UNIT 2 CURING AND SMOKING

Structure

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2.0 OBJECTIVES

After reading this unit, you will be able to:

- explain basic principles of curing of meat;
- narrate different ingredients and their functions in curing;
- describe methods used for application of curing ingredients and smoke to meat;
- state the composition of smoke used for meat; and
- enlist advantages of curing and smoking.

2.1 INTRODUCTION

In the previous unit, you have read about general principles of meat processing viz. comminution, formulation, emulsification, enrobing, canning, restructuring etc. In this unit, you will learn about curing and smoking of meat in detail. Cured and smoked products are popular and comprise large volume of total processed meats in the developed countries. Curing and smoking are generally done to preserve the meat products and to develop desired colour, flavour and texture of the meat products.

Curing of meat was originally developed in ancient times for preservation of meat by addition of table salt. Modern meat curing employs use of many other chemicals/ additives to produce characteristic flavour and colour. Smoking of meat is primarily done to preserve and provide characteristics aroma and flavour to meat products. For smoking, meat cuts or products are kept in the atmosphere of smoke generated from saw wood. Example of cured and smoked meat products are ham, bacon, corned beef (cured and canned).

2.2 CURING

In curing, generally intact muscle is subjected to some process to ensure distribution of salt (NaCl) and other curing agents throughout the product. Curing is mainly done in ham and belly portions of pork and large cuts of beef. Here we will study what are the different chemical agents used for curing of the meat and how they are applied.

2.2.1 Advantages of Curing

Advantages of curing are listed below:

- Curing improves keeping quality by inhibiting growth of spoilage bacteria.
- It produces characteristic pink colour.
- It provides salty flavour, which is liked by most of the consumers.
- It improves tenderness and juiciness.
- It improves functional properties.
- Curing ensures microbiological safety of the product by preventing food poisoning due to *Clostridium botulinum*.
- Larger meat cuts can be cooked or smoked directly after curing.
- Nitrite reduces rancidity in cured meats.

2.2.2 Curing agents

(i) **Salt (Sodium chloride):** Salt is the most important curing ingredient. The main functions performed by salt during curing are as follows:

- It preserves meat by inhibiting bacterial growth.
- It provides basic taste to meat products.
- It interacts with fatty acids and provides flavour.
- It retards microbial growth thus has preservative effect.
- It acts synergistically with sodium nitrite in preventing growth of *Clostridium botulinum*.
- It helps in extraction of salt soluble proteins.
- It improves water holding capacity and thus improves juiciness and cooking yield.
- It enhances the transport of nitrite and sugar into the muscle (salt penetrates faster into tissue due to osmotic action).
- It increases fat binding in emulsified products. This occurs due to solubilization of proteins.

The generally used salt level in most of the meat products is between 1.5 and 2 per cent. In fermented and cured meat products higher level of salt are used e.g. 3 to 4 per cent in fermented sausages, 2 to 3 per cent in brine cured hams, 5 to 8 per cent in dry cured hams.

(ii) **Sodium nitrate/nitrite ($NaNO_3$/$NaNO_2$):** Sodium nitrate or sodium nitrites are essential components of curing mixture. When sodium nitrate is used, it is converted into nitrite by microbes or by reducing agents such as ascorbate. Sodium nitrite can also be used directly in the curing mixture. The different functions performed by sodium nitrite are given below:

- It is responsible for the colour fixation of meat pigments and this results in characteristic cured pink colour.

- It provides characteristic cured flavour to meat.
- It has bacteriostatic properties. It inhibits growth of pathogenic bacteria specially *Clostridium botulinum.*
- It retards lipid oxidation and thus, prevents development of rancidity during storage.

The maximum permitted level of nitrate or nitrite or combination of both for most of the meat products is 120 to 200 ppm (120 ppm in bacon and 200 ppm in hams). The limits have been prescribed because during smoking or frying excess nitrite gets converted into nitrosamines that are carcinogenic in nature.

