Preservation and Processind of Fish


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Introduction

- **In some islands, more fish is caught at times than can be consumed.**
- **Methods are used in keeping the surplus fish in good condition for later consumption.**
- **Again, fishermen sometimes cannot return to their villages promptly with fresh fish they have caught, and it will be of value to them to know how to preserve their catch by simple means.**

FISH PRESERVATION

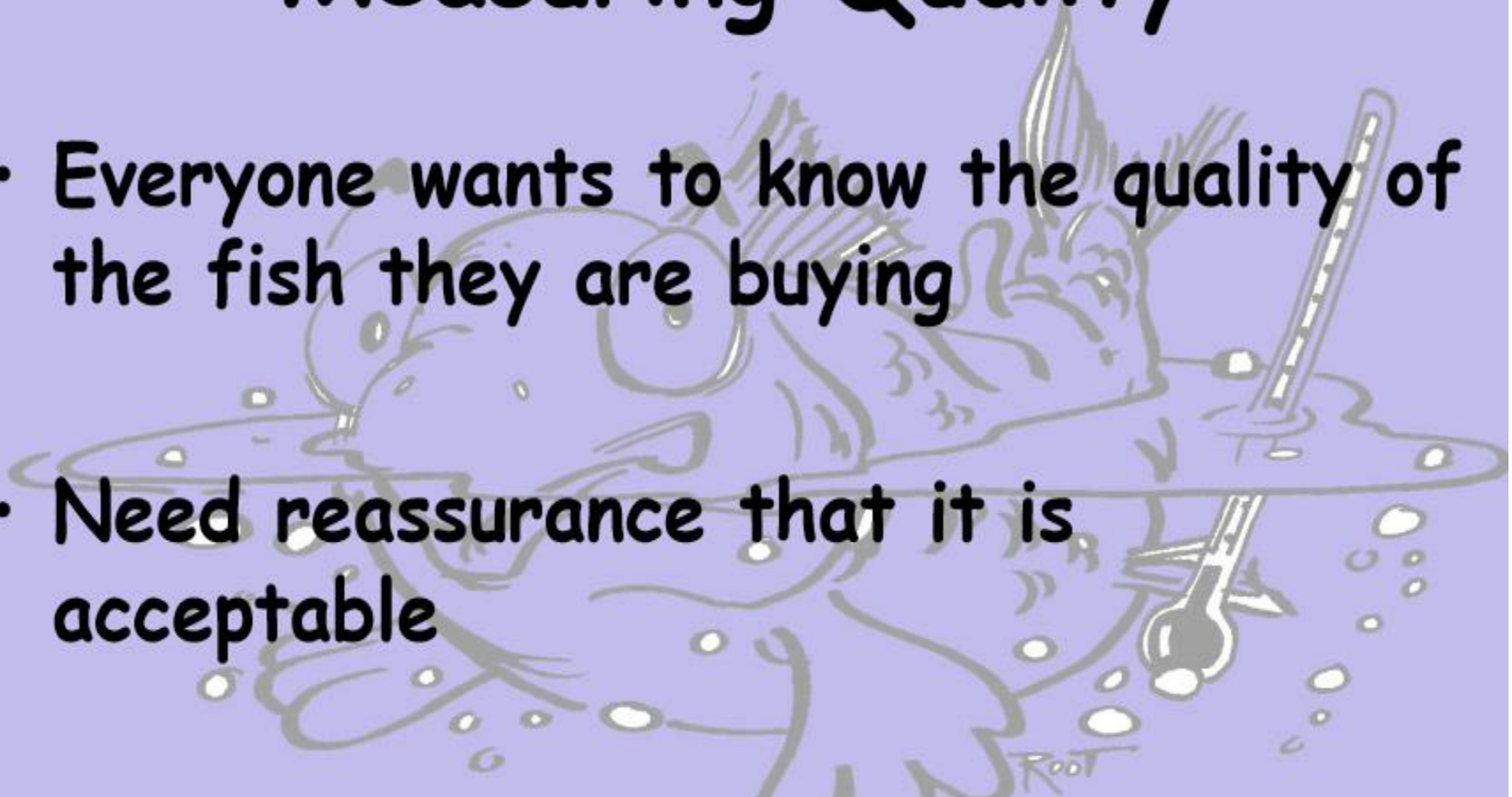
- **Preservation of fish is done to prevent spoilage.**
- **Since fish is very perishable, it is therefore, necessary to preserve fish if not consumed or disposed immediately.**
- **Fish preservation is the method of extending the shelf life of fish and other fishery products by applying the principles of chemistry, engineering and other branches of science in order to improve the quality of the products.**

Some of the important reasons for preserving foods are:

- **To take care of the excess produce.**
- **Reaches areas where the food item is not available**
- **Makes transportation and storage of foods easier**
- **Preserving Foods at Home**

Measuring Quality

- Everyone wants to know the quality of the fish they are buying
- Need reassurance that it is acceptable
- Want quantitative measures



