

## SESSION 3. SLAUGHTER

REVIEW: SLAUGHTER. SOME DEVELOPMENTS AND PERSPECTIVES  
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### INTRODUCTION

It is self-evident that in a meeting on meat science and technology "slaughter" is one of the most important topics. Even after 32 meetings this topic still gives rise to research and to exchange of knowledge, opinions, and reflection. Slaughter is, after all, a crucial part of the meat production line in relation to:

- welfare of animals. Although much has been done already to reduce stress and discomfort for the slaughter animals, much can and must still be done.
- quantity and quality of human labor. Slaughtering is in general a hard job for workers. There is still a great deal that can be done to improve working methods and to reduce the human work-load.
- safety, quality and keepability of the products. The initial contamination of meat with spoilage-, pathogenic or perhaps useful micro-organisms remains a decisive factor in Good Manufacturing Practices and Processing for Safety. Furthermore, the relation between construction and operation of equipment, working methods and hygienic aspects of production and products is closer than one sometimes realises!
- the image of the meat production chain. It is clear that this image in the mind of the consumer must be improved. It is necessary to continually improve production methods and conditions. If economic reasons and also - consequently consumption rates - were our only considerations, it would be enough to continue our normal efforts to mechanize, automate, and probably robotize the slaughtering process. However, society is more and more sensitive to questions like quality of human and animal life. Ethical aspects of animal production are of increasing concern to the public. Improvement of the image of the meat industry is also necessary for attracting people to work in it! However, the problem is how we should manage this.

It is clear that, within the framework of this review, limitations are necessary. It is the privilege of the reviewer to make a choice, based on a personal (and maybe Dutch!) point of view. These topics are:

- pre-slaughter handling and transport;
- stunning and bleeding;
- slaughter process, processing for safety and quality assurance;
- offal and by-products.

### PRE-SLAUGHTER HANDLING AND TRANSPORT

Patricia Barton presented an excellent review during the 31st EMMRW, entitled "Developments in the pre-slaughter treatment of slaughter animals" (1). Her review mainly concentrated on pigs. She mentioned that "several developments were underway which must be expected to radically change the pre-slaughter treatment of animals - at least for pigs". She stressed the fact that different aspects of pre-slaughter treatment must never be considered separately but as a whole chain of interacting events.

I agree with that. But let us not forget that it is exactly this chain of interacting events that makes it so difficult to radically improve the scene, i.e. to reduce animal suffering, to reduce skin damage, bruising, PSE and DFD meat, blood splashing, etc. Nevertheless, much has been achieved (5) although

much can still be done. For instance:

- selection of pigs on stress-susceptibility (halothane test etc.);
- separate delivery of social groups of animals;
- fixed lairage times: (a) for cattle as short as possible, (b) for pigs at least 2 hours and at most 4 hours (15);
- showering of pigs. At least during warm days. Other advantages: pigs become more clean, less pollution of slaughter line, less PSE (9);
- rewarding the farmer and the truck drivers for smaller transport losses and better meat quality;
- improvement of transport, lairage and stunning equipment and circumstances (7).

With respect here we must mention the excellent work and ideas of our American colleague Temple Grandin. Less respect should be given to the use of drugs like tranquillizers and  $\beta$ -blocking agents. As far as I am aware, however, although residues seem not to be harmful to the consumer, the use of these drugs has decreased sharply. Here too the statement is justified that meat production must always deliver a product as free as possible from meat-foreign substances!

### 2 Stunning and bleeding

Stunning is a topic that has been discussed intensively over several decades. Quite rightly! The quality of life for man and animals, and especially the killing of animals are matters of (growing?) concern in our society. And, if we claim that we have the right to kill slaughter animals we are at least obliged to protect these animals from any unnecessary harm. An important factor in this respect is the (in some countries very strong) psychological reaction of the public to the methods used. Scientists do have responsibility for the choice of responsible methods. Another aspect that we have to take into account is the psychological and physical load of the workers in the stables and on the stunning floor.

