MEAT TECHNOLOGY

ABDELRAHIM H.A. HASSAN (Ph.D.)
FOOD SAFETY & TECHNOLOGY DEPARTMENT, BSU

1

INTRO

- Worldwide, per capita meat consumption was about 41.9 kilograms in 2010.
- People in the developing world eat 32 Kg of meat/year, compared to 80 Kg per person in the industrial world.
- The global consumption of meat is in a continuous elevation, which necessitate a compensatory increase in production.

2

DEFINITION OF MEAT PROCESSING

- Meat processing, also known as further processing of meat, is the manufacture of meat products from muscle meat, animal fat and certain non-meat additives.
- Additives are used to enhance product flavour and appearance. They can also be used to increase product volume.
- For specific meat preparations, animal by-products such as internal organs, skin or blood, are also well suited for meat processing.

3

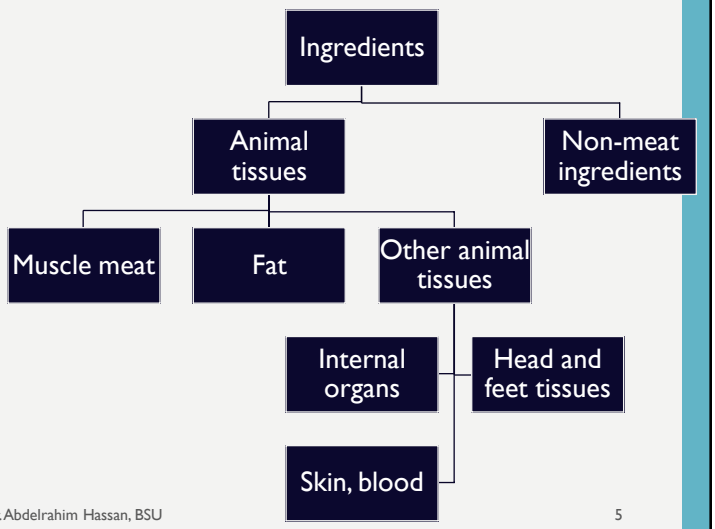
SIGNIFICANCE OF MEAT PROCESSING

1. The integration of certain animal tissues (muscle trimmings, skin parts or certain internal organs) into the food chain as valuable protein-rich ingredients.
2. Lean meat is the most valuable but also most costly foods. The blending of meat with cheaper plant products through manufacturing can create low-cost products.
3. Unlike fresh meat, many processed meat products can be made shelf-stable, such as (1) canned heat sterilized products, or (2) fermented and slightly dried products or (3) products with low moisture content.
4. Meat processing adds specific flavour, taste, colour or texture components to products.

4

MEAT PRODUCT INGREDIENTS

- Muscle meat
- Fat
- Other edible parts of slaughter animals (internal organs such as "tongue, liver, kidneys, lungs, heart, intestine, diaphragm, oesophagus", and
- Other slaughter by-products such as "head, feet, skin, and blood"
- Non-meat ingredients (Food additives)



5

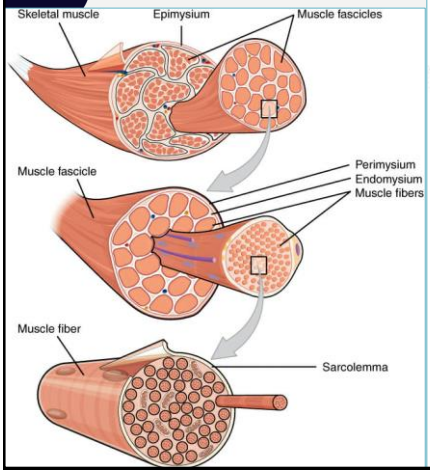
CHEMICAL COMPOSITION OF MEAT

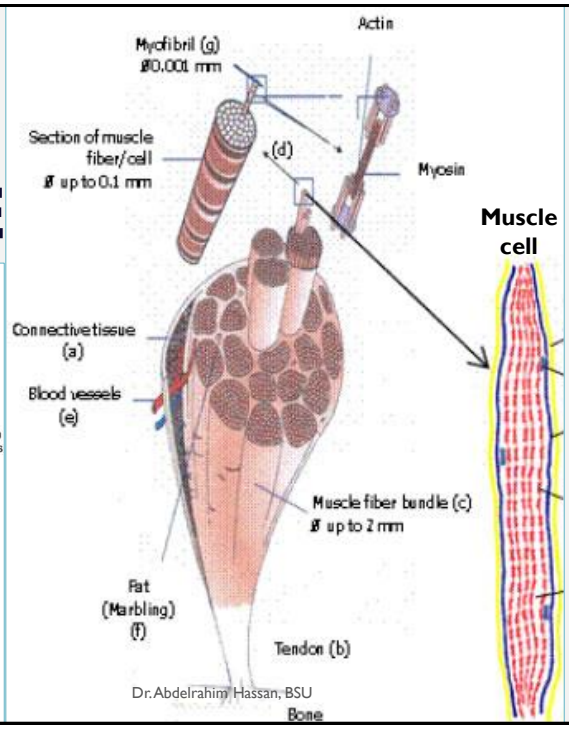
Composition of mammalian muscles

#	Component	% of muscle weight
1	Water	75 % (65-80%)
2	Protein	18.5% (16-22%)
3	Lipid	3% (1-13%)
4	Carbohydrates	1% (0.5-1.5%)
5	Non-protein nitrogenous substances (Creatine, creatine phosphate, nucleotides "ATP, ADP", free amino acids …etc.)	1.7% (1-2%)
6	Other non-protein substances (minerals and vitamins …. etc.)	0.85% (0.5-1%)

6

SKELETAL MUSCLE STRUCTURE





Cover of connective tissue (collagen)

Nucleus of muscle cell

Cell membrane of muscle cell

Myofibril (0.001 mm)
70% of muscle cell

Sarcoplasma
30% of muscle cell

7

1- MUSCLE PROTEINS

Product costs are largely based upon the quantity of meat protein in their formulations

- Myofibrillar protein (50-55%): 10% of whole muscle.
- Sarcoplasmic protein (25-35%): 6% of whole muscle.
- Connective tissue protein (10-15%): 2% of whole muscle

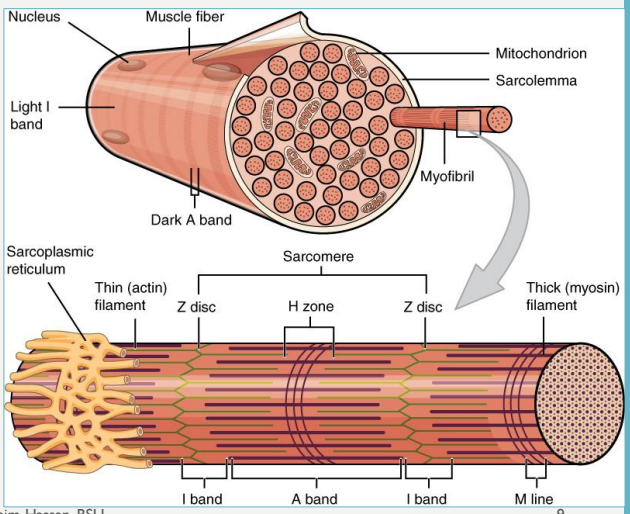
8

1.1. MYOFIBRILLAR PROTEIN

It consists of

1. Myosin 50-60% (thick filaments): Light and heavy myosin
2. Actin 20% (thin filaments)
3. Tropomyosin: in thin filaments, attach actin to Z-line
4. Troponin (I, C and T): in thin filaments
5. M-protein
6. Actomyosin (while muscle contraction)

- Regulate muscle contraction and relaxation
- It is extracted by dissolving in conc salt solution



9

FUNCTIONAL PROPERTIES IN MEAT PROCESSING

- Myofibrillar protein is very important for the product texture and cohesion.
- If not enough quantity of these proteins are extracted during processing due to improper product formulation (in terms of salt and phosphates), there will be an adverse effect on the role of these proteins in binding together such insoluble product components as muscle chunks, C.T. particles and fat droplets.

10

1.2. SARCOPLASMIC PROTEIN

- Consists of:

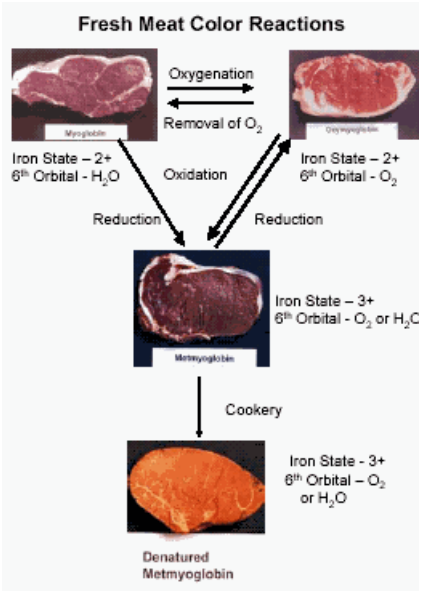
1. Cytoplasmic supernatant
2. Nuclear fraction protein (ribonucleic acid, deoxyribonucleic acid and lipoprotein)
3. Microsomal fraction protein
4. Myoglobin 0.2-0.4 % of muscle: muscle pigment
5. Hemoglobin: 0.4 % of muscle: blood pigment
6. Organelles: lysosomes, sarcoplasmic reticulum

- Soluble in water and can be extracted by dissolving in diluted salt solution
- Most of them are lost during improper processing procedures such as thawing of frozen meat.
- So, it is advisable to use frozen meat in processing without previous thawing.

11

MYOGLOBIN

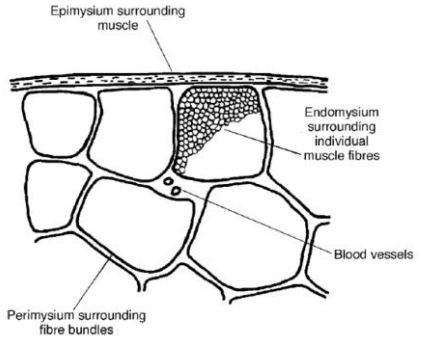
- Meat colour is largely due to the water-soluble protein 'myoglobin'.
- The difference in myoglobin concentration is the reason why there is often one muscle group lighter or darker than another in the same carcass.
- The concentration of myoglobin in meat is affected by species and age of the animal as well as the type of muscle fibers.
- Beef has considerably more myoglobin than pork, veal or lamb, thus giving beef a more intense colour.
- The maturity of the animal also influences pigment intensity, with older animals having darker pigmentation.

