Microwave Vacuum Drying of Fruits and Vegetables

(Value-added Processing of Food Materials)

KERONE

(AN ISO 9001: 2008 CERTIFIED COMPANY)

Role of Agriculture and Allied Sector in Indian Economy

- Largest economic sector, plays a significant role in socio-economic
- development of India.
- More than 58% of country's population depends on agriculture.
- India: largest producer and consumer of tea in the world - accounts
- for around 14% of the world trade.
- Highest milk production, 2nd largest production in wheat and rice
- and largest in pulses.
- Also, ranked 1st in total irrigated land in terms of area.

  However, potential of Indian agriculture as a profitable activity yet not realized. Agricultural sector accounted for only 18.6% of the GDP in 2005.

What is drying?

- Process of removing moisture in the product up to certain threshold value.
- The oldest method of food preservation.
- Fresh vegetables which only keep for a few days, after drying can be stored for months or even years.
- Reduces the bulk weight thus facilitating ease of packaging and transportation.
- May lead to a considerable reduction in volume, thus reduction in storage space requirements.

Drying Techniques:

- Air drying.
- Vacuum drying.
- Freeze drying.
- MW assisted Air drying (MWAD).
- MW Vacuum drying (MWVD).
- MW assisted Freeze drying (MWFD).

❖ **Most Common Method: Air Drying**

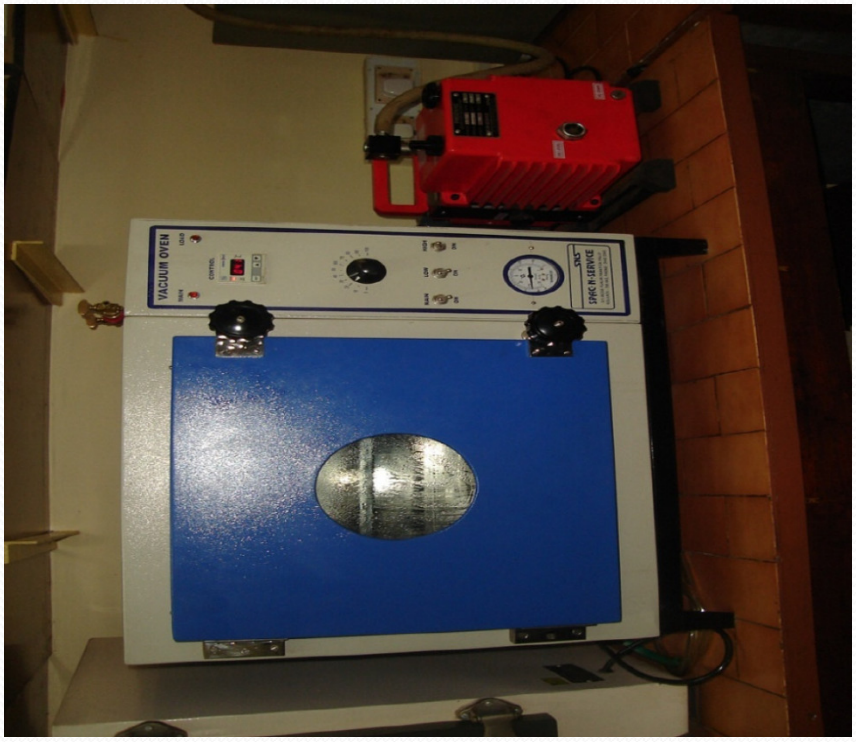
- Drawback - longer drying period and higher drying temperature.

❖ **Conventional Drying follows either:**

- Conduction
- Convection
- Radiation

Vacuum Drying

- Removal of moisture from food products takes place under low pressure. This allows drying temperature to be reduced and higher quality to be obtained.
- Vacuum expands air and water vapor present in the food products and creates a frothy or puffed structure.
- Less energy usage and hence greater energy efficiency, improved drying rates, and in some cases, less shrinkage of the product.



Freeze Drying

- Allows nutritional and sensorial qualities to be retained, together with extreme reduction in weight, high solubility, long shelf life at moderate temperature.
- Causes less damage to the substance than other dehydration methods using higher temperatures.
- Does not cause shrinkage or toughening of the material.
- Flavors and smells generally remain unchanged.
- Expensive and lengthy dehydration process because of low drying rates.

Here`s how Freeze Drying works

Why Microwave heating?

- Heat isn't transferred to a material. Instead, the material is induced to heat itself.

❖**General advantages:**

- reduction of drying time.
- lower energy consumption.
- high-quality product.

Microwaves

- **Electromagnetic waves**

  [*frequency : 300 MHz - 300 GHz]*

  [wavelength(l) : 1m - 1 cm]

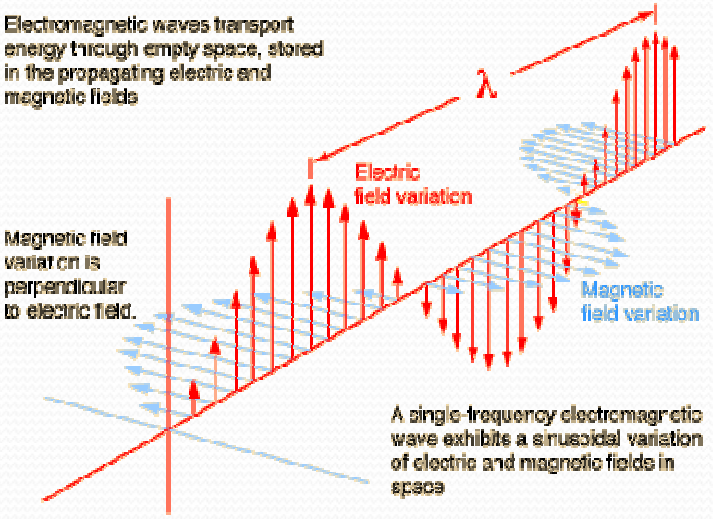
- **Frequencies assigned for ISM heating:**