So in my opinion, the choice of responsible stunning methods is the result of a overall estimation of factors related to (the welfare of) man and animals. People who want to know more about stunning of animals for slaughter may read the Proceedings of three important seminars dedicated to this subject, during the last few years: one in Zeist, The Netherlands in 1982 (3), one in London in 1986 (6), and one recently in June in Brussels (10).

Some conclusions and recommendations made until now are:

- Stunning must cause instantaneous loss of sensibility and consciousness.
- Duration of insensibility produced by stunning has to be at least as long as the time from stunning to death.
- When designing a humane process, the following durations must be known and minimised: a) the time between onset of stunning and complete insensibility. b) the total duration of insensibility. c) the time between onset of bleeding and insensibility. d) the time between stunning and bleeding.
- Animals must be bled by incision of both carotid arteries or of the vessels from which they arise.

Recommended stunning methods are:

- captive bolt stunning. The right positioning of the captive bolt pistol is very important.
- electric stunning by "head only" or "head to body". "Head only" stunning with high electrical currents and effective head to body stunning can cause permanent cardiac disfunction. This has the advantage of rapid brain disfunction, whereas debleeding is not influenced negatively.

Stunning of pigs by  $CO_2$  is still being discussed:

- capital and running costs are relatively high

- handling of animals before and after stunning is simpler
- the system gives a guarantee of 100 % effectiveness
- there is insufficient evidence about the relation between 10-15 seconds of myoclonal jerks and stress symptoms, (in)sensibility, and (un)consciousness. We may hope that the excellent scientific research carried out by our Swedish colleagues in Kävlinge will give us very soon the necessary insight into these questions.

### 3 Mechanisation, automatisisation and robottisation

All over the world there is a great deal of attention for this topic. The reasons for this are the reduction of costs, the improvement of the quality of the process and the product, humanisation of work, reduction of risk and stress for man and animal, replacement of lacking skilled personnel.

Ole Braathen (2) told us two years ago: "third generation robots will take their cues from computers via data communication networks instead of human operators" and "sensing and vision technology is getting better and software cheaper". In The Netherlands, for instance, a programme was started, called "Slaughterline 2000" (see paper Paardekooper). We may indeed expect revolutionary changes in slaughter techniques and data handling. But we may also assume that these developments will take a few decades! In any case, we have to do with biological, sometimes very variable material, which needs specific treatment as such, for instance:

- scalding of pigs at exactly  $60 \pm 2^\circ\text{C}$
- need for constant minimisation of microbial contamination at dehairing and polishing of pig carcasses, skinning, vent cutting and evisceration, in the equipment.

Much has been done recently or is going on in relation to:

- for instance: lay out and construction of new plants
- regulation of air temperature and humidity
- reduction of noise and ergonomic discomfort
- internal transport of carcasses, organs and meat, less floor-transport, less crossing of traffic
- splitting and deboning of carcasses.

Some interesting new developments are:

- better electronic equipment for regulation of processes
- biosensors
- better machines for dehairing and polishing of pigs
- machines for vent cutting and handling of organs
- (semi) automatic equipment for estimation of slaughter and meat quality (FOM-Denmark, HGP-New Zealand)
- cleaning-in-place (C.I.P.) systems.

Within the framework of this paper there is no room for more details.

### 4 Safety and Quality Assurance

Much has been done in the past to assure a sufficient safety and quality standards for the products of our meat industry. However, a new approach is needed in order to respond to new and future developments, such as:

- increasing scale, intensity and complexity of modern animal production methods
- eradication of the most acute infectious diseases as zoonoses in animals as the leading causes of human morbidity and mortality. Nevertheless, we still do have problems enough with different zoonoses, like Salmonellosis, Campylobacteriosis, Q-fever and Listeriosis.
- (sometimes improper) use of an increasing number, amount and variety of chemical and biological substances in the environment, especially in modern husbandry and meat production
- increasing microbiological contamination of meat

- from clinical healthy animal carriers of pathogenic micro-organisms entering the slaughterlines and by slaughter equipment
- increasingly complex production - with the use of still more biological and chemical substances - of meat and meat products
- increasing inadequacy of traditional quality control systems, mainly based on visual inspection and end-product control
- (augmenting) concern and criticism on the part of consumers towards modern animal production systems and sensory, microbial and chemical quality of food of animal origin.

