 Microbiology and Technology of Chinese Meat Products

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Introduction

In all probability the human population will increase drasticly world-wide in the next decades and at the same time food stuffes and especially meat will become more scarce and precious, because even by using advanced methods in breeding, feeding and production of livestock not enough meat will be available for the many people who like to eat it (World Conference on Animal Production, 1983). Therefore, it will become even more necessary than to-day to prevent spoilage of meat. In this regard the use of sprays for carcass meat stored with little or no refrigeration and the dissemination of simple technologies for the preparation of safe meat products storable without refrigeration could be valuable contributions (Leistner, 1983).

Traditional intermediate moisture meats (a_w-range 0.90 - 0.60), which need no refrigeration, are encountered in Asia (tsusou-gan, njorsou-gan, sou-song etc. of China, dengdeng giling of Indonesia), in Africa (biltong, khundi, quanta, etc.) and in America (beef jerky, charque, carne de sol, etc.). In Europe intermediate moisture meats (IM-Meats) are not common. However, if traditional meats, such as fermented sausages, Brühdauerwurst, Speckwurst, raw hams, dried beef (Bindenfleisch) are intensively dried, then these products may acquire an a_w < 0.90 (Leistner et al., 1981). The a_w adjustment of traditional meats in the intermediate moisture range is achieved by drying and addition of salt or sugar or both. In our laboratories we investigated the attributes of traditional IM-Meats from Africa and Asia (Leistner, 1984), with the intention to suggest simple processes for safe meat products which could be of benefit for developing countries. We found that especially traditional Chinese meat products are recommendable from the sensoric and hygenic point of view, therefore the microbiology and technology of these products is described here.

Chinese meat products are known from time immemorial, however, apparently became only recently a subject of meat science. Lin et al. (1980,1981) as well as Ockerman and Kuo (1982) investigated the manufacturing of these meats. Our laboratories studied the microbiological stability of Chinese dried meats (Shin et al., 1982; Shin and Leistner, 1983; Shin, 1984; Leistner, 1984) and Chinese sausage (Lin and Leistner, 1984).

Chinese Dried Meats

In China these meat products are highly esteemed for their taste and nutritional value, and are considered to be safe. Apparently for decades or even centuries in China empirical technologies have been used for making tsusou-gan and sou-song from pork or njorsou-gan from beef. Huang (1974) briefly described three recipes of these Chinese meats. We visited several manufacturers in Taiwan and Singapore, and attempted to reproduce and standardize Chinese meat products in our laboratories. Recently we published the recipes and technology of seven Chinese meat products (Shin et al., 1984).

Three different processes are distinguishable in the manufacturing of Chinese dried meats and can be summarized as follows: Process I (pork and beef in slices): Lean meat is cut along the grain into very thin slices, then mixed with sugar, salt, soya sauce, monosodium glutamate, and spices (anise, cinnamon, clove, fennel, watchau). The pickle is held for 24 h at room-temperature. Afterwards the meat slices are spread side by side and overlapping on bamboo matting and dried for several hours at 50 - 60°C to 35 ± 5 % moisture content. Then the meat layer is cut into squares, which are grilled for few minutes at 130°C and are finally further dried at room-temperature to a_w < 0.69. Process II (pork, beef or chicken in pieces or cubes): Lean pork or beef is cut in fairly large chunks and cooked with 10 % water over medium heat. Then the meat is cooled, drained (liquid retained) and cut into pieces or cubes. To the liquid sugar, salt, soya, sauce, monosodium glutamate and spices (such as anise, cinnamon, clove, fennel, watchau, ginger, paprika, cayenne pepper or curry powder) are then added. The meat is placed in a pan with the liquid and stirred over low heat until the mixture is dry. Finally the meat is spread flat on plates and dried for several hours at 50 - 70°C to a_w < 0.69. Process III (pork floss): Lean pork is cut along the grain in pieces and cooked with 10 % water until soft. The meat is drained and the liquid evaporated to 10 % of its volume. To this liquid sugar, salt, soya sauce, monosodium glutamate and spices are added. The cooked meat is mashed, i.e. separated into fibers, and added to the liquid. Finally, the flakes are stirred for several hours at 80 - 90°C until very dry (a_w < 0.6). To make the flakes crispy, about 20 % hot vegetable oil or lard is added and the product is further stirred over low heat until dry and golden brown (a_w < 0.4). From beef, chicken or fish similar products are made with the same technology.

