HANDBOOK OF
ANIMAL BYPRODUCTS UTILIZATION

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FOREWORD

I am very much pleased go through the contents of the "**Handbook of Animal Byproducts Utilization"**, by Dr. Tanbir Ahmad, Dr. Devendra Kumar and Dr. Suman Talukder and S.K. Mendiratta, Division of Livestock Products Technology, ICAR-Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly, UP, India. The valuable experience of the authors in teaching the very subject of Animal Byproducts and Slaughterhouse Byproducts at various levels has enabled them to prepare this highly useful handbook, which will surely serve as an excellent guide to the students and the teachers involved in teaching and research in the same field. This book covers the complete syllabus of Animal Byproducts Technology prescribed by Veterinary Council of India for B.V.Sc. & A.H., M.V.Sc and Ph.D programme. Besides, I appreciate the usefulness of this book for both undergraduate and post graduate courses in Animal Byproducts technology prescribed for Veterinary Sciences, Food Sciences and Agriculture & Food Engineering Colleges.

I congratulate the authors for their efforts in bringing out this highly useful hand book and wish them all success in their efforts to promote the knowledge in the subject of Animal Byproducts Technology and Slaughterhouse Byproducts Technology.



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PREFACE

Slaughtering of animals generates huge amount of valuable byproducts. In organized slaughterhouses these byproducts are economically processed into different value added products. If the slaughterhouse byproducts are efficiently utilized, contribution of the livestock sector to the total GDP can be further increased. It has direct impact on the economy and the environment of our country. Non-utilization or under utilization of animal byproducts not only leads to loss of potential revenues but also causes an increasing cost of disposal of these products. Proper recovery and utilization of animal byproducts would bring wealth from waste and will also improve the quality of life of the processors.

In this book the scope for processing and utilization of major animal byproducts from slaughter and fallen animals has been discussed thoroughly. This book is divided into 14 Chapters spread over more than 150 pages dealing with animal byproducts, classification of animal byproducts, edible and inedible byproducts, recovery and utilization of fat from animal by-products, preparation of stock feed and fertilizers, pharmaceuticals derived from animal by-products, harvesting and processing of hide and skin production of gelatin from bones and skin/hide, processing of hoofs and horns to value-added products, processing and utilization of blood, use of intestine and production of casing, processing and utilization of poultry byproducts and classification, grading and processing of wool.

Several standard books on the subject have been consulted for compiling the information and the references has gratefully been acknowledged. Suggestions for improvement are welcome from teachers, scientists and students.

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ABOUT THE AUTHORS



Dr. Tanbir Ahmad was born in a village called Hasanpur Surat, Shahpur Patory, District Samastipur, State Bihar, India on 20th November 1980. He received his primary education at Chittaranjan city, West Bengal, India. He completed his secondary and senior secondary schooling from Jawahar Navodaya Vidyalaya (JNV), Samastipur, Bihar, India. He obtained his Bachelor's degree in Veterinary Science from Madras Veterinary College (under Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu), Chennai, India in 2005. He got his Master degree in Livestock Products Technology from Bihar Veterinary College (under Dr. Rajendra Prasad Central Agriculture University, Pusa, Bihar), Patna, Bihar, India in 2008. In November 2009, he joined Indian Council of Agricultural Research (ICAR), New Delhi, India as Scientist and was posted at ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab, India. He did his Ph.D Degree in 2018 from Universiti Putra Malaysia, Malaysia as in-service candidate by availing ICAR-International Fellowship from Indian Council of Agricultural Research, New Delhi, India. He is the recipient of Best Ph.D Thesis Award (2018) from Faculty of Agriculture, Universiti Putra Malaysia, Malaysia, Best Employee Award in the category of Best in Publication (2018) from ICAR-Central Institute of Post-Harvest Engineering & Technology, Ludhiana, Punjab, India and ICAR-Senior Research Fellowship (PGS)-2009 with Fellowship in Livestock Products Technology from ICAR, New Delhi, India. Currently, he is working as Senior Scientist at ICAR-Indian Veterinary Research Institute (IVRI), Bareilly, UP, India.



Dr. Devendra Kumar was born in 1980 in Saran, Bihar. He completed his graduation in Veterinary Science and Animal Husbandry (B.V.Sc. & A.H) from College of Veterinary and Animal Science, Khanapara, Guwahati in 2005, M.V.Sc. (2007) in Livestock Product Technology (LPT) from Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and Ph.D Livestock Product Technology (LPT) from Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana in 2016. He joined Indian Council of Agricultural Research (ICAR) in 2009 as Scientist and served at ICAR-National Research Centre on Camel, Bikaner from 2010 to 2019 and presently working as Scientist (Senior Scale) in LPT Division of ICAR-IVRI, Izatnagar, Bareilly. Dr. Kumar has work experience in meat/dairy science, food safety, protein/peptide and health oriented meat/milk products processing. Dr. Kumar has published several articles in National and International Journals including Research Papers, Popular Articles, Book Chapters and many research papers abstracts in National/ International Scientific Seminars and Conferences.



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Dr. S. K. Mendiratta completed his M.V.Sc. (Gold Medal, 1990) and Ph.D in Livestock Products Technology and joined as a scientist in ICAR-IVRI, Izatnagar in 1992. Because of this outstanding research work he got selected by FAO in 2000 for training in the USA. Again in 2005, he was selected by INSA-DFG for training in Germany. Dr. S.K. Mendiratta has expertise in the field of various meat quality improvement, new product development and animal byproducts technology. With experience of more than 30 years in the field of Livestock Products Technology, he has developed more than 15 new technologies, published more than 150 research papers and authored many books. Dr. S.K. Mendiratta received best teacher awards and was associated with many organizations of national and international repute in the field. He has vast experience in teaching undergraduate and post-graduate students in the subject of Livestock Products Technology.

CHAPTER - 1

AN INTRODUCTION TO ANIMAL BYPRODUCTS PROCESSING

1.1 INTRODUCTION

Anything which is not part of the dressed carcass is considered as **animal byproducts**. Animal byproducts are divided into two categories designated as edible and inedible animal byproducts. Organ of a slaughtered animal is called offal and it is also known as organ meat.

Some edible animal byproducts that are processed under hygienic conditions and are therefore wholesome, are classified as **Variety meat**. This category includes heart, liver, kidney, brain, tongue, oxtail, sweetbreads (thymus and/or pancreas gland), tripe (stomach), intestines and fries (lamb or calf testicles). Sometimes, blood is also considered as an edible product for human use. The head meat trimmings are also utilized as edible byproducts and fat recovered from slaughtered animal is 'edible fats'. For instances, caul fat are fats obtained from rumen and/or stomach and its surrounding and pork kidney fat is called 'leaf fat'. Heart, liver and gizzard from poultry is collectively designated as 'giblet'.

Table 1.1. Dressing percentage of different food animals and poultry

S. No.	Food animal/poultry	Carcass dressing % (range)	Carcass dressing % (average)
1.	Cattle (prime)	62–67	64
2.	Buffalo		
3.	Calves and veal	59–65	62
4.	Lambs (prime)	47-55	51
5.	Sheep	49-54	52
6.	Goat	45-50	45
7.	Pig (head, leaf fat, ham facings, and kidneys excluded)	68-72	70
8.	Poultry (broilers)	-	70

1.2 CLASSIFICATION OF OFFALS

Classification of offals in another way by following the English Food Standards Committee as

1. List A items 2. List B items

1.2.1 List A items

Heart, kidney, liver, pancreas (sweetbreads), diaphragm (also known as skirt; from cattle only), head meat (ox cheek, cattle only~ bath chip, pig only), tail meat (oxtail, skinned, cattle only), thymus (sweetbreads, cattle and sheep only) and tongue. From poultry parts, heart and liver is included in this list.

1.2.2 List B items

Esophagus meat, rectum, spinal cord, blood, blood plasma, brains, feet (cow heel, from cattle only known as pig trotters, from pig only; known as sheep trotters, from sheep only), large intestines (chitlings, pigs only),

small intestines, lungs (lites), stomach (non-ruminant), rumen (tripe), reticulum (tripe), abomasum, udder and testicles (lamb fries, lamb only). Gizzard and neck from poultry are also considered to be part of List B.

1.3 ANIMAL 'WASTE' UTILIZATION

It is said that, "nothing is wasted except the cry of the animal". Every animal part is useful to human being in one or another way. Utilization of edible and inedible (wool, hair, feathers, ruminal content etc.) animal byproducts is summarized in Fig.1.1.

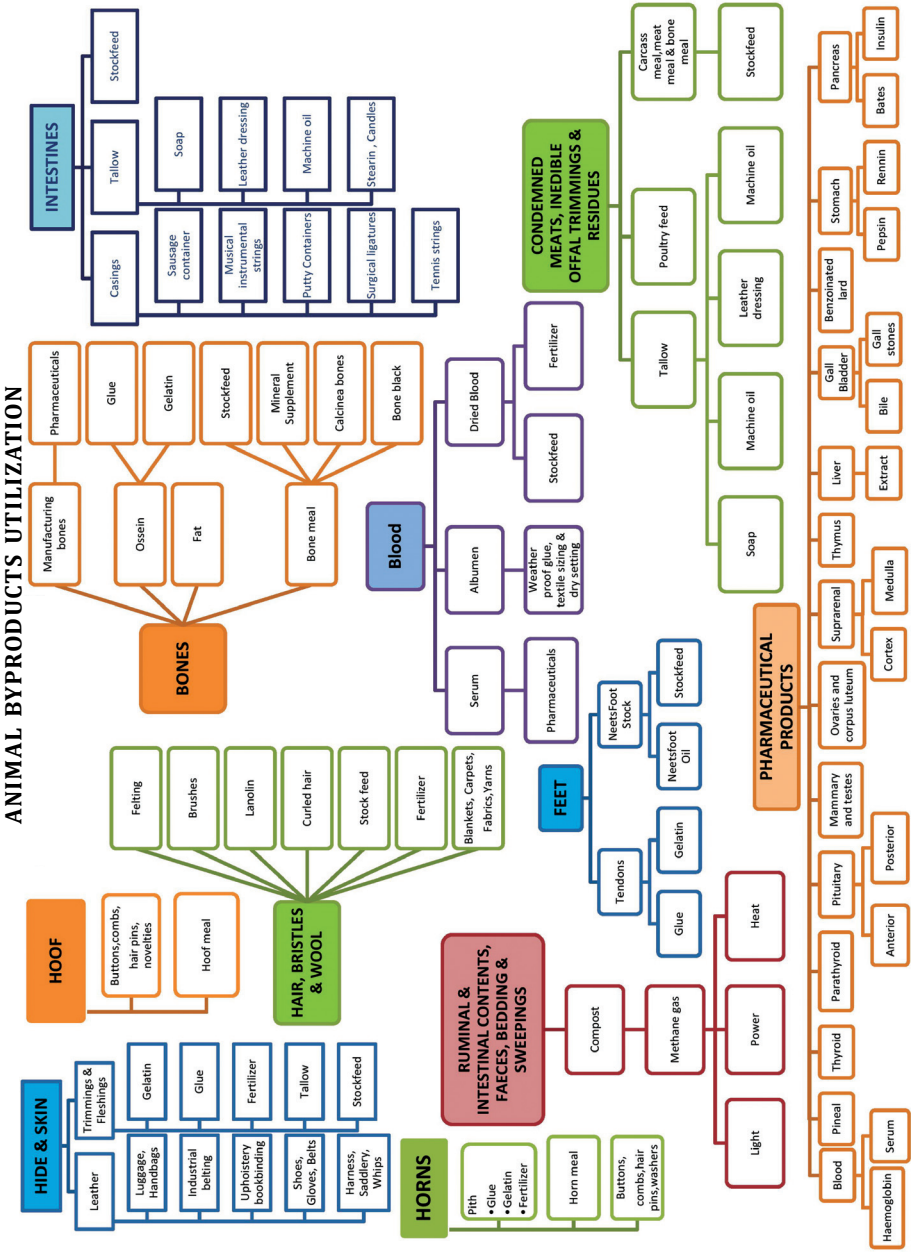


Fig. 1.1 Different useful ways of utilization of animal byproducts (Adopted from Mann, 1962).

CHAPTER - 2

RENDERING OF ANIMAL BYPRODUCTS

2.1 INTRODUCTION

The edible and inedible application of slaughterhouse byproducts can be accomplished by their value addition. This can be done by rendering process to produce human edible fat (tallow/lard), livestock feed (meat meal/carcass meal/bone meal) and fertilizer. As the animal originated raw materials are the concentrated source of valuable nutrient, human, animal and plants can get essential nutrients from them. The neutralized rendered animal products are safe for human, plant and animals.

2.2 RENDERING

The rendering is the recovery of fat from animal materials and involve the application of heat, the extraction of moisture and the separation of fat. In current perspective, the rendering is process of conversion of slaughterhouse waste into stock feed, fertilizers and fats. Fat recovered from fresh and healthy parts are edible and from decomposed and condemned parts are used for industrial purposes such as manufacturing of soap and greases.

2.3 TALLOW AND LARD

- Animal fats are triglycerides made up of a glycerol ($C_3O_3H_8$) molecule which is bound to 3 fatty acids via ester bondings

- Normally, rendered fat from cattle and sheep is called tallow
- Rendered fat from pig is termed lard
- However, a more precise definition of tallow is the animal fat having titre of more than 40 °C (104 °F)
- Lard or grease shows lesser titre
- Titre denotes the temperature of solidification of the fatty acids of a particular fat and it shows the softness or hardness of animal fats

2.4 DETERMINATION OF QUALITY OF EDIBLE AND INEDIBLE ANIMAL FAT

The quality of edible and inedible animal fat is determined by various parameters such as

1. Titre
2. Free fatty acid (FFA)
3. FAC color (standard laid down up by the Fat Analysis Committee of the American Oil Chemists Society) or Lovibond color
4. Moisture, impurities (insoluble), and unsaponifiable matter (MIU).

2.4.1 Titre

- Titre indicates the softness or hardness of tallow or lard
- It is the temperature at which a given fat solidifies
- Fats of animals from different species show different titre values For example, cattle, and sheep fat have higher titre value than the pig fat (lard)
- Even fats from different location of animal body of a specific animal have different titre
- For instance, kidney fat has higher titre compared to titre of fat trimmed from the loin area
- Depending on feed type also the fat titre may vary *e.g.* peanuts fed pigs yield lard of lower titre than those raised on maize (higher)

- Additionally, the health condition of the animal can influence the titre
- Fat from emaciated animal will have lower titre value than fat from animal having good physical condition

Table 2.1 Titre (solidification points) values of different animal fats:

Animals	Titre value of fats (°C)
Pig	36-40
Cattle	42-45
Sheep	44-48

- The occurrence of bone oil influences the titre of a fat but the titre is not affected by the way of processing of fat
- The American Fats and Oils Association (AFOA) rule for variance of specification is given below:

  Titre: The seller would allow the purchaser 0.2% of contract price for every 0.1% titre deficit, fractions in proportion. The purchaser may reject the tender when titre deficit surpasses 0.5 °C (0.9 °F).

2.4.2 Free Fatty Acid (FFA)

- Free Fatty Acid (FFA) is the percentage of free oleic acid present in the total fat sample weight
- The extent of spoilage of tallow is indicated by the amount of FFA
- Production of FFA can be arrested to maximum by storing the tallow either at below 20° C (68° F) or at 65° C (149° F), the temperature of inactivation of microorganisms and enzymes
- Besides, FFA production can be reduced by adding an acid so as to decrease the pH to 3.5-4.0
- American Fats and Oils Association (AFOA) specifications requires that the FFA to be not more than 2%

Table 2.2 Penalties under American Fats and Oils Association (AFOA) for the FFA in animal fat:

Contractual limit of FFA content	Situations
less than 10%	2% of agreement price for every 1% of more FFA
more than 2.0% of agreement limit	Reject
10% or more	1% of agreement price for every 1% more FFA
more than 5.0% of agreement limit	Reject

2.4.3 FAC Color (Fat Analysis Committee Color)

- Fats color varies from white to yellow
- It can also be green, brown, or red
- Fat colour is controlled by feed, breed, age, fat location and health status of the animal
- Fat colour may be determined by using Lovibond color

Table 2.3 Different tallow colours and its causes

Tallow color	Reason
Green	contact with gut contents
Reddish	overheating by dry rendering
brownish	presence of blood in tallow

Table 2.4 Penalties under AFOA rules for colour deviation:

FAC color specified in the contract	Decision
One shade darker	2% of contract price
Darker by two shades or more	Rejection

2.4.4 Moisture, impurities (insoluble/oil soluble) and unsaponifiable matter

2.4.4.1 Moisture

- Normally, pure fat is completely moisture free
- Water in tallow is objectionable because it promotes bacterial growth and enzymatic action
- Due to lack of moisture in the tallow, bacteria can not grow if they gain the entry to it
- Moisture in tallow is expressed as parts per centum (parts per hundred by weight)
- Moisture should not exceed 0.2% level

2.4.4.2 Impurities (Insoluble)

- Raw tallow has 90-95% of fatty substance
- The rest is insoluble foreign materials like protein particles, bone powder, hair and gut content
- Further impurities might be fine gut content present in colloidal form

2.4.4.3 Impurities (Oil Soluble)

- Oil soluble impurities consist of copper, zinc and tin (from brass) as well as soluble polyethylene
- The maximum permissible limit of polyethene in tallow is 50 parts per million

2.4.4.4 Unsaponifiable matter

- Saponification is the breaking of ester linkages of fat by hydrolysis using an alkali producing soap as well as glycerol
- Soap is generally sodium salts of the lengthy chain fatty acids like oleic acid

- Unsaponifiable matter (UM) is the fatty substances in tallow which can not be translated to soap by using an alkali
- Small quantities of UM occur normally in a tallow such as cholesterol

Bleachability

- The lower the processing temperatures and pressures for tallow extraction and cleaner (more white) the tallow raw material, the lighter will be the bleach
- High processing temperature fixes color in fat
- Activated clay and Lovibond Tintometer are used to perform the bleach test. It is essentially a color test
- Because of direct connection between red and yellow readings so, generally only the red readings are taken
- As per specification, tallow should have bleach reading not greater than 0.5 R

Following are the penalties under the AFOA for not meeting specifications:

- The seller will allow the buyer 2% of agreed price for every surplus 0.5R, fractions in proportion
- If color surpasses the agreed limit by more than 0.5 R, the tender may be rejected by the buyer

2.5 QUALITY TESTS TO DETERMINE THE PROPERTIES OF THE TALLOW

1. Saponification number or iodine value
2. Peroxide value
3. Smoke point

2.5.1 Saponification number or iodine value

- The saponification number specifies the average chain length of any given fatty acid

- The iodine number points to the extent of unsaturation
- The saponification number and iodine value helps to differentiate the different kinds of fats and oils used in tallow manufacture
- Animal fats show low whereas vegetable oils have high iodine value
- The greater iodine value indicates lower melting point and high level of unsaturation i.e. more number of carbon double bonds
- By this way, the incidence of pig fats mixing in beef fat can be identified

2.5.2 Peroxide value

- The peroxide value indicates the rancidity of tallow
- Lower peroxide value signifies that the tallow has not become rancid
- Peroxide value of fresh fats is 12 whereas value of 15-20 indicates rancid fats
- Rancidity is caused by oxidation and hydrolysis of fat

2.5.3 Smoke point

- Smoke point is the temperature to which the fat may be heated before it begins to smoke
- Smoke point is inversely proportional to FFA

Table 2.5 FFA and its corresponding smoke points

Tallow having FFA of	Smoke point (°C)
0.2%	225
1.0%	145
5.0%	120C

2.6 MEAT AND BONE MEAL

- The solid material left out after obtaining fat during rendering from the slaughterhouse waste is called tankage/cracklings
- This material is high in nitrogen (from proteinaceous material), phosphorus and calcium (from bone) and was sold for use as fertilizer
- Tankage/cracklings are found to be an excellent animal feed, high in protein, calcium, phosphorus and fat
- Importance of tankage/cracklings has increased as it is used to prepare animal pet foods. Tankage must not have impurities such as hoof, horn, hair, manure and gut contents
- Protein percentage in tankage/cracklings is around 60% but is low in some specific amino acids. Tankage having more than 4.4% of phosphorus is referred as ‘’digester tankage with bone,’’ “meat and bone meal digester tankage,” “meat and bone meal tankage,” or “feeding tankage with bone”
- Meat meal or meat scraps are identical to tankage/cracklings but they are rendered by dry rendering in steam jacketed tanks
- Again, if phosphorus content in tankage is greater than 4.4%, the tankage/cracklings must be called either “meat and bone meal,” or “meat and bone scrap”
- Feather meal is derived from feathers using wet rendering and then ground to feather meal containing high protein (80%). Feather meal is digestible but is deficient in some essential amino acids
- Blood meal is prepared by drying blood followed by grinding it to meal.
- Blood meal is rich in protein particularly lysine amino acid but low in palatability and digestibility
- Fish meal is like meat scraps and will differ in composition based on the kinds of fishes used to prepare fish meal. Fish meal is rich in good type of protein (60%)
- Bone meals are mainly composed of mineral having up to 15% protein

2.7 DIFFERENT USES OF RENDERED MATERIAL

2.7.1 Inedible tallow

- Animal fat makes animal feed rich in energy
- Fat decreases the dust and enhance color as well as texture
- Increases palatability, pelleting efficiency and decreases wearing off machinery of feed mill
- Animal feed is the most important use of inedible tallow and grease (higher titre)
- Industrial chemicals and synthetic oils especially fatty acids are obtained from tallow
- Various products are prepared from fatty acids such as abrasives, cement additives, shaving cream, deodorants, paints, asphalt tile, candles, cleaners, cosmetics, polishes, perfumes, printing inks, synthetic rubber, detergents, plastics and water repellent compounds
- A large volume of tallow is used to make soap. The two main categories of soap are
  1. Boiled soap and
  2. Cold or semi boiled soap

2.7.1.1 Boiled soap

- Soda based soaps are boiled soap which is sold in markets as hard soap
- Sold as fragrant toilet soap and soap powder

2.7.1.2 Cold or semi boiled soap

- Cold soaps are potash based
- Semi boiled soaps are also known as green soap
- Having medicinal use

- Soft soap (potash based) is costlier than hard soap because the glycerine is left in the soap
- Glycerine is recovered while making hard soap and is vital and expensive byproduct
- Purified glycerine finds its use in medical field and in preparing explosives (nitroglycerine)

2.7.2. Edible Tallow

- Oleomargarine (margarine), shortenings and cooking fats are prepared out of edible tallow and lard
- Large quantity is used for cooking fats and shortening than margarine
- Tallow imparts enhanced flavour to fried foodstuffs compared to vegetable oils

2.7.3 Meat Meal

- Meat meals are good source of energy, high quality protein, B vitamins, and minerals
- Animal requirement of EAA such as lysine, methionine, threonine, and tryptophan is achieved by adding 10% meat meal
- Essential minerals like calcium and phosphorus are provided by the bone content present in the meat meal

Table 2.6: Classic composition of meat and bone meal

Components	Meat and bone meal
Moisture	4-10%
Crude protein	Min 87%
Fat	8-11%
Available lysine	Min. 3.6% of crude protein & 71% availability
Salt (NaCl)	Max. 1%
Calcium	8-11%
Phosphorus	4 - 5.5%
Untreated hair/feathers	Max. 2%

✓ Crude protein content of blood meal and meat cum bone meal is 80 and 50%, respectively.

