PRODUCTION AND PROCESSING OF SLAUGHTER BY-PRODUCTS. PRIORITIES AND PROCESSING TECHNOLOGY.

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SUMMARY

The production of meat and meat products inside the EU has increased from 30 million tons in 1989 to almost 34 million tons in 1991 (meat with bones, including poultry). Not only ready to eat, or ready to process meat is produced, together with the meat approximately 25 to 40% inedible animal by-products are produced. That means that the volume of inedible animal by-products inside the EU was in 1991 approximately 8 to 14 million tons. To protect animal and human health, the environment, and to be economically competitive, optimal processing of these animal by-products is obligatory. Even counteracting objectives should be considered regarding processing of these by-products. Nutritive value, animal health, human health, environmental protection and free trade are the main considerations to set up rules for processing of these by-products into basic materials for animal feed. The most outstanding hazards relating to the use of animal by-products can be specified as microbiological and biochemical hazards.

Microbiological hazards

The spread of any communicable disease through the use of animal by-products needs to be prevented. In this respect not only the spread of parasitic, bacterial, and viral agents need to be considered, but also the dispersion of small agents, such as the agent of BSE. Official regulations need to focus for that reason on the endemic disease situation in a certain region or country. For that reason the survival of viral agents needs much more attention in practice.

Biochemical hazards

The breakdown of fat and protein in slaughter by-products not only results in a substantial loss of nutritive value, but can also cause high levels of toxic and malodorous substances. These hazards indicate that preservation and/or full processing of slaughter by-products at source, must include also inactivation of enzymes.

Nutritive value

The application of high temperatures (> 100°C) and long processing time causes a marked loss of the availability of certain amino acids.

Environmental aspects

These can be divided in two main problems: the release of bad-odours and micro-organisms, and the pollution of water in processing plants. The next solutions are suggested to tackle these problems: (i) processing at source, and (ii) immediate cooling after release of the slaughter by-products combined with fully hygienic transport to the processing plants. Preservation of the wet substance without drying can also be considered to reduce the production of process water.

Depending on the size of the slaughterhouse, and the infrastructure concerning the sale of the by-products, treatment to preserve the quality of the slaughter by-products before processing will be applied. When the volume of the slaughter by-products of an individual slaughterhouse is large enough processing at source will probably become economically feasible.

INTRODUCTION

In areas of intensive animal production relatively large amounts of slaughter by-products are produced. In the European Union approximately 15 million tons are produced annually. Mainly as a result of the concentration of animal production during the past decade, the production volume per farm and per slaughterhouse has increased, resulting in a concentration of the release of slaughter by-products to only a few places. It is obvious that these larger volumes of slaughter by-products create considerable logisticand environmental problems during collection and disposal. However economically feasible alternative ways of processing and new products could be created. There is also a need for strict rules for the disposal and processing of these by-products to prevent the dispersion of pathogens so that animal and public health and the environment are protected (EU Council, 1990; Oosterom, 1986). Until now hardly any attention, in practice or in research, has been paid to the collection and disposal of these by-products. There are, however, several reasons why this situation should be improved: 1) storage of by-products at slaughterhouses - in general not chilled and for relatively long periods (6-30 h) - can result in high levels of metabolites because of degradation processes in the product which makes it less suitable as a raw material for animal feed. Furthermore, the production of volatile degradation products at the slaughterhouse and the rendering plant results in pollution of the environment (Urlings et al., 1992). Some form of preservation at the slaughterhouse - at source - is, therefore, necessary; 2) disposal of these often malodorous and highly contaminated by-products is mainly by road transport. This represents a certain risk in terms of environmental pollution and spread of microorganisms. Also the time between release of these by-products and processing is often prolonged by long transportation.

Because of their high protein and fat content and generally good amino acid composition slaughter by-products can serve as a highly valuable raw material for animal feed production (El Boushy et al., 1990; Hector, 1991; Hector et al., 1991a,b; Pesti et al., 1986; Tibbetts et al., 1981, 1987). The main threat to human health from the use of slaughter by-products is the spread of pathogenic bacteria, such as salmonella and *Campylobacter jejuni*. Risks for livestock constituted by slaughter by-products are pathogenic viruses, bacteria, toxins, and undefined pathogenic agents, such as that of BSE, bovine spongiform encephalopathy, (Lange and Kaaden, 1978; McKercher et al., 1978, 1987; Yuassa et al., 1978; Blackwell et al., 1985; Oosterom, 1986; Ur Rehman, 1986; Southwood, 1989; Wilesmith, 1991).

At the moment it is important to consider whether the applied methods of valorization really contribute to a sustainable animal production for the future. In our opinion we have to focus on the following issues:

1. Short term preservation (e.g. chilling) at source together with controlled transportation and immediate processing on arrival at rendering and animal feed plants.

2. Flowtherm heating to process for safety and additionally drying at low temperatures (below 80°C) to maintain the quality of the animal protein and fat as high as possible (Fernando, 1992).
3. Processing at the slaughterhouse of the low risk materials by means of a short term moderate heating to process for safety and preservation of the wet substance (e.g. by means of fermentation).