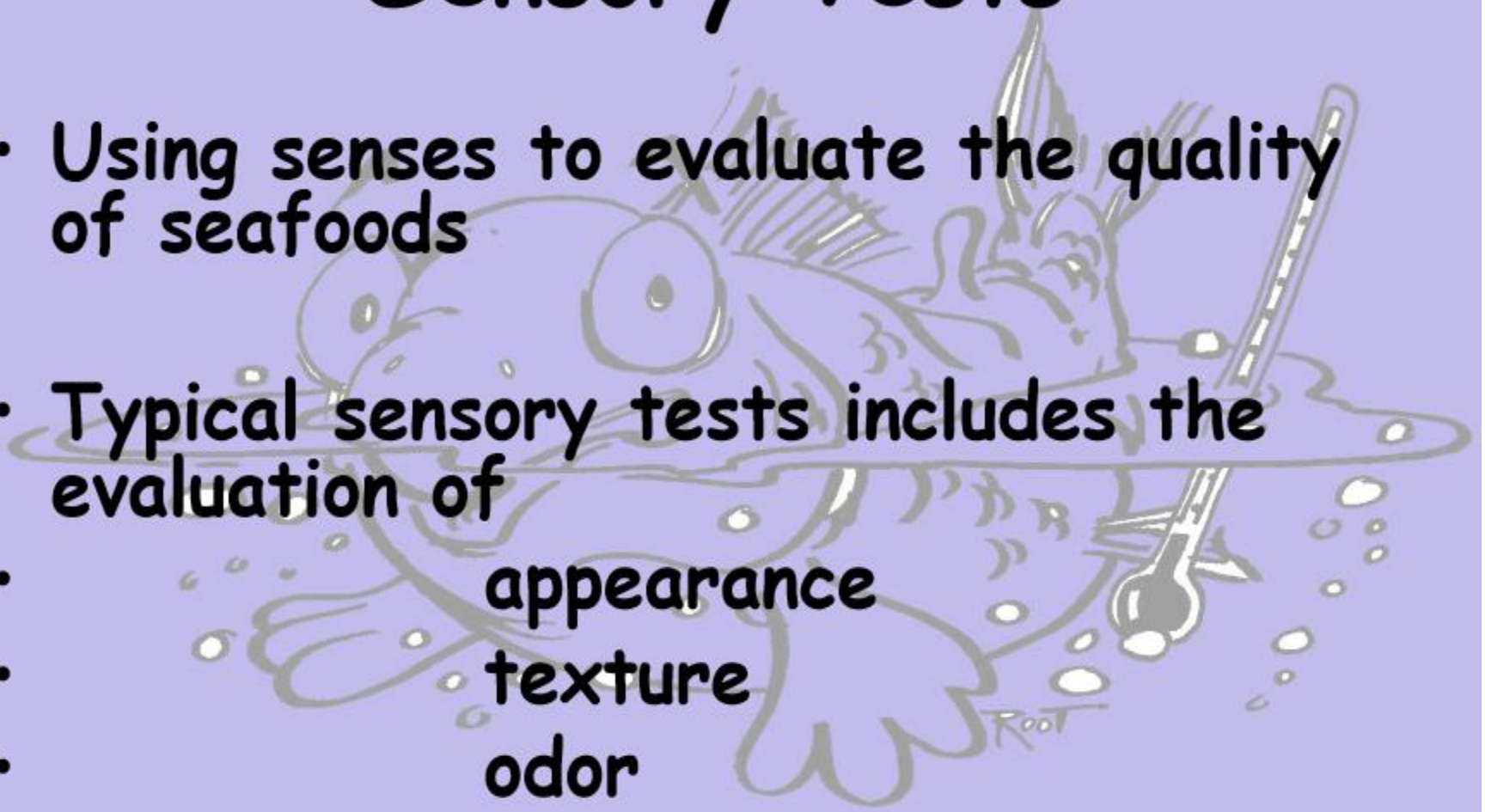
Methods

- Testing Quality By

- 1. Sensory
- 2. Chemical
- 3. Physical
- 4. Microbiological

Sensory Tests

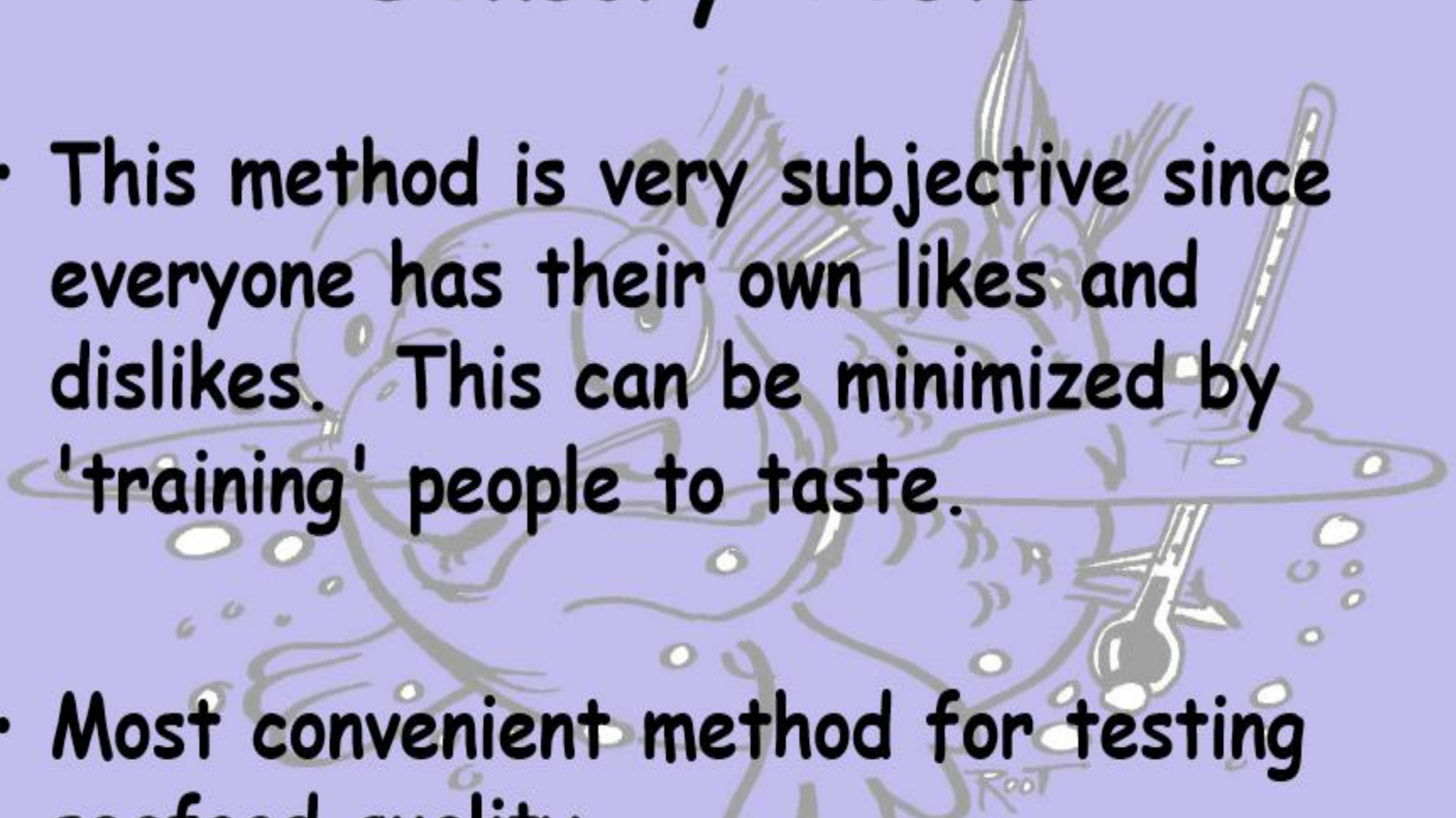
- Using senses to evaluate the quality of seafoods
- Typical sensory tests includes the evaluation of
  - appearance
  - texture
  - odor
  - flavor
  - other attributes



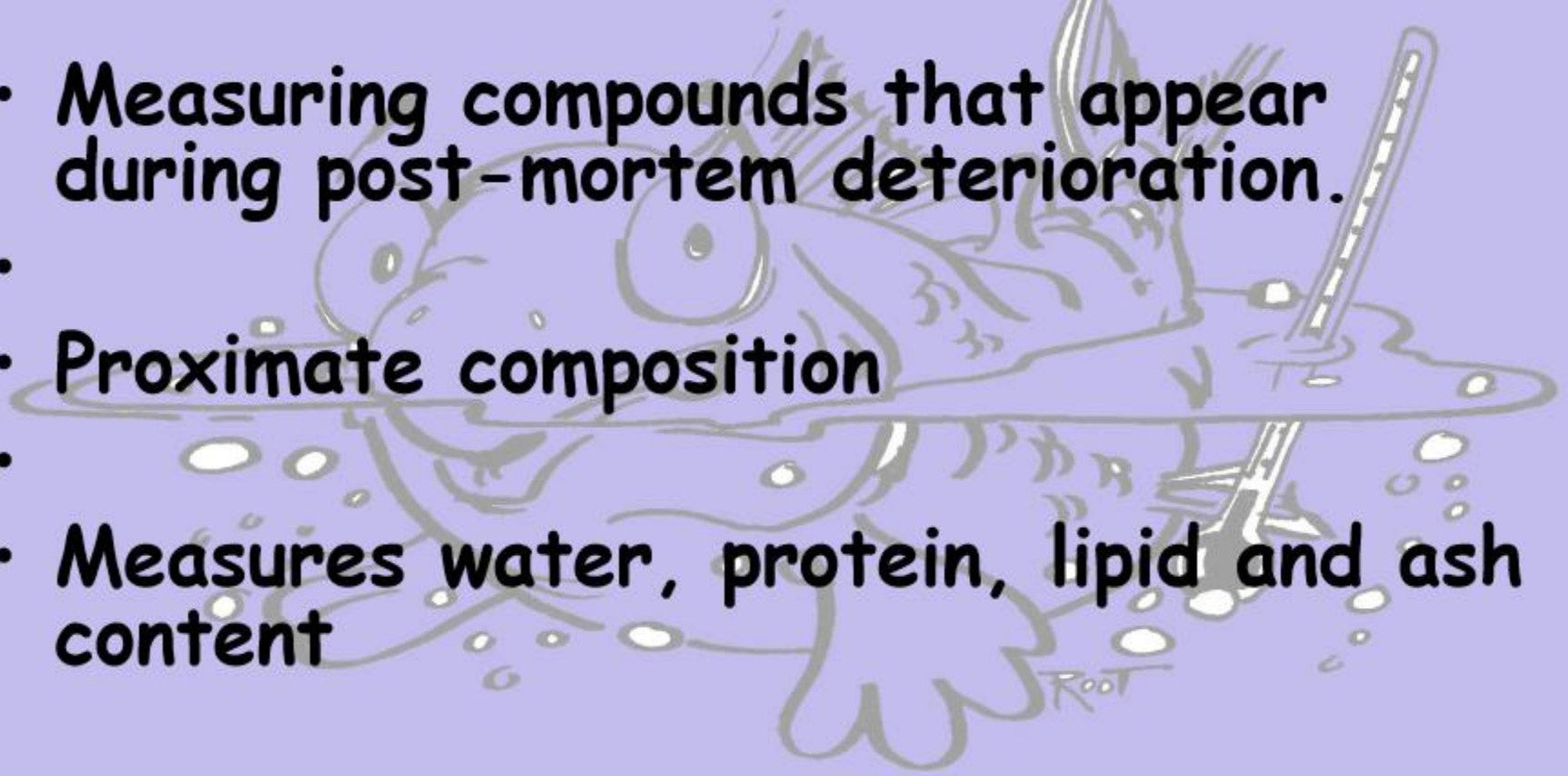
Sensory Tests

- This method is very subjective since everyone has their own likes and dislikes. This can be minimized by 'training' people to taste.

- Most convenient method for testing seafood quality.



Chemical Tests



- Measuring compounds that appear during post-mortem deterioration.
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- Proximate composition
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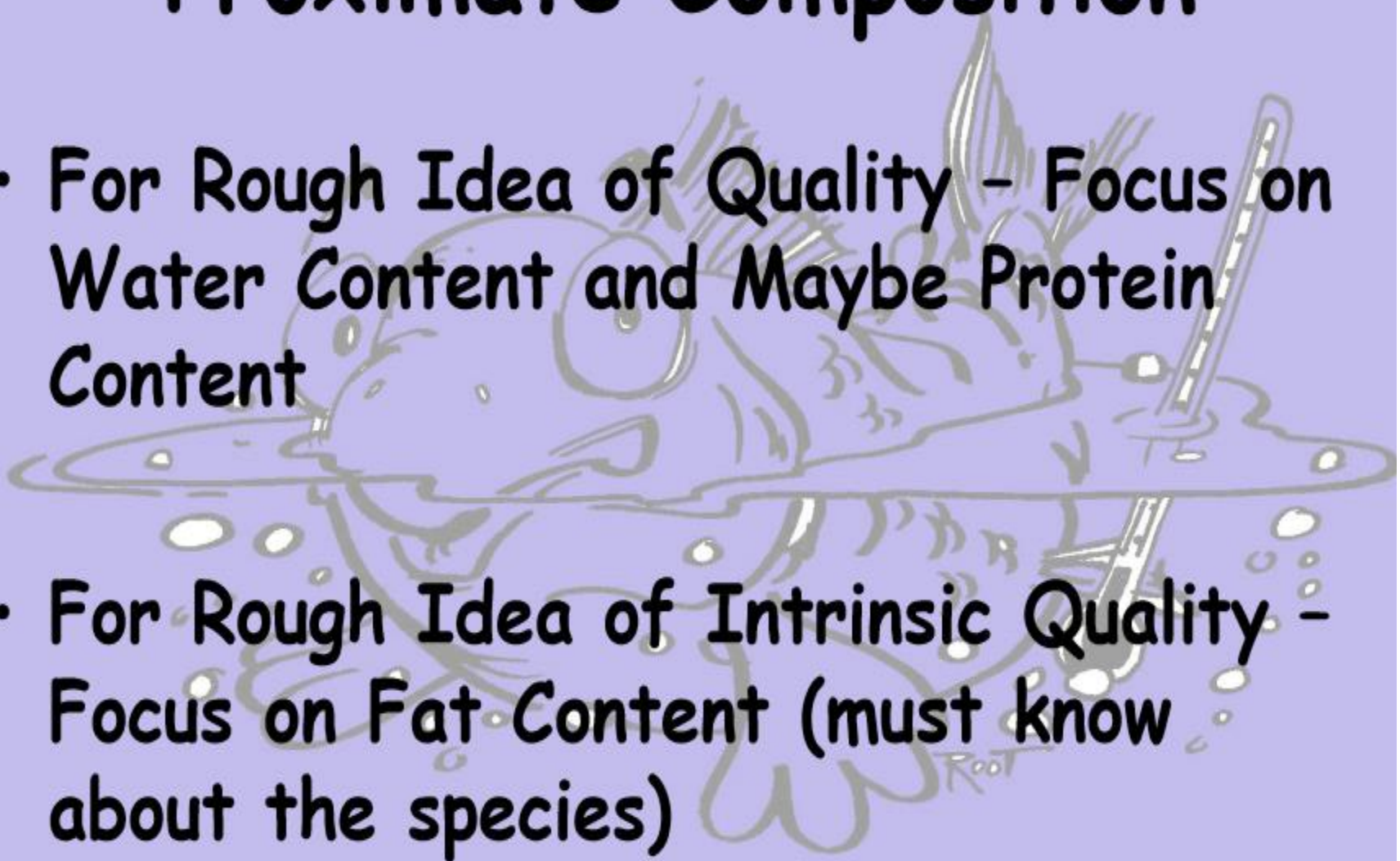
- Measures water, protein, lipid and ash content