2.7.4 Bone meal

- Fed to poultry as source of calcium for bone development and egg shell formation
- Used to enhance calcium and phosphorus to livestock and pet foods
- Animal glue is used in wood, leather, paper industries and is manufactured from bones by heating it in water

Table 2.7 Mineral content of meat and bone scrap (49-50% Protein)

Minerals	Range (%)	Average (%)
Ash	30-32	31
Calcium	8.0-12.0	8.1
Phosphorus	4.0-5.5	4.1

2.8 RENDERING SYSTEMS

All the different rendering systems can generally be classified into four different categories:

1. Wet (autoclave) rendering
2. Dry batch rendering
3. Continuous dry rendering
4. Continuous low temperature rendering

2.8.1 Wet (autoclave) rendering

- In this rendering method, raw material is processed with added water or condensate derived from steam
- The wet rendering tank is a vertical, cylindrical boiler having a cone shaped bottom, with a gate valve outlet

- In the top of the tank, a valve is set to let the obnoxious gases escape without reducing the inside pressure
- Several draw-off cocks enable the fat and water to be removed
- After loading the tank with raw materials, steam is passed from the bottom of the tank
- Pre-ground raw material is filled into autoclave or cooker
- Steam is injected into the raw material after closing the system and the temperature and pressure reached are 140 °C and 361 kPa, respectively
- Since, steam is in direct contact with raw material so it is designated as wet rendering
- After about 3-4 hours, the pressure is gradually decreased to 101 kPa
- Reducing pressure slowly prevents emulsification
- The fat being light comes at the top and is removed through the vent
- The moist solid material is pressed to take out further liquid Then, it is dried and the dried material is called **Tankage**

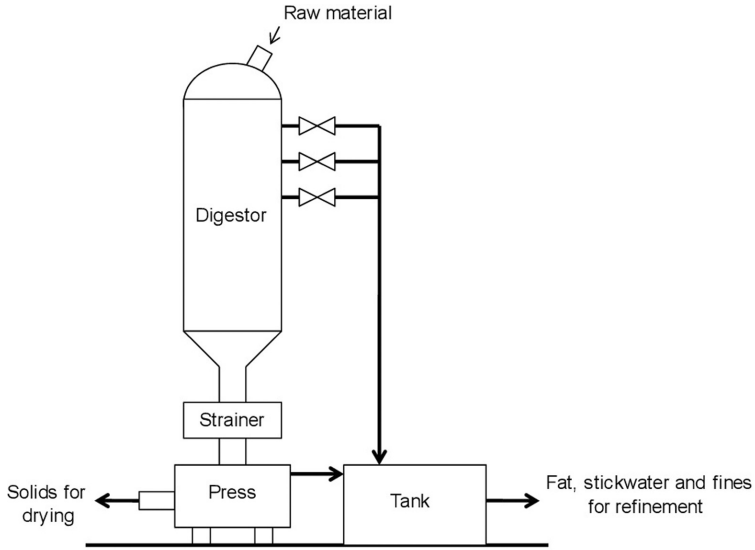


Fig. 2.1. Wet batch drying system (Shamsuddin, 2013)

- The liquid recovered by press contains water, fat and fines
- Additional fat is obtained by centrifugation or by gravity method where fines are settled down and fat comes to the surface
- A press is used to further reduce the moisture % of tankage/ slush to 8%
- Tankage/slush contains moisture- 55% and fat- 15%
- Tank water contains high protein- so evaporators are used to remove the excess water and final product obtained is called **Liquid Stick**
- Satisfactory method of wet rendering produce sterilized material for bone and meat meal

2.8.2 Dry batch rendering

- Process of sterilization, digestion and drying takes place in one step and in a single tank
- Horizontal double jacketed or steam jacketed cooker with hollowed steam filled agitator is employed in dry batch systems
- All the unwanted moisture is eliminated without the loss of nutrients (protein)
- The dry heat converts the available moisture into steam which increases the internal pressure gradually
- This build up pressure breaks down the fat cells
- Thus, pressure is build from the steam generated inside from the moisture of the tissues unlike in wet rendering where steam from outside is injected to build up the pressure inside the tank
- Raw byproducts never comes into direct contact of steam and hence called dry rendering
- Material is loaded and unloaded in batches and system is closed before steam injection
- Steam present in the jacket and agitator supplies dry heat
- Material is ground to smaller than 2.5 cm (1 in) and the unit is closed

- Generated water is moved out and the fat is not adversely affected by scorching heat
- Heat transfer to the byproducts is enhanced by the steam circulating in agitator
- The fat gets separated from the raw material in 1.5-2 hours
- Liberated liquid fat is drained out through the vent
- Left out solids are passed through press to remove additional fat
- The final dried material is called **cracklings**
- Fat can be recovered from crackling by three mechanical methods (viz, Hydraulic press (4000 lb/sqin), Centrifugal turbine fat extractor and Fat Expeller) and one chemical method (Solvent extraction)
- Fat content of cracking is reduced to 10% by the mechanical methods

Table 2.8 Different drying methodology for the cracklings

Hydraulic press	Centrifugal turbine fat extractor	Fat expeller	Solvent extraction
Cracklings are loaded into the metal curb after piston has been retracted.	After the crackling has been loaded into the basket of centrifuge, the steam is injected which spins the basket at 700 rpm.	Works on the principal of continuous screw	Solvents such as petrol, ether or heptanes is used
The applied pressure raises the bottom plate against the top plate thus pressing the crackling and fat is recovered through drains.	Steam melts the fat and centrifugal force drives out the fat.	Steam is injected and fat melts and drained out	Fat content reduced to 0.5%
		Very efficient and labour saving	Odourless and the resulting meal has extended shelf life

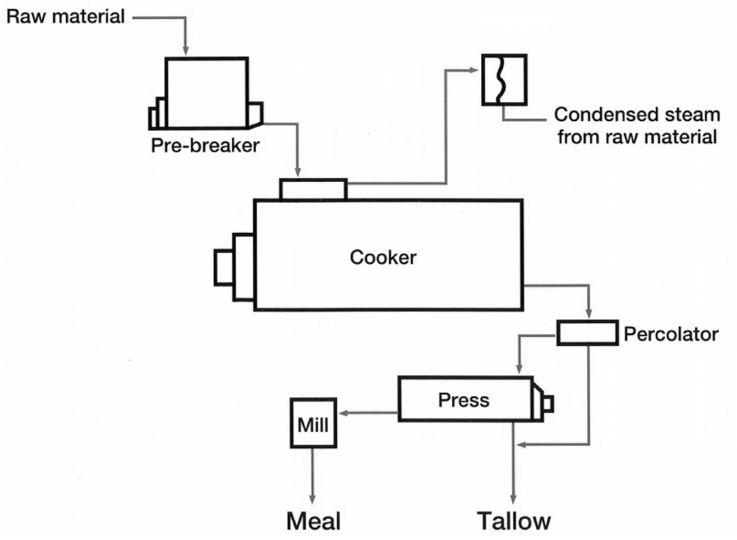


Fig. 2.2. Dry batch rendering (Swan, 1992)

2.8.3 Continuous dry rendering

- Similar to dry batch rendering system where dry heat (steam in double jacketed cooker) is used to cook the raw material and thus moisture is removed
- The raw material flow is continuous and the system works at atmospheric pressure
- Generally, the cooker is steam jacketed (double walled) and horizontal having hollowed, steam heated agitator
- Ground, raw material is fed at one end and the final product comes out at the other end in continuous fashion
- Then, the whole material is pushed to percolator having a strainer or drainer screw at the bottom
- Then the cooked material is pushed to screw press where further fat with moisture is separated
- Finally, the remaining pressed solids are ground in mill to obtain the meat meal

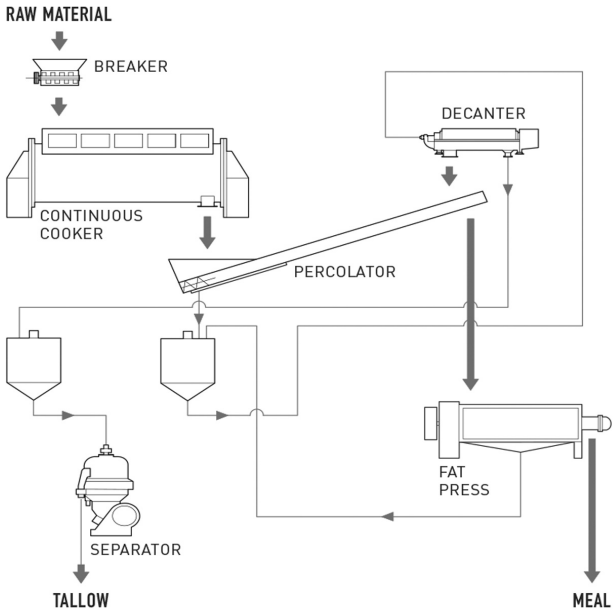


Fig. 2.3. Continuous dry rendering (Shamsuddin, 2013)

2.8.4 Continuous low temperature rendering

- The continuous wet rendering system is also termed as continuous low temperature rendering system
- Similar to wet batch rendering in term of moisture removal—moisture is removed taking the advantage of density difference between fat, water and solids
- Minced raw material is loaded into to a low temperature dry/wet cooker. The material is heated to 60-90 °C for 10-30 minutes resulting in cell disruption releasing the liquid fat
- Liquid fat is pressed out together with water in a continuous screw press
- Then the liquid mixture (fat and moisture) along with solids fines is centrifuged in tricanter and thus, water, fat and solids are separately recovered
- If evaporator is used, then the liquid mixture is initially filtered

- Filtered liquid passes to the evaporator and water is removed at low temperature (>100 °C) and low pressure
- The waste steam from the cooker/drier is provided to the evaporator to save energy
- Additional centrifuge or filter press may be applied for further removal of moisture from the tallow
- The cooker/drier used to dry the solids is similar to the system employed in continuous dry rendering
- Steam from boiler supplies heat to vaporize the moisture and thus producing the dried meal

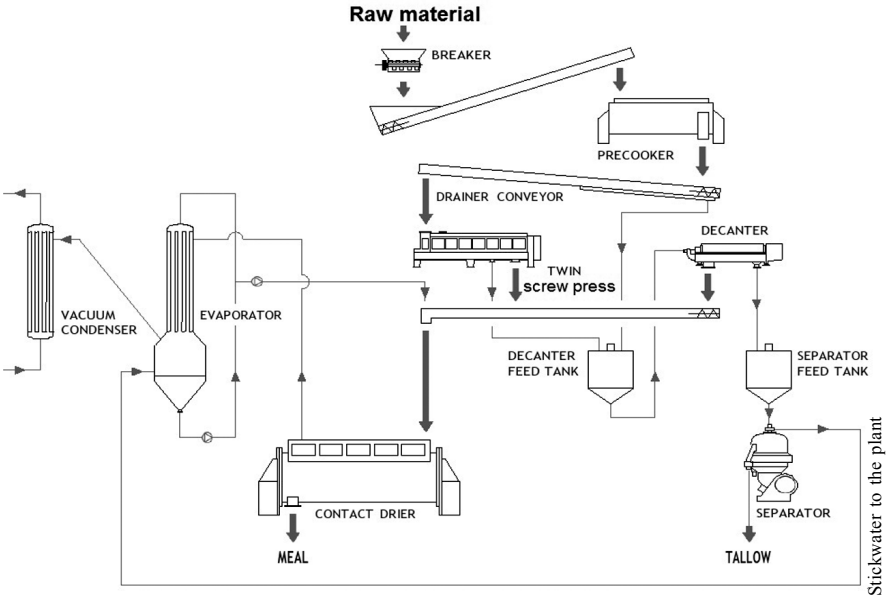


Fig. 2.4. Continuous low temperature rendering (Colley, 2008)

2.8.4.1 Advantages of continuous low temperature rendering

1. Production of high quality tallow
2. Decreased energy expenditure than heat drying of tallow
3. It can remove greater amount of fat from the raw material and final meal can contain 7-10% fat which is quite lower than that in dry systems

- ✓ Blood is problematic to dry in a cooker/drier due to its sticky nature acquired after it reaches a certain moisture level
- ✓ It sticks to the side wall of the drier

Use of anti-oxidants: The proneness of oxidation of the recovered fat obtained from rendering downgrades their quality. To overcome this problem antioxidants are to be used. The commonly used antioxidants are Butylated hydroxyanisole (BHA) and Butylated hydroxytoluene (BHT). In the present day, plant-based antioxidants are also in use because of their high acceptability.

2.9 ASSESSMENT OF VARIOUS RENDERING SYSTEMS

Usually, rendering systems can be classified into

1. Batch or continuous
2. Dry or wet

The present continuous wet rendering system is also known as low temperature or mechanical rendering system.

The various advantages and disadvantages of each system is mentioned below:

2.9.1 High temperature rendering systems

In high temperature rendering, temperature is more than 100 °C (212° F).

2.9.1.1 Digester wet rendering/wet batch rendering

- Old method of rendering
- Byproducts are loaded into a vertical digester/autoclave which is very similar to the domestic pressure cooker
- Steam is straight away injected into the raw material through the vents located at the base of the cooker

Advantages

1. Yield of a good quality tallow

Disadvantages

1. Takes longer processing time
2. Labour intensive
3. Up to 25% of meal is lost in the gravy
4. Viscera must be washed and cut to produce good quality tallow
5. Two equipments are required to dry the product completely
6. Loss of protein through stick water

2.9.1.2 Dry batch rendering

Advantages

1. Material loss from the cooker is scanty- 20% more yield
2. Cooking and sterilization in the same cooker
3. Being a batch operation, separate cookers are not required for different operations
4. Spent steam from the cooker can be reused to generate hot water for other purposes
5. Saves labour and steam

Disadvantages

1. Compared to tallow recovered during wet/ low temperature rendering (LTR), dry rendering produces darker tallow
2. Fines solid remains in tallow which is lost in effluent
3. Dry rendered meal contains lower fat (10-16%) than meal obtained from LTR systems (fat % is 38)
4. Viscera must be cut and washed to produce good quality tallow and this leads to loss of fat and protein
5. Gelatinous material such as slunks (unborn calves) are diffult to process

6. Since cooker is not closed completely, there is possibility of recontamination
7. More expenditure of steam if waste steam is not recycled for other purposes
8. Labour intensive process

2.9.1.3 Continuous dry rendering

Continuous dry rendering requires the continuous use of only one cooker and thus, there is no need of 2 to 5 batch cookers required in classical dry batch rendering process.

Advantages

1. Lesser labour and floor area required compared to dry batch system
2. Very less amount of material loss from the cooker
3. Waste/spent steam from the cookers is used to supply hot water

Disadvantages

1. In this rendering, final meal is not sterilized since pressure is not build up
2. The tallow color is little darker compared to tallow from dry batch rendering due to high temperatures of cooking
3. Apart from being not labour demanding, all the drawbacks of dry batch rendering are encountered (see all the 8 disadvantages of batch rendering)

2.9.1.4 Semi-continuous process incorporating both wet and dry rendering

- Minced raw material is loaded into dry batch cooker and heated for 45-60 minutes under pressure and thus sterilization of the rendered material is ensured

- Separation of the tallow, water, meal as well as sludge is achieved by decanter centrifuge and disc centrifuges
- Wet meal is dried in continuous driers and the process water is dried in evaporators
- The concentrate having 40% total solids is added to the wet meal and dried in the drier

Advantages

1. High quality tallow and meal
2. 8% fat in the meal
3. 40% lower consumption of steam than dry rendering.
4. Automation cab be achieved with this process

Disadvantages

5. Installation cost is high
6. Maintenance and repairs costs are high

2.9.2 Low temperature rendering (LTR) system

- During high temperature rendering (HTR), raw material is initially heated and cooked
- When cooker temperature reaches 100 °C, water begins to boil and evaporates rapidly and there is build up of pressure
- Ultimately, the temperature reaches to 110-130 °C and the raw material is fried in hot fat
- Due to high temperature (more than 100 °C) for long time duration, the viscera must be cleaned and washed to prevent the staining of the resultant tallow leading to inferior quality tallow
- Pressing is used to further remove the tallow but still it produces a meal with high fat content
- Thus, the meal from high temperature rendering (HTR) is low in moisture and high in fat

- In LTR, tallow, water and meal are separated out at low temperatures (70-100 °C)
- At low temperature, washing of the raw material is not required because the color of dirt and stomach and intestinal contents is not fixed in the tallow
- After low temperature phase separation, the wet solids and tallow are rendered separately to attain highest yields and better quality product

Advantages of LTR

1. Low losses in stick water
2. The meal is low in fat
3. The meal is low in moisture

✓ Dry rendering requires 1.0 kg of steam/kg of raw material however LTR rendering needs only 0.5 kg of steam/ kg of raw material

Table 2.9 Evaluation of traditional dry rendering and LTR systems

Yields	In dry rendering (%)	In LTR (%)
Moisture in meal	3.0	8.0
Fat	95.0	99.5
Fat in meal	12.0	8.0
Fat free solids	96.0	94.0

CHAPTER - 3

EDIBLE SLAUGHTERHOUSE BYPRODUCTS

3.1 INTRODUCTION

A substantial part, varying from 10 to 30% of live weight of cattle, sheep and pig and 5 to 6% in case of poultry is obtained as edible byproducts. Normally, organs and edible blood are about 12, 14 and 14% of the live weight of cattle, sheep and pig (skin included), respectively.

3.2 RED VISCERA/ FANCY MEAT

Heart, liver, kidney, tongue and neck sweetbread (thymus) are collectively referred as 'Red viscera' or 'Fancy meat'.

3.3 VARIETY MEAT

This term is used for 'Red viscera' or 'Fancy meats' together with brain, other sweetbreads, tripe and sausage casings. Some other items may be included in this list depending on the region and culture.

Edible byproducts

- The non-carcass parts, also referred as animal byproducts, are also categorized according to declining value such as:
  i. Main ingredient- fancy meats comes in this group
  ii. Sausage material- head trimmings, cheeks and pork rinds
  iii. Pet food

iv. Animal feed- blood, lungs, spinal cord, breast fat, bones and stomachs

v. Fertilizer

- Edible byproducts have less shelf-life compared to carcass proper because of their higher glycogen content and lesser fat covering and hence they should be hygienically cleaned and chilled as soon as possible
- Many animal byproducts are rich source of cholesterol, among them brain has highest concentration of more than 2000 mg cholesterol/100 g

Table 3.1 Various uses and cooking methods of different edible byproducts obtained from cattle

Byproducts	Used in
Blood	Blood food preparation, blood sausage, sausage ingredient, black pudding
Blood plasma	Ingredient in sausage
Bone	Jellied products, gelatin, refining sugars, soup
Brain	Cooked by poaching, frying, precooked in water followed by broiling or scrambling
Cheek and head trimmings	Sausage ingredient, stew, processed meat
Oesophagus	Sausage ingredient
Extract	Soup, bouillon
Fat	Frying
Oleo stock	Margarine production
Oleo oil	Shortening, drippings, oleomargarine, shortening
Oleo stearin	Sweets, chewing gum, shortening
Edible tallow	Shortening, mincemeat, paste, pudding
Feet	Foot jelly, jelly, cow heel
Heart	Stew, boil, loaf, fry, processed meat, braise, stuff, bake, cook in liquid, patty, sausage ingredient
Large intestine	For preparing sausage casing
Small intestine	For preparing sausage casing
Kidney	Stew, fry, stuff, bake braise, processed meat, patty, loaf

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Byproducts	Used in
Liver	Cooked by frying, boiling, broiling, grilling or braising; used in loaf, patty or sausage preparation
Oxtail	Used to prepare soup, soup stew
Skin trimmings	Source material for gelatin and jellied food
Skirt, thick	Cooked by stewing, used as sausage ingredient
Spleen	Blood preparation, pie flavouring melt, variety meat
Rumen	Ingredient of sausage (known as tripe)
Reticulum	Sausage ingredient (known as honeycomb tripe)
Abomasum	Source of sausage ingredient (known as red or black tripe)
Calf Abomasum	Source of rennet (known as tripe)
Sweetbread Thymus	Comes under 'variety meat'; cooked in sauce or poached with sauce; cooking by frying and stewing
Pancreas	Also known as gut bread; one of the variety meat; cooked in sauce; precooking in water is followed by broiling, frying or braising
Tongue	Used as boiled, cured, smoked, cooked, salted and boiled; used as sausage ingredient
Udder	Cooked by boiling, frying, salting or smoking

Table 3.2 Various uses and cooking methods of different edible byproducts obtained from pig

Byproducts	Uses
Blood	Blood food preparation, blood sausage, sausage ingredient, black pudding
Blood plasma	Ingredient in sausage
Bone	Gelatin, jellied products, rendered shortening, mechanically deboned tissue
Brain	Cooked by poaching, frying, precooked in water followed by broiling or scrambling
Cheek and head trimmings	Sausage ingredient, stew, processed meat

[Table Contd.

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Byproducts	Uses
Ears	Cooked as stew along with feet
Oesophagus	Source of sausage ingredient, added in processed meat
Fat	Termed as lard; used for shortening
Head	Sausage ingredient, boar's head, jelly (cold), salt, boil, blood sausage, pie brawn, liver sausage
Heart	Blood preparation, braise, sausage ingredient, luncheon meat, cook in liquid, loaf, patty
Large intestine	Chitlings, sausage casing
Small intestine	Sausage casing
Kidney	Fry, grill, braise, stew, broil, soup is prepared, cooked in liquid; used in patties, loaves
Liver	Cooked by frying, boiling, broiling, grilling or braising; used in loaf, patty or liver sausage preparation
Lung	Pet food is prepared, various blood preparation
Omentum	Used as covering for various processed meat such as meat pie, pate etc.
Skin	Termed as rind; rind emulsion, gelatin, jellied food products, rind french fry etc. are prepared
Spleen	Also known as pig's fry; comes under variety meat; cooked as fried

3.4 LIVER

- Liver of cattle has thinner left lobe (called the "thumb piece") and thick upper end
- Pig liver has 5 lobes with tapering at the borders and appears as "nutmeg" (Morocco leather) because of the connective tissue covering
- Grinding allows liver to be added into various types of dishes, loaves, spreads and sausages

- Braunschweiger is liver sausage byproduct prepared from 50% liver to which 50% fresh/smoked pig jowls is added along with/or pork trimmings
- Raw liver, desiccated liver and liver extract are rich source of vitamin B_{12} and iron and therefore used as food/feed supplement to treat anaemia
- Liver is particularly rich in vitamin A which is almost nil in meat
- Liver shows low binding quality due to high collagen content and imparts high colour values

Table 3.3 Various uses and cooking methods of different edible byproducts obtained from sheep/goat

Byproducts	Uses
Blood	Blood food preparation, blood sausage, sausage ingredient, black pudding
Blood plasma	Ingredient in sausage
Bone	Gelatin, jellied products, rendered shortening, mechanically deboned tissue
Brain	Cooked by poaching, frying, precooked in water followed by broiling or scrambling
Cheek and head trimmings	Sausage ingredient, stew, processed meat
Oesophagus	Sausage ingredient
Oleo stearin	Used in sweets, in shortening and added in chewing gum
Edible tallow	Used as shortening and as dripping
Feet	Source of jelly
Heart	Cooked by roasting, braising or cooked in liquid; source of sausage ingredient, added in meat loaf, luncheon meat or patty stuff
Large intestine	Sausage casing is prepared
Small intestine	Sausage casing is prepared
Liver	Cooked by grilling, frying, braising and broiling; used as sausage ingredient such as in liver sausage, also used in loaf, patty etc.

[Table Contd.

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Byproducts	Uses
Stomach	Honeycomb tripe is used as container for haggis (the national dish of Scotland)
Kidney	Prepared by frying, braising, stewing, boiling, grilling or cooked in liquid; consumed as soup or ingredient for loaf, patty etc.
Lungs	One of the Ingredient of Haggis and used in pet food
Tongue	Consumed after stewing, boiling, cooked in liquid or jelly is prepared
Spleen	Blood sausage ingredient, pie, variety meat, melt
Sweetbread	Comes under 'variety meat'; cooked in sauce or poached with sauce; cooking also by frying and stewing
Testicles	Consumed by grilling or frying

3.5 HEART

- Heart is good source of high quality protein
- It is tougher than the liver and so, moist cooking for log time is needed
- It gives high colour value to the product to which it is added because of their high myoglobin content
- Heart is average in collagen content and hence, has a low to medium bind value

3.6 TONGUE

- The tongue is quite high in fat content
- It requires long duration moist cooking as it is tougher
- It is available as fresh, pickled (corned), smoked or canned form

3.6.1 Curing of tongue (Canning of tongue)- Immersion Cure Method

- Long duration immersion in brine is used for curing beef tongues
- First, the tongue is chilled for 24 hours and then immersed in an 80° (80% of saturation) brine solution for 24 hours and then finally, keeping it in 80° sweet pickle brine solution
- Thereafter, the tongues are cured at 2 °C for 5 days in this way and then removed. New amount of salt is added to maintain the salinity and further cured for 8 or more days
- This is followed by canning
- The curing results in 0.5-3% shrinkage in the final product

✓ Tongue is also utilized as one of the ingredients in luncheon meat

✓ It possesses poor to average bind character due to high collagen and passes on an average color

3.7 KIDNEYS

- The kidneys are surrounded in cattle by fat called kidney knob (suet fat)
- The cattle kidney is lobulated having 15-25 lobes
- The left portion of the carcass is referred as ‘’raison’’ or “open” side and normally, has less amount of kidney suet fat than the right portion of carcass (termed as “closed” side of carcass)
- Right side kidney is fixed to the abdomen and elliptical in shape
- Pig kidney is reddish brown, bean shaped having single lobe and contained in fat
- Sheep kidney is also bean shaped with single lobe and the colour is deep brown
- It also lies in kidney knob (fat)
- Kidney being high in collagen protein shows low binding character but high in colour value

3.8 SWEETBREADS

Sweetbreads are recovered from young animals like calves, lambs and young cattle. Two separate organs and three separate sites in food animals body are termed as 'sweetbreads':

1. Thymus
2. Pancreas

3.8.1 Thymus

- The thymus consists of two parts
- One part is located in the cervical region beside the trachea and is labelled as "neck bread", "throat sweetbread," or "throat bread"
- Second part is situated in the thorax area and is referred as 'heart sweetbread' or 'heart bread'
- The thymus is rich in fat content and is large during the younger age of the animal
- As the animal ages, it becomes atrophied and fibrosed
- Hence, the thymus is only present in young calves and lambs
- The thymus sweetbreads are tender but have short shelf-life

3.8.2 Pancreas

- Pancreas, termed as 'gut bread' or 'stomach sweetbread', is lobulated and brownish yellow in clour
- They are also rich in collagen resulting in low binding character and color value

3.9 TRIPE

- Rumen is colloquially referred as pounch/ tripe
- Reticulum is called honeycomb

- The omasum (colloquially called 'bible') is tough to clean and perishable. Therefore, it is generally not used for edible purpose and thus rendered

3.9.1 Processing of tripe (Paunch)

- The "raw unscalded" beef tripe is cleaned in flowing tap water for 5 min followed by cleaning in a horizontal rotary machine with constant flushing of hot water (50-70 °C) for 15-20 min. Alternatively, it is cleaned by diluted soda water (limewater) at 50-55 °C for 15-20 min
- The black internal covering is removed by scraping on a conical surface (umbrella type or a vertical rotary washing machine with a revolving floor)
- The reticulum (white honeycomb) is cleaned with soda ash or lime hot water solution or solution prepared from washing soda and the black inner coating is taken out by scraping
- Scalded tripe (80-85 °C for 15-20 min) is also termed as 'Tripe, cooked' and cooked tripe is termed as 'tripe, cooked and bleached' which is additionally bleached and neutralized chemically
- 'Mountain chain beef tripe' is the beef tripe obtained by washing in cold water from mature cattle having muscular pillars on tripe, coinciding with the outer side grooves

3.10 BRAINS

- Richest animal byproducts in term of cholesterol content
- Brains are consider delicacy and are thinly sliced and deep fat fried after dipping the slice in flour batter
- Owing to high collagen quantity, binding property is low and so is the colour imparting ability

3.11 OXTAIL

- Oxtail enhances the meaty flavour and provides texture to soups

3.12 BONE STOCK

- Cooked or uncooked bones can be used to prepare soup stock
- The bone stock is source of nutrients and adds flavour besides being low in cost

3.13 MEAT EXTRACT

- Meat extract is prepared by pressing or cold water soaking or hot water cooking
- Hot water cooking is the most popular method
- Obtained juice is further concentrated to recover the final extract

3.14 DIAPHRAGM, OESOPHAGUS AND MEAT TRIMMINGS

- The 'beef outside skirt' is the term applied together to free thin portion (wing) of the diaphragm and the pleura (tendon like tissue) attached to it
- The 'beef outside skirt' is rich in fat
- It is ground and then mixed with comminuted meat products leading to average collagen content having poor to average binding property and pigment color
- The beef "hanging tender" is the thick part (pillar) of the diaphragm located beside the spinal cord
- The "hanging tender" has a fairly high collagen and adequate binding and color values for sausage preparation
- The inner smooth muscular lining of oesophagus is called "beef weasand" (gullet) and extends from the larynx to the rumen (paunch)
- The weasand has a high collagen content, fair binding and color imparting ability
- The head trimmings are normally high in collagen and hence, poor to average in binding property and color imparting ability but are high in fat

- Pork snouts are rich in collagen content resulting in poor binding characteristics and provide low to average color in the added meat products

3.15 PIG TAIL

- Pig tails are high in fat content
- Brine cured mildly for 2 days or used as a jelly stock for brawn (brawn or headcheese- a jellied loaf or sausage)

3.16 PIG FEET

- 'Pig' feet' or 'trotters' are scalded and then skin, toenails and the hairs between the toes are removed

3.17 JELLIED PRODUCTS

- Gelatin, head trimmings and pig skin which are rich source of collagen are used to prepare jellied products like headcheese (brawn), souse, and scrapple
- Normally, pork cheeks, ears, tongues, hearts and snouts are cured for one week and are utilised for making headcheese (a jellied loaf or sausage)
- Gelatin from pork skin is also employed as the binding additive

3.18 HAGGIS

- Haggis is pudding prepared from ground sheep pluck (heart, liver and lungs), onion, oatmeal, animal fat, spices and salt. All are minced, mixed together, stuffed in animal stomach and cooked
- Seasoning is used in large quantity and then whole content is stuffed in sheep stomach and cooked

3.19 INTESTINES

- Chitlings are pig large intestines and stomach that are often cooked with sauce
- The intestines and different parts of the gastro-intestinal tract of various food animals are utilized for sausage casings preparation

3.20 TESTICLES

- Lamb testicles and calf fries or testicles are colloquially called mountain oysters
- Delicacy is prepared by thinly slicing, dipping in batter or flour and frying in deep fat

3.21 PORK SKINS

- Being rich in collagen, it is used in jellied products
- Used for gelatin production and popped snack item
- Popped pig rinds (bacon skins, "skeens") are puffed snack food manufactured from pig skin by expanding it to much larger volume than the original

3.22 BLOOD

- The first byproduct obtained after slaughter is blood
- It is source of about 60% available protein that can be obtained by slaughter byproducts
- 10-12 litres of blood can be obtained from beef animal having 400-500 mg of iron/ ml
- 1.5 litres of blood can be collected from one sheep
- Normally, healthy animals produce blood free from microbes but it may be infected at the time of bleeding/collection
- To prevent this contamination, a hollow knife attached to a collection tube is used which is kept inserted into the veins while bleeding for collecting the blood more hygienically

- Not more than 0.5 to 2% of sausage weight, blood can be added. At this level, it improves the colour of the product
- Beyond this level, sensory characteristics especially colour and flavour goes down

3.23 SPLEEN

- The spleen is essentially a lymphatic organ
- Used in different blood sausages or blood preparations
- Spleen may used as flavouring agent or fried and used in pie or melt
- Spleen imparts strong dark colouration and its high collagen content leads to poor quality

3.24 POULTRY GIBLETS

- Giblet refers to heart, liver and gizzard collectively
- The giblets are normally wrapped in parchment paper or kept in parchment bags or film and put inside the poultry carcass body cavity
- It is convenient to keep the giblets in warm dressed poultry carcass but if tumbling action is used to chill the carcass, giblets are kept in the cold carcass resulting in long shelf-life of the giblets

CHAPTER - 4

PHARMACEUTICAL USES OF ANIMAL BYPRODUCTS

4.1 GLANDS

Glands are about 0.28% of the live weight of animal. Digestive enzymes are obtained from the red portion of the stomach lining around the pylorus (pepsin), from the fourth stomach of the calf (rennin) and from the pancreas (diastase (amylase), lipase and trypsin).