Low temperature drying is described by Fernando (1992), in this paper attention is drawn to chilling and fermentation of slaughter by-products.

FERMENTATION OF SLAUGHTER BY-PRODUCTS.

Fresh poultry slaughter by-products, such as heads, feet and viscera, mixed with carbohydrates and a starter culture can be fermented to a stable raw material for feed production, at least as far as the pH and the number of Enterobacteriaceae are concerned. Although methods to ferment raw animal by-products have been reported (Lindgren and Pleje, 1983; Delatte, 1985; Tibbetts et al., 1987; Skrede and Nes, 1988; Russel et al., 1992), necessary scientific information, e.g. about the preservation of amino acids is lacking. A more thorough analysis showed that, in fact, amino acids were not stable in the fermented raw poultry by-product, as shown by the increase of total volatile nitrogen (TVN) and the concentration of biogenic amines, such as histamine, putrescine and cadaverine. Even when fish by-products, with a low initial contamination (i.e. low Enterobacteriaceae count) were fermented, a steady increase in both NPN (non-protein-nitrogen) and TVN was observed (Lindgren and Pleje, 1983). Manipulation of the fermentation conditions, e.g. initial acidification with 0.4% lactic acid or a high inoculation level of almost 10^9 *Lactobacillus plantarum* per gram of product, did not substantially reduce the biochemical breakdown of amino acids in the fermented product. It is clear that, despite reports in favour of fermentation of raw animal by-products, our results have shown that amino acids are not preserved sufficiently. Therefore fresh slaughter by-products first need a heat treatment before fermentation.

AMINO ACID BREAKDOWN IN POULTRY BY-PRODUCTS.

To elucidate the mechanism of amino acid breakdown in poultry by-products, it was shown that heating (2 min 80°C core temperature), without storage, substantially changed the NPN level in poultry viscera (Urlings, et al. 1993c), but no change in NPN was observed in poultry breast meat and heads. These findings are in accordance with De Masi et al. (1990), who reported no increase of NPN after heating in beef and pork. The increase of NPN in the viscera is probably a result of increased enzymatic activity during the beginning of heating, as also reported by Raa and Gildberg (1976) in cod viscera. From this observation, a high initial proteolytic activity was demonstrated in the viscera: when bacterial growth was stopped by γ-irradiation the increase of TVN and cadaverine (a breakdown product of lysine) over the first 24 hours of storage at 20°C was equal to untreated viscera (Urlings, et al. 1993c). This implies that bacterial proliferation was not the reason for the breakdown of substantial amounts of e.g. lysine in poultry viscera. Concerning the formation of other biogenic amines, such as putrescine or histamine, no increase was observed in any of the products when there was no bacterial proliferation. Only this last observation was in accordance with results of other studies, which involved less contaminated products (Edwards et al., 1985; Askar and Treptow, 1986; Dainty et al., 1986; Klausen and Huss, 1987).

Our conclusion, based on these observations, was that, because of the high enzymatic load of viscera (exogenous and/or endogenous), the application of preserving methods which also stop the enzymatic reactions is required. Moderate heating was shown to be effective at stopping the enzymatic breakdown of amino acids in animal by-products. Thus it is suggested that, prior to fermentation of slaughter by-products, a short, low temperature heating (e.g. 2 min 80°C) should be applied in order to inactivate amino acid decarboxylating and deaminating enzymes.

VIRAL DECONTAMINATION OF ANIMAL PRODUCTS.

Transmission of viruses through the use of slaughter by-products as a feed ingredient constitutes a potential risk for livestock. Because of the nature of chicken anemia virus (CAV), which has a small, circular single-stranded DNA and no envelope (Noteborn, et al., 1991), it was choosen as a model to study the inactivation of virus in viremic animal tissue during heating and fermentation. Our results show that a time-temperature profile of 30 min at 95°C, or 10 min at 100°C is necessary for the inactivation of CAV (Urlings, et al. 1993b). It was therefore concluded that CAV is more resistant to heat compared with other pathogenic viruses, such as swine fever virus (30 min at 65°C, or 1 min at 71°C), Aujeszky disease virus (10 min at 60°C), and foot and mouth disease virus, 22 min 60°C, or 15 min 70°C (Terpstra and Krol, 1976; Lange and Kaaden, 1978; Stewart et al., 1979). This confirms that small, simple DNA viruses need a more severe processing to ensure inactivation, compared with more complex viruses.

As with swine fever virus and African swine fever virus in salami and peperoni (McKercher et al., 1978), CAV was not inactivated during fermentation of infected poultry tissue. It is obvious that fermentation alone does not make a substantial enough contribution to inactivation of small pathogenic viruses in infected host tissue (Urlings et al. 1993b)

To prevent the spread of pathogenic viruses through the feeding of fermented slaughter by-products it is suggested that moderate heating is applied before fermentation of slaughter by-products; time-temperature figures need to be adapted depending on the target viruses to be inactivated. To achieve thorough heating at a choosen temperature the use of flow-therm heating is recommended over batchwise heating.