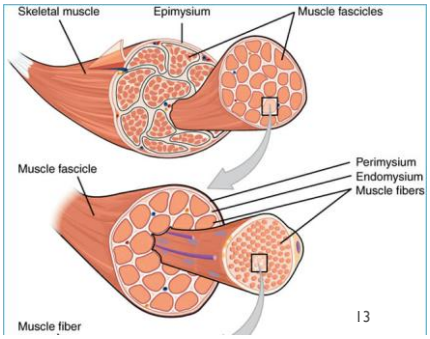


12

1.3. CONNECTIVE TISSUE PROTEIN

- Called extracellular (stromal) protein.
- Consists of collagen and elastin
- Connective tissue presents in all muscles as fascia. Enclosing each muscle is a layer of connective tissue known as the **epimysium**; enclosing each fascicle (bundle) is a layer called the **perimysium**, and enclosing each muscle fiber is a layer of connective tissue called the **endomysium.**
- Insoluble in conc. salt solution

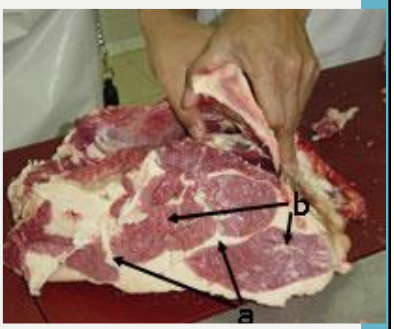




13

FAT

- Fats accumulate in and around the muscles (70% of fat is subcutaneous or intermuscular).
- About 90% of adipose tissue is triglycerides.
- Triglycerides consist of one molecule of glycerol and three molecules of several types of fatty acids.
- Fat deposits between the fibers of a muscle bundles are called intramuscular fat and lead in higher accumulations to marbling.
- Marbling of muscle meat contributes to tenderness and flavour of meat.
- For processed meat products, fats are added to make products softer and also for taste and flavour improvement.



a) Intermuscular fat. b) Intramuscular fat

14

EXTRACTIVES

- Constitute 2-3%, they are divided into nitrogenous and non-nitrogenous extracts.
- The nitrogenous group (0.8% of the muscle) includes carnosine, anserine, creatine, creatine phosphate, ammonia, ATP, ADP and free amino acids. All these substances contain nitrogen, but they are not protein.
- They are strong stimulant of digestion and assimilation of food. Carnosine increases the secretion of gastric juice. They also activate the nervous system and are responsible for meat aroma.
- The non-nitrogenous extracts includes carbohydrates (1%), mainly glycogen, glucose, maltose, lactic acid.
- Glycogen is about half amount of carbohydrates in muscle.
- The muscle obtained from healthy animal contains about 550mg% glycogen, while that from fatigued animal has only 220mg%.
- Glycogen content in young animal is higher than adult one.

15

MICRONUTRIENTS

MINERALS:

- The ash content of muscle is about 1%.
- The following present in meat: Na, K, Ca, Mg, Fe, P, and S.
- The Ca, Na, P, and S forms about 90% of the total minerals of meat.
- A daily intake of 100 g of meat and liver can supply up to 50% of the recommended daily allowance for iron, zinc, selenium, vitamins B1, B2, B6, B12 and 100% of vitamin A.
- The importance of meat as an essential source of some micronutrients is due to the fact that it is either their only source, or they have a higher bioavailability.
- Iron has a higher bioavailability from meat than from plant sources, as has folic acid which is nearly 10-fold more, especially from liver or eggs, compared to vegetables.

VITAMINS

- Vitamins A and B12 occur exclusively in meat and can hardly be compensated for by plant-derived provitamins.
- Vitamin B12 (cobalamin) can be taken up only from animal products; it does not exist in plants.
- Processing of meat affects its vitamin content, e.g. thiamine losses about 15-40% on cooking, 40-50% on frying, and 50-70% on canning.
- Vit. B6 and B12 are similar to thiamine.
- On the other hand, vit A retain 80-90% after heating at a temperature of 80^0C.

16

WATER

- Water constitutes about 65 -80% of lean tissue.
- There is a relatively consistent relationship between the moisture and the protein contents
- Moisture : protein ratio is 3.5 to 3.7:1.
- As fat content of muscle increases, the content of moisture and protein combined decrease.
- The amount of water in meat subjected to variations due to gain occurs during processing or losses through drip and evaporation.
- Such gains or losses are important due to its effect on keeping the sensory qualities of meat in terms of juiciness and palatability.
- **Forms of water in meat**

1. Bound water: (4-5%) binds to protein (5-10g/100 g protein)
2. Immobilized water:: attracts to bound water (50-60 g/ 100g protein)
3. Free water: loosely held in the capillary spaces between and within muscle proteins (300 g/100g protein

17

MEAT PROCESSING TECHNOLOGY

- It comprises the steps and procedures in the manufacture of processed meat products
- Meat processing involves a wide range of physical and chemical treatment methods, includes

  - Cutting/chopping/comminuting (size reduction)
  - Mixing/tumbling
  - Salting/curing
  - Utilization of spices/non-meat additives
  - Stuffing/filling into casings or other containers
  - Fermentation and drying
  - Heat treatment
  - Smoking

18

EQUIPMENT USED IN MEAT PROCESSING

1. FROZEN MEAT CUTTER

Frozen meat cutter with rotating round knives for cutting out pieces/chips from frozen meat blocks.

The purpose of cutting frozen meat blocks into smaller pieces is to make frozen meat suitable for immediate comminution in grinders, bowl cutters etc. without previous thawing

19

2. SLICER

- Meat blocks must be tempered to -2°C to be sliced on any of several different types of machine.
- Power cleavers often used to portion steaks and chops of tempered material.
- Slicer with circular blades can be used to reduce either tempered or cooked material to thick or thin slices.

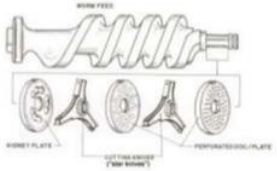
20

3. MEAT GRINDER (MINCER)

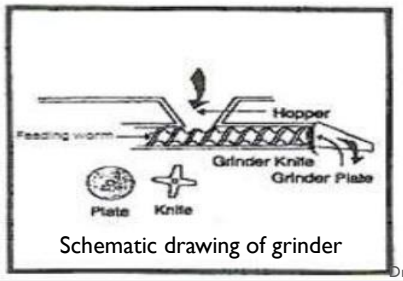
- A meat grinder is a machine used to force meat or meat trimmings by means of a feeding worm (auger) under pressure through a horizontally mounted cylinder (barrel).
- At the end of the barrel there is a cutting system consisting of star-shaped knives rotating with the feeding worm and stationary perforated discs (grinding plates). The perforations of the grinding plates normally range from 1 to 13mm.
- If frozen meat and meat rich in connective tissue is to be minced to small particles, it should be minced first through a coarse disc followed by a second operation to the desired size.

MEAT GRINDER

Grinder: Worm feed (feeding worm/auger) and cutting set with plates and knives (system "Unger")



Grinder plates of different hole size, star knives and spacer rings for tightening of cutting assembly

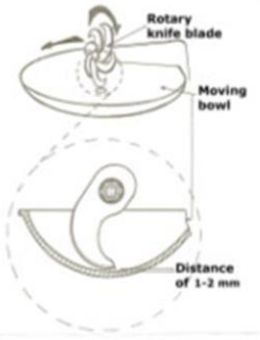


Schematic drawing of grinder

Manual grinder

4. BOWL CUTTER (BOWL CHOPPER)

- The bowl cutter is the commonly used meat chopping equipment designed to produce small or very small ("finely comminuted") lean meat and fat particles.
- Bowl cutters consist of a horizontally revolving bowl and a set of curved knives rotating vertically on a horizontal axle at high speeds of up to 5,000 rpm.

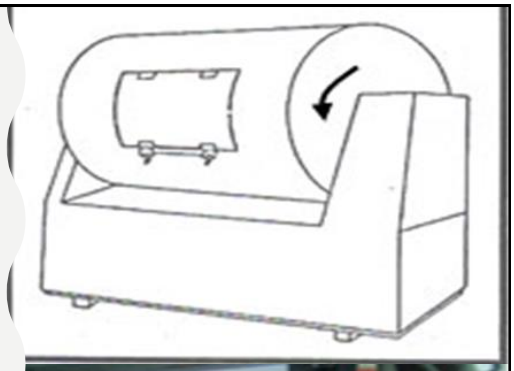


Dr. Abdelrahim Hassan, BSU 23

23

5. TUMBLER OR MASSAGER

- Tumblers are used for the processing of meat products such as whole-muscle or reconstituted hams. Such machines resemble in principle a drum concrete mixer.
- A rotating drum with steel paddles inside slowly moves the meat pieces thus causing a mechanical massaging effect.
- This mechanical process is assisted by the addition of salt and phosphates to achieve equal brine distribution and liberates muscular protein from the meat tissue (protein extraction).
- For hygienic reasons it is important to place the tumbler below 10°C to avoid excessive microbial growth during lengthy tumbling times (more than 4 hours or even overnight).