  915 ± 13 MHz

  2450 ± 50 MHz

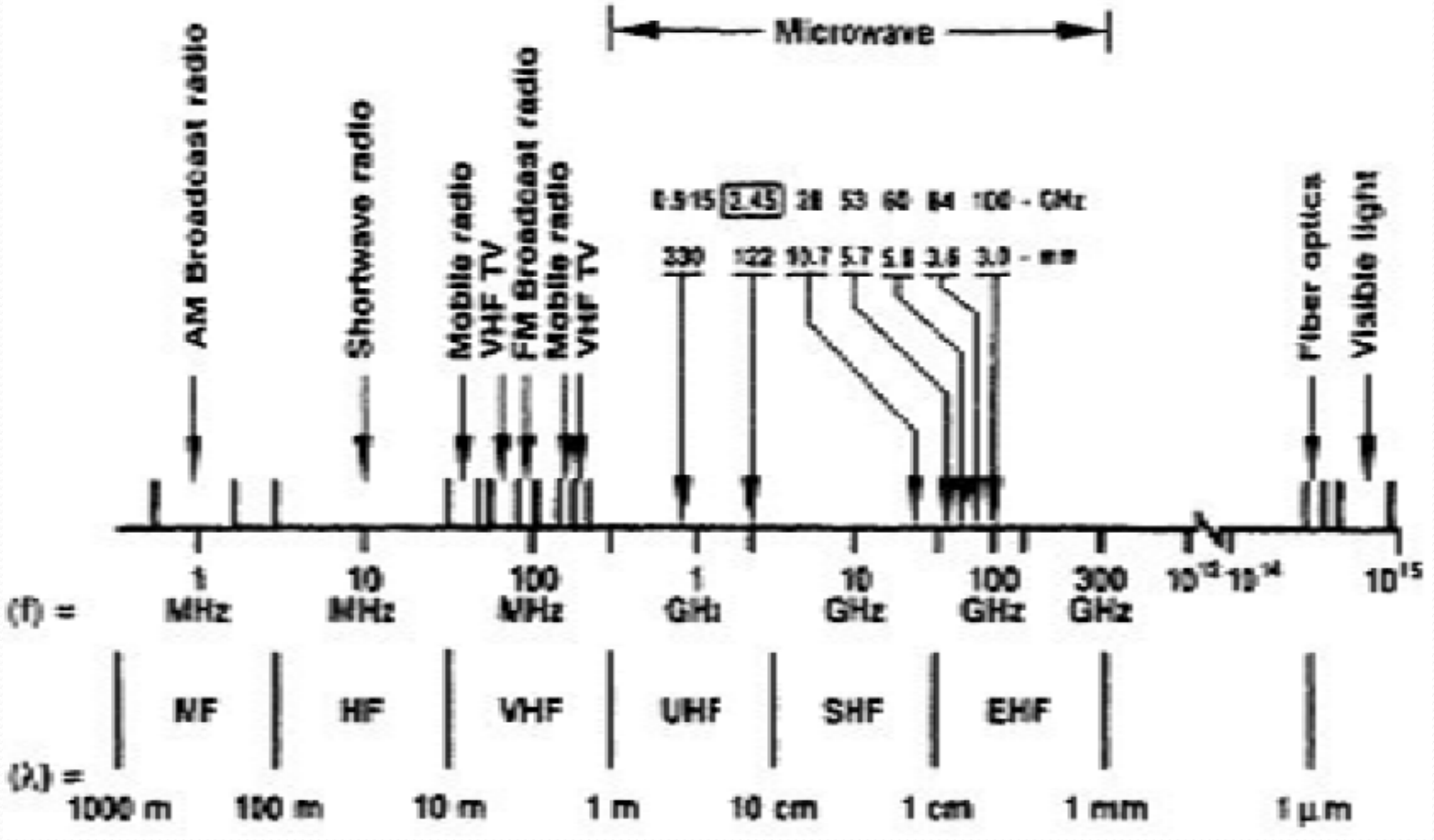
  5800 ± 75 MHz

  24125 ± 125 MHz



- **Have both an electric and magnetic component.**
  - Electric component is responsible for heating.
- **Have some properties similar to visible light.**
- **Can move through space, air, and even materials.**
  - All metals reflect microwaves.
  - Glass, polymers and ceramics transmit microwaves.
  - Dielectric materials (Food, wood, paper etc.) absorb microwaves and get heated.

Microwaves: Electromagnetic waves within a frequency band of 300 MHz to 300 GHz.



❖ **Frequency bands are reserved for ISM applications to prevent interference problems.**

✓ Most commonly used frequency for microwave ovens is 2450 MHz.

❖ Two types of <u>safety regulations</u>:

- the regulation concerning the maximum exposure or absorption of a human - Limit is 1 mW/cm2 body surface.
- the regulation regarding the maximum emission of the microwave equipment - limited to a value of 5 mW/cm2 measured at a distance of 5 cm from the point where the leakage has the maximum level.

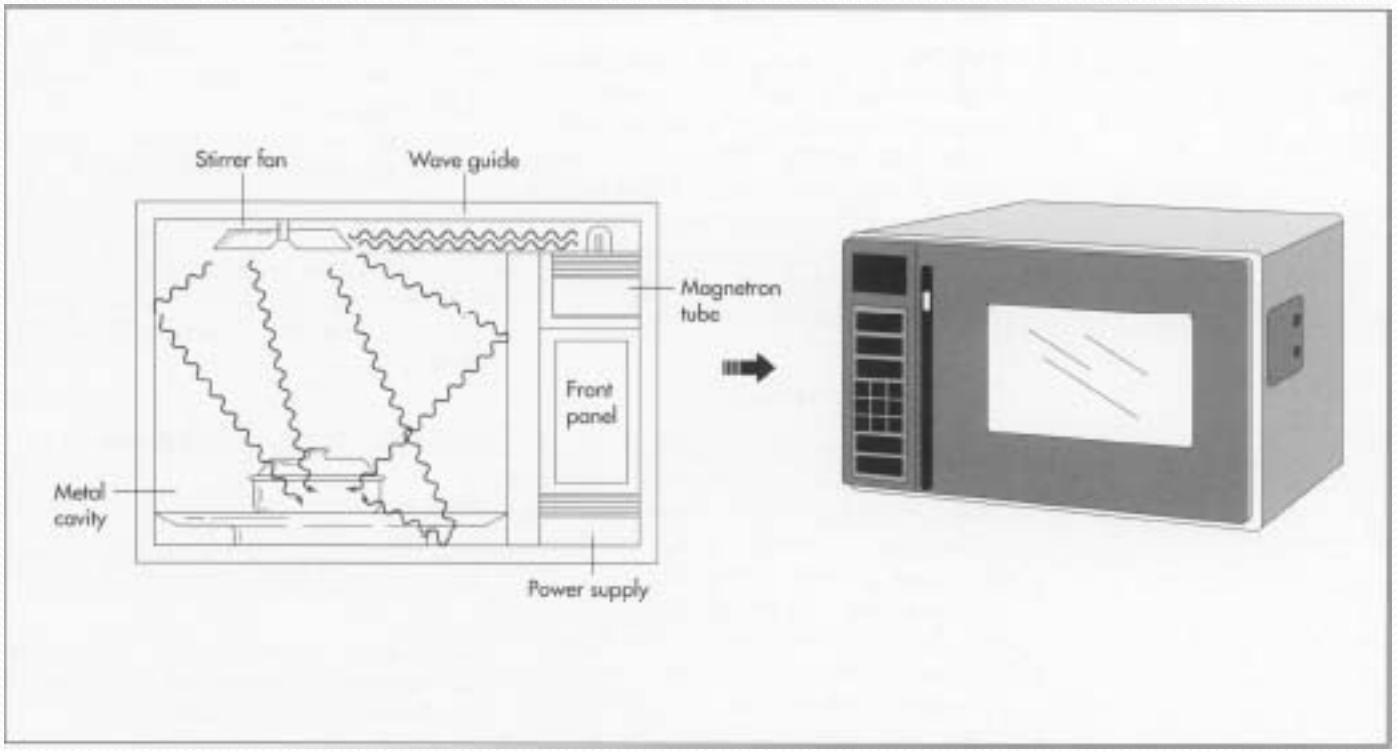
Microwave Drying:

- MW drying offers to shorten the drying time without degradation of final quality of the dried product.
- Food material is heated directly due to agitation of the polar molecules contained in it.
- Microwave drying utilizes very fast volumetric heating.

Advantages of Microwave-related Drying:

- adjustment of energy absorption level by the wet products automatically.
- possible selective heating of the interior portions - (microwave focusing effect).
- rapid energy dissipation throughout the material.
- relatively minor migration of water-soluble constituents.
- lower product temperatures in combination with vacuum.
- more efficient drying in the falling rate period.

A typical microwave oven (basic components)

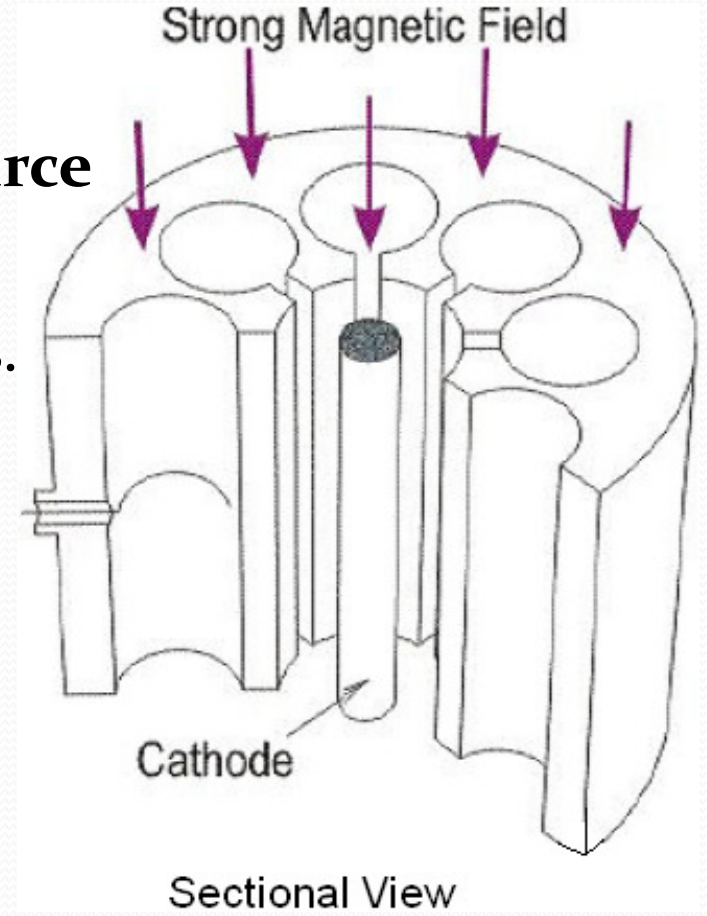


❖ **Basic parts of microwave system:**

- The microwave source.
- The waveguide.
- The applicator.

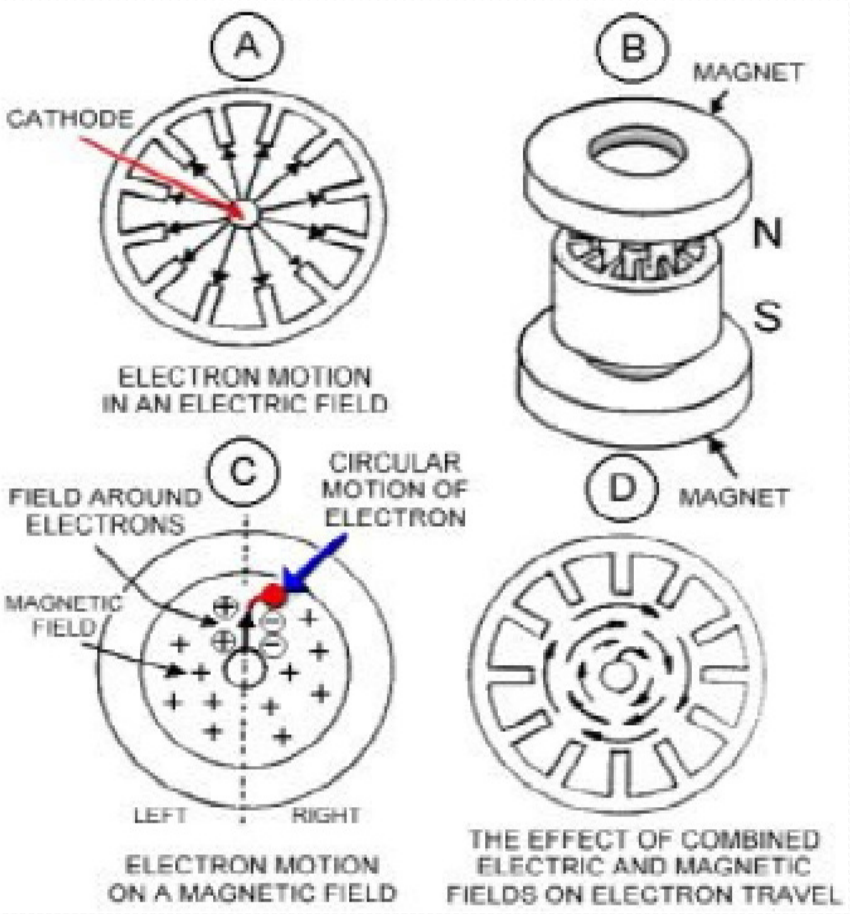
❖ **Magnetrons – The microwave source**

- Central electron-emitting cathode.
- Structured anode that forms cavities.



