RECYCLING OF SLAUGHTER BY-PRODUCTS- AN INTEGRAL APPROACH OF LOGISTICAL, ECONOMICAL, ENVIRONMENTAL AND SAFETY ASPECTS

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SUMMARY

In areas which have an intensive animal production also large amounts of slaughter by-products are produced. About 20-30 percent of live weight of slaughtered animals are disposed to animal feed. In the Netherlands at least 800.000 ton of these by-products are produced annually. Mainly as a result of the concentration of the animal slaughter during the past decade, the production volume per slaughterhouse has increased.

In the Netherlands also the process of rendering is centralised in two large plants. It is obvious that these larger volumes of slaughter by-products create considerable logistical and environmental problems during collection and disposal. Quality, safety and economical profitability of the slaughter by-products can be influenced negatively by applying wrong logistics and processing strategies:

(i) insufficiently differentiated collection of the products at slaughter;
(ii) storage at too high temperatures;
(iii) too long time lag between slaughtering and processing.

A practically-oriented optimization model has been built to find the optimal processing strategies of slaughter by-products for animal feed for the meat processing industry in the Netherlands. Current processing methods are compared with new methods. Different ways of sorting, storage, and processing are built into the model for integral evaluation of benefits, costs and environmental loads. The Mixed Integer Linear Programming model optimizes investments in technology, operational costs, market yields, quality, odour emission, energy consumption and sludge production at dutch circumstances. Regarding costs and product prices, processing investments, environmental investments, and product application can be found in such a way that total yields minus costs are maximized taking into account capacity and environmental restrictions. This optimization model can be used to find optimal processing strategies.

1. Introduction

Any type of industrial processing creates waste (by-products and pollution). Meat production and processing is no exception to this general rule. The main objective of meat production is to produce food for the consumer and anything else leaving the abattoir or meat-packaging plant may be qualified as by-products or waste. If these are not handled and disposed of properly they may create pollution problems.

In this paper the assumptions for a prototype-mathematical-model are reported to trace the optimal processing configuration of these slaughter by-products for animal nutrition. The model is focused on optimization of economical and technological factors within environmental restrictions and veterinary assumptions and legislation. The current processing strategies are compared with alternative innovative ways of processing. The model includes both process integrated as end of pipe measures to meet environmental objectives. Investments, operational costs, quality development, product values and environmental loads are integrated into a so-called mixed integer linear programming model, a common way of modelling, in operations research.

2. Modelling

2.1 General

With vertical integration it is possible to improve the efficiency and effectivity in the chain. The total efficiency and effectivity can be improved by determined efforts that will give a higher product quality and reduced environmental costs.

A mathematical model (a so-called mixed integer linear programming model) has been built (Hendriks, 1991). In this model the disposal and upgrading of slaughter by-products can be optimised. Costs of energy, environmental costs and restrictions, durable investments, and labour are incorporated in the model. Also the product quality and value have been taken into account.

Objective of the model is to be a tool that represents the slaughter by-product business, and that finds and evaluates optimal processing strategies for these products. Main purpose is to compare the current central large scale rendering with decentral processing at source (of a relatively small scale) at the slaughterhouse, at different ways of sorting the by-products, and different storage methods.

If the by-products are treated immediately after slaughter then the highest nutritional value can be preserved, with a lower disintegration of the best amino- and fatty-acids. This means some logistical flexibility, less environmental costs, a more valuable product, a different energy consumption, changes in processing costs, and shifts of the processing costs within the chain. The modelling of these cost- and benefit identifiers can result in valuable management support for future strategic decisions concerning chain structure.

It is expected that in future a full chain analysis to optimize all aspects of disposal and upgrading of slaughter by-products is necessary to undertake strategic decisions regarding this subject.