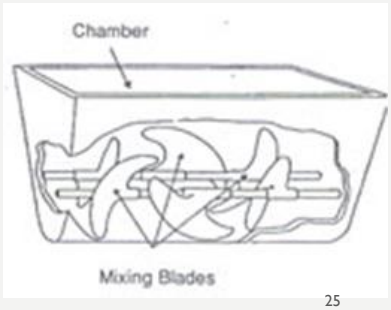
Dr. Abdelrahim Hassan, BSU

24

6. MIXER / BLENDER

Mixers are used to blend meat and spices, or coarse and finely chopped meat

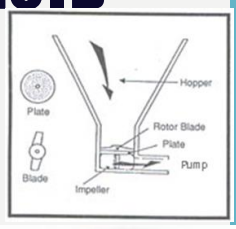
- The machine generally consists of a rectangular or round bottom vessel through which two parallel shafts operate. Various paddles are mounted on those shafts to mix the meat.
- The mixer is discharged through tilting by 90 degrees.
- Some mixers are designed as vacuum mixers, as the mixing under vacuum (exclusion of oxygen) has advantages for the development of desirable product colour and texture



7. EMULSIFYING MACHINE (COLLOID MILL)

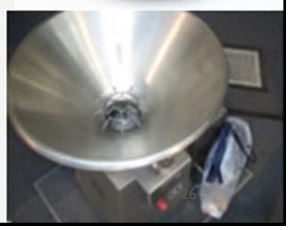
- The emulsifier serves for the preparation of very fine meat emulsions (e.g. for luncheon manufacturing)
- Its functional parts are a perforated plate, attached to which two edged blades are rotating (rotor blade). Next to the blades there is a centrifugal pump that forces the pre-ground meat through the perforated plate.
- Most emulsifiers are vertical units.
- Compared to the bowl cutter the emulsifier operates at much higher speed, producing a finer emulsion-like mix.
- The emulsifier is also perfectly suited to produce semi-processed products such as pig skin emulsions.

Emulsifying machine, schematic



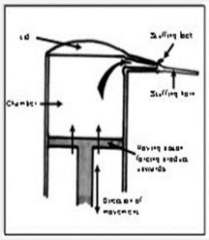
Emulsifying machine (plate and rotating blade)

Emulsifying machine (top down view)



8. FILLING MACHINE "SAUSAGE STUFFER"

- Filling machines are used for filling all types of meat batter in containers such as casings, glass jars, cans, etc.
- The most common type of filling machine in small and medium size operations is the piston type.
- A piston is moved inside a cylinder forcing the meat material through the filling nozzle (stuffing horn) into the containers.
- Modem filling machines for larger operations are designed as continuous vacuum stuffers.



Piston stuffer

27

9. CLIPPING MACHINE

- Clipping machines place small aluminium sealing clips on the sausage ends.
- Clipping machines can also be connected to filling machines, and can be used for both artificial and natural casings.
- Such machines work with so called casing brakes, which are devices for slow release of the shirred casings from the filling horns ensuring tight filling.
- Then the filled casing segments are clipped in portions. So called double clipping machines place two clips next to each other, which ensures that the individual sausage portions remain clipped on both ends and easy separation of the sausage portions is possible.

28

10. PATTY-FORMER

- Patty former is used for shaping burger patties.
- With some modification, the machine can shape steaks or chops at high speed delivering the shapes onto a conveyor belt for transfer to a freeze tunnel or continuous cooker.
- Using proper conveyor belt and patty stacking and boxing equipment helps to assure efficient operation and minimal damage to the patties.

11. BRINE INJECTOR

- This equipment serves for the injection of brine into meat.
- Brine is water containing dissolved salt and curing substances (nitrite) as well as additives such as phosphates, spices, sugar, carrageenan and/or soy proteins.
- The injection is done by introducing pointed needles into the muscle tissue.
- Brine injection is mainly used for the various types of ham, bacon and other whole muscle products.
- Brine injectors are available in different sizes from manually operated single-needle devices for small-scale operations to semi-automated brine injectors with up to 32 needles and more.

12. COOKER AND SMOKEHOUSE

- Smoking and cooker are generally combined, except in cases of application of cold smoking, addition of liquid smoke to the meat mixture, using of pre-smoked casing, or when using water or steam cooking.
- Meat products are cooked either in dry or humid atmosphere.

13. ICE FLAKER

- In this machine, ice flakes are continuously produced from potable water.
- Ice is needed in meat processing for some types of meat products.
- Water added in the form of ice is an important ingredient in order to enhance protein solution and to keep the temperature of the meat batter low.
- Ice flakers with built-in ultraviolet-water disinfection device are available for areas with unsafe water supply.

MEAT PARTICLE SIZE REDUCTION

- The method and degree of comminution of the meat ingredients of processed meat products affects both the sensory characteristics of the product and the processing characteristics of the materials.

33

1. SECTIONING

- Sectioning is a process denotes the separation of entire muscles by seaming, a procedure that is very useful for large muscles of the hind leg and shoulder.
- In some cases, sheaths of epimysium connective tissue are removed 'denuding', which results in extremely high quality meat materials.

34

2. CHUNKING

- Meat can be made into chunks with an ordinary knife, a meat dicer, a bowl chopper or a coarse grinder plate.
- Grinder plates with kidney shaped openings are useful for making chunks.

3. SLICING

- Frozen and tempered meat may be sliced on high-speed slicers.
- Slicing is useful for tissues that are relatively high in fat intended for use in restructured products.
- Careful control of knife sharpness and meat temperature are necessary.

4. FLAKING

- Boneless frozen meat blocks can be cut into cubes or flakes by frozen meat cutters or flakers.
- The process may be a useful initial step in breaking down frozen blocks for further comminution.
- Flaking usually referred to the process resulted in meat flakes of predictable size, while in hydroflaking the meat blocks reduced to coarse flakes or slices of unpredictable size.
- The fat portion should be tempered to about 0°C and the lean to about -5°C.
- Meat high in connective tissue and fat usually flaked more finely, while meat higher in lean can be flaked into larger size.
- The frozen meat flakes (2-10 cm) can be directly minced or chopped without previous thawing thus avoiding drip losses, bacterial growth and discolouration which would occur during thawing.

5. GRINDING

- Larger pieces of meat mass can be reduced in size by passing them through meat grinders.
- Meat is usually ground in thawed state; some machines are able to handle soft frozen tissues, others are equipped with devices to separate "hard" tissues such **as** tendons and bone particles from the "soft" tissues.
- Other grinders can directly handle frozen meat blocks.
- Meat low in connective tissue and fat can be coarsely ground through a plate with large openings. Other plates can produce very finely comminuted ground meat.

6. CHOPPING

- Bowl cutters (choppers) are used to mix and chop fresh or frozen lean meat and fat together with water, functional additives and extenders to reduce particle size to coarsely or fine chopped material.
- These machines are available with vacuum and some are able to add cooking operation during the chopping.
- Careful control of knife sharpness and number of knives, as well as proper bowl and knife speed are essential.

39

7. EMULSIFYING

- Meat to be emulsified must be pre-mixed with all other raw materials, functional indigents and seasonings and pre-cut using grinders or bowl cutters.
- Thereafter they are passed through emulsifiers (also called colloid mills) in order to achieve the desired build-up of a very finely chopped or emulsified meat mix.
- This machine is widely used to reduce particle size to a very uniform state for the manufacture of frankfurters.

40

NON-MEAT INGREDIENTS (NMIs)

- Along with the main components meat and animal fat, a wide range of substances of non-meat origin are used as ingredients in processed meat products.
- Some of them are absolutely necessary, such as salt and spices. Others are used for specific products.

41

CATEGORIES OF NMIs

Functionality	Food type	Origin
• Functional • Non-functional	• Additives • Full food ingredients	• Chemicals • Plant origin • Animal origin

42

CATEGORIES OF NMIs

- **NMIs usually are functional ingredients that add certain quality characteristics such as:**
- taste
- flavour
- appearance
- colour
- texture
- water binding
- counteracting fat separation
- preservation

- **Food type:**

1. **Additives:** not consumed by itself. E.g. salt, curing agents, spices, water binding and gelation enhancing substances.
2. **Full food ingredients:** e.g. vegetables, flour, eggs.

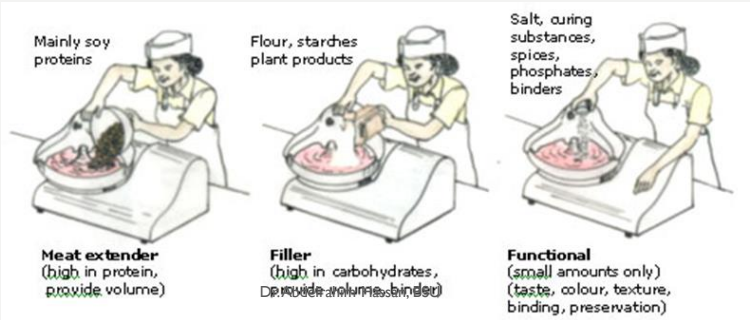
1. FUNCTIONAL NMIs

- Ingredients which are only functional without any other effects, such as filling or extending the volume of the product.
- They are normally used in small amounts (e.g. common salt 1.5-3%, nitrite 0.01-0.02%, phosphates 0.05-0.5%, ascorbic acid 0.03%, isolated soy protein or non-fat dried milk proteins 2%).
- **Functional NMIs** must be

1. Safe for consumers
2. Improve the processing technology and/or sensory quality of the products

2. NON-FUNCTIONAL NMIs (EXTENDERS OR FILLERS)

- They are not primarily intended for change of appearance or quality improvements
- *They add volume* to the meat products
- Their main purpose is to make meat products lower-cost.
- They include cereals, legumes, vegetable, roots
- They are used in larger quantities, on average between 2 and 15%



NON-MEAT INGREDIENTS - CONTINUED

- While most substances have one dominating effect, there are in many cases also desirable side effects.
- E.g.. textured vegetable protein/TVP, which are primarily intended for non-functional purposes, namely meat extension, have a water binding effect, which qualifies them also as moderately functional.
- Also soy isolates or dried milk powders, which are used as binders, also have a slight extension effect as the amounts added (approx. 2%) moderately increases the protein level.
- Most substances have double or even multiple effects.

NMI ORIGIN CATEGORIES
1- CHEMICALS

1. ***Salt*** (for taste, impact on meat proteins, shelf-life)
2. ***Nitrite*** (for curing color, flavor, shelf-life)
3. ***Ascorbic acid*** (to accelerate curing reaction)
4. ***Phosphates*** (for protein structuring and water binding)
5. ***Chemical preservatives*** (for shelf-life)
6. ***Antioxidants*** (for flavor and shelf-life)
7. ***Monosodium glutamate MSG*** (for enhancement of flavor)
8. ***Food coloring substances*** (synthetic and of plant origin)

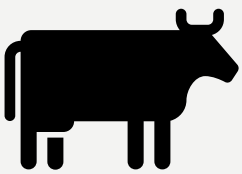
- Chemical additives have exclusively functional properties, they are used in small amounts usually below 1% (with nitrate as low as 0.02%). Only salt is in the range of 2% (with up to 4% in some fermented dried products).

