Some current trends in meat product technology

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Introduction

The traditional meat products, at least within a country, are often considered by the consumer to remain fairly unchanged. Yet, when thinking about it they do change considerably, sometimes even within a few years. This is partly due to the influence of developments in technologies, partly because of the impact of change in public opinion. Thus, not many decennia ago canned hams were very different to what they are today, with fairly high fat content, more uneven in salt content, cooking losses, and formation of jelly, which often exceeded 10 to 12 per cent for the semi-preserved hams.

Today most semi-preserved, canned hams have very low fat percentages, often below 3 per cent, they are often lower in salt content and for that matter in nitrite as well. Further, the cooking loss and jelly formation is of the order of 0 to 4 per cent.

It is well known that such changes are due to improved technologies, but public opinion has certainly also had a decissive impact on why the fat content as well as the content of salt and not least the content of nitrite is so low as it is today.

In this paper it is intended to mention some of the current trends in changes in the production of meat products, which are taking place. In particular will be mentioned the changes in production methods, in the use of ingredients, i.e. salt and nitrite, new methods for sterilization of spices, and some of the new packaging systems used today.

Changes in production methods

The technclogy of mechanical treatment (tumbling) of whole pieces of meat such as ham muscles is well known and need no further mentioning. This technology is now used not only for the production of cooked, cured hams and foreends, but also for pork loins and bacon slabs. In fact, some manufacturers now produce slab bacon solely through adding the curing ingredients, including the brine, in connection with a mechanical treatment.

It may be less known that mechanical treatment during manufacture of hams and foreends has been extended to include a tenderizing treatment. The principle consists in that the raw materials are passed through a machine furnished with roller bars or movable, solid needles. The tenderizing process has further speeded up the uptake of pickle, but because the membranes round each of the muscles are cut through in so many places, this has also the effect that shrink of the individual muscles is minimized during the subsequent cooking. This means that not only the cooking loss is minimized, but the products also get much more full-squared, which make them better suited for slicing.

The treatments now available - and used routinely - during manufacture of whole meat products such as hams and foreends nearly enables any kind of manipulation when adding ingredients. Cooking losses can be minimized in this way, but by adhering to "Good Manufacturing Practise" (GMP) it is also possible to control the composition of the products very accurately.

However, as has been seen in several countries, this new technology has also opened up for possibilities for the manufacture of very competitive products, the merits of which first and foremost are that they are economic. For competitive reasons there has at least in Denmark been a steady decline in quality of meat products for domestic consumption during the past decennium. Improved technologies have made this possible. However, both industry and public administration are now taking measures to increase the quality of the meat products for the home market.

Changes in the use of ingredients

Salt

For a number of years many countries and international authorities have officially advocated the consumer to reduce the salt intake. This of course also affects the attitude to the use of salt in meat products.

Various sources estimate that the per capita intake of salt ranges from 10 to more than 20 grams per day. Pearson and Wolzak (1982) estimate the intake of salt per capita per day in the USA to be 10 to 12 grams, out of which 25 to 40 per cent comes from food and water, 40 to 50 per cent are added during food processing, and 25 to 40 per cent are added during cooking, or as a condiment. According to the Food and Nutrition Board of the National Research Council, the intake is approximately twentyfold higher than the nutritional requirement. According to Jul (1983) the salt intake in Denmark is as follows:

Source	Amount
Food raw materials	0.5 - 3.
Food processing	5 - 10
Water	0.02- 0.3
Cooking	0 - 4
Table salt	0 - 4
Total	7 - 22

It would therefore be a natural conclusion that a recommendation on a reduction in the intake of salt could be met by reducing the salt content in cured meats, or simply to stop eating these types of products. According to Jul (1982) fairly little would be accomplished this way. Surveys carried out in Denmark and Sweden show that the intake of salt from processed meats amounts to 1.2 to 1.5 grams per person per day, equivalent to 12 to 19 per cent of the total intake. For comparison it is estimated that the intake of salt from bread in many countries amounts to more than 40 per cent of the intake. With the proportion of salt which stems from processed foods it therfore seems reasonable to consider a reduction in the use of salt in bread before altering anything else, especially when one considers that the total amount of salt in bread differs considerably from one country to another, which means that it is possible to produce satisfactory bread with different salt levels. Further, when looking at the total salt intake, it would also be obvious to reduce the intake if the consumer refrained from using most of the table salt he uses today, purely as a habit.