It is in fact rather surprising that these developments in animal production and food quality (control) have received relatively little attention in our last 10 or 15 meetings. European meat researchers can learn a lot about modern concepts of safety and quality assurance from their colleagues in the United States (16), Australia, and New Zealand. A modern system could be based upon three elements:

- vertically integrated quality assurance in animal production lines
- Good Manufacturing Practices in the meat industry
- modern concepts of meat quality control and meat inspection.

### A Vertically integrated quality assurance in animal production

This includes integration of quality assurance and quality control in and between the different stages of vertical integrated animal production: the feed and additives industry, farms more or less specialised in selection, breeding, and fattening, and the meat industry.

It also includes identification and categorization of various potential risks present in different parts of the production chain, such as: some clinical and subclinical infectious diseases, contamination with entero-pathogenic micro-organisms, use of animal drugs, contamination of environment etc.

Intensive cooperation and exchange of useful information is needed between different segments of animal production and - at the end - the slaughterhouse and the meat inspection service. In 1986 we started in the Netherlands a rather extensive programme, intended to work out such a system of vertically integrated quality (safety included) surveillance of the production of pigs, poultry and veal calves. You can imagine, that very many problems have to be solved, such as identification of animals, reliability and confidentiality of computer assisted information transfer, motivation of people, a national Residue Programme with a well-defined and well-controlled system of permits for use, tolerance levels for hazardous agents and control monitoring systems. We assume that it will eventually be possible for the farmer to take responsibility for the delivery of healthy slaughter animals, free from a number of chemical and biological substances: either totally free or not above a particular level.

### B Good Manufacturing Practices (GMP) in the meat industry

This includes controlled use of production methods, guidelines for the use of animal products, chemical and biological substances, etc., according to fixed specifications combined with vertically integrated quality surveillance.

It includes continuous education and training of all personnel in reliable and safe production methods. An example could be the voluntary "Total Quality Control", first permitted in the U.S.A. in 1980. This system places major responsibility for producing safe products and inspecting them on the industry. Monitoring is performed by a state inspection service. However, this system could be developed not

only for safety control, like in the U.S.A., but at the same time for various other quality aspects of production methods and of products.

GMP during slaughter means a primary responsibility for the slaughter plant, not for the meat inspection service. It includes all measures taken to produce meat with a contamination as low as possible:

- prevention of contamination has to start in the ante mortem phase
- strict separation of healthy and sick animals
- slaughter via strict specifications under controlled circumstances
- prevention of contamination of the slaughterline, equipment and carcasses
- identification of critical control points in the slaughterline (Example: Fig. 1 and Fig 2)
- adequate chilling
- optimal cleaning and disinfection supported by bacteriological monitoring
- continuous training and motivation of personnel
- continuous hygiene control during the slaughter process.

GMP requires long-term investments and long-term programs. Incidental actions without follow-up are senseless and ineffective.

We have started a long term quality and hygiene-program in The Netherlands in about 25 pig slaughterhouses. First we try to convince management that long-term action is necessary. Long-term actions are planned to prevent errors and to improve working methods and conditions. The program includes intensive training and motivation in relation to hygiene and quality by means of theoretical courses, practical training and vice versa exchange of views and knowledge between staff and workers. (Fig. 3 and 4 give an indication of possible results.)

In spite of the application of increasingly sophisticated measures of hygiene, carcasses are still found to be contaminated with pathogens. It seems wise to consider the use of additional means of sanitizing. The use of meat-

Foreign substances seems to be unacceptable. But the use of for instance a spray of lactic acid on dressed carcasses may be permissible, provided that everything possible is done to prevent or to reduce bacterial contamination of carcasses during slaughter (12).

