ANIMAL BYPRODUCTS

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Animals are slaughtered mainly for meat. A sizeable quantity of byproducts are also generated in the slaughterhouses. The EC regulation defines animal byproducts as whole carcasses or parts of animals or products not intended for human consumption. Since many byproducts are edible, the term byproduct may imply negative meaning for the consumers. Co-products, co - streams or rest raw materials are the other terms suggested for byproducts, which indicate something than can be edible. However, the term byproduct is used in this communication. Many of these byproducts are potential sources for value added products. They are either discarded as waste or under utilized in this country. The annual loss due to non / under utilization of animal byproducts is estimated to be about Rs 500 million.

Many byproducts provide nutrients like protein and several compounds of pharmaceutical interest. Improper handling of byproducts leads to their putrefaction causing environmental pollution. Recovery of byproducts and their conversion to value added products is essential for better economics of meat industry. Hence, processing of byproducts is important in view of public health and environmental pollution.

The following aspects are covered in this topic.

- **1.** Types of byproducts
- 2. Handling and preservation of byproducts
- **3.** Processing of byproducts
- 4. Utilization of byproducts
- **5.** Regulatory aspects

1. TYPES OF BYPRODUCTS

Animal byproducts can be classified into edible, inedible and dual purpose categories (Table 1). Edible products may be directly used as food. Inedible products are products of industrial importance and are mainly used for animal feeds. Dual purpose products are those that may or may not be used as food. The yield of meat and byproducts differs for different meat animals. Total yield of meat varies from 28 to 53 % and byproducts from 44 to 72 % of live weight of the animal (Table 2). The yield of different byproducts from cattle, pig and sheep differ significantly (Table 3). The cost of live animal often exceeds the selling price of meat alone. Therefore, the value of byproducts must overcome this deficit. It is possible to process and convert various byproducts in to value added end products. Processed product will fetch more value than raw byproduct.

2. HANDLING AND PRESERVATION OF BYPRODUCTS

Byproducts must be inspected for abnormalities and disease conditions prior to further handling. Many byproducts are highly perishable and need careful handling. Blood, liver, trachea, oesophagus, heart, spleen, brain, kidneys and fat should be collected under sterile and clean conditions for human consumption. They should be used immediately or stored at 4 - 7 °C in stainless steel containers. Blood may be transported within 4 - 6 h to processing units for use in live stock feed. Pancreas, endocrine glands and testes should be collected in ice and preserved under frozen conditions. Skins / hides are transported within 8 hours of collection and salted before storage.

Removal of contents and primary cleaning of intestines and stomach should be done in the slaughterhouse. They should be transported in closed containers. Bones should be freed of adhering flesh, broken, boiled, dried and stored at room temperature. Legs, hooves, horns, hair, bristles and tail should be shifted to cool places and transported to processing units within 8 hours.

3. PROCESSING OF BYPRODUCTS

Edible byproducts

Edible byproducts are a source of essential nutrients. The protein content of liver, beef tail, ears and feet are closer to lean meat tissue of animal. The protein content of other byproducts is slightly lower than fresh lean meat. Tongue provides highest calories due to very high fat content. Lungs provide very low calories due to very low amount of fat (Table 4). The vitamin content of some organ byproducts is greater than lean meat tissue. Edible byproducts are a good source of minerals (iron, zinc and copper) and vitamins (riboflavin, nicin and vitamin B_{12}). Most organs contain less fat than the lean meat tissue.

Blood: Blood is used in many countries as human food either directly or in sausage making. In India, blood is collected from slaughterhouses and cooked thoroughly before use. For purposes of human consumption, blood must be collected under sanitary conditions from healthy animals. A special hollow knife is developed for blood collection under sterile conditions. Plasma is used in sausage as binder and also in processed meats. Whole blood can also be used in meat specialties.

Casings: Natural casings are made from gastrointestinal tract of cattle, pigs and sheep. There are five distinct layers of tissue in the intestines namely mucosa, sub - mucosa, circular muscle layer, longitudinal muscle layer and serosa – from inside to the outside in order of appearance. The viscera are manually removed from the slaughtered animal. The intestinal tract is then carefully removed from the viscera and processed immediately. There are three essential steps in the preparation of casings.

