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By-products of the meat industry

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Abstract

The aim of this paper is to present the issue of food loss and waste in the meat sector as a current, widespread and serious problem. Being a high production sector, the level of losses is high both during production and during consumption by consumers. It is estimated that up to 23% of meat production is lost and wasted. Data on the loss and waste of food in the meat sector are limited, but at the same time the production of meat and meat products is characterized by an unfavorable impact on the environment (meat producing the highest emissions per kilogram of food compared to other foods. Therefore, determining the size and causes, as well as methods of reducing food losses and waste in the meat sector, is important for both economic and environmental reasons. The quantity and type of waste consisting mainly of organic residues of processed raw materials may not be altered, provided that the quality of the finished product must remain consistent. However, they can be reduced by using by-products.

Keywords: meat industry, raw materials, economic, environmental reasons

1. Introduction

Around 18 million tonnes of waste are produced annually in the European Union in the meat industry. The proposed solution for the management of this waste from the meat industry would be a cleaner production that involves: pollution prevention, reduction of pollution source, recovery of by-products and energy [2].

An important aspect in the recovery of by-products from the meat industry is the adherence to the legislation on animal by-products, etc. According to European legislation [3], an animal by-product is "a whole body or part of an animal, of animal origin or other products obtained from animals not intended for human consumption". This legislation divides by-products into three categories based on the risk they pose to human health. Categories 1 and 2 include materials with the highest risk, and category 3 includes materials considered to be with the lowest risk. Category 1 materials are not recovered and are subject to incineration, while Category 2 materials may be used in the production of fertilizers, compost or anaerobic digestion facilities.

Category 3 materials include parts of animals which have been considered fit for human consumption but are not suitable either because they are not normally consumed or because they have not been so processed for commercial reasons. However, they can be used for animal feed (subject to several restrictions under the regulations on transmissible spongiform encephalopathies). More importantly, they can be used for production of derivatives [1].

This paper will describe the by - products of category 3.

The most important and valuable use of by-products in the protein-rich meat industry is as an ingredient for animal feed, poultry, aquaculture and pets. Although the use of these by-products in feed and fertilizer is technologically and economically viable, there is also a growing market for protein hydrolysates [8], which can be used as flavor enhancers, functional ingredients or for increase the nutritional value of foods considered low in protein. In addition, some inedible by-products are processed in such a way that they can be used in the pharmaceutical industry and for the isolation of amino acids which are subsequently used in value-added products.

In most countries, everything derived from the animal, except the carcass, is considered a by-product. These by-products include skin, hair, feathers, head, horns, hooves, legs, toenails, bones, tendons, glands, muscle and fat tissue, shells and contents of the gastrointestinal tract, blood and

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internal organs. They represent about 30–50% of the live weight of the animal and are equivalent to the annual production of about 60 million tons of by-products globally [4].

The literature indicates that by-products (including organs, fat, lard, skin, feet, abdominal and intestinal contents, bones and blood) from cattle, pigs and lambs account for 66,0, 52,0 and 68,0% respectively. of live weight. More than half of the animal by-products are not suitable for human consumption due to unusual physical and chemical characteristics [5].

Table 1. Amount of solid waste generated by slaughterhouses for cattle, goats, sheep and pigs [5]

Animal	**The amount of solid waste**	
	Kg/head	% by animal weight
Cattles	83	27.5
Sheeps	2,5	17
Pigs	2,3	4

Table 2 Classification of edible and inedible by-products [7]

