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Heat Pump Drying of Neglected and Underutilized Species: Status, Potentials and Applications

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Introduction

- South Africa has nutritious minor crops that can be referred to as been neglected e.g. canola and amaranths.
- These crops possess high moisture content which ought to be reduced to prevent losses.
- Drying is indispensable but energy intensive and different crops require drying techniques.
- Heat pump drying technology has unique importance for drying of high-quality temperature-sensitive products as well as being environmentally friendly but it is misconstrued by would be users.
- This paper tried to divulge the principles and potentials of heat pump drying technology and the conditions for its optimum use for Neglected and Under utilized Species (NUS).

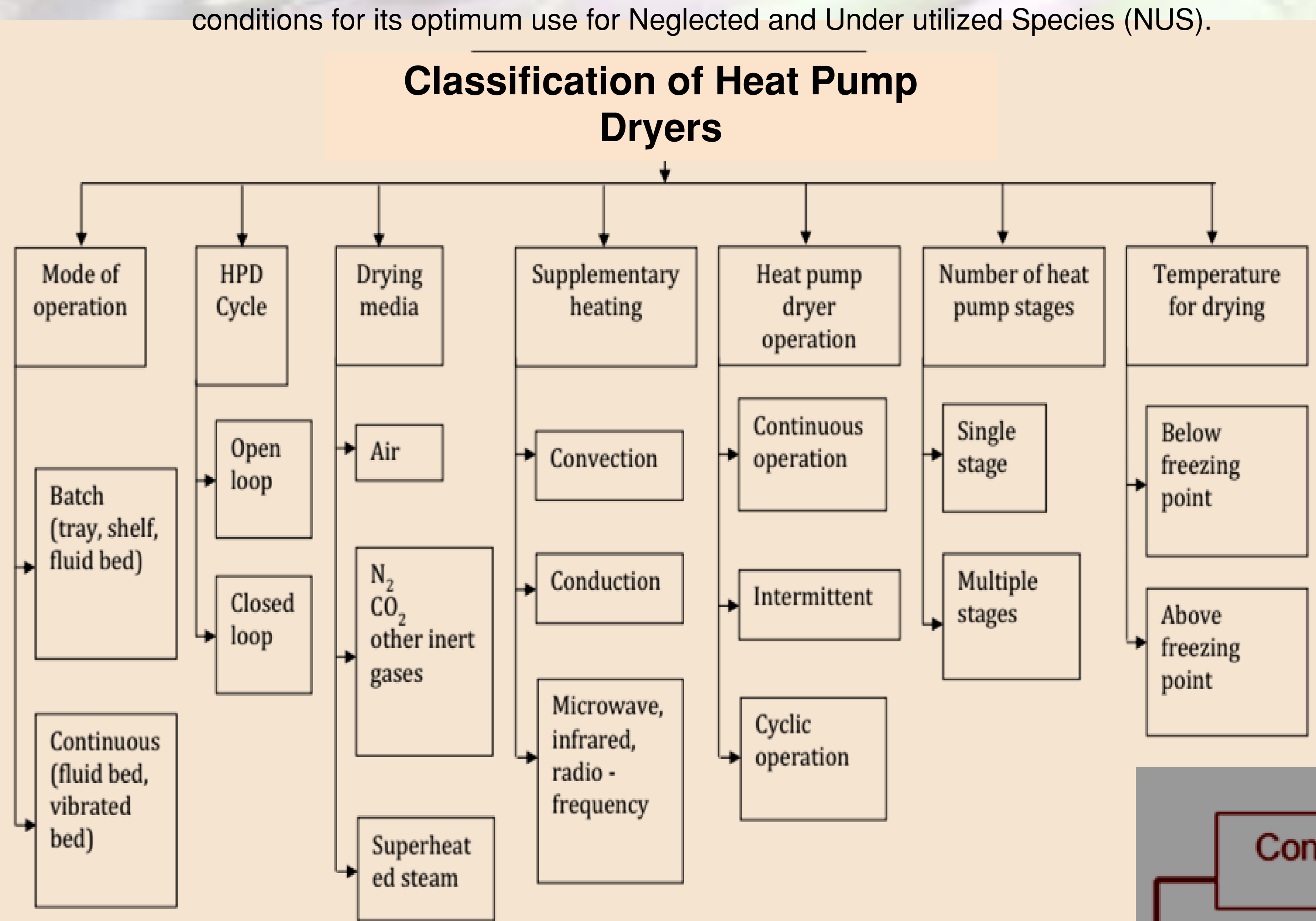

Fig 1: Classification of HP Dryers (Chaughule & Thorat, 2011)