(iii) **Sugar:** It is also an important curing ingredient. The main functions of sugar in curing are listed below:

- It counteracts harshness of salt.
- It provides characteristic flavour to the product.
- It enhances water retention and thus, improves cooking yield.
- It provides energy to bacteria to convert sodium nitrate to sodium nitrite thus accelerates curing process.
- It provides substrate for the formation of acid and thus, lowers the pH of cure.

The most frequently used sugars in meat curing are sucrose, dextrose and cane sugar. Maximum permissible limit for sugar in the final product is two per cent.

(iv) **Sodium ascorbate and erythorbate:** Use of ascorbate (commonly known as Vitamin C) and erythorbate has been proved very useful in the curing. The main functions performed by sodium ascorbate or erythorbate are as follows:

- These substances accelerate curing process specially colour development.
- These prevent fading of cured colour of meat. The residual ascorbic acid maintains reducing conditions on the exposed surfaces and thus, no fading of colour takes place.
- Ascorbate also inhibits the formation of nitrosamines (carcinogenic substances) in cured meats.
- By using ascorbate, the nitrite level can be reduced.

Generally, upto 550 ppm of sodium ascorbate is used for curing of meat products.

Ascorbates accelerate or speed up cured colour development by:

- Reducing metmyoglobin to myoglobin (metmyoglobin can not combine with nitric oxide but myoglobin can combine).
- Speeding up the reduction of nitrous acid to nitric oxide.

(v) **Phosphates:** Alkaline phosphates improve the water binding quality of meat and thus improve the final yield of products. As much as 10 per cent improvements in cooking yield can be achieved by use of phosphates. Different types of phosphates are approved e.g., sodium tripolyphosphate, sodium pyrophosphate, di-sodium phosphate etc. Sodium tripolyphosphate is commonly used in restructured and emulsified meat products. This is also called alkaline phosphate. Its moisture retention properties mainly occur due to increase in pH. Acid phosphate like sodium acid pyrophosphate reduces pH. This is mainly used to promote cured colour formation.

The main functions performed by phosphates are as follows:

- These increase yield by increasing water holding capacity

- Increase fat emulsifying capacity
- Improve cooking yield
- Improve juiciness and tenderness
- Prevent auto-oxidation
- Accelerate development of cured colour

Level of phosphates in the curing mixture is selected in such a way that the finished product shall not contain more than 0.5 per cent phosphates.

(vi) **Monosodium glutamate:** It is a flavour enhancer and used as a component of curing solution to improve the flavour of meat products.

For immersion or injection curing, dry ingredients are dissolved in water. The different functions performed by water in meat curing are as follows:

- It acts as dispersing medium for salt, nitrite, sugar, phosphate and other curing ingredients and helps in uniform distribution of these ingredients in the meat.
- It assists in maintaining the juiciness of end product.
- It helps in compensating moisture loss during thermal processing.

It helps in reducing the product cost by improving the moisture percentage in the end product.

A number of spices and flavouring agents are used to provide unique flavour to ham and other cured products. These may be dissolved in curing solution or mixed with curing salts. Generally mixture of pepper, cinnamon, clove, nutmeg etc. is used.

2.2.3 Methods of Curing

There are several methods to infuse cure ingredients into meat tissue. We can apply dry cure mixture directly or after dissolving ingredients in water. The distribution of ingredients into meat tissue can also be facilitated by use of machines.

(i) **Dry curing:** Dry curing is a traditional method. In this method, dry ingredients are rubbed over the external surface of meat. This is a slow method. Completion of curing may take months. In dry salt curing, common salt alongwith nitrite or nitrate is used.

Dry curing of hams usually consists of three stages:

- Dry cure mix is applied on the muscle surface of hams and hams are kept for 2 to 3 weeks at around 5°C.
- After 2 to 3 weeks of curing, excess cure mixture is washed from the surface. Hams are hanged for 2 to 4 weeks at 10 to 16°C and relative humidity between 55 and 70 per cent. This is called equalization period.
- In next stage, hams are placed in a chamber maintained at temperature of 25 to 30°C and relative humidity of 55 to 70 per cent for 3 weeks or more. This is called aging period.

Advantages

- Dry curing results in very good flavour and texture.
- No special curing equipment is required.
- Dry cured products have very long shelf life.