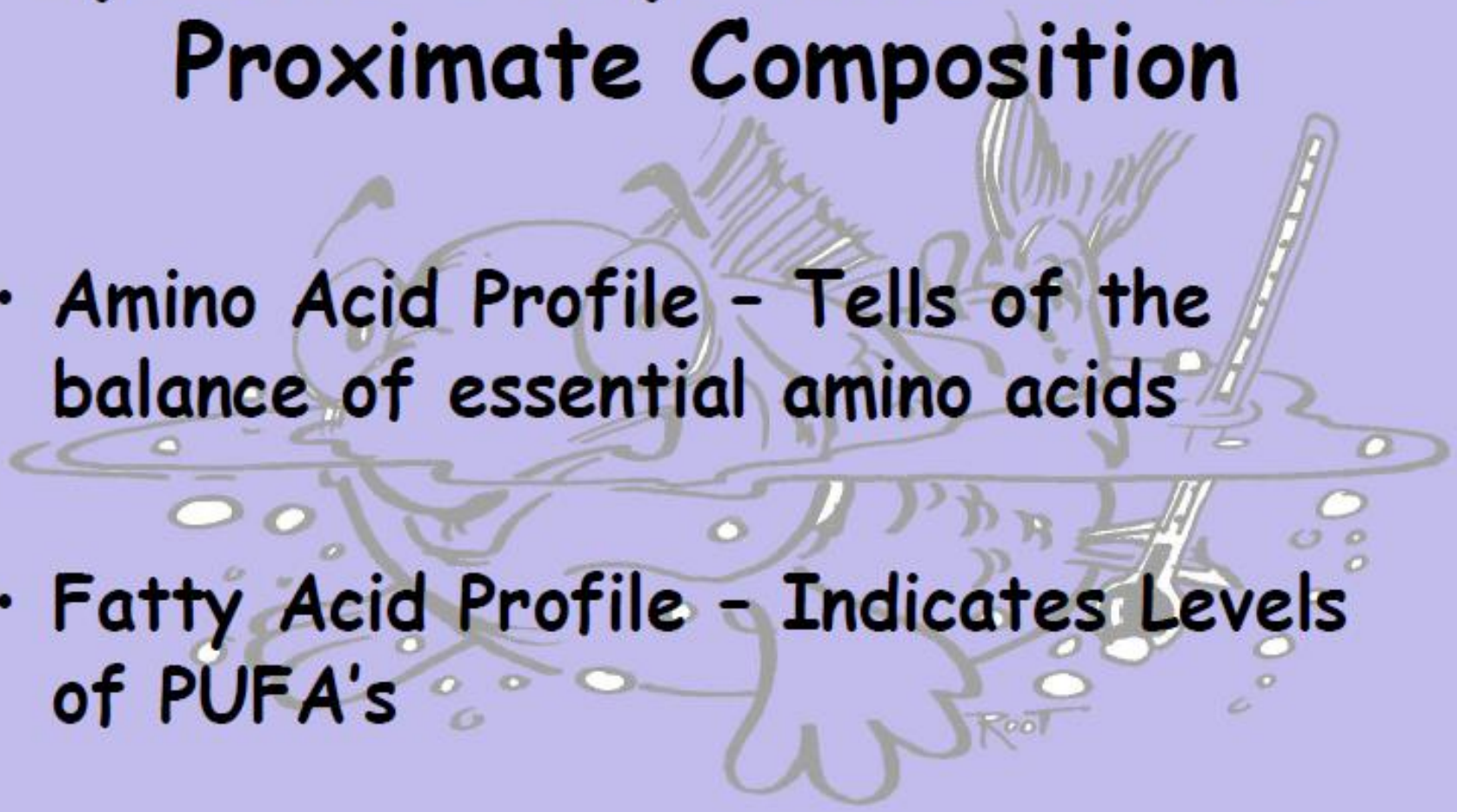
- Rough estimate of quality, but not really useful. Fish to fish variation can be great.

Proximate Composition



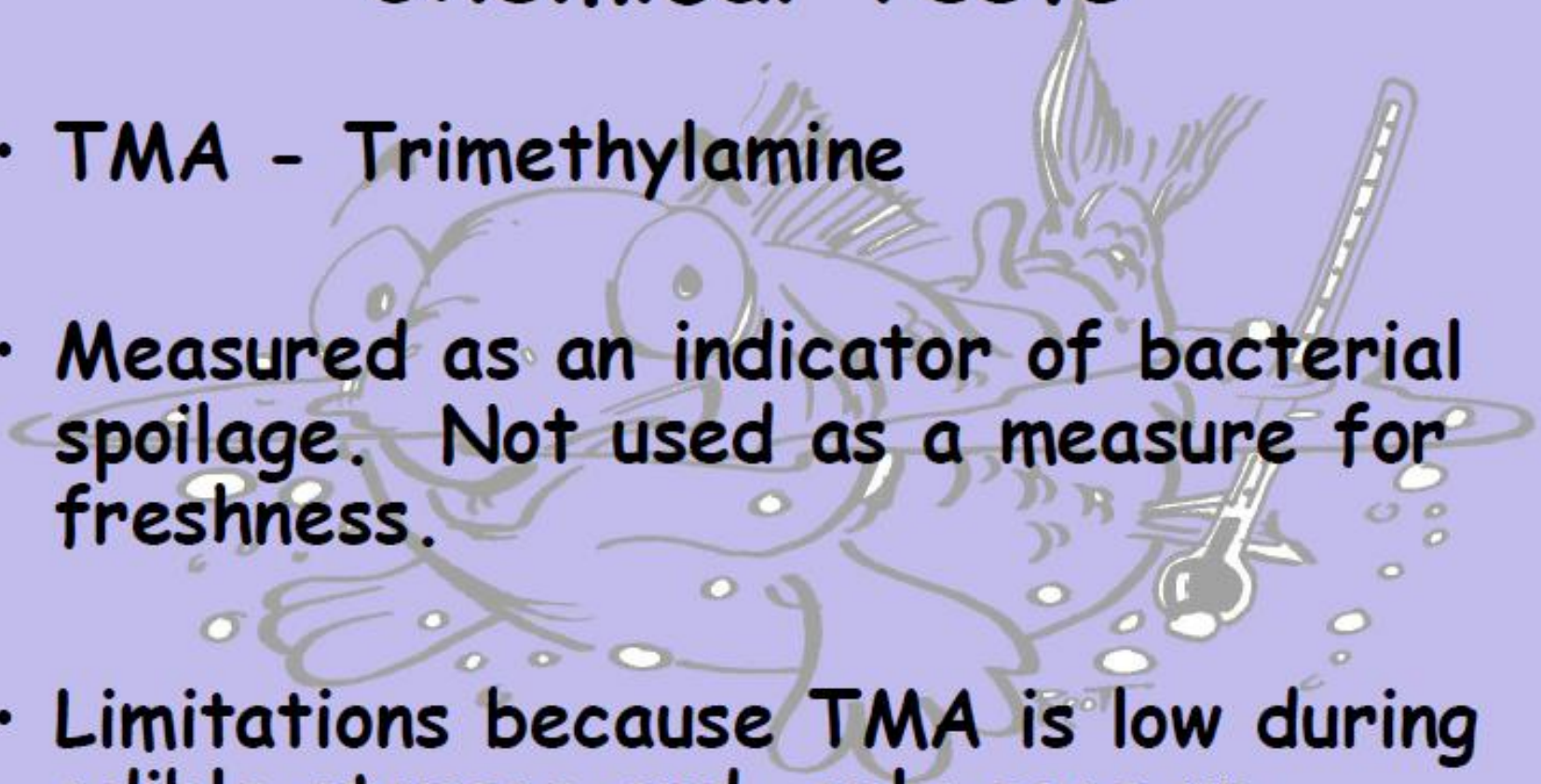
- For Rough Idea of Quality – Focus on Water Content and Maybe Protein Content
- For Rough Idea of Intrinsic Quality – Focus on Fat Content (must know about the species)

Specific Components of the Proximate Composition



- Amino Acid Profile – Tells of the balance of essential amino acids
- Fatty Acid Profile – Indicates Levels of PUFA's
- Both Nutritional Quality Measures

