Polish Journal of Chemical Technology, 9, 3, 91 — 94, 2007, 10.2478/v10026-007-0062-3

Waste release from meat processing

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The aim of our work is model solution management of waste from meat industry, which would lead to zero waste production with the use of cleaner technology. The process will allow to obtain semi-finished products to be then reused for both meat industry and energy recovery. The model will include thermal utilization of meat, meat-bone and other meat industry waste. The ashes with strictly specified properties containing phosphorus components will be used as a potential raw material for the production of phosphoric acid and salts used in meat production. The new technology is going to be developed in one of the biggest meat factories in Poland – DUDA-BIS in Sosnowiec. The strategic aim of the factory is meat processing with zero waste. That would help to avoid problems with meat waste transport and the expensive utilization of waste to meat-bone meal. The reuse of suitably processed meat waste in meat production will permit to lower production costs. This model will satisfy the requirements of BATNEEC – Best Available Technology No Entailing Excessive Costs. This procedure is advantageous also because in the EU market there are 18 million tons of meat by-products[1, 2] per year.
Regardless of how the utilization problems could be solved, suitably processed meat industry waste can be treated as a potential substitute for phosphoric raw materials. According to the forecast, 50% of phosphoric raw material deposits used at the moment will be exhausted in the next 60 – 70 years. As a result a necessity for a new source of the raw materials has arisen.

Keywords: meat, meat-bone meal, fat, bones.

Presented at VII Conference Wasteless Technologies and Waste Management in Chemical Industry and Agriculture, Międzyzdroje, 12 – 15 June, 2007.

INTRODUCTION

The aim of our work is model solution management of waste from meat industry, which would lead to zero waste production with the use of cleaner technology. The process will allow to obtain semi-finished products to be then reused for both meat industry and energy recovery. The model will include thermal utilization of meat, meat-bone and other meat industry waste. The ashes with strictly specified properties containing phosphorus components will be used as a potential raw material for the production of phosphoric acid and salts used in meat production. The new technology is going to be developed in one of the biggest meat factories in Poland – DUDA-BIS in Sosnowiec. The strategic aim of the factory is meat processing with zero waste. That would help to avoid problems with meat waste transport and the expensive utilization of waste to meat-bone meal. The reuse of suitably processed meat waste in meat production will permit to lower production costs. This model will satisfy the requirements of BATNEEC – Best Available Technology No Entailing Excessive Costs. This procedure is advantageous also because in the EU market there are 18 million tons of meat by-products[1, 2] per year.

Regardless of how the utilization problems could be solved, suitably processed meat industry waste can be treated as a potential substitute for phosphoric raw materials. According to the forecast, 50% of phosphoric raw material deposits used at the moment will be exhausted in the next 60 – 70 years. As a result a necessity for a new source of the raw materials has arisen.

Now[1, 2] the procedure of dealing with particular waste from meat industry depends on its category. The classification into specific categories is based on determining the hazard that particular waste causes. Meat-bone pulp, as an example of meat industry waste, and all the elements of body parts of animals suspected of contracting BSE, belong to the first category of high risk waste. The one and only method of dealing with the waste is thermal utilization in incinerators at the controlled temperature of minimum 850°C.

The second category of material includes animal by-products such as droppings and digestive system content, animal stuff collected during the slaughterhouse waste treatment, animal products containing veterinary medicine residues. This category of materials must be collected and utilized by thermal utilization. Fat matte and protein materials are then converted into fat so that protein derivatives are obtained and used as organic manure or soil enhancers.

Bone sludge – deproteinased and degreased bones, apart from skin, hoofs, horns, pigs bristle, feathers, blood derived from animals other than ruminants, elements of slaughtered animals which are both suitable and unsuitable for human consumption and which do not carry disease symptoms that can be passed to humans, all belong to the third category of waste. They must be collected, transported, identified and converted to feed, biogas and compost, or immediately removed by thermal utilization at 850°C.

So far almost all the waste from meat industry has been converted into meat-bone meal. Because of the threat of BSE disease the use of meal of animal origin as feed was banned. This resulted in considerable problems connected with meat industry waste utilization, especially the rise in the utilization costs that are now fully incurred by meat factories. Currently some of the meat-bone meal is used as a fuel additive (co-burning with coal) and in soil reclamation. At present 400,000 tons of meat-bone meal is produced in Poland annually.

Meat-bone meal is also produced from non-edible animal products which belong to the third category of low risk, and from meat products withdrawn from the market. After the removal of metallic parts, breaking up and mixing, the material is sterilized for 30 minutes at 133°C under 0.3 MPa. Then the material gets into a dryer where moisture evaporates and some fat is removed. The rest of the fat is removed from the partly dried and degreased material in filter presses under a pressure of 1 MPa at 90 – 100°C. It results in a solid fraction consisting of meat-bone meal which is next broken up and sieved. The raw materials contain about 40% of moisture, 2/3 of dry mass is meat-bone meal and 1/3 is fat. The procedure satisfies the EU demands.