These hormones and enzymes, along with vitamins, food supplements, and other biological chemicals are often collected and derived from animal byproducts.

4.2 COLLECTION AND HANDLING OF ANIMAL GLANDS

i. Glands should be rapidly cut separated from the slaughtered animal to reduce the exposure to high environmental temperature

ii. Glass or metal buckets with perforation for drainage should be used for small glands

iii. Ice or dry ice may be kept in buckets for rapid chilling of glands (chiefly for pituitary and suprarenal glands)

iv. Care taken not to bring glands into direct contact of the ice because some hormones may be lost for being water soluble

v. Large glands can be harvested swiftly and placed inside the chiller.

vi. Individual parts of some glands like pituitary, ovary and corpus luteum must be separated and then stored

vii. The best method of preserving most glands is by quick freezing

viii. For chemical preservation of some glands, 1 part gland to 1 part acetone or 1 part phenol or 2 parts 37% formalin is used

ix. The next step- cleaning and trimming of surrounding fat and connective tissue

x. Within an hour, the glands should be placed on a clean, pre-chilled tray or on waxed paper without touching each other for sharp freezing at -18 °C (0 °F) or less; never above -9 °C

xi. Later, frozen glands should be kept in lid containers to reduce the air contact and avoid freezer burn

xii. Glands should never be allowed to thaw under any condition which may lead to destruction of some of the active principle present in glands

xiii. Drying, vacuum drying and freeze drying (for extremely heat sensitive glands) are used for further processing

4.3 ARTERIES

- Bovine carotid arteries is treated with enzyme-ficin and subsequently tanned which makes the collagen stronger and more nonreactive
- It is then sterilized for implantation into humans as a femoro-popliteal or ilio-femoral substitute

4.4 ADRENAL (SUPRARENAL CAPSULES) GLAND

- The "cocked hat" shaped adrenal (also termed suprarenal) gland (two per animal) secretes steroids
- The glands are located above and touching the kidney and are made of two portions, called outer cortex and inner medulla
- Corticosteroids are secreted from the adrenal cortex and the adrenal medulla secretes epinephrine (adrenaline) and norepinephrine (noradrenalin) hormones

4.5 BEZOARS

Bezoars are accumulation of foreign substances (lumps) occasionally present in the animal stomach or intestines. It is categorised into:

1. **Phytobezoars**
   - Aggregation of vegetable substances and calcium and phosphorus salts
   - Encountered in the intestines of gazelles, llamas, vicunas, horses, goats and some other ruminants
   - Considered as antidote for poisons
2. **Pilobezoars**
   - Composed of hair and some other keratinous matter
   - Generally, lodged in rumen and other portions of the gastro-intestinal tract
   - No commercial value

Table 4.1 Classification of bezoars

Type	Animal	Description
Bezoar	Goat	In stomach or intestine
Oriental bezoars	Gazelle	Sometimes contain elagic and/or lithofellic (benzoaric) acid
Occidental bezoars	Llama, Vicuna	Calcium, phosphate
German bezoars	Chamois	Made up of vegetable and animal fibres

Source: Divakaran, 1973

4.6 BILE

- Bile is a intricate mixture consisting of bile pigments, fatty acids, phospholipids, conjugated bile acids, proteins, cholesterol and other insignificant components
- About 70% of the bile solids obtained from ruminants are cholic and deoxycholic acid- involved in the corticosteroids synthesis

Uses of bile

- Prednisone, prednisolone and progesterone are made from bile acids
- Liver secretion is enhanced by bile extract
- Cortisone having similar anti-inflammatory properties of ACTH is prepared from pig bile
- Chenodeoxycholic acid derived from pig bile has the ability to dissolve cholesterol gallstones

4.7 BLOOD

- Blood proteins contributes to nearly 10% of the total protein available in an animal
- Primarily, albumin from blood is utilised in animal feeds and sausage products and as a sticking agent in insecticides industry
- 63% of blood is liquid plasma of which about 4% is globulin plus fibrinogen and 3.5% is albumin

Blood collection

- Just after slaughter, a clean container measuring 20 inch in diameter and 6 inch in depth is placed near the opening to collect the blood
- Alternatively a cannula is fixed at the cut opening and blood is collected through a duct supplied with anticoagulant
- 3% salt is added and stored in a cool

Uses of blood and its components

- As blood meal
- Amino acids are derived from pork blood fibrin
- Blood clots found in heart attack patients are digested by hog blood plasmin (enzyme)
- Thrombin (enzyme) recovered from cattle blood encourages blood coagulation
- Thrombin is applied to hold skin grafts in proper position and act as “cement” for filling the gaps arisen out of surgery

Table 4.2. Composition of spray dried red blood cells

Composition	Value in %
Protein	93
Fat	1.2
Moisture	4.5
Ash	2.3
pH	7.7
Total plate count	Less than 10,000
Salmonella	Negative
Spray dried powdered plasma obtained from whole blood of cattle	
Protein	75

4.8 BONE CARTILAGE

- Specifically processed xiphoid cartilage derived from breast bone of immature cattle is used as substitute of facial bone by plastic surgeons
- ✓ Bone meal is composed of nearly 32.5% and 15.1% calcium and phosphorus, respectively.

4.9 BRAIN

- Brains of all food animals are a rich source of cholesterol (15% of the dry weight of the brain)
- Cholesterol — steroid pharmaceuticals are prepared from it
  — utilized as an emulsifying agent in beauty products.
- Thromboplastin, a blood coagulant used in surgery, is extracted from brain
- Cephalin is another product obtained from brain assisting in blood clotting

4.10 DUODENUM

- Pig duodenum is the source for getting enterogastrone (hormone) — regulates the gastric secretions of the stomach
- Secretin is also obtained from the duodenum that stimulates the pancreas to release pancreatic juice.
- An intrinsic factor is also isolated which aids in the absorption of vitamin B_{12}

4.11 EGGSHELL POWDER

- Eggshell powder is added to poultry feed since it contains 94% calcium carbonate

4.12 FEATHER

- Feather fats contain cholesterol

4.13 GALLBLADDER

The bile (gall) from gallbladder of different species is used to produce different products like

- cholic acid - from bile of sheep and ox
- desoxycholic acid - from bile of sheep and ox
- chenodeoxycholic acid - is recovered from bile of pig
- dehydrocholic acid - used as a choleretic agent (increases bile secretion)
- cortisone - anti-inflammatory property

✓ Chenodeoxycholic acid discourages the production of cholesterol and is used to break gallstones

4.14 HAIR

Cholesterol is obtained from wool fats

4.15 HEART

- Heart valves from pigs are treated and transformed into biological plastic before it is used to surgically replace the faulty valve in the human heart

4.16 HORNS

- Keratin from horns is used as a hair care product

4.17 HYPOTHALMUS

- Oxytocin is obtained from this gland and is used to stimulate milk secretion

4.18 INTESTINES

- Heparin is sourced from inner mucosal layer of the small intestine and lungs of pig and cattle
- Catgut is manufactured from the intestines of sheep, calves and other food animals
- Violin string is manufactured similarly as catgut

4.19 LIVER

- Source of vitamin B_{12} (cyanocobalamin)
- Heparin is obtained from the liver, lungs and intestines
- Catalase enzyme from liver of pig is
  - o used in food industry to eliminate the hydrogen peroxide
- Liver meal is prepared out of ground liver by drying—contains riboflavin

4.20 LUNGS

- Source of heparin
- Contain aprotinin— trypsin inhibitor

4.21 NERVOUS SYSTEM

- Cholesterol is steroidal alcohol which is nearly 15% of dry weight of nervous tissue and is obtained from the spinal cord

  Cholesterol

  - o Building block for male sex hormones
  - o Precursor of bile acids and aids in the steroidal hormones synthesis.
  - o Chief component in the vitamin D synthesis

✓ Pure cholesterol is approximately 3% of the spinal cord's tissue weight.

4.22 OVARIES

- Pig ovaries are extracted for the progesterone and estrogens
- Relaxin, a hormone which aids during child birth is recovered from ovaries (corpora lutea) of pregnant sow

4.23 OYSTER SHELL

- Source of calcium and hence, used as dietary supplement

4.24 PANCREAS

- Also known as sweetbread
- It has two sections.
- The internal section secretes insulin- regulates sugar metabolism
- The external section secretes amylase (starch), lipase (fat), trypsin (protein).
- Insulin hormone is a double chain protein consisting of
  - o A chain- having 21 amino acids
  - o B chain- having 30 amino acids
  - o is produced by specific β-cells found in the pancreas known as Islets of Langerhans.

- Glucagon is recovered from the α-cells of the pancreas—elevates blood sugar

Handling of pancreas

- Pancreatic glands are kept in tray as single layer without touching each other and quickly frozen
- It is stored in frozen condition prior to extraction
- Insulin extraction-
  - o Frozen glands are ground in acetone and alcohol while it is hard
  - o This procedure prevents proteolytic destruction

4.25 PARATHYROIDS

- Four in number
- Glands are situated adjacent to the base of the tongue
- Their secretions control
  - o blood calcium level
  - o tone of the nervous system

4.26 PINEAL

- Located in the brain cavity
- Generally harvested from beef and calf
- Melatonin is obtained- regulate child growth, puberty, maturity and color of skin

4.27 PITUITARY

- Master gland of the body
- Gland is situated at the base of the brain
- Composed of an anterior and a posterior lobe showing different roles

Handling and processing of pituitary

- The pituitary is harvested, quickly frozen and kept at -30 °C till it is processed
- The entire pituitary is used after drying, defatting and powdering it

The large anterior lobe produces:

1. Growth promoting hormone (GH)
2. Thyroid stimulating (thyrotropic) hormone (TSH)
3. Prolactin or mammary stimulating (lactogenic) hormone
4. Gonad stimulating (gonadotrophic) hormone (function of ovaries and testicles)
5. Adrenal cortex stimulating hormone (ACTH)

The smaller posterior lobe (more valuable) secretes:

1. Pituitrin hormone
2. Vasopressin (ADH- anti diuretic hormone)
3. Prolactin hormone
4. Oxytocin hormone

4.28 SEMINAL VESICLES

- Situated on the urinary bladder of male animals
- Prostaglandins are recovered
- Uses of prostaglandins:
  - o Used to induce parturition and abortion
  - o Used for the treatment of bronchial asthma and gastric ulcers
  - o Synchronization of estrous
  - o Treating thrombosis and high blood pressure

4.29 SERUM

Fetal bovine serum- used in cell culture

4.30 SKIN

- Pig skin is edible and gelatin is derived from it
- Skin is mostly collagen protein which is almost 33% of the total organic matter present in animal body

4.31 SPINAL CORD

- Source of cholesterol

4.32 STOMACH

- Many protein and enzymes related to digestion and acting as antacid are obtained from the outer layer of pig stomach
- The pig stomach thin outer layer is source of pepsin enzyme

Following steps are involved in recovering pepsin enzymes from animal stomach:

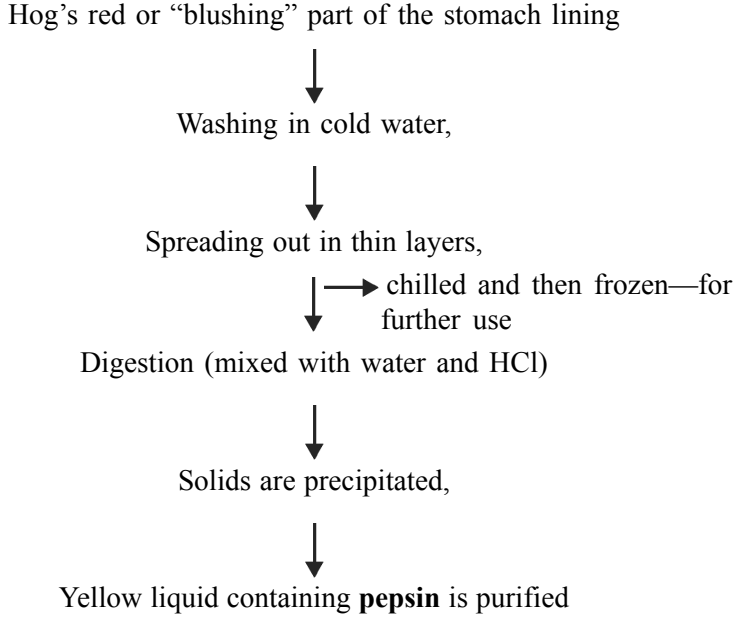


Fig.4.1. Flow chart for production of pepsin

4.32.1 Protein and enzymes obtained from stomach:

i. Rennin

- Rennet is raw substance having rennin enzyme (chymosin- milk curdling enzyme) obtained a milk-fed calf
- Obtained from calf fourth stomach called abomasums

ii. Intrinsic factor

- Stomach has the thin pyloric covering from which "intrinsic factor" (glycoprotein) is derived- responsible for absorption of vitamin B_{12}

iii. Gastrin

- The stomach produces gastrin which induces gastric juices production

iv. Secretin

- The stomach also releases secretin responsible for inducing the action of the pancreas leading to production of pancreatic juice

v. Cholecystokinin (CCK)

- The stomach and upper intestine produce cholecystokinin which promotes the emptying of the gall bladder

4.33 TESTES

- The enzyme hyaluronidase is extracted from the testes which hydrolyses the mucopolysaccharides and thereby, enhancing the rate of absorption, dispersion and distribution of drugs
- Obtained from bull testes

4.34 THYROID

- Consists of two lobes found on the both sides of the trachea and near to the larynx
- It releases thyroxin enzyme containing iodine as active element which is used to treat hypothyroidism

- Lack of sufficient thyroxin causes Cretinism in infants and Myxoedema in adults
- Calcitonin is also released by the thyroid which reduces the calcium and phosphate level in the blood

4.35 TRACHEA

- The trachea is used as a source of collagen

4.36 WOOL

- Wool grease contains 15% cholesterol

CHAPTER - 5

CASINGS AND ITS PREPARATION

5.1 INTRODUCTION

Casing has been used as the container for sausages since prehistoric time. Preparation of natural casing from the animal intestine by butchering of animals is most common practice. The sub-mucus layer of intestine made up of collagen is the most suitable for casing preparation. However, the use of artificial casings is gradually replacing the age old natural one at the present scenario. The application of modern technologies has allowed for the industrial production of casings by use of different polymer viz., cellulose, viscose, collagen, nylon, polyolefin, etc.

For sausage preparation, the ground and comminuted meat mixed with all other essential formulation based ingredients need to be stuffed in casing. The meat stuffed casings are cooked or fermented as per requirements. There are basically three types of casings:

i. Natural casings
ii. Reconstituted collagen casings
iii. Artificial casings made from cellulose

5.2 FACTORS INFLUENCING CASING QUALITY

1. **Cleanliness:** it should be clean, devoid from stains, odour, parasites, nodules, ulcers, pinholes and other defects.
2. **Strength:** it should be strong enough to withstand meat filling & stuffing pressure and other processing.

3. **Length:** it should be of standard length. Casing from sheep and hog: 91.4 m/ hank. For beef casings: 18 m. For catgut, tennis rackets & musical strings: 6 m.

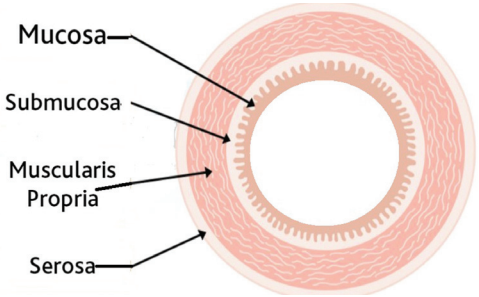


Fig. 5.1. Cross-sectional view of intestine

4. **Thickness:** uniformity should be there. For sheep: 14 mm, Hog: 35 mm, Beef rounds: 35 mm.
5. **Curing/salting:** it should be salted and cleaned. For this purpose good quality fine salt should be used.
6. **Packaging:** wooden/plastic containers, tins and plastic bags are suitable

Table 5.1 Glossary of animal casing

Terms used	Explanation
Algien process	Process of sausage preparation by using collagen casing
Animal casings	Sausage container made up by using sub-mucous layer animal intestine of food animals.
Beef bung	Casing made by using blind gut or caecum
Black gut	Casing made by using a part of the hog's large intestine
Bladder	Casing made by using urinary bladder of cattle or pigs
Bundle	Beef casings set, length 18 m
Bung	Large Intestinal part extends up to the anal opening or crown
Bung cap	Casing made from blind end cut at the nipple hole
Bung end	Casing made by using end part of small intestine which is connected to the large intestine
Bung skin	Outermost layer of blind gut cap
Cap	Salted and dried casing made from sheep or hog caecum
Caliber	diameter in mm of a casing when filled with water or air

[Table Contd.

Contd. Table]

Terms used	Explanation
Casing	Cleaned and salted or dried envelopes made from intestine of beef, goats, hogs, horse, and sheep and the bladders and weasands from beef
Cellulose casing	Casing made from cotton
Chitterling or black gut	Same as *Black gut*
Curing	Salting of casing to prevent microbial growth
Dry pack	Overnight draining of casing before packing
Dry ready to wet casing	Chemically processed casing
Fresh casing	Un-salted clean casing
Goat casing	Casing from goats' small intestine
Hank	Sheep/goat/hog casings set of 91.4 m length
Hog bung	Casing made from the rectum and the anal ring of the hog's large intestine
Holes	Opening of 3 mm or more in diameter in casing
Large intestine	Intestinal part between the small intestine and the bung
Maws	See stomach
Middle cap	Casing from hog caecum
Middles	Casing from cattle/pig large intestine
Patches of peyer	is where nodes were removed from the casing causing light spots
Prepared ready to use casing	Casing packed in a container with a special liquid
Pretubed casing	Casing set wrapped over spool
Pulling	Separation of mesentery and fat manually from intestine of sheep, goat, or pig intestine
Reconstituted collagen casing	Reconstituted casing prepared from collagen from cattle hides
Red dog	Casing spoiled by halophylic (salt tolerant) bacteria that produces apigment that turns salt red
Rounds	Casing made by using small intestine of cattle or from sheep, goats, or hogs
Runners	Casing made by using small intestine of cattle

[Table Contd.

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Terms used	Explanation
Running	Cutting and separation of mesentery and fat from cattle intestine
Set	Single casing cleaned but unsalted/selected small or large intestine
Sheep casing	Casing made by using small intestine of sheep
Slime	Inner mucous layer of intestine
Sliming	Removal of intestinal mucous layer
Slush pack	Putting casing in brine
Slush salting	Casing is packed in a container without draining the superficial brine
Small casing	Casing from hogs' small intestine
Splits	Damage of casings by cleaning machines
Stomach or *maws*	Casing made by using hog stomach
Stripping	Removal of intestinal contents
Stump casing	Casing of 1.83 m or less length
Veiny	Caused by blood vessels and surrounding fat
Weasand	Casing made from cattle oesophagus (No. 1: > 24 inches, No. 2: 18-24 inches, sausage weasand: <18 inches)
Whisker	When blood vessel is attached to the casing after pulling
Windows	Casing damaged by over-crushing.
Worm holes	Refer Patches of Peyer

5.3 BASIC EQUIPMENTS USED FOR CASING PREPARATION

- *Crusher:* used to break the inner mucous layer of intestine and to separate it
- *Soak tank:* used to soak the intestine in water at 41-42 °C
- *Mucous stripper:* used to strip the intestine to remove all cellular debris from inside
- *Finisher:* used to remove all strings (whiskers) remaining on the casing and the remaining mucosa

5.4 PROCESSING OF CASINGS

- The finished casings are soaked in cold water or brine at 10-16 °C/ ice water for easy removal of adhered blood
- Further casings are salted with common salt (NaCl) by using hand or machine
- Finally casing is slush packed by adding 10-15% salt water brine
- Salt concentration of brine for slush or wet salting should be 20 ± 2° Baumé and dry salting standards should result in visible salt crystals being seen on the casing
- Temperature standards for fresh or slightly salted casings should not exceed 7 °C

Mucosa

- The inner slimy layer of intestine. During processing of casing this layer is soaked, crushed, striped and squeezed out
- Heparin can be extracted from this layer

5.5 COLLAGEN CASING

- This casing may be either edible (small size) or inedible (large casings) variety
- Connection between natural and artificial casings. Used to prepare fresh, smoked, dried, and processed sausages
- Collagen from corium layer of beef hides are extruded into the casing format
- Sausages in this casing should be cooked at 40-45% RH to prevent splitting and hydrolyzing of this casing if cooked at lower RH
- If cooked at lower than this RH, results in splitting of sausage casing.
- If cooked at higher than this RH, casing will hydrolyze.
- The small casings used for fresh pork sausage are edible
- As the large collagen casings are treated with aldehyde to increase the strength, they should be removed before eating

CHAPTER - 6

BLOOD AND ITS INDUSTRIAL APPLICATIONS

6.1 INTRODUCTION

Animal body contains around 6-7% of its live weight as blood. During bleeding, around 50% blood is collected, remaining retained in capillary system. During bleeding, average blood obtained from cattle is 10-12 L, from pig 2.5 L, from sheep 1.5 L, from chicken 0.2 L/ 2 kg live weight from chicken. Blood remains sterile in healthy animal body but when comes out of vessels, contamination starts. Improperly bled animal carcass discolours quickly and the keeping quality reduces. Animal blood obtained in sterile condition during slaughtering of animals can be used in human food as protein supplement. It can provide appropriate texture to the meat protein in processed meat products. Blood can be used as a clarifying agent for liquid foods like wine, as stabilizer for cheese, as emulsifier for butter and as colouring agent for poultry meat products.

Waste animal blood is a slaughterhouse byproduct that has potential for both animal feed and human food due to its high protein content. In our country, majority of the blood is used for animal feed production. The remaining blood is disposed of by municipal sewers and landfills, causing environmental issues because of its high organic matter and microbial loads. Release of whole blood into sewage system results in 3-times increase in suspended solids and 10-times increase in biochemical oxygen demand of the sewage water. The waste blood contains a high

concentration of high-quality protein, but because of the aesthetic concerns of the consumers, its use for animal feed and human consumption is limited. Before application into animal and human food, blood is made discolored by applying various techniques such as treatments with acid-acetone, hydrogen peroxide, carboxymethyl-cellulose and enzymatic hydrolysis. Blood intended for food or industrial purposes should not clot and clotting is avoided by defibrination and is done by stirring the blood using a wooden ladle or wire whip. The fibers start setting on the ladle or whip in the form of red color thread. Fibrin is water-insoluble and is used as food for poultry and human- the source of peptone and lecithin. Defibrination leads to dark-colored serum due to the destruction of red cells during churning. So, it is not desirable.

6.2 STORAGE OF BLOOD BY USING ANTICOAGULANT

Anti-coagulants such as sodium citrate or sodium or potassium oxalate are added at the level of 0.2% to freshly collected blood to prevent clotting. Later, blood is centrifuged to collect serum. The defibrinated serum is dried and is referred to as blood albumen. Drying must be done below 130 ºF (55 ºC) to prevent clotting during drying.