An interesting development in the salt intake is that a general reduction is in fact taking place. According to Westin (1980) it is thus estimated that e.g. the Swedish average salt intake has decreased about 20 per cent within the last 20 years.

Similarly, Cerveny (1980) has shown, as cited by Sofos (1983) that dramatic reductions in many processed meats have taken place in the USA over the years:

Changes in the salt content of certain processed meats from 1932 to 1979

Product	Year			
	1932		1979	
	Salt %	Brine %	Salt %	Brine %
Cooked ham	4.6	7.7	3.0	4.0
Raw bacon	2.3	11.6	1.7	4.8
Cooked corned beef	3.9	7.9	2.6	4.8
Bologna	2.5	4.2	2.7	4.8
Wieners	2.3	3.8	2.5	4.4

When assessing whether the prevailing brine concentrations in processed meats used today are sufficient to ensure protection against growth and toxin formation from Cl.botulinum most researchers will agree that brine concentrations below 4.5 appear to have but little if any effect as the only preservative. Only if the system also contains nitrite some protection can be obtained. Generally it is accepted that preservation of meat products is accomplished by the combination of curing salts, low contamination, refrigeration, pH, severity of heat treatment and other factors involved in the manufacture and formulation of the products. (Sofos et al, 1979, Sofos and Busta, 1980, Roberts et al, 1981a, 1981b, 1981c, 1982). One may therefore conclude that by following the general trend to reduce the salt content, this has also lowered the safety margin, so that today the safety of these products depends on a whole range of synergistic factors, where salt counts less than it used to.

Another way of meeting the consumer's demand to reduce the sodium intake from processed meats is to attempt to replace sodium with other cations.

It is well known that the water holding capacity (WHC) of meat is improved if sodium chloride is added. Terrell et al (1981) showed that replacing sodium chloride with equivalent ionic strength of either potassium chloride, calcium chloride, magnesium chloride or monocalcium phosphate resulted in poorer WHC except if calcium chloride was added, where the difference was insignificant, or the phosphate, where the WHC was improved. From a safety point of view there was an improvement in most cases, both regarding survival of the microbial flora and of Tricinella because of the decrease in pH.

In storage tests by Rhee et al (1983) it was concluded that sodium chloride seems to accelerate development of rancidity more than if e.g. potassium chloride or magnesium chloride was present.

However, when replacing sodium with other chloride salts this has a detrimental effect on the organoleptic properties of meat products, even if only part of the sodium is replaced. Olson (1982) quotes the following results:

Mean sensory scores for Bologna sausages having various levels of NaCl, KCl, and MgCl

Salt concentration	Flavour	Texture	Colour	Bitterness
NaCl 2.5%	2.6^{a}	2.5^{a}	2.6^{a}	1.6^{a}
NaCl 1.25%, KCl 1.57%	2.7^{a}	2.6^{ab}	2.5^{a}	2.1^{b}
NaCl 1.25%,-PO_4 0.15%	2.6^{a}	2.7^{bc}	2.6^{a}	1.5^{a}
NaCl 0.63%, KCl 0,79% -PO_4 0.15%	3.5^{b}	2.9^{d}	2.8^{b}	1.6^{a}
NaCl 0.88%, $MgCl_2$ 0.5% -PO_4 0.15%	3.4^{b}	2.8^{cd}	2.8^{b}	1.5^{a}

(Scale 1=extremely like, 5=dislike extremely)

It will thus be seen that if, as shown above, half of the sodiumis replaced by potassium, the product becomes bitter, and if some of the chloride salts are replaced by phosphate, the taste as such is seriously affected, it becomes too bland. Therefore, several researchers, such as Terrell (1983) today recommend that if sodium is partly to be replaced in meat products, it seems advantageous to use more than one other salt for the replacement.