Chinese dried meats are preferably prepared from hot-boned meat (but chilled meat is suitable too), and also need not much energy and only simple equipment for processing. Depending on the animal species from which the meat orginates (pork, beef, poultry) and the type of spices added, about 30 different types of Chinese meat products are distinguishable. These meats may be stored without refrigeration for at least one months, but if not sufficiently dried the products are spoiled by moulds, in particular by the *A. glaucus*-group. Rancidity is the limiting factor for the shelflife of microbiologically stable products, but if the products are spicy, rancidity is less noticeable and if they are vacuum packaged, it is delayed. For pork floss vacuum packaging is not advisable.

We imported 42 commercial Chinese IM-Meats from Taiwan (20 samples), Singapore (18) and Hong Kong (4) for analysis. These products had at the time of arrival water activities in the range 0.785 - 0.200, and a pH-range 6.21 - 5.27. In order to examine the microbial stability of these products, portions were inoculated with pools of xerotolerant moulds of the *A. glaucus*-group and stored 3 months at 25°C. Of the 42 samples tested, 35 (83 %) proved stable. These stable meats had an $a_w \leqslant 0.69$, which therefore could be regarded as the critical water activity for microbiologically stable Chinese IM-Meats (Shin et al., 1982). In Table I are listed the average physico-chemical data of the 35 microbiologically stable products, which represented 9 different Chinese IM-Meats.

From all the data obtained in the investigation of the 35 stable products, it may be concluded that such meats, if prepared according to process I and II, range in a_w from 0.55 - 0.69 and in pH from 5.8 - 6.0, and contain 15 - 35 % sucrose, 3 - 5 % NaCl and 10 - 20 % moisture. If process III was applied, an a_w-range of 0.20 - 0.59 and a moisture content from 2 - 12 % was encountered in commercial products, i.e. such meats are no longer intermediate moisture foods (IMF), but low moisture foods (LMF). The same was true for some products prepared with processes I and II, which were dried more intensively than required for microbial stability.

The microbial stability of Chinese dried meats depends primarily on the hurdles a_w and F, i.e. water activity and heat treatment, with little contribution from the pH hurdle. Nitrate and nitrite, which are sometimes added to these meat products, improve their color but not the stability, because the residual nitrite levels are low (Table I). Contrary to African bilton, which depends on the hurdles a_w and pH only, few microorganisms are present in Chinese meats. From stable, imported products we rarely recovered more than 10^4 microorganisms/g, and most samples were in the range 10^2-10^3/g. Shin (1984) conducted in our laboratories inoculation studies with reproduced Chinese IM-Meats and observed that salmonellae, pathogenic staphylococci, yeasts and moulds are eliminated during the usual processing by heat applied. Enterococci may survive the process, but die during storage of the products. Spores of bacilli and clostridia decrease during processing and storage too, but do not disappear completely. Most organisms recovered from imported Chinese meats belonged to the genus *Bacillus*.

Table I. Average data of 35 commercial Chinese dried meat products which proved microbiologically stable

Product	Process	Samples n	a_w	pH	Sugar %	NaCl %	H_2O %	NO_2 ppm	NO_3 ppm
Pork slices	I	7	0.64	5.9	34	3.7	13	2	100
Beef slices	I	6	0.62	5.8	32	4.3	13	2	40
Pork cubes	II	2	0.66	5.9	25	3.6	15	3	50
Beef cubes	II	3	0.59	5.9	25	4.9	14	2	100
Pork pieces	II	1	0.57	6.0	34	3.9	14	1	1
Beef pieces	II	6	0.63	5.9	23	4.8	16	3	120
Chicken pieces	II	2	0.48	5.9	41	4.1	7	1	1
Pork floss	III	7	0.40	5.8	22	4.6	7	1	90
Chicken floss	III	1	0.48	5.9	32	5.1	8	1	60

