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TRANSPORTATION TECHNIQUES FOR PERISHABLES

PUNE

COLD CHAIN CONCEPT
IMPORTANCE OF PRODUCT KNOWLEDGE & TECHNIQUES WHILE TRANSPORTING REFRIGERATED CARGO

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What is Cold Chain Concept?

It is an integrated approach for movement of perishable products from the point of production to consume

An efficient perishable handling system carries not only fresh chilled fruits and vegetables but also othe chilled/frozen or processed foods like ice cream, dairy products, seafood & meat.

In the entire process, nowhere the temperature/humidity conditions should be allowed to be disturbec As this happens in most of the cases, the products would almost be better off if its entire chain is nor refrigerated. Stop gap measures like putting products on refrigerated truck from production region to col storage located in metro region and then sale the same in regular open markets may impart very littl quality benefit to the product. The cold chain concept is therefore not something one would do in bi and pieces. Systems developed for moving products in cold chain should try to get the product all th way to the consumer in controlled conditions.

Value Addition:

Improper or careless handling of fruits & vegetables, during transportation can lead to damaged cargoe & extensive losses. The inadvertent destruction is often due to incorrect temperature & humidity setting during transportation. It can also result when products which are ought to be stored separately a mistakenly put to gather.

The cold chain infrastructure not only helps in preserving the value of perishables, but also generatir more value.

The provision of scientifically controlled conditions, ensure that a crop harvested over a period of or or two months meets a year round demand of the market.

The role of cold storage is immense in cutting down looses due to spoilage, avoiding gluts and distre sale by farmers. This happens due to over production and low prices during relatively small peric leading to transport bottlenecks at the peak of production Cold storages also help in maintenance quality of produce for a longer duration, as all of us know very well.

India is the second largest producer of vegetables/fruits, however most of it is destined for local consumptic since no proper infrastructure exists and more than 30% is therefore wasted. Many small farm enterpris produce good quality fruits & vegetables, but post harvest losses in distribution, mishandling, improp packaging, poor road conditions resulting in abnormal travel time, hold ups at octroi posts, docks a procedural paper work delays result in deterioration of product quality. Similarly erratic power supp makes it necessary to have back up generating sets making storage facilities economically unviable.

Currently very less efforts are also being made to produce perishables with an idea of exporting. W exports in mind entirely different mindset is required as to the packaging, appearance, flavour and qual of product needs to meet global competition.

The lack of knowledge of produce and its storage requirements also plays a significant role & those who take extra efforts in understanding the basics, know the rewards they get in the process. A good quality product, whether its fruits or vegetables, attractively packed, and with fresh appearance, fetches a premium price & is sold off in a short period compared to cheaper, stale, shrunken and tasteless varieties normally available in bulk in main markets.

We, refrigeration engineers, normally have very limited vision in this respect and concentrate on either providing refrigeration requirements for cold storages or at the most recommend transport refrigeration units. Very rarely we go in to the details of product to be stored, its characteristics, its special requirements of stacking, packaging, susceptibility to chilling/freezing injuries or tolerance to Ethylene. Let us therefore understand a little more in details some finer aspects

Before designing the cold storage, if all these issues were studied, we would be in a better position to recommend the appropriate facility for the particular product to the owner.

In this article we shall cover some of the most popular fruits we normally consume in India and their special requirements. These fruits are apples, grapes, mangoes and bananas.

Shelf Life:

Every product has a unique shelf life depending upon chosen storage temperature. Some commodities deteriorate rapidly (mushrooms) other are less susceptible (onions).For different temperature and humidity conditions the shelf life is also different.

Ideal Conditions:

The ideal temperature and relative humidity ensures the optimal shelf life of the commodity.

Sensitivity:

Certain commodities like (Bananas, mangoes, cucumber) are very sensitive to storage at low temperature. The resulting damage is called chilling injury. It is different than freezing injury or frost damage. Chilling injury occurs long before the product freezes. In bananas for example it occurs when the temperature drops below 12 deg C. Similarly it is also highly sensitive to ethylene. Certain varieties of apples also fall in this category, although they are not as sensitive to chilling injury

Chilling injury:

Is termed as physiological damage, which results from exposure of fruit & vegetables to temperatures below critical threshold limits.

Chilling injury is caused when the product is subjected to lower than normal recommended temperatures but above freezing.

The fruits and vegetables are susceptible for chilling injury. The symptoms are surface pitting, tissue breakdown as in mangoes.

Internal discoloration (browning) likes in pineapple, failure to ripen like in mangoes or papaya, accelerated degradation in grape fruits, cucumbers or off flavour taste like in tomatoes, mangoes or papaya are some symptoms of chilling injury.

Normally bananas require storage not below 12°C and all citrus fruits above 8°C

As a norm every 10°C rise in temperature approximately doubles respiration rate.