- i. *Fat removal:* Varying amount of fat is attached to the gut. Removal of fat is done manually using a knife. The fat must be removed as completely as possible.
- ii. *Stripping:* The intestinal contents are stripped either by hand or by machine under a spray of water.
- iii. Sliming: Sliming is the removal of the mucosa. After stripping, small intestines are first crushed between rollers and then passed between successive rollers or strippers. This removes, smooth muscle layers and serosa associated with the mucosa leaving only the sub mucosa. Larger casings are turned inside out, passed through crushing rollers and then between rubber rollers under a spray of warm water. The washed casings are stored overnight in a saturated solution of salt prior to grading.

Casings are graded according to the type, size and quality. After grading, the casings are salted and placed in a bin to further cure and drain. When thoroughly drained, they are shaken out and resalted and packed. A majority of the casings are dry salt packed. These casings can be stored at ambient temperature for several months.

Inedible byproducts

Rendering: Rendering is used to process fats, blood, offals, condemned carcasses, feathers, bones and trimmings. are Wet, dry and continuous low temperature rendering are three types of rendering.

Wet rendering: This process (Fig. 1) is also called as steam rendering. Raw material is loaded in a large tank and sealed. Steam is introduced into the material and maintained at $2 \text{ kg} / \text{cm}^2$ pressure till the fats are freed from the tissues. Three layers form in the tank – fats on top, water layer in the middle and slush at the bottom. Fat and water layers are removed to obtain solid portion, which is dried and pulverized for use as feed ingredient.

Dry rendering: Dry rendering (Fig. 2) refers to the process in which raw material is cooked in steam jacketed kettle. Dry rendering system is usually more advantageous because of maximum recovery of protein and it does not contribute much to pollution.

Continuous low temperature rendering: The system uses low temperature heating, separation and cooling on a continuous flow basis and is usually regarded as an ideal process.

Rendering of products

Animal fats: Major edible animal fats are lard and tallow. Lard is obtained from pig and tallow from cattle and sheep. Fats with a titer point of 40 $^{\circ}$ C or higher are inedible. Fats with a titer less than 40 $^{\circ}$ C are edible. The titer value is a measure of temperature indicated as a result of the heat of crystallization during cooling of melted fatty acids from fat. High quality edible fats have low free fatty acids.

Offals: Offals are converted in to meal by dry rendering process. The cooker is charged with the raw material which is then sterilized at 2.4 kg/cm² pressure maintained for 15 minutes. The material recovered is dried and used as feed ingredient.

Inedible blood: Blood collected under unhygienic conditions is used for processing into blood meal for use as a protein supplement in animal feeds. Process sequences for blood meal are – heating for coagulation, draining, pressing, rendering, drying, grinding, packaging and storage. The material is sterilized under a steam pressure of $1.7 \text{ kg} / \text{cm}^2$ for 15 minutes.

Bones: Processing of bones is done in a digester. The steam pressure is raised to $1.75 \text{ kg} / \text{cm}^2$ and maintained for 1 h. The fat liquefied in the process is allowed to trickle off. A strong solution of gelatin runs off from lower opening of the digester. After extraction of fat and gelatin, the bones remaining in the digester are soft and chalky. Bones are then ground into bone meal, the main component of which is calcium phosphate. Blood meal, offal meal and meat – cum - bone meal are very rich source of protein (Table 5).

4. UTILISATION OF BYPRODUCTS

Bones are used in the production of ossein, glue, gelatin, bone meal and bone ash. Bone meal is a rich source of calcium and phosphorous and used in poultry feeds. Edible raw blood is processed for the preparation of plasma and red cells, which are used as binders in sausages or puddings. Blood albumen is used in leather processing. Inedible blood is converted in to meal for use in animal feed, glues and foam fire extinguishers. Edible raw fat is used for frying, candy and chewing gum and inedible fat in livestock feed, lubricant, soap and candles. Oil and meal are prepared from cattle feet for use in fine lubricants, leather, glue, gelatin and buttons. Stomachs, if not used as human food, can be rendered and used as pet foods. Brushes can be prepared from tails. Pancreas, pituitary thymus and thyroids are used for pharmaceutical purposes (Table 6). Natural casings made from gastrointestinal tract of cattle, pig and sheep are used for the preparation of sausages.

5. REGULATORY ASPECTS

By statutory regulations, each slaughter house should have its own methods of utilizing byproducts. This is done in its own dry rendering plant or in a separate unit for recovering different valuable materials.

