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Review

# Innovations in value-addition of edible meat by-products

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ABSTRACT

While muscle foods are the more commonly consumed portion of an animal, meat by-products such as the entrails and internal organs are also widely consumed. Considered high-priced delicacies or waste material to be tossed away, the use and value of offal-edible and inedible meat by-products depend entirely on the culture and country in question. The skin, blood, bones, meat trimmings, fatty tissues, horns, hoofs, feet, skull, and internal organs of harvested animals comprise a wide variety of products including human or pet food or processed materials in animal feed, fertilizer, or fuel. Industry is using science and innovation to add value to animal by-products far beyond its usual profitability. Regardless of the final product's destination, it is still necessary to employ the most up-to-date and effective tools to analyze these products for nutritional properties, to search for key active molecules in nutrition like bioactive peptides, food safety (antimicrobial peptides), medicine, cosmetics or other fields, to develop new technological applications and to continue innovation towards advanced value-addition of meat by-products.



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## 1. Introduction

Slaughterhouses as well as the processing of meats generate a significant amount of solid and liquid by-products. Wholesalers, retailers and renderers also produce large amounts of by-products. So, millions of tons of processing wastes are produced every day and the problem is the disposal of such wastes, which remains a huge problem for the processors. The disposal of processing by-products and wastes incurs considerable cost to processors for their treatment according to strict regulations. Of course, there are industrial systems to treat and reduce by-products but there is a growing awareness that most times these by-products are under-utilized and represent a valuable resource if treated in the correct manner.

It is no longer practical to discard by-products and wastes, especially when a significant amount of valuable raw materials have a strong economic potential like the production of new products and functional ingredients with a significant added-value (Toldrá & Reig, 2011; Zhang, Xiao, Samaraweera, Lee, & Ahn, 2010). It is desirable to process all by-products into valuable products, for human foods, pet foods, animal feeds, pharmaceuticals, or fertilizer and lately for biodiesel generation. New technologies and uses for meat by-products have been developed around the world but most times they are difficult to be implemented. The reason is the difficulties

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found to combine the use of innovative technology, processing methods, and adequate marketing of the product.

Adding value to meat by-products implies a degree of innovation that makes a by-product that could be considered as waste, to be used as raw material subjected to further processing into edible food items desirable to consumers (Ockerman & Basu, 2004a) or inedible products with economic profitability (e.g. plastics, pharmaceuticals, energy) (Ockerman & Basu, 2004b; Pearl, 2004). In the case of edible items, meat by-products constitute an excellent source of nutrients like essential amino acids, minerals and vitamins (Aristoy & Toldrá, 2011; García-Llatas, Alegría, Barberá, & Farré, 2011; Honikel, 2011; Kim, 2011). Such added value can be obtained in terms of shelf stability, improved technological functions (flavoring compounds, water bonding agents, emulsifiers), better sensory quality (color, texture, flavor) or even more convenience. Another alternative is to produce functional ingredients like bioactive peptides and antioxidants. A good example is blood that has a long history of use in Europe and Asia as an ingredient in traditional foods like blood sausages, puddings, blood soups and crackers. Blood serves several technological functions such as the increase in protein levels, and the enhancement of the water binding and emulsification capacity (Mandal, Rao, Kowale, & Pal, 1999; Ofori & Hsieh, 2011). On the contrary, blood products use to be discarded in the USA as an unwanted by-product; for instance, beef plasma is no longer used in the United States for surimi or other food preparations.

Meat industry is using science and innovation to add value to animal by-products far beyond its usual profitability based on hides and internal organs. Appropriate research and development activity can help to convert animal by-products into key components (bioactive molecules) in scientific, medical, and technological advances. In summary, the processing of by-products can convert a product of low value, or even having relevant disposal costs, into a product capable of covering all the processing and disposal costs, and reducing the environmental damage. A diagram showing the main routes for applications of meat by-products is shown in Fig. 1. This manuscript reviews the latest innovations to add value to edible meat by-products far beyond its usual profitability.