Nr. Crt.	**By-product**	**Main use**
	Subproduse edibile	
1.	Brain	Human consumption
2.	Liver	Human consumption
3.	Heart	Human consumption
4.	Kidney	Human consumption
5.	Spleen (melted)	Human consumption
6.	Language	Human consumption
7.	Ox tails	Human consumption
8.	Cheeks and head gaskets	Ingredient for salami
9.	Beef extract	Soups
10.	Blood	Component în salami
11.	Bones	Confectionery gelatin, ice cream and gelatinous food products
12.	The fat from the cattle, calves, lambs and sheep	Food fat, candy, chewing gum
13.	Pork fat	Animal fat (lard)
14.	Small intestines	Membranes for sausages
15.	Large intestines	Membranes for meat preparations
16.	Esophagus	Ingredient for sausages
17.	Pig skin	Confectionery gelatin, ice cream and gelled food; fried pork skins
18.	Calf skin	Garnishes, confectionery gelatin, ice cream and gelatinous food
	Unnecessary by-products	
19.	Pig skin	Various leather ware
20.	Cattle skin	Felt, plaster binder, upholstery
21.	Sheep skin	Various leather ware
22.	Wool	Textile industry
23.	Lanolin	Different ointments
24.	Inedible tallow	Industrial oils, lubricants, glycerin
25.	Dry bones	Glue, hardening steel
26.	Fresh bones	Bone meal and feed fertilizer
27.	The albumin from blood	
28.	Cattle feet	Fine lubricants, leather preparations
29.	Glands	In pharmaceutical industry
30.	Lungs	Animal feed

In some countries, the industry has secured markets for many of these by-products. Also, some of the products have either a neutral value (no cost for destruction) or a negative value (which requires cost for destruction). Many of these by-products are rich sources of valuable components, such as proteins, lipids, minerals, etc., which in themselves may be more valuable than the original source (e.g., plasma proteins in the blood are more valuable than blood). Such wastes include bones, tendons, skin, contents of the gastrointestinal tract, blood and internal organs. They vary according to each type of animal [5]. The specific quantities of waste generated for each animal type are listed in Table 1.

Efficient use of meat by-products is important for the profitability of the meat industry. It has been estimated that 11.4% of the gross income of bovine slaughterhouses and 7.5% of the total income of pig slaughterhouses come from by-products. In the past, by-products were the favorite food of Asians, but over time, health concerns increased, leading to their elimination from the diet and to other non-food uses, such as pet food, pharmaceuticals, cosmetics, and animal feed [6].

The by-products of the meat industry are divided into edible by-products and inedible by-products.

2.Nutritional value of meat by-products

Edible meat by-products contain many essential nutrients. Some are used in medicine because they contain special nutrients such as amino acids, hormones, minerals, vitamins and fatty acids. The liver, tail, ears and legs of cattle have a protein content close to that of lean meat, and a large amount of collagen is found in the ears and legs [9]. The lowest protein content is found in the brain, large intestine and fatty tissue. The amino acid composition of meat by-products is different from that of lean tissue due to the large amount of connective tissue. As a result, by-products such as the ears, feet, lungs, stomach, and stomach contain more proline, hydroxyproline, and glycine, and lower levels of tryptophan and tyrosine. The vitamin content in organs is usually higher than in lean meat. The kidneys and liver contain the highest amount of riboflavin (1,697-3,630 mg / 100 g), which is 5-10 times more than lean meat. The liver is the best source of niacin, vitamin B12, B6, folacin, ascorbic acid and vitamin A. The kidney is also a good source of vitamin B6, B12 and folacin. A 100 g serving of pork or beef liver contributes 450% –1100% of the RDA of vitamin A, 65% of the RDA of vitamin B6, 3700% of the RDA of vitamin B12 and 37% of the RDA of ascorbic acid. Lamb kidneys, liver, lungs and pig spleen are an excellent source of iron and vitamins. High copper content is recorded in beef, lamb and veal liver, contributing 90–350% of the copper RDA (2 mg / day). The liver also contains the highest amount of manganese (0.128–0.344 mg / 100 g). However, the highest content of phosphorus (393–558 mg / 100 g) and potassium (360–433 mg / 100 g) in meat by-products is found in thymus and cakes [10]. With the exception of the brain, kidneys, lungs, spleen, and ears, most by-products contain sodium at or below the levels found in lean tissue. Mechanically boned meat has the highest calcium content (315–485 mg / 100 g).

