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RECENT ADVANCES IN FRESH MEAT TECHNOLOGY

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SUMMARY

Today's food industries derive great benefit from the rapid progress of electronics. Even more significant in engineering is the impact of the computer, changing our way of thinking and becoming an integral part of almost every problem-solving approach. It is generally accepted that computers have moved into the forefront of technology.
Besides the rapid development of electronics new working techniques like high pressure water jet and laser became available for the industry together with processing techniques such as (co)extrusion and meat-bone separation by pressure. All this enabled the meat industry to proceed faster with the application of computerization and robotics. In combination with sensor technology, the simple butchery operations and slaughter process control have proved to be accessible to automation.
Some recent developments in connection with the above mentioned new techniques are:

- The first tentative steps in automation of several unit operations of the slaughter and cutting line (2).
- A high pressure water jet system to clean the carcasses after singering (flaming) instead of mechanical scraping.
- A video image analysis system to replace human observation in cutting operations.
- The evaporimeter a sensor to measure the evaporation of water from the meat surface.

Attention should not only be paid to development in techology but also to the changing needs of the present consumer oriented society. One area of interest is the consumer's increasing concern about the safety, shelf life and nutritional value of food products. In particular for meat, awareness for the freshness of the meat products and a preference for lean meat is encountered.
As a consequence research is focussed on the development of leaner meat products and of packaging systems for extending the shelf life of fresh meat. These specific and goal oriented research resulted in the following achievements.

- The development of new fresh composite meat products using the combination of fibrinogen, blood plasma as substrates and thrombin as an enzyme to form "a glue" for the binding of meat trimmings and raw meat cuts.
- A new method which consist of packing individual cuts firstly in evacuated bags -skin packed- and then in a foil laminated bag that is evacuated, flushed with CO_2 and sealed. This flexible modular skinpacked and gasflushed system doubles the storage life of red meat (primal- or consumer cuts) compared to standard vacuum packaging.

Following is a survey of research and development activities performed by TNO in cooperation with the meat industry.

Slaughterline

In 1983 the project "Slaughterline 2000" in co-operation with the pig meat industry was started (2). To guide the project the following concept was set up:

- the project should be divided into "achievable" subprojects, which should be worked out step by step, starting at the beginning of the killing and dressing line.
- each subproject should be economically viable in its own right and be integrated into modern existing lines with a capacity of at least 300 pigs per hour.

In this paper only the most recent developments will be explained (1).
The hogs are nudged from the live stock pens through a corridor into a chute and from there to a restrainer. By the Institute for Animal Husbandry in Zeist (The Netherlands) a modification of the automatic restrainer is being examined.
A solution for keeping the live animal in a "free moving position" during stunning is fastening the animal at the bottom.
After immobilization the pig can be fixed to allow the possibility for mechanisation. So far a process sticking device has shown the feasibility of an automatic system.
In the "dressing" line an automatic carcass opener (2) is being developed by the Centre for Construction and Mechanisation CCM at Nuenen-The Netherlands. This flexible "robot" (3, 4) - a set of cutting devices controlled by a microprocessor performs the following functions:

- finding the rectum, positioning the device and excising the rectum (Fig. 1a)
- cutting ham and rind from the flank (Fig. 1b)
- finding and cutting the aitchbone (Fig. 1b)
- positioning the shearing device in the stabhole and cutting the breastbone (as far as) beyond the flank (Fig. 2c and 2d).

The microporcessor based control system has the following features:

- fully automatic sequence,
- simultaneous operation of several processes,
- data communication through a serial data line,
- control system for fitting the geometry of the carcasses and
- continuously operating production line performed step by step for the starting up stay.

Elaborate experiments have been carried out with a prototype, during which approximately a hundred carcasses were opened.

A noteworthy development in the killing line is the high spray water cabinet. (1)
After leaving the flaming or singering oven in which the remaining hairs are burnt off, the carcass passes a sweeping and brushing machine. Instead of keeping the number of bacteria on the skin as low as possible, this brushing machine contaminates the carcass.
To remove the brown layer resulting from flaming or singering and to decontaminate the carcass a high pressure water jet system was tested (Fig. 3).
Experiments with a prototype installation, in which high pressure water nozzles circle the carcass -a manipulation controlled by a programmable logic control (PLC)- proved to be effective in removing the remaining hair and the brown layer.
Moreover, using a water pressure of 200 bar and a water consumption of 40 l/pig, the amount of bacteria on the skin surface was found to be the same or slightly lower than after singering/flaming.
It is to be expected that this high pressure water cleaning system will replace the sweep and brush machines.