47

2- INGREDIENTS OF ANIMAL ORIGIN

- They all have functional properties (except whole milk), in particular improvement of water binding and prevention of fat separation during heat treatment.
- Apart from their functional properties, some of them can also be considered **meat extenders**, as mentioned below:

1. ***Milk caseinate*** (90% protein; used in small quantities (2%); have functional water and fat binding properties)
2. ***Whole milk*** or ***non-fat dried milk*** (=skim milk) (sometimes used in indigenous meat preparations as a protein extender)
3. ***Gelatin*** (binding properties and meat extender)
4. ***Blood plasma*** (predominantly binding properties)
5. ***Eggs*** (extender and binding ingredient for meat pieces and fried sausages)



48

3- INGREDIENTS OF PLANT ORIGIN

1. Spices: all *spices* are of plant origin. They are predominantly *functional* and used in small quantities to add flavor and taste to meat products.

2. Binders: another group of predominantly *functional* substances of plant origin with high protein content are used as ***binders*** to increase water binding and fat retention. E.g.:

1. ***isolated soy protein (soy isolate)*** (90% protein)
2. ***wheat gluten*** (80% protein)

3. Extenders: a third group of plant origin are used as ***meat extenders*** (if rich in proteins) for meat product formulations. The purpose is to replace expensive meat by cheaper ingredients of plant origin.

- **E.g. Meat extenders / Plant products with high protein content are**
  1. ***Soy flour*** (50% protein)
  2. ***Soy concentrate*** (70% protein)
  3. **Other food legumes** (***beans***, ***peas***), used for special products only.

3- INGREDIENTS OF PLANT ORIGIN

4. Fillers are rich in **c**arbohydrate with low protein content (usually added in quantities of 2%-15%, some of them – in particular roots and vegetable – up to 50%).

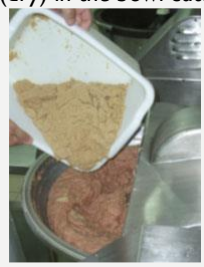
- Apart from cost reduction and adding to volume, some flour and starches belonging to this group of fillers also act as *binders*. This property serves important functions such as increasing water binding for more juiciness or fat binding for improved texture.

1. ***Cereal flours*** from wheat, rice and corn
2. ***Starches*** from wheat, rice, corn, potato and cassava
3. ***Breadcrumbs***
4. ***Rusk*** (derived by mixing and baking wheat flour)
5. ***Cereals*** to be added without milling, e.g. rice, corn
6. ***Roots*** and ***tubers***, e.g. cassava, sweet potato
7. ***Vegetable*** and ***fruits***, e.g. onions, bell pepper, carrots, green vegetables, bananas
8. ***Polysaccharides*** (Hydrocolloids)
9. ***Carrageenan*** (is the only hydrocolloid product of this group popular in meat processing, added in quantities of max. 1%, improves slice-ability and cohesiveness).

APPLICATION OF NMIs

- A **uniform distribution** is crucial for equal intensity of flavor, color, texture or any other quality characteristic expected from the product.
- **a) During grinding**
- Chemical additives and smaller quantities of either fine or coarse non-meat ingredients or granulated substances (such as TVP) are easily incorporated in ground meat products by mixing them with the raw meat materials prior to grinding.
- **b) During chopping**
- In finely comminuted or chopped meats, NMIs are easily dispersed by **mixing** them with the rest of the batter in comminuting equipment (e.g. bowl cutter).
- NMIs such as binders (isolated soy protein/ISP, milk caseinate) are preferably added in emulsion form, while finely milled fillers (flours, starches) in dry form.

Addition of filler /starches (dry) in the bowl cutter



Addition of extender / soy concentrate (rehydrated) during chopping

51

APPLICATION OF NMIs

- **c) Application to non-comminuted meat**
- The addition of non-meat ingredients to larger meat pieces or intact muscles is more complex.
- **Injection** of ingredients as part of the curing brine, if they are water soluble or can be dispersed in water (salt, nitrite, spices, ascorbate, phosphates, soy products, Carrageenan), is the most rapid method of equal distribution.
- The **surface application** of such dry substances (e.g. nitrite curing salt, spices) or **immersion** of meat in salt/curing salt and flavoring solutions is another way of application, but requires days or weeks to diffuse throughout the muscle tissue.

Application by injection of additives in watery solution; pump and injection needle for brine

Application by surface treatment / dry salting

52

TREATMENT OF NMIs BEFORE APPLICATION

- Finely milled ***fillers*** of plant origin (flours, starches) are added dry.
- Coarse fillers such as breadcrumbs or rusk and cereals are usually re-hydrated.
- Granulated ***extenders*** of plant origin (TVP) are also re-hydrated before blending them to the product mix
- Some ***binders*** (e.g. milk caseinate, isolated soy protein) are either added as dry powder or as a fat/water/protein emulsion.

53

IMPORTANT NMIs IN MEAT PROCESSING

54

WATER

- Water is the main component of meat (up to 80% in lean meat). Therefore typically all meat products contain lower or higher amounts of "natural" water.
- Besides its "natural" presence, water is used in many processed meat products also as an ingredient.
- However, the assumption by some consumers that water is added only to increase product weight and manufacturers' profits is incorrect.
- There are many types of meat products where the addition of water is needed for technical reasons or to compensate for cooking losses.
- The addition of water is essential during the manufacture of raw-cooked meat batters (meat loaves, frankfurter sausages etc). In this case water acts together with salt and phosphates to solubilize muscle proteins, thus creating a strong protein network structure holding the product together after heat-treatment.

55

WATER

- In the case of **precooked-cooked meat mixes**, water is added to compensate for the cooking loss, as precooking of raw meat materials generates cooking losses of approximately 30%. In order not to make the final products too dry, water losses are supplemented in the final meat mix. Care must be taken that no excess water is added, as this could lead to fat and jelly separation in the final product.
- Water is also needed as a ***substrate*** for curing substances or other non-meat ingredients and for ***re-hydration*** of meat extenders.
- For **cured-cooked products**, solutions of curing salt, which may also contain spices, phosphates and other ingredients, are injected into larger meat pieces for quick and equal distribution. In these cases the volume of the product will be increased by the injection of the curing brine, but will be reduced again during subsequent cooking.

56

COMMON SALT (SODIUM CHLORIDE)

- Salt has been used for centuries for seasoning of foods, curing meats (basic ingredient to all curing mixture) and preserving fish and other foods.
- The amount of salt in a processed meat product may be up to more than 5% of the finished product weight.
- **Significance:**

1. Improve the taste,
2. Salt in combination with water assists in solubilization of myofibrillar proteins. These proteins gel upon heating and by entrapping moisture and fats give firm structure and firmness to the finished product.
3. Salt also improves the water holding capacity and the cooking yield of meat (cooking loss is minimum at 5-8% salt).
4. Bacteriostatic effect, retard the growth of spoilage and pathogenic bacteria.

57

COMMON SALT (SODIUM CHLORIDE)

- **Drawbacks:**

1. Salt promotes flavor and color deterioration during storage.
2. It is an oxidant and thus promotes rancidity of fats.
3. The purity of salt used in a meat product is an important consideration in its oxidant capacity. Trace amounts of impurities increase the development of oxidative rancidity, therefore, only food grade salt should be used.
4. Cause hypertension

- Recent trends are focused to reduce salt level in meat products due to the increased relation between sodium and hypertension.
- The replacement of sodium chloride can be achieved by using sodium chloride/potassium chloride mixture at a rate of 60/40. Potassium lactate can also be used at a rate of 20% instead of equal amounts of sodium chloride without inducing any significant changes in sensory properties. However, too much lactate (>30%) may result in a chemical taste.

58

SODIUM NITRITE/NITRATE

- Sodium nitrite and sodium nitrate are two closely related chemicals used to preserve meat. Sodium nitrite is most commonly used.
- **Significance:**

1. The relatively small quantities of sodium nitrite develops the desired color "pickling red" in processed meat products. Without nitrite meat products turn grey in color when heat treated.
2. In canned meat products nitrite inhibits microbial growth (delays production of botulism toxin).
3. Nitrite also retards development of rancidity and off-odors and off-flavors during storage,
4. It preserves flavors of spices, smoke, etc.
5. It retards the oxidative rancidity by stabilizing fats.

- The common commercial form of nitrite is ***"nitrite curing salt",*** a mixture of 0.5 - 0.6% nitrite and 99.4 - 99.5% sodium chloride. Nitrite salt levels: 100-200 ppm (150 ppm).
- At a common dosage level of 1.5-3% common curing salt is added to the meat product, the desired salty flavour is achieved and the small amount of nitrite needed for the curing reaction is also provided.

59

SODIUM NITRITE/NITRATE

- When nitrite is added to meat for curing, generally less than 50% of the added amount could be detected chemically after processing.
- Nitrite may either be lost from the meat to the atmosphere or remain in the meat as a reaction product undetectable by the present methods.
- When nitrite combines with secondary amines, it forms **nitrosamine** which is **carcinogenic**. The chemical reaction occurs most readily at the high temperatures of frying.
- So, **nitrosamines** can only be found in **strongly cooked or fried meat products** which were previously cured with nitrite.
- Fresh meat for cooking and fresh burgers or sausages for frying do not contain nitrite but salt only. Hence the risk of formation of nitrosamines does not exist in such products.
- One product, where such conditions may be met, is bacon. Keeping the residual nitrite content low in bacon minimizes the risk of formation of nitrosamines.