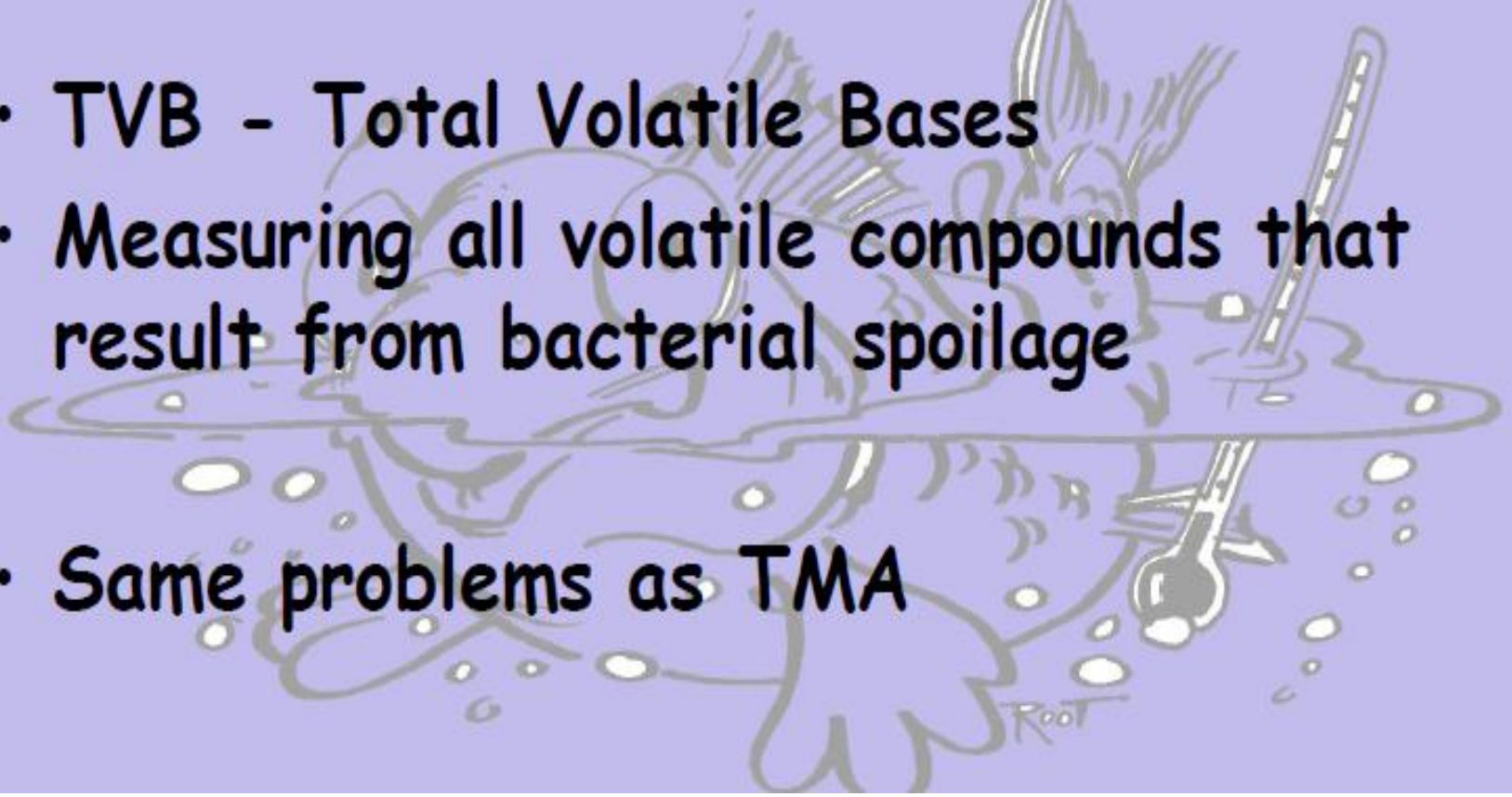
Chemical Tests



- TMA - Trimethylamine
- Measured as an indicator of bacterial spoilage. Not used as a measure for freshness.
- Limitations because TMA is low during edible storage and only goes up rapidly when fish is close to spoilage.

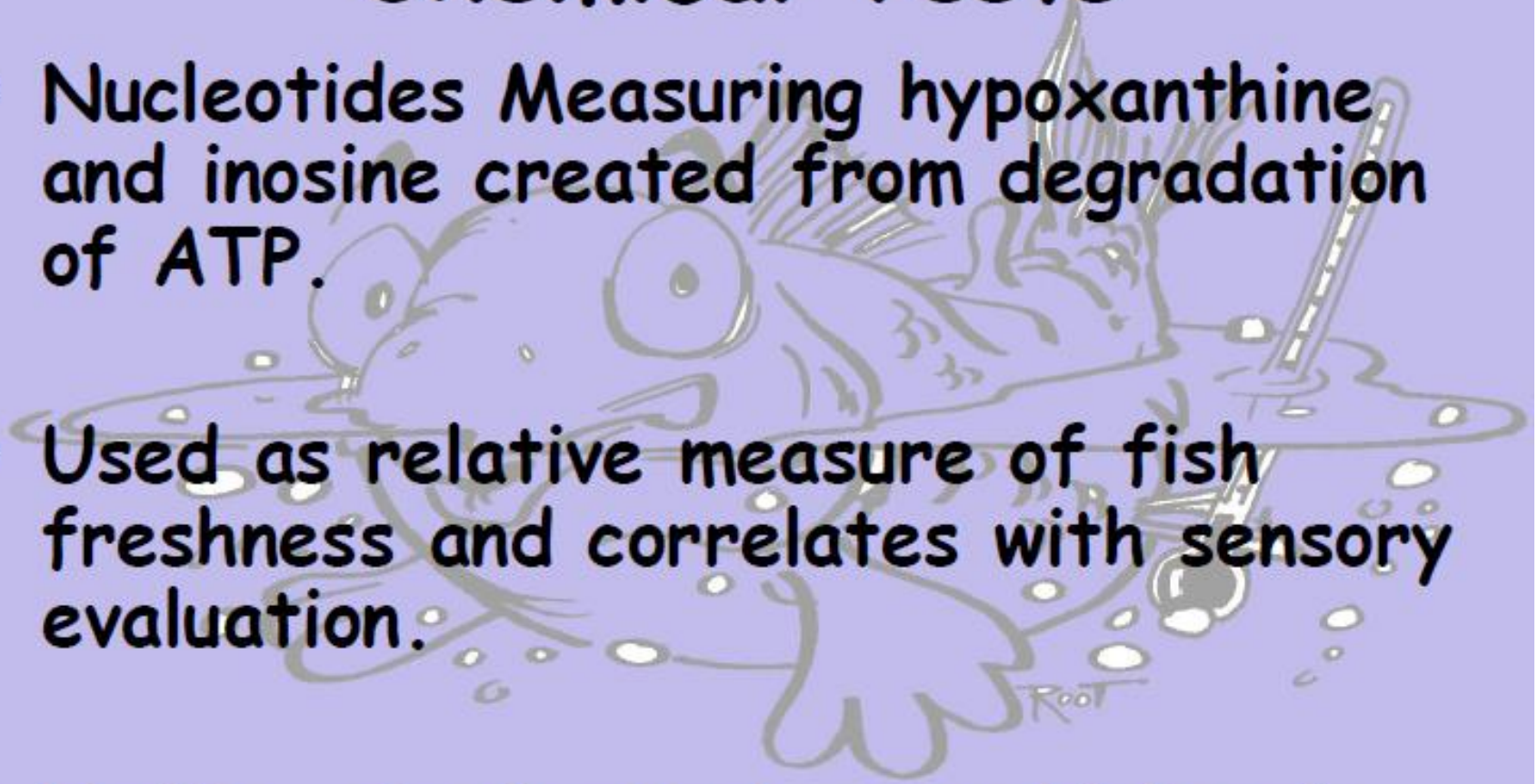
Chemical Tests

- TVB - Total Volatile Bases
- Measuring all volatile compounds that result from bacterial spoilage
- Same problems as TMA



Chemical Tests

- Nucleotides Measuring hypoxanthine and inosine created from degradation of ATP.
- Used as relative measure of fish freshness and correlates with sensory evaluation.
- Limits - Dark muscles are higher in these compounds and there are variations in ATP degradation



Microbiological Methods

- Not used to assess freshness or eating quality, but rather the hygienic quality of the fish, hygiene during processing and the presence/absence of public health risks.