Effect of Ethylene:

It is a colourless gas, which has ether like odour. It accelerates ripening process. All plants produce ethylene in large or small quantities. Apples, papaya have high ethylene production rate.

Presence of Ethylene accelerates ripening process as well as degeneration. All plants produce ethylene in large or small quantities.

Papaya, pear, apple, melon have significant ethylene production rate

The presence of ethylene to sensitive commodities like leafy vegetables, cucumbers, flowers are adverse and they either turn yellow or become soft or drop off.

Effect of excess ethylene

Leafy vegetables	turn yellow, spotting on leaves
Cucumber	Turn yellow
Unripe fruits	Bananas, mangoes accelerates ripening
Flowers	Wilt or drop off

Ethylene or similar substances are also used commercially to accelerate ripening of some fruits like bananas. Ethylene monitors are available in typical range of 0.01 ppm to 50 ppm.

Excess Ethylene can be removed by absorption with activated carbon, potassium permanganate or ozone scrubber or fresh air ventilation.

1. Respiration of fruits, vegetables, atmosphere surrounding the produce

During growth in fields, fruits and vegetables are supplied with sugar from leaves through photosynthesis and with water and minerals through roots.

Once harvested, this supply is cut off, but plants continue to respire and mature. They have to depend on their own internal resources to generate energy required for metabolism.

Potatoes, onions, apples have low respiration and hence longer storage life. The fruits like strawberry, pear, peach have moderate rate of respiration whereas vegetables like spinach, sprouts, mushrooms have very high rate and hence very short storage life.

2. What is Controlled Atmosphere (CA)/ Modified Atmosphere (MA)

Air contains 21% oxygen and commodities have unlimited access to this oxygen necessary for respiration and correspondingly unlimited ability to generate carbon dioxide.

One can slow down the process of ripening either by reducing the oxygen content in the surrounding air or by increasing the nitrogen content. This process of controlling atmosphere to a desired level is known as (CA) controlled atmosphere.

When the product is packaged, it creates modified atmosphere inside the packaging and increases carbon dioxide percentage without any control. By using different type of packaging the life can be prolonged and the quality can be maintained. This method is called as (MA) modified atmosphere.

In CA storages normal oxygen content is maintained at 2% level or below. Too low oxygen concentrations (below) 1% will result in suffocation of commodities due to lack of oxygen. Too high concentration of CO_2 will also cause suffocation because commodity will be unable to emit CO_2.

Normal recommended conditions for most of the products are

3% Oxygen 3% Carbon Dioxide

4. Evaporation & water loss - Importance of humidi

We must understand that moisture removal leads to weight loss and thus loss of revenue. If we try to analysis as to from where the moisture comes to the coil? It either comes from the trapped air inside the space or from the product. As the air is cooled it sheds moisture and the same settles on the coil, however this is a small quantity compared to water loss from the product.

We, refrigeration engineers must keep this important point always in our mind. If we design and select equipment so that moisture loss from the product is kept bare minimum then we will not be guilty of taking out moisture from the product, allow it to settle on cooling coil and then remove it from room with efficient defrost methods and then try to device ways and means to inject additional moisture to increase humidity. Majority of such efforts fail miserably since when air is saturated additional moisture injected will always be suspended moisture in mist form and would settle on the product and cause product damage.

Utmost care therefore should be taken to keep water loss from the product to bare minimum. This of course requires more careful design and selection of equipment The temperature difference between coil air outlet and cabin should be minimum so that moisture from product does not get absorbed by air and subsequently travels to the coil, due to vapour pressure difference between commodity and surrounding atmosphere. This means high Apparatus Dew Point (ADP) selection and large air volume needs to be provided.

The perishable products require high humidity over 95% at a temperature near 0°C. It is practically impossible to have evaporator coil temperature lower than circulating air temperature by say 2°C without water condensing on the coil surface, thereby lowering R.H.

Water loss is one of the main causes for deterioration in fruits and vegetables.

Some products like cauliflower/carrot can tolerate loss up to 7% weight without noticeable quality deterioration.

Apples/strawberry/mushroom-about 6% and lettuce/broccoli only up to 4%.

Maintenance of correct humidity and temperature therefore reduces water loss.

As an example to stress the point if we consider a 5000 Ton cold storage and water loss of 6%, then we will have a product weight coming out as 4700 Ton which means 300 Ton loss. At the rate of Rs. 30/ Kg, this means a loss of 90 lacs. Isn't it a staggering figure?

R.H. is also a misleading indicator of moisture content, because warm air may contain more moisture than cool air for similar R.H. e.g.

90% R.H. at 5°C has 0.6 g/kg moisture

Whereas 90% R.H. at 15°C has 1.2 g/kg moisture, twice the amount.