SENSOR TECHNOLOGY

Vision-system

Accurate and reliable measurement of process conditions and product quality is important in ensuring adequate performance of automatic control systems. Among the non-destructive techniques, imaging systems are being introduced in the meat industry. Solid-state cameras have helped to make these systems more compact and efficient.

The system is capable of grading live animals and carcasses. In addition it can be used for detection of the stabhole in the pig carcass.
The Centre for Construction and Mechanisation CCM at Neunen-The Netherlands developed a "vision" system to determine the exact place of the stabhole in the pig carcass (1).
The next method was followed:
1. Looking to the frontview, the carcass contour has to be determined.
2. Starting from this contour an area in which the stabhole will fall, has to be fixed.
3. Searching at this clearly defined area the stabhole is located as a dark spot of sufficient dimension.

The vision-system can be divided into two parts:
- an image processing assembly consisting of illumination, a TV camera, interface and a memory.
- a computer system with an entry to the memory.

After locating the stabhole a simple mechanical device can remove the contaminated meat around the stabhole.

The evaporimeter

The need for fast and reliable instruments suitable for the acquisition of updated information on the physical, chemical and microbial parameters of meat has stimulated the application of novel sensors. One of these sensors is the evaporimeter, originally intended for the measurement of water loss from severe burns.
One of the main points of interest in the slaughter line, in cutting line and in meat processing is weight loss of meat.
Substantial information on the systematic water loss of meat during for instance flaming or chilling of the carcass and deboning of primal cuts (in relation to tissue aspects and physical parameters) is needed for the process analysis and design.
As a specialized sensor for direct quantative determination of water evaporation from surfaces the evaporimeter (4) became available. The operating principle is as follows:
Close to the surface the water vapour transportation is determined by the formula $\frac{1}{A} \cdot \frac{dm}{dt} \doteq -D \frac{dp}{dx}$
where A = area of surface (m^2),
m = mass of watertransport (g), t = time (hr),
D = a constant, p = partial pressure of the vapour in the air (mmHg), x = distance from the surface (m). See Fig. 4.
At each of two different distances from the surface there is a pair of transducers, one for the relative humidity(Crh) the other a thermistor (th).
We started with a study of the weight loss through evaporation of a warm carcass. The water loss through evaporation of the leg (pork) as a function of the cooling time is given in Table 1.
Just after slaughtering the pork leg has a high rate of water evaporation. After a few hours the evaporation rate decreases to low values. When the temperature at the surface is several degrees C lower than the surrounding temperature, and the driving force (namely, the water partial pressure difference) is negative, water condensates on the surface of the carcass.
The change in weight of the carcass can be calculated with the formula (5).
$\Delta z = z_w - \phi z_a = 0.622 (p_w - p_a)/P$
with $z = 0.622\, p/P$.
p = watervapour partial pressure (mbar).
P = barometric pressure (mbar).
ϕ = Relative Humidity (kg/kg)
subscripts a = air and w = surface.

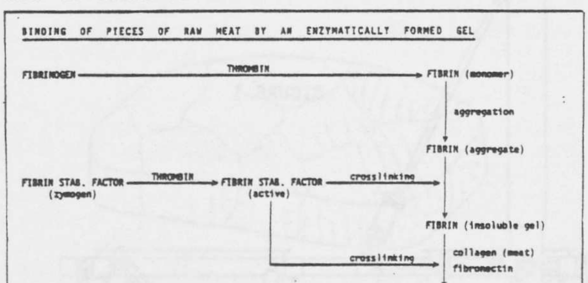
As long as the surface is sufficiently "wet" in the sense that water evaporates freely at a rate corresponding to the difference in driving pressure, there will be no resistance to evaporation.

A NEW TECHNIQUE FOR BINDING RAW MEAT

Preparation of a composite meat product with an enzymatically formed protein gel is being studied. Several methods have been developed for the preparation of so-called restructured meat products. In general, the aims of these methods are:
1. To obtain an economically more favourable processing of small pieces of meat produced during the cutting of carcasses.
2. To offer to the consumer an essentially consistent product.
3. To offer a standardized, portion controlled, product.

In the production of restructured meat products usually small meat cuts and trimmings are comminuted with a chopper or grinder to produce smaller meat pieces or flakes. This comminuted meat is blended with a binder generally comprising water, salt and phosphate. Further handling up to the preparation is performed in a frozen state in order to maintain binding of the product. During preparation binding is obtained by heat denaturation of proteins mobilized by the additives.
Consumers appreciation of these frozen, restructured meat products is often less than that of fresh, unfrozen meat products. Therefore, in the CIVO Institutes TNO a study has been performed with the aim of developing a new binding method which will be applicable to fresh meat.
Recently we developed and patented (6) a method for binding pieces of meat with an enzymatically formed gel containing fibrinogen, thrombin and a transglutaminase as essential components.