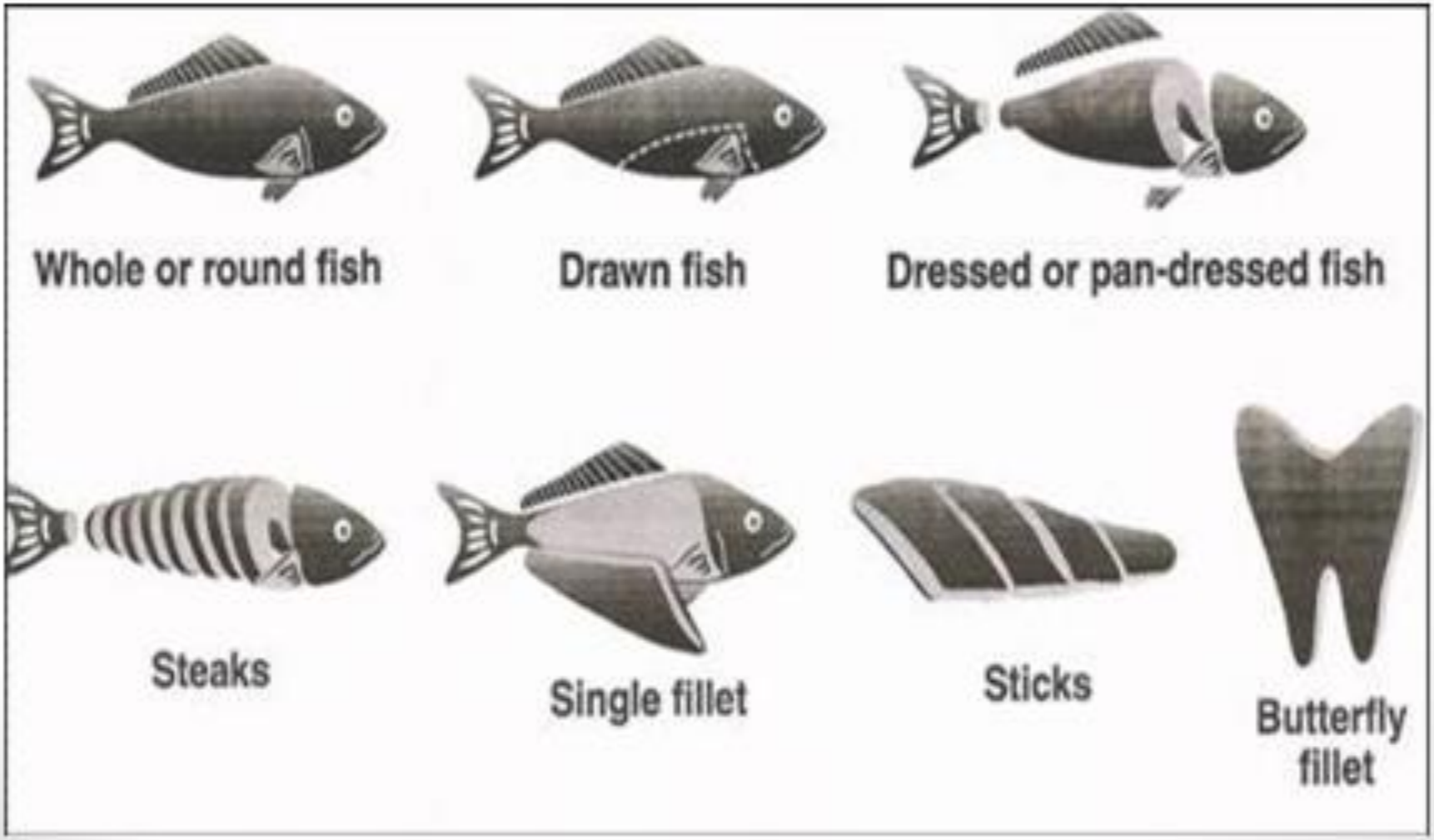
Characteristics of fresh fish

1. Eyes are bulging, clear, full and bright.
2. Gills are red and covered with clear shine.
3. Odor is sea water smell, not foul.
4. Flesh is firm and elastic.
5. Scales are complex, shinny and intact.
6. Color is bright and shiny.
7. Belly walls are undamaged.

Causes of Fish Spoilage

- Fatty fish spoil faster than bony fish
- Small fish decay faster that large fish
- Cold water fish spoil faster than warm water fish
- Bacteria are also present in the external slime, on gills, and in the interiors of fish.
- The most common chemical action that causes spoilage is when oxygen in the air attack unsaturated oils in fish causing rancidity.

MARKET FORMS OF FISH



MARKET FORMS OF FISH

1. Whole fish – are sold in the market fresh and sometimes alive.

MARKET FORMS OF FISH

2. Dressed fish – is whole but entrails, scales, fins and head are detached.

MARKET FORMS OF FISH

3. Butterfly fish – is done by slicing a whole fish lengthwise to remove its backbone and ribs.

MARKET FORMS OF FISH

4. Fillet – is the boneless form of fish.

MARKET FORMS OF FISH

5. Steaks – are slices cut horizontally form a large fish.

MARKET FORMS OF FISH

6. Fish sticks – are cut evenly from large slabs of frozen fillets.

Types of Shellfish

Scallops

Crabs

Mussels

oyster

Types of Shellfish

Shrimp

Lobster

Market Forms of Shellfish

- Live Shellfish

- Whole Shellfish

- Shucked shellfish

Market Forms of Shellfish

- Headless Shellfish

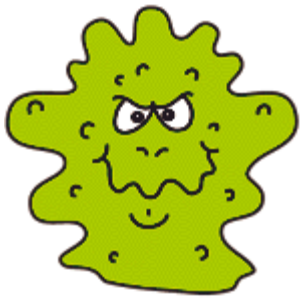
- Cooked Shellfish

PROPER STEPS IN HANDLING FRESH FISH

- Avoid exposing the fish to sunlight. Keep them in a shaded area.
- Ice the fish immediately after they are caught to lower their temperature.
- Remove the gills and internal organs.
- Avoid soaking the fish too long in the water after death as this easily spoils the fish.
- Use mechanical refrigeration if there are facilities.

Preserving

- **Controling of temperature**
  - **Lower temperature (freezing)**
  - **Increasing temperature (canning)**
- **Reducing the free-water**
  - **Drying**
  - **Salting**
  - **Smoking**
- **Chemical means**
  - **Fermentation**
  - **Pickling**

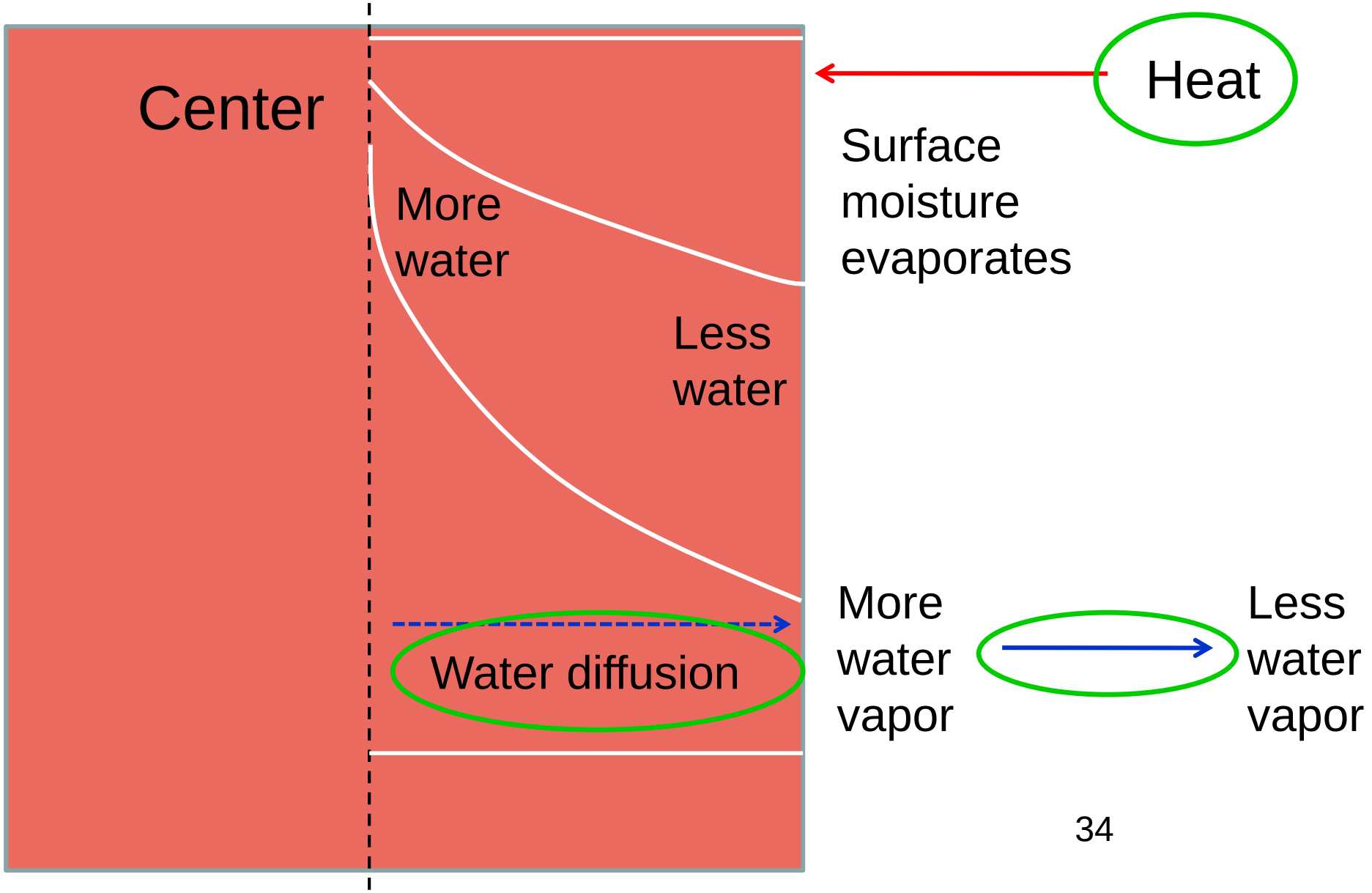


Drying

- **Removal of water from fish (to reduce water activity) to extend shelf life**
- **Requires input of heat (evaporate water)**
  - **Sun, wind, flame, electrical etc.**

- **Requires removal of water in the form of vapor**

Drying Process



Drying principles

- **Drying occurs in two phases**
  - **Phase 1 (constant rate period)**
    - **Water removed from surface**
  - **Phase 2 (falling rate period)**
    - **Water is removed from muscle**
    - **Water migrates to the surface (diffusion)**
    - **Water evaporates at surface (requires heat)**
    - **Water is removed from the atmosphere surrounding the fish surface**