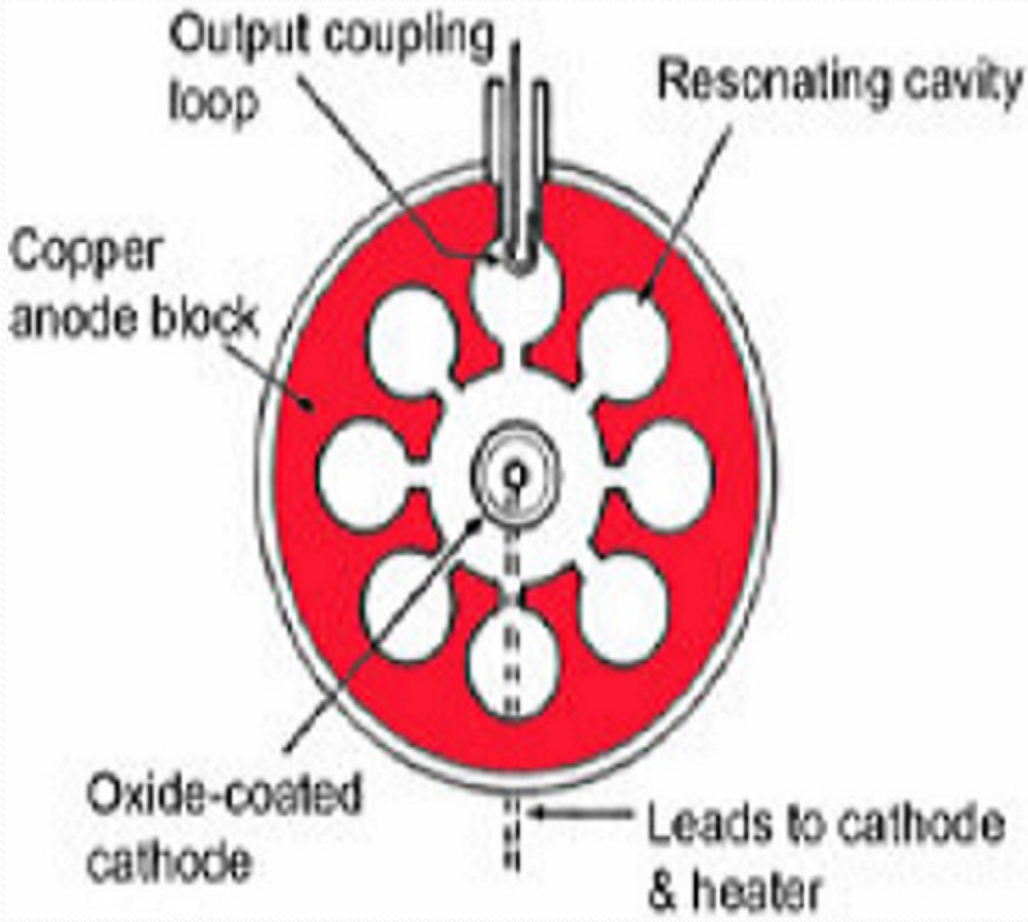
The theory of magnetron operation is based on the motion of electrons under the combined influence of electric and magnetic fields.

- For the tube to operate, electrons must flow from the cathode to the anode.
- Electrons tend to move from a point of negative potential toward a positive potential.
- The force exerted on an electron in a magnetic field is at right angles to both the field itself, and to the path of the electron. The direction of the force is such that the electron proceeds to the anode in a curve rather than a direct path.



The resonant cavities take energy from the electrons.

The stored electromagnetic energy can be coupled out by a circular loop antenna in one of the cavities into a waveguide or a coaxial line.



Dielectric Properties of Foods:

Relative Permittivity, $\in^* = \in' - j \in''$

The real part $\in'$ is the dielectric constant; the imaginary part $\in''$ is the dielectric loss factor.

Loss Angle, $\tan\delta = \in''/ \in'$

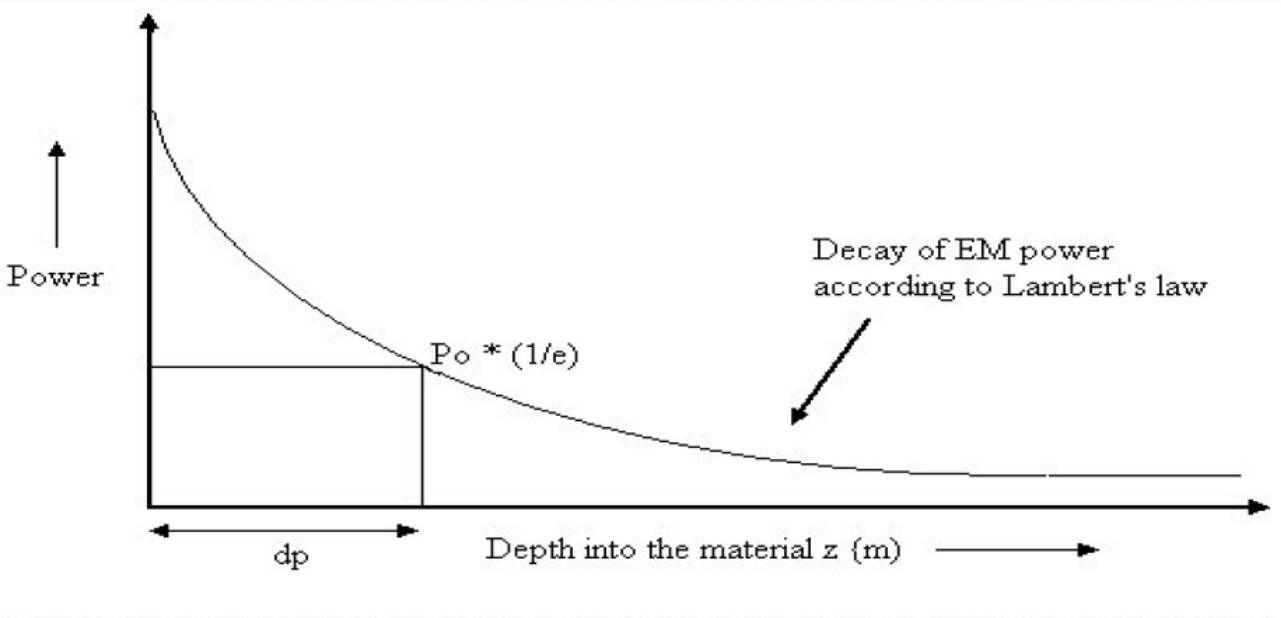
Amount of thermal energy converted in food is proportional to the value of the loss factor $\in''$.

$$Q = 2 f E^2 \in_0 \in''$$

Penetration Depth

- Depth where the dissipated power is reduced to 1/*e of the power entering the* surface.

$$D = \frac{c}{2\pi f (2\,\varepsilon')^{0.5}} \left\{ \sqrt{1 + (\tan \delta e)^2} - 1 \right\}^{-0.5}$$



Typical penetration depth inside a large sized material

- Other factors also influence how microwaves affect food.
- **Starting temperature:**

  Foods will cook faster if the starting temperature is higher.
- **Size:**

  Try to include items of a similar size because smaller items cook faster than larger ones.
- **Shape:**

  Regular shapes heat more uniformly, while thinner, narrower portions of irregular foods may overcook. This extends further to foods of different heights.
- **Quantity:**

  To a point, a microwave oven will heat more efficiently as the load becomes larger.
- **Consistency:**

  Denser foods typically require longer heating times than do open, porous, lighter density foods.