6.3 FEATURES OF BLOOD AND DERIVED PRODUCTS

- Blood contains 6-7% useable animal protein
- Albumin of blood can be used as substitute for egg albumin in confectionary foods and for sausage casing preparation
- Blood meal prepared by cooking the blood, removing the water and drying to a granular product are used for animal feed preparation as protein supplement
- Blood is rich in amino acid lysine and deficient in tryptophan and isoleucine
- Spray dried blood meal contains 10-12% lysine and vat dried blood meal 6-8% lysine

- Blood can be used in different industry like adhesive, paper, lithograph, plywood, veneering, fibre, plastics, fertilizer, insecticide, fungicide and glue
- Used in foam fire extinguishers, ceramic products and in leather finishers
- Blood sausage, pudding, soup, bread or crackers can be prepared from blood
- Indiscriminate discharge of blood into drainage water may cause 10 times increase in biochemical oxygen consumption (BOD) and 3 times increase in suspended solids

6.4 BLOOD COLLECTION PROCESS AND YIELD

- Blood should be collected in a blood-collecting pan of 20" diameter and 6" depth with two handles at the sides
- Blood-collecting tank may be used in hoist or bleeding rail system
- Sticking is done by cutting the carotid artery and jugular vein in the neck region after proper cleaning and sterilizing the hide/skin of that area
- After sticking, the hollow knife is inserted into the neck opening
- A specially designed hollow knife attached with hose helps to collect blood into sterile container
- To prevent coagulation of blood anticoagulants viz., heparin, sodium or potassium oxalate, ethylene diamine tetraacetic acid (EDTA) can be used
- Anti-coagulants are added to the knifepoint and in the container
- Before human consumption blood need to pass inspection
- The yield of blood from an animal is about 1/11 to 1/14 of the live body weight

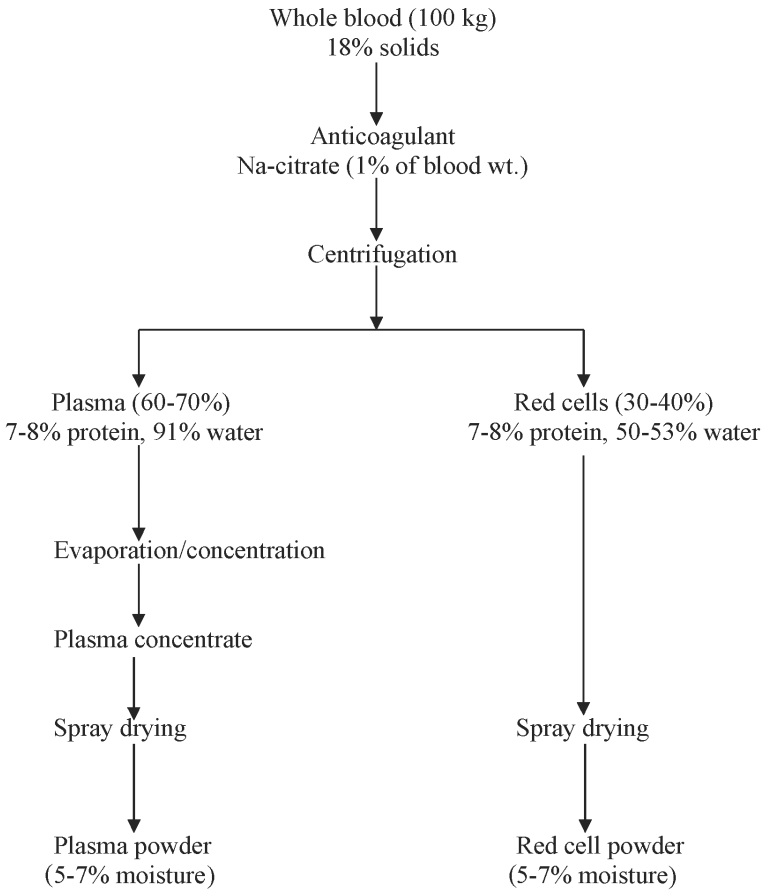


Fig.6.1. Separation of blood into dried fractions (Ockerman and Hansen, 1988).

The dried blood plasma can be produced (96.4% protein and 2.5% moisture) by using ultrafiltration and spray drying process

6.5 BLEEDING TIME & STORAGE OF BLOOD

- For cattle & pig: 6 minutes, sheep: 4-5minutes and calves: 3-4minutes
- The whole blood is stored at 2 °C for 4 days and at 0-2 °C for of 4-6 days

Table 6.1 Blood composition

	Whole blood (%)	Plasma (%)
Dry solid	18-20	8-9
Protein	13-15	6-8
Salt	5	1.5
Moisture	80-82	90-91

6.6 UTILIZATION OF PLASMA

- Blood plasma from gel if heated, on further heating for 15-20 minutes by boiling it turns into solid
- Plasma proteins viz., albumin and globulins are used as emulsifier
- Plasma decreases shrinkage and increases yield of sausages and improve the texture if used at more than 2% level
- Due to its foaming and leavening properties, this is used as egg substitute in bread formulation at 2-6%
- Textured plasma protein can be used as meat analogue

6.7 UTILIZATION OF HAEMOGLOBIN (HB)

- Erythrocyte fraction contains 60-70% of the protein in the haemoglobin
- If Hb is added in food at more than 1 % level, it produce undesirable dark red color
- Hb acts as catalyst for oxidation of unsaturated fatty acids
- Because of its color, Hb is confined to products which are darker in color such as black sausage, black pudding, blood breads, and blood cookies
- To reduce the dark color of Hb, bleaching can be done with 3% H_2O_2
- By adjusting pH to 2, the heme fraction can be removed and precipitation of globin fraction is possible and heme remains in solution

- Alkalase enzyme is also used to remove heme from Hb
- The globin fraction of plasma does not form a gel on heating

6.8 BLOOD ALBUMIN

- Used as dried egg albumin substitute in processed food
- Used to gloss leather, coat on lithographs, as adhesive, colouring textile, as feed stabilizer
- Dried albumin composition: protein 80%, moisture 5% and salt 15%

6.9 ALBUMIN COLLECTION

- Blood collection is done without adding lime. The clotted blood is cooled to 10 °C
- Collected in perforated trays, then cut into cubes and the serum is allowed to drain
- Phenol is added into it at 0.5% (v/w) as a preservative
- 10-20% weight of the whole blood is serum
- Drying of plasma by spray/vacuum/drum drying at <60 °C to prevent denaturation
- Further vacuum drying is conducted at 50-55 °C & 25 mm pressure
- Yield: 20% of the weight of blood plasma or 1-2% weight of whole blood

6.10 RED BLOOD CELL PASTE

- By centrifuging blood plasma is removed and the sediment of blood cells are washed several times with 1% NaCl to remove plasma. The paste is then vacuum evaporated at 25-30 °C
- Yield is 25-30% of whole blood
- Hemin or amino acids are prepared from this paste

6.11 SPRAY DRIED BLOOD/DARK BLOOD ALBUMIN/ BLOOD POWDER

- It is a water soluble dark reddish brown powder prepared from anticoagulant added blood. Contains 5-8% moisture and 10-15% ash
- Defibrinated blood product
- For spray drying, process is conducted at 200-250 °C. Outlet temperature is maintained 70 °C or less
- Use: adhesives, clarification of liquids, stabilizers in food etc.

6.12 PROCESSING OF RAW BLOOD TO BLOOD MEAL AT PILOT SCALE

6.12.1 Lime treatment

- Blood can be preserved for up to one week by adding unslaked lime at 1% level
- Lime-treated blood can be sun-dried as the blood does not stick to the drying pan or decompose or attract flies
- The addition of lime does not decrease the blood value. Contrarily, its value is increased as the calcium source

6.12.2 Blood meal

- Dry (5-8% moisture), granular, dark brown colored product derived by drying whole blood
- Yield: 20%
- During processing lime is added (at 0.5-1.5%) to increase shelf life and to decrease the odour
- Blood meal is prepared by cooking blood in a double jacketed boiler by injecting steam with continuous stirring to prevent clumping or it can be cooked in open vat over flame with stirring. The obtained dark brown product is pressed to remove moisture. Then sundried or

baked at 60 °C for drying. Dried product is then grounded and used as feed (80% protein) or fertilizer (12% nitrogen and 0.22% phosphorus)

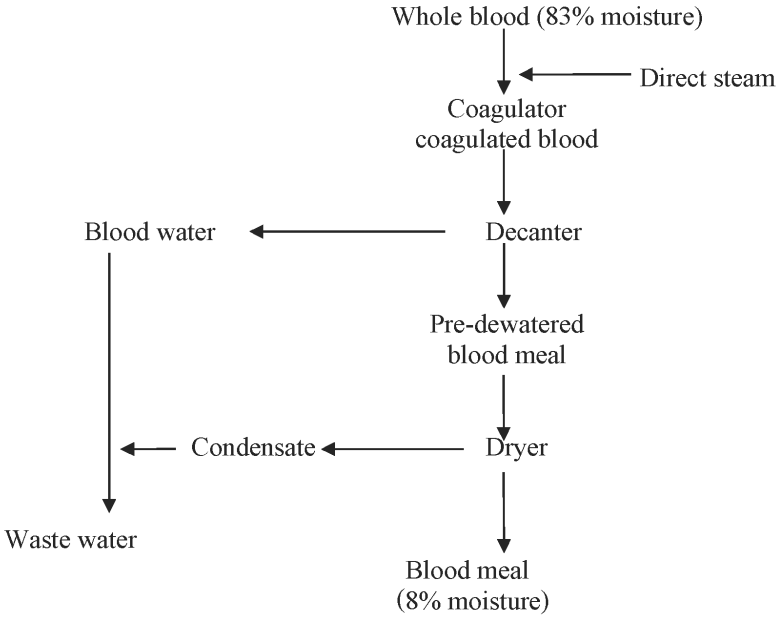


Fig. 6.2. Blood meal production using mechanical pre-dewatering

6.13 PROCESSING OF RAW BLOOD TO BLOOD MEAL AT A LARGE SCALE

6.13.1 Spray-drying

The spray drying of blood is done similarly to spray milk drying and yields a very fine water-soluble powder of light color. Defibrinated blood is blown through a fine nozzle into a heated chamber and blood falls as powder.

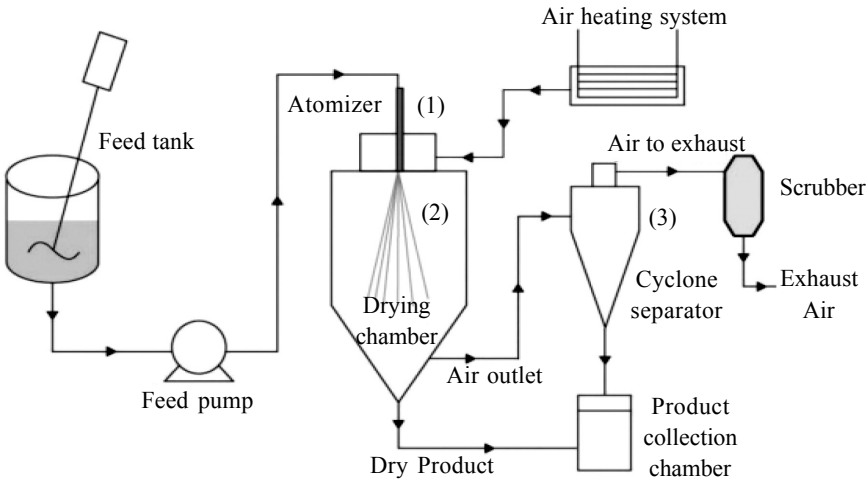


Fig.6.3. Schematic representation of spray-drying mechanism.
(1) Atomization (2) Droplet-to-particle conversion (3) Particle collection

6.13.2 Batch-drying

A batch dryer is similar to that used in dry-rendering of animal byproducts. To coagulate blood, steaming at 212 ºF (100 ºC) for 20-25 min is needed.

6.14 QUALITY TEST FOR A BLOOD MEAL

- Moisture and ammonia (protein) content are the two indicators determining blood meal quality.
- The moisture should be 10-12% and the protein content should be 75-85%.

6.15 PRESERVATION

To preserve blood meal, 1% urea, 0.5% ammonia or most effectively, 1% metabisulphite is used.

Table 6.2 Blood meal composition

Composition	Value (%)
Moisture	8-12
Protein	75-83
Lysine	6.3
Fat	1.2-1.6
Crude fibre	0.8
Ash	3.8-5.6
Calcium	0.3-0.4

Table 6.3 Comparison of blood meal dried in a ring or vat dryer

Components	Vat	Ring
Protein (%)	82.1	89.6
Lysine (%)	7.0	8.5
Available lysine		
Chemically (% of total)	80.4	86.5
Biologically (% of total)	49.0	83.0

6.16 PICKLED OR ACIDIFIED BLOOD

- Acidification or pickling of blood is done with 3% sulphuric acid for preservation
- Used in animal feed
- Sun dried to produce blood meal with high lysine

6.17 CO-PROCESSING OF BLOOD AND PAUNCH-MANURE

- Paunch manure and blood is processed together
- The product is rich in proteins (40%), vitamins, some minerals and fibres

6.18 BLOOD CHAR/ BLOOD CHARCOAL

- It is the carbonized whole blood (80% carbon)
- Add activating agent viz., zinc chloride, potassium sulphide, magnesium chloride, calcium chloride etc. to 20% whole blood or 50% blood meal. Then heat this mixture to 650-750 °C in an airtight oven for 6-8 hours
- Use: absorption of gases, decolorant, antidote for poisoning

6.19 BLOOD FOAM COMPOUNDS

- Foam compounds are used in fire fighting
- Use: fire extinguisher in fires gasoline, oils, paints, fats, naphtha etc.

6.20 NUTRIENTS IN BLOOD

- Contains most of the amino acids (deficient in isoleucine and low in methionine)
- Rich in biologically active and available heme iron
- Protein efficiency ratio (PER) for plasma is 2.8 and for globin is 1.0 (based on a casein value of 2.5)
- Hemoglobin content: 150 mg/g (15%) of blood

CHAPTER - 7

HIDE, SKIN AND LEATHER PROCESSING

7.1 INTRODUCTION

Hides and skins could be obtained from livestock, fish, birds and reptiles as well as from wild and domesticated animals. The most important sources are cattle, sheep, and goats. Hide obtained from cattle and skins from goats and sheep are important economic products contributing to the largest share of the total agricultural export commodities. The availability of hides and skins through slaughtering is of particular importance to the leather industry. Hides from bull are inferior in quality whereas ox produces best raw material for hide. Goat skin is considered as the first skin tanned by human race. Leathers of superior quality are made from goat skins.

- In recent years, the world has seen sharp fall in hide and skin price. Earlier animal hide/skin used to be one of the most expensive (59% of total byproducts value) byproducts obtained from animal slaughter
- Animal hide/skin constitutes about 4-11% of the live animal weight (Table 7.1)
- Hide is from the large animal and skin is from sheep, goat and other small animals

Table 7.1 Hide/skin as percentage of live weight of various animals

Animals	Hide/skin yield (% of live weight)
Cattle	7
Sheep and lamb	11.0-11.7
Pig	3.0-8.0
Boar	10.0-12.0

Besides being used for leather, other parts of the skin such as subcutaneous fat adhering to skin, wool, hair, fat and trimmings are utilized in a food, cosmetics and medical prosthetics. Five pig skins nearly equals to one bovine skin in surface area.

7.2 CLASSIFICATION OF HIDES/SKINS

Hides are classified according to weight, level of animal fatness, sex of the animal, branding and the location of the brand, defects in the hide and the skill of the person involved in removing the hide. Hides are graded according to the following:

- **No. 1 hides/skin**
  - ✓ A sufficiently cured hide that is free from holes, cuts, deep scores or gouges, visible grain defects, and broken grain (over 25 mm (1 in long) and that has substantially the correct pattern.
- **No. 2 hides/skins**
  - ✓ A hide that is off pattern, or contains a hole, cut, deep score or gouge less than 152 mm (6 in), or visible grain defects or warts less than 1 ft^2.
- **No. 3 hides/skins**
  - ✓ A hide that contains hair slips, five or more holes, cuts, deep scores or gouges, any holes or cuts 152 mm (6 in) or longer, insufficient cure, warts or any defect covering 1 ft^2 or more of the hide.

Table 7.2 Various terminologies associated with hide/skin

Various terminologies	Explanation
Skin	Refers to small hides; in cattle this specifically shows hide of less than 13.62 kg (30 lb) after curing.
	Body covering of calves, sheep, goats and pigs is called skin.
Slunk	Skin of unborn calf
Native	An unbranded hide
Colorado or Texas hide	The hide is branded on the butt or on the side
Country or small packer hides	Refers to the hides removed from the carcass by less skilled person
Big packer hides	Refers to the hides removed from the carcass by skilled person
Shearlings	Term used for sheep skin with the wool still attached.
	Skin from merino and other heavy woolly breeds used for fur goods such as wool-lined coats and gloves.
Renderer or "murrain hide	The hide recovered from an animal that died due to some reason other than slaughter
Hide	Skin from a fully grown large animal, which are thick and heavy called hide. For cattle and buffalo it should be more than 13.62 kg.
Kip	Skin of older calf that has not attained maturity.
Kid	Skin from the young goat and leather from such skin is called kid leather.
Suede skin	The sheep skin having flesh side finished and used for garments, handbags and other apparel.
Chamois leather	Oil tanned soft suede skin finished on both side used mostly for cleaning

[Table Contd.

Contd. Table]

Various terminologies	Explanation
U.S. nomenclature of hide/skin	
Native hide	Hide that has not been branded
Colorado hide	Hide having one or several brands
Texas hides	Hide from steer
Packers hides	Hides obtained from meat-packing houses
Frigorifico hides	Hides originated from South America meat-packing plants where a good method of brining prior to salting improves the quality
Nomenclature of hide according to methods of its preservation	
Green hide	Hide which is as it has come from animal and not been preserved
Bush hide	Hide procured from animals slaughtered in country side areas without proper slaughter provisions.
Pickled skin	Hides which have been unhaired and then kept in salt solution to which 0.5-1% sulphuric acid is added.

Table 7.3 Grades of shearlings or sheep pelts based on wool length

Wool Grade	Wool length
Number 4	Bare to 1/8 in
Number 3	1/8-1/4 in
Number 2	1/4-1/2 in
Number 1	1/2-1 in
Fall clip	1-2 in
Wool pelts	1 & 1/2 in

7.3 SOME DEFECTS OF HIDE

- *Fallen hides*
  - o Hides from animal died naturally.

- Fallen hides are of inferior quality because
  - hide substance is reduced due to fever and starvation
  - flaying of dead animal is difficult
  - blood vessels are full of blood resulting in rapid decomposition

- *Brands:* Careless branding severely damages the hide value
- *Cracks:* Cracks are result of multi folding of over dried hides for transportation and then opening it under conditions of high temperature and low humidity
- *Pressure sores:* Pressure sores occur due to prolonged lying down of animals prior to death due to weaknesses and starvation. Hip and shoulder blade are mostly affected
- *Insufficient bleeding:* Lack of hoisting facilities, slaughtering fatigued animals contribute to incomplete bleeding resulting in blood remaining in blood vessels and producing a hide referred as 'vieny hide'

7.4 INFLATION OF SHEEP AND GOATS SKINS

- Inflation is the blowing of air just beneath the skin of slaughtered animal for flaying
- Inflation by tearing the connective tissue between the body and skin
- Reduces the use of knife thus decreasing the gouge marks, scores and cuts
- Excellent method of obtaining faultless skins
- Keeping quality of carcasses is improved
- The absence of cuts reduces bacterial invasion
- Hide obtained is of good quality
- To get good quality hide, fisting should be preferred than the use of knife

7.5 HIDE/SKIN COMPOSITION

The thickness of the hide/skin differs with species, age, sex and region of the body (thinner on the ventral and on the flexor surfaces and thicker

on the back and on the external surfaces of the limbs). The skin is made up of three main layers:

1. The epidermis- Outermost and its surface may be pigmented
2. The corium- under the epidermis
3. The subcutis- deep under the corium

1. The epidermis

- The thin epidermis covers the skin/hide and expands inside as tubular invaginations and makes part of the surface of the hair follicles
- Collagen fibres start from near the epidermal surface, go deeper and turn thicker close to the core of the skin

2. The corium

- The underlying corium is linked with the hair follicles
- The sebaceous glands, the erectile follicular smooth muscles and elastic reticulum and collagenous fibres are found in the upper area of the corium
- Corium is also called the grain layer which normally makes 10% of the skin
- This layer forms the major portion of the sink
- It provides elasticity to the skin but is contributes little in the leather strength
- Interwoven collagen fibres are bundled in the deeper portion of the corium
- Collagen I is a triple helical chain structure made up of repeating units of amino acids (Gly-X-Y) and connected to the adjoining helix chain via a telopedtide end
- The collagen fibres contribute to the inherent strength of the leather

3. The subcutis

- The subcutis is made up of a loose membrane network of collagen and elastin fibres
- The subcutis has fat layer particularly in pig and decides the tightness or slackness (tension) of the skin

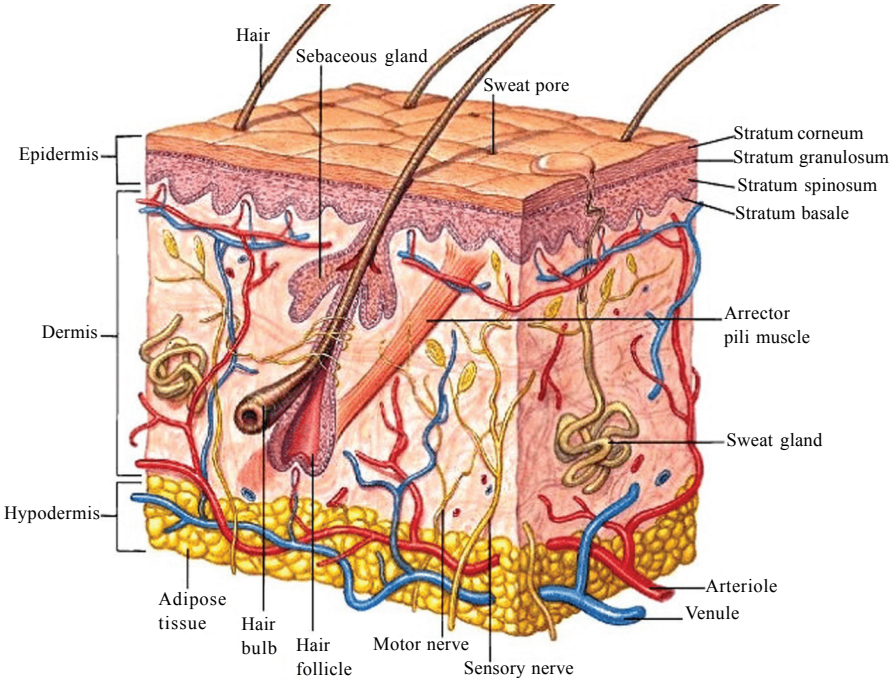


Fig. 4.1. Schematic cross-sectional view of animal skin

7.6 CHEMICAL COMPOSITION OF THE SKIN

- Age, sex, the fat level of the animal and the treatment given to the hide/skin after removal from the carcass affect the average chemical composition of the skin (Table 7.4)

Table 7.4 Chemical composition of hide/skin

Age of the animal	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Average slaughter age cattle	62-70			1.0
Mature cattle hide (without hair)	65	30.0		
Old cow	60.2	36.0	3.1	1.1
Goat skin	60.0		3-10	
Pig skin	37.0	14	30-50	

- Generally, the hide is low in minerals and fat and is high in protein called collagen
- The collagen is a major component of the leather converted from the hide skin
- Hair is composed of protein called keratin which generally constitute about 6-10% of the total hide or skin protein

7.7 PRESERVATION OF SKIN

- Freshly flayed skin (green hide) contains 62% water
- Air dried hides are lightest followed by dry-salted hides and finally wet-salted hides
- Air-dried hides are cheapest to transport as the hide volume can be reduced by pressure-baling

1. **Air drying:** Two ways of air drying

   i) Ground drying

   - Poor quality hide is produced
   - Lack of air circulation from beneath the skin
   - Heat is retained in the hair- chance of putrefaction
   - Blisters are common in such hide
   - Blisters- incipient putrefaction of hair follicles and epidermis

   ii) Suspension drying (Air drying over wire)

   - Drying hides on frames that are hanged on wire
   - Allows free circulation of air on both sides of hide- better and faster drying
   - No hairslips and no putrefaction as there are no folds or point of contact of hide with any solid object and ground
   - Improved keeping quality- salted hides undergo progressive deterioration
   - Cheaper transport- air dried hides are lighter than salted hides

- If atmospheric conditions are favourable, salting of hides and skin should be replaced with air drying
- Produces hide no way inferior to those from wet-salted
- Sun dried hides should be removed after drying and kept in shade to avoid over drying
- Sheep skins are prone to heat damage

Lacing: The method of stretching the hide or skin by making holes on it and securing it to the loop or frame by lengths of bark, string or fibre.

2. Wet-salting

- Leather-forming substance starts deteriorating once the RH exceeds 90% and the temperature reaches 86-108 ºF (30-42 ºC)
- Temperature of celler or cool room where skin/hides are salted and stored should be 50-60 ºF (10-16 ºC)
- Delay between flaying and salting leads to poor salt absorption due to partial drying of hide/skin
- Red heat- certain slat tolerant micro-organism can grow in high salt concentration and cause defects called 'red heat'

Quality & quantity of salt

- Impurities in salt such as iron and copper cause stains on hides/ skins
- Too coarse salt dissolves slowly and damages grain
- 23 lb of salt will dissolve in 100 lb of hides/skins. So, slightly higher amount is to be used

Pitting

- Also a method of wet-salting
- For temporary storage of hides/skins
- If delay in transportation of hides/skins, the hides/skins are rubbed with minimum salt and put into a pit/wooden barrel/drum
- Pit liquid is salt solution (pickle) containing blood, dirt, bacteria etc.