HP Dryer Contribution to Product Quality

Fig 2: HP Dryer Contribution to Product Quality

Performance Indicators of Heat Pump Drying Systems

- **Coefficient of Performance (COP_{HPD})**

$$COP_{HPD} = \frac{Q_H}{W_c + W_f} \quad \text{-------------(1)}$$

Where Q_H: heat rejected at the condenser
Wc: Energy consumption by a compressor,
W_f: work input to the fan/blower [kJ],

- **Specific Moisture Extraction Rate (SMER)**

$$SMER = COP_{HPD} \cdot \frac{\Delta x}{\Delta h} [kg/kWh] \quad \text{-------------(2)}$$

Δx: amount of removed water [kg]
Δh: amount of energy consumed [kJ]

- **Drying Rate**

$$DR = \frac{m_t - m_{t+\Delta t}}{\Delta t} \quad \text{--------------(3)}$$

m_t: the mass at time t.

- **Drying Efficiency**

$$\eta = \frac{T_1 - T_2}{T_1 - T_a}$$

T_1: the inlet (high) air temperature into the dryer,
T_2: the outlet air temperature from the dryer,
T_a: the ambient air temperature.

- **Exergy**

$$Exergy = m_{da} c_{pda} \left[(T - T_{ref}) - T_{ref} In \frac{T}{T_{ref}} \right] \quad \text{--------------(4)}$$

m_{da}: air flow rate (kg/s),
C_{pda}: thermal capacity of air (J/kg/K),
T: temperature (K),
T_{ref}: reference temperature (ambient temperature (K)