60

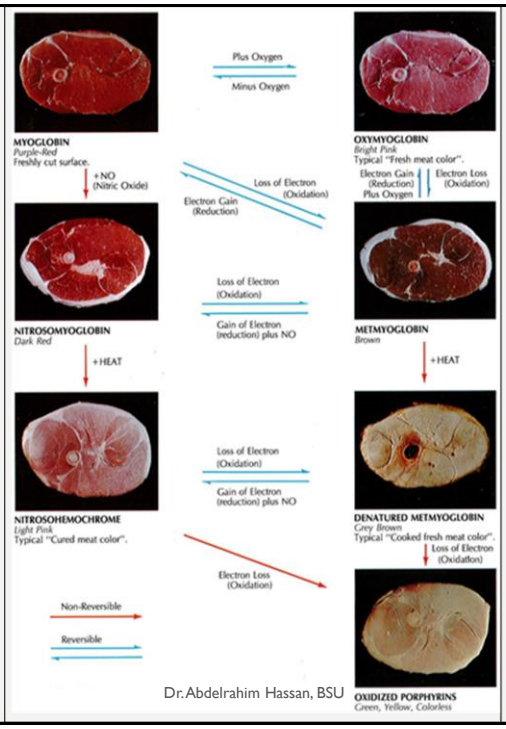
SODIUM NITRITE/NITRATE

- In a series of normal reactions, nitrite is converted to **nitric oxide**. Nitric oxide combines with myoglobin to form **nitrosomyoglobin,** which is a **deep red color** that changes to the characteristic bright pink normally associated with cured and smoked meat when heated. Heat denaturation fixes the pigment as a stable **nitrosohemochrome** (**pink**).
- Sodium or potassium nitrate (Na/KNO3) may also be used for curing but it is limited to certain dry cured products such as raw hams, which require long curing and aging periods. Nitrate must be broken down by bacteria to nitrite, which is the substance to react through its NO with the muscle pigment myoglobin.
- The bacterial process is slow and time consuming. As most products require an immediate curing effect, the nitrite is the substance of choice in most cases and there is little use for nitrate

Right: salt only
Left: salt + nitrite

61

Color changes in cured meat Vs uncured meat



62

PHOSPHATES

- **Levels used: 0.05 – 0.5%.** Phosphates are safe when added within the permitted level (not more than 0.5% in the finished product).
- **Phosphates have a wide application in the meat processing industry:**

1. Primarily to **increase water holding capacity** of meat products,
2. **Reduce the amount of shrinkage** during cooking, increase the yield,
3. Stabilize the texture of meat products by **increasing protein solubility** in connection with salt,
4. Reduce oxidative rancidity by reducing the pro-oxidant activity of heavy metals in the salt,
5. Improve the color stability and flavor,
6. Reduce microbial growth

63

PHOSPHATES

- The most common phosphates used in meat processing are:

1. **Sodium tripoly-phosphate STPP (pH 9.8): high soluble**
2. **Sodium di-phosphate SDP (pH 7.3): less soluble**

- For meat preparations such as sausage mixes, where phosphates are added as **dry powder**, phosphates with moderate alkaline effect are preferred, in particular ***di-phosphates***.
- Di-phosphates are the most effective form of increasing water binding. However, di-phosphates have a low water solubility. Thus, for meat curing brines containing phosphates, the more soluble ***poly-phosphates*** can be used.

64

PHOSPHATES

- **Disadvantage** of using alkaline phosphates is mainly the development of a soapy flavor at high levels, and the production of rubbery texture in high protein meat mix.
- The effects of combining NaCl and phosphates in meat emulsions are synergistic. It seems that phosphates exert more effect on pH and protein solubility and salt exerts more effect on ionic strength and water-holding capacity.
- They act by solubilizing the myofibrillar proteins that contribute to water-holding capacity, thus reducing cooking loss.
- These ingredients also enhance fat binding in meat products, entrapping other ingredients to form a uniform and cohesive mass.

65

ASCORBIC ACID, SODIUM ASCORBATE, ERYTHORBATE

- **Level used: 0.03%**
- Ascorbic acid is perhaps better known as vitamin C. Its more stable salt form is sodium ascorbate or the chemically equivalent but cheaper sodium erythorbate.
- These so-called ***"cure accelerators"*** are used in curing-salt for processed meats because of their reducing properties.
- They accelerate the reaction of nitrite with myoglobin resulting in the development of the red curing color.
- Another effect of cure accelerators is that the chemical curing reactions will be more complete and hence less residual nitrite will be left in the product.
- Also it acts as antioxidant thereby stabilizes the color and flavor.
- High level of ascorbic acid may reduce the pH to acidic which could negatively affect the water holding capacity.

66

GLUCONO DELTA LACTONE (GDL)

- It is a cure accelerator commonly used at a rate of 0.5%.
- It reduces the pH of the meat mix by 0.2-0.3 units which accelerates the conversion of the meat pigments to the desirable color.
- It is also used in dry and semidry sausage, where it reduces the pH by 0.5 units which aids in controlling the growth of spoilage microorganisms until the development of fermentation.

67

EXTENDERS AND FILLERS

- Extenders and fillers are not standard ingredients in processed meats, in fact high quality products are often manufactured without them.
- But they are useful tools in cost reduction enabling the manufacture of lower-cost but still nutritive meat products.
- Such products are particularly suitable to supply valuable animal proteins in the diets of consumers who cannot regularly afford expensive meat and meat preparations.

68

MEAT EXTENDERS

- **Meat extenders** are primarily plant ***proteins*** from legumes, with *soybeans* as the major source.
- ***TVP*** (Textured Vegetable Protein) is the most common soy bean extender. These cheaper plant proteins ***"extend"*** the more expensive meat proteins, resulting in acceptable overall protein contents of lower cost meat products.
- From animal protein sources, whole milk, milk proteins and eggs can be considered as meat extenders.
- Extenders are added in sizeable amounts that increase the bulk of the meat products, but this may also alter their quality.

FILLERS

- **Fillers** are also mostly plant substances, low in protein and high in ***carbohydrates*** such as cereals, roots, tubers and vegetables and some refined products such as *starches* and *flours*.
- Pure meat products are very low in carbohydrates. Hence the addition of carbohydrate-rich substances is not an "extension" of the protein mix, but some new components ***"fill-up"*** the product volume.
- Apart from their volume-filling capacity, some fillers, in particular starches and flours, are also used for their capability to absorb extensive quantities of water.

BINDERS

- The term **binder** is used for substances of animal or plant origin, which have a significant high level of protein that serves for both ***water*** *and* ***fat binding***.
- Such substances include ***high-protein soy, wheat*** *and* ***milk products***, such as **soy isolate, wheat gluten** and **milk caseinate**. They are not extenders in the first place due to the low quantities added (approx. 2%), but act through their high quality proteins that are instrumental in water binding and protein network structuring.
- On the other hand, some substances with little or no protein level, like ***starches*** and ***flours*** mentioned above under "fillers", can bind water and fat by means of physical entrapment and could also be considered "binders".

71

SOY PROTEINS
*1-*SOY GRITS OR SOY FLOUR

- **Soy grits** (pressed dehulled and de-oiled soy beans) or soy flour, finely ground, contains 50 % protein. It is used in meat loaves and minced meat products to add protein and help hold the meat juices.
- Its main limitation is taste ("beany") and texture of the final product.
- Amounts to be added vary, but should not exceed 5% (dry).

72

2- SOY CONCENTRATE

- ***Soy concentrate***, contains about 70 % protein. It may be used in flour or granular form for finely comminuted meat products.
- If its structure is changed to granular form to duplicate the texture of ground meat, it is called *textured vegetable protein* (*TVP*).
- Soy concentrates are almost neutral in taste and cause less "beany" flavor in processed meats than soy flour.
- Amounts to be added to heavily extended products may be as high as 15% (dry) for hamburger type goods and up to 6% (dry) for raw-cooked goods.
- Before processing, re-hydration in water at a ratio of 1:3 is essential.

Textured vegetable protein (TVP).

TVP shaped as meat-like structures, re-hydrated

3- SOY ISOLATE (ISOLATED SOY PROTEIN)

- ***Soy isolate*****,** contains 90 % protein.
- It is the only soy product that functions like meat (it interacts with meat protein) in forming protein network structures and binding water and fat.
- It is particularly useful in "weak" formulations, where the meat protein content is low.
- Soy isolate is usually applied in quantities around 2% as a binder, due to its high price.

MILK PROTEIN (CASEINATE)

- Similar to isolated soy protein, milk caseinate has the ability to interact with meat proteins or complement deficiency in meat protein available in extended meat mixes.
- Due to the small amount required (2%) and its relatively high price, milk protein is primarily not a meat extender for volume increase but a functional binder to increase water holding and fat binding and reduce cooking losses.
- But milk protein can impart a pale color and soft texture to meat products.
- The levels of milk protein used should not exceed 2%.
- Milk protein is added to meat mixes as dry powder or as a prefabricated emulsion.
- The emulsion is usually composed of milk protein/fatty tissue/water in ratios of 1:5:5 to 1:8:8. Emulsions can easily be made in the bowl cutter, where ingredients are mixed and emulsified under high-speed rotation.

Preparation of milk protein/fatty tissue/water emulsion

75

SKIM MILK POWDER

- Skim milk powder is dried defatted milk containing up to 36% protein and as low as 0.8% fat.
- It increases the water and fat binding, and improves the texture and flavor of emulsion type sausage.
- It is sometimes used in extending raw-cooked meat products, and can be considered as an extender with binding properties.

76

GELATINE

- Gelatine is an edible jelly composed of collagen proteins extracted from animal tissues (mainly skins, also bones) through boiling.
- Commercially available gelatine is a dry powder of various granule sizes, which is first dispersed in cold water and then completely ***solubilized in water of 50-60°C***.
- The protein molecules of the gelatine absorb water and form a gel when cooling down.
- If meat pieces are mixed with the liquid gelatine, the cohesive properties, which are gradually strengthened with lowering the temperature, result in a solid, elastic and sliceable product.

77

CARRAGEENAN

- Carrageenan is a hydrocolloid (often known as "gum") derived from aquatic plants (seaweed).
- Carrageenan is available as a refined powder, which is water soluble and has strong ***water-binding and gelling*** properties.
- Upon cooling it forms an elastic gel which remains stable during refrigerated storage.
- Carrageenan, needed only in small quantities of up to 1% and added as a dry powder, can provide improved cooking yield and better sliceability and cohesiveness.

