Energy efficient solutions to optimize your banana ripening application

India is the world’s largest producer of bananas accounting for 26% of global production. Despite being the world’s largest banana producer, India is yet to become an efficient producer, according to the annual wastage figures. Poor post-harvest and cold chain infrastructure coupled with low consistency in quality is the main reason behind post harvest loss. This calls for state-of-the-art banana ripening chambers. Danfoss helps the industry to create optimum cold chain solutions for banana ripening chambers and has helped banana farmers control post-harvest losses and increase shelf life.

www.danfoss.com/India
Understanding the ripening process

Ethylene (C₂H₄) is a naturally occurring simple gaseous hydrocarbon hormone that is produced by climacteric fruits when they are mature. Ethylene has direct relation to the ripening process of the climacteric fruits. Immature fruits are being harvested to enable them to transfer to the long distances to reduce the wastage. Depending on the requirement, the ripening process is being artificially initiated in the ripening chambers by dosing ethylene.

Until recent times, this ripening process was being done using carbide stones. Due to health related issues associated with carbide ripening, ethylene ripening has become popular. Ethylene ripening in a controlled environment helps in getting the right colour for the banana. Ethylene ripened fruits can develop natural flavour as all the natural biological processes take place similar to the way it happens when the fruit ripens in the plant.

Optimum ambient conditions for banana ripening

Temperature requirement:
- 13 °C to 14 °C – for storage and transport
- 15 °C to 20 °C – for ripening

Relative humidity requirement: 90-95% RH

Color Index No.

<table>
<thead>
<tr>
<th>Peel Color</th>
<th>Color Index No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Green</td>
<td>1</td>
</tr>
<tr>
<td>2 Green - trace of yellow</td>
<td>2</td>
</tr>
<tr>
<td>3 More green than yellow</td>
<td>3</td>
</tr>
<tr>
<td>4 More yellow than green</td>
<td>4</td>
</tr>
<tr>
<td>5 Green tip</td>
<td>5</td>
</tr>
<tr>
<td>6 All yellow</td>
<td>6</td>
</tr>
<tr>
<td>7 Yellow - flecked with brown</td>
<td>7</td>
</tr>
</tbody>
</table>
Suggested guide for banana ripening

**BANANA RIPENING DRIVERS**

<table>
<thead>
<tr>
<th>Automated process</th>
<th>Reduction in food wastage</th>
<th>Energy efficiency</th>
<th>Reliable systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Built in ripening process algorithm in MCX controller to manage all the processes of the ripening application</td>
<td>• Evaporator pressure regulator to always maintain temperature above chill injury temperature</td>
<td>• Electronic expansion valve to enable higher efficiency through improved evaporating temperatures.</td>
<td>• Factory tested Optyma condensing unit</td>
</tr>
<tr>
<td>• Highly efficient pressure and temperature sensors</td>
<td>• Reliable Optyma condensing unit with wide operating envelope</td>
<td>• Condensing units with high efficiency compressors and Micro channel heat exchangers</td>
<td>• Liquid line solenoid valve to improve life of refrigeration systems</td>
</tr>
</tbody>
</table>

**Notes:**
- Temperatures are °C
- Temperatures are PULP not AIR
- Proper temperature, humidity, time, air circulation, mature bananas and ethylene are required for ripening.
- Use the Super-Ripening Center® and Ethy-Gen® II to hasten ripening
- Maintain 100-150 ppm of ethylene until color breaks.
- After 24 hour ripening initiation period, vent room for 15-20 minutes with fan on
- For delayed shipment hold at 14 °C.

**Pulp Temperatures °C**

<table>
<thead>
<tr>
<th>Day Schedule</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>4 Day Schedule</td>
<td>18°</td>
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<td>17°</td>
<td>16°</td>
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<tr>
<td>5 Day Schedule</td>
<td>17°</td>
<td>17°</td>
<td>17°</td>
<td>17°</td>
<td>16°</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6 Day Schedule</td>
<td>17°</td>
<td>17°</td>
<td>16°</td>
<td>16°</td>
<td>16°</td>
<td>14°</td>
<td></td>
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</tr>
<tr>
<td>7 Day Schedule</td>
<td>16°</td>
<td>16°</td>
<td>16°</td>
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<td>14°</td>
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<tr>
<td>8 Day Schedule</td>
<td>14°</td>
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<table>
<thead>
<tr>
<th>Day</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>14°</td>
<td></td>
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</tr>
<tr>
<td>Day 3</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Day 4</td>
<td></td>
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<tr>
<td>Day 5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Day 6</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 7</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 8</td>
<td></td>
<td></td>
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</tr>
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Danfoss products for banana ripening application

Compressors

MLZ series scroll compressors (4 to 23 kW)
- Multi-refrigerant compressor suitable for R404A, R134a, R 22, R507
- Suitable for operation down to 10°C condensing temperature for improved energy efficiency
- Oil sight glass and schrader connection for oil fill/drain
- Oil injection system ensures adequate lubrication in varying operating conditions
- Teflon coated or carbon bearings
- Unique disc check valve design insures quiet operation

Inverter speed scroll compressors (13 to 83 kW)
- VZH - 2nd generation Inverter scroll compressor
- AHR expo innovation award winner 2013
- 30% energy savings over fixed speed; 4:1 turndown ratio to save energy
- Permanent magnet high efficiency motors
- Pre qualified and tested compressor and Drive package