Disadvantages

- Complete cure penetration may require 35 to 45 days for hams and 8 to 14 days for bacon.
- Souring around bone may occur during curing.
- Rancidity may also develop during curing.
- Storage cost during curing is high.
- Yield of final product is low.
- High salt concentration in product is not good from health point of view.

(ii) **Pickle curing:** In this type of curing, water is used as a medium for dissolving the curing ingredients and the product is placed in a vat containing brine solution (solution containing cure ingredients). The curing process is accomplished by diffusion of brine into the tissue at refrigerated temperature. Curing process completes within 2 to 3 days.

Advantages

- This method results in more uniform distribution of cure throughout the product as compared to dry curing.
- This method is faster.
- Final yield of the product is higher than dry curing because some water is also absorbed into the product.

Disadvantages

- If refrigerated temperature is not maintained or contaminated curing solution is used, then spoilage of meat (specially near bones) can occur.
- Solution becomes ropy during storage and thus, imparts off flavour to the product.

Injection curing is one type of pickle curing. In this method, brine is injected directly into the meat chunks. This reduces the risk of spoilage. Also less curing time is required.

Advantages

- Injection curing ensures rapid penetration of curing ingredients.
- Incidences of spoilage are greatly reduced.

Disadvantages

- Rapid curing may not result into development of the characteristic flavour and texture.
- There are chances of tissue disruption and formation of pickle pockets in the tissue.

Generally three methods are used for injecting brine.

(a) ***Artery pumping:*** Curing solution is injected into the ham through femoral artery. This results in uniform distribution of cure. However, this method cannot be followed if femoral artery is cut or damaged. The process does not lend itself well to high speed, high volume production and is therefore seldom used today.

(b) ***Single-needle Stitch pumping (Pump pickling):*** The curing solution is injected under pressure into the meat with the help of brine pump. This has a long hollow needle with holes along the length. An experienced operator and equilibration period for even diffusion of cure is required.

(c) ***Machine pumping (Multiple-needle Stitch pumping):*** Under commercial processing, curing solution is injected with the help of multiple needle machine called **'cure injector'**. Curing solution is pumped under pressure into the product moving over the conveyor belt through the rows of multi-hole needles. It's a very speedy process.

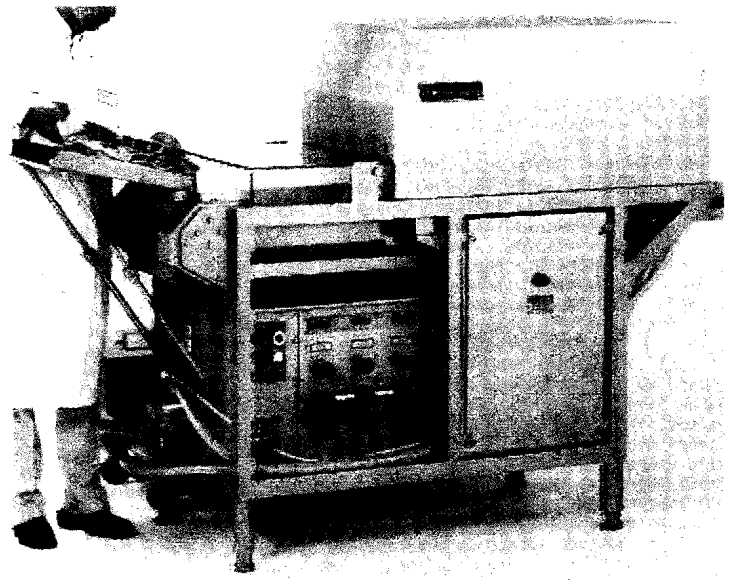

Fig. 2.1: Cure injector (used for injecting curing solution with multiple needles)

(iii) Combination curing: This is a quick method of curing. In this method, both dry and injection curing or injection and immersion curing is done. Under commercial practice, injection curing combined with mechanical agitator like tumbler or massager is preferred. Thus, the combination curing can be of following types :

- Injection followed with liquid curing – In this method, first brine is injected and then meat cuts are placed in liquid brine.
- Injection combined with dry curing – In this method, first brine is injected and then dry cure mix is applied on meat. Thus, the product will be like dry curing, but shorter curing time is required. Also risks of souring or spoilage are reduced.
- Injection with mechanical agitation – This is the method of choice under commercial operations. This method combines stitch pumping or multiple-needle pumping with massaging and tumbling. This method allows maximum yield and less time is required for curing than other methods.

