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Heat load calculation of ice requirement in finfish and shellfish

CHILLED STORAGE OF FISH

- Chilling is an effective way of reducing spoilage in fish if it is done quickly and handles carefully and hygienically.
- The objective –To cool the fish as quickly as possible to as low temperature as possible without freezing
- It can not prevent spoilage but slow down the enzymatic and bacterial activity.
- To chill the fish they must be kept in a medium colder than fish
- Medium can be liquid, solid or gas
- Ice is the best

Properties of Ice

- Ice is simply solid water which has been changed from a liquid to solid state by the removal of heat energy.
- At normal atmospheric pressure, pure water changes from liquid to solid at $0^{o}C$.
- It will melt or change back to liquid at same temperature.

- To change from liquid to solid, heat energy must be removed which is latent heat of fusion of 1g of water at $0^{o}C$.
- The latent heat of fusion for water is 334.7 J/g (80 cal/g) or 334.7 kJ/kg (80 kcal/kg).
- This can be compared with the specific heat of water which is only 4.21 J/g or 1 cal/g.
- Specific heat is the amount of heat required to raise the temperature of 1 g of substance by $1^{o}C$.

- When ice melts, or changes from solid to liquid, it absorbs heat energy at same rate i.e. 334.7 J/g (80 cal/g) from the surroundings.
- However, 1 g of water only absorbs 4.2 J from its surroundings when its temp increases by $1^{o}C$.
- The latent heat of fusion of ice is very high compared with other materials and when it melts, ice is able to absorb large quantities of energy.

- If ice is put into contact with fish above $0^{o}C$, it will absorb heat from the fish.
- The temperature of fish will drop and the ice will melt.
- As ice melts at $0^{o}C$, the temperature cannot drop below this level which is an ideal temp for the chilling and storage of fresh fish.

Advantages of using ice as cooling medium

- High heat absorption capacity
- As ice melts, chilled water is formed which helps to wash away surface bacteria and contaminants.
- The ice melt-water keeps the surface of the fish wet which prevents dehydration and preserves the glossy appearance.
- The ice melt-water in contact with the fish is a good conductor of heat and facilitates cooling

- Ice made from potable water is not toxic
- It can be transported from place to place and is a method of portable refrigeration.
- As ice melts at $0^{o}C$, it will not freeze the fish.
- It is relatively cheap and easily available

Heat load calculation

- If wet fish has a specific heat of 4 J/g, the amount of heat which would need to be removed would be equivalent to

Wt of fish x temperature change x specific heat

Therefore the energy required to chill 60 kg of fish from 30 ^{o}C to 0^{o}C would be

60 000 x (30 – 0) x 4 = 7 200 000 J or 7200 kJ

- As 1 kg of ice will absorb 334.7 kJ when it melts, the amount of ice required can be calculated as

$$7200 / 334.7 = 21.5 \text{ kg}$$

Here Ice to fish ratio is 1: 2.79

However this is strictly theoretical

Factors affecting heat load calculation

- Surrounding air melts ice at high ambient temperature
- Proper insulation to protect both fish and ice from increase in temp (particularly in tropical countries)
- The cooling of the box or container in which the fish are held.
- How the fish are packed in the ice (all ice in direct contact with all fish)

- The length of time the fish need to be kept chilled once cooled.
- How quickly the fish are chilled
- The thickness of the fish

Table 1- Weight of ice needed to cool 6.5 kg of fish

Initial temp of fish ($0^{o}C$)	Weight of ice (kg)
18	1.5
15	1.2
13	1.1
10	0.8
7	0.6
5	0.4
1.5	0.1

- Extra ice required to combat the extra warmth from outside.
- The cooler the fish, the smaller the quantity of ice needed for the initial cooling.
- Taking into consideration all the factors, the ratio of ice to fish is roughly 1:1 by weight
- A successful icing is one in which the fish are still chilled with a little ice remaining at the end of the voyage or journey