- Storing by pitting adversely affects the grain
- Harm the corium
- Loss in weight of hide due to leaching of leather forming materials

3. Dry-salting

- Hides/skins preservation method used in tropical countries
- Same as wet-salt drying except that salt is used for few initial days in dry-salting

7.8 HIDE CURING

- To a large extent, flaying (hide removal) and temporary storage treatments given to hides/skin determines the quality of the final leather
- The hide/skin undergoes different kinds of treatments at the abattoir such as
  - o hide removal
  - o preservation (hide curing)
  - o fleshing
  - o trimming
  - o selection and grading
  - o storage and shipping
- All of these operations are performed in steps, must be done correctly to generate good quality leather
- Goat skins are more costlier than sheep skins because they are bigger and make durable leather
- Sheep skins takes many hours to cool because of wool and grease layer

Curing

- Hide/skin should be cooled as soon as possible by immersion in cold/ ice water or acidic/caustic or a bactericide spray

- Thereafter, curing is performed to prevent enzymatic and bacterial degradation

Curing methods are as follows:

1. Air drying
2. Salt pack curing
3. Mixer curing
4. Raceway curing

1. Air drying: Hides and skins can be air dried in areas having low relative humidity

2. Salt pack curing

- The oldest method of hide curing
- Done in hide cellar with good ventilation.
- Salt is applied on flesh side of the hide and hides are kept one above the other after application of salt to create 3-4 ft high hide stack
- The salt prevents bacterial growth and takes out moisture from the hides
- Preservatives used are sodium fluoride (1%) or naphthalene (1%) plus boric acid (1%) based on the weight of salt

Salt curing requirements:

- Room temperature- 10-13 °C
- RH- 85-90%
- Salting of flesh side
- Salt and hide ratio: 1: 1
- Salt size- 2-30 mm

3. Mixer curing

- Nowadays, mixer curing is mostly used curing method particularly in small plants
- The hides are charged into the drum mixer which is similar in function to the cement mixer

- Hides are cooled and washed by clean water (13-16 °C) for 10-30 min
- Then the mixer is filled with a saturated salt solution and hides are rotated in this mixer for 6-12 hours
- This mixer can cure 250 and 400 cattle hides (1,000-2,000 pigskins) in one run
- This brine curing can shorten the curing time to 24 hours from 30 days

4. Raceway curing

- Nowadays the most widely used hide curing method
- The raceway shaped tank (raceway vat) is loaded with hides and saturated brine solution
- It is stirred up by two overhead paddle wheels revolving at 12-16 rpm and ensuring the brine and hides in circulation and movement and thus speed up the process of salt uptake
- The whole curing process takes 16 h
- A typical 50,000 gallon raceway vat can handle 800 to 1,200 cattle hides
- The brine solution is maintained at 98% saturation point
- For every 454 g (1 lb) of fresh (green) hide, 1.8 kg (4 lb) of saturated brine is required
- ***Float*** is a term relating the weight of brine solution to the weight of hides
- For instance, a vat containing 400% float denotes 400 lb (181 kg) of brine per 100 lb (45 kg) of hide
- Bactericides (2 parts per 100 parts of salt) are used in the brine to arrest the growth of spoilage bacteria
- Sodium fluoride (NaF) and Sodium silicofluoride are the common bactericides
- A correctly cured hide by brine should contain not greater than 40% moisture and a minimum 85% salt saturation level

- "Frigorificos" hides were salt preserved refrigerated hides produced in Latin America by large plants. Shelf-life of such hides were quite long under refrigeration
- Pig skins are not as efficiently preserved by salt as the case with the cattle hides
- They are cured by 20% float having 1% sodium bisulphite and 1% acetic acid in relation to the skins weight
- Halophilic bacteria which grow in concentrated salt solutions produce the "red heat" staining in hide

7.9 FLESHING

Removal of flesh, fat, hairs and manure from hide by passing it through fleshing machine to produce a good quality hide is called fleshing

7.10 TRIMMING

Removal of unwanted portion from the hide is called trimming

7.11 SORTING

Separation (grading) of hides based on sex, weight, branded or unbranded (native), steer hides etc. is referred as sorting

7.12 STORAGE AND SHIPMENT

- Finally, graded hides/skins are dusted with 454 g (1 lb) of "safety salt" to make sure the arrest of degradation during storage and shipment
- Hides are singly folded with flesh side up and transported

7.13 LEATHER PROCESSING

Various Steps of leather processing are:

1. Soaking
2. Unhairing
3. Deliming
4. Bating

5. Pickling
6. Tanning
7. Wringing and setting
8. Splitting and shaving
9. Retanning
10. Dyeing or colouring
11. Fat liquoring
12. Setting out
13. Drying
14. Conditioning
15. Staking
16. Buffing
17. Finishing

1. Soaking

- To replenish the lost moisture during the hide curing

2. Unhairing- by 3 ways

i) In older days, hides and skins were kept in warm, damp room. Bacterial enzymes used to uproot the hair and thus accomplishing the unhairing process
   - The process was referred as "sweating"
   - Chance of damage to danger so this procedure was abandoned.

ii) Green hides/skins are sprayed with acetate at pH 4 and then incubated at 32° C for 20 hours causing loosening of wool.

iii) Chemical depilatory agents are used at pH 12.5 such as
   1. Saturated solution of calcium hydroxide $Ca(OH)_2$ — slacken the hair follicles base
   2. Sodium sulphide (Na_2S)- it dissolves the hair
   3. Sodium sulphydrate (NaHS) - hydrolyzes the amino group of glutamine and asparagines amino acids

3. Deliming

- Removal of lime (calcium hydroxide) used in previous step by washing the hides
- After unhairing, hides/skins are loaded into rotating large wooden drums (16 rpm)

- Water is added and lime is removed
- Further lime removal is ensured by adding salts like ammonium sulphate or ammonium chloride and sometimes trisodium phosphate or sulphuric acid which make the remaining lime more soluble
- Deliming process lowers the pH of limed hides from 10-13 to 8-9 pH

4. Bating

- Bates are proteolytic enzymes obtained from animal GI tract and are used to degrade and digest
  - o the hair follicles and
  - o non-collagen substance of the hide/skin
- The bates degrade and dissolve the non-collagen protein constituent of the skin but do not act on collagen which is the most important part of leather
- The bates also eliminates the glue like substance found between the collagen fibres. This glue like substance impart hard and "tinny like" leather
- Bating converts the hide into softer, less harsh and cleaner
- Trypsin and other proteolytic enzyme are used as bating agent at alkaline pH
- Bates are obtained from animal organs, fungus, bacteria and plant

  There are two theories of working of bates:

  1. The removal of elastin and other degraded proteins
  2. Changes brought in the collagenous or leather making fibres.
- The rate of bating process is controlled by the enzyme concentration, temperature (27-38 °C) and pH (8-9) and takes about 16 h
- To control bacterial growth bacteriocides like sodium fluoride (NaF), sodium pentachlorophenol are seldom used
- After the bating process is over, the hides/skins are washed again to get rid of the unwanted, digested, non-leather substances

5. Pickling

- Sulphuric acid is added to the hides to bring down its pH to less than 3 so as to encourage the further binding of chrome ions with hides during tanning process
- This process is called pickling
- Firstly, common salt (sodium chloride) is added in the pickling process

6. Tanning

- Tanning is the process of conversion of collagen fibres of the skin into resistant non-perishable leather
- Tanned leather exhibits properties like abrasion resistance, dimensional stability, chemical resistance, the ability to flex, heat resistance and the ability to endure multiple wetting and drying cycles

Chrome tanning is the most accepted (90%) of tanning process due to:

✓ Process is completed fast

✓ Obtained leather is having required physical and chemical properties

Tanning process

- Generally, chrome (chromic sulphate) is used for tanning
- Chromium salt (e.g., sodium bichromate, $Na_2Cr_2O_7$) is combines with a reducing sugar (maltose) and sulphuric acid (H_2SO_4) to produce **chromic sulphate [$Cr(OH)SO_4$, called chrome**]
- The pH of the hide/skin is brought to 2.5-2.8 and tanning material (Chromic sulphate commonly known as Chrome) at the rate of 1.5 to 3% is added to the revolving drum
- To further enhance the uptake of chrome ions by the skin collagen, the pH of the chrome solution is raised later to 3.4-3.6 by mixing sodium bicarbonate ($NaHCO_3$, baking soda) into it

This process is called basification or liming

- The tanning process takes 4-6 hours
- The ensuing blue stock is called leather which is now preserved against putrefaction and thermally stable

The theory of chrome tanning

- Cross linkages are formed between the chrome ions and the free carboxyl groups present in the collagen side chains through the bond formation
- The liming (basification) exposes extra carboxyl groups for chrome ion attachment by hydrolysis of amine side chains

Other tanning processes:

✓ Vegetable tanning—time consuming process involving months but yields firmer leather showing high water resistance

✓ Alum tanning — process called "tawing" to produce pure white or sole gray leather such as baseball leather and furs.

✓ Oil tanning—this yields soft leather for moccasin or chamois leather by using fish oil (cod, whale, shark or seal oil)

7. Wringing or setting

- To remove excess moisture, wrinkles and smoothen the grain, the hides are passed between two large rollers of the wringing machine

8. Splitting and shaving

- Hide thickness changes from animal to animal due to age, body areas from where it is obtained
- "Splitting" and "shaving" is done to correct the leather thickness to 1/48" or 1/64" for its final use
- The thickness correction is accomplished by a horizontal band saw that is fixed with a sharp flexible knife
- The hide is passed through the machine with grain side up and undesirable flesh ('split') side down. The flesh side is 'shaved' to achieve the desirable thickness

9. Retanning

- To prevent the leaching of chrome and stabilize it, hides are additionally tanned with other agents and the process is known as retanning
- Besides, retanning makes the leather imparts soft and in instances removes the blue chrome colour
- For retanning, the hides are loaded again in the rotating drums, washed and neutralized with alkali to bring the pH to 5 for vegetable tanning

The retanning agents are

1. Vegetable extracts
2. Syntans

9.1 Vegetable extracts

- The active ingredient of vegetable extracts is tannin (tanic acid) extracted from trees and shrubs
- It is obtained from Chestnut, Eucalyptus, Hemlock, Mangrove, Mimosa, Oak, Spruce, Wattle

  Vegetable tannins are polyphenolic compounds of two kinds:

  a. The hydrolyzable tannins (from chestnut) - derivatives of pyrogallols
  b. The condensed tannins (from hemlock and wattle) - derivatives of catechol
- Vegetable tanning causes the attachment of the tannin phenolic groups with the peptide bonds of the protein chains by hydrogen bond formation
- The vegetable retanning causes firmness, body and additional uniformity in chrome tanned leather

9.2 Syntans

- Syntans are synthetic chemicals manufactured by condensing aromatic sulphonic acids or phenols with formaldehyde
- Syntans may also be from acrylic resin type

- Use of syntans results in more softer and white or pastel leather due to their bleaching action on the blue green colour of the chrome tanned leather

10. Dyeing or Colouring

- The subsequent step is dyeing (colouring) of the leather to get the intended color
- Besides, colouring imparts the correct strength (contraction) and shade (hue or dullness) to the leather that can be dry cleaned or washed and that will defy colour fading

11. Fat liquoring

- Fat liquoring is lubricating the internal fibres of hide
- Achieved by applying different available oils such as vegetable, fish, mineral or animal (Neat's foot oil) oils, glycerine and related fatty substances, soaps, egg yolk and at times waxes (called sponging compounds) to adjust the firmness or softness of the leather

12. Setting Out

- The next step, termed as 'setting', is passing the hide/skin through fleshing like machine to smoothen and stretch the leather and to compress and remove the excess moisture and grease

13. Drying

- The next step is removal of extra moisture
- The skins should have10-12% moisture after drying

There are four different drying methods:

1. Hanging- in which the leather is spread and hung like washed clothes and oven dried at below 54 °C to reduce shrinkage
2. Toggling- the skins are stretched and tied on metal perforated frame by fastening hooks known as toggles and then air dried
3. Pasting- in which the hides are pasted to big stainless steel plate with the help of starch like substance ensuring wet

leather sticking to the plate and then oven dried at 60-66 °C and 40% relative humidity for 4-6 h

4. Vacuum drying- drying the leather under vacuum by keeping it on a hot stainless steel plate

14. Conditioning

- After drying, the leather becomes hard and thus unworkable but some degrees of softness (called temper) is required for its final use
- So, controlled amount of moisture is introduced by shower like nozzles and this process is called conditioning or wetting back
- The moisture level is raised to about 25%

15. Staking

- The combination of pulling and rolling of leather by the staking machine (called staking) softens and makes the leather more pliable

16. Buffing

- Smoothening the grain surface by little mechanical sanding to enhance the look of the leather and to reduce any stains/spots on leather is referred as buffing

Table 7.5 Terminology related to finished leather

Leather	Term used
Not buffed	Full grain
Lightly buffed	Corrected grain
Intermediately buffed	Snuffed leather
Deeply buffed	Buffed leather

17. Finishing

- The final step is "finishing," which is the application of film forming substances (polymeric impregnants) that grant abrasion and stain resistance, enhance the colour and thus produce the leather which can be easily maintained

- Coating materials used for finishing are acrylic polymers, blood albumin, casein, egg albumin, isinglass, linseed oil etc.

7.14 PHYSICAL PROPERTIES OF LEATHER

- Leather possesses numerous distinctive and important physical properties due to its internal structure
- The top portion is the grain layer (hair or grain side) and the bottom portion is the flesh side and together it is termed as corium
- Following are the physical properties of leather:
  - Leather has a high tensile strength (the greatest longitudinal stress a substance can bear without tearing)
  - One of the strongest flexible sheet materials known
  - Leather also has a high tear strength- tear resistant
  - Stitching is not required around a punched hole
  - Excellent flexibility
  - Puncture resistance by a sharp object
  - Leather can absorb and transmit moisture
  - Has the ability to breathe
  - Has the ability to cool in hot weather and insulate in cold weather
  - Windproof
  - Moulding ability-retains the shape

CHAPTER - 8

UTILIZATION OF BONES

8.1 INTRODUCTION

Bone constitutes 15% weight of dressed carcass whereas, 15-30% of live weight for cattle and buffalo and 20-30% of sheep and goat is bone. Bones from slaughtered animals have been utilized traditionally for soup and gelatin production. Earlier, due to high cost involvement, it was impractical to recover meat attached to bone using various technologies. However, a market for specialty items like sausage, spread, pastes, fish sticks, cakes and stuffing from ground fish and poultry frankfurters, turkey rolls, casserole dishes and customary sausages from ground poultry meat are growing day by day. These products could be prepared economically by using mechanically separated bone meat and so, there is necessity for a suitable and competent method of segregating meat from the bone.

About 6-10 kg of meat per beef carcass and 12 kg/pork carcass that are attached to bones are lost and recovering meat from irregular bones such as from neck, back and loin areas becomes very tedious. Several methods and technologies have been innovated for separation of meat from bone for different species.

Table 8.1 Regulations for mechanically separated meat

	Specifications
Bone particles size	> 0.5 mm
Bone particles	None larger than 0.85 mm
Maximum calcium	0.75% (3% bone solids)

[Table Contd.

Contd. Table]

	Specifications
Protein	Minimum 14%
Fat	Maximum 30%
Use in meat products	Maximum of 20% of product; Cannot be included in baby food, ground beef, hamburger, fabricated steaks, some cured pork items and meat pieces
Mechanically deboned poultry	
Bone content	Maximum 1%
Use in meat products	Listed in ingredient section as chicken or turkey
Use in meat products	Up to 100% in bologna and frankfurters
Use in red meat products	Maximum 15%

Source: USDA (1982).

8.2 MECHANICAL SEPARATION OR DEBONING MACHINES

Different types of machines are described below:

1. Poultry and fish meat with bone are squeezed between rotating steel drum having perforations at the surface and rubber belt resulting in passing of softer tissue (ground meat without bone) via the perforations into the drum whereas the bones with the meat are left on the outer side of the drum. Depending upon the species and hardness of bones and associated tissues, the pressure on the belt can be adjusted to optimize the yield.
2. Some mechanical deboner first grinds the bones to which meat is attached using a bone cutter and thereafter, the ground mixture is introduced into a screw-driven boning head. With a continuous increasing pressure, the material is pressed towards the filter of a perforated steel cylinder and the meat being soft escapes through the holes and the fragmented bone particles leaves through the end of the head.

3. The third type of machine breaks the bones to which meat is attached and loaded into a constant volume chamber containing superimposed rings in the cylinder wall and concentric rings at the end of the cylinder. It uses a high pressure hydraulic powered ram piston which forces out the hard muscle through the cylinder perforations. This is a batch system and varies with the above two continuous system described previously.

Table 8.2 Bone composition (averages are in brackets)

	Pork (%)	Beef (%)	Lamb (%)	Mutton (%)
Bone % (based on live weight)	7.5–12	7–12		
Bone % (based on carcass weight)	9–30 (11)	12–30 (15)	13–19 (16)	24–41
Calcium % (in inorganic matter)	35–68.4	33–38.4	35–38.4	35–38.4
Phosphorus % (in inorganic matter)			15	
Moisture (%)	43	32–50		
Protein (%)	20.6	20.6–29.0		
Fat (%)	12.4	15.2–22.0		
Ash (%)	21.4	13.0–29.0		

Source: Ledward et al. (1983), Mann (1962), Field (1981).

8.3 SALIENT FEATURES OF MECHANICALLY DEBONED MEAT (MDM) OR SEPARATED MEAT

- Higher fat, ash and calcium levels and reduced moisture and protein than hand boning
- Due to the high fat content of red bone marrow, fat content of MDM is significantly greater and the protein percentage to be little lower compared with hand deboned meat

- Bone marrow and powdered bone contents are high and connective tissue content is less than the manually deboned meat
- Contains 2-3 times more haemoglobin which is the abundantly found in marrow. Thus, contains 2-3 times more iron and appear darker red than hand deboned meat
- Ash content of MDM is greater compared to manually deboned meat
- The ash is primarily calcium in MDM. The calcium content can be utilized to predict the bone content in MDM
- USDA limits the calcium level of MDM to 0.75% (not more than 3% bone content)
- Sausage emulsion product prepared from MDM exhibits good emulsifying capability, water holding capacity, cooking stability and cooking yield
- MDM shows greater pH than manually deboned meat

Table 8.3 Compositions of mechanically deboned meat (MDM)

	Bone from beef (%)	Bone from pork (%)
Protein	15–17	13
Fat	16–25	28
Moisture	58–68	58
Ash	0.9–2	1–3
Collagen	3–4	3–4
Heme (mg/kg)	500	300

Source: Bengtsson and Holmquist (1984), Bijker et al (1979), Demos (1995), Field (1988)

8.4 MICROBIOLOGICAL QUALITY

- Is ensured by lower temperatures, limited period storage and hygienic handling of MDM (pre-rigor bones obtained from hot deboning are desired)

- The mechanically separated meat must be utilized within 24 hours or stored at -18 °C or further lower

8.5 OXIDATION OF MDM

- Unsaturated fat content of bone marrow fat is higher than subcutaneous or intramuscular fat content
- Additionally, various steps involved in recovering MDM such as high temperature, grinding, mixing of bone marrow, air and heme pigments inclusion, contact of MDM with iron parts of the machine make it prone for fat oxidation leading to off flavours and color depreciation (brownish red)
- Predominant phospholipid found is phosphatidyl choline
- Owing to larger quantity of saturated fat in the ruminant fat, MDM obtained from mutton and beef is less susceptible for oxidation than MDM from pork

Ways to avoid oxidation

- Incorporation of antioxidants- not phenolic antioxidants due to low solubility
- Addition of chelating agents and polyphosphates

8.6 EMULSION PROPERTIES OF MDM

- The added bright red colour of mechanically separated meat is considered desirable for many products
- MDM possesses good emulsifying and water holding capacity and somewhat higher emulsion stability than its hand deboned counterpart.
- The higher pH (increases its water holding capacity) of MDM is due to the red bone marrow (pH 6.8 - 7.4) and basic calcium phosphate present in bone powder can affect it

8.7 USES OF MECHANICALLY DEBONED MEAT (MDM)

- MDM can be used as one of the ingredients to prepare ground beef patties, comminuted fresh, smoked, and cooked sausage type products, stews, sauces, spreads and even chunked and formed meat products

8.8 GREEN AND DESERT BONES

- Bones from freshly killed animals are referred as green bones
- The bones which have undergone changes due to bacterial action, insects and atmosphere for long duration are called desert bone
- Desert bones are devoid of meat, fat, periosteum and tendons

8.9 CALCINED BONES AND BONE ASH

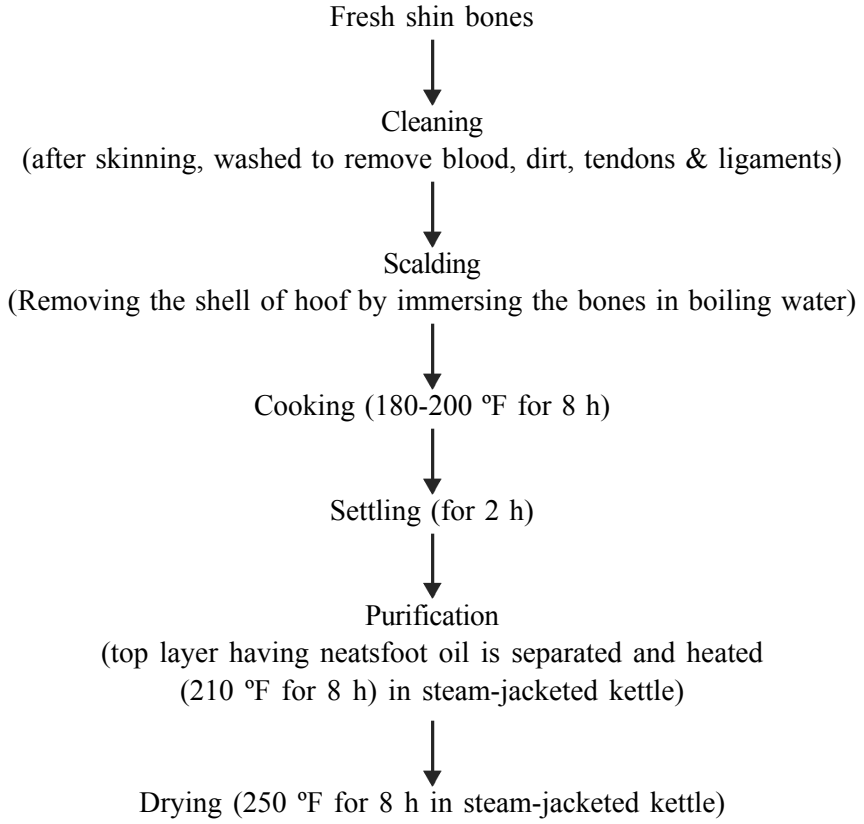
- Burning the bones and using it as animal mineral supplement or as fertilizer
- Bones are burnt by keeping the bones on large grill and make a fire from beneath
- Trench firing is another option
- Burning of bones cause
  - Sterilization of the bone
  - Burns off the fat, ossein, marrow
  - Makes the bone softer- easier to ground to powder

8.10 NEATS FOOT OIL

- Is pale, golden-yellow colour oil obtained from feet (shin bones)
- On long keeping, a solid portion similar to tallow will settle down called ‘stearin’ and the pure Neats foot oil remains fluid
- Use- leather dressing, lubricant for delicate textile machinery

8.11 PROCESS OF NEATS FOOT OIL EXTRACTION

Only fresh bones are used for extraction



CHAPTER - 9

HORNS AND HOOFS

Horns vary in size, shape colour and curvature according to the breed, age, sex, etc. It is a very valuable raw material for gelatin production. Alternatively, may be used for the production of bone meal. The horn, on the other hand, has as its main component keratin. It is unpalatable and indigestible as stock feed; horns should not be used in the production of bone meal. Hoofs (shine bones) are used for similar purposes to horns and are removed from the feet in the same way that is by steaming and immersing in warm water.

9.1 HORN

Horn consists of two parts, the horn pith and horn proper. Horn pith is the inner part and the horn proper is the outer keratinous shell like structure. These are used for different purposes.

- *Horn pith (horn core)*
  - o Is a process of frontal bone
  - o Structure similar to bone but contains more ossein
  - o Valuable material for gelatin- more price
- *Horn proper*
  - o Main component is keratin
  - o Cannot be used for gelatin production
  - o Not used for bone meal

9.2 USE OF HORN

- For making articles such as buttons, handles, comb etc.
- Ground to powder and used as plastic substitute
- Cracks easily on heating
- Most valuable part of horn is its tip

9.3 HOOFS

- Similar purpose as horn
- Removed from the feet by steaming and immersing in hot water

9.4 HOOF AND HORN MEAL

- For preparation of hoof and horn meal, they are collected from healthy slaughtered cattle
- Cleaned properly with water and steamed for sterilizing it and for cooking as well. Further it is crushed and disintegrated in the renderer for 8 hours for preparation of horn and hoof meal by drying and milling to a fine powder
- This meal contains 16-17% nitrogen and is super fertilizer for tea gardens, and coffee plantations
- As the horn and hoof meals are poorly digestible and unpalatable in nature they should not be mixed with cattle feed bone meal but can be mixed with bone meal intended for the use as fertilizer for plants
- Horns and hoofs from sheep, goats and hoofs of pigs are not usually further value added and allowed to go waste
- Hoof and horn meal can be profitably processed by using the available facilities for the production of bone meal either by using wet-or dry-rendering machinery
- Horn and hoof meal enriches the fertility of the soil because of its high nitrogen content
- This fertilizer commands a price approximately 50 percent higher than bone meal

CHAPTER - 10

GELATIN

10.1 INTRODUCTION

- Gelatin is water soluble, hydrophilic, partially denatured colloidal proteins produced by controlled and partial hydrolysis of fibrous connective tissue protein called collagen which is water insoluble
- Physically and chemically glue and gelatin are similar
- The main distinction is that gelatin is edible and is made from edible collagen raw materials in a good hygienic way whereas glue is inedible and for industrial use
- Collagen is composed of right-hand woven triple helix tropocollagen monomers arranged in overlapping fibrils with molecular weight ranging from 40 to 240 kDa
- The conversion of collagen to gelatin/glue involves the cleavage of hydrogen bondings present in triple coil helix structure and transform it into the random coil configuration of gelatin/glue lacking helix confirmation
- The physico-chemical properties of the hydrolyzed gelatin/glue depend on the cross linkages remaining between the peptide chains and reactive amino and carboxyl terminal groups that have been created while conversion from collagen to gelatin/glue
- Three types of protein chains are found in glue/gelatin known as α chain, β chain and γ chain
  i. α chain- having only single polypeptide chain
  ii. β chain- possessing two polypeptide chains
  iii. γ chain- having three polypeptide chains

- Hence, a single gelatin sample has various molecular weight components
- The molecular weight distribution of gelatin controlls its functional properties
- Gelatin having low molecular weight molecules will have lower viscosity and lower gel strength
- Normally, the low molecular weight proteins in gelatin are produced due to:
  a. high gelatin extraction temperatures and/or
  b. highly acidic or alkaline conditions
  c. type of raw materials
  d. long liming time

10.2 AMINO ACID CONSTITUENTS OF GELATIN

- Collagen and gelatin or glue are composed of polypeptide chains consisting of amino acids connected by peptide bonds
- The amino acid composition of collagen and subsequent gelatin/glue is
  - rich in glycine and lysine
  - tryptophan is absent
  - low in methionine, cystine, and tyrosine
  - Unlike other proteins, fairly high in proline and hydroxyproline
- Therefore, it is not a complete protein
- Collagen is repeating sequence of three amino acids such as -Gly-Pro-Hyp- which ultimately makes polypeptide chains

10.3 RAW MATERIALS FOR GELATIN

- Collagen is 30% of the total organic matter present in animal body or 60% of the total protein available in animal body

Table 10.1 Various nomenclatures used in the area of glue and gelatine

Term	Obtained from	Definition	Use
Glue	Hide, bone,blood albumin	Crude form of gelatine	Adhesive in plywood, furniture, paper board, match heads to give an airtight cap over phosphorus, gummed tape, paperboxes and book binding
Gelatin	Hide, skin, bone and any collagenous material	Hydrolysed protein fromcollagen	Used in ice cream, mayonnaise dressing, emulsion flavours, bakery products, to clarify wine, beer, and vinegar, pharmaceuticals (capsules and coating for pills), photography, gel candies etc.
Ossein	Bone	Demineralized bone, spongy undissolved matrix of collagen	A desirable raw material for the extraction of gelatine
Isinglass	Fish bladder	Gelatine obtained From fish bladder	Same as gelatin

- Hides/skins (including pig skins) and bones are industrially available raw materials
- Hoofs, horns, hair, feathers and eggshell waste are not gelatin source since they are not made up of collagen protein

10.4 MANUFACTURING (EXTRACTION) OF GLUE AND GELATINE

The gelatin or glue are extracted by the partial hydrolysis of insoluble collagen and converted into soluble glue/gelatin.