Massaging and tumbling are mechanical processes that ensure quick diffusion and binding of curing ingredients with meat. After pumping, muscles are tumbled or massaged in tumbler or massager.

Both procedures allow greater pick up and retention of moisture by meat. Tissue structure is disrupted and thus, cure ingredients are distributed faster. Extracted proteins bind muscle pieces together. This function is also utilized in preparation of restructured cured products. Effect of tumbling and massaging is further enhanced if vacuum is created during agitation.

Massager is a drum type machine fitted with horizontal arms that rotate and slowly massage the muscle pieces. In this, minimum tearing of muscle takes place. Massaging employs the principle of frictional energy to extract proteins.

Vacuum tumbler machine has provision for creation of vacuum in the rotating drum. Dropping of meat pieces from top to bottom in a rotating drum and abrasion between

pieces cause extraction of proteins. Tumbling employs the principle of impact energy to extract proteins and is more severe type of physical treatment.

Advantage of vacuum tumbling and massaging:

- Ensure quick diffusion of curing ingredients.
- Improve the final yield of the product.
- Enhance tenderness.
- Improve final appearance

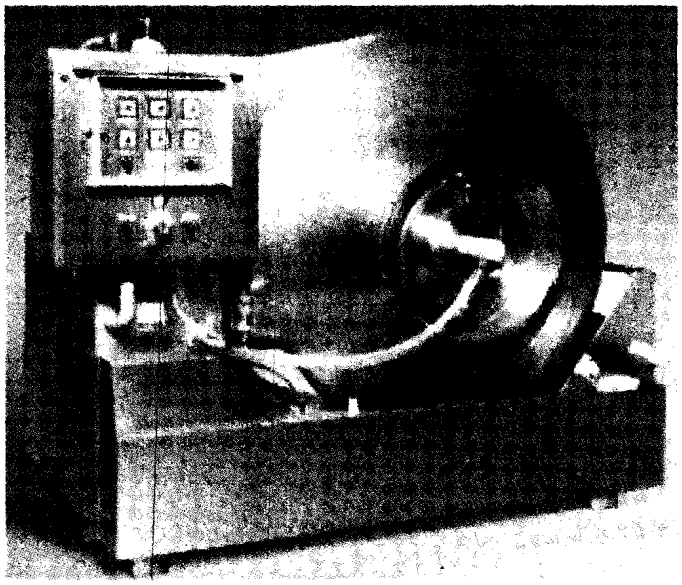

Fig. 2.2.: Vacuum tumbler (used in curing and preparation of restructured meat products)

2.2.4 Development of Cured Pink Colour

- The meat absorbs sodium nitrate added into the curing solution. The bacteria present in meat convert sodium nitrate to sodium nitrite. We can also directly use sodium nitrite to reduce curing time.
- Sodium nitrite is then converted to nitrous acid and then to nitric oxide.
- This nitric oxide reacts with myoglobin (natural pigment present in muscle) and nitric oxide myoglobin is formed.
- The nitric oxide myoglobin on heating is converted into cured pigment nitrosyl hemochromogen, which is pink in colour.