After crosslinking between fibrin and collagen, the gel is bound to the meat. In principle the process runs as follows:



The binding strength between the constituent meat pieces is dependent on the fibrin concentration of the gel, the character of the surface - lean or fatty tissue - and the collagen content. Using a fibrin concentration of 50 mg/ml, binding forces of up to 200 g/cm^2 can be obtained (7).
A schematical presentation of the whole procedure is given in Figure 5.
Pieces of meat and the gel-forming components are mixed, put into a mould, and allowed to stand overnight yielding a coherent mass of meat. Subsequently, this mass is taken from the mould, sliced, and is then ready for distribution as a fresh-meat product.
The procedure can be performed at normal working temperatures for fresh meat, that is 2 to 10 °C. The product can be marketed without being frozen or heated, which appeals to the consumer. For consuming the composite meat product can be heated, cooked, fried or grilled. This increases the firmness of binding between the pieces and yields an attractive meat product.

At present this method is being introduced in the meat industry in the Netherlands.
Remarkable developments in packaging and distribution of fresh meat took place during the last 2-3 decades. Among the most important ones are:

1. The application of vacuum and controled atmosphere packaging of primal cuts.
2. Prepacking of retail meats.

Vacuum packed primal cuts having a pH lower than 6.0 can be stored for several weeks where as storage time of meat with higher pH is much shorter. For the latter, skin packing in gas permeable film prior to gas packing (8) and CO_2 packaging proved to be a good method for prolonging the storage life.
The other development is the distribution system of prepacked retail meats to supermarkets. Here the short storage life was a limiting factor for this way of handling meat cuts (Table 2). In this respect, big improvement was achieved by vacuum packaging and the sophisticated approaches of; vacuum skin packaging and vacuum peelfilm packaging.
In addition, the flexible modular gaspack system (Fig. 6) seems to be a most promising method. Here, retail meat may or may not be skinpacked in gas permeable film. Then, it is placed in a mother gaspack, which holds the gas and consists of gas impermeable film. At the distribution level the mother gaspack is removed and the retail meat is sold in the conventional way.

REFERENCES

1. Paardekooper, E.J.C.
"Slaughter Processing: Developments" in Trends in modern Meat Technology PUDOC Wageningen, 1985.

2. Paardekooper, E.J.C.
Automatisering in slacht- en uitsnijlijn
Vleesdistr. en Vleestechn. no. 8, 14-16, 1986.

3. Dutch Patent Application NR. 86.02219
Inrichting voor het opensnijden van het karkas van een slachtdier.

4. Dutch Patent Application NR. 86.02220
Inrichting voor het delen van vlees en/of beenderen van een slachtdier.

5. Öberg Äke and G. Nilsson. Hin köping University Sweden in Servo Med. AB. Stockholm Sweden (1985).

6. Levy, F.J.
Measuring the convective heat transfer coefficient while chilling carcasses.
Int. J.F. Refrig. (1986) 9, 84-88.

7. European Patent Application NR. 32766
Composite meat product and method for the manufacture thereof.
Paardekooper, E.J.C. and G. Wijngaards TNO.