Those who want to know more about contamination and decontamination are referred to the Proceedings of a symposium, organised by our department in 1986 (11).

### C Modern concepts of meat quality control and meat inspection

Meat quality and meat inspection have, until recently, almost completely relied on sight, smell, and touch. This inspection protected consumers from grossly visible meat quality defects, lesions or diseases. This system is rather laborious and not very efficient, as indicated earlier.

Methods are becoming available for a more objective assessment of meat quality and for mechanization and automation of the procedures involved. I suppose that within a few years these methods will be in use for the estimation of meat quality of pork and veal.

Modern concepts of meat inspection are also available. It will probably be difficult to introduce these methods, due to a long tradition of existing systems, large differences in standards of animal production in and between different countries, and the usual complexity of discussions on changes in international legislation.

It would be wise to introduce - while maintaining the traditional system for inspection of traditional animal production - a new meat inspection program, based on:

- vertically integrated quality assurance in animal production, so that only apparently healthy animals

can be slaughtered in regular slaughterhouses. Not normal animals have to be slaughtered in sanitary slaughterhouses.

- categorisation and identification of (groups of) animals which are at the basis of various risks of defects in meat quality and safety. This system must also create possibilities to identify and to trace back animals to their farms. (chips?, laser-brands?).
- application of GMP and Hazard Analysis and Critical Control Points (HACCP) in slaughterhouses.
- new scientifically based definitions of objectives relevant to public health and based on a scientific analysis of different risks to public health.
- use of modern, fast, statistically based laboratory methods for screening the whole slaughter population for residues, some specific pathogens and diseases and for detection of specific defects. Screening is necessary a.o. to control the reliability of the certificates signed by the farmer. One could imagine that blood analysis directly after bleeding of slaughter animals could give a useful indication. So it will be possible, for instance, to trace back residues in samples to their sources.

Rapid, sensitive, and inexpensive techniques based on immunological and recombinant DNA principles are available or could be developed in the near future. Some of these methods can be applied in the slaughterhouse. All relevant information about animal diseases and residue problems, could be stored at a national centre and used - under strict conditions - by people in veterinary herd health services, the meat industry and meat inspection.

In the U.S.A. and in some Western European countries research is going on with the aim of studying feasibility of these new concepts.

### 5 Offals and byproducts

It seems quite dangerous for a Dutchman to discuss the best definition of these products. However, the notion "offal" has - at least in Holland - a negative sense. So I prefer to speak about (Fig. 5):

- edible byproducts for human consumption (variety meats)
- edible byproducts for pet food and animal feed
- non-edible byproducts of offal destined for animal feed, pharmaceutical and technical processing (4, 8).

In the group of edible byproducts much attention in research and in practice has been given to blood. In the meantime a great deal is known about methods for hygienic debleeding, blood collection, and blood technology (13). Much less attention has been given to other edible byproducts, although the economic value of these products is interesting enough. Optimal valorisation of these products seems to be an important factor in the efficiency and the output of meat plants. Therefore, in my opinion we should give more attention to topics such as GMP for the collection of different organs, handling, safety and quality, prevention of contamination and decontamination, chilling, (vacuum) packaging, to sensory and technological properties, processing into meatproducts, use as ingredients for pharmaceutical or cosmetic industries, cost-benefit relations.

Even if edible byproducts are destined for pet food we need - at least in relation to risk for zoonoses - more knowledge about the GMP for handling and manufacture and about hygiene and technological aspects. In general, as far as I can see, too little attention is given to chemical and microbiological safety (14) and to the quality of these products. Keepability is in general rather poor. Better conservation techniques must be developed. We also need better techniques for the assessment of the quality of these

products in relation to marketing (valorisation, quality/price relation). Another aspect which needs more attention is proper handling of (a concentration of) the contents of stomach and intestines, and its influence on the environment. This is particularly of interest in regions, where a concentration of bioindustry and consequently slaughterhouses exist.