Series of reactions are given below:

Nitrate reducing organism — Favourable condition

$NaNO_3 \longrightarrow NaNO_2 \longrightarrow HNO_2$

(Sodium nitrate) (Sodium nitrite) (Nitrous acid)

Favourable condition

$HNO_2 \longrightarrow NO + H_2O$

(Nitrous acid) (Nitric oxide)

Favourable condition

$NO + Mb \longrightarrow$ NOMb (**Red Colour**)

(Nitric oxide) (Myoglobin) (Nitric oxide myoglobin)

Heat

NOMb $\longrightarrow$ Nitrosyl hemochromogen

(Nitric oxide myoglobin) (**Pink colour**)

2.2.5 Composition of Curing Solution

Let us assume that, we want to cure boneless hams by injecting curing solution at the rate of 20 per cent. The expected cooking yield is 100%. The percentage of curing ingredients (salt, sugar, sodium tripolyphosphate, sodium nitrite, erythorbate and water) will be decided in such a way that after injecting @ 20%, they should not exceed the prescribed limits in the final product. To understand this, you can critically see the example given below. If we prepare brine by dissolving 13.5g salt and inject this solution @ 20% into meat, then the product will have 2.25% salt. Similarly, levels for other ingredients are decided.

Ingredients	**Percentage in brine (%)**	**Amount in product (if injected @ 20%) (%)**
Ham		83.33
Non-meat ingredients		
Salt	13.5	2.25
Sugar	5.4	0.9
Sodium tripolyphosphate	2.1	0.35
Sodium nitrite	0.114	0.019
Sodium erythorbate	0.295	0.049
Water	78.6	13.1
Total non-meat ingredients	***100***	***16.67***

*The ingredient levels will change with the change in injection level and expected cooking yield.

Check Your Progress 1

1) Match the curing ingredients with their major function.

Sl. No.	Ingredients	Sl. No.	Function
1.	Salt	a.	Provides colour
2.	Sodium nitrite	b.	Improves tenderness, has preservative effect
3.	Sugar	c.	Improves cooking yield
4.	Phosphate	d.	Prevents harshness of salt

2) Match the terminology with the method of application of cure ingredients.

Sl. No.	Terms	Sl. No.	Application
1.	Dry curing	a.	Injection combined with other methods
2.	Stitch pumping	b.	Marinating or dipping in curing solution
3.	Combination curing	c.	Rubbing of cure ingredients on the surface
4.	Pickle curing	d.	Injection of brine into meat

3) List advantages of curing.

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4) List different functions performed by salt during curing of meat.

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5) List important functions performed by sodium nitrite during curing of meat.

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6) List important functions performed by sugar during curing of meat

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7) List important functions performed by ascorbates and erythorbates during curing.

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8) List chemical reactions take place for formation of cured pink colour of meat.

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2.3 SMOKING

In ancient times, hunters used to hang meat near fire or on smoke to get products of longer shelf life. Thus, in the early days smoking was primarily done to preserve meat. Now-a-days due to availability of other methods of preservation, the primary objective of smoking has changed to get product of characteristics flavour and colour. Generally, heat is applied during smoking for cooking of meat products. This is called hot smoking. If no heat is applied then it is called cold smoking. After cold smoking, separate cooking is required.

2.3.1 Advantages of Smoking

The advantages of smoking are:

- Smoking of meat and meat products provides characteristics flavour and colour to the cured products.
- Smoke has antimicrobial properties and inhibits microbial growth.
- Smoke has antioxidant properties and retards oxidation of fat.
- Smoking of meat cause surface dehydration.

Thus the preservative effect of smoke is due to surface drying (reduced moisture content), antimicrobial and antioxidant properties.

2.3.2 Composition of Smoke

Smoke is generated through combustion of saw dust at about 300°C. Generally hard wood saw dust is used. Smoke contains more than 200 components. These are derived from different components of wood i.e., cellulose, hemicellulose and lignin. The major components of smoke are given bellow:

Phenols

- act as antioxidant,
- have bacteriostatic effect,
- contribute to smoky flavour and aroma,
- responsible for surface shine.

Aldehydes

- contribute colour
- have bactericidal effect.

Alcohols

- have bactericidal effect.

Organic acids

- have antimicrobial effect
- accelerate cure reaction.

Carbonyls

- contribute to smoky colour and browning.

Hydrocarbons

- contribute to undesirable compounds such as benzopyrene
- affect colour and flavour.

Gases such as carbon dioxide, carbon monoxide, oxygen, nitrous oxide etc. contribute to formation of undesirable compounds such as nitrosamines and also contribute to colour.