Fats

The general consumer trend to wish to cut down on fat in the diet does not seem to have affected the intake of meat as much as one could have thought. Although the consumer is told that one important source of fat intake is derived from meat and meat products, the statistics on meat intake show that a number of factors besides nutritional considerations are playing a role. The following table shows that meat consumption has increased over the later years:

Meat consumption in selected countries in kg per capita per year (OECD, 1981)

Country	1964	1978
Denmark	59.3	79.5
Federal Rep. of Germany	72.1	97.1
Spain	32.0	64.8
United Kingdom	74.6	75.1
USA	104.7	116.8

Although the increase seems to have come to a stand-still, see the following table, it is worth noting that the present level is quite high:

Consumption of red meat in kg per capita per year within EEC (EUROSTAT)

Year	1972	73	74	75	76	77	78	79	80	81	82
Kg per cap.	56	56	58	57	58	59	62	63	63	62	62

The consumer therefore seems not to intend to cut down on the fat intake by reducing the meat consumption.

Indirectly, fat consumption from meat has been reduced over the years because the meat is leaner now than it used to be due to changed rearing methods. In several countries the percentage of fatty tissue in pig meat has thus been reduced appreciably. E.g. there was an average of 5 per cent reduction in fatty tissue in the Danish pigs from 1960 to 1970. During the last ten years all this has changed, though, since it has been found that too lean pig meat also tends to be inferior in eating quality (Jul and Zeuthen, 1980). It therefore seems that a further reduction in the fat content of the raw materials is not possible.

There are also numerous examples of meat product manufacturers who are trying to market "fat reduced" products (Anon. 1983). In most cases the reduction in energy of whole meat products such as ham consists in a careful trimming of the meat, so that the analytical fat in the products only amounts to 2 to 3 per cent fat. In comminuted meat products the reduction in energy often consists in removal of carbohydrates or, in very fat products, a replacement of some of the fat with non-meat proteins or water.

A drastic reduction in fat content in meat products would alter the properties completely and it is a question whether it would affect the diet. According to Jul (1982) fat from processed meat amounts to approximately only 10 per cent of the total intake. Any real change through a changed composition of the meats would therefore in the author's opinion literally spoil the quality. A dietary change in this way therefore only seems possible if marketing of excessively fat products is avoided.

Changes in packaging materials and methods

During the past few years changes in packaging materials and methods for processed meats have changed and been improved in several ways.

The most important change after the introduction of vacuum packaging is the presently common use of packaging in modified atmosphere, "gas-packs", with a gas composition for meat products of either pure nitrogen or a mixture of nitrogen and carbon dioxide. Although these packagings are much more voluminous they are popular with the consumer because of their convenience. It is estimated that shelf life is not increased compared to storage of the same products in vacuumpackages.

The rigid can for meat products saw its perfection during the 1970'ies with the built-in anode to prevent internal corrosion and at least for the large cans for semi-preserved hams and foreends, the heat-sensitive paint, which indicates whether or not the can and its content has been heat-treated.

A further development of packaging of canned semi-preserved hams was to pack the hams in a polyethylene pouch, the purpose of which was among other things to minimize corrosion, but it was discovered that cooking loss could be further reduced, if one used a biaxially oriented nylon pouch. When this is heated during the cooking process, it shrinks as the temperature increases, and thus minimizes the jelly formation. The principle and the production of these pouches is patented, and the system is used quite widely.

The plastic lamination "can" for meat products has also been marketed, but for several reasons it was not well accepted. However, within the last two to three years an interesting alternative to the meat can has been introduced. Up to very recently many plastics which could resist high temperatures could not be used for containers for meat products, but with the development of new deep-draw and thermoforming techniques, and laminations of nylon and Surlyn, it is now possible to produce packages with capacities as high as 10 kg.

Packaging takes place in the following way: The bottom film is thermoformed by a combination of vacuum, heat and a piston, after which the product is filled into the cavity. The top film is then sealed onto the bottom film, and the package is shrinked in a heat tunnel or in hot water directly on the packaging line.

One of the problems of thermoforming of wrapping materials and deep-drawing is the uneven thickness of the packaging material in the finished pack, but because of the shrink process it is claimed that the unevenness is leveled out.

This kind of package will most likely be replacing the traditional can in the 1980'ies. Up to now the packaging procedure has mainly been used for hams, but in principle it can of course equally well be used for comminuted meat products. It has been claimed that the

Spices

The problem how to decontaminate - "sterilize" - the spices used in meat products has been unsolved for a number of years. It is now commonly agreed that ethylene oxide (ETO) treatment of spices may be risky because of formation of chlorhydrins, which may be left as residues for a considerable time. ETO-treatment is therefore being prohibited. The German proposal of treating spices and aromatic herbs with alcohol has apparantly not made much progress, and there is no doubt that as long as the consumer demands special labelling of any food which has been subjected to radiation, the chances that spices will be radiated are very remote.