The EU (European Union) has stringent regulations (EC #1774/2002) concerning safe collection, transport, storage, handling, processing, usage and disposal of animal byproducts. Animals that died on farm or unfit for human consumption were recycled earlier for use in animal feed. Now it is prohibited due to fear of spreading of mad cow disease and food and mouth disease. Classification of animal byproducts given below is as per EU regulations based on risk to animals, the public and environment.

- **A. Category 1 materials:** They include animal byproducts posing highest risk (residues of prohibited substances like dioxins or polychlorinated byphenyls). These must be completely disposed by incineration or landfill after appropriate heat treatment.
- **B. Category 2 materials:** These are the materials that present a risk of contamination with other animal diseases (animals that die on farm or are killed in context of spread of disease or at

risk of residues of veterinary drugs). These materials may be recycled after appropriate heat treatment for use other than feeds such as biogas, composting and oleo - chemical products.

C. Category 3 materials: They include byproducts derived from healthy animals. These may be used for feed purposes after appropriate heat treatment in approved plants.

(Source: Anon 2016)

CONCLUSION

Apart from meat, a sizeable quantity of byproducts are generated in the slaughterhouses. Byproducts can be categorized as edible, inedible and dual purpose materials. They are either discarded as waste or under utilized in this country. Improper handling of byproducts leads to their putrefaction resulting to environmental pollution. Recovery of byproducts and their conversion to value added products is essential for better economics of meat industry. This also minimizes public health hazards and environmental pollution.

Byproducts yield value added end products, generate income and provide valuable sources of protein for human as well as for livestock. Soft organs such as blood, stomachs, intestines, lungs, carcass trimmings, liver and reproductive organs (if not utilized for edible purpose) can go either for meat meal or hydrolysate. Blood is dried into blood meal and used in animal feeds. Gut contents are used for compost or fertilizer or for biogas production. Hard organs such as horn, hoof and bones can similarly (but separately) processed into horn / hoof meal and bone meal for use as feed ingredients or as fertilizers. Proteins extracted from horns and hooves are used as foams in fire extinguisher.

Edible	Inedible	Dual purpose
Blood	Skin / hide	Blood
Brain	Horns	Bone
Liver	Hoof	Intestine
Heart	Hair	Lungs
Trachea	Spleen	Trachea
Oesophagus	Bone	Oesophagus
Intestines	Cheek	
Kidneys	Head trimmings	
Stomachs	Feet	
Sweet bread (Thymus and pancreas)	Tail	
Tongue		
Udder		
Lungs, Fat, Testes		

 Table 1. Classification of animal byproducts

Source: Bhaskar and Mahendrakar 2011

Animal Species	Meat	Byproduct
Cattle [*]	30	70
Buffalo [*]	28	72
Sheep [*]	30	70
Goat [*]	29	71
Pigs*	53	47
Poultry [#]	56	44

Table 2. Yield (as % live weight) of meat and byproducts from animal processing

* Major byproducts from meat processing include intestines, blood, skin / hide, bones, liver, heart, tongue and kidney.

[#]Major byproducts from poultry processing include intestines, blood and feathers.

Source: Bhaskar and Mahendrakar 2011

Observation: Total yield of meat varies from 28 to 53 % and byproducts from 44 to 72 % of live weight of the animal.

	Animal				
Product	Cattle	Pig	Sheep		
Blood	2.4 - 6.0	2.0 - 6.0	1.5 - 4.0		
Head	3.0 - 4.5	-	3.0-4.0		
Skin / hide	5.1 - 8.5	3.0 - 8.0	7.5 - 10.0		
Feet	1.9 – 2.1	1.5 – 2.2	1.5 - 2.0		
Small intestine	1.0 - 1.5	1.8 - 2.0	1.5 - 2.0		
Large intestine	1.0 - 1.5	-	1.0 - 1.5		
Stomach	2.0-3.0	-	2.5 - 3.0		
Liver	1.0 - 1.5	1.1 – 2.4	0.9 - 2.2		
Heart	0.3 - 0.5	0.2 - 0.35	0.3 – 1.1		
Kidneys	0.07 - 0.2	0.2 - 0.4	0.4 - 0.6		
Spleen	0.1 - 0.2	0.1 - 0.12	0.1 - 0.4		
Lungs	1.2 – 1.5	-	-		
Tail	0.1 - 0.25	0.1	-		
Tongue	0.2 - 0.5	0.3 - 0.4	-		
Free fat	1.5 - 2.0	1.3 - 3.5	1.0 - 1.5		
Bones	10.0 - 12.0	7.5 - 12.0	6.0 - 8.0		