Mechanism of Microwave Drying

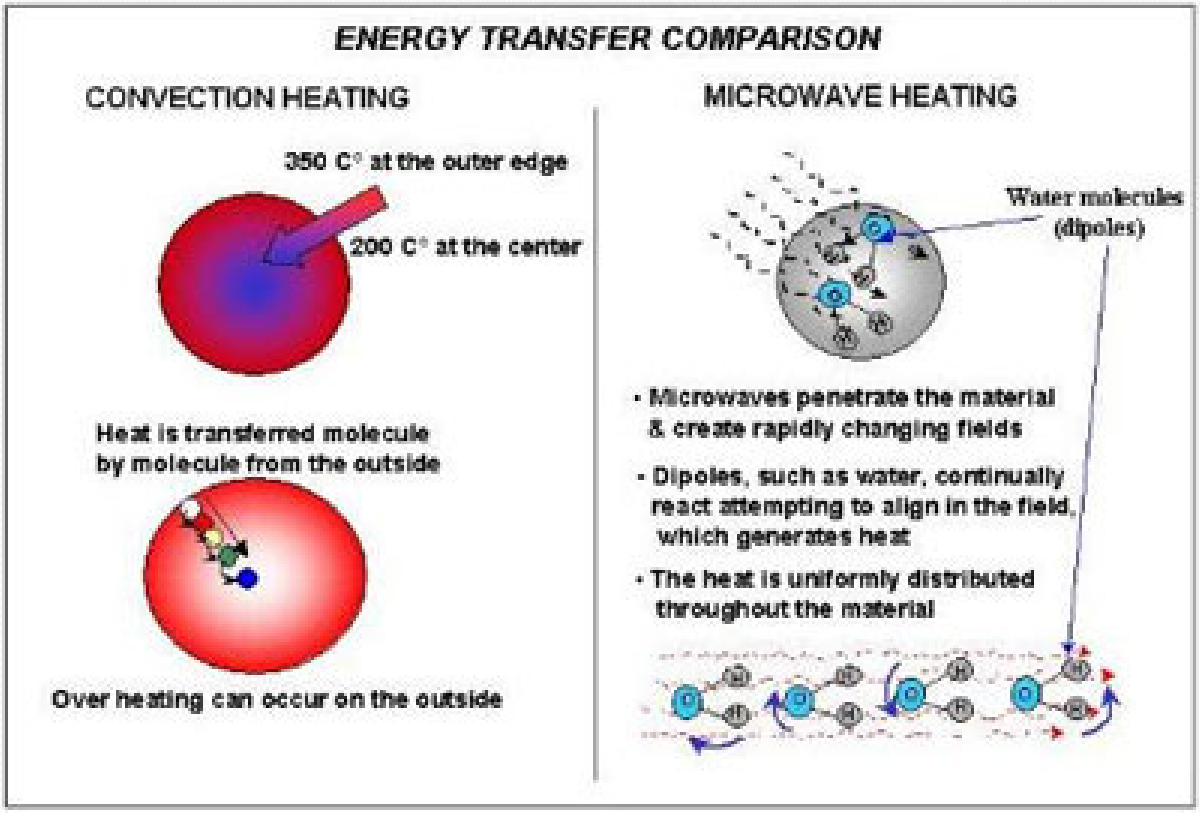
- **The microwave energy is mainly absorbed by liquid water present in food owing to its higher loss factor than other components**
- **The absorption of microwaves results in the temperature to rise, some water get evaporated and the moisture level reduces**
- **Internal heating and evaporation of liquid water takes place inside the food materials and generates significant pressure**
- **Moisture is pumped to the surface due to the pressure gradient. The resulting pressure-driven flow becomes an additional mechanism of internal moisture transport.**

Minor contributions from other factors:

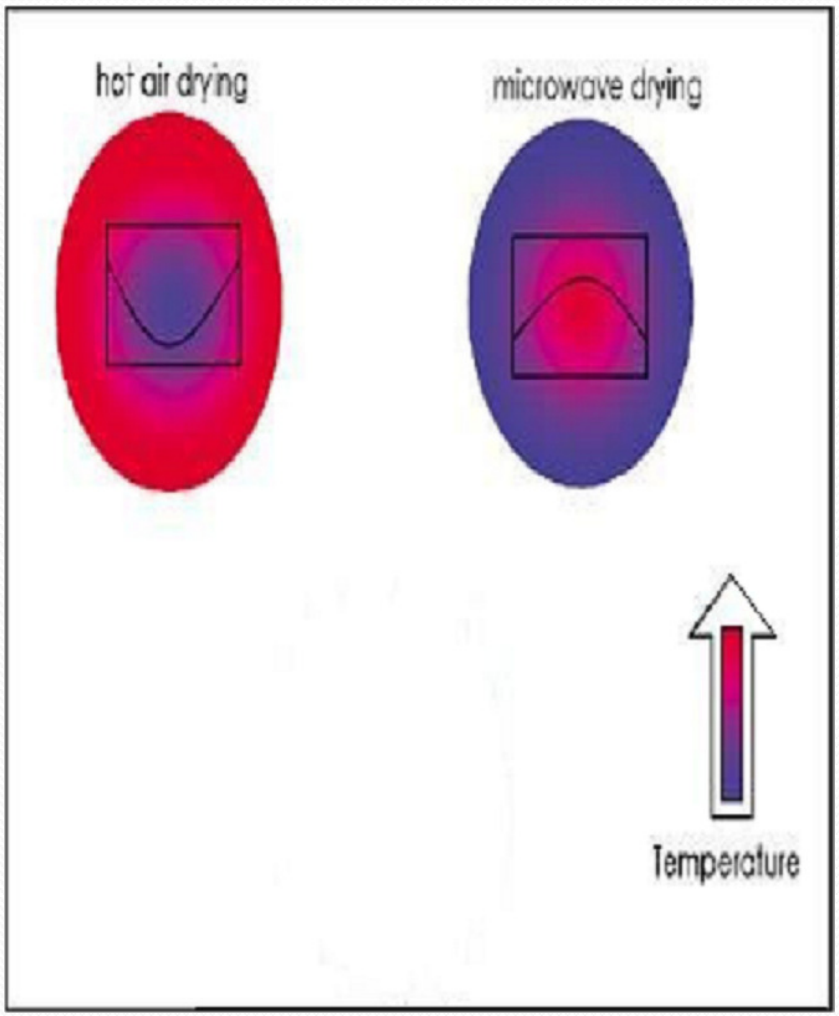
Heating is accelerated by ionic effects (mostly salt content) and specific heat of the composite material.