78

VEGETABLE OIL

- Vegetable oil can be used to ***replace animal fat***, in particular pork fat for Halal products.
- Vegetable oil can be considered a meat extender as it replaces part of the animal tissue.
- It also assumes the function of the animal fat to make the meat mix soft and juicy after heat treatment. Thus the oil has also functional properties.
- Vegetable oil is added in the same way as animal fat to comminuted meat batters.
- It is important that the oil be cooled down (+1 °C) before adding in order to keep the temperature of the meat mixes low.

Adding vegetable oil to meat batter curing comminuting

79

FLAVOR ENHANCER

- These substances must not be confused with seasonings. They are intended to intensify flavour characteristics in specific meat preparations.
- Food proteins such as soy, milk or blood proteins or yeast extracts are partially hydrolyzed, i.e. broken down to simpler components (mainly peptides) which may have meat flavour or the property to strengthen meat flavours.
- One well known substance to strengthen meat flavour is **monosodium glutamate** (MSG). It is particularly popular in Asia where it is widely used in most meat dishes but also in many processed meat products (0.5% or higher).

80

PRESERVATIVES

- **Some non-meat ingredients**, primarily used for purposes such as reddening, binding or flavoring, also develop moderate antimicrobial effects e.g. nitrite and phosphate. Also the common salt has antimicrobial effects, in high concentrations directly, and in lower concentrations indirectly through reduced water activity.
- **Chemical preservatives such as organic acids** such as lactic, citric or acetic acids are common preservatives permitted in any type of food processing. They can reduce microbial growth on fresh meat surfaces. For meat products, they are less suitable as they will have a negative impact on water binding and taste. Sodium salts of the organic acids are better suited for meat products, in particular sodium lactate. Also sodium acetate or di-acetate is used, in low concentrations in combination with sodium lactate.
- **Potassium sorbate** is an effective **mold inhibitor**. It is only intended for dipping sausage casings (for dry sausages) and for surface treatment of dried meat to avoid mold growth during drying and storage. Sorbates also has a potent inhibition effect against *C botulinurn* when used with low levels of nitrites.

81

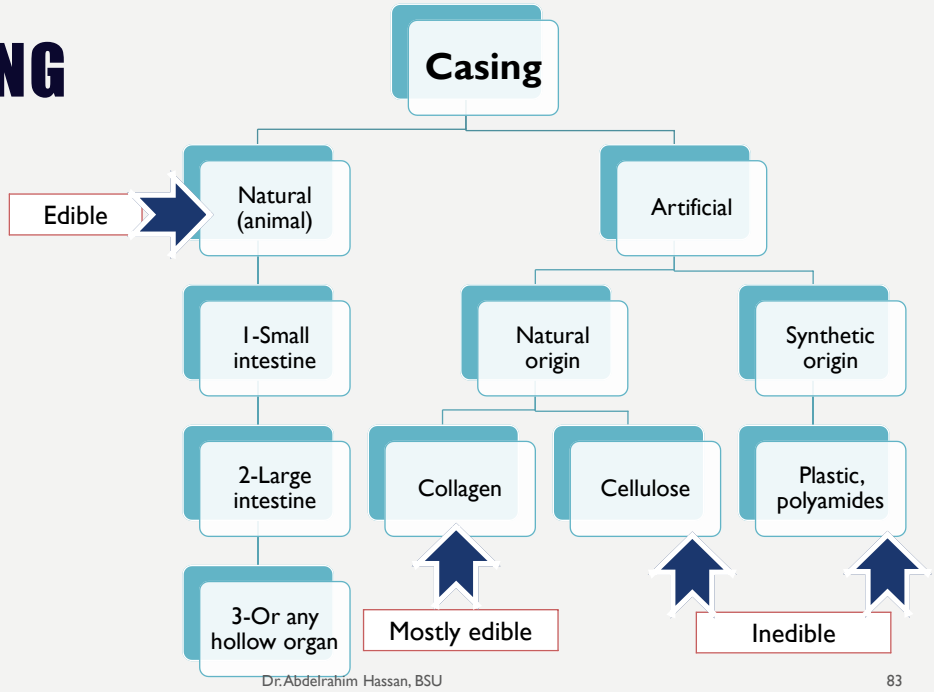
ANTIOXIDANTS

- Meat products are susceptible to rancidity.
- Some commonly used meat processing ingredients moderately counteract oxidation, e.g. nitrite, ascorbic acid, phosphates and also some spices, helpful for short term.
- For longer storage, the products should be vacuum-packed, not exposed to light and kept under refrigeration.
- Antioxidants e.g. butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) may be added to retard the development of oxidative rancidity. They may be used at levels between 0.002 and 0.003 % of the finished product weight, depending upon fat level in the finished product.
- However, the International Agency for Research on Cancer considered both BHA and BHT to be possibly carcinogenic to human.
- So, **tocopherol (vit. E)** may be used in particular for products with high fat content.

82

CASING

Casings are soft cylindrical containers used to contain sausage mixes. Sausage fillings are mostly minced or comminuted meat mixes held together by the casings during further processing steps. In addition, casings also protect products during storage.



83

NATURAL (ANIMAL) CASINGS

- Derived from small or large intestines of cattle, calves, sheep and pigs, or any hollow organs. All animal casings are edible, except if treated by something inedible.
- **Examples**

1. Rounds: small intestine of cattle, calves, sheep and pigs
2. Middles: large intestine of cattle, and pigs
3. Bungs: blind gut (cecum) of cattle
4. Hog stomach: stomach of pig
5. Weasands: from cattle esophagus

84

NATURAL (ANIMAL) CASINGS

- **Advantages:**

1. Strong enough to resist the pressure produced by filling them with sausage mix,
2. Permeable to water vapor and gases, thus allowing contents to dry (for fermented sausage),
3. Absorb smoke for additional flavor and preservation (for smoked products),
4. Expand or shrink firmly attached to the sausage mix,
5. Can be closed at the ends by tying or clipping.

- **Disadvantages:**

1. They are not uniform
2. If infested with parasites, could perforated and leak the contents

- Used for fresh oriental sausage.

ARTIFICIAL CASINGS

- Either made from animal byproducts (**collagen**), plant material (**cellulose**) or synthetic materials (**polyamides)**,

1. **Collagen casings:**

- Collagen is the main structure in the connective tissue protein in skin, tendons, ligaments cartilages and bones of animals.
- Usually obtained from the corium layer of cattle hides.
- It is an alternative for animal casings

Advantages:

1. Small calibers are edible (e.g. breakfast sausage), while large one is usually treated with alkali so it must be peeled off before eating (e,g. fresh, cooked, smoked and fermented sausages).
2. can be folded together in long lengths.
3. used for manual or automatic filling stations without pre-soaking in water.
4. permeable for smoke and water vapor

ARTIFICIAL CASINGS

2. Cellulose casing:

- Cellulose as a natural material derived from tree bulb or cotton. It is inedible casing. May be cleared or coloured.
- Suitable in small caliber casing as frequent breakages appear in large diameter, due to rupture of cellulose. E.g. small diameter is used for frankfurter then peeled off (removed) after cooking.
- To solve this problem in large caliber, fibrous casings were developed. E.g. traditional Egyptian luncheon.
- Fibrous casing is a cellulose casing reinforced with strong cellulose fibers to resist breaking, then may coated with a layer of polyvinylidene dichloride (PVDC) to increase the barrier property. Uncoated fibrous casing is preamble while coated one is impermeable.
  - Advantages of cellulose casings:
    1. mechanically resistant,
    2. widens when soaked in water and shrinks when dried (makes a tight and smooth casing without formation of wrinkles)
    3. permeable for gases, smoke and water vapor (can be used for fermented or smoked products) except coated fibrous coating.

87

ARTIFICIAL CASINGS

3. Synthetic casings

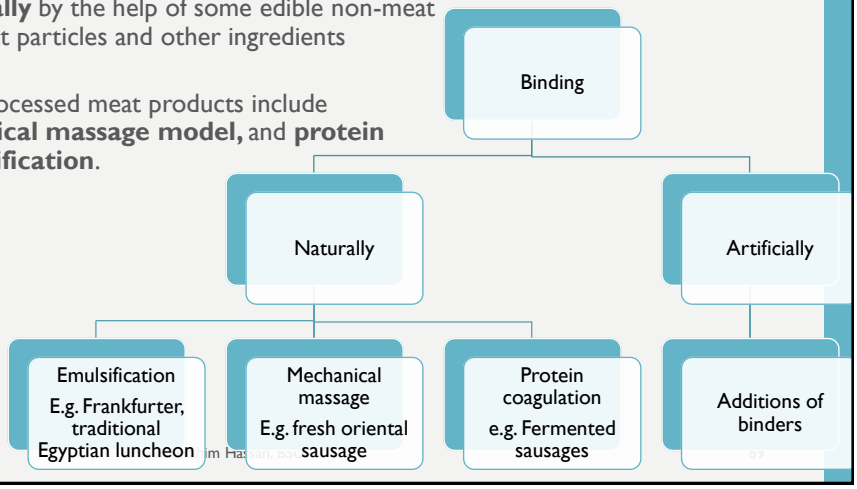
- These casings are made of synthetic thermoplastic materials like plastic. Suitable materials are Polyamide (PA), Polyethylene (PE), Polypropylene (PP), Polyvinylidene chloride (PVDC), Polyester (PET), Tripan.
- They are mechanically strong, relatively heat resistant (temperature resistance from -18° to 105/121°C), impermeable for smoke, gases and water vapour (cannot be used neither for fermented nor for smoked sausages).
- **Synthetic casings are particularly well suited for:**

1. Sausages with larger calibre
2. Sausages where water vapour losses are not wanted
3. Sausages to be cooked at relatively high temperatures
4. Sausage ends to be clipped
5. Sausages with long shelf life and good preservation of taste and flavor (prevention of rancidity, discoloration, flavor losses).

88

BINDING IN MEAT PRODUCTS

- The way by which binding is induced between the meat particles in processed meat products can be either **naturally** through the technological behavior of the meat components in a comminuted meat system and/or **artificially** by the help of some edible non-meat additives which can bind meat particles and other ingredients together.
- Natural binding in further processed meat products include **emulsion model, mechanical massage model,** and **protein coagulation through acidification**.