## 2. Safety issues

Apart from strict hygiene considerations, there are other recent issues that deserve attention when treating meat by-products. Bovine spongiform encephalopathy (BSE) is a disease that was first detected in 1982 in UK. It affects adult cattle; BSE has not been detected in animals younger than 30 months. BSE belongs to a family of diseases known as transmissible spongiform encephalopathies (TSEs), which result from the build-up of abnormal prion proteins in the brain and central nervous system. A TSE disease that affects humans is the Variant Creuzfeldt–Jacob Disease (vCJD) which causes death. Because of this disease, certain tissues of cattle (spleen, tonsils, intestine, mesentery, spinal cord and full head), sheep and goats (full head, ileum, spleen and spinal cord if a permanent incisor tooth erupted through the gums or are aged over 12 months) that are most likely to contain the BSE agent are considered to be specified risk materials and they must be removed and destroyed in order to avoid their inclusion in either the human or animal food chains. In countries with risk of BSE, the bones from beef, sheep and goats are also considered to be specified risk materials and they are also forbidden for the production of mechanically recovered meat. Sheep and goats may suffer from scrapie which is another TSE disease that, even though not affecting humans, may mask BSE detection. In the European Union, the rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies are described in Regulation 999/2001 (EC, 2001). Regulation 853/2004 (EC, 2004) describes the specific hygiene rules for foodstuffs including those of animal origin while health rules regarding animal by-products and derived products not intended for human consumption and repealing the animal by-products Regulation (EC) No 1774/2002 are described in Regulation 1069/2009 (EC, 2009). The Food and Drug Administration (FDA, 2004) also announced new rules to prevent the establishment and spread of bovine spongiform encephalopathy (BSE) in the United States, including a prohibition on the use of high-risk, cattle-derived materials that can carry the BSE agent which are defined as specified risk material. These materials are brain, skull, eyes, trigeminal ganglia, spinal cord, vertebral column and the dorsal root ganglia of cattle more than 30 months of age and also the tonsils and the distal ileum of the small intestine of cattle of any age. The small intestine of all cattle, and mechanically separated meat from beef are also banned.

## 3. Edible meat by-products as human food

The consideration of by-product depends on the market demand. So, some non-carcass products that are considered inedible in a country can be considered as precious products in other countries (Ockerman & Basu, 2004a; Spoonger, 1988). By-products such as blood, liver,

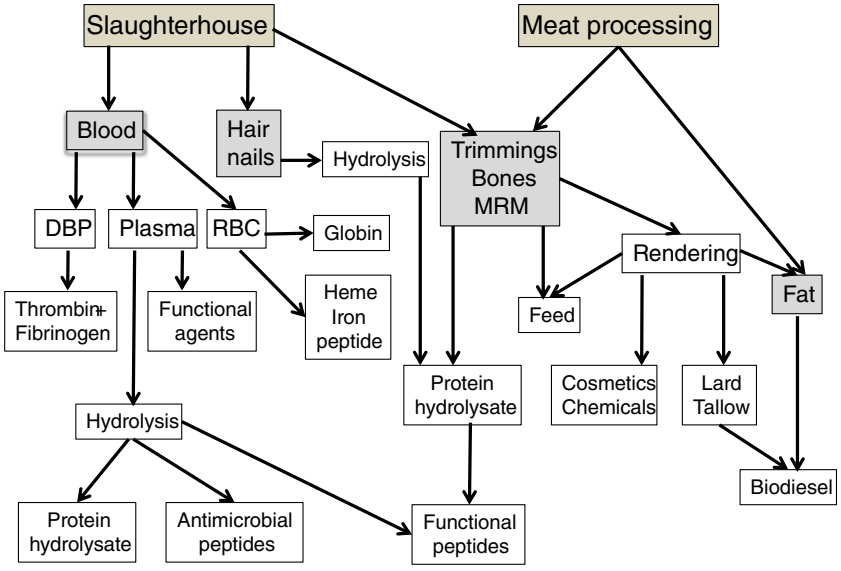


**Fig. 1.** Flow diagram of main routes for value-addition to meat by-products.