The scope of our work focuses mostly on introducing technologies of animal blood processing into plasma of both technical and pharmaceutical quality, powdered red blood cells, protein hydrolysates, recovery of fat from the processed bone waste and the post-flotation waste and its use as a natural gas substitute for the technological steam production. The widest range of our work concerns the method of thermal utilization of meat-bone meal, bone waste and other meat industry waste which results in the ash of clearly specified properties. The ash must contain phosphorus compounds which could be used as a potential raw material for the production of phosphoric acid and salts. These solutions would provide an example of implementing methods of cleaner production in technological processing[3].

CHARACTERISTIC OF MEAT INDUSTRY WASTE AND AREAS OF ITS USE

The quantities of meat industry waste are varied and they depend on a type of a raw material processed, proportions of particular groups of raw materials used, the technological level, the apparatus used and many different factors, especially the present production volume. Table 1 shows the meat waste quantities produced in one of the most modern meat factories in Poland and then recalculated as a proportional part of the whole country's produce.

The calculations are rather underestimated and the actual quantity of waste all over the country is bigger because especially small meat factories are not so modern and produce more waste. It should be added that in Poland there are 3,000 mainly small meat factories and over 50% of production is achieved by 20 big factories[4].

Table 1. The meat waste data for one meat factory and on a country scale[2, 4]

By-product:	Meat factory[2] [tons/year]	Poland[2,4] [tons/year]
Waste animal tissue: soft	432	14,388
Non-processable raw materials and products	38	1,281
Fat from waste water and wastes	1,354	45,141
After-processing bones	3,761	125,356
Waste animal tissue: intestine content and haslets	1,200	40,000
Waste animal tissue: bristle	240	8,000
Waste animal tissue and blood	560	18,667
Post-flotation waste	11,475	382,500
Feed content	2,745	91,493
Slaughter by-products	5,733	191,090
Legs, horns, nails and the like	788	26,280
Total	28,326	944,196

OBTAINING THE POWDERED PLASMA AND RED BLOOD CELLS FROM ANIMAL BLOOD

In food production plasma of different concentration is used: plasma solution (up to 91% of moisture), plasma concentrate (up to 79% of moisture) and powdered plasma (5 – 7% of moisture). Blood constitutes the most nutritional by-product in meat industry. Its general content in the ratio to the mass in slaughtered animals is as follows: 4.6% – pigs, 8% – cattle and sheep, 9.8% – horses. From the total blood amount 50% is found in the blood circulation system, about 20% in liver, 16% in spleen, 10% in skin and 4% in other organs. During the slaughtering process only 40 – 60% of the total blood amount is recovered. Blood contains over 80% of water connected mainly with proteins: albumin, globulin, fibrinogen - all dissolved in plasma – and haemoglobin from erythrocytes. Plasma is a fluid blood component with red blood cells (erythrocytes) suspended in it, blood platelet cells (trombocytes) and white blood cells (leucocytes). Erythrocytes contain haemoglobin, complex protein – chromoprotein built of a protein part – globin and a red pigment – haem.

Basic blood components with a practical use are as follows:

– plasma – blood without red blood cells – food industry;

– serum – plasma without fibrinogen – contains 0.7% less protein than plasma – food industry;

– fibrin – pharmaceutical industry;

– globin – a colourless haemoglobin part – food industry;

– haem – dyeing agent in meat substitutes and chemical synthesis of different compounds;

– leucocytes – pharmaceutical industry.

There is a frequent need to extend the life of blood because of its extended storage or transport. The most popular methods of extending the life of blood are[5, 6]:

– blood precooling to 0°C (durability: 2 – 3 days);

– freezing below -30°C and storing frozen blood or its serum at -10°C (durability up to 6 months);

– serum blood proteins drying below 60°C;

– blood consolidation with 6.05 kg mixture of: sodium citrate – benzoatic acid – sodium chloride in proportion 1 – 200 – 1000, added to 100 kg of blood (durability up to 3 months).

The most popular method of blood separation into plasma and red blood cells is centrifuging. Because the density of haematocytes is about 0.046 – 0.073 g/cm^3 higher than that of plasma, both components can be separated under the influence of centrifugal force. In the centrifuging process about 55 – 60% of the slightly coloured plasma can be obtained[5, 6]. The plasma solution after the centrifuging process can be condensed in a vacuum evaporator and dried in a spryer dryer. The powdered product significantly lowers the transport and storage cost. Another way of enhancing the concentration process is implementing membrane techniques. The possible condensation and drying process must be performed at a temperature lower than 60°C – under these conditions the properties of plasma do not undergo any changes.

OBTAINING PROTEIN HYDROLYSATES WITH ENZYME USE IN BONE WASTE DEPROTEINASE PROCESS

Animal protein from milk, meat and from after-slaughter waste such as skin, horsehair, blood and bones can be used as a raw material in the deproteinase process. The deproteinase process can take place through enzymatic or chemical (base or acid catalysis) hydrolysis. The protein hydrolysates are used not only in meat industry but also in food and cosmetic industry[7].