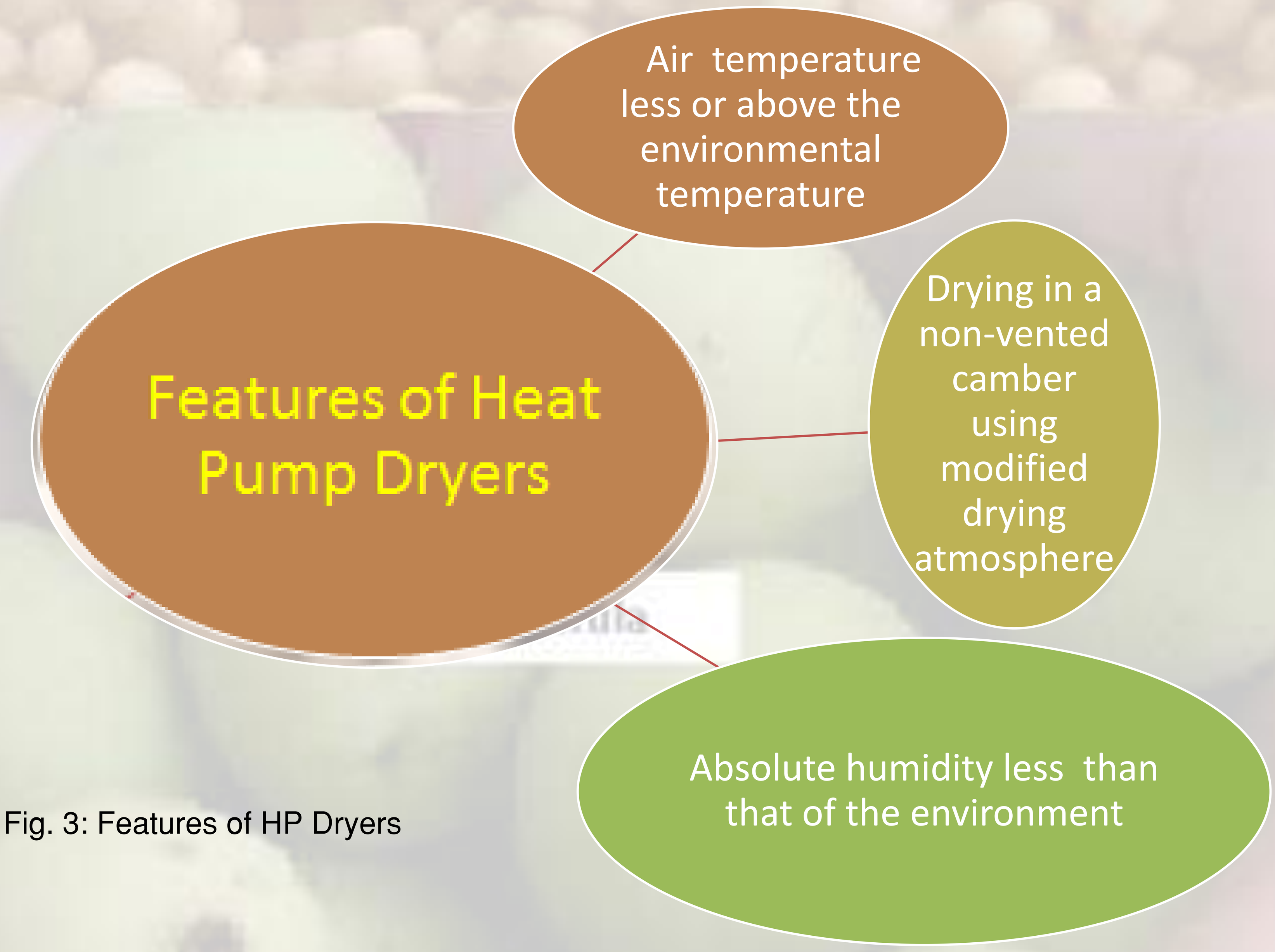

Fig. 3: Features of HP Dryers

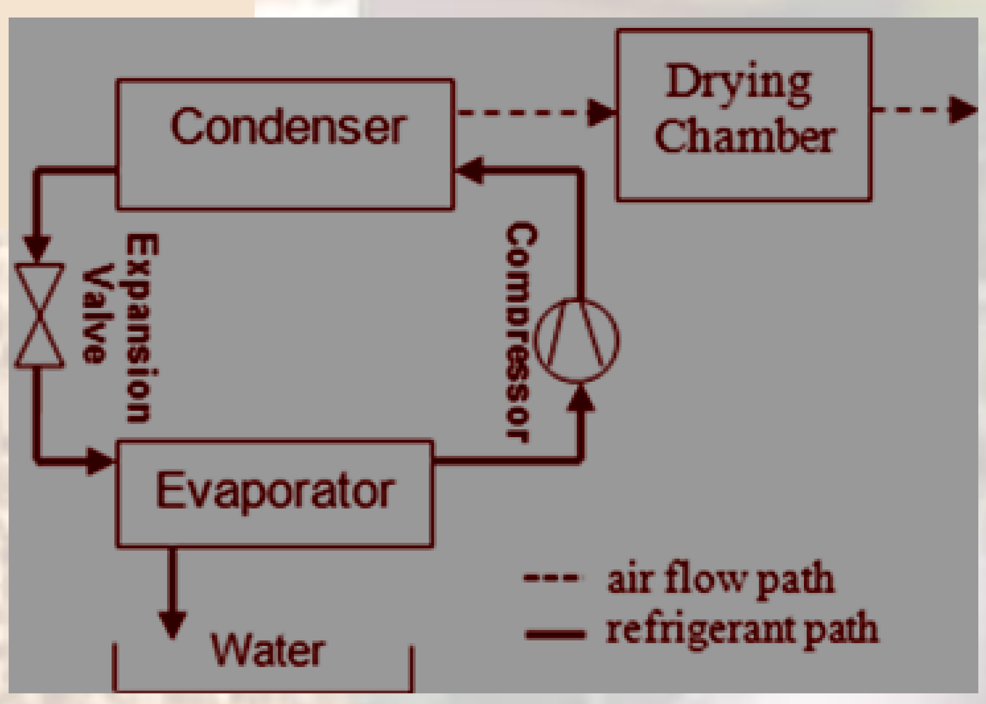

Fig 4: HP Drying system

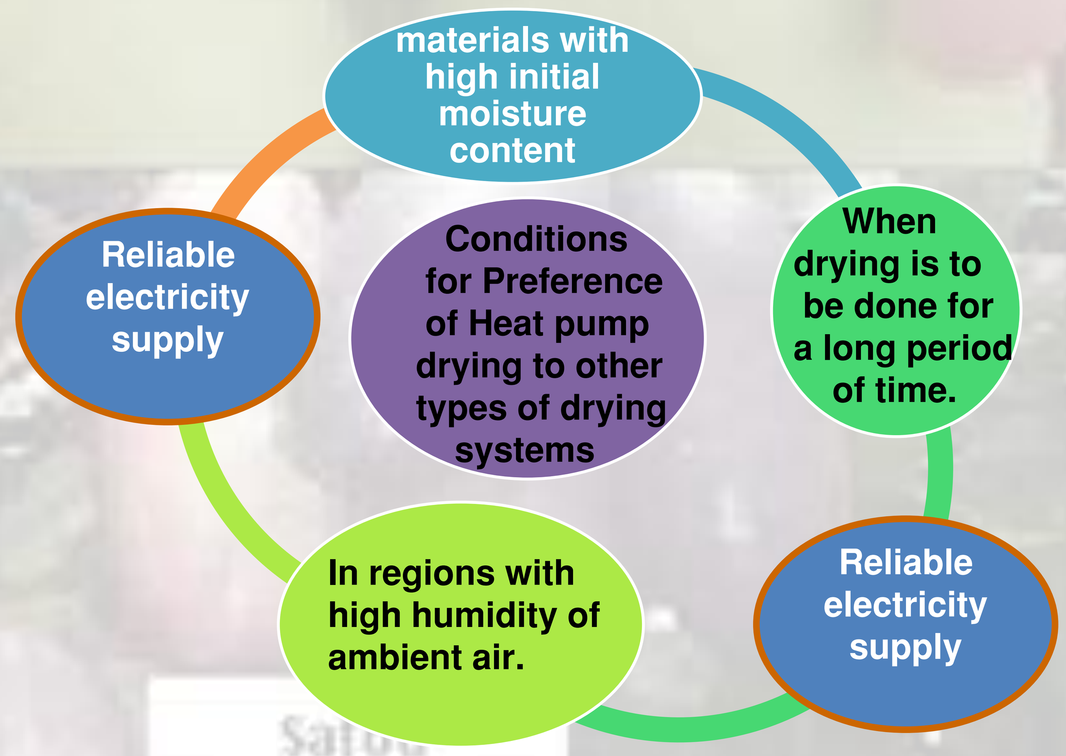

Fig 5: Conditions for preference of HPD to other drying systems

Comparing HPD with other drying Systems (Mujumdar & Jangam, 2011

Parameter \ Type of dryer	Heat pump dryer	Hot air dryer	Vacuum dryer	Freeze dryer
SMER (kJ kg⁻¹)	1.0-4.0	0.1-1.3	0.7-1.2	0.4 and lower
Operating temperature (°C)	-10 to 80	40 to very high	30-60	-35 to >50
Operating humidity (% RH)	10-80	Varies depending on temperature	Low	Low
Dryer Efficiency (%)*	Up to 95	35-40	Up to 70	Very low
Product quality	Very good	Average	Good	Excellent
Capital cost	Moderate	Low	High	Very high
Drying rate	Faster	Average	Very slow	Very slow
Operating cost	Low	High	Very High	Very high
Control	Very good	Moderate	Good	Good

Conclusion

Heat pump drying technology offers exceptional advantages for drying food products that are highly prone to change, especially where humidity environment low is required and energy efficiency is a significant advantage.

References

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