89

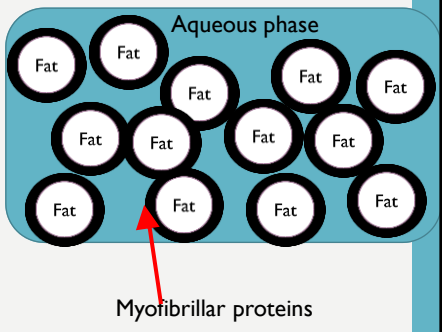
1- MEAT EMULSIONS

- Meat emulsions or batters are formed by extraction or solubilization of the salt soluble proteins (especially myosin) of the lean muscle by addition of **salt and water** and/or ice and by the aid of grinding, chopping, mixing and addition of **phosphates**.
- The presence of NaCl and phosphate ions open up the structure of proteins, so they are more easily dissolved in aqueous phase. This exposes the segments of proteins which are hydrophilic to a new environment.
- There is a tendency for the **fat** to become **a disperse phase**, while the **proteins and water** to become **a continuous phase**, which surrounds the fat particles (means the fat particles become coated with the myofibrillar proteins).
- The presence of fats allows the lipophilic portions of proteins to unfold and associate with the fat particles, while the hydrophilic portion remains associated to the aqueous phase.
- On subsequent heating the fat particles are entrapped within the protein network (gel matrix) that has formed around the fat particle. This is responsible for the texture of emulsion-type products.

90

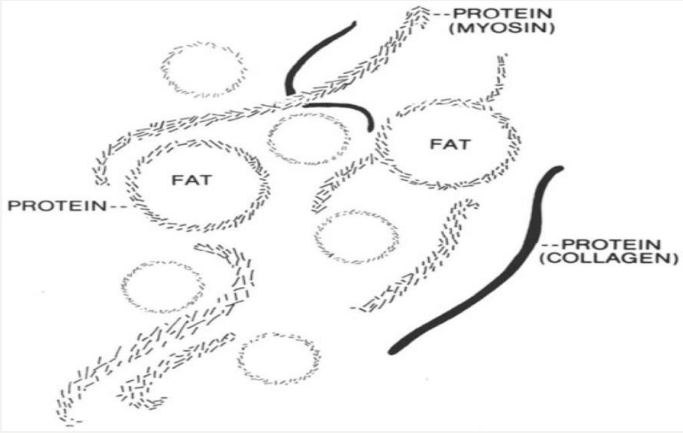
1- MEAT EMULSIONS

- In the process of forming the solution and coating the particles in a chopper or an emulsifier, considerable heat is generated, which must be absorbed to prevent coagulation of the protein at the emulsifying stage.
- It is important to keep the temperature of the meat batter below 15.5 °C during chopping and below 21 °C during emulsification to prevent fat cap formation.
- Ice or cold water is added to aid emulsification of the fat.
- By sequential chopping, part of the water is added in the beginning then the remaining added later in the form of ice. This allows high salt conc at first, thus a better protein extraction.
- The concept of emulsification is useful in understanding some of the problems related to sausage stability. An analysis of these problems using the concepts of emulsion chemistry provides an understanding of the corrective measures needed.



91

Schematic representation of an emulsion, showing solubilized protein and fat globules coated with protein.



92

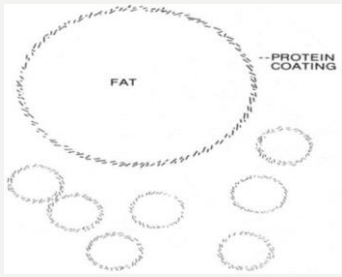
TECHNICAL FAULTS DURING EMULSIFICATION

- Overchopping
- Short meat
- Heat breakdown

93

1- OVERCHOPPING

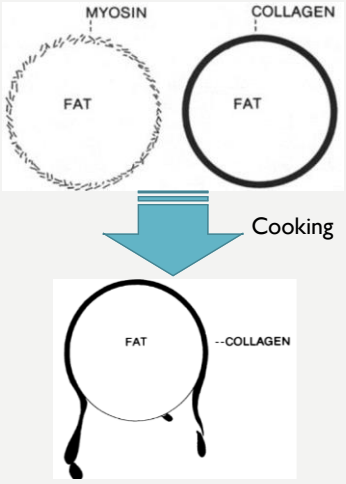
- Shows isolated fat globules coated with the myosin-type protein.
- As chopping is continued, the fat particles become smaller and smaller in diameter and the surface of the fat increases greatly, however the volume remains the same.
- Eventually the fat surface becomes of such magnitude that the protein solution cannot adequately coat all of the fat particles, and uncoated or partially coated fat surfaces result.
- The uncoated fat renders from the mixture during heating and causes **fat pocketing or greasing out** of the emulsion which lead to unsightly and unsatisfactory sausage emulsion.



94

2. SHORT MEAT

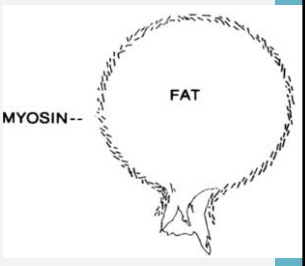
- The problem is related to an imbalance of myosin to collagen in the meat components, or to a low content of lean meat in the formula.
- The fat particles covered with myosin and those covered with collagen-type protein seem identical.
- However, on heat-processing the collagen shrinks, converts to gelatin, and drains from the fat surface, resulting in an uncoated fat particle and a droplet of a gelatin solution.
- This is very serious and results in a most unsatisfactory product with a **fat cap** at the top of the sausage and a **jelly pocket** at the bottom.
- When this occurs it is necessary that a thorough check be made of the formulation and the meat supply.



95

3. HEAT BREAKDOWN

- Even when the formulation and handling techniques are satisfactory, a problem of fat separation may arise as a result of heating too rapidly or at too high a temperature.
- During rapid heating the protein coating sets solid and entraps the fat particle.
- The fat particle expands on continued heating, whereas the protein coating has a tendency to shrink.
- The coagulated protein sac ruptures, and entrapped fat separates or renders.
- This is encountered at times with frankfurters, and results in a small tip of fat at the smoke stick mark. The surface of the frankfurter may have only a small amount of grease.
- This condition is not as unappealing as that resulting from overchopping or from short meat.
- When this type of fat separation occurs, it is necessary to review and correct the smoking and cooking schedules.

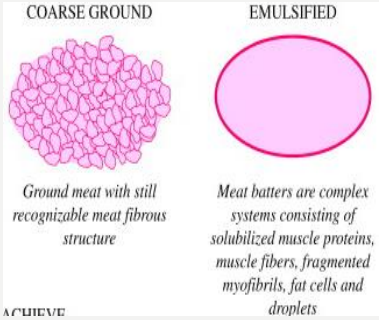


Ruptured myosin coating and fat draining away

96

2. MECHANICAL MASSAGE BINDING

- Mechanical massage model of binding is applicable in the production of simple sausages, burgers, restructured meats and molded products, where some binding is required but without going fine with the meat particle size.
- In most of these products, the raw meat is just chunked, sectioned or coarse comminuted, and then binding is developed naturally through mechanical means e.g. mixing, massaging, tumbling and mechanical tenderization.



97

CATEGORIES OF PROCESSED MEAT PRODUCTS

- Based on the **processing tec hnologies used and** taking into account the treatment of raw materials and the individual processing steps, it is possible to categorize processed meat products in **six broad groups**.

Group of products	Typical examples
Fresh processed meat products	Hamburgers, Fried Sausage, Kebab, Chicken nuggets
Cured meat pieces	Raw cured beef, Raw ham
Raw–cooked products	Cooked beef, Cooked ham, Reconstituted products, Bacon
Precooked–cooked products	Frankfurter, Mortadella, Lyoner, Meat loaf
Raw (dry) – fermented sausages	Liver sausage, Blood sausage, Corned beef
Dried meat	Salami, Some traditional Asian products
	Dried meat strips or flat pieces (Biltong, Beef jerkey, etc.), Meat floss

98

SAUSAGES

- Sausage — any meat that is chopped, seasoned and formed into a symmetrical shape.
- The term sausage covers a wide range of products that no single classification is completely satisfactory.
- Some of the more common classification systems are degree of chopping and amount of cooking, smoking, water added, curing, fermentation as well as the amount of moisture in the final product.
- In actual sausage production, the products frequently cut across classification and may fall into two or more systems.

99

SAUSAGES

- **One of the most useful classifications of sausages is its categorization as:**

1. **Fresh sausage:** made from uncured raw meat then must cooked before serving (e.g. fresh beef sausage, fresh pork sausage, fresh breakfast sausage (beef and/or pork))
2. **Uncooked smoked:** made from cured meat, smoked then later cooked before serving [e.g. fresh smoked pork sausage, fresh smoked kielbasa (pork with beef or mutton)].
3. **Cooked smoked:** made from cured meats that are lightly smoked, then cooked. They do not require further cooking. These include frankfurter, liver sausage.
4. **Cooked:** made from uncured meats that are cooked but not smoked [Bolonga sausage (pork)].
5. **Dry and semidry fermented sausages:** made from cured sausage that is air-dried under controlled time temperature-humidity conditions and subjected to fermentation. E.g. Summer sausage, Lebanon bologna, salami, kosher sausage.
6. **Specialty meats and loaves**. E.g. Luncheon meats, deli meats, meat loaves.

- Another classification which depends on the model of binding developed during processing categorizes sausages into emulsion, ground, and fermented dry and semi-dry ones.

100

EMULSION-TYPE PRODUCTS

- Emulsion sausage products include frankfurters, bologna, liver sausage and traditional Egyptian luncheon.
- The steps in preparation of emulsion type sausages are common to either small diameter products (frankfurter) or large items (bologna and Egyptian luncheon).
- For formulation of the emulsion-type sausages, it is important to consider that the collagen to total protein ratio must not exceed 1: 25.

1. TRADITIONAL EGYPTIAN LUNCHEON

- The term luncheon is usually referred to a canned, ready to eat, finely ground or chopped meat product. In Egypt, the term is usually applied to a loaf item.
- The traditional Egyptian luncheon could be considered as a large diameter, emulsion type, cooked sausage. It has the ability to be sliced into very thin slices and has high binding property.
- **Processing steps:**

1. The frozen beef must be first flaked frozen, and then minced (2-4 mm plate). It is important to notice that the meat comes out of the mincing machine in continuous chain of threads with no squeezing of meat or smearing of fat for successful emulsion production.
2. Minced meat is chopped at the first speed of the bowel cutter with common salt, polyphosphates and other non-meat ingredients (spices, nitrite etc.) for short time before addition of water (ice).