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Fig. 1

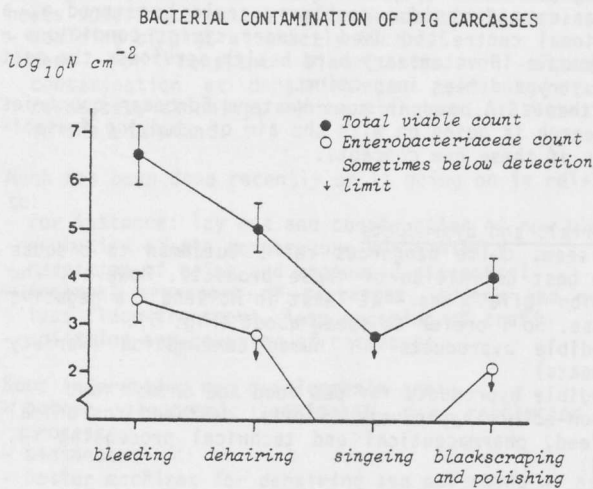


Fig. 2

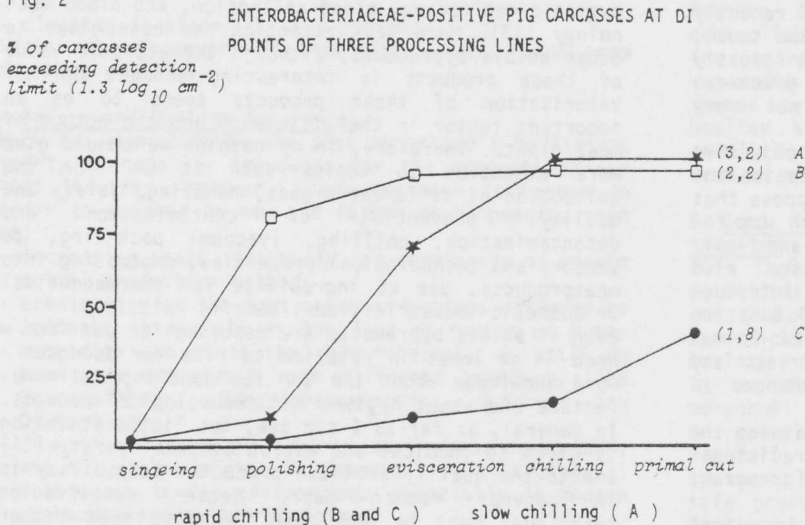


Fig. 3

ENTEROBACTERIACEAE-POSITIVE PIG CARCASSES AFFECTED BY MORE OR LESS HYGIENIC EVISCERATION PROCEDURES

% of carcasses exceeding detection limit ( $1.3 \log_{10} \text{ cm}^{-2}$ )

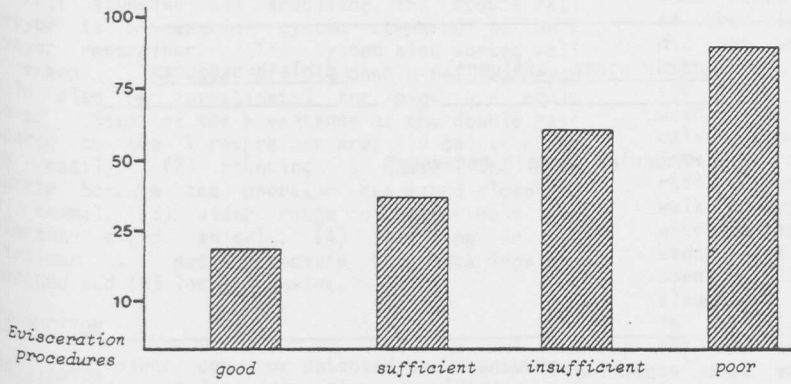


Fig. 4

ENTEROBACTERIACEAE-POSITIVE PIG CARCASSES BEFORE AND DURING THE INTRODUCTION OF A HYGIENE MANAGEMENT PROGRAMME

% of carcasses exceeding detection limit ( $1.3 \log_{10} \text{ cm}^{-2}$ )