Extraction process consists of three major steps:

1. Removal of non-collagenous materials from the new material
2. Hydrolysis of collagen to gelatin
3. Recovery and drying of the extracted gelatin

$$\text{Collagen (360-345 kDa)} \xrightarrow{\text{Controlled hydrolysis}} \text{Gelatin (10-65/250 kDa)}$$

10.5 PROCEDURE OF GLUE/GELATIN EXTRACTION:

1. Alkaline procedure (Type B Gelatine)
2. Acid procedure (Type A Gelatine)
3. High pressure steam extraction- not discussed here

10.5.1 Alkaline procedure (Type B gelatin)

- The most extensively used industrial method of gelatin production from collagen
- Any collagenous material such as hides, skins, ossein from bones, sinews etc. can be processed by this procedure

Process

- The collagenous raw materials are washed and loaded into tank or vat
- Saturated solution of calcium hydroxide (calcium oxide, CaO, in water) is added @ 10% of the weight of the raw material

- Ammonia (NH_3) is released during the liming of the hides/skins by the hydrolysis of amide groups present in the collagen protein chains
- Completion of liming is indicated by the swollen raw (hide/skin) material
- During liming specific peptide chain regions are attacked and intermolecular cross linkages are broken down (hydrolysis) resulting in depolymerizing
- This converts a highly polymerized collagen into a lower intra molecular crosslink units called gelatin
- The recovered gelatin is mixture of protein polypeptide chains of different lengths and hence of different molecular weight
- These polypeptide chains are lightly branched chain molecules having average molecular weight of 30 kDa (range 10-65 kDa)
- After completion of liming, the raw material is washed in cold running water
- The collagen is still swollen and basic after washing and so, treated with dilute hydrochloric acid (HCl) or sulphurous acid to neutralize the raw materials
- Thereafter, the collagenous material has pH varying from 5 to 8 (normally pH of 6-7) and fit for gelatin/glue extraction
- The length of liming varies from 7 days to 3 months
- Ossein requires a lengthier liming time
- Sinews take 30-45 days for liming and pigskins takes 15-20 days
- Vegetable tanned hides are immersed in mild alkali such as borax (Na_2B4O_7) or sodium carbonate (Na_2CO_3) to remove the tanning substance (detanned) for many days and then extraction is completed by the alkaline process
- The isoelectric point of the collagen reduces from 6.0 (day 0) to 4.8 pH (at 44 days) during liming period with the best grade gelatin exhibiting isoelectric pH of 5.0

Principle of alkaline procedure

1. The alkaline treatment brings about chemical alterations (hydrolytic reactions) in the collagen without making it soluble (solubilisation) and successive thermal solubilization is only desired to cleave weak physical forces remaining in collagen helical structures.
2. The alkalinity also causes the dissolution of non-collagen materials (keratin, globulins, muco polysaccharides, elastin, mucins, albumins) to a more soluble product and thus, are removed by subsequent washing.

Extraction of gelatin

- The delimed collagen stock is then loaded into extraction kettles
- Initially, extraction is starts at 54-60 °C for 3-5 hours and carried up to boiling
- The highest quality gelatin *i.e.* higher gel strength and better clarity gelatin is recovered at the low extraction temperature but yield is low at lower temperature
- Higher gelatin yield is obtained at higher extraction temperatures

Filtration

- The recovered liquid gelatin is pressure filtered through cellulose paper to remove small particles and enhance the clarity
- Sometimes centrifugation or diatomaceous earth or activated carbon is also used for filtration

Deionization

- Strong cation exchange resin is used to deionise so that the resultant gelatin would have less than 0.5% ash content

Drying

- Drying tunnels, vacuum evaporators or drum drying are used to dry the liquid gelatin to 10% (8-10%) moisture level
- After drying, the gelatin or glue is in the form of sheets or coarsely broken or in the form of flakes. So, it is ground to obtain powdered or granulated gelatin

Pearl or bead dried glue

- Obtained by dropping liquid glue from a height into cold white spirit (high boiling paraffin) or naphtha
- The pellets (small beads) are formed which are easy to dry and durability is longer than the sheet glue

10.5.2 Acid procedure (Type A gelatin)

- Although any collagenous material can be processed by acid processing but generally pigskins and bones are processed by this method
- This technique is specially favoured if the collagen byproducts contain some bone or cartilage

Process

- Pigskin contains 8-15% fat which is removed by treating the skins in hot (55-60 °C) water followed by removal of skimmed fat from the top
- Instead, pigskins fat can be removed by solvent extraction (hexane)
- The next step is washing the pig skins in cold water and then soaking in up to 5% inorganic acid (10 to 72 h) such as hydrochloric (HCl), sulphurous, phosphoric (H_3PO_4) or sulphuric (H_2SO_4) acid bringing down the pH to 4
- This pH results in swelling of the collagen and solubilise it to major extent
- The raw material is taken out after acid treatment (10 to 72 h) and is washed raising the skin pH to 4-5
- Non-collagen proteins show isoelectric point at pH 4-5 and thus, are least soluble and quickly coagulate and settle down during extraction
- Acid treatment yields gelatin having isoelectric point of 8.9 (range 8.5-9.4)

Principles of acid procedure

1. Acid treatment causes only physical reorganization of the collagen triple helical structures with least hydrolytic degradation leading to a little increase in primary amino groups and free carboxyl groups. This process maintains many of the covalent cross linkages of collagen protein chains.

- Average molecular weights of gelatin obtained using this method varies from 70-90 kDa
- After acid treatment, the collagen raw material is subjected to extraction as explained above under alkaline procedure
- The pig skin gelatin demonstrates better gel strength, clarity and color than alkaline treated cattle hide products
- Alkaline and the acid pretreated gelatins are two different category of gelatin and one category cannot be replaced by another category by the user

10.6 OSSEIN PRODUCTION FROM BONES

- Initially, bones are washed using water and then by dilute sulphurous acid and are then heated at 80-95 °C water to remove adhering meat and fat
- Afterwards, it is washed and the clean bones are adequately dried and referred to as packer bones
- The next step is milling using a stone crusher
- Thereafter, the remaining fat is recovered from the bones by using non polar solvent like ethylene dichloride or hexane to bring down the fat level to below 0.5%
- The bones are then dried in ovens at 50-60 °C to eliminate the residual solvent
- Generally, crushed bone yields 55–60% gelatin
- Then the bones may be pressure steam extracted but this results in lower quality gelatin
- Generally, ossein is obtained from bones by acid removal of minerals followed by steam extraction
- This includes incubating the bones (counter current demineralization) with hydrochloric acid (HCI) to take out the mineral elements from bones

Calcium phosphate + HCl ⟶ Soluble monocalcium + Calcium chloride
(bone mineral) phosphate

- Crushed bones are loaded into the tanks/vats and 1 N HCl is added
- Acid and bone mixture is stirred continuously for 24 h at 25 °C

- Finally, obtained ossein is washed with water until the waste water has a pH of 6-6.5
- The ossein is loaded into liming vat and lime is added @ 10% of the dry weight of the ossein for 30-60 days. The liquid lime is agitated at frequent interval
- The ossein is then processed through deliming, washing, gelatin extraction and drying as similarly described previously

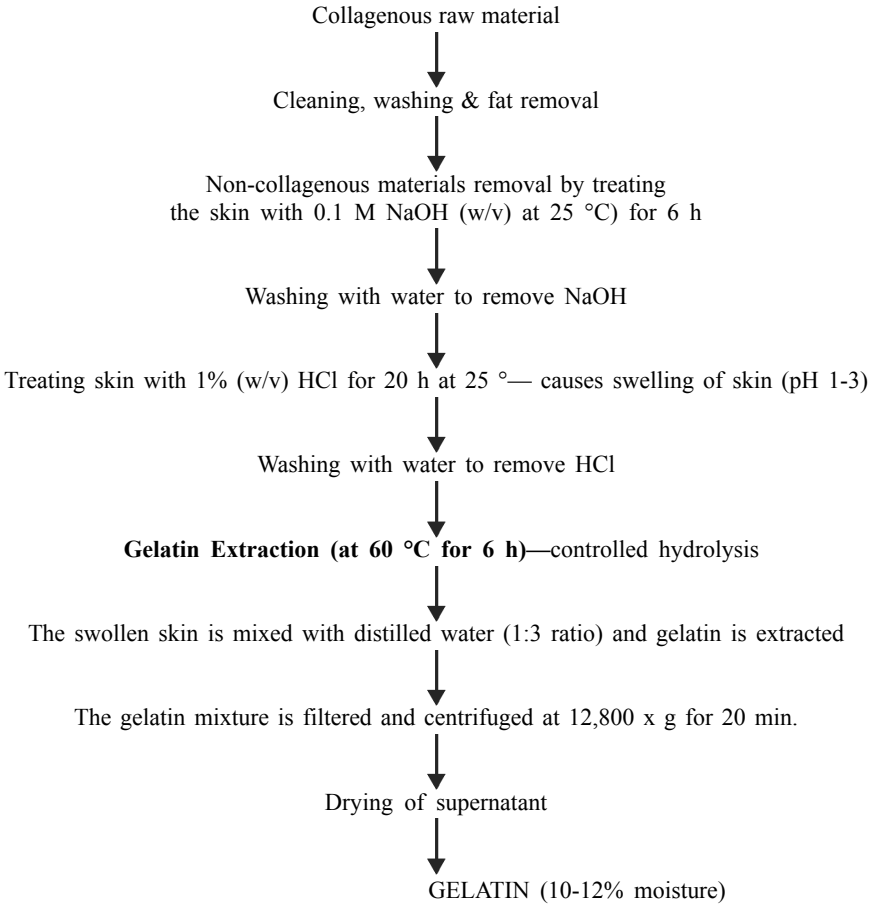


Fig.10.1. Flow diagram for gelatin/glue extraction

10.7 USES OF GELATIN/GLUE

- Food thickening and emulsifying agent
- Used as clarifying (*i.e.*, isinglass) agents for fruit juice, vinegar, some pharmaceutical items and alcoholic beverages such as wine, beer etc.
- Manufacturing capsules coat
- Used at 1-2.5% level in food to modify the physical properties of food
- If gelatin level in food item is more, the confection dissolves slowly and the flavour is retained for long duration
- In marshmallows, 1-2% gelatin (bloom value 250 g) converts a 20% sugar syrup into a highly viscous solution which can be whipped (gelatin lowers the surface tension and stabilizes the foam by increasing the viscosity)
- Lower bloom gelatin is used to prepare 'drops' and 'particles'
- In Europe, gumdrops are also manufactured from gelatin
- Gelatin is used to make lozenges and wafers
- The protective colloidal action of 0.3-0.5% (250 g bloom value) gelatin is utilized to change the body, texture and whipping qualities of ice cream
- Used at the level of 1-5% in jellied tongue, jellied beef, corned beef, loaves, scrapple, brown sauces, aspics, meat pies
- Provide glaze for loaves and hams
- Used to provide smooth appearance to the casing and the loaf by filling voids between it
- Gelatin (10-20%) is used as a moisturizing agent in making tablets
- As a plasma expander
- Used in photography plates
- Used to manufacture smokeless gunpowder

- As sticking power in insecticide sprays
- Used in microencapsulation

✓ Fish skin produces good quality glue whereas fish waste (trimming and bones) yields low quality gelatin and

✓ fish head glue is turbid and combined with zinc oxide for use as wood glue

10.8 PHYSICAL PROPERTIES OF GELATIN/GLUE

- Gelatin is tasteless and odourless and is a vitreous and brittle solid
- Amphoteric
- Gel strength is a measure of the hardness, stiffness, strength, firmness and compressibility of a gel at a specific temperature

Table 10.2. Some properties of gelatin

Property	Gelatin type	
	Type A (acid procedure)	**Type B (liming procedure)**
Isoelectric point (IEP)	7.0–9.5	4.7–5.5
pH	3.8–6.0	5.0–7.5
Gel strength (g) (Bloom)	75–300	75–275
Viscosity (mp)	20–75	20–75
Ash (%)	0.3–2.0	0.05–2.0

CHAPTER - 11

POULTRY BYPRODUCTS

11.1 INTRODUCTION

The rapid growth of poultry production has led to a massive generation of food-processing byproducts like bones, viscera, feet, head, blood and feathers. The poultry industry creates animal waste from excreta/manure together with waste from poultry and egg processing. It has been estimated that bones and trimmings constitute about 7-8% to the broiler live weight, resulting in 12.5 million tons of potentially valuable phosphorus-rich byproduct on global scale. Poultry manure is considered as a byproduct from the poultry farm industry.

Table 11.1 Yield of byproducts from broilers, fowl and turkeys

	Material % of live weight		
Materials	**Broilers**	**Fowl**	**Turkey**
Offal	17.5	17.0	12.5
Blood	3.5	3	
Feathers	7.0	7.0	7.0

11.2 FEATHERS AND DOWN

Feathers can be chemically or biologically treated to improve their nutritional value for animal feed. In addition, they can be converted to biodiesel, biodegradable plastics, and organic fertilizers. Chicken feathers contain about 91% protein (keratin), 1% fat, and 8% water. The amino acid

composition of chicken feathers shows high levels of serine, cystine, glutamine, and proline and low levels of histidine, lysine, tryptophan, glutamic acid and glycine. Serine is the most abundant amino acid (16%) in chicken feathers. Feathers and down, byproducts of the poultry industry, may be utilized for clothing, insulation, bedding, decorations, sporting equipment, feather meal and fertilizer. Feathers are often classified in the following groups:

- *Hard feathers*: hollow, stiff quills with stiff heavy vanes radiating in a flat two dimensional plane
- *Saddle feathers*: long, narrow, vaned feathers from the saddle and back of a rooster
- *Half fluff*: vaned feathers with fluff along the lower half of the quill
- *Three quarter fluff*: vaned feathers with fluff along the lower three quarters of the quill
- *Fluff*: body feathers with firm shafts
- *Plumules*: small down feathers with soft shafts
- *Down*: insulating undercoat of lightweight feathers without a shaft or stiff quill and with a long fibre length.

11.3 REMOVAL OF CHICKEN FEATHER BY SCALDING PROCESS

Scalding is the process of easy and economic removal of poultry feather. For scalding, the chicken carcass along with sleeves are immersed into hot water and feather follicles get denatured and feather get removed easily. For scalding of chicken, the water temperature should be kept between 53-58 °C and carcass are immersed in water for 90-120 seconds and a slightly higher temperature of 60 °C and longer time being used for turkeys. Waterfowl carcasses are scalded in the range 60-63 °C for 21 minutes, and if the feathers are not saved, they are dipped in wax at 91 °C and then into cold water.

11.4 USE OF FEATHER

- Chicken feather keratin can be hydrolyzed by the lime method (calcium hydroxide) into a liquid product of amino acids and polypeptides. This can be used as a feed supplement for livestock feed
- Feathers can be converted to feather powder to be used as a livestock feed or to organic fertilizer
- Poultry processing waste includes feathers, blood and viscera and heads are the rich is a source of nitrogen as animal feed or as fertilizer. This processing waste contains 10% fat which can be potentially used for biodiesel production
- Non-woven textiles can be produced using chicken feathers at a relatively low cost
- Poultry feather can also be converted into biodegradable plastics by a process called polymerization

11.5 FEATHER MEAL

- Feathers are composed of keratin protein which must be broken down by hydrolysis to make them digestible
- Feathers can also be used for fertilizer and mulch
- Feather meal is rich in cystine, threonine, and arginine but is deficient in four essential amino acids: lysine, methionine, histidine and tryptophan
- Level of use of feather meal in the diet: 0.5-1.5%
- Utilization of feather meal in the ruminant animal can be improved by supplementing the diet with urea

Table 11.2 Composition of feather meal

Protein	80–90% crude protein (75% of crude protein as digestible protein)
Moisture	Maximum 10%.
Fibre	Maximum 3 or 4%
Fat	Maximum or minimum as specified. (*e.g.*, not less than 6%)

11.6 EGG SHELLS

- 11% of the total weight of an egg and are available from egg breaking plants and hatcheries
- Contain approximately 94% calcium carbonate, 1% magnesium carbonate, 1% calcium phosphate and 4% organic matter
- May be used for land application (calcium source) or dried to be used as meal
- Egg shell is probably the best natural source of calcium being 90% absorbable.
- Egg shell powder is made by boiling the egg shells for 5–10 minutes to kill any pathogens, followed by drying and grinding
- Egg shell powder can be used as food supplements, for instance, for people with osteoporosis
- Extrusion technology has been used to incorporate egg shells into the feed of laying hens

11.7 GELATIN

A new potential source for gelatin is chickens using the skin, bone, etc. remaining after further processing. It has a higher content of glycine, hydroxyproline and proline and has a higher thermal stability than mammals and fish gelatin. In the food industry, poultry gelatin is used in the following:

- Sweets/candy provide chewing ability, texture and foam stabilization
- Low fat spreads to provide firmness and texture
- Baking products as emulsions, gels and stabilizers and
- Meat products allow water content

11.8 MECHANICALLY SEPARATED POULTRY MEAT

- Mechanically-separated chicken meat is made from the deboning and cutting of parts with lower commercial value such as the back and the neck

- In every deboning process, after the removal of the usual meat cuts, there is always an amount of meat which is firmly attached to the bones
- Mechanically separated meat is a product resulting from the mechanical separation of the meats attached to the bones. Normally the mechanical separation is made for bones of irregular shape, more difficult to be manually deboned, such as vertebral column and neck.
- However, other bones with attached meat or whole carcasses can be submitted to mechanical separation
- Large amounts of mechanically deboned poultry residues produced after traditional processing of poultry
- This meat has average composition of 17% protein and 13% fat
- The protein is primarily collagen but 20% is sarcoplasmic and myofibrillar protein
- Extraction of this protein may be accomplished with NaCl or by alkali treatments followed by acid precipitation

CHAPTER - 12

PET FOODS

Meat, poultry and seafood byproducts, feed grains and soybean meal are the principal ingredients in pet food products.

Pet foods are categorized as

1. Dry pet food
2. Semi-moist (intermediate moisture) pet food
3. Canned pet foods
4. Frozen desserts/feeds

12.1 DRIED PET FOOD

- Dried pet food occupies approximately 80% of the pet food market
- Most of the products are gelatinized and expanded product made by extrusion technology
- Exploded products are light, popped and more palatable
- It contains
    - o animal byproducts (e.g., meat meal, meat and bone meal, meat byproducts, and poultry byproducts)
    - o fats and oils (e.g., animal fats)
    - o milk products (e.g., dried skimmed milk and dried whey)
    - o whole or dehulled cereal grains, cereal byproducts, soybean products and
    - o mineral and vitamin supplements

- During manufacturing process, the product is usually heated sufficiently for partial conversion of starch into dextrin
- It can be moulded in the form of meals, pellets, biscuits, or extruded (expanded) products
- Offered to animals either dry or moistened by the addition of water at the time of feeding

Table 12.1 Nutritional quality of dried pet foods

Nutrients	Level (%)
Moisture	10-12
Fat	5-12.5
Protein	20-35
Carbohydrates	35-50
Digestible kcal/g	2.94

12.1.1 Marbled dry pet food

- Produced by blending the required ingredients, processing and cooking portions in an uneven manner and then the uneven processed portion are mixed in a manner so that discrete boundaries separating the portions are discernible
- Other techniques require making two doughs, coloring thems eperately and extruding these two doughs together

12.1.2 Dry bone substitutes

- Bone substitutes may be manufactured by making slurry of animal byproducts (e.g., bones, skins, lungs, livers, hearts, kidneys, heads, and feet), adding a binder, moulding into a hard bone like shape and then dehydrating to make hard structure

12.1.3 Dry pet food with a meat like texture

- Pet food can be made by mixing large proportion of amylaceous ingredients (e.g., starch or starch like material) with conventional dry food ingredients, specific proteinaceous adhesives (e.g., collagen, albumens and casein) and plasticizing agents to produce a product having meat like texture and appearance
- The blended dough is then extruded to get dried products

12.1.4 High fat dried pet food

- By using a homogenization step in the manufacturing process, a dry expanded pet food having high levels of fat (25-30%) without external greasy surface can be prepared

12.1.5 Soft crumb dry pet food mixture

- By mixing ingredients high in starch or grain with flavour ingredients (e.g. fish or meat scrap), hydrolyzed protein, fibrous ingredients and plasticizing agents, a soft crumb dry product is produced
- Fat and fat transport material is then added and thoroughly mixed before the product is extruded

12.2 SEMI-MOIST (INTERMEDIATE MOISTURE) PET FOOD

- Having moderate moisture (25-50%), appears like meat or meat products and contains protein, fat, carbohydrates and digestible energy (kcal/kg) in the range of 16-25%, 3-10% 25-35% and 2,180, respectively
- Sucrose, propylene glycol and sorbates can be used as preservative
- Other bacteriostats like potassium sorbate, calcium sorbate, sorbic acid and 39% polyhydric compounds (e.g., propylene glycol, 1,3 butanediol with 3% acid (acetic) can also be used as preservative for semi-moist pet food

- Modified atmosphere packaging (carbon dioxide packaging) can be used to controls microbial growth during storage
- It contains animal products (e.g., meat and meat byproducts), fats and oils (e.g., animal fat), milk products (e.g., cheese rind), soybean products, carboxymethyl cellulose and mineral and vitamin supplements
- Semi-moist foods are higher in palatability than dry diets and are easy to store and serve

12.2.1 Binders in semi-moist pet food

- Typical binders includes cereal flour as well as pre-gelatinized starch. Sulphur containing amino acids, lower alkyl mercaptans, lower alkyl sulphides and disulphides, thioacids, salts and thiamine are also used as binder sources in some cases
- Typical texture to the product is given by gels
- Heat coagulated proteins such as wheat gluten can also be used as binder

12.3 CANNED PET FOOD

- Animal byproducts (e.g. bones, cheek meat, damaged carcass parts, intestines, liver, lungs and stomach tissue) from slaughtered animals are processed by canning to improve the shelf life of the products
- It contains 74-80% moisture, 8-20% protein, 2-15% fat and 12 kcal/g energy
- It is superior in palatability than the other categories of pet food products

12.3.1 Types of canned pet food

I. Nutritionally complete
II. Nutritionally incomplete

I. Nutritionally complete

- May be either a dry type pet food formula to which water has been added and the product is canned
- May be a high fat product containing animal products (meat and meat byproducts), fats and oils, soybean products and mineral and vitamin supplements

II. Nutritionally incomplete

- It may contain only animal products (e.g., meat and meat byproducts), therefore, it will be low calcium and phosphorus content

12.3.2 Gravy in canned pet food

- pH of the gravy in canned food is lowered to 4.5 by adding sufficient acid (1-2% phosphoric or 0.53.5% citric). It acts as preservative and helps to inhibit the gelling properties of collagen

12.3.3 Gelling agents

- Gelling agents in pet foods are used
  - o to maintain homogeneity during processing and
  - o to control the added moisture
- locust bean gum, carboxymethyl cellulose, guar gum, carrageenan, and other starches and thickeners are used as gelling agent in different types of pet foods

12.4 FROZEN PET FOOD

- Made by combining meat trimmings with dry pet food
- May be prepared from tissue salvaged from animal that have died naturally

12.5 PALATABILITY ENHANCERS

- Added to enhance odour, flavour or texture to make it more acceptable to the pets
- They can be directly added/mixed with the food or may be coated on the surface
- The examples of palatability enhancers are - yeast (e.g., *Ascomycete*/ *Asporogene*), some bacterial cultures, fish solubles, citric and phosphoric acid solution (for cat food), meat digests, amino acids, sweeteners such as fructose and sugar and modified animal or plant fat extracts
- Textural changes also assist palatability like communiting large particle size in food matrix results in improved texture and palatability

CHAPTER - 13

AQUATIC BYPRODUCTS

13.1 SURIMI (FORMED FISH)

- Surimi is the mechanically deboned fish flesh which is repeatedly washed in 5-10 °C water to remove all the water soluble proteins and then cryoprotectant is added
- About 5-20 times volume of water is used to removes water soluble proteins as well as undesirable substances and enzymes resulting in a concentration of the actomyosin
- The last wash can be done with a solution containing 0.01-0.3% sodium chloride
- To remove black skin, bones and scales, the product is dewatered with a screw press and then strained
- Cryoprotectants consisting of 4% sugar, 4% sorbitol and 0.2% polyphosphates is mixed properly with a silent cutter or ribbon blender
- The cryoprotectants protect denaturation of actomyosin during frozen storage

Surimi uses

- Used in manufacturing of many reformed meat and seafood items
- Used as raw material for artificial or imitation crab leg, lobster chunks, shrimp etc.