The carcinogenic compounds like benzopyrene are produced at higher combustion temperature but their quantity is very less and thus, considered harmless.

2.3.3 Methods of Smoking

Traditionally fire pits or cabins were used for smoking of meat. Now-a-days automatically controlled chambers called **Smoke ovens** are used for smoking. The meat products are placed in the sealed smoking chamber of the oven. Smoke is

generated outside of this chamber by controlled combustion of moist sawdust and allowed to go inside the chamber. Meat products are smoked continuously for many hours. Control of temperature, air velocity, smoke density and relative humidity inside the chamber are very important for quality of smoked products.

Smoking of meat products generally consists of following stages:

Drying: Optimum moisture is required for penetration of smoke into the product. So before starting smoking, product is slightly dried to reduce surface moisture to the desired level. This stage may take 30 minutes to 1 hour.

Smoking: Meat products are generally exposed to smoke for 4-24 hours. The temperature and the relative humidity are adjusted depending upon the type of product.

Cooking: After smoking, the temperature is raised to cook the product. Generally, internal temperature of product is taken into consideration during cooking.

Showering and chilling: Immediately after cooking, the products are showered or washed to remove external salt and fat steaks. After washing, products are cooled to 5°C, sliced and packaged.

In computer based smoke ovens, all factors affecting amount and rate of smoke deposition and quality of product can be controlled. These include smoke velocity, relative humidity, smoke density, temperature etc. For control of relative humidity, moisture in the form of humidity is added in the smoking chamber.

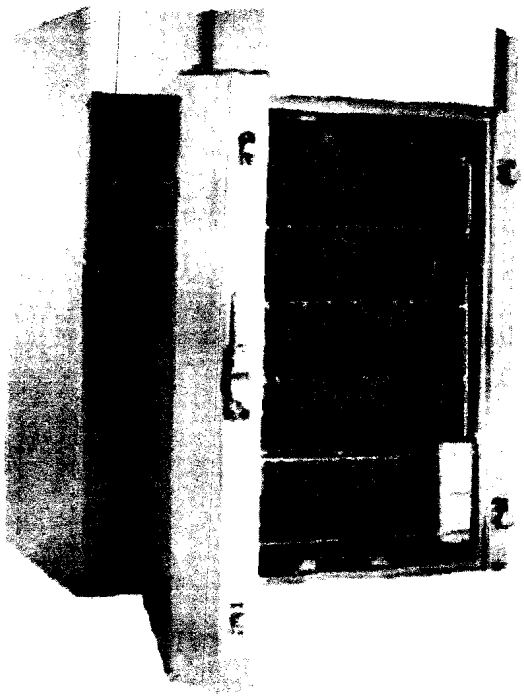

Fig. 2.3 : Sausages in a smoke chamber

2.3.4 Liquid Smoking

Liquid smoking is another method of smoking of the the product. This method is followed in the developed countries. Liquid smoke is prepared by passing smoke through liquids i.e. smoke is captured in water. During preparation, carcinogenic compounds are filtered. Meat pieces are either sprayed with or dipped in liquid smoke. Some times liquid smoke is added directly in the ground meat formulation to provide characteristic smoked flavour.

The advantages of use of liquid smoke are as follows:

- It does not contain any carcinogenic or harmful substance.
- Less time is required in preparation of product.
- Minimum variation occurs in different batches because composition of liquid smoke is constant.
- It is easy to apply.
- No air pollution occurs in the processing premises as it does not require installation of smoke generator or smoke oven.
- Use of liquid smoke also reduces the financial outlay for establishing meat processing unit. Readymade liquid smoke can be purchased from the market.

Methods of application of liquid smoke:

- Can be added directly to meat emulsion.
- Products can be dipped into smoke solution.
- Smoke solution can be sprayed over the product.

Check Your Progress 2

1) List advantages of smoking.

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2) List important components of smoke.

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3) List advantages of use of liquid smoke.

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4) Name important stages of smoking and cooking meat products in a smoke oven.

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5) List different factors that can affect quality of smoked products.

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6) Match the components of smoke with major function.