To improve the colour and odour the protein hydrolysate is usually purified with the use of activated carbon. The attempts to use hydrogen peroxide were also made. Cation precipitation is also often used in order to reduce the content of mineral parts, and separation of components responsible for bitter taste of a product is made using adsorption and membrane techniques. Powdered protein can be obtained by spryer drying of purified and filtrated solutions of protein hydrolysates[7].

The preliminary studies included obtaining protein by the low temperature method from meat-bone tissue with the use of Protamex and Flavourzyme enzymes and milk acid.

The conducted research shows that the following are the most advantageous conditions under which the hydrolysis process with the use of enzymes may be carried out:

a) using the Protamex enzyme only:

– temperature: 40°C;

– consumption: 1.7 kg of enzyme per 1,000 kg of meat-bone pulp;

– pH level: about 6;

– processing time: 4 h.

b) using a mixture of enzymes:

– temperature: 40 – 45°C;

– consumption: 1 kg of Protamex and 4 kg of Flavourzyme per 1,000 kg of meat-bone pulp;

– pH level: about 6;

– processing time: 3 h.

TECHNICAL FAT RECOVERY FROM MEAT AND POST-FLOTATION WASTE AND ITS USE AS A NATURAL GAS SUBSTITUTE

Fats from the utilization of meat and bone waste which have the same quality as fuel oil can be recovered in the bone deproteinase processes and in the meat-bone meal production[8].

Both after-slaughter meat waste and occasionally delivered remaining types of waste will take part in the process. The waste will be broken up and dried in a non-membrane steam dryer with a stirrer. Vapours from the drying process are condensed and directed to a wastewater treatment plant. The product from the dryer is then transported by worm feed with a perforated bottom to an intermediate tank. From the intermediate tank the product is transported by another worm feed to a magnetic separator and to a filter press where the fat is separated from the remaining part of a degreased meal named „greaves". The fouling metallic waste will be transported to a rotary oven. The „greaves" will be transported to the third tank where they undergo cooling and stabilizing, which makes them easier to break up in a hammer mill. Then the product is stored in an intermediate tank and packed into bags. The fat from both the feed with the perforated bottom and the filter press is pumped into an intermediate tank and then drips to a decanter. After the decantation process the purified fat is transported into a storage heating tank and then used as a fuel in steam boilers.

Another issue taken into consideration is using fat from animal waste recovered from the post-flotation waste as a fuel and substitute for natural gas. The current amount of the post-flotation waste in meat factories is up to 51 tons/day, which results in 12,750 tons/year if we consider 250 installation working days per year. The waste contains up to 15% of fat, which accounts for 1,912 tons/year. Assuming that 90% of fat may be recovered from waste, its full recovery may be estimated at 1,721 tons/year. The recovered fat could be sold as a technical fat or used in team boilers as a fuel source.

The post-flotation process precipitate would be stored in a heated tank and then filtered in pressure filters. The filtrate would be directed into a steam boiler and the rest of the precipitate would be utilized as it is happening now.

THERMAL UTILIZATION OF MEAT-BONE AND BONE WASTE

Thermal utilization of meat, meat-bone, and after-slaughter waste has been preliminarily estimated at about 10,000 tons/year. Studies carried out so far have referred mainly to the thermal utilization of bone sludge. Bone sludge is waste in bone deproteinase process where the main product is protein hydrolysate. The raw material for this process is bones from the partition of the meat. After breaking up, the mixture of bone pulp, water and small amounts of milk acid is boiled at 125 – 135°C under pressure 0.26 – 0.30 MPa. Next the boiled bones are separated on a sieve and the solution goes to a decanter where the bone sludge is separated. The deproteinased and degreased bone pulp contains about 7% of moisture and up to 18% of organic parts[2, 9, 10, 11].

The typical bone pulp has a size ranging from a few to tens of centimeters and contains 55% of moisture. In the dry mass it contains about 37% of organic substances, 3.0% of fat, 14.3% of protein, 10.7% P, 29.3% Ca. The bone sludge coming from different animal waste contained respectively:

– from beef bones: 7.1% of moisture, 14.1% P, 25.8% Ca, 2.4% of fat and 20.4% of protein;

– from pork bones: 6.5% of moisture, 14.1% P, 22.8% Ca, 3.1% of fat and 24.0% of protein;

– from pork legs: 7.0% of moisture, 14.0% P, 20.6% Ca, 2.9% of fat and 18.7% of protein.

The study results so far show that it is possible to develop a technology of thermal processing of all kinds of bones and bone semi-products from meat industry. The technology makes it possible to obtain ash containing almost pure hydroxy apatite, which can be used as a source material for the production of phosphoric acid and its salts. The obtained ash contains on average 39.0% P_2O_5 and 65.0% CaO. Typically 60% of ash was obtained from the dry bone mass. The thermal processing of bones into ash containing hydroxy apatite of high purity and devoid of any traces of organic compounds is possible at 650 – 950°C and within the time of 30 – 120 minutes in oxidizing atmosphere. The first phase of the process conducted in a rotary oven is water evaporation from the bone pulp. The second phase is a thermal decomposition of the bone pulp when the organic compounds from proteins and fat (up to 37% of dry mass) melt, break-down and burn.

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