Condensing units

Optyma™ slim pack condensing unit (4.4 KW to 13.9 KW) (43 Amb and 0 Deg C SST)
- Multi-refrigerant usage
- Plug and play
- Refrigerant charge quantity less by 35%
- Weight and space compact
- Silent running
- High Danfoss quality and reliability
- Weather proof housing IP54 for outdoor applications

VLT® drives

VLT® refrigeration drive FC 103
- Sleep mode- optimum system efficiency
- Advanced energy monitoring
- Automatic energy optimizer (AEO) function
- Robust single enclosure

Expansion valves

Electronic expansion valve
- Better evaporator efficiency which saves compression energy
- Capacity range: 2 to 455 TR
- Wide range in connections
- Stepper motor
- Improves overall system performance

Thermostatic expansion valve
- Wide capacity range
- Adjustable superheat setting
- Laser welded diaphragm housing resulting in strong stainless steel power element
- Bulb and strap technology that ensures stable and responsive superheat control
- Improves overall system performance
Pressure and temperature regulating valves

**Evaporator pressure regulator**
- Constant surface temperature on the evaporator
- Controls humidity in the room
- Protects against chill injury by ensuring that the temperature is always above the risk level
- Low pressure drop over the seat under normal load conditions
- Improves overall system performance

**Pilot operated servo valve**
- Used for bigger capacities (above 20KW)
- Low temperature steel body
- Low weight and compact design
- V-port regulating cone ensures optimum regulating accuracy particularly at part load

**Shut-off and regulating valves**

**Shut-off ball valve**
- Connects indoor and outdoor units with high Kv value
- Low internal leakage when closed avoiding refrigerant loss and faster vacuum during service
- Shut-off valve is also useful to replace the filter drier and for other service related activities

**Solenoid valves**

**Solenoid valve**
- Safeguards the compressor against liquid migration and slugging
- Provides proper system balancing after shutdown

**Sight glasses and filter driers**

**SG sight glass**
- Shows the health of the refrigerant inside the system
- Shows refrigerant status which can be useful input for right diagnosis of the system

**Electronic controllers**

**MCX controller**
- Built-in ripening process algorithm
- Complete automation of temperature, humidity, CO₂, ethylene etc.
- User friendly with logging facility
- Option for in-built and external remote display
- Remote monitoring & complete data logging using 7” TFT touch screen

**Heat exchangers**

**Micro Channel™ heat exchanger**
- Improved energy efficiency
- Less refrigerant charge
- Reduction in overall size of the system
- Enhanced heat transfer
- Low carbon footprint
**Recommended Danfoss solutions**

<table>
<thead>
<tr>
<th>Ripening chamber capacity</th>
<th>No. of pallet</th>
<th>Refrigeration capacity</th>
<th>Optyma™ Slim Pack condensing units</th>
<th>Thermostatic expansion valve</th>
<th>Electric expansion valve</th>
<th>Evaporator pressure regulating valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT</td>
<td>-</td>
<td>KW</td>
<td>R22 - Reciprocating</td>
<td>R404A (R22) - Scrolls*</td>
<td>R22-X; R404A-S</td>
<td>R22-X; R404A, R717</td>
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<tr>
<td>4.0 - 6.5</td>
<td>5 - 8</td>
<td>8</td>
<td>OP- MCE060MTA06D</td>
<td>OP- MCE064MLA06D</td>
<td>TE 2, orifice 03</td>
<td>ETS 6 - 18</td>
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<td>6.5 - 8.0</td>
<td>8.0 - 10</td>
<td>OP- MGE086MTA06D</td>
<td>OP- MGE094MLA06D</td>
<td>TE 2, orifice 04/S(R404A)</td>
<td>ETS 6 - 25</td>
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<tr>
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<td>8.0 - 13.0</td>
<td>10.0 - 16.0</td>
<td>OP- MGE121MTA06D</td>
<td>OP- MGE107MLA06D</td>
<td>TE 2, orifice 04/S(R404A)</td>
<td>ETS 6 - 25</td>
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<td>13.0 - 17.5</td>
<td>16 - 22</td>
<td>OP- MGE171MTA06D</td>
<td>OP- MGE126MLA06D</td>
<td>-</td>
<td>ETS 6 - 32</td>
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<tr>
<td></td>
<td>17.5 - 22.5</td>
<td>22 - 28</td>
<td>OP- MGE215MTA06D</td>
<td>OP- MGE162MLA06D</td>
<td>-</td>
<td>ETS 6 - 32/ETS 12.5 (R404A)</td>
</tr>
</tbody>
</table>

- Condensing unit supplied with MLZ scroll compressors suitable for multi-refrigerant use with PVE oil
- The selections are made for banana ripening at ambient temperature 38 °C
- Average pallet = 800 kg bananas

**Tips to maintain a good banana cold room**

- The room must be as air tight as possible to prevent the ethylene from leaking out.
- The room must be properly insulated to be able to control the temperature within a few degrees.
- The room must have adequate refrigeration to accurately control the pulp temperature as bananas produce a lot of heat when they are ripening.
- The room may need heating equipment in order to maintain proper room temperature in cold weather. Electric heating elements give the most satisfactory results and hence often used as a part of the cooling system.
- Maintain proper humidity levels. For best ripening results, humidity should be 85-95%. If the humidity is too low, install a humidifier; wetting the floor of the room with water may increase the humidity but may cause sanitation issues.