- In intermediate and high moisture products water absorbs the MW energy. However, because of their high heat capacity they tend to heat unevenly.
- Variations in electric fields, food constituents and the location of the food in a microwave oven can lead to non-uniform heating.
- A number of techniques to improve uniformity of microwave heating, such as rotating and oscillating foods.

Convective Vs Microwave Heating



Temperature profile



MW assisted air drying

Three methods in which MW energy may be combined with hot air drying:

1) By applying the MW energy at the beginning of dehydration processes.
2) By applying MW energy when the drying rate begin to fall.
3) By applying MW energy in the falling rate period(s) or at low moisture content to facilitate finish drying.

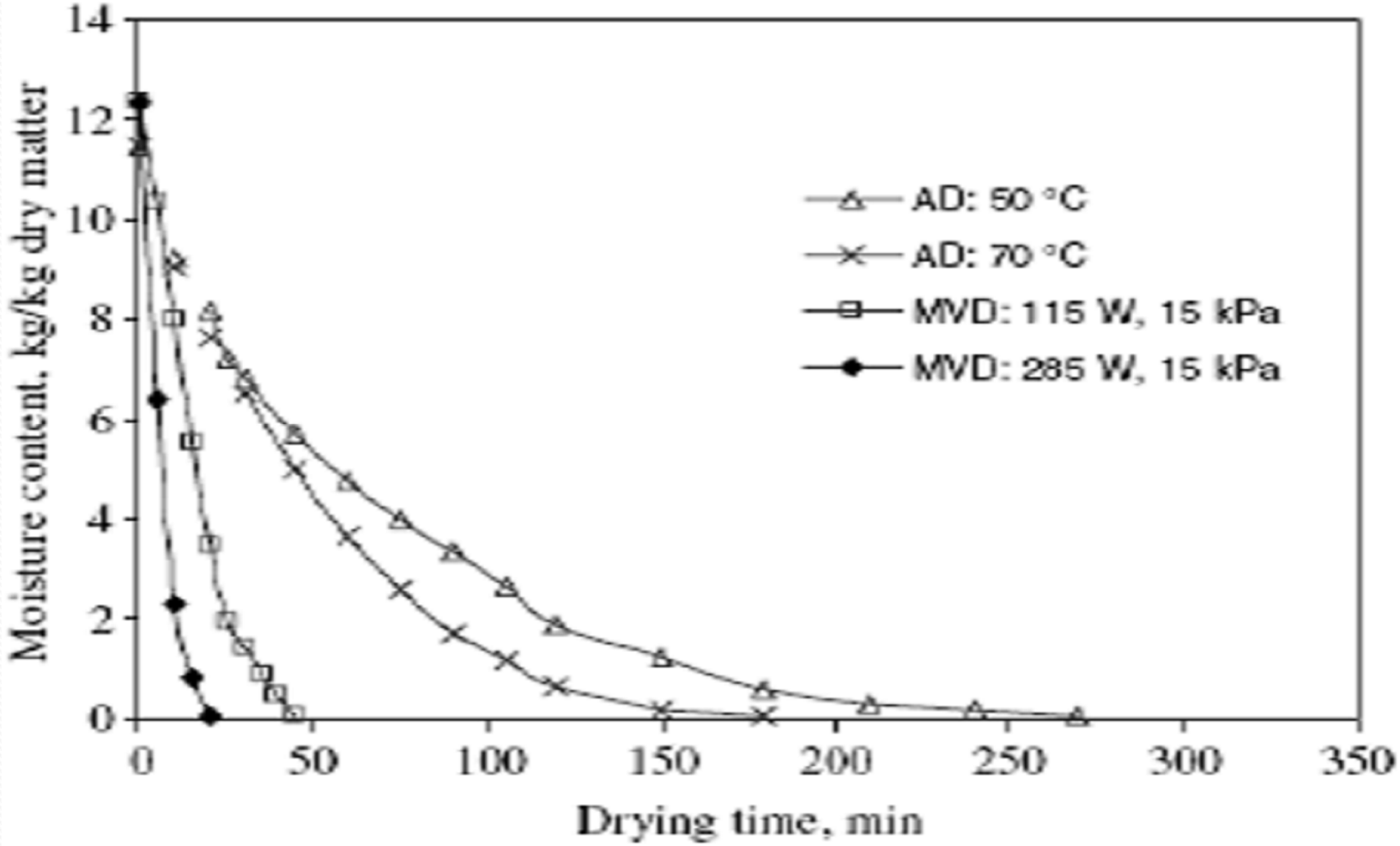
- Prevents the shrinkage of tissue.
- Very efficient in removing bound water from the product.