FEEDING PASTEURIZED AND FERMENTED POULTRY BY-PRODUCTS TO PIGS.

It has already been shown that for effective preservation of protein in animal by-products fermentation alone is not sufficient, and that, to prevent the spread of certain pathogenic agents, such as small viruses, additional processing is necessary. The use of sterilization and hightemperature drying, such as in conventional rendering processes (Oosterom, 1986) had been criticized for its detrimental effects on protein quality (Papadopoulos, 1989). From the standpoint of the nutritive value of protein, only the chemical modifications of the primary structure brought about by processing (severe heating) may have really detrimental effects. These modifications can be 1) the Maillard reaction, a reaction of proteins with reducing substances (Cheftel, 1979; Hurrell, 1984) and 2) protein-protein interactions (Bohak, 1964; Ziegler, 1967; Asquith and Otterburn, 1969; Bjarnason and Carpenter, 1970; Hayase et al., 1975; Nasheff et al., 1977; Bender, 1978).

A marked loss of the availability of lysine has been reported for blood meals (Waibel et al., 1977), meat-and-bone meals (Batterham et al., 1986; Johns et al., 1986) and feather meal (Papadopoulos et al., 1985 and 1986a+b). The depressing effect increases in these products with higher processing temperatures and prolonged processing time.

To preserve poultry by-products, for reasons of amino acid quality and safety, mild heating was chosen (4 min at 90°C) in combination with a fermentation using *Lactobacillus plantarum* as starter culture. Finishing pigs fed fermented poultry by-products, which made up 17.6% of the dry matter of their diet, had a significantly improved feed:gain ratio compared with controls (2.46 vs 2.57). In addition the carcass weight was higher (86.1 vs 81.8 kg), the meat percentage lower (50.9 vs 52.5%) and the backfat thicker 21.5 vs 18.7% (Urlings, et al. 1993d). It is speculated that these effects could be the result of the higher energy intake of the pigs fed the fermented poultry by-products and(or) an enhanced digestibility of protein caused by the mild processing of the by-products, as also suggested by Papadopoulos (1989). An additional explanation of the better growth and feed:gain ratio is the lower incidence of diarrhoea in the pigs fed the fermented poultry by-products.

Lower bacterial counts in the rectal content of pigs fed fermented poultry by-products were observed. The number of colony forming units of the mesophilic aerobic flora, the Enterobacteriaceae and lactobacilli was lower and differed significantly from those counts in the control pigs, while the pH in the rectal content of the pigs fed fermented poultry by-products was higher. The same effects were observed by Morishita and Oyata (1970) when feeding fermented *Chorella* to adult pigs. These effects could be explained by substrate limitation in the large intestines as a result of enhanced digestibility in the small intestines: enhanced digestibility of fermented products has been suggested in other publications (Demeyer et al., 1986; Fernandes et al., 1987; Gurr, 1987; Gilliland, 1990). It seems that a direct antimicrobial effect of the starter culture (*Lactobacillus plantarum*) or its metabolites (such as short-chain fatty acids) was less important than substrate limitation. The decreased proliferation of Enterobacteriaceae in the large intestines of pigs fed fermented poultry by-products could be beneficial to both animal and human health since important pathogenic bacteria belong to this family, e.g. *Escherichia coli* and salmonella.

CONCLUSIONS

- Processing of slaughter by-products at source deserves some more attention. This can be considered in the near future because of the marginal profits in agriculture and increasing amounts of slaughter by-products produced at a single location as a result of centralization of slaughtering and intensification of meat processing.
- To protect the environment the release of off-odours, mainly breakdown products of proteins, must be minimized. For this reason effective treatment of slaughter by-products at the slaughterhouse is preferred.
- In regions with intensive animal husbandry it is necessary to set rules to protect animal health. Spread of communicable diseases (e.g. parasitic, protozoic, bacterial, fungal, viral and virus-like diseases) through the use of animal products needs to be prevented. For this reason processing parameters for animal by-products need to be aimed at the endemic diseases of the particular region and be based on scientific knowledge about the inactivation conditions of the target pathogens.

- Safe animal feed is a basic prerequisite of healthy animals for the production of safe animal products. For this reason the application ofmodern (bio-)technology, such as a mild flow-therm heating followed by fermentation, should be considered as a processing method for the production of safe feed constituents.
- Fermentation of slaughter by-products could serve as an intrinsic safeguard against recontamination with bacteria. In an acid-fermented product recontamination with enteropathogens, such as salmonella, and *Campylobacter jejuni* will not result in colonization of the product due to the unfavourable growth conditions.
- Using fermented by-products as feed constituents could result not only in the provision of highly digestible nutrients, resulting in fewer substrates for microbial growth in the digestive tract, but also in the presence of larger numbers of lactic acid bacteria, which are recognised as beneficial to health. The exact mechanism of regulation of the gut flora in animals fed with fermented by-products should be elucidated in future research. Prevention of bacterial contamination of animal products by these kinds of measures at source (e.g. the primary animal production) could be of significant benefit to both human and animal health.

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