Many organs contain more polyunsaturated fatty acids than lean tissue. The brain, large intestine, heart, kidneys, liver and lungs have the lowest levels of monounsaturated fatty acids and the highest level of polyunsaturated fatty acids. There is three to five times more cholesterol (260–410 mg / 100 g) in the organs than in lean meat and large amounts of phospholipids. The brain has the highest cholesterol level (1,352–2,195 mg / 100 g) and also has the highest amount of phospholipids compared to other by-products [11].

Animal blood is high in protein and iron and is an important edible by-product [12]. In Europe, animal blood has been used for a long time in the manufacture of sausages, blood puddings, biscuits and bread. In Asia, it is used in curd, cake and blood pudding [13]. It is also used for non-food products such as fertilizers, feed and binders. Blood is approved for food use when collected by bleeding an animal that has been examined by a veterinarian. Blood from a healthy animal is usually sterile [5]. It has a high protein content (17.0%), with a reasonably good balance of amino acids. Blood is a significant part of the animal's body mass (2.4-8.0% of the animal's live weight) [11].

Blood is one of the most problematic by-products of the meat industry due to the large amount of results (3.0–4.0% in pigs and cattle and 3.5–4.0% in lambs [5] and its capacity. However, the blood has a high content of good quality protein (about 15-18% in the blood as such). The main obstacle to the full utilization of the blood cell fraction is the presence of hemoglobin, which provides a strong color, distinct aroma and influences oxidation, however, many industrial applications have been developed

[15]. Whole plasma proteins (such as albumin, fibrinogen, and globulins) can be readily separated by chemical precipitation and then dried.These proteins have relevant functional properties such as gelation, foaming, emulsification, or thickeners, which allow them to be used in the food industry as food supplements. More recent applications of blood proteins include the development of products with improved functional properties and new biological activities, such as antioxidant, antimicrobial, mineral, antigenotoxic, analgesic, or antihypertensive activity [16].

Collagen is a major component of mammalian connective tissue, and accounts for 30% of all proteins. Twenty-seven different types of collagen have been identified, with type I being the most abundant and widespread in connective tissue. The largest sources of gelatin are pig skin (46%), cow skin (29%) and pig and cattle bones (23%).

Two types of gelatin are available, depending on the pretreatment procedure, being commercially known as type A gelatin (isoelectric point at pH ~ 8–9) obtained under alkaline pretreatment conditions and type B gelatin (isoelectric point at pH ~ 4 –5) obtained under acidic conditions [17]. Collagen has great versatility and, for example, can be used as a calcifiable matrix system for implantable biomaterials. Collagen can also form liposome scaffolds, which control the rate of release of heat-trapped drugs. It can also be used in gene transfer, by subcutaneous collagen pellets for somatic gene therapy or for microencapsulation of probiotic bacteria by spray drying technology [18]. *Zeugolis et al*., 2008 [19] used collagen extracted from Achilles tendons from cattle to create extruded fibers capable of forming scaffolds for tissue engineering and tendon and ligament regeneration.

Collagen and gelatin from pig and bovine skins can be used as a source of bioactive peptides using enzymatic methods. However, gelatin from poultry, ducks and other minority sources has also been studied in recent years [20, 21], especially in Asian countries. Other proteins recovered from animal sources have also demonstrated strong heat-induced gelling and emulsifying capacity [22].

Gelatin is produced by the controlled hydrolysis of a water-insoluble collagen derived from proteins. It is made from fresh raw materials (skins or bones) that are edible. Both the skin and the bones contain large amounts of collagen.

Gelatin extracted from animal skins can be used in food [23]. The raw material can also be transformed into lard. In the United States, Latin America, Europe, and some Asian countries, pork skin is soaked, boiled, dried, and then fried to obtain a snack (pork rind). Collagen in the skin also acts as an emulsifier in meat products because it can bind large amounts of fat. This makes it useful as a useful additive or filler for meat products. Collagen can also be extracted from cattle skins in order to obtain collagen membranes used to fill sausages.