MW Vacuum drying

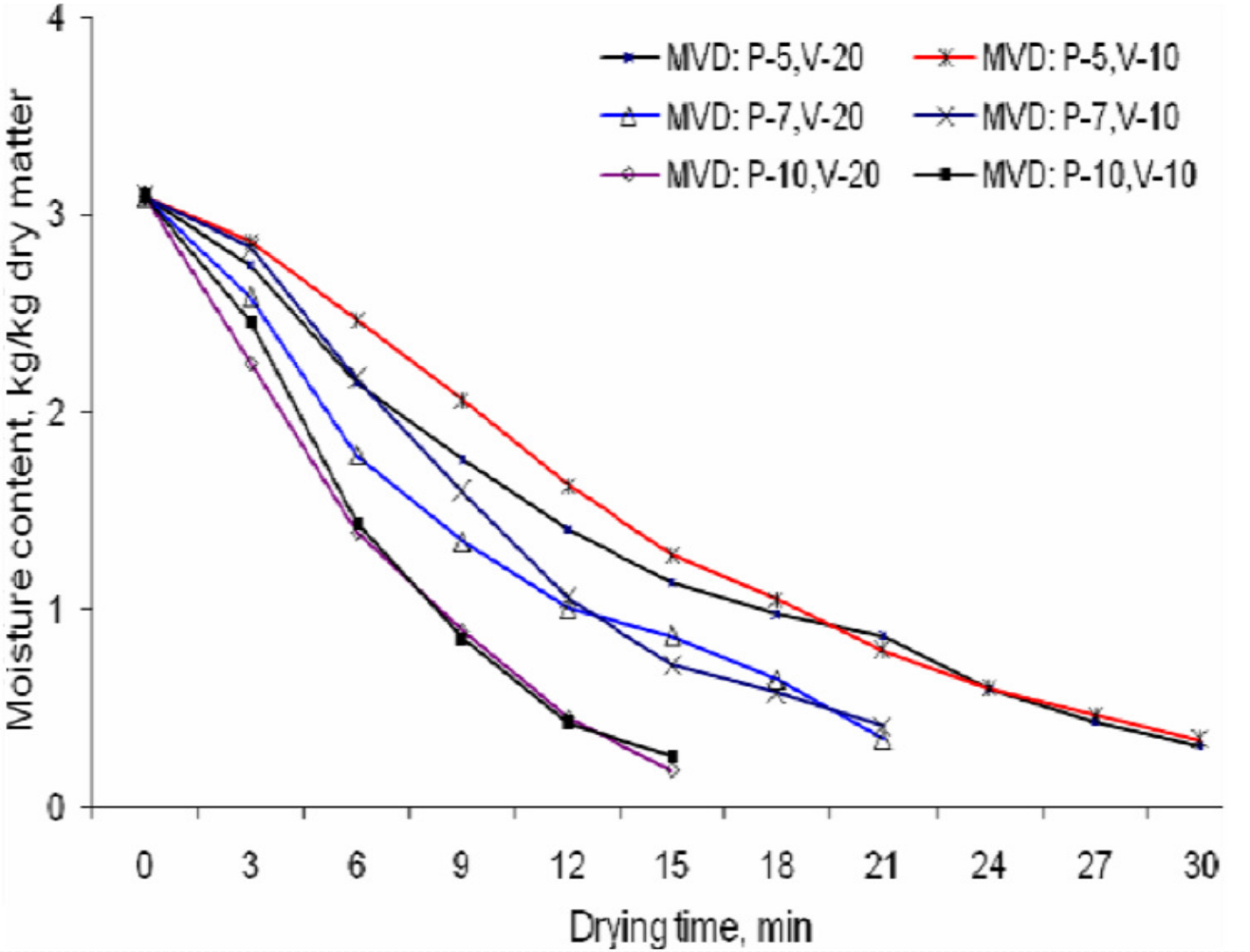
- Result in significantly rapid drying rates. Hence, vacuum enables the products to be dried at a lower product temperature.
- External heat transfer by convection is, however, absent in vacuum. Thus, by using MW drying time is reduced. Results in significant decrease in operating costs.
- This technique is reported to be used successfully for the dehydration of grapes, cranberries , bananas and tomatoes, carrots and garlic, kiwifruit, apple and pear.

Microwave-Vacuum Dryer

Dehydration curves of air dried (AD) and microwave vacuum dried (MVD) mushroom slices.



Drying Curves of microwave vacuum dried Saskatoon berries at various levels.

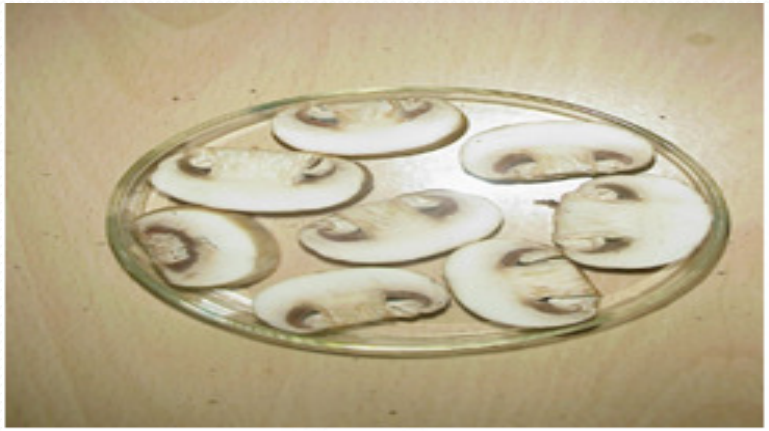


microwave vacuum drying at 374W microwave power level and 67 KPa vacuum pressure.

- Before Saskatoon berries before microwave vacuum drying.

- After Saskatoon berries microwave vacuum drying after microwave vacuum drying at 374W microwave power level and 67 Pa vacuum pressure.

