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Utilization of animal by-products and waste generated in Estonia

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Abstract. Three main directions must be considered in valorisation studies of animal by-products:

1. Creation of a monitoring system that reflects the generation of animal by-products and waste in the food production chain (livestock farming companies – meat industries – marketing and consumer); this includes mapping of by-products and waste, and the creation of a relevant database and models;
2. Study of pre-treatment of various types of animal by-products and waste, which includes of size-reduction and fractioning as well as a physical and chemical study;
3. Studies concerning the use of animal by-products and waste fractions (fat, protein, carbohydrates etc.) for the production of goods and energy.

Large amounts of waste and by-products, which are suitable for further use, are generated in the food production chain. Animal by-products and waste consist of organic substances, which contain fat, protein, carbohydrates and often also important bioactive compounds. However, their use in Estonia is still rather modest and there is no complex approach to this. For example, the common technology for processing the by-products generated in meat industry is not designed for optimal use of protein-rich materials suitable for food (connective tissue, tendons, bones, rind and blood) to reduce the deficit of food protein of animal origin, but instead it is used for technical purposes, poured into sewerage or burnt.

Many positive examples of the reuse of animal by-products and food waste can be found in European Union Member States (Denmark, Finland, Germany and Austria). This reduces environmental pollution and supplies energy production and industry with additional raw material. In this paper establishing research for a complex approach in the utilisation of animal by-products and waste for food, feed and technical purpose in the production chain is proposed.

Keywords: animal by-products, food, feed, energy, biofuels.

INTRODUCTION

Food production volumes generally meet the biological needs of the world's population, but up to a billion people around the world are suffering from hunger due to the uneven availability of food. Deficit for proteins, including protein of animal origin, is high. Proteins of animal origin should comprise approximately half of the

total protein ration and 100 g of pure protein per day is considered the optimal consumption quantity (FAOSTAT, 2010).

Animal by-products are generally created during the slaughter of animals meant for human consumption and production of animal products as well as elimination of dead animals and implementation of measures against disease.

There are many ways of changing or updating the technology used in the meat and dairy production chain in order to prevent raw material containing large quantities of animal protein ending up among animal waste, where on the basis of the current system it turns into material belonging to Category 1st (specified risk material), which according to regulations must be immediately eliminated from the food production chain and destroyed (Sannik et al., 2009).

Rendering of animal by-products is widely applied in North America (about 25 million tons yearly), but this is growing trend in EU Countries also where nearly 15 million tons of it is reused per year (Swisher, 2006).

Proteins of animal origin which are suitable for consumption as food comprise less than a fifth of the entire food protein 'fund' available in the world. An unreasonably large quantity – up to 30% – of protein suitable for consumption as food is at the same time lost in meat processing (Sannik et al., 2009). For example, meat and bone meal or meat meal are an cost-effective source of protein and the quantities of this produced in the European Union exceed 3,500,000 tons per year, but its use is not realised (EU Council, 2011).

It is proposed waste and by-products of animal origin to be used for production of organic fertiliser as well as pet feed. The implementation of new technology would expand its use even further – food for human consumption, fish feed, biogas production, partial substitute for fishmeal and bird feed. This material is predominantly valuable resource and instead of letting it burden the environment, it could be reused to produce added economic value (Fig. 1).

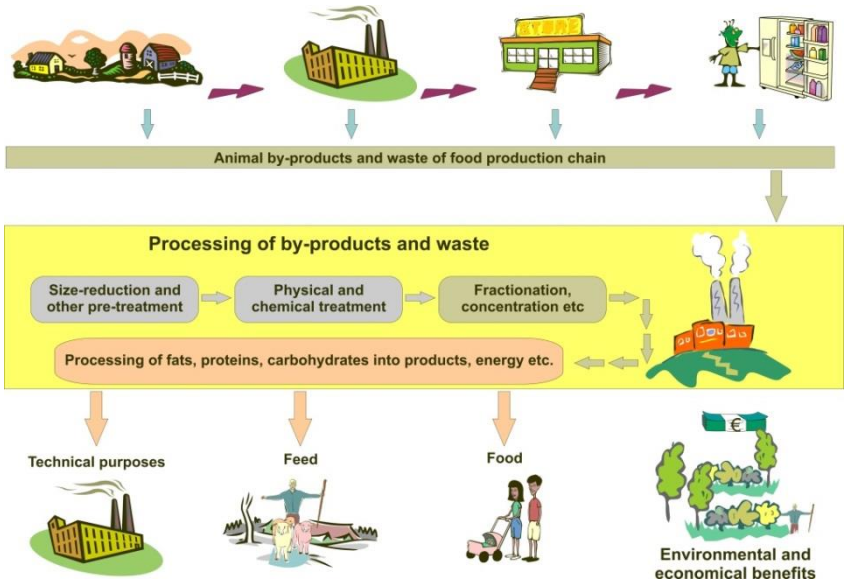

Figure 1. General scheme of animal by-product and waste valorization.