8. Wijngaards, G. and E.J.C. Paardekooper to be published.

9. Mulder, S.J. and E.J.C. Paardekooper to be published.

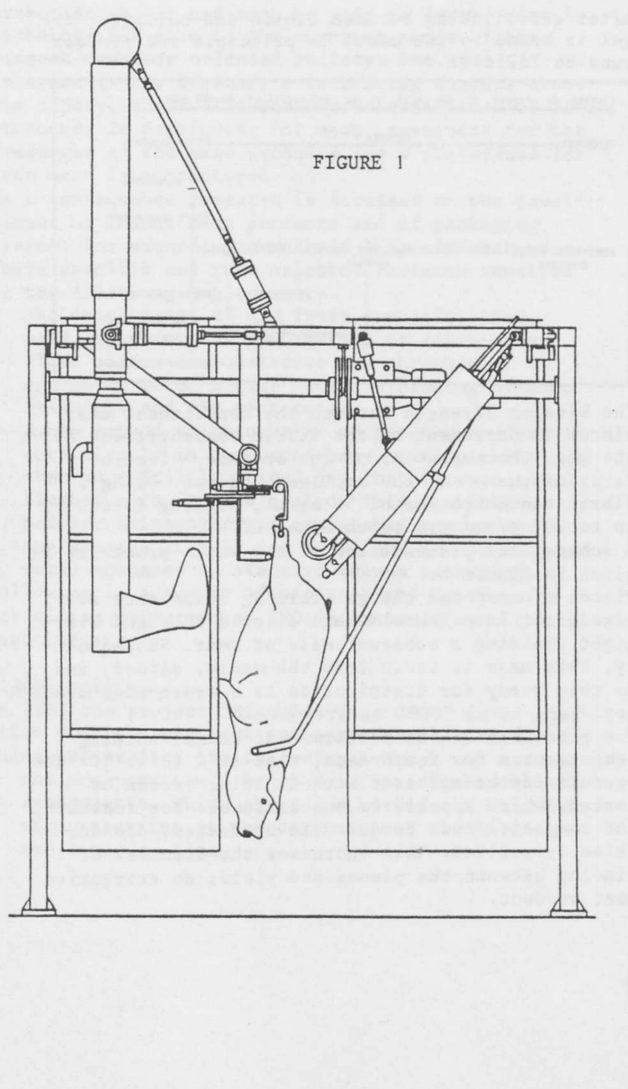


FIGURE 1

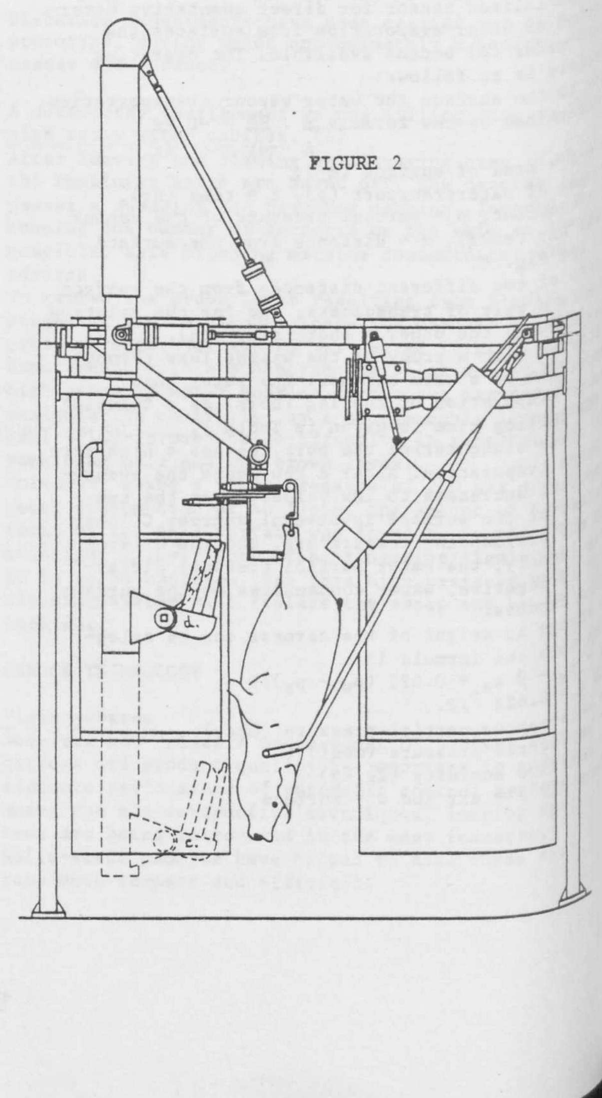


FIGURE 2

FIGURE 3
High pressure (200 bar)
Water system
Annular spraying cabinet

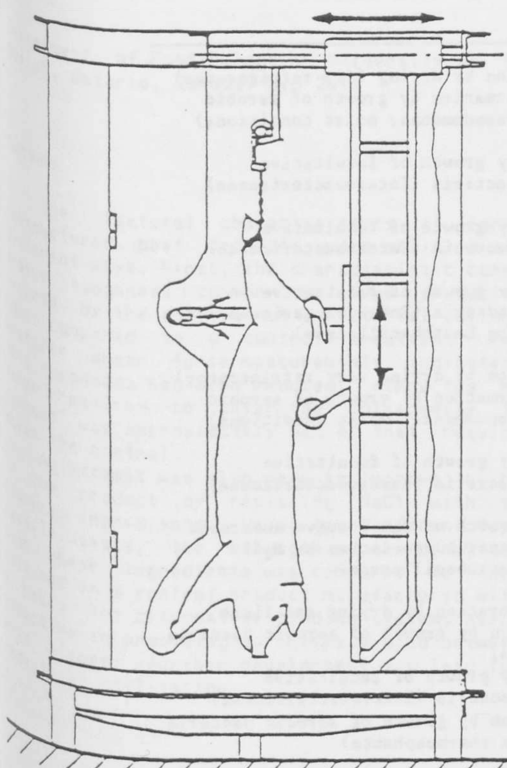


TABLE 1 - WEIGHT LOSS THROUGH EVAPORATION (W_E) AND SURFACE TEMPERATURE OF THE LEG (T surface) AS FUNCTION OF THE COOLING TIME AFTER THE SLAUGHTERPROCESS