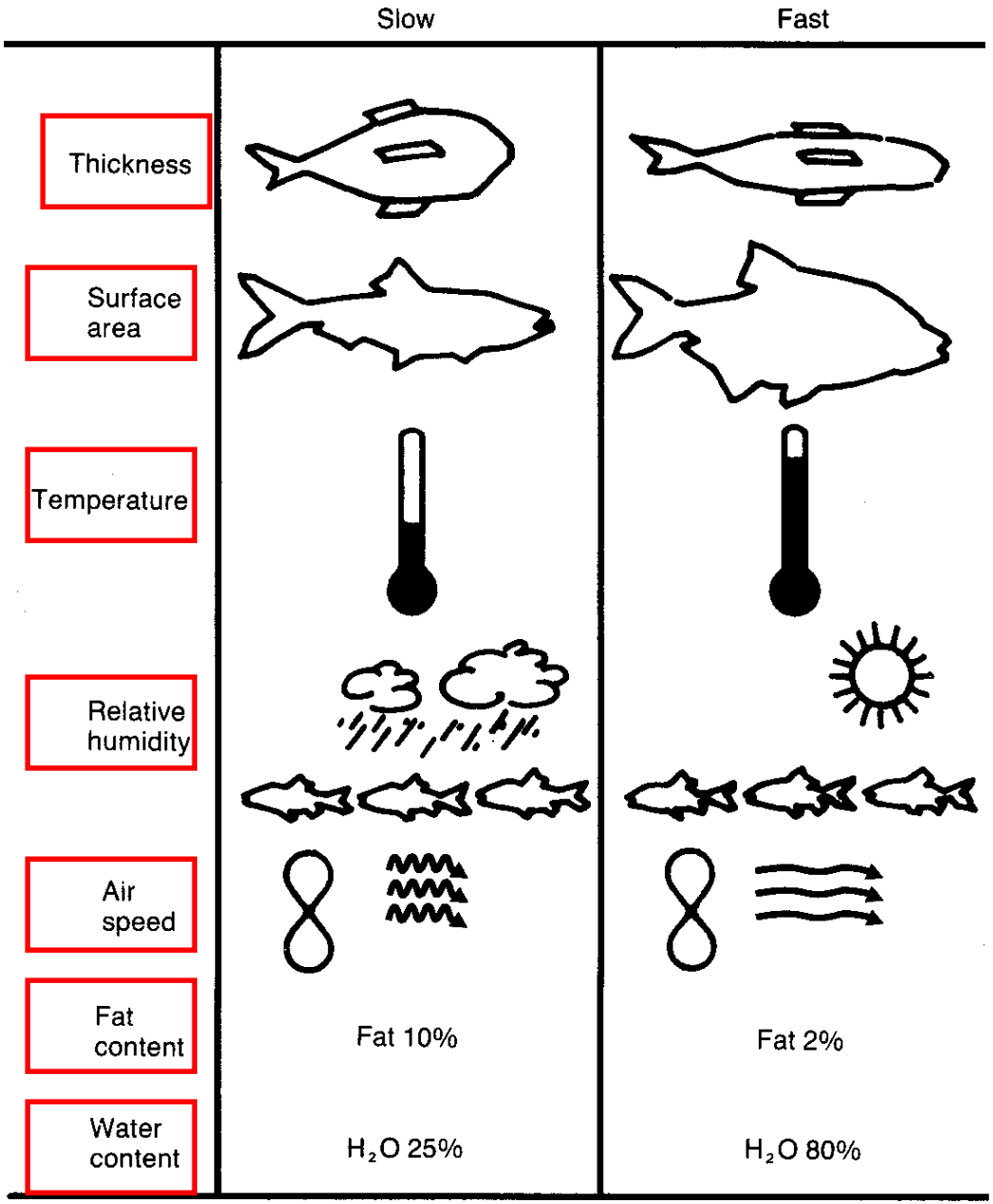
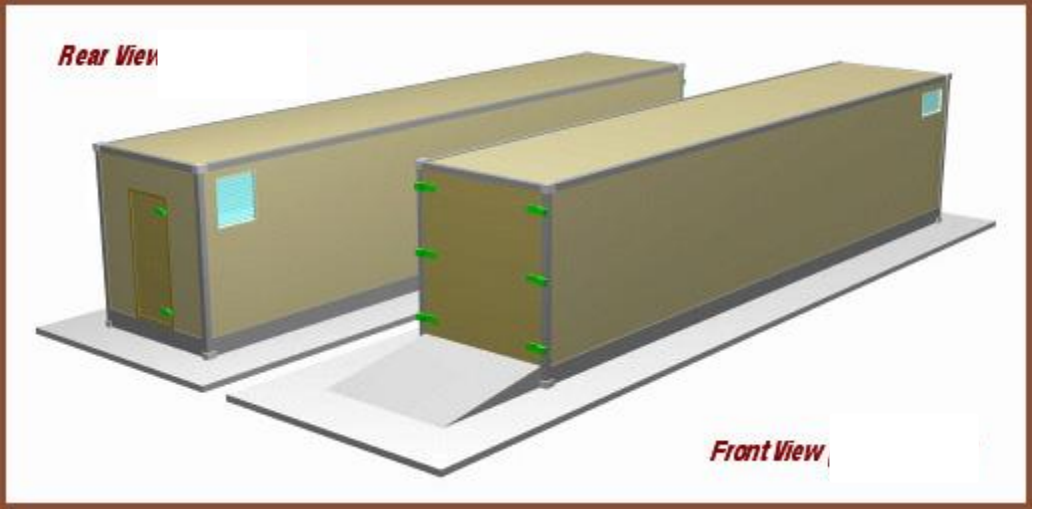
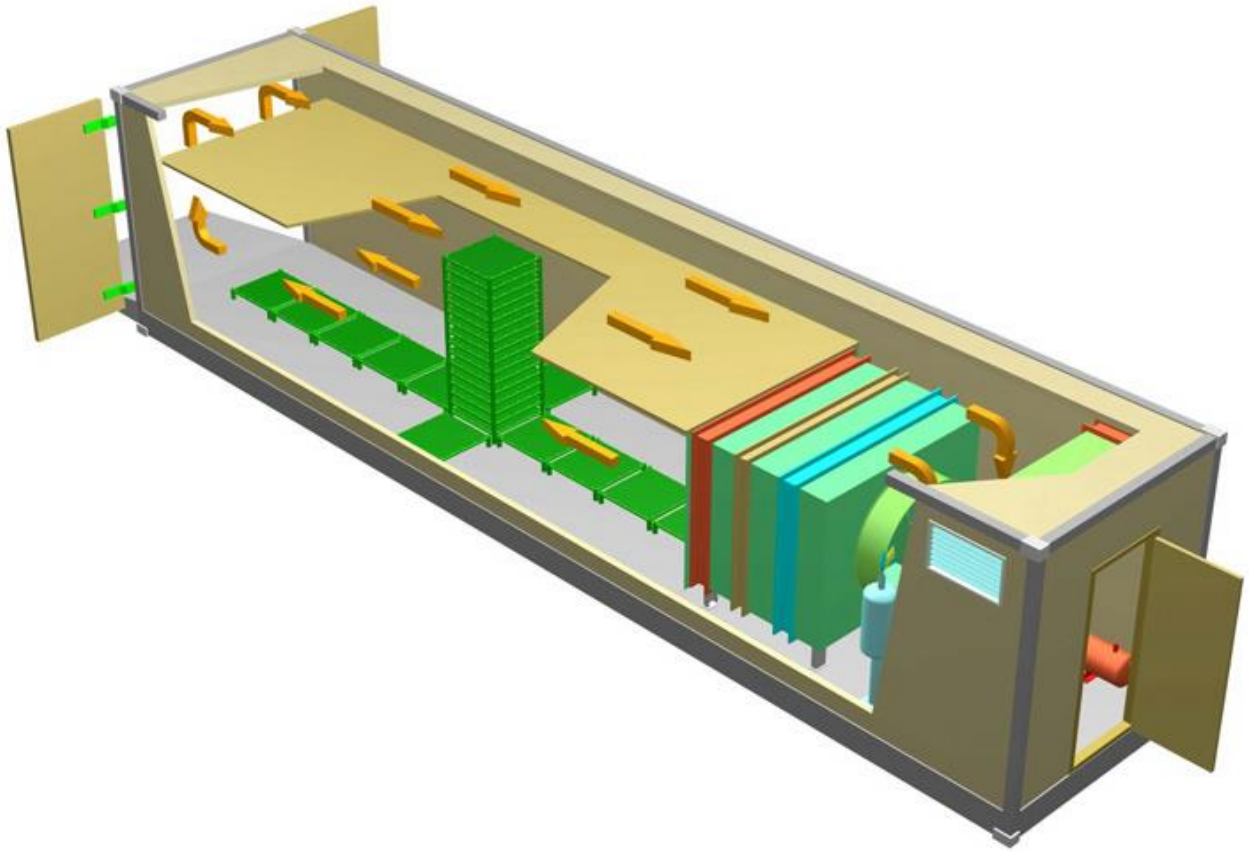


Figure 59. Some factors affecting drying rate.