Since recontamination of Chinese IM-Meats after processing is likely, Shin (1984) also investigated the survival of microorganisms inoculated onto imported and reproduced meats. He observed that during storage of stable IM-Meats the number of organisms decreased, especially in products close to the critical a_w 0.69. Staphylococci and yeasts decreased rapidly, salmonellae more slowly, and enterococci and bacilli survived best. This study confirmed that Chinese dried meat products are safe products, because the heat treatment eliminates most organisms present in the raw material, and survivors as well as microorganisms which recontaminate the product are inhibited and inactivated by the a_w. Therefore, Chinese dried meats if properly processed are indeed safe foods.

Chinese Sausage

Apparently little is known about the physico-chemical and microbiological data of Chinese sausage. It is not even clear whether this product should be called a fermented sausage, in the precise sense of the word. Our experimental studies revealed some growth of lactic acid bacteria in every batch during the ripening of Chinese sausage. However, this product is primarly preserved by a rapid decrease of a_w and not by pH, because the number of lactic acid bacteria increases rather slowly in this sausage, and therefore the pH remains quite high in spite of a large amount of sugar present. Products with very high numbers of lactic acid bacteria and a corresponding low pH are even considered to be spoiled. Therefore, the microbiology of Chinese sausage is not identical with the microbial processes in fermented sausages of the European type, which have been reviewed recently by Lücke (1984). Another peculiarity of Chinese sausage is the fact that this product generally is warmed up before consumption and is eaten in the hot state. This custom eliminates undesirable bacteria and parasites (e.g. trichinae), which may be present in the product. Fortunately, for the processing of Chinese sausage only simple equipment and no precise climatic control is needed, therefore such a product could be easily manufactured in developing countries.

Table II. Ingredients (in gram) used for Chinese sausage produced in our laboratories

Lean pork (from ham) 75 % Back fat (from pork) 25 %	1000,0
Sucrose	100,0
Nitrite curing salt	20,0
Liquor (Kao-Lian, Chinese product)	10,0
Monosodium glutamate	5,0
5-spice powder*	0,5
Cinnamon	0,5
Pepper (white)	0,5
Sodium erythrobate	0,5

* Cinnamon, anise, clove, fennel, watchau; ratio 2:1:1:1:1

The components of the Chinese sausage produced for our studies are listed in Table II. Traditionally for this sausage only pork is used which often is hot-boned; we used chilled pork for our experiments. The lean meat and the back fat are coarsely ground and mixed with the additives. Then the batter is stuffed into thin swine casings (small intestine; 25 mm in diameter), because this facilitates the drying process considerably. Our experimental sausages were dried for 5.5 hours at 45 ± 2°C, initially for one hour at 80 % RH and then 4.5 hours at 60 % RH. In Chinese butchers' shops, charcoal is often used for this drying procedure. After drying, we stored the sausages at 15°C and 80 % RH up to 20 days. Chinese sausages are eaten preferably around New Year (in February), therefore they are produced mainly in the cold season, and thus the product can be ripened at room temperature.

Table III. Changes of a_w, pH and microbial flora (per gram) in Chinese sausage during 20 days of ripening (average data of several experiments)

Ripening time (days)	a_w	pH	Total count	Lactic acid bacteria	Enterobacteriaceae	Yeasts
0 (1)	0.96	5.7	1×10^6	6×10^3	3×10^3	4×10^3
0 (2)	0.94	5.7	3×10^5	1×10^3	5×10^2	1×10^2
1 (3)	0.93	5.7	4×10^5	2×10^4	9×10^2	3×10^2
2	0.92	5.7	5×10^5	4×10^4	1×10^3	1×10^3
3	0.91	5.7	5×10^5	5×10^4	1×10^3	1×10^3
4	0.90	5.7	4×10^5	1×10^5	7×10^2	2×10^3
6	0.88	5.7	1×10^6	9×10^5	5×10^2	6×10^3
8	0.86	5.6	2×10^6	2×10^6	3×10^2	4×10^3
10	0.84	5.6	2×10^6	2×10^6	4×10^2	1×10^4
12	0.83	5.7	1×10^6	1×10^6	5×10^2	2×10^4
16	0.80	5.7	1×10^6	1×10^6	1×10^2	4×10^4
20	0.79	5.7	1×10^6	1×10^6	1×10^2	6×10^4

(1) Batter before being stuffed;
(2) Sausage after 5.5 hours drying at 45 ± 2°C;
(3) Every day another sausage from the same batch was investigated.

