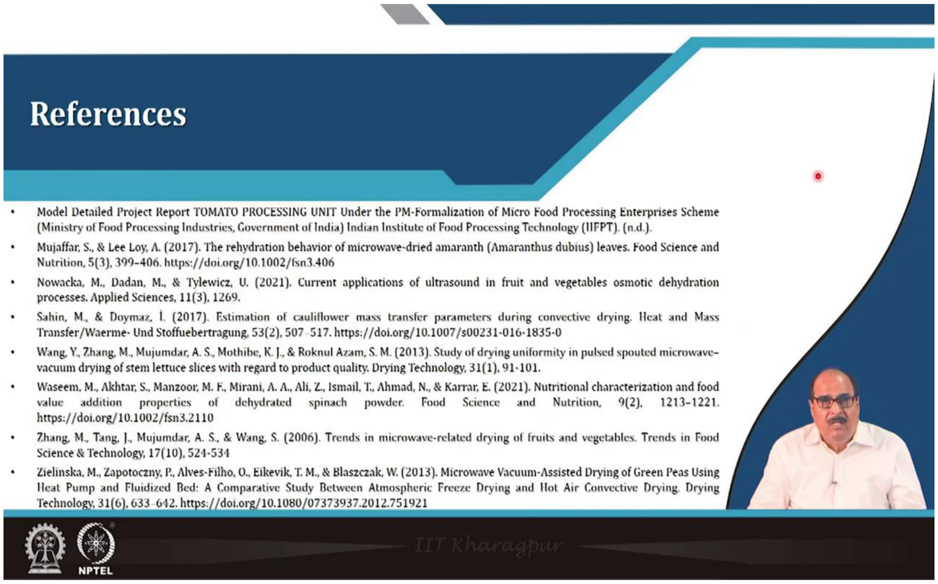


Rehydration behavior and colour attributes of microwave dried amaranth leaves

Rehydration of MW dried leaves was successfully done at 35°C. The rehydrated leaves were darker than the fresh leaves. Increasing the temperature to 50 °C improved the rehydration capacity and the color of the leaves. Rehydration ratio versus time curve for drying conditions of 700 W microwave power and 780 s drying time has been shown in the graph. Color attributes at different drying temperatures have been shown in the table.



Dehydrated products can be used during off season and the fresh produce of far off places can be saved from decomposition due to severe weather conditions and inefficient transport facilities. Proper drying conditions are important factors in producing quality dehydrated vegetables. Among the technologies osmotic dehydration, vacuum drying, freeze drying, and spray drying have great scope for the production of quality dried products and powders. Pre-treatments (e.g. blanching) before drying showed significant increase in rehydration properti



So, these are the references that are used in this lecture. Thank you very much for your patient hearing.