Food Research International 65 (2014) 322–328

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Recovery and utilization of effluents from meat processing industries

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ARTICLE INFO

Article history:
Received 1 July 2014
Received in revised form 22 September 2014
Accepted 26 September 2014
Available online 11 October 2014

Keywords:
Meat
Waste material
By-products
Organ meat

ABSTRACT

Production of wastes during the processing of meat products is not desirable because it significantly deteriorates the quality of the final product as well as causes some serious health threats if not properly disposed-off. The majority of the waste, in the meat industry is produced during slaughtering. The composition of waste generated by the meat industry depends on species of animals slaughtered. The waste material of the meat processing industry contains plentiful amount of organic compounds due to which its disposal is quite difficult. Efficient utilization of by-products has direct impact on the economy of the country and reduce environmental pollution. Edible meat by-products are claimed to have high nutritional value as compared to the lean meat. Organ meats can be used for human consumption, animal feed production and medicinal purposes after proper treatment and processing. This article provides information regarding the waste material generated by meat processing plants, its health impacts, nutritional status of meat by-products and their utilization.

1. Introduction

Waste in the food industry mainly includes organic residues of the raw material after processing. Production of wastes during processing of several products is not desirable as it significantly deteriorates the quality of finished products if incorporated. Disposal and utilization of waste materials is a difficult task due to its poor biological stability, high water activity, poor oxidative stability, pathogenicity and optimum enzymatic activity. Wastes generated by different food industries can be quantified on the basis of their respective production levels. Unlawful disposal and utilization of untreated or poorly treated waste without following the regulations of handling, transport and disposal of waste material causes serious threats on environment (Russ & Pittroff, 2004). When raw material and other supportive ingredients enter the production line then several types of products are produced including desired finished product, product-specific waste and non-product-specific waste. Product-specific waste accumulates in the processing line through various processing steps during the extraction of desired components. After extraction of desired components during processing of raw materials there are certain other useful constituents that remain in the remaining materials. Some common examples of this type of waste include consumed grains during the production of beer and waste generated by slaughter houses. This waste contains plentiful amount of organic compounds due to which its disposal is quite difficult.

Efficient use of by-products greatly influences the economy of the country and environmental pollution. Poor utilization of meat by-products results in revenue losses and increase disposal cost. It also creates major catastrophic health problems. Moreover, traditional cultural and religious norms are often important in the use of these kinds of products as food. Many countries also limit using meat by-products as food for safety point of view. On the other node, wastes of meat industry have a potential for recycling and conversion into useful products with high biological value. By-products of meat industry such as offal, blood, kidney, liver, lungs, spleen, tripe and brain have high nutritional value. These parts can also be used in the production of different drugs by pharmaceutical industries. Moreover, bioactive peptides isolated from the meat by-products can be used in functional foods for the prevention of heart and mental health problems and obesity (Tomas & Maria, 2014). Fish waste can be efficiently used in the production of several valuable products including natural pigments, dietetic products (chitosan), biodiesel, animal feed and cosmetics after proper treatment. Waste products from the meat processing plants must be efficiently dealt with as proper waste management plays a vital role in the growth of these industries. Information regarding the treatment and use of waste materials generated by the meat processing industries has been reviewed here.

2. Wastes generated by meat processing industries

The waste generated by the abattoir contains inedible parts including skin, bones, blood, gastro-intestinal tract, tendon and visceral organs. The ratio of these contents depends on species of animals to be slaughtered (Grosse, 1984; Sielaff, 1996). Table 1 shows the amount of animal-specific waste. To improve the profitability of the meat industry, there is a need to develop some techniques for proper recycling and potential use of meat by-products. A survey estimates that beef and pork share about 11.4% and 7.5% of the total revenue come from the by-products

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http://dx.doi.org/10.1016/j.foodres.2014.09.026
0963-9969/

Table 1
The specific waste index for slaughter houses with respect to the type of animal.

Animal	Specific waste index[a]
Cow	0.56
Calf	0.87
Pig	0.2
Sheep	0.1

(Russ & Pittroff, 2004).
[a] Mass of accumulated waste divided by the mass of saleable product.

(USDA, 2001). In early days, meat organs and offal were efficiently used in different food products in Asia, but due to several health-related threats the use of by-products was diverted to non-food utilization including pet foods, animal feed, cosmetics and pharmaceuticals (Rivera, Sebranek, Rust, & Tabatabai, 2000). Health concerns of using meat by-products for food purpose also affect the market. Another factor responsible for disappearance of these markets is low price. These economic concerns have diverted the focus of scientists towards non-food uses of by-products generated by meat processing units. In addition to health and economic concerns, improper treatment of waste cause solemn environmental threats. However, these losses can be overcome by proper treatment, disposal and utilization of meat by-products. Slaughtering process in the abattoir, processing, preservation and storage conditions of animal skins and poultry feathers have a great influence on the environment. Thus, it is needed to keep an eye on all the sources of waste generation and types of effluents produced during each processing step. Generally, waste materials associated with the meat processing industry include waste water, solid material, gases and volatile compounds that can cause serious environmental threats.