 Table 3. Byproduct yields (% of live weight)

Source: Bhaskar 2007

Byproduct	Water (g)	Protein (g)	Fat (g)	Carbohydrate (g)	Calories
Brain	79.2	10.3	8.7	0.4	124
Heart	76.5	14.8	5.7	2.1	123
Kidney	79.3	15.4	2.9	1.1	97
Liver	71.0	21.0	4.6	1.8	138
Lungs	79.7	16.7	2.6	-	95
Sweet bread	73.8	14.8	9.8	0.2	153
Tongue	66.7	15.8	17.5	-	225
Tripe	79.7	12.9	6.6	0.3	116

Table 4. Proximate composition and calorie content of edible byproducts from sheep (per 100 g)

Source: Bhaskar and Mahendrakar 2011

Observations

- The protein content of liver, beef tail, ears and feet are closer to lean meat tissue of animal.
- The protein content of other byproducts is slightly lower than fresh lean meat.
- Tongue provides highest calories due to very high fat content.
- Lungs provide very low calories due to very low amount of fat.

Product	Dry matter	Crude protein	Crude fiber	Ether extract	Nitrogen free extract	Calcium	Phosphorous
Offal meal	93.0	56.4	0.9	17.9	7.6	3.90	1.73
Blood meal	88.8	73.4	0.7	1.4	2.7	0.32	0.31
Bone meal	95.5	14.6	2.5	3.1	5.6	25.00	12.00
Meat – cum - bone meal (carcass meal)	94.0	53.8	2.3	17.5	2.4	11.25	5.39

Table 5. Proximate composition of rendered products (%)

Source: Bhaskar and Mahendrakar 2011

Observations:

- Blood meal, offal meal and meat cum bone meal are very rich source of protein.
- Bone meal is rich in calcium and phosphorus.

Raw byproducts	Processed byproducts	Use	
Edible raw blood	Plasma and red cell	Binder in sausages, blood	
	Processed byproducts	sausage or pudding	
Inedible raw blood	Blood meal	Livestock feed, pet food,	
		fertilizer, glues, foam fire	
		extinguishers	
	Blood albumin	Leather processing	
Edible raw fat	Edible fat, oleo oil,	Frying fat, shortening, candy,	
	oleoresin	chewing gum	
Inedible raw fat	Cracklings, Inedible fat	Livestock feed, lubricants, soap,	
		candles, glycerin	
Meat scrapings	Meat meal	Poultry feed	
Raw bone	Edible fat, bone pieces,	Shortening, bone gelatin (edible	
	collagen	and inedible), bone meal, tallow,	
		pet food	
Cattle feet	Neatsfoot oil, feet meal	Fine lubricants, leather, bone	
		meal, tallow, glue, gelatin,	
		buttons, heel jelly	
Pigs and sheep feet	Meal	Tallow	
	Feet	Edible use	
Horns and hooves	Extracted protein	Foam fire extinguisher	
	Meal	Mixed with livestock feed,	
	TT 11	fertilizer	
	Horns and hooves	Button, handles	
Stomach (Cattle, sheep, pig)	Edible rendered	Edible use, pet food, meat meal	
Skin / hide	Cleaned	Leather	
Large intestines, colon,	Rendered	Meat meal	
caecum, rectum, mammary		Casings, surgical sutures,	
gland, bladder, small	Cleaned	heparin, meat meal	
intestines			
Lungs		Pet food, heparin	
Tongue, brain, heart, liver,		Edible	
diaphragm, kidney			
Tail		As tail brushes	
Gall		Cleaning agent in leather, paints,	
		dyes, pharmaceuticals	
Gall stone		Pharmaceuticals	
Pancreas (cattle and pigs)		Insulin	
Pituitary, thymus, thyroid		Pharmaceuticals	
(cattle)			

Table 6. Various uses of different byproducts emanating from animal processing

Source: Bhaskar and Mahendrakar 2011; Deng-Cheng Liu 2001



Fig. 1. Schematic representation of wet rendering process *Source:* Bhaskar and Mahendrakar 2011

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Fig. 2. Schematic representation of dry rendering process *Source:* Bhaskar and Mahendrakar 2011