Cooling time t(h)	0	1	2	3.5	4.5	6	7	24	~ 100
W_E (g/m^2h)	45 ±5	23 ±2	17 ±2	12 ±2	8 ±1	7 ±1	6 ±1	1 ±1	-3 ±1
T surface (°C)	27	23	20	18	17	16	16	4	2

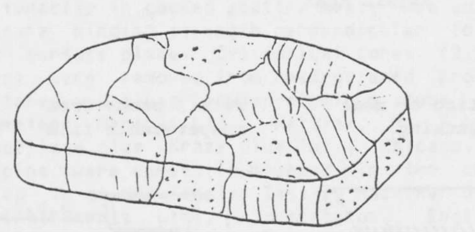
Measuring conditions T environment = 12 °C, air velocity 0 - 0.3 m/s
relative humidity 65 %

except at t = 0 h, V_0 = 0.5 - 1 m/s

t = 24 h, T environment = 4 °C,
relative humidity 55 %

t = 100 h, T environment = 0 °C,
measurement after 15 minutes
at T enviroment = 10 °C and
relative humidity 60 %

FIGURE 5 COMPOSITE RAW MEAT PRODUCT



PREPARATION OF A COMPOSITE RAW MEAT PRODUCT

MEAT TRIMMINGS
↓ temp. 2 - 10°C; + plasma enriched with fibrinogen, and thrombin
MIXING
↓
MOULD
↓
RESTING
↓ overnight
UNMOULDING
↓
DISTRIBUTION
↓
MARKETING
(fresh, vacuum packed, frozen)

FIGURE 4

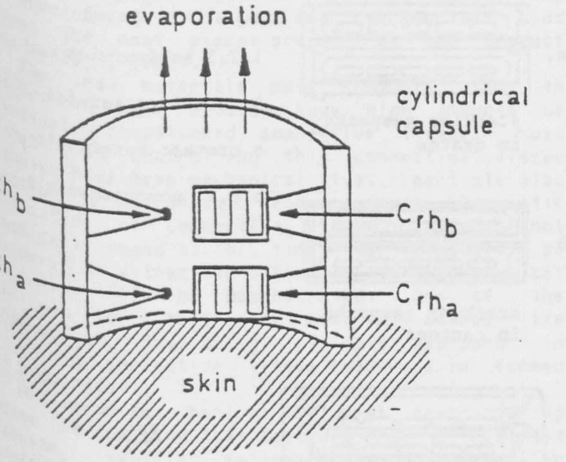


TABLE 2 - EFFECT OF PACKING METHOD ON STORAGE LIFE OF FRESH MEAT (10^4-10^5 bacteria/cm^2)

product	package	storage temperature (°C)	global storage life (days)	general cause of spoilage
beef carcass	no	0	7 - 14	discoloration by drying (dry refrigerator) or slime formation by growth of aerobic bacteria (Pseudomonas; moist conditions)
beef primals pH < 6.0	vacuum	0	28	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae)
veal primals pH > 6.0	vacuum	0	14	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae)
veal primals pH > 6.0	gas:50%CO_2+50%N_2	0	28	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae or H_2S producing Lactobacillaceae)
pork carcass	no	0	7-14	discoloration by drying (dry refrigerator) or slime formation by growth of aerobic bacteria Pseudomonas; moist conditions)
pork primals pH > 6.0	vacuum	0	7-14	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae)
pork primals pH > 6.0	gas : 100 % CO_2	0	14-28	off-odour growth of facultative anaerobic bacteria (Enterobacteriaceae or H_2S producing Lactobacillaceae)
retail meats	no	3	1- 2	dark discoloration by drying and light
retail meats	tray + film overwrap	3	2- 3	discoloration by growth of aerobic bacteria (Pseudomonas)
retail meats	vacuum (dark colour)	3	7-14	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae)
retail meats	gas:30%CO_2+70%O_2	3	4- 7	discoloration by growth of aerobic bacteria (Brochothria thermosphacta)
retail meats	gas:50%CO_2+50%W_2 (dark colour)	3	14-21	off-odour by growth of facultative anaerobic bacteria (Enterobacteriaceae or H_2S producing Lactobacillaceae)

FIGURE 6 - FLEXIBLE MODULAR GASPACK SYSTEM FOR RETAIL MEAT