One another way of keeping the humidity high is to inject fresh warm and humid air from outside. The limiting factor is however increased refrigeration load and power consumption.

5. Ventilation - Fresh air

Ventilation during transport can either be internal ventilation with cold air to maintain a pre-set product temperature, or fresh air ventilation. Fresh air is introduced to remove carbon dioxide which has been

released by the products during respiration and which can lead to oxygen deficiency in the transport unit

Fresh air requirement is generally maintained at 1-2 M^3 per Ton/hr and the heat of respiration is approximately taken as 0.2 litre CO_2/watt

Internal Ventilation:

Air circulation around the product is necessary to maintain uniform product temperature at right level The temperature difference between supply cooling air and return air indicates whether the amount o air may be reduced or increased.

If the temperature difference is less than 1°C, the consideration should be given to reducing the amoun of air in the container and if the difference is more than 3 to 4 °C, the amount of air need to be increased

Maximum air requirement should be approximately 600-700 M^3/kw of cooling with 1 or 2 steps of fan speed regulation.

The key to uniform cooling is uniform air distribution.

6. Mixed loads - Transport

While transporting mixed cargo care should be taken for different temperature and humidity requirement (onions, potatoes), products having undesirable emission of odours like citrus fruits, garlic should not be transported together.

Normally high relative humidity is preferred so prevent weight loss as discussed, however certain product like onion or potato if subjected to more than required humidity can have adverse effect. While loadin different products in the same compartment may cause such problems. Many trucks are therefore equippe with compartments these days to store different products at different conditions.

7. Packaging

There are two types of packaging for fruits and vegetables, outer packaging which is the unit in whic the products are handled, and the inner packaging which is required as sales packaging.

The **outer packaging** should be designed to protect from rough handling and -withstand stacking heigh of 2.5m.

-The packaging should not collapse due to high humidity
-Should allow adequate air flow so that inner packaging will maintain desired temperature
-Ventilation holes should be at the top/bottom
-Material used could be wood, fiberboard, and plastic

Inner packaging has following advantages

-Protects against rough handling and contamination
-Prevents dehydration
-Retards aging
The disadvantages being, impedes chilling and danger of suffocation.

Normally the materials used for inner packing are plastic films as bags or wrapping, nets, paper bag coated with plastic.

The design of packaging should be capable of maintaining desired humidity level and airflow should b able to allow heat of respiration to flow out.

Nets and bags give good ventilation but poor stacking ability. Rigid boxes give good stacking but poo

air circulation so ventilation holes are needed.

Pre-coolig:

Transport equipment is designed to hold the product at a desired temperature. These units are not designed and therefore do not have sufficient capacity/cooling power to reduce the temperature of the mass of the cargo to the required level in a timely way. It is therefore necessary to pre-cool the cargo before loading.

Where the pre-cooling facilities are not available and the product is to be loaded hot, then every precaution should be taken to reduce the heat absorbed in the cargo prior to loading. This can be achieved partially by harvesting at night or early morning, keeping the product in the shade and in some cases damping down with ice or water. Loading cargo without pre-cooling causes condensation probiems. The most damaging problem is that the free water provides a breeding ground for bacterial growth.

Loading the cargo without pre cooling causes condensation problems.

As the vehicle temperature drops, water vapour will condense out of the air. This condensate will settle on the evaporator coil fins, forming ice and restricting airflow.

Condensation will also collect on cardboard boxes, thus weakening the Strength of packing.

Also free water provides breeding ground for bacterial growth. If wrapped in plastic bags and product is not pre cooled, the subsequent cooling results in free moisture trapped inside the bag, providing suitable environment for bacterial growth.

Care for good transporting practices

Receipt quality-

This should be thoroughly inspected to find whether commodity is able to withstand the transport period.

High temperature at start could be disastrous.

Packing should be such that will remove heat of respiration.

Transport

Proper stacking to ensure adequate air circulation

Temperature sensors at right points

Proper documentation

Delivery

At no point the product to leave cold chain.

Loading/unloading of product from refrigerator to refrigerator with proper maintenance of temperature.

Marked temperature differences would lead to moisture condensation on surface accelerating deterioration.

Temperature probes should be calibrated in ice water before loading cargo. Discrepancies should be within 0.5°C.

Conclusion:

The paper covers some of the aspects that are normally overlooked by majority of refrigeration engineers who are involved in designing/ selecting refrigeration equipment for cold storages and fro transport refrigeration. The usual considerations like insulation requirements, construction of properly build truck

body, selecting proper refrigeration unit etc. have been covered in earlier papers presented by the author and those who are interested in this material can approach the author on the mail address given below

Ref : books : Guide to Food Transport Mercantila Publication Denmark
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