Advanced automated driers



- **Problems with dried fish**
  - **If environmental T is warm and fish is too wet**
    - **Molds (A_w>0.75)**
      - **Grow very well when drying in tropical areas**
    - **Aerobic spoilage bacteria (if non-salted)**

    - **If salted (solar salt) can get halophiles growing**
      - **Pink colonies**
      - **Major problem with salted and dried cod**
    - **Pests**
      - **Insect parts and eggs a major quality problem**
      - **Flies (*Dipteria*) lay eggs and can spread disease**

      - **Less problem with fish pre-drying**
        - » **Salting can deter flies**
        - » **Some use insecticides on fish!**

      - **Rodents and birds are a constant problem**

- **Problems with dried fish (cont.)**
  - **Lipid oxidation (rancidity)**
  - **Protein denaturation**
    - **Get muscle fragmentation**
  - **If drying is too rapid we can get "case hardening": water-impermeable skin at the surface**
  - **Case hardening**
    - **Flesh soft on the inside and spoiled by bacteria (extreme putrid odor)**

Salting

- Salting - traditional method
- Reduces water activity (a_w) to retard microbial spoilage and chemical reactions
- Salt penetrates into the muscle and binds the water.
- At 6-10% in the meat will spoilage

- **Different grades of salt, from 80-99.9% purity**
  - **Purer salt leads to less problems**
    - **less contaminants (less water uptake, bitterness)**
    - **less halophilic bacteria (salt tolerant)**
    - **Some salts can have up to 10^5 of bacteria**
  - **At least 95% purity should be used**
    - **Impure salts about 80% NaCl**
    - **Solar salt most impure (major source of halophiles)**
    - **Can purify by washing briefly with water (calcium and magnesium dissolve sooner than NaCl)**
  - **Finer salts are ideal for brines (dissolve rapidly)**
  - **Larger size salt preferred during dry salting**

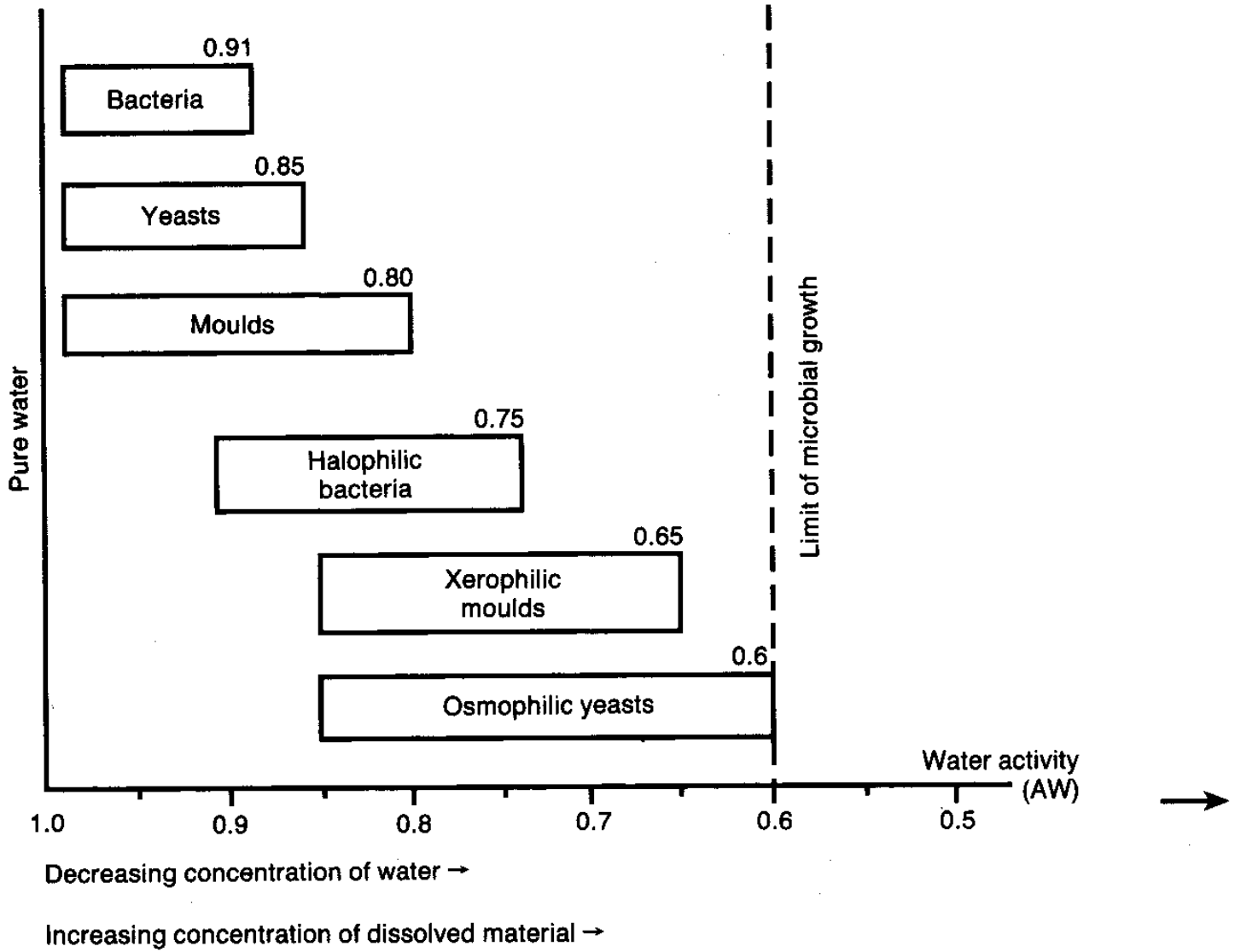


Figure 57. Growth ranges of micro-organisms with respect to water activity.

Source: Redrawn from Figure 30 of *Principles of Microbiology for Students of Food Technology* by T. J. Parry and R. K. Pawsey. 2nd edn. Hutchinson, London. 1984.

Table 2.1 Limiting water activities and examples of appropriate foodstuffs for the growth of various specific micro-organisms

a_w	Micro-organisms inhibited	Food examples
1.00	None	Most fresh, high water content food
0.95	Gram negative rods like *E. coli* and spores of Bacillaceae	40% sucrose or 7.5% salt (NaCl) solution; breadcrumb, cooked sausage
0.91	Most cocci and lactobacilli. Vegetative cells of Bacillaceae	55% sucrose or 12% salt solution; Parma ham
0.88	Most yeasts	65% sucrose or 15% salt solution; salami; sausage; fishmeal
0.80	Most moulds. *Staphylococcus aureus*	Wheat flour; dry cereal grains and pulses; fruitcake; dry sausage
0.75	Most halophilic bacteria	26% salt solution; jams; fondants; kench-cured cod prior to drying
0.65	Xerophilic moulds	Marzipan; marshmallow; fishmeal dried to 5% moisture; 'stockfish'
0.60	Osmophilic yeasts	Liquorice; fruit gums; kench-cured cod after drying

- **Methods of salting**

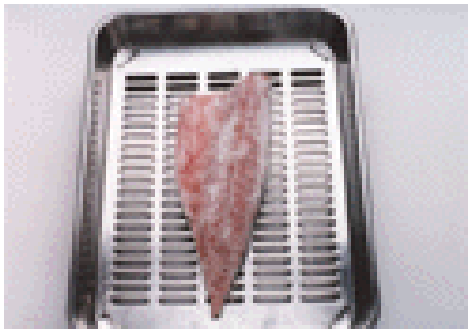
  - **Brine salting (15-25% solution)**
    - **Fish immersed in solution of salt**
    - **Frequent stirring necessary**
    - **Replacement of salt in brine may be needed**
    - **Need to supply fresh brine to new batch of fish**

  - **Dry salting (3-4 parts fish to 1 part salt)**
    - **Salt rubbed into fish surface and fish left uncovered to dry**
    - **Not recommended in tropical regions due to insects and rodents**

- **Methods of salting (cont.)**
  - **Kench salting**
    - **Salt rubbed on split fish and stacked. Pickle formed which leaks away**
  - **Pickle salting**
    - **Same as above but pickle is not removed. Fish are packed in water tight containers**
    - **Pickle is from water and blood leaking from the muscle as salt penetrates**
    - **Need about 30% salt for this to occur**
  - **Salt brine injection**
    - **Fish injected with salt solution and phosphates, then soaked in salt solution for 2 days (10 C=50 F) and then kench salted**





Mackerel being dry-salted

Process example (salted groundfish)

Head, gut and wash fish

↓

Soak in 10% brine for 30 min

↓

Drain

↓

Dry salt fish in shallow boxes

↓

Stack fish up first one skin down, last one skin up

↓

Leave for about 12 h (or up to 30 days)

↓

Wash salt crystals away with 10% brine or seawater

↓

Dry fish during day

↓

Pile fish up overnight

↓

Pack product

Typical cod salting operation (kench salting)


Salting the cod

Maturation period in salt


Drying the cod


Drying fish the old way (still widely done)

Quality inspection and packaging

Injection

Distributing the fish

2 day soaking period in salt

Fillet sorting/grading and packaging

Pickle salting

Early stages

Late stages

- **Factors influencing the salting process**
  - **Thickness -> thicker = slower NaCl uptake**
  - **Fat content -> more = slower NaCl uptake**
  - **Quality -> older = faster NaCl uptake**
  - **Salt concentration and quality**
  - **Temperature**
    - **More rapid salt penetration at higher temps**
    - **More chance of spoilage (normally in center of fish, turns into a smelly paste)**
- **Storage**
  - **Keep cool, dry and well ventilated**
  - **Have plenty of insect/rodent traps**
  - **The saltier the product the longer the shelf-life**

Table 37 Rough guide to the good quality storage life of dried fish with different water and salt contents

Water content (%)	Salt content (% wet wt)	Minimum 'good quality' storage life
40	5	0.5 week
40	10	1 week
40	15	3 weeks
40	20	1.5 months
35	5	0.5 week
35	10	2 weeks
35	15	2 months
35	20	1.5 months
30	5	0.5 week
30	10	1.5 months
30	15	2 months
30	20	2 months
25	5	1 week
25	10	2.5 months
25	15	2 months
25	20	2 months
20	5	3 weeks
20	10	4 months
20	15	4 months
20	20	3.5 months
15	5	More than 1 year
15	10	,, ,, 1 year
15	15	,, ,, 1 year
15	20	,, ,, 1 year

Source: Poulter, N. (1980) The prevention of losses in cured fish. *FAO Technical Paper* No. 219. Rome: Food and Agriculture Organization of the United Nations.