Leistner (1984) has reported on a workshop held in Kulmbach on the necessity of an antibacterial treatment of spices. The participants concluded that for meat products they found some kind of treatment of spices indispensable. Only in special meat products they found a treatment desirable, but not necessary.

A new antimicrobial treatment of spices now seems to be available. At the COST 91 Seminar in Athens, 1983, Gry et al (1984) reported that spices could be "degerminated" by extrusion. Extrusion cooking has earlier been proposed for decontamination of foods, e.g. starches, and two patents also describe decontamination, but in both cases, though, these patents do not cover the process described in the paper by Gry et al cited above.

So far, processes for black and white pepper, as well as for paprika and nutmeg have been worked out successfully. With the oil content in nutmeg it was not possible to decontaminate it in pure form, but if it was mixed with pepper in the porportions commonly used in the meat industry, it was possible to decontaminate it. Similarly, the colour of paprika has to be protected both through extrusion and storage, but extensive sensory evaluation using trained panels concluded that there were only insignificant differences between untreated and treated specimens.

Tests after six months' storage have shown similar encouraging results.

One may well ask how spices can be extruded without this affecting the aroma. It has been shown, though that the temperature during processing is kept relatively low and that the spices and with them the volatile components are cooled before the process is completed.

At the moment further experimentation is in progress to optimize processes cn how to decontaminate other heavily contaminated ingredients such as onion flour.

At this stage it seems that extrusion cooking will be an acceptable alternative to other decontamination processes proposed so far, expecially when one considers that the process is fairly cheap to carry out. Some calculations have shown that the cost of decontamination amounts to £ 0.1 to 0.2 per kg which means that decontamination of spices by extrusion cooking is very competitive indeed.

replacement has mainly taken place for economic reasons, but this "cook-in" method offers considerable other advantages as well, first of all a great extension in shelf life of many meat products which hitherto have been re-wrapped after cooking.

Concluding remarks

Although the consumer may think that meat products are very stable and do not change much it is quite evident that the changes which have taken place within the past twenty years are quite dramatic.

The changes have not only had to do with changed technology, they have in fact also tried to meet the changing wishes of the consumer.

From the statistics above it will finally be seen that although there is a trend towards not increasing the consumption of meat - and with that meat products - consumption per capita is on the average higher than ever before.

References

Anon., 1983, Meat Processing, 39
Cerveny, J.G., 1980, Food Technology, 34, 240
EUROSTAT, 1973-83, Luxembourg
Gry, P., Holm, F., and Kristensen, K.H., 1984, in Thermal Processing and Quality of Foods, 185, Elsevier Applied Science Publishers, London
Jul, M., 1982, Manuscript No 223, Danish Meat Prod.Lab.
Jul, M., 1983, Fleischwirtschaft, 63, 1739
Jul, M. and Zeuthen, P., 1980, Progress in Food and Nutrition Science, 4, 19
OECD, 1981, OECD, Paris
Olson, D.G. The National Provisioner April 17, 1982, 7
Pierson, A.M. and Wolzak, A.M., 1982, J. Animal Science, 54, 1253
Rhee, K.S., Terrell, R.N., Quintanilla, M., and Venderzant, C., 1983, J. Food Science, 48, 302
Roberts, T.A., Gibson, A.M., and Robinson, A., 1981a, J. Food Technology, 16, 239
Roberts, T.A., Gibson, A.M., and Robinson, A., 1981b, J. Food Technology, 16, 267
Roberts, T.A., Gibson, A.M., and Robinson, A., 1981c, J. Food Technology, 16, 337
Roberts, T.A., Gibson, A.M., and Robinson, A., 1982, J. Food Technology, 17, 307
Sofos, J.N., 1983, J. Food Safety, 6, 45
Sofos, J.N. Busta, R.F., and Allen, C.E., 1979, J. Food Protection 42, 739
Sofos, J.N. and Busta, R.F., 1980, Food Technology, 34, 244
Terrell, R.N., 1983, Food Technology, 37, 66