Gelatin is added to a wide range of foods and forms a major ingredient in jellies and aspic [24]. Its main use is the production of gelled desserts, due to its "melting in the mouth" properties, but it is also added to a range of meat products, especially meat pies. Gelatin is also widely used as a stabilizer for ice cream and other frozen desserts. Gelatin is also widely used as a protective colloid for ice cream, yogurt and cream pies. Gelatin is thought to inhibit the formation of ice crystals and the recrystallization of lactose during storage.

About 6.5% of total gelatin production is used in the pharmaceutical industry [25]. Most of it is used to make the outer shell of the capsules. Gelatin can also be used as a binding and mixing agent in the manufacture of tablets and medicine pills. It is used as an important ingredient in protective ointments. Gelatin can be turned into a sterile sponge by whipping it into foam, treating it with formaldehyde and drying it [26]. Such sponges are used in surgery and also to implant a drug or antibiotic directly in a certain area. Because gelatin is a protein, it is used as a plasma expander for blood in cases of severe shock and injury. Gelatin is an excellent emulsifier and stabilizing agent for many emulsions and foams. It is used in cosmetics and in printing for screen printing, photo printing, etc. [27].

Skins. Animal skins have been used in the manufacture of shelters, clothing and containers by humans since prehistoric times. Skins represent a significant part of the weight of the live animal, from 4% to 11% (eg cattle: 5.1–8.5%, average: 7.0%; sheep: 11.0–11.7%; pigs: 3.0–8.0%). Skins are generally among the most valuable animal by-products. Examples of products made from cow and pig skins and sheepskin are leather footwear and bags, raw leather, athletic equipment, refurbished sausage and cosmetic coating, sausage membrane, gelatin and edible glue.

Once the skin is removed from the animal, it must be treated quickly to avoid decomposition by bacteria and enzymes. There are four basic treatments. One is air drying, the other is salt curing, and the third and fourth are tanning. Salt hardening is often used for raw hides. Leather quality is usually based on moisture and salt content. The moisture content of the skins should be in the range of 40-48%, to ensure that they are kept in good condition during storage or transport.

Pig skin is similar to human skin and can be turned into a dressing for skin burns or ulcers. Pigskin used as a dressing should be cut into strips or patches, cut by hair, split to a thickness of 0.2-0.5 mm, cleaned, sanitized and packaged. Can be used for skin grafting. When used for grafting the skin, it is removed from the carcass within 24 hours of the pig's death [5].

Feathers and hair also have a high protein content, but the low content of certain essential amino acids (Lys, Met, His and Trp) makes them less usable as supplements in feed, as artificial amino acids need to be added. A promising approach for feathers and hair is as a culture medium for screening for keratinolytic bacteria that seek to characterize and recover new keratinase enzymes. Such enzymes have a potential use in the skin industry for the development of more environmentally friendly hair removal processes [18].

Animal fats are important by-products of the meat industry. The main edible animal fats are lard and tallow. Lard is the fat obtained from the clean tissues of healthy pigs. Seoul is hard fat obtained from the adipose tissue of cattle or sheep. Lard and edible salt are obtained by dry or wet pouring. Melted lard can be used as edible fat without any further processing. However, due to consumer demand, lard and tallow are now often bleached and given a deodorizing treatment before being used in food. Seoul and lard are also used in the manufacture of margarine and shortenings. Some edible fats are used in the manufacture of sausages or emulsified products [5].

Seoul is used in the manufacture of candles, soaps and cosmetics, paints, printing inks, water repellent and biodiesel production [28].

The bones. In addition to the production of gelatin, skimmed bone is used in the manufacture of glues used in the manufacture of plywood and abrasive paper, and bone meal in the production of fine porcelain [29].

Bones account for 11% of pig carcases, 15% of beef carcases and 16% of lamb carcases. These values are higher if they include bone-in meat. The marrow inside some of the bones can also be used as food. The marrow can be 4.0–6.0% of the weight of the carcass. For centuries, bones have been used in the kitchen to make soup and gelatin. In recent years, the meat industry has tried to get more meat from the bones, and new techniques have been used for this purpose. During the boning of beef, pork or lamb, a tissue called "mechanically separated meat", "mechanically boned meat" or "mechanically removed meat" results. Such meat is now approved for use in meat products (mixed or individual) in many countries.