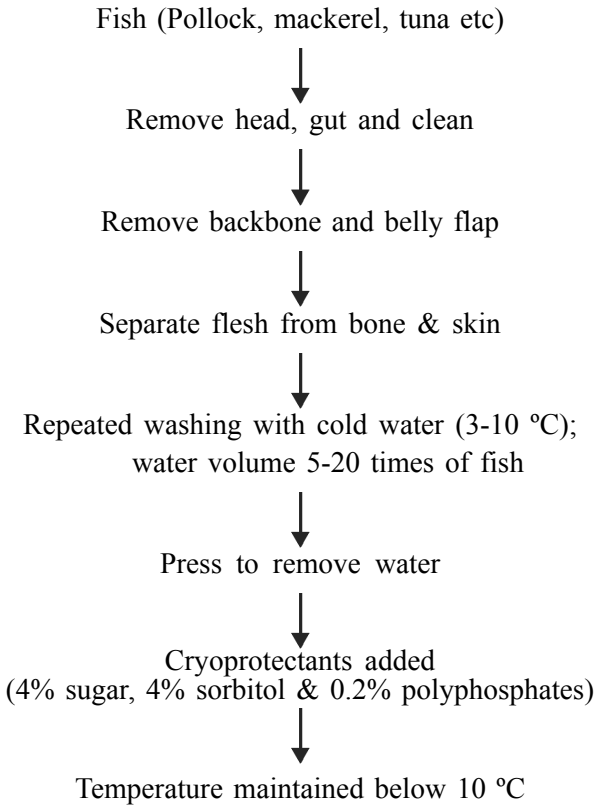


Fig 13.1. Flowchart of surimi manufacturing

13.2 Fish protein concentrate (FPC)

- FPC is bland in flavour and has good functional properties. It can be produced enzymatically modifying whole fish protein using papain, pancreatin, bromelain, ficin etc.
- A tasteless, odourless, colourless powder with a minimum of 67.5% crude protein and a maximum of 0.75% fat is termed as FPC A
- It can be used up to 5-10% level without affecting acceptability of the finished products
- As FPC A is prepared from whole fish, including viscera, bones, scales, etc., it may contain some adulterants

- FPC is highly nutritious, stable and safe
- A products with 10% fat content and a distinct fishy smell and taste are categorized as FPC B

13.3 PRODUCTION OF FISH MEAL AND OIL

- Fish meal has become very popular animal feed ingredient because of its high nutritional value
- It has high level of essential amino acids especially lysine, B-complex vitamins (B_{12}, choline, niacin, pantothenic acid and riboflavin) and minerals such as calcium, copper, iron, phosphorus and other trace minerals and is low in fibre
- Feeding of fish oil to poultry leads to increase in omega-3 levels in meat and eggs
- It may impart ''fishy'' odour to egg or milk
- Fish meal and fish oil are produced in a ratio of 3:1

Table 13.1 Chemical composition of fish meal

Component	Percentage range	Comment
Protein in fish flesh	15-18	
Protein in fish meal	50-77	Most meals 60-65 %
Fat	5-15	Desired level 8% (maximum)
Free fatty acid	7.5-12	
Ash	8-33	18% satisfactory12% in high proteinmeal33% in low protein meal
Salt	3-4	
Moisture	6-1	8% is satisfactory, 12% subject to mould growth
Digestibility (%)	92	

13.4 PROCESSING OF FISH FOR FISH MEAL AND FISH OIL PRODUCTION

- Most commonly used methods are: batch dry rendering and continuous wet rendering method

1. Batch dry rendering method

- This method is used only for non-oily fish such as cod and haddock canning waste
- It is much easier to manipulate the processing conditions than the continuous wet reduction method

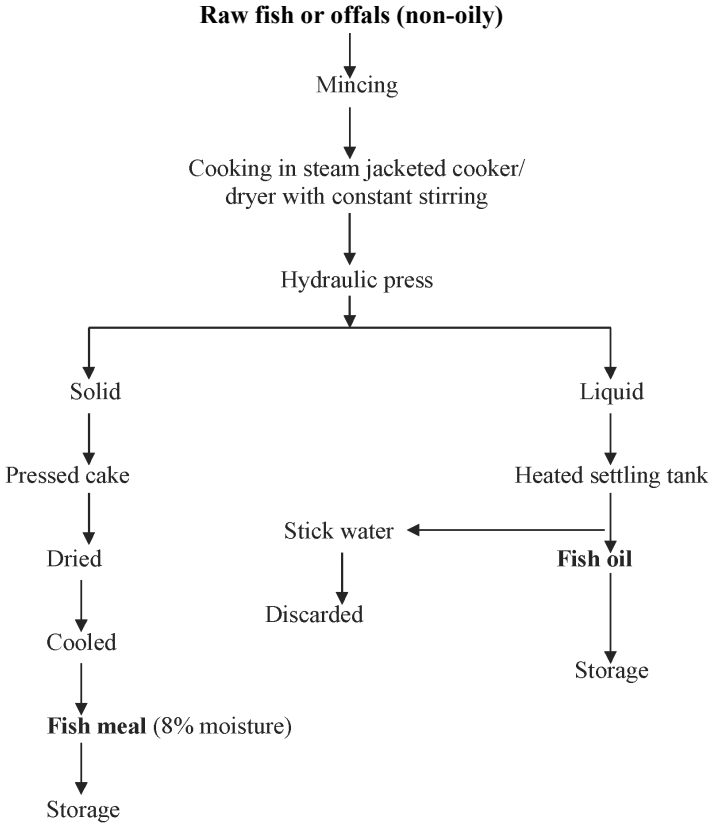


Fig. 13.2 Flowchart for preparing fish meal and fish oil

2. Continuous wet rendering method

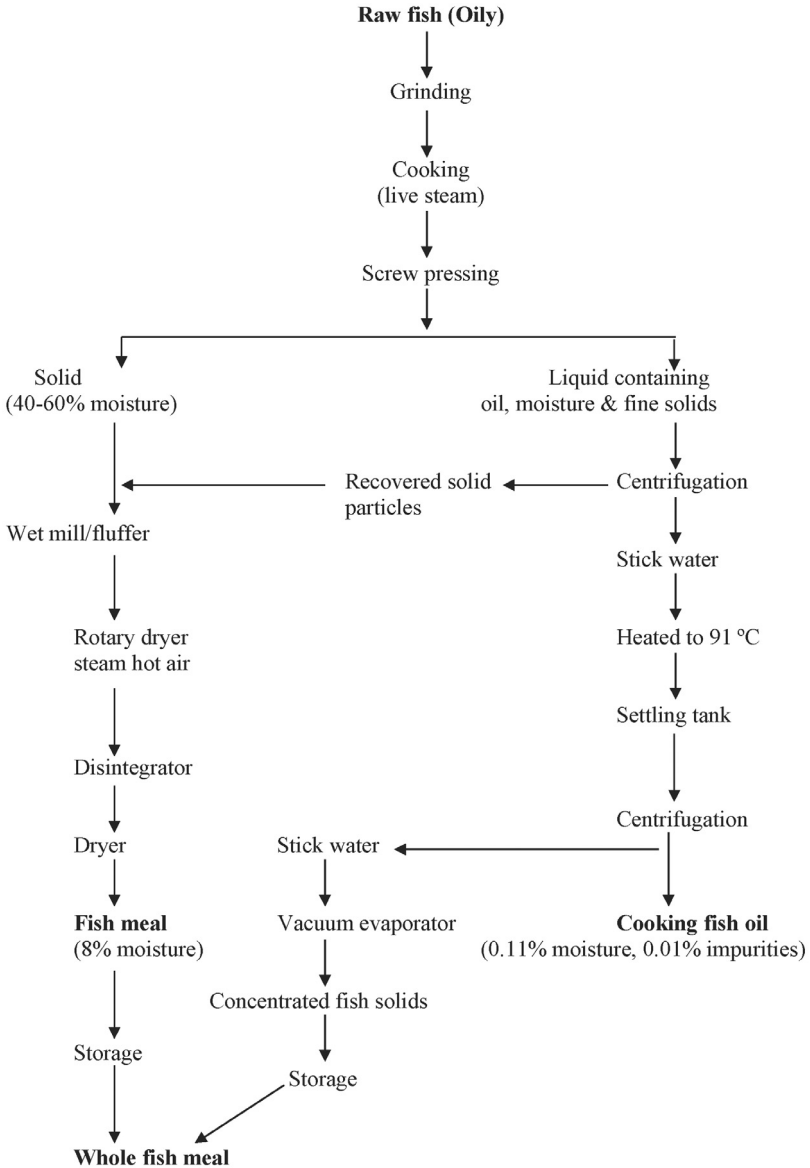


Fig. 13.3 Flowchart of continuous fish wet reduction for preparing fish meal and fish oil

- The wet reduction method is a continuous process and can handle large quantities of fish in one shift
- It uses a continuous cooker with the product being moved through the cooker by a screw conveyor
- Later, steam is injected into the cooker which coagulates the protein and releases the oil

Table 11.4 Comparisons of dry and wet reduction methods of producing fish meal

	Dry method	Wet method
Type of operation	Small, batch & slower	Large, continuous & faster
Installation and cost of operation/capacity	More expensive	Less expensive
Ease of operation	Easier	More complex
Flexibility of operation	More	Less
Production capacity	Less	High
Yield of oil from low oil fish	Large	Smaller
Yield fish solubles	No	Yes
Oil quality	Darker and inferior	Light and superior
Meal contains water soluble material	Yes	Usually does not

13.5 PRODUCTION OF FISH PROTEIN HYDROLYSATES

- The fish protein can be progressively hydrolyzed into peptones, albumin or amino acids using different proteolytic enzymes
- Of the protein fraction, approximately 16-22% is albumin which has chemical properties similar to egg white

I. Fish peptones

- Peptones are partially hydrolyzed proteins that are soluble in water but non-coagulable upon heating

- Fish peptones is prepared by grinding the fish flesh with water and hydrolyzing it with peptic or tryptic enzymes or with acid or alkali at elevated temperature and pressure

II. Fish albumin

- Low-fat fish such as mollusks and crustaceans are used to extract fish albumin
- The flesh or scraps are cooked for 1 h at 80-90 °C after mincing with 0.5% acetic acid, by which the flesh is partially hydrolysed and most of the connective tissue get extracted
- After that the material is washed to remove acid and digested proteins
- To remove the fat, ether alcohol or trichloroethylene is used for extraction for duration of about 6-8 h
- The final products can be used as whipping, suspending or stabilizing agent in place of egg albumin
- It can be used in confectionery products, bakery products, ice cream, soap, puddings, custard and mayonnaise etc.
- Industrial uses include paints, varnishes, lacquers, foam extinguishers, textiles, paper, soaps and cosmetics as one of the ingredient

III. Fish amino acid

- Proteolytic enzymes, acids, or alkalis can be used for hydrolysis of fish protein for production of fish amino acid
- Can also be hydrolyzed by yeast, enzymes produced by molds or bacteria or plant enzyme like bromelain
- Used in pharmaceutical products and may also be supplemented in human food, animal feed or fertilizer

13.6 CANNERY WASTE

- Cannery waste includes salmon canning industry waste where one third of the fish goes as waste
- It is composed of 56% head

- It can be fed directly to mink or processed into pet food and the heads can also be used as halibut bait

13.7 CONCENTRATED FISH SOLUBLES

- It is a byproduct obtained from fish processing and fish meal/oil producing industries
- After steam cooking of these fish byproducts and whole fish, these are pressed using continuous screw press
- The resulting press cake (contains 50% moisture) is dried in oven and the resultant dried product is called fish meal
- The filtrate contains about 5-10% solids is known as press water which is heated (88 °C) and centrifuged to remove the oil
- The resultant product is now called fish stick water which contains 1% oil, 0.75-1.25% insoluble proteins and 3-5% soluble proteins
- Now, to obtain concentrated fish solubles with 50% solid content, the stick water is heated to 82 °C to evaporate the excess water

13.8 FISH SILAGE

There are two principal methods of production of fish silage:

1. **Acid preserved silage:** To lower the pH of silage, inorganic and/or organic acids are added in required amount and liquefaction occurs in silage because of action of naturally occurring enzymes.
2. **Fermented silage:** A fermentable sugar is required to facilitate fermentation process which may occur either with naturally occurring lactic acid bacteria or a suitable starter culture can also be added to generate lactic acid and lower the pH of silage. However, this technique has not been used commercially.
    - Fish silage can be used as a protein supplement to animal feeding and may be fed as a liquid or mixed with carbohydrates
    - In case of high oil content fish, the oil needs to be removed from silage before feeding
    - It may impart a “fishy taint” to the animal products and may leads to rancidity development upon storage

The advantages of silage in relation to feed/meal include the following:

- Storage stability even at high temperature storage
- Microbiologically safe and *Salmonella* is destroyed during processing
- Compared with fish meal, the production costs are low for fish silage
- Can be mixed with carbohydrates for feeding and sundried without fly infestation

The disadvantages of fish silage compared with fish meal include the following:

- Because of more bulkiness, the transportation becomes very expensive
- There are some nutritional disadvantages to fish silage, when fed at high levels

13.8.1 Production of fish silage

- The inorganic acids such as sulphuric, hydrochloric or phosphoric acids can be used for production of silage which lowers down the pH to 2 or below and thereby helps in preservation
- Chalk (calcium carbonate @ 15%, w/w) should be added to neutralize the acidity before feeding it to animals
- Addition of salts at higher concentration results in undesirable flavour in silage
- Organic acids (3% of formic/ propionic acids) are more effective than inorganic acids and neutralization is not required when organic acids are used for silage production but are expensive
- To reduce the cost of production, a mixture of organic and inorganic acids can be used

13.8.2 Nutritional qualities of fish silage

- Amino acids are readily available and stable in fish silage
- Because of presence of thiaminase enzyme, vitamin B_1 present in feed may get degraded and feeding of fish silage for longer duration may lead to thiamine deficiency in animals

- High salt levels in silage can reduce feed intake and growth of animals
- When fed to food animals, it may impart off flavour to carcass
- To reduce off flavours in carcass, the fish lipid level in feed is limited to 1% of the dry weight of feed
- However, in pig feeding, a level of 5-10% of the dry weight of the diet is permissible
- In poultry feeding, 30% of total protein level in chicken diet and 12-23% level for broilers diet can be used

13.9 FISH OILS

- Fish oil in general contains approximately 25% saturated and 75% unsaturated (usually highly unsaturated) fatty acids
- The quantity of unsaponifiables fat is extremely variable in fish oils and cholesterol content is very high in most of fish liver oil, however, the body oils are relatively low in cholesterol content
- As compared to fats from animals, fish oils are more complex due to the presence of long chain of highly unsaturated fatty acids
- Typical odour in fish oil is due to the presence of high level of unsaturated fatty acids
- Fish oils deteriorate rapidly because of the action of natural lipases present in the fish tissue or from microorganisms in the fat. This process generates free fatty acids which causes development of oxidative rancidity
- Release of lipase to some extent can be minimized by maintaining the fish tissue intact rather than minced
- The enzymes can be inactivated by heating tissue or oil to 80-100 °C for 15-20 min.
- Some metals act as catalyst, therefore, avoidance of metals contact will also retard oxidation

13.10 FISH OIL REFINING

Refining of fish oils consists of processes for removal of

1. Free fatty acids
2. Stearine (cold clearing)
3. Pigments (bleaching) and
4. Odors (deodorization)

13.10.1 Removal of free fatty acids can be accomplished by any of the four methods

I. Alkaline refining
II. Vacuum steam distillation
III. Esterification or
IV. Solvent separation

I. Alkaline refining

- This is a most popular and efficient techniques for removal of free fatty acids from oil
- The free fatty acids present in oil are neutralized with NaOH or $NaCO_3$ and heated at 20-30 °C for NaOH and 90 °C for $NaCO_3$ to react with the free fatty acids which leads to separation of oil and soap
- Thereafter, the oil obtained is washed several times with hot water
- Some of the pigments and proteinaceous particles are also removed due to the absorbing properties of soap

II. Vacuum/ steam distillation

- Fishy odour from oil can be removed by this method
- It is very useful technique for deodorization but also removes some of the free fatty acids

III. Esterification

- In this process free fatty acids present in fish oil reacts an alcohol
- Short chain alcohols such as methyl or ethyl and their esters may be removed by vacuum (or steam) distillation process, however, polyhydroxy alcohols such as glycerol and esters may satisfactorily be removed by alcohol esterification

IV. Solvent extraction

- Free fatty acids are more soluble in solvents such as alcohol or dilute acetone, therefore, it can be used to remove the free fatty acids from oils

13.10.2 Removal of stearine (Cold clearing)

- Cold clearing/ winterization/ destearination is the process of separation of the solid triglyceride from the oil in cold condition which prevents the oil from clouding in cold weather or under refrigeration
- This process is desirable for cooking oil and as a constituent in fast drying paints

13.10.3 Removal of pigments (Bleaching)

- It can be achieved by adsorption of the pigments on natural or activated clay or carbon particles.
- The adsorbents along with pigments are removed by filtration

13.10.4 Deodorization

- This can be accomplished by vacuum or steam distillation at high temperatures or by hydrogenation of the oil

13.11 Uses of fish oils

- Food uses as canning oil (salmon and sardine), margarine production, cooking and shortening

- In the medical and animal feed as supplementation for vitamin A and D content. Feeding excessive amounts of fish lipids to animals results in fish taint in animal products
- Industry uses- for the production of soaps and detergents, paints and varnishes, floor coverings and oil cloths, oiled fabrics, printing inks, rubber and lubricants and in the processing of insecticides, cosmetics and processed leather

13.12 TYPES OF COD LIVER OIL

There are three types of cod liver oil depending on purity and vitamin level:

1. **Number 1 oil**
   - Light straw coloured, medical grade oil used for pharmaceutical purposes
   - It is obtained from fresh livers by the thermal rupture (82-87 °C) of the cells which allows the oil to ooze out
   - It has high vitamin A content
2. **Number 2 oil**
   - Due to partial oxidation of the oil, it becomes reddish orange in colour and used as stock feed and for industrial purposes
   - Vitamin A content is low
   - It is obtained by further processing of the residue after extraction of no. 1 oil
3. **Cod oil**
   - It is obtained from partially decomposed livers and appears dark in colour and has high free fatty acids content
   - Similar to fish body oils and has industrial use in lubricating leather and making printing inks, paints and varnishes

13.13 FISH LIVER OILS

- Fish liver oil is high in vitamin A (vitamin A, 4,600 IU/5 ml), D (cholecalciferol, vitamin D3, 460 IU/5 ml), E (*d*-alpha tocopheryl acetate, 0.9 IU/5 ml) and several essential fatty acids such as eicosapentaenoic acid (EPA)

13.14 FISH LIVER PRESERVATION

- Fish liver can be preserved by various ways like:
  i. For short term storage, it can be packed in ice
  ii. Vacuum packaging along with freezing is the best way of preserving fish liver
  iii. A 10% NaCl or a 0.25% formalin can also be added to preserve liver
  iv. 5% solution of 9:1 ratio of soda ash and sodium nitrate is also useful for fish liver preservation

13.15 FISH GELATIN

- Collagen found in skin and bones are the source of gelatin
- In one collagen molecule, three alpha polypeptides chains are coiled together in a triple helix and stabilized by hydrogen bonds
- Each alpha chain has approximately 1,050 amino acids joined together by peptide bonds and there are usually 20 different amino acids in each alpha chain
- The amino acids are in a specific repeating pattern~ usually, glycine is often repeated with proline and hydroxyproline
- Gelatin obtained from fish does not have as good gelling properties as of animal gelatin

Uses of fish gelatin:

- **Edible:** it is free from heavy metals and are also aesthetically acceptable

- Industrial: Chemically and physically suitable for industrial applications
- Glue: Adhesive

13.16 ISINGLASS

- It is made from the air bladder, sound bladder or swimming bladder (rich in collagen) of fish
- Used for production of high grade fish gelatin or glue
- Isinglass is also used as a clarifying agent for wine, beer and vinegar

13.17 LEATHER FROM FISH SKINS

- Skin from aquatic animals can be converted into leather by using the same techniques that are applied to land animals

13.18 CHITIN AND CHITOSAN

Introduction

- Chitin and chitosan are basic (high pH) in nature and are primarily acetylated polymers of glucosamine
- Chitosan (aliphatic polyamine) is a collective term applied to deacetylated chitins in various stages of deacetylation and depolymerisation
- Chitin is a polysaccharide, found in the exoskeletons of a wide variety of aquatic species like clams/oysters, krill, shrimp, crab (all having 3–6% chitin), squid etc.
- After cellulose, chitin is the second most abundant organic substance on earth
- Shellfish waste is mainly used for chitin production and the immediate principal source is shrimp and crab waste
- The backbone or pen of squid which accounts for 1% of the squid body weight is one of the purer forms of chitin. It contains about 40% chitin on dry weight basis
- As chitin fibre is not digestible, it has no calorific value

- It can be used as 'fat trapper' because it attaches itself to lipids or fat in the stomach before it is metabolized

Extraction of chitosan

The manufacture of chitosan from the exoskeletons of crustaceans involve the following steps:

i. Demineralization with dilute acid
ii. To purify chitin, deproteinization with dilute alkali is done at a moderate temperature
iii. Chitin is converted to chitosan by the process of deacetylation with concentrated alkali at a high temperature

Uses of chitin:

i. Paper and textile additives
ii. Food wrapping film and speciality filaments
iii. Absorbents for metal ions
iv. Cements for leather
v. Photographic products
vi. Coagulants useful for flocculating suspensions
vii. Wound healing activity
viii. To produce yeast single cell protein

Uses of chitosan:

i. Dewatering of sludge
ii. Water purification
iii. Ion exchange
iv. Chelating solids for chromatography
v. Tough, flexible films
vi. Wound healing
vii. Adhesives
viii. Ion exchange membranes
ix. Laundry shrinkage control

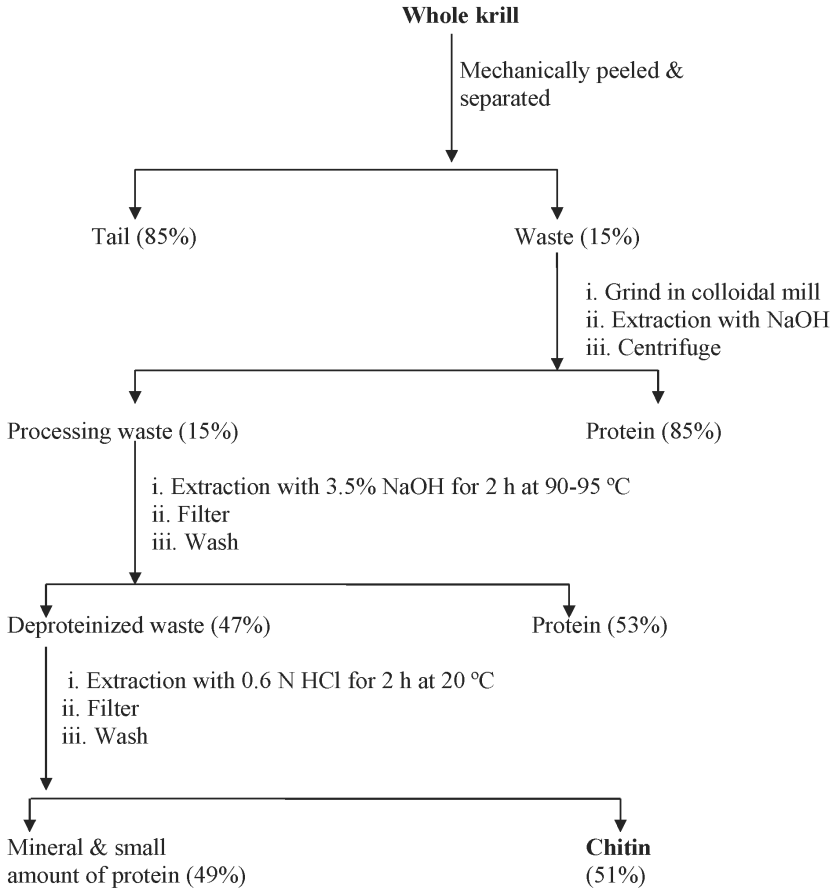


Fig. 13.4 Processing of krill for chitin production (from Anderson et al., 1977)

13.19 PEARL ESSENCE

- Epidermal layer and on the scales of fish species that swim near the surface of the water (e.g., herring and mackerel) contains *Quanin* (a nucleoprotein) which is an iridescent substance
- Used to coat objects to give them a lustrous effect
- A suspension of crystalline quanin in a solvent is called pearl essence

- When quanin is deposited on the inside of hollow beads or coated on the surface of solid beads, it produces an optical effect similar to real pearls
- Pearl essence can be obtained from the scales of many pelagic fish

Recovery of pearl essence by
scrubbing & washing quanin from **fish scales**

↓

Done using large agitator similar to a domestic washing machine

↓

Centrifugation

↓

Impure pearl essence

↓

Protein removal by pepsin digestion
in an acid medium at 25-30 °C for 50 h

↓

Fat removal by solvent

↓

Centrifugation

↓

Crystalline quanin

↓

Suspension in aqueous (water) or
a non-aqueous liquid (acetone etc)

↓

Pearl essence (pure)

13.20 USE OF SHELLS

Shells have been used to raise the pH of agricultural soil (liming), as a feed additive to add calcium and other minerals to animals' diets and to build roads.

CHAPTER - 14

WOOL

14.1. INTRODUCTION

Indian wool industry is a rural based export oriented industry and caters to civil and defence requirements for warmer clothing. In our country, sheep wool is the major source of woollen fibre. India is the 3rd largest sheep populated country in the world with 65.07 million sheep and produced 43.50 million kg of raw wool in 2017-18. The sheep population increased to 74.26 million and wool production decreased to 36.74 million kg in 2019-20. Out of this, about 85% is carpet grade wool. The 5% apparel grade and remaining 10% coarse grade wool for making rough *Kambals* etc. Average annual yield per sheep in India is 0.9 kg against the world average of 2.4 kg. A small quantity of specialty fibre is obtained from *Pashmina* goats and Angora rabbits. The domestic production is not adequate, therefore, the industry is dependent on imported raw material and wool is the only natural fibre in which the country is deficient.

14.2 WOOL

Wool consists of the following major layers:

i) *Scales*

- On the outer side of wool as protective sheath
- Irregular shaped scales
- Pointed towards the end (root) of the wool
- Scales are lubricated naturally by fat called wool sweat, wool soap, yolk or suint

- Wool sweat is produced in special glands
- Excessive wool sweat is undesirable
- Degree of wool sweat is denoted by conditions
- Suint is water soluble
- Purified suint is called lanolin- forms emulsion with water- used in different ointments
- Scales protects the inner structure of fibre called cortex

ii) *Cortex*

- Cortex is the main fibre body
- Consists of long cemented fibrils
- Gives the fibre strength and elasticity
- Have intermediate cells that hold the color pigment

iii) *Medulla*

- The innermost layer which consists of large spiral-shaped, air filled cells
- Found in hair
- Absent in true wool
- The medulla is discernible only in coarse and medium wools and only under high magnification
- Some wool fibres that have no cortical layer are compensated with a large proportion of medullary cells
- The larger the medulla, the lower is the quality (breaks easily) and harsher the fibre
- Wool having large central medulla becomes harsh, dull and lack strength and elasticity
- Wool having larger medulla reflects the light differently
- The presence/absence of medulla depends on breed- Merino- no medulla
- Sheep raised in tropical/subtropical regions have large medulla
- By crossing wool sheep with hair sheep, medulla is eliminated and fibre appears in the form of true wool

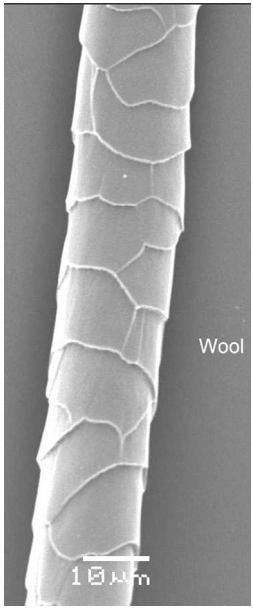


Fig. 14.1. Wool fibre under microscope showing only the outer cuticle of wool (Ainsworth & Zhang, 2005).