We produced fourteen batches of Chinese sausage and recorded in each experiment during twenty days of ripening, the a_w and pH as well as the total count and the numbers of lactic acid bacteria, Enterobacteriaceae and yeasts. In Tabelle III the data of a typical batch are listed, indicating the observed changes in a_w, pH und the microflora in Chinese sausage during processing. Due to the added humectants (sugar, salt), the small calibre of the sausage and the intensive drying, the a_w of the product decreased already within six hours to 0.94, and after one day of ripening to 0.93. Thereafter a gradual decrease of a_w was observed, and after four to five days of ripening, the product was already in the intermediate moisture range. There occured only little changes in the pH of the sausage during the whole ripening time. The lactic acid bacteria increased slowly and constituted the main component of the total count after about six days of ripening. We observed a little temporary increase in the Enterobacteriaceae count and a slow increase of the yeast count. The microflora recorded in Table III could neither cause spoilage nor food-poisoning. If Chinese sausage was experimentally inoculated with a pool of osmotolerant, yeasts (genera Debaryomyces and Candida), the yeasts also increased only from 10^3 to 10^5/g during the sausage ripening of 20 days and caused no spoilage.

Table IV. Behaviour of Salmonella spp. and Staphylococcus aureus in Chinese sausage during 20 days of ripening (average data of several experiments)

Ripening time (days)	a_w	pH	Salmonella spp. (per gram)	S. aureus (per gram)
0 (1)	0.96	5.8	6×10^4	6×10^4
0 (2)	0.94	5.8	4×10^4	1×10^3
1 (3)	0.93	5.8	3×10^4	2×10^4
2	0.93	5.8	2×10^4	3×10^5
3	0.92	5.7	2×10^4	1×10^6
4	0.91	5.7	6×10^3	3×10^6
6	0.88	5.7	5×10^3	8×10^6
8	0.85	5.7	4×10^3	9×10^6
10	0.84	5.7	3×10^3	1×10^7
12	0.82	5.7	3×10^3	4×10^6
16	0.81	5.7	2×10^3	1×10^6
20	0.80	5.7	1×10^3	8×10^5

(1) Batter after being inoculated;
(2) Sausage after 5.5 hours drying at 45 ± 2°C;
(3) Every day another sausage from the same batch was investigated, different batches were inoculated with salmonellae or staphylococci.

Experimentally we also investigated the behaviour of salmonellae and pathogenic staphylococci in Chinese sausage, using pools of Salmonella spp. or Staphylococcus aureus isolates as inoculum. Typical results are summarized in Table IV. Due to the rapid a_w decrease, salmonellae are of no concern in Chinese sausage, since a steady decline of their number occurs during ripening of the product, and the survivors are eliminated during the heating of the sausage before consumption. However, Staphylococcus aureus could be a problem, because this organism survives the drying process at 45°C and grows up to high numbers during the ripening of the product. If lactobacilli as starter cultures (we used Duploferment 66, Fa. Müller, Gießen, West Germany) or glucono-delta-lactone (0.3 % addition to the product) or potassium sorbate (0.1 % addition) are added to Chinese sausage, then the multiplication of S. aureus is inhibited, however, the number of these pathogenic staphylococci remains on the same level as originally present. Further studies on the elimination of the risk of S. aureus in Chinese sausage are advisable.