2.1. Wastewater

Water is a very important constituent of any food processing industry. Activities in the slaughterhouse and meat processing plants need plenty of water. Moreover, water is also used for cleaning purposes in the processing area. Wastewater is generated and discharge of this wastewater has an important environmental impact. This discharge also results in flagging the quality of surface water. Nature of the processes involved in the processing industry highly influences the type, composition and concentration of pollutants present in the wastewater. Following are the most common ways in which wastewater pollutes the surface water.

Presence of plenteous amount of biodegradable organic materials in the wastewater binds oxygen and reduces its availability which ultimately causes death of aquatic animals. Moreover, eutrophication may occur due to certain macronutrients (N, P) and excessive growth and mineralization of algae which results in the mortality of aquatic residents. Additionally, wastewater also contains several toxic compounds including unionized ammonia, chromium and tannins that are directly involved in the deaths of aquatic animals.

Wastewater also contains several suspended solids of organic and inorganic nature that cannot be collected as solid wastes. Presence of these wastes in the water increases its turbidity. These wastes utilize huge amount of dissolved oxygen present in the water. Organic material constitutes fat, carbohydrates and proteins. Protein degradation results in the production of ammonium which eventually leads to the discharge of nitrites and nitrates that result in the higher oxygen consumption. Furthermore, different microbial activities are also involved in the oxidation of organic fraction of suspended solids which ultimately produces CO_2, H_2O, CH_4 and biomass.

Nitrogen is bound with organic material or in the form of ammonium in wastewater. It may also occur in the form of nitrate if HNO_3 is used as cleaning agent in the industry. Production of ammonia in the water is toxic to the fish and other aquatic animals (Barnes, Forster, & Hrudey, 1984). Removal of nitrogen can be accomplished through several wastewater purification systems. Phosphate is present in wastewater as inorganic phosphate and organically fixed phosphate. Phosphorus contents in the water can be determined photometrically. Phosphorus contamination can also be removed by using various biological or physico-chemical processes.

2.2. Solid waste

By-products of meat industry that cannot be further re-processed are termed as solid waste and must be properly dumped. These include different toxic substances, organic compounds and non-biodegradable material. Viscera of animals and poultry birds have very high microbial load including several types of pathogenic bacteria like *Salmonella*, *Escherichia coli* and *Shigella*. These pathogens produce special types of toxic substances called Shiga toxins that inhibit protein synthesis in the body (Barkocy-Gallagher et al., 2003; Sandvig & van Deurs, 2000). Moreover, ammonia chromium and tannins are also toxic substances which are produced during the processing of fish and other aquatic animals (Metcalf & Eddy, 1991). Special care is needed to dispose-off these compounds. A common practice to discard these toxins is entombing in dumping grounds. Several body parts including skin, feathers, head, feet, hooves, lungs, udder and rectum are also included in the category of solid wastes (Schrieber & Seybold, 1993). Organic compounds also require special care while disposing-off due to off-odor and leaching problems. Moreover, spreading of these substances in the atmosphere may also cause serious health threats. Non-biodegradable material may also be buried properly in the ground.

2.3. Toxic gases produced by meat processing plants

A number of toxic gases (CO_2, CO, NO_x and SO_2) are discharged in the air due to the use of energy during freezing, chilling, smoking and scorching of meat products. Several volatile compounds are also discharged in the air by using different sanitizing compounds for cleaning purposes. Moreover, dust is also mixed in air from bone cutting and processing industries. Air pollution leads to problems of various kinds including global warming, ozone layer depletion, acid rain, bad odor and health risks (RIVM, 1994). Measures should be taken by meat processing industries to minimize the production of toxic gases.

3. Slaughtering activities and production of waste

Several types of by-products and waste materials are generated during the slaughtering like manure, rumen and intestinal material, liver, blood, feathers, bones, fat and wastewater. Slaughtering is carried out in a very centralized way in most of the developed countries. The consumers in the developed countries mostly prefer lean meat or some offal including kidneys, brain, tongue and sweetbread. Moreover, carcasses are mostly cooled and deboned in the abattoir and then sent to the retail outlets. Huge amount of waste is left in the slaughterhouse that contains hides, bones, esophagus spleen and lungs. This waste material can be carefully disposed-off or can be further utilized to prepare different by-products after proper treatment. Contrarily, in the developing countries inedible offal are discarded on the nearby land of processing plants or slaughter houses without any further treatment which may lead to several environmental and health hazards (FAO, 2008). There is a need to reuse offal. Fatty tissues can be converted into edible fat and some other tissues can also be processed into a number of products including composite bone-cum-protein meals, meat meal, blood meal and bone meal. With proper treatment and processing, these by-products can be further utilized in feed-industry, pet food, fertilizer industry and human consumption.

Modern slaughter houses are well equipped with several facilities including running water, power, steam, refrigeration, transport etc. However, large variety of slaughtering sites can be seen in developing countries. It varies from simple slabs to very modern abattoirs.