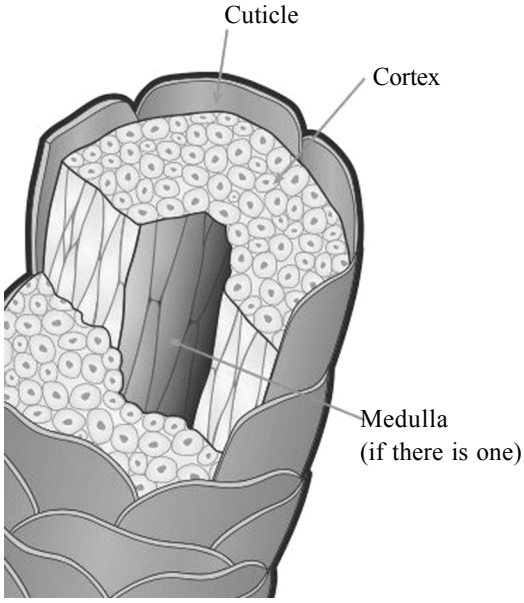


Fig. 14.2. Components of wool fibre (Mouery's Flooring, 2019).

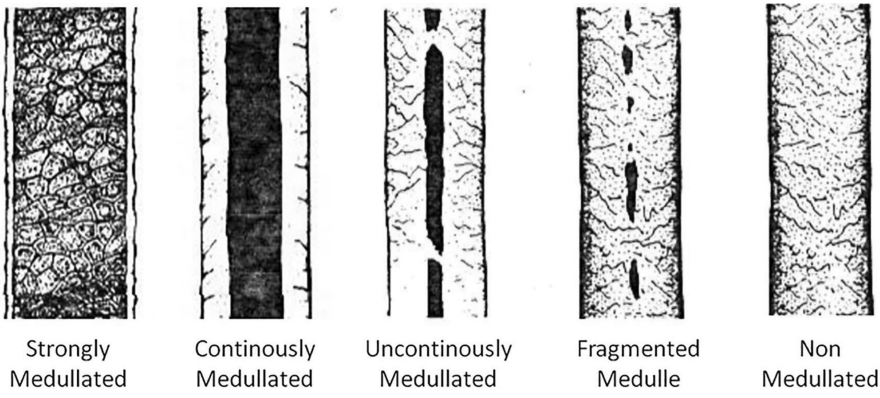


Fig. 14.3 Medullation in wool fibre

Kemp

Short hairy fibres grow on the body of even in true wool sheep called kemp

Shorn wool

Vast quantities of wool derived by shearing is called shorn wool

Fleece

Denotes the whole coat of wool shorn from a sheep at one time

Pulled wool

Wool obtained from slaughter houses, packing plant or tanneries

Raw wool/grease wool

- Shorn/pulled wool as it comes from sheep
- Contains grease, suint, mineral and vegetative impurities

Wool shrinkage

Weight difference between raw and clean wool

14.3 DESIRABLE CHARACTERISTICS OF WOOL

- *Fineness*
  - Finer the fibre, the higher the insulating properties of wool and thus, more valuable the wool. Fibre diameter varies from 1/500th to 1/1500th of an inch.
- *Length*
  - 2.5" for fine wool and 4" for coarse wool
- *Soundness*
  - Must withstand rough treatment in carding machines
  - Drought, malnutrition, disease affects the soundness
- *Colour*
  - Market prefers white wool
  - Black wool- wool of any other colour

- *Elasticity*
  - o Wool fibre can stretch up to 70% of its length without breaking
  - o Elasticity and strength are the two most desirable qualities governing wool durability
- Softness and lustre
- Heat-retaining property
  - o Makes wool superior
- Moisture absorbance
  - o The ability to absorb water up to 35% of its own weight before the moisture become apparent is preferred quality of wool

14.4 PHYSICAL PROPERTIES OF WOOL FIBRES

Physical properties of wool fibres are given below:

I. Fibre size and shape

- Typical merino fibres are 50–125 mm long
- Have irregular crimp (curvature)
- The fibre surface is rough as a consequence of the outer layer of overlapping cuticle cells
- The most important dimension is the fibre diameter
- Coarse wool fibres (25–70 μm diameter) are used in carpets
- Fine merino fibres (10–25 μm) are used in apparel

II. Color

- The color of wool fibre could be white, near white, brown and black

III. Tensile properties

- The tensile properties of wool are variable
- Typically, at 65% RH and 20 ºC individual fibres have a tenacity of 110– 140 N/ktex (Newton per kitotex) (140–180 MPa), a breaking elongation of 30–40% and an initial modulus of 2100–3000 N/ktex (2.7–3.9 GPa) (Gigapascal)

IV. Elongation at break

- Standard elongation is 25 – 35% and 25 – 50% in wet condition

V. Elastic Recovery

- Good

VI. Specific Gravity

- Specific gravity of wool is 1.3 – 1.32

VII. Moisture Regain (MR %)

- Wool is hygroscopic and able to absorb and desorb large amounts of water as the relative humidity surrounding the fibre changes
- The amount of water absorbed is generally expressed as a percentage of the dry weight. This is referred to as "regain"
- Standard moisture regain is 16 – 18%

VIII. Resiliency

- Excellent

IX. Lustre

- Lustre of course fibre is higher than fine fibre

X. Effect of Heat

- Heat affects the wool fibre greatly
- Wool becomes weak by heat
- It softens when heated or treated with boiling water for long time
- At 130 ºC, it decomposes and chars at 300 ºC
- Wool does not continue to burn when it is removed from flame

XI. Effect of Sun Light

- The main chemical components (keratin) of wool decompose under the action of sun light
- The sulphur in wool is converted into HSO
- The fibres become discoloured and develop a harsh feel

14.5 CHEMICAL PROPERTIES OF WOOL

Wool is a keratin protein fibre. Chemical properties of the wool fibre are given below:

I. Effect of acids

- Wool is attacked by hot concentrated sulphuric acid and decomposes completely
- It is resistant to mineral acids of all strength even at high temperature
- Nitric acids damages it by oxidation
- Dilute acids are used for removing cotton from mixtures of two fibres
- Sulphuric acid is used to remove vegetable matter during the carbonizing process

II. Effects of alkalis

- Wool keratin is sensitive to alkalis
- Wool will dissolve in caustic soda solutions
- Strong alkali affects the wool fibre
- Weak alkali does not affect wool

III. Effect of organic solvent

Wool does not get affected in organic solvents

IV. Dyeing ability

Wool fibre could be dyed by basic dye, direct dye and acid dye

14.6 COMMON DEFECTS OF WOOL

- *Hairiness*
  - The presence of wool hair in the true wool fleece is a definite degrading factor
- *Breaks*
  - Wool breaks easily due to nutritional factors, diseases or changes in climate, pasture etc

- Draught, fever, starvation or even pregnancy and lactation result in poorer fibre which breaks easily

- *Cotts*
  - Term denotes a condition where the coarse fibres which are shed into the fleece become felted together
- *Lack of uniformity*
  - Variation in length and diameter of the fibre
- *Impurities*
  - Vegetable and mineral origin, stains from urine, parasites, plants etc.
- *Skirting*
  - Process of separation of inferior wool (greasy, dirty, seedy or hairy) from the superior quality of wool from the fleece

14.7 CLASSIFICATION OF WOOL ON THE BASIS OF ITS USE

Wool is classified based on its end-use. According to its fibres length, wool is divided into following three categories:

14.7.1 Combing wool

The long fibres are combed and then twisted during the spinning of the yarn

14.7.2 Clothing wool

- They are the shorter length wool which cannot be twisted easily and therefore, they are carded and mixed so that the fibres point in different directions
- Carding is a process of separating and straightening the raw wool fibres into long strands in order to make it easier to spin into wool yarn
- It is then drawn into yarn

14.7.3 Carpet wool

- Wool which contains some proportion of medullated coarse and resilient hair and kemp fibres are used in the manufacture of carpets
- The fibre diameter and staple length are the most important characteristics
- Carpet wool quality and its value are primarily determined by fibre diameter and length
- Wool with average fibre fineness ranging from 30 to 50 μm containing hetero and hairy-type medullated fibre admixed with pure fibre with an adequate fibre length is termed as carpet wool
- In general, wool with average fineness (diameter) ranging from 30 to 50 μm with medullation ranging from 15% to 68% is considered to be carpet wool
- Promising Indian breeds producing carpet-type wool are *Chokla, Magra, Nali, Patanwadi, Marwari and Jaisalmeri*

✓ Wool coming out from combing is called worsted and those from carding are called woollens

14.8 CLASSIFICATION OF WOOL ON THE BASIS OF ITS QUALITY AND FINENESS

14.8.1 Merino wool

- Merino sheep produces best wool. The staple is relatively short
- Staple length ranges from 1 to 5″
- The fibre is strong, fine and elastic
- It has greatest amount of crimp
- Has maximum number of scales
- Used for best wool clothing

14.8.2 Class-two wools

- Quality slightly lower than merino wool
- Staple length ranges from 2 to 8″
- Has a large number of scales per inch and has good crimp
- The fibres are strong, fine and elastic

14.8.3 Class-three wools

- The fibres length varies from 4 to 18″
- Coarsened fibres having few scales and less crimp than merino and class-two wool
- Smoother and more lustrous
- Good enough for clothing

14.8.4 Class-four wools

- Fibre length ranges from 1 to 16″
- Fibres are coarse, hair like
- Have relatively few scales and little crimp
- Fibres are smooth and lustrous
- Mainly used for carpets, rugs and inexpensive low-grade clothing

14.9 CLASSIFICATION OF WOOL ON THE BASIS OF FLEECE ORIGIN

Wool shorn from young lambs differs in quality from that of older sheep as fleece differs from live or dead sheep. Therefore, fleece needs to be classified as:

14.9.1 Lamb's wool

- The first fleece sheared from a lamb about six to eight months old is known as lamb's wool or fleece or first clip wool

- This wool is of very-very fine quality
- The fibres are extremely soft

14.9.2 HOGGET WOOL

- Wool from 12 to 14 month old sheep for the first time
- The fibre is fine, soft, resilient and mature
- Good strength and is used for warps

14.9.3 Pulled wool

- Wool from slaughtered animal
- Is of inferior quality
- Roots of fibres are generally damaged

14.10 IMPURITIES OF WOOL AND ITS REMOVAL

- The impurities consist principally of wool wax, dirt, proteinaceous contaminants and suint
- The latter is a water-soluble component, consisting mainly of potassium and other inorganic salts arising from perspiration
- Raw wool contains 40% or more by weight of impurities in the form of waxes, suint, cellulosic material such as straw and dried grass, dirt and proteinaceous material
- Besides, during spinning and weaving other impurities are added

Removal of wool impurities

- Wool waxes are recovered/ removed from the grease during scouring
- These waxes are comprised of a variety of monocarboxylic, dicarboxylic and hydrocarboxylic acids as well as steroidal alcohols
- Suint is water-soluble materials removed by scouring
- The dirt that is removed from the scoured wool consists of both inorganic and organic materials

- The proteinaceous material from the skin flakes of the sheep is also present in wool as impurity

The process that can remove the impurities has various steps:

a. Wetting: The first treatment given to wool is wetting. This treatment releases latent strains and gives permanent set.

b. Scouring

- Wool contains a high percentage (30-60%) of wool grease
- Wool is degraded rapidly with alkali and so, sodium carbonate, ammonia or ammonium carbonate solution is used for scouring
- The pH should never be above 10

c. Carbonizing (removal of burrs)

- Burr is mainly cellulosic material
- The method consists of hydro extracting with 6-8% H_2SO_4 then drying the wool by heating
- After carbonizing, fabric is passed through milling machine and thus, removing all vegetable impurities from wool

d. Bleaching: Yellowish color on the fibres is removed only if the goods are to be sold as white or light colour. Bleaching can be done by

i) Sulphur dioxide (SO_2)

- It is a cheap process known as **staving**
- Sulphur is burnt in chambers where the wool is hanging in loop on wooden poles
- Sulphur forms sulphur dioxide which acts on the yellow colouring matter

ii) Hydrogen peroxide (H_2O_2)

- It gives a better white colour
- Fabrics are treated in winch machine
- The materials are left overnight in the bleach liquor

- For complete bleaching, wool is washed after overnight dipping in bleach water and then treated with dilute acetic acid and again washed with water
- This method is preferred over staving

14.11 FACTORS INFLUENCING THE WOOL QUALITY

1. Genetic influences

- The rate of production of wool or hair and the range of variation in the quality characteristics of wool is determined by genotype
- Genetically high-producing Merino sheep have follicles which are usually straighter and deeper in the skin, grow wool of a lower sulphur content and have a lower concentration of cystine in plasma than low-producing sheep

2. Physiological and environmental influences

2.1 Nutrition

- Variations in the supply of nutrients to the follicles can exert a considerable influence on the rate of fibre production and the characteristics of the fleece
- The herds with higher diseases and ill health have lower production such as growth rate, meat and wool production
- Many of the effects of minerals appear to be due to changes in the supply of major nutrients brought about by changes in feed intake or in the balance of nutrients flowing from the rumen
- Specific effects on fibre growth for zinc and copper
- Zinc deficiency in sheep causes brittle wool and loss of crimp; extreme deficiency causes cessation of fibre growth and fleece shedding

2.2 Hormones

- Fibre growth is markedly hormone dependent

- The pituitary hormones including thyroid stimulating hormone (TSH), adrenocortico-trophic hormone (ACTH) and growth hormone (GH), exert a controlling influence on wool growth
- Growth hormone stimulates wool growth in normal sheep by stimulating secretion of polypeptides known as somatomedins

3. Physiological state: Wool production is influenced by the age and sex of animals and by reproduction in the ewe.

3.1 Age

- Less wool is grown by young animals per unit of feed intake, presumably due to competition for nutrients between follicles and other tissues
- Maximum fleece weights in sheep have been observed as from 3 to 5 years of age, with variable rates of decline in wool production thereafter
- The number of active follicles decreases with age

3.2 Sex

- Wethers generally produce 10–15% greasier and clean wool than non–breeding ewes
- Also, wethers and breeding ewes may produce lower strength wools compared to rams due to;
  - o wethers are often run in poorer paddocks
  - o Pregnancy and lactation can depress staple strength in breeding ewes
- Rams tend to produce more wool than wethers and ewes, due mainly to their greater size and the better feeding given to rams
- There can be substantial reductions in wool growth rate during both the latter half of pregnancy and early lactation

4. Parasites and diseases

- Various microbial infections and external parasites can reduce wool production
- Infections with internal parasites can considerably reduce wool growth

5. Weather and photoperiod

- Wool growth, especially length growth rate, is specifically retarded by low temperatures
- The effects are presumably related to reduced blood flow and hence nutrient supply
- Follicles actively produce fibre for only a short period of time followed by lengthy periods of inactivity
- The environmental stimulus is day length or photoperiod, inactivity being induced by decreasing day length and activity stimulated by increasing day length

14.12 WOOL PROCESSING

The conversion of raw wool into a textile fabric or garment involves a long series of separate processes. There are two main processing systems:

i. Worsted

ii. Woollen

A significant volume of wool is also processed on the semi-worsted system for carpet use. The scouring and carbonizing processes are common to both the systems.

i) Scouring

- The first stage in wool processing is to remove the fleece impurities by scouring
- The impurities consist principally of wool wax, dirt, proteinaceous contaminants and suint
- Scouring is carried out by washing the raw wool in an aqueous medium, a solvent medium or a combination of the two
- This involves washing the raw wool in aqueous solutions (neutral or slightly alkaline) of non-ionic detergent or, less frequently, soap and alkali
- This is followed by rinsing in water

ii) Carbonizing

- Carbonizing is a process used to remove excessive amounts of cellulosic impurities like burrs and vegetable matters (eg, burrs and seeds from pastures) from wool
- The wool is treated with aqueous sulphuric acid and then baked
- The cellulosic matter is rapidly destroyed by the hot concentrated acid by conversion into friable hydrocellulose whereas wool is scarcely affected by the treatment

iii) Processing on the worsted and woollen systems: After scouring, the wool is dried and blended.

In worsted processing

- First, carding is done
- Carding individualizes the entangled fibres and reassembles them into a "sliver"
- Gilling also removes the remaining vegetable matters
- After carding, there are three stages of gilling, to align fibres and remove hooked fibre ends before combing and finally, yarn is obtained

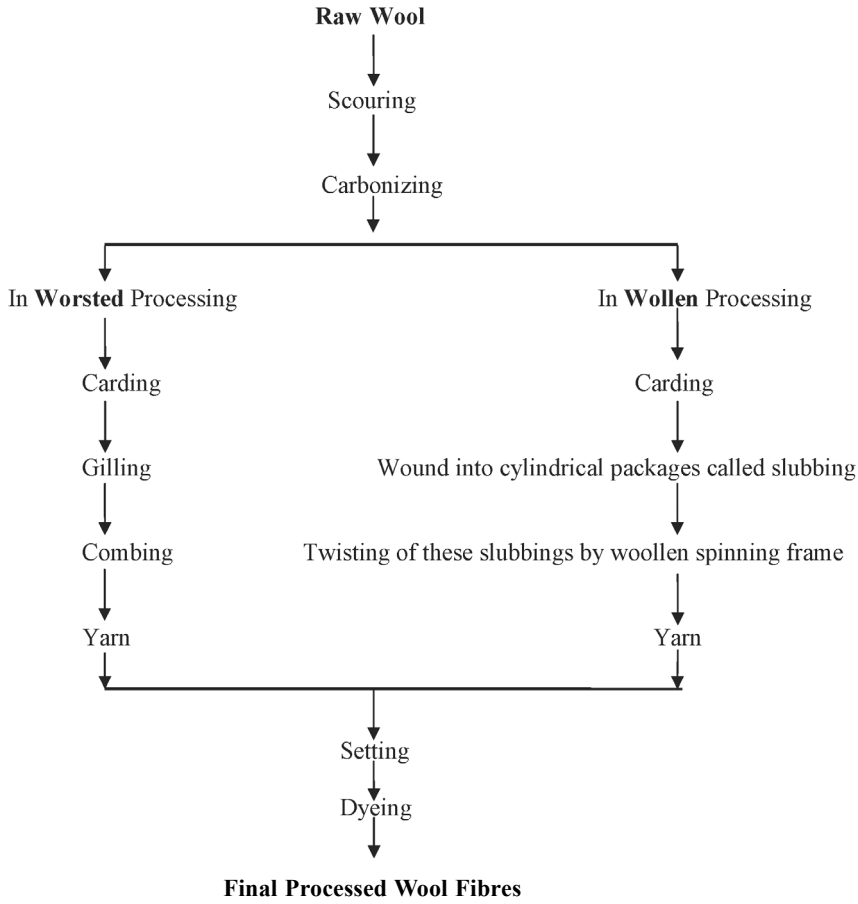
In woollen processing

- There are no highly efficient mechanical methods to remove vegetable matter
- Generally, very clean scoured wool, combed wools or carbonized wool must be used as inputs
- Alternatively, fabrics must be carbonized
- A much longer carding than in worsted processing
- Shorter fibres are used
- The web of fibres at the card delivery is split longitudinally into about 120 ends, rubbed to impart cohesion and wound into cylindrical packages called slubbing
- Twisting of these slubbings occurs on the woollen spinning frame to produce woollen singles yarn
- This yarn can be woven without any further processing

- Thus, woollen spinning has very short sequence of operations compared to worsted processing
- Woollen yarns are coarse and so economically uncompetitive with worsted yarns

iv) Setting: Yarn is set in steam to stabilize twist and prevent snarling during winding and warping. Fabrics may be set after weaving to prevent the formation of distortions during wet processes such as dyeing.

Flowchart of wool processing:



v) Dying

- Wool is dyed from aqueous solutions usually under acidic conditions
- The majority of dyes used on wool are sodium salts of aromatic anions
- The ratio of the mass of dyestuff solution to the mass of wool ranges from approximately 10:1 to as high as 60:1

14.13 GRADING OF WOOL

- Certain qualities such as fineness, length, color and appearance determine the end use and value of wool
- Fineness, the fibre diameter, or grade, and its distribution is one of the most important of these quality factors
- Fineness largely determines the end use of the wool like suit, sweater, blanket or socks
- In general, grade refers to the average diameter or thickness of the fibres

Three systems of wool grading are commonly used

I. American or Blood system

II. English or Spinning Count system and

III. Micron system

All three systems are measures of average fibre diameter and can be related to each other.

Major Wool grading systems are:

14.13.1 THE AMERICAN OR BLOOD SYSTEM

- The American system of grading wool was developed in the early 1800s when the native coarse-wooled sheep were being bred to fine wooled Merino rams imported from Spain

- It assumes that the offspring of the cross would have fleece intermediate in fineness between the two parents
- The wool grade is defined as the percentage of Merino blood carried by the sheep that typically would produce a particular fineness of wool
- The grade or fibre diameter came to be expressed as fine, 1/2-blood, 3/8-blood, 1/4-blood, low 1/4-blood, common and braid
- Nowadays, not used by wool processors

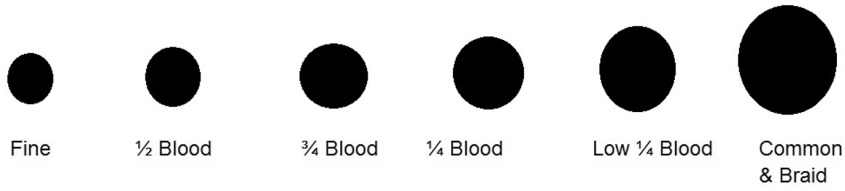


Fig. 14.4. Representational diameter of different grades of wool based on American or Blood System of wool grading. Note that the diameter of the wool increases as the wool quality decreases.

14.13.2 The English or Spinning Count System

- The English system of grading wool provides narrower ranges and a more exact nomenclature than the American system
- It uses a measurement called the "spinning count" expressed as 's'
- Shipping ount is the number of "hanks" of yarn which could be spun from one pound of clean wool on the equipment available at the time the system was developed
- As wool becomes finer, more hanks or yards of yarn can be spun from a pound of clean wool and the spinning count becomes larger
- In theory, one pound of clean 62s spinning count wool could produce 62 hanks or 104,160 feet of yarn (A hank of yarn is 560 yards in length)
- The English or Spinning Count system of grading wool provides a numerical designation of fineness

- English or Spinning Count grades of wool commonly used are the 80s, 70s, 64s, 62s, 60s, 58s, 56s, 54s, 50s, 48s, 46s, 44s, 40s, and 36s

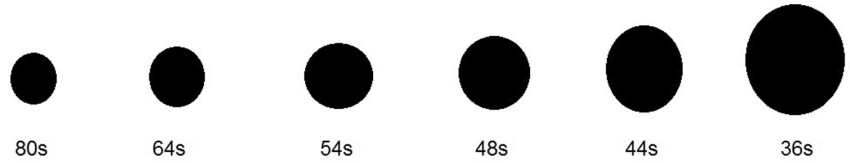


Fig. 14.5. Representational diameter of different grades of wool based on English or Spinning Count System of wool grading. Note that the diameter of the wool increases as the wool quality decreases.

14.13.3 The Micron system

- Increased emphasis on an exact and highly descriptive method of describing wool grade in which individual fibres are accurately measured
- The unit of measure is the micron, which is one-millionth of a meter or 1/25,000 of an inch
- Fineness is expressed as the mean fibre diameter
- Prevalent system of wool grading

14.14 FUR

- Fur is the hair covering of non-human mammals, particularly those mammals with extensive body hair that is soft and thick
- Animals like fox, rabbit, mink, beavers, otters, seals, chinchilla, raccoon and opossum produce fur
- Fur consists of two layers, down hair/undercoat/ground hair and guard hair
- *Down hair/undercoat/ground hair*
  - o The bottom layer consisting of wool hairs
  - o Usually wavy or curly without straight portions or sharp points

- Tend to be shorter, flat, curly and more numerous than the top layer
- Its principal function is thermoregulation
- It maintains a layer of dry air next to the skin and repels water, thus providing thermal insulation

Table 14.1 Relationship between the American, English and Micron Systems of grading wool

Type of Wool	American or Blood Grade	English or Spinning Count Grade	Micron (range in avg. fibre diameter)
Fine	Fine	Finer than 80s	Under 17.70
Fine	Fine	80s	17.70-19.14
Fine	Fine	70s	19.15-20.59
Fine	Fine	64s	20.60-22.04
Medium	1/2 Blood	62s	22.05-23.49
Medium	1/2 Blood	60s	23.50-24.94
Medium	3/8 Blood	58s	24.95-26.39
Medium	3/8 Blood	56s	26.40-27.84
Medium	1/4 Blood	54s	27.85-29.29
Medium	1/4 Blood	50s	29.30-30.99
Coarse	Low 1/4 Blood	48s	31.00-32.69
Coarse	Low 1/4 Blood	46s	32.70-34.39
Coarse	Common	44s	34.40-36.19
Very Coarse	Braid	40s	36.20-38.09
Very Coarse	Braid	36s	38.10-40.20
Very Coarse	Braid	Coarser than 36s	Over 40.20

- *Guard hair*
  - The top layer consisting of longer, generally coarser, nearly straight shafts of hair that protrudes through the down hair layer

- This layer of the coat displays the most marked pigmentation and gloss, including coat patterns adapted to display or camouflage
- It is also adapted to repelling water and blocking sunlight, protecting the undercoat and skin from external factors such as rain and ultraviolet radiation
- Many animals, such as domestic cats, erect their guard hairs as part of their threat display when agitated

Use of fur

Animal furs are used in garments and may be dyed bright colors to mimic exotic animal patterns or shorn down to imitate the feel of a soft velvet fabric

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