Conclusions

Chinese dried meats (IM-Meats) are simple to prepare, nutritious and safe. Therefore they should be introduced into developing countries outside of Asia. They could be of interest also to food designers in industrialized countries. However, for people unused to sweet meat products, the sweetish taste might be strange. In view of this, it might be desirable to replace sugar by humectants with neutral taste in meat products outside of Asia. However, sugar is not only relatively cheap, easily available and toxicologically unobjectionable, but it has benefical effects on the texture and plasticity of meat products. Hence it is difficult to replace sugar, and unfortunately no better humectant is at present within sight.

Chinese sausage could also be of benefit for developing countries, since it is easy to prepare and does not need precisely controlled ripening conditions. Due to the rapid decrease of a_w during the drying process, this product is not inclined to spoil and most food-poisoning organisms are effectively controlled. However, S. aureus could pose a problem, therefore further research is needed to eliminate this risk.

In general the knowledge and facilities of meat research in industrialized countries should be used more frequently and effectively for a better understanding and the improvement of meat preservation in developing countries.

References

Huang, S.H. 1974. "Chinese Snacks". Dept. of Home Economics. Wei-Chuan Food Corp., Taipei, Taiwan, R.O.C. (in English).

Leistner, L., Rödel, W. and Krispien, K. 1981. Microbiology of meat and meat products in high- and intermediate-moisture ranges. In "Water Activity: Influences on Food Quality" (L.B. Rockland and G.F. Stewart, eds.), Academic Press, New York, USA, p. 855.

Leistner, L. 1983. Prospects of the preservation and processing of meat. Proceedings of the Vth World Conference on Animal Production, held Aug. 14-19, 1983 at Tokyo, Japan, Vol. 1, p. 255.

Leistner, L. 1984. Hurdle technology applied to meat products of the shelf stable product and intermediate moisture food types. In "Influence of Water on Food Quality and Stability" (D. Simatos and J.L. Multon, eds.), Martinus Nijhoff Publ., The Hague, The Netherlands, in print.

Lin, S.Y., Chang, P.Y., Lai, C.S. and Li, C.F. 1980. Studies on improvement of processing and packaging for dried shredded and sliced pork. Research Report No. 149. Food Industry Research and Development Institute, Hsinchu, Taiwan, R.O.C. (in Chinese).

Lin, S.Y., Chang, P.Y., Lai, C.S. and Li, C.F. 1981. The new process for preparing dried pork slices. Research Report No. E-41. Food Industry Research and Development Institute, Hsinchu, Taiwan, R.O.C. (in English).

Lin, S.Y. and Leistner, L. 1984. Unpublished data.

Lücke, F.-K. 1984. Fermented sausages. In "Microbiology of Food Fermentations" (B.J.B. Wood, ed.). Appl. Science Publ., London, in print.

Ockerman, H.W. and Kuo, J.C. 1982. Manufacture and acceptability of an oriental dried pork product. Proceedings 28th European Meeting of Meat Research Workers, held Sept. 5-10, 1982 at Madrid, Spain, Volume 1, p. 230.

Shin, H.K., Hechelmann, H. und Leistner, L. 1982. Mikrobiologische Stabilität traditioneller IMF-Fleischerzeugnisse. Jahresbericht der Bundesanstalt für Fleischforschung, Kulmbach, C 22.

Shin, H.K. und Leistner, L. 1983. Mikrobiologische Stabilität traditioneller IM-Meats, importiert aus Afrika und Asien. Jahresbericht der Bundesanstalt für Fleischforschung, Kulmbach, C 21.

Shin, H.K. 1984. "Energiesparende Konservierungsmethoden für Fleischerzeugnisse, abgeleitet von traditionellen Intermediate Moisture Meats". Thesis, Universität Hohenheim, Stuttgart-Hohenheim, West Germany.

Shin, H.K., Lin, S.Y. und Leistner, L. 1984. Rezepturen und Technologie einiger Chinesischer Fleischerzeugnisse. Mitteilungsblatt der Bundesanstalt für Fleischforschung, Kulmbach, Nr. 84, in print.

World Conference on Animal Production, 1983. "New Strategies for Improving Animal Production for Human Welfare". Proceedings of the Vth World Conference on Animal Production, held Aug. 14-19, 1983 at Tokyo, Volume 1, Japanese Society of Zootechnical Science, Tokyo, Japan.