2.2 Model options

The mixed integer linear programming model (see figure 1) is based on a decision tree containing three decision moments (indicated by d=1,2,3):

d=1: way of sorting the by-products (raw materials) after slaughtering
d=2: way of storage
d=3: way of processing (both central and decentral processing)

d=1: *Sorting raw materials*

At decision moment 1 can be chosen in which way three kinds of poultry and pork slaughter by-products A, B and C will be sorted. Possibilities are given in figure 2. So it is suggested to sort the slaughter by-products in four ways so-called sorting groups. These sorting groups result in six different raw-material combinations. Because of incomparability the combination A+B is not considered.

FIGURE 2. The four sorting groups (I to IV) in the model for poultry slaughter by-products. Different combinations of A, B, and C are collected in containers. Also the mass percentage in relation to live weight has been displayed.

d=2: *Storage*

After the release of slaughter by-products some way of buffering is necessary. The following options are considered:

(i) Unconditioned storage: this storage is interesting for the sorting groups with a relatively low spoilage rate and a short time lag between release and processing.

(ii) Cooled storage: this storage is interesting for the sorting groups with a relative high spoilage rate and/or a long time lag between release and processing.

(iii) Frozen storage: this storage is interesting for the sorting groups with a relative high spoilage rate and/or a very long time lag between release and processing. Because of common demand fluctuations in the season and a constant supply, storage of the products during a few months can be profitable. To cope with these demand/supply discrepancies it could be interesting to freeze the products. Of course this option is only feasible for high market prices.

d=3: *Processing*

In the third stage has to be decided which way of processing has to be applied. There are four (sub)decisions considered:

(i) Central processing versus processing at source, i.e. at the slaughterhouse.

(ii) When central processing at the rendering plant is applied, it can be chosen between: conditioned and unconditioned transportation. In case of processing at the source the way of processing can be: on-line, full-batch, and semi-batch.

(iii) Processing for safety:

- (a) sterilization (high temperature, long time, high pressure)
- (b) pasteurization (relative low temperature, short time)
- (c) no treatment (immediately fresh to fur animal and petfood processor)

(iv) preservation treatment:

- (a) drying
- (b) fermentation

On-line processing: This means that the product almost immediately after the slaughter process is treated for safety and additionally preserved. There is a storage of raw materials needed for situations of irregularity to decouple the slaughter process from safety-treatment. If the by-products are separated after the slaughtering and it is intended to produce several types of products then more processing units are required.

Full batch processing: This way of production implies that the slaughter by-products will be collected (several tons or for several houres). In case of partial or no sorting only one processing unit is used for the different slaughter by-product. If one storage batch is full, the batch will be processed, followed by the next full batch.

Semi-batch processing: This alternative is a combination of on-line processing and batch processing with one processing unit. In this way of processing the products that are the most vulnerable to spoilage are processed on-line during slaughtering. The other products are processed in batch after slaughtering.

Central sterilization followed by drying is in the Netherlands the conventional rendering process. Although processing efficiency has been improved during the last decade considerably, the process is not yet optimal. Sterilization is considered as necessary because of the microbiological contamination. Odour emission, sludge production, energy consumption and relative low product quality are considered as main environmental problems in centrilized rendering plants. For sterilization investment costs are high while the installation has to resist to high temperatures and pressures. It is an effective way to reduce microbiological contamination, but at very high costlevels.

Pasteurization is a relative low cost process. If this process is used immediately after slaughtering energy consumption is low. The heating traject, from ca. 30°C to 90°C and the heating time are considerable shorter than in case of severe heating during sterilization. Quality reduction of the product is less too.

Preservation: The use of heating and drying, such as in conventional rendering processes had been criticized for its detrimental effects on protein quality. An effective preservation of slaughter by-products after pasteurization is fermentation (Urlings, 1992). Fermentation holds also some promises towards a reduction of the environmental pollution.

3. Conclusions

Assumptions for a practicable optimization model have been reported to find the optimal processing strategies of slaughter by-products for animal feed for the meat processing industry. Current processing methods are compared with new methods. Different ways of sorting, storage, and processing are built into the model for integral evaluation of benefits, costs and environmental loads. The Mixed Integer Linear Programming model optimizes investments in technology, operational costs, market yields, quality, odour emission, energy consumption and sludge production at dutch circumstances.

Literature

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