Complex approach for processing of animal by-products and waste in food production chain

Research with pilot projects should be started in three main directions:

1) Creation of a monitoring system that reflects the generation of animal by-products and waste in the food production chain (livestock farming companies – meat industries – marketing including catering companies and sales chains and domestic consumption). The following should be done in the course of the above:

a. Primary mapping of the generation of animal by-products and present handling. For example, the amount of by-products and waste of animal origin generated in Estonia from slaughtering at present is *ca.* 23 thousand tons per year. One-third or even half of this quantity could be saved with the reorganisation of technology and used partly for food, pet food, fish food and animal feed (Ockerman & Hansen, 2000; Arvanitoyannis & Ladas, 2008; Hardy, 2010).
b. The model of a primary computer-based monitoring, which would form the basis for a well-functioning applied system and development of logistic solutions, will be created on the basis of the research carried out in a chain consisting of surveillance farms, industries and shops, waste handlers and consumers. The monitoring system should also reflect data of substance and energy content (Edström et al., 2003).

   In this part of pilot study by-products and the waste of animal origin will be classified on the basis of their characteristics and other features, and the locations and quantities of their generation will also be specified. Obtained data is necessary for planning the logistics of subsequent production and marketing.

2) Study of various pre-treatment types of animal by-products and waste, which includes size reduction and fractioning as well as chemical, physical and thermal treatment. In the majority of animal by-product sterilisation plants or production units use the high-pressure method (133 °C, 3 bar, 20 min, 50 mm) (EU Council, 2003). The by-products of poultry production are, for example, materials containing keratin (feathers, bristles and hair); hydrolysate, which is rich in soluble proteins and amino acids, is obtained when these are processed with calcium hydroxide (150 °C, 25 min). This concentrate contains a number of essential amino acids: lysine, threonine, leucine, isoleucine and valine. Dissolving proteins at lower temperatures takes more time; however, selecting 'soft' processing parameters (100 °C, 300 min, 0.1 g $Ca(OH)_2$ $(1\ g)^{-1}$ dry feathers) makes it possible to obtain a protein product in which 95% of keratin fibres are digestible (Bureau et al., 2000; Guerro-Legretta, 2001; Valladao et al., 2007).

3) Studies of the use of fractions from processing of by-products and waste of animal origin (fat, protein, carbohydrate etc.) for the production of goods and energy:

a. **Food Production**. Whey (derived from cheese and casein production) is probably most suitable by-product for food production. Its World output is estimated about 200 million tons per year. With the rise of cheese popularity whey production increases 2% yearly (Illanes, 2011). Whey is the most important by-product of the Estonian dairy industry too (200 thousand tons per year). This could be processed to make food with a high protein and lactose content. Most widely whey is used for production of Ricotta-type cheese

(Pajumägi et al., 2012). From the secondary whey of Ricotta lactose could be produced applying crystallization process (Pisponen et al., 2013). Lactose can be used as raw material for an array of lactose derived products (Aider & Halleux de, 2007). Highly valuable are different kind of whey protein concentrates and isolates (Smithers, 2008) production of which has not been introduced in Estonian dairy industry yet. There are quite a lot of possibilities to upgrade whey by enzymatic hydrolysis also (Plou et al., 2007; Illanes, 2011).

b. **Feed Production**. Using by-products for the production of fish feed has particularly good prospects (Coutand et al, 2008). Different types of fish need to consume different quantities of protein, but it is still the key element in the fish feed used on fish farms. The appropriate protein content of feed guarantees the good health and growing conditions of fish. The total feed ration must contain 15–30% protein for herbivorous fish and 45% protein for carnivorous fish. The feed ration of young fish must contain at least 50% protein. Mineral compounds are the second most important component of fish feed, especially calcium and phosphorus (Houlian et al., 2001; Hernandez et al., 2008; Hardy, 2010).
c. Technical **usage**. Using animal by-products as a substrate additive to increase the efficiency of the biogas production process would be a feasible solution (Salminen & Rintala, 2008; Appels et al., 2011). Another important direction is researching the possibility of producing biodiesel (stove and engine fuel etc.) from the fat of animal by-products (Bautista et al., 2009; Awad et al., 2013; Cunha et al., 2013).

This part of the pilot project includes generation and screening of ideas, searching for and assessing technological solutions and preparing the concepts behind innovations. Technical and technological solutions will be mathematically and physically modelled and optimisation tasks will be solved as a result of the pilot projects. The suitability and safety of goods made on the basis of animal by-products and waste will be measured and issues concerning intellectual property will be resolved (Pahl et al., 2007). Strategic partners of research concerning the utilization of animal by-products in Estonia will be Competence Centre of Food nad Fermentation Technology and Estonian University of Life Sciences (Fig. 2).

Figure 2. Scientific laboratories suitable for utilization-studies of animal by-products: Fermentation Laboratory at the Competence Center of Food and Fermentation Technology (left) and Micro-Dairy (right) at the Estonian University of Life Sciences.

CONCLUSION

None of the companies that process the by-products of meat and dairy production chain in Estonia presently reuse the raw material to the extent that is possible and necessary; a large part of this or the semi-processed components go unused, are poured into sewerage or burnt. This pollutes the ecological environment and leaves the by-products unused despite them being a source of highly valuable protein, fat and carbohydrates. Resulting the pilot projects the product development will be implemented in cooperation with companies, which include completion of semi-industrial and then industrial technological solutions. Technical and technological documents will be prepared and licensing and other issues will be resolved.

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