1. TRADITIONAL EGYPTIAN LUNCHEON

- **Processing steps (continued):**

3. The mixture is then chopped at fast bowel cutter speed until the ice is evenly incorporated and a sticky batter is achieved.
4. Then, the pre-minced frozen fat (or oil) is added and the mixture is chopped at high speed until homogeneous batter made of lean and fatty tissue is achieved.
5. After passing 0°C (+2°C) the starch is added since they will readily absorbed water and interfere with the protein extraction.
6. The chopping is continued, taking into consideration that the final batter temperature must not exceed 15 °C for beef and pork and 7 °C for poultry.
7. The batter can be manually filled into casings using simple filling machines (piston stuffers) or by vacuum filler. Permeable fibrous cellulose or polyamide casing are used but nowadays polyamide is the most commonly used.

- The period between production of the batter and filling it into casings should be kept as short as possible. Even under relatively low temperatures, acid producing microorganisms can develop, lower the pH and reduce the water binding capacity of the batter.

103

1. TRADITIONAL EGYPTIAN LUNCHEON

- **Processing steps (continued):**

8. Cooking to a core temperature of 65°C is sufficient to achieve the required texture; however, for safety reasons and in order to eliminate a major part of the microorganisms present in the batter, core temperatures of 70-72°C must be reached.
9. After cooking, the temperature of the product must be quickly reduced by immersing the products in a container of cold water or by showering with cold water for about 30 minutes.
10. After dropping the product temperature, the product must be immediately dispatched to a clean well-ventilated store.

- Core temperatures above 78°C should be avoided as it would negatively affect the sensory characteristics of the products.
- The traditional Egyptian luncheon is commonly cooked using a humid cooking program in case of using polyamide casing with 100% relative humidity, 90°C chamber temperature and 75-80°C core temperature in view of the ambient hot environment during handling and transport.

104

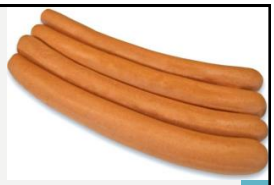
2. FRANKFURTERS (HOTDOG, WIENERS, VIENNA)

- Frankfurter is one of the popular processed meat products. It is usually made of beef and pork mix but could be made of all beef.
- In all beef frankfurter formulations, it is important to overcome the difficulties of beef fat emulsification by using high quality beef together with relatively fresh beef fat.
- Good quality plant oils (corn oil) and some milk proteins (caseinate-oil-water Emulsion) can be used so as to simulate the original bite of the franks.
- **Processing steps:**

1. Minced meat is chopped in the bowl cutter with the common salt, phosphates and other non-meat ingredients (nitrite, seasonings etc.) shortly before 2/3 of the ice are added, and the whole mixture is chopped for several revolutions. It is necessary to restrict water addition at this stage in order to ensure a maximum extraction of the salt soluble proteins.
2. Finally, the rest of the ice is added together with the minced fat; and the meat batter is chopped at high speed of the bowel cutter to the final batter temperatures.

105

2. FRANKFURTERS



- **Processing steps (Continued):**

3. Meat batter is then stuffed into either small intestinal or small cellulose casing.
4. The tube of sausage meat is divided into lengths of 12 to 13 cm either by manual or by automatic linking machines.
5. After linking, the sausage is hung on sticks in a way that they do not touch each other, thus allowing air circulation around the individual pieces and then sprayed with cold water to wash off adhering meat.
6. A simple smoking and cooking cycle lasts for 2.5-3 hours, and usually carried out in three steps (**reddening, smoking,** and **cooking**).
7. For the **reddening phase**, the frankfurter is transferred to the pre-heated smokehouse and exposed to hot air without smoke at 50°C.
8. If a smoking/cooking chamber is used, reddening is done under controlled conditions at 45-50°C for 30-45 minutes. At this temperature the curing process in the product mixture is accelerated, and is completed during the heating up in the subsequent cooking process.

106

2. FRANKFURTERS

Processing steps (continued):

9. After reddening is completed and the frankfurter developed a red curing color, the process of hot smoking is initiated. Frankfurter is hot-smoked at temperatures of 65-70°C until a desired product color is achieved (30-60 minutes).
10. After the hot-smoking is completed, the frankfurter is then cooked to a core temperature of 68°C.
11. After completion of the cooking cycle, the frankfurter is showered for about 30 minutes to slow down the temperature (internal temperature of 30°C). This causes the sausage to swell slightly and improves its appearance.
12. After that, the cellulose casing is peeled, and immediately transferred to chillers for packaging and storage either chilled or frozen.

MECHANICAL MASSAGE BINDING PRODUCTS

1. FRESH ORIENTAL SAUSAGE

- Fresh sausages are probably the oldest form of processed meat products. Their production is well suited for small-scale meat processing outlets, since the manufacture can take place with basic meat processing machinery, and binding in is created through the mechanical massage (mixing).
- High quality fresh sausages are primarily composed of lean meat and fat. Generally, the taste, texture, tenderness and color of the finished products are directly related to the ratio of fat to lean.
- The meat and fat used in fresh sausages can originate from different animal species. The meat selection and lean/fat ratio vary, depending on cultural preferences and consumer expectations.

1. FRESH ORIENTAL SAUSAGE

- Most fresh sausages are coarsely comminuted products. Hence the lean meat should be free of tendons or hard connective tissue, and only solid fats (beef body fat) should be used, since the soft fatty tissues make the product greasy.
- In addition, the fat content in the final product should not exceed 25%, as otherwise the shrinkage by melting fat during frying or cooking would be high.
- **Processing steps:**

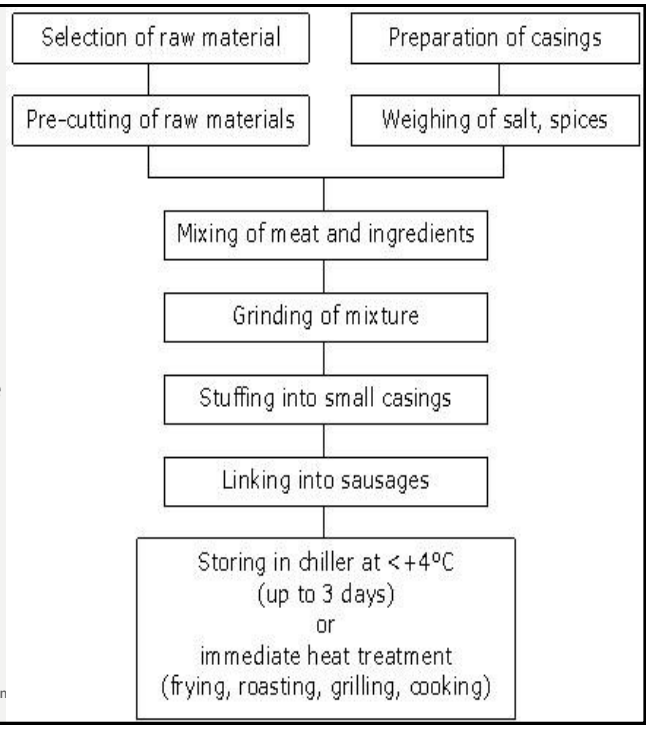
1. The proper manufacture of fresh sausages depends on proper meat and fat comminution (4-6 mm). Comminuted meat is then mixed with salts; water and other non-meat ingredients until binding develop (maximum 10°C) but avoid smearing of fat.
2. After mixing, the meat mix is stuffed into edible natural casings. The casings are filled almost to their maximum capacity and thereafter divided into shorter units of the desired size by linking and twisting (10 cm fingers). The sausage is finally rinsed with clean water, and cooled to 5°C.

1. FRESH ORIENTAL SAUSAGE

- Low-cost formulations of fresh sausages are widely available and are vary in their composition depending on the type and quantity of non-meat extenders used. Vegetables, fresh plant ingredients and their derivates (bread crumbs, textured soy, potato, etc) are used.
- Small amounts of binders such as starches and flours are also common.
- All components are cut into uniform small pieces and mixed with meat and spices. For a good degree of blending, the mixes containing all ingredients are minced through 3-5 mm plate before stuffing into casings.
- Fresh sausages are highly perishable and can subject to fast microbial spoilage and oxidative rancidity.
- The production should take place without delay, and the product should be cooked and consumed as soon as possible, or otherwise stored immediately for not more than 3 days at 4°C or for 3 months at -18°C.

1. FRESH ORIENTAL SAUSAGE

Production diagram of fresh oriental sausage



111

2. BEEF BURGER

- Beef burger is an example of formed meat product. The product is formed usually in a disc-like shape or balls. The processing technology of the product depends on the mechanical model in developing binding.
- Originally, burgers were made from beef, but in recent years chicken and mutton burgers have become common.
- Beef trimming, foreleg and neck are used for the manufacture of burger, although flank may be used where high outputs are necessary. When flank meat is used, the level of added fat should be reduced.
- Other animal tissues e.g. connective tissue/tendons can also be part of the mixture, with quantities depending on the quality of the products.
- Freshness of the raw materials is the key to good-quality burgers. Old, bruised or dirty trimmings should not be used.

112

2. BEEF BURGER

- **Processing steps:**

1. Frozen meat is first flaked using frozen meat cutter, and then minced at 4-8 mm mincing plat. It is important to keep the knives and plates as sharp as possible to minimize the crushing of the meat and to keep the temperature as low as possible.
2. Salt and spices are added and other additives should be added slowly during mixing until they are fully taken up in the meat mix.
3. After that, the meat mix is formed into patties of 75-100 g in weight.
4. In some cheaper industrial formulations textured soy protein is commonly used in quantities up to 25%.
5. Other non-meat ingredients suitable for this purpose include breadcrumbs and dried flakes.
6. Unless the beef burgers are processed for immediate sale, they should be tunnel freeze at -60°C then stored at -18°C throughout distribution and marketing.

113

PICTURES OF SOME COMMON MEAT PRODUCTS

114

115