Sl. No.	Component	Sl. No.	Major function
1.	Phenols	a.	Smoky colour or browning
2.	Hydrocarbons	b.	Antimicrobial activity through reduction of pH
3.	Carbonyls	c.	Antioxidant, bacteriostatic agent
4.	Organic acids	d.	Undesirable compounds e.g. benzopyrene

2.4 LET US SUM UP

Cured and smoked products are characterized by their unique colour and flavour. Generally, ham and bacon portions of pigs and larger cuts of meat from other animals/ birds are cured and smoked. Smoking is also done on restructured, fermented or emulsion based products.

In dry curing, ingredients like salt, sodium nitrite, phosphates are applied directly on meat. In immersion curing, ingredients are dissolved in water and meat cuts are dipped in the solution. Under commercial practices, curing solution is injected with the help of multiple-needle injector. The penetration of liquid brine can be increased by use of vacuum tumbler or massager.

Cured products are generally smoked in smoke oven under controlled humidity, air velocity and temperature. Now-a-days, liquid smoke is also used to get smoky flavour and colour in the meat products.

2.5 KEY WORDS

Brine/pickle : A solution made from curing ingredients.

Curing : Addition of salt, sugar and nitrate/nitrite to meat for preservation, flavour enhancement and colour development.

Cure : Mixture of, salt, sugar, sodium nitrite and other ingredients used to preserve and improve flavour and colour of meat.

Liquid smoke : Prepared by passing smoke through water. Flavour of smoke is entrapped in water but carcinogenic compounds of smoke are filtered.

Smoke oven : Electrically operated oven consisting of large chamber where products are smoked under controlled conditions.

2.6 SOME USEFUL BOOKS

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2.7 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) 1. Salt—Improves tenderness, has preservative effect,
   2. Sodium nitrite—Provides colour
   3. Sugar—Prevents harshness of salt
   4. Phosphate—improves cooking yield
2) 1. Dry curing—Rubbing of curing ingredients on the surface
   2. Sticth pumping—Injection of brine of meat
   3. Combination curing—Injection combined with other methods
   4. Pickle curing—Marinating or dipping in curing solution.
3) Advantages of curing are as follows:
   - Improve shelf life,
   - Provide characteristic colour and flavour,
   - Improve tenderness and juiciness.
4) During curing of meat, salt performs the following functions:
   - Provides taste and flavour,
   - Preserves meat,
   - Improves tenderness,
   - Acts synergistically with sodium nitrite,
   - Improves yield.
5) During curing of meat, sodium nitrite is responsible for cured pink colour development and it provides flavour, inhibits growth of *Clostridium botulinum* and retards lipid oxidation.
6) Sugar counteracts harshness of salt, improves flavour, accelerates curing reaction and improves cooking yield during curing of meat.
7) Ascorbate and erythorbate accelerate colour development, inhibit formation of nitrosamines, reduce level of nitrite required and prevent fading of cured colour during curing.
8) Sodium nitrate is converted to sodium nitrite; nitrous acid and then nitric oxide are formed; nitric oxide react with myoglobin and nitric oxide myoglobin is formed; nitric oxide myoglobin gets converted into nitrosyl hemochromogen on heating which is pink in colour.

Check Your Progress 2

1) Smoking provides characteristics flavour and colour to the processed meat products. It has preservative effect due to antimicrobial and antioxidant properties.

2) Important components of smoke are—phenols, aldehydes, alcohols, organic acids and carbonyls.

3) Liquid smoke is advantageous because:
   i) it does not contain carcinogenic compounds;
   ii) it is easy to apply; and
   iii) causes no air pollution.

4) Important stages of smoking and cooking meat products in a smoke oven are as follows:
   - Surface drying
   - Smoking
   - Cooking
   - Washing and chilling

5) Following factors can affect quality of smoked products:
   - Relative humidity
   - Temperature
   - Smoke or air velocity
   - Smoke density

6) 1. Phenols— Antioxidants, bacteriostatic agent
   2. Hydrocarbon— Undesirable compounds e.g. benzopyrene
   3. Carbonyls— Smoky colour or browning
   4. Organic acid— Antimicrobial through reduction of pH