Meat and bone meal has been widely recommended and used in animal feed as a source of protein instead of protein feed, due to its content of essential amino acids, minerals and vitamin B12 available. Meat and bone meal as well as melt protein products have a high potential for use in applications other than animal feed, including as a fuel or phosphorus fertilizer [5].

3.Glands and organs as food

Animal organs and glands offer a wide variety of flavors and textures and often have a high nutritional value. They are highly valued as food in many parts of the world, especially in Southeast Asia. Those used as food for human consumption include the brain, heart, kidneys, liver, lungs, spleen, tongue, pancreas and udder of cattle, stomach and uterus of pigs, rumen, reticulum, omas and absomasum of sheep and cattle and testicles and thymus of sheep and pigs [30]. The brain, nervous system and spinal cord are usually prepared directly for meals, rather than processed for industrial use. The liver is the most widely used edible organ. It is used in many processed meat dishes, such as liver sausages and liver paste [31]. Livers from lambs, calves and young cattle are preferred at the table in the United States and Europe because they have a lighter flavor and texture. Pork, veal and lamb lungs are mainly used for the preparation of fillings and some types of sausages [32].

In some countries, the intestines of animals are used as food for humans, pets, or for making meat meal, manure, or fertilizer. However, the most important use of the intestines is as a coating for sausages [5].

Animal glands and organs are traditionally used as medicine in many countries, including China, India, and Japan. The endocrine glands secrete hormones (ie enzymes that regulate the body's metabolism). These include the liver, lungs, pituitary, thyroid, pancreas, stomach, parathyroid, adrenal glands, kidneys, corpus luteum, ovary and follicle. Glands are only collected from healthy animals.

The brain, nervous system and spinal cord are sources of cholesterol which is the raw material for the synthesis of vitamin D3. Cholesterol is also used as an emulsifier in cosmetics. Other materials can be isolated from the hypothalamus of the brain for the same purpose. The hormone melatonin, extracted from the pineal gland, is evaluated for the treatment of schizophrenia, insomnia and other problems, including mental retardation. The bile consists of acids, pigments, proteins, cholesterol, etc. and can be obtained from the gallbladder. It is used to treat indigestion, constipation and biliary tract disorders. It is also used to increase the secretory activity of the liver. The bovine or porcine ball can be purchased as a dry extract or in liquid form. Some bile ingredients, such as prednisone and cortisone, can be extracted separately and used as medicine. Gallstones are said to have aphrodisiac properties and can be sold at a high price [33].

They are usually used as ornaments to make necklaces and pendants. The liver is the largest gland in animals. The liver of mature cattle usually weighs about 5 kg, while that of a pig weighs about 1.4 kg. Progesterone and estrogen can be extracted from pig ovaries. It can be used to treat reproductive problems in women. Relaxin is a hormone taken from the ovaries of pregnant sows and is often used during birth. The pancreas provides insulin, which regulates sugar metabolism and is used to treat diabetes. Glucagon extracted from the cells of the pancreas is used to increase blood sugar and to treat insulin overdoses or low blood sugar caused by alcoholism. Chymotrypsin and trypsin are used to improve healing after surgery or injury. The intestines of sheep and calves are used to make clot to make internal surgical sutures. The mucosa of the small intestines of pigs and cattle can be collected while the intestines are processed into shells [11].

5. Conclusions

The issue of food loss and waste in the meat sector seems to be of particular economic and environmental importance. As indicated in the literature, the production of meat and meat products is characterized by an unfavorable impact on the environment (meat forming the highest carbon emissions per kilogram of food compared to other foods), which requires a rational management of these products throughout the production, processing, transport and consumption chain. At the same time, the increase in meat production and consumption in recent years has led to an increase in food losses and waste in this sector. Thus, it is necessary to develop specific methods to reduce losses in the individual stages of the food chain for the meat sector and to take measures to prevent them.

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