Smoking

Old preservation method.
In developed countries, used for flavor and color

Flavors

Smoke
(Hot air)

Water

SMOKING

Any kind of fish can be smoked. There are three main methods of smoking:

- (a) Smoking and roasting;
- (b) Hot smoking;
- (c) Long smoking.

- **Smoking and Roasting:** This is a simple method of preservation, for consumption either directly after curing or within twelve hours.
- Re-smoking and roasting can keep the product in good condition for a further twelve hours. Fresh unsalted fish is put over a wood or coconut husk fire.

- **Hot Smoking:** The hot smoking system can be used for immediate consumption or to keep the fish for a maximum of 48 hours.
- Small fish can be salted first for half an hour (see wet salting).
- After salting they are put on iron spits and dried in a windy place or in the sun for another half hour.
- It is necessary to have an oil drum to make the smoking stove.

- **Long Smoking:** If fish must be kept in good condition for a long time, for instance, two or three months or even longer, it can be done by smoking, provided the fish is not oily.
- For this purpose, a small closed shed made of palm leaves or other local material can be used.

Preparation

Start with good quality seafood.

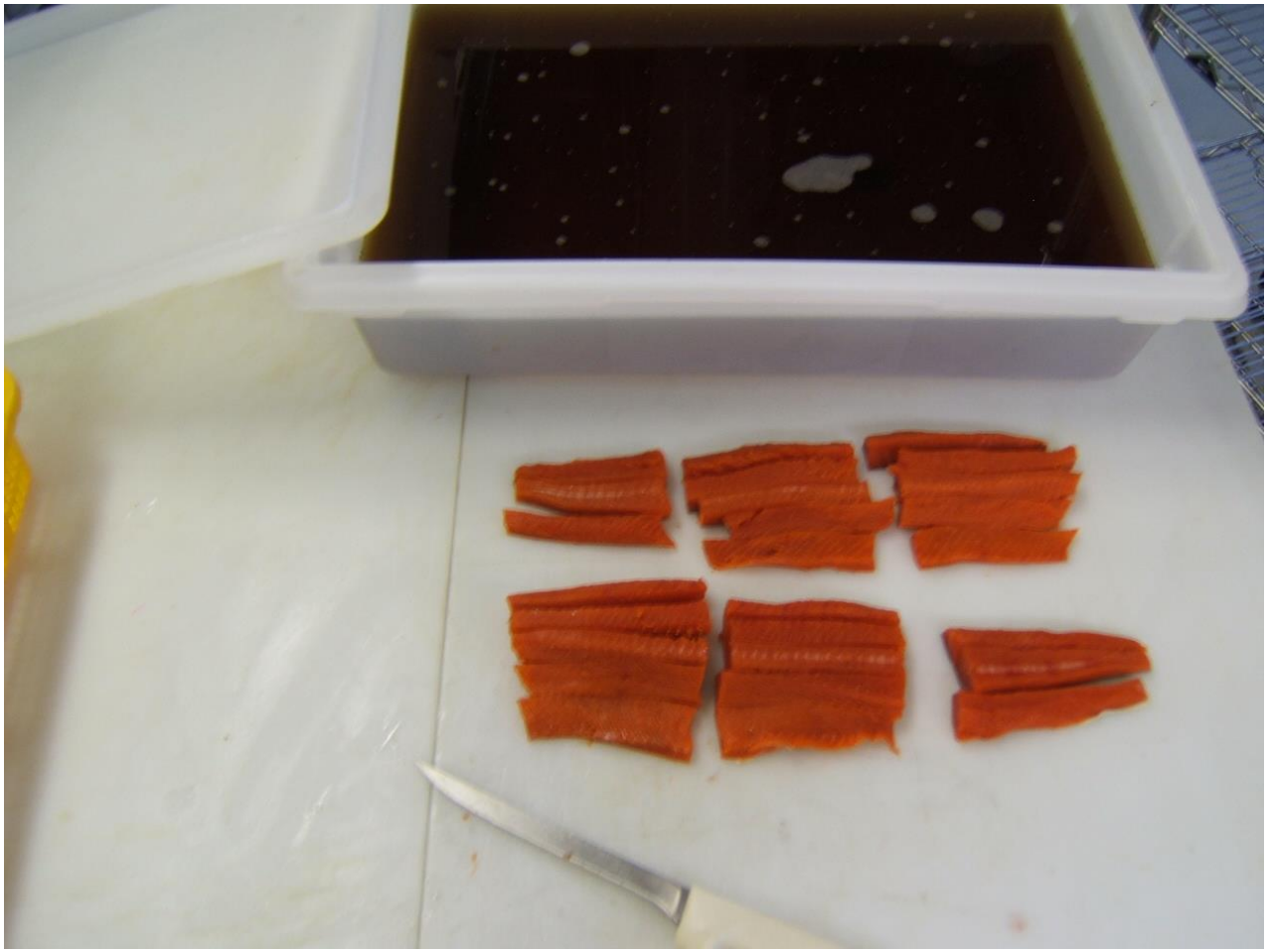
Whole, headed, gutted, split, fillets, chunks,

Salting

Brine (2-5%), spices, sugar

Air drying (a few hours)

Prepping



Brining

Dry Brining

Racking

Into the Smoker

Finished!

Smoking temperature

1. Cold smoking
   - Room temperature (<90 F)
   - Not cooked
   - Perishable product
2. Hot smoking
   - Temperature (>150 F)
   - Cooked

Liquid smoke

Smoke is absorbed by a liquid, and concentrated.

Rapid, uniform, but different than "real" smoke

Nature of smoke

Mixture of particles and vapors.

1. Vapors

More than 200 chemicals

Carbonyls, organic acids, phenols, organic bases, alcohols, hydrocarbons, others.

Impart color and flavor enhancement

Vapors

Antioxidants: high boiling phenols

Smoldering fire is better

Bactericidal: formaldehyde, acetic acid, creosote.

Also heat, drying, salt.

Reduces bacteria, fungi, viruses

Safety

Smoke has carcinogenic substances.

Polycyclic aromatic hydrocarbons (PAH):

Benz(o)pyrene. Thermally generated.

1-60 ppm in food.

Lower smoke generation T is better.

Use liquid smoke, or electrostatic filters.

Nitrosamines

Nitrous oxide in smoke: very low concentrations in food

Smoke generation

Wood:

Sawdust or wood chips heated to form smoke, but no flames.

Hardwood. Oak, mahogany, teak, hickory, redwood, cedar, pitch-pine.

Resinous wood: bitter taste.

Smoke generation

Temperature:

High T: cooking, rapid drying, reaction between smoke and food.

Dry surface: less smoke absorption.

Optimum smoke generation = (550°F).

At higher T more smoke, but less active components.

Relative humidity

Surface moisture is needed for smoke absorption.

60 % RH optimum

Skin-side absorbs less smoke.

Too high RH: slow drying.

Smoke velocity

Faster smoke= better penetration

Absorbed smoke near surface is replenished.

Stagnant film on surface decreased, and diffusion path shortened.

Smoked Quality

Flavor: Low T is better.

Nutritive effects: loss of vitamins

Phenols react with sulfhydryl groups

Carbonlys react with amino groups

Texture: Drying, smoke-protein interactions

Color: carbonyl-amino reactions

Phenolics

Fermentation

- **Fermentation = treat with microbes**
  - **Desirable microbes digest food first**
  - **Preserves food (depending on microorganism)**
- **Makes food inedible for undesired microbes**
  - **Alcohol, acid buildup**
  - **Makes food digestible**
- **Breaks down indigestible fibers**
- **Adds nutrients**
- **Microbially produced vitamins**

Fermentation

- **In developed countries, fermentation is used to provide desired tastes and / or flavors. Preservation is a secondary benefit.**

- **In developing countries, and the Far East, fermented aquatic products provide a significant portion of the protein need.**

Fermentation

- **Since sauces and pastes prepared in these areas are salty and spicy, they provide a significant departure from a rather bland cereal diet.**

- **Because the high salt content limits the consumption, sauces and pastes used as flavor/taste enhancers often served over rice.**

Fermentation

- **Fermented aquatic products are prepared by salting and then fermenting.**

- **Salting selects desired bacteria,eliminating spoilers, prevents putrification.**

- **Controlling oxygen content determines characteristics. The most common putrefactive microorganisms on fish are inhibited at salt contents above 6 to 8 percent.**

Effects of fermentation

- **Microorganisms (bacteria, yeasts, or molds), and digestive enzymes decompose the product into a soluble protein portion and a high ash portion.**

- **The fermentation process has several benefits. The product is far more stable than the original raw product, and there is often a volume reduction.**

Variables

(1) the microflora in the fish and salt,

(2) the proteolytic enzymes in the fish,

(3) initial quality of the product,

(4) presence or absence of oxygen,

(5) nutritional state of the fish,

Variables

(6) fermenting temperature,

(7) pH of the fermentation mixture,

(8) the presence of enzymes,

(9) presence/concentration of carbohydrates,

(10) the length of fermentation.

Quality (fermentation)

- **Calcium, magnesium, sulfate ion impurities= bitter flavor, tough texture light color.**

- **Several techniques are available for increasing the rate of fermentation:**
- **(1) using higher temperatures, (2) adding concentrated chemical enzymes, (3) bacterial seeding, and (4) acid additions.**

Canning

- **Fish canning: - is a process involving heat treatment of fish in sealed containers made of tin plates, aluminum cans or glass, until the product has been fully sterilized.**

- **The canned food fish is also prevented from contamination by pathogenic organisms by storing them in a virtually airtight package.**
- **If heat treatment is properly carried out canned fish may remain in storage for several years without refrigeration.**

Questions?