Dehydrated Mushrooms Slices



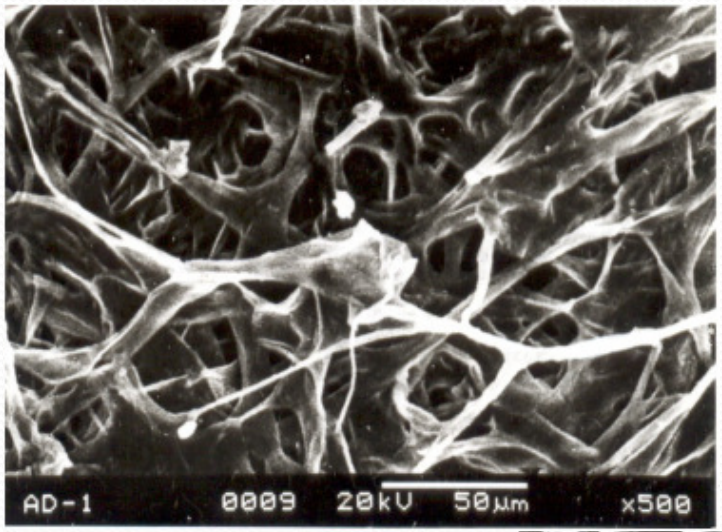
Fresh

FD

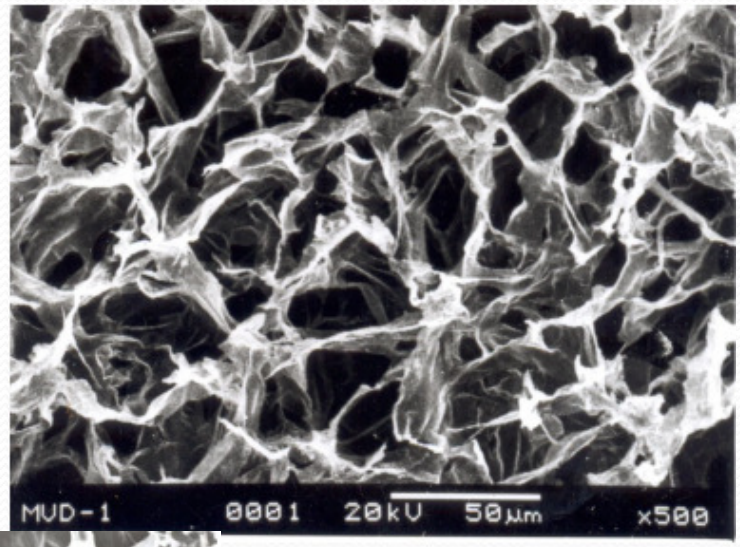
MVD

AD

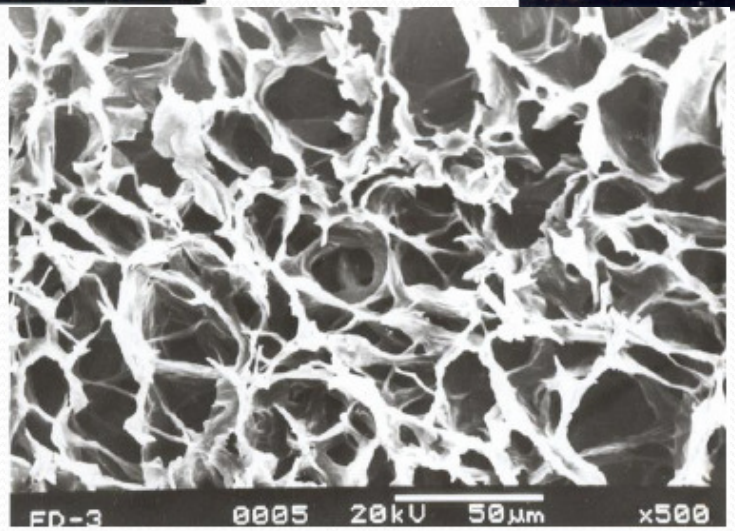
SEM Structures of Dehydrated Mushrooms



AD

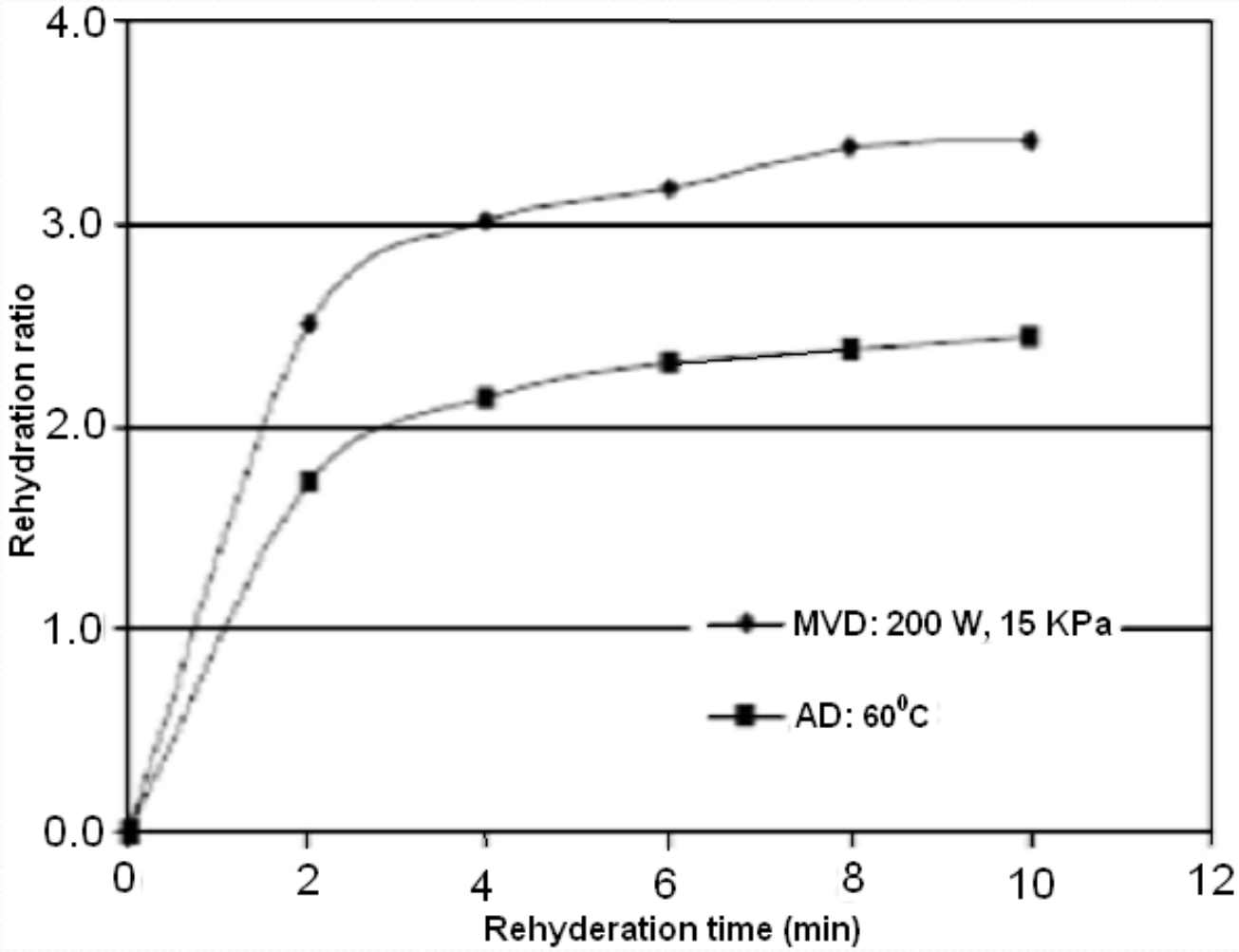


MVD



FD

Comparison of rehydration ratio of microwave-vacuum and air dried mushroom slices.



SUMMARY

Electromagnetic energy at 915 and 2450 MHz can be absorbed by water containing materials and converted to heat.

- **Advantages:**
- • Higher drying rate – yield increases manifold.
- • Product quality enhancement.
- • Reduced energy consumption.
- • Lower operating costs.
- **Limitations:**
- • High initial costs.
- • Product texture affected.
- • Requirement of particular sample size.
- **Combining two methods:**

The combination of microwave-vacuum drying and air drying is perhaps the most obvious option as air drying is relatively cheap, the first unit in the process chain is preferably an air drier. When it becomes inefficient, microwaves and vacuum can be used not only to continue the dehydration, but to create a huge volume of steam, enough to inflate the product and regain much of its original volume.

How we can help you?

If you plan to set-up any Heating System and are confused about its feasibly, we can help you….

Just mail us your requirements at **kerone2007@yahoo.co.in** or at **vhpl@bom5.vsnl.net.in**

we will reply with our complete techno-commercial quote within 7 to 8 working days

In case you have any query please feel free to contact us:

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THANK YOU