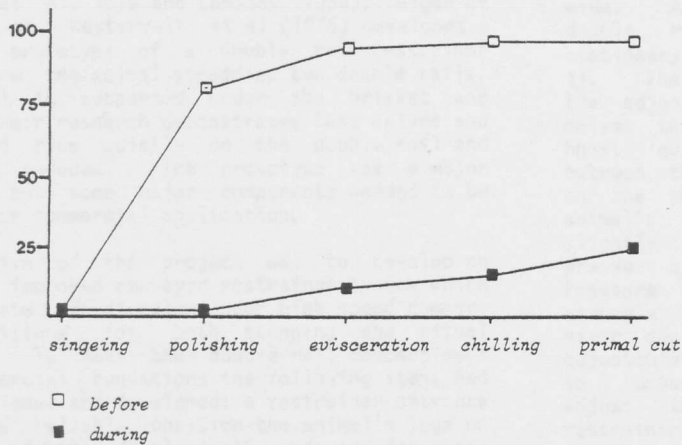
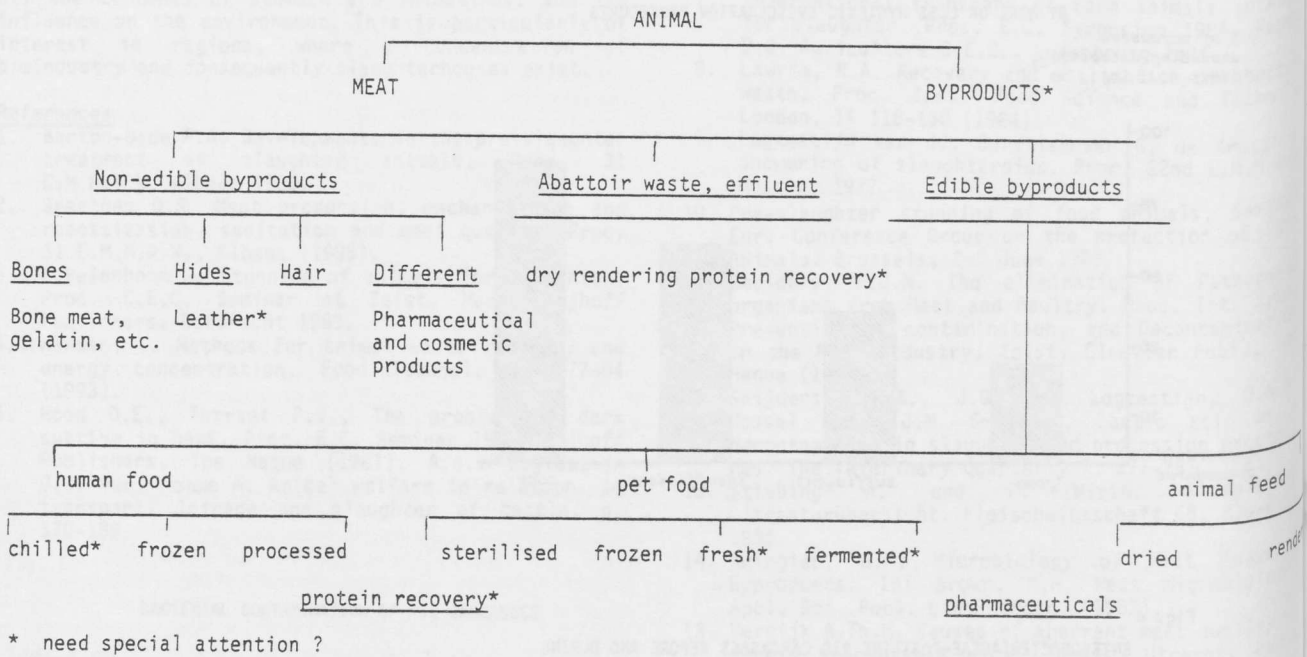


Fig. 5 CLASSIFICATION OF MEAT INDUSTRY BYPRODUCTS



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