MICROBIOLOGICAL FACTORS AND THE FUTURE OF PREPACKAGED MEAT

MICROBIOLOGICAL FACTORS AND THE FUTURE OF PREPACKAGED MEAT

W. L. SULZBACHER

Meat Laboratory
Eastern Utilization Research and Development Division
Agricultural Research Service
United States Department of Agriculture
Beltsville, Maryland 20705 (U.S.A.)

SUMMARY: The prepackaging of chilled meats and meat products has been proven by experience to be a successful method for meat distribution in the United States and Western Europe. The short period, however, during which such products retain their best salable qualities, has limited the complete realization of the economies possible from prepackaging. The growth of microorganisms is the principal limiting factor in the storage life of prepackaged meats and must be more adequately controlled if storage life is to be extended.

Three possibilities would seem to exist, and data will be presented on their applications. The first of them is better sanitary control. While no doubt highly desirable, it is doubtful that better sanitary control will accomplish more than has already been achieved in the best of existing prepackaging installations. The second possibility is to reduce the microbial load by pasteurizing techniques. Several possible techniques will be considered and their possible applications discussed. The third possibility is to use a technique that will prevent the growth of microorganisms. Freezing is the most practical of these techniques and offers many advantages. These will be compared with those of radiation and chemical or antibiotic treatment.

Viande préemballée — Considérations microbiologiques et avenir

RÉSUMÉ : *L'expérience a montré le succès du préemballage de la viande et des produits carnés à l'état réfrigéré comme méthode de distribution de la viande aux États-Unis et en Europe occidentale. L'économie à attendre de la méthode est limitée par la brièveté de la période pendant laquelle les produits ainsi traités conservent le maximum de leurs qualités. Le développement des microorganismes est le principal facteur limitant cette période et on doit l'inhiber si on veut prolonger la durée d'entreposage de la viande préemballée.*

Trois possibilités semblent exister, dont les applications sont examinées. (1) Meilleures conditions d'hygiène; bien que cela soit souhaitable, il est douteux qu'on puisse faire mieux que dans les meilleures installations existantes de préemballage. (2) Réduction de la charge microbienne par des techniques de pasteurisation; on discute des applications possibles des diverses techniques à envisager. (3) Utilisation d'une technique empêchant la croissance des microorganismes; la congélation est la plus pratique de ces techniques et elle offre beaucoup d'avantages, qu'on compare avec ceux de l'irradiation et des traitements chimique ou antibiotique.

The economic advantages of prepackaged meat have been well demonstrated by its success in both American and European markets. Those who are interested in the reasons for and degree of that success will find the subject

amply treated in the recent "Documentation in Food and Agriculture", No. 68 of the Organisation for Economic Cooperation and Development [9]. My colleague, Mr. Volz, is pointing out at this meeting, the further economic advantages to be had from prepackaging in large scale at central locations. If these advantages are to be completely realized, however, we must be assured that our prepackaged meats and meat products will not deteriorate under the influence of saprophytic microorganisms, and that they will not be a source of microbial food poisoning. I will try in this paper to clarify the more important microbiological factors involved in meat prepackaging and to direct your attention to important future developments that await our ingenious solutions of technical problems.

Preliminary Considerations

It is first important to have a clear picture of the kinds of microorganisms to be found on fresh, chilled meat in order to understand the succession of species found in processed, frozen, or packaged products. The predominant microorganisms found on freshly chilled carcasses are gram negative, oxidative bacteria of the genus *Pseudomonas* [3]. These pseudomonads make up about 90% of the flora of fresh, chilled meat. On salted or cured products, such as ham and bacon, a rather high percentage of cocci are found [5]. The *Pseudomonas* species found on fresh meat are strongly aerobic organisms; and, when the meat is packaged in flexible films, they are rapidly succeeded by lactic acid organisms, frequently of the genus *Microbacterium*, but also some catalase negative lactobacilli and streptococci [2, 3, 4]. This is also true in the case of vacuum packed bacon and sliced luncheon meats where the original micrococci are likewise succeeded by lactic acid producers [5].

The growth of microorganisms on meats, whether prepackaged or not, results in a steady loss of acceptable quality. It is estimated that, in most current situations, the best quality of prepackaged meats will not be maintained for more than 48-72 hours [9]. Obviously, to realize the great savings possible from centralized prepackaging, longer shelf life is necessary, and we must consider ways of achieving it.

Improved Temperature and Sanitary Control

In general terms we may consider that fresh meat usually develops off odors or slime when the surface microbial flora reaches a density of about 10^7 cells/sq.cm [2]. Obviously, if we can insure a low initial inoculation by good sanitation and if we can lower the growth rate by maintaining low storage temperatures, we will be able to extend the storage time. Figure 1 shows the effect of temperature on the generation time of microorganisms

responsible for slime development on meat. It can be seen that this curve becomes asymptotic near 0° and, if all the bacteria with which we were concerned followed this pattern, it would only be necessary to hold our meat at -1^{c}, a very good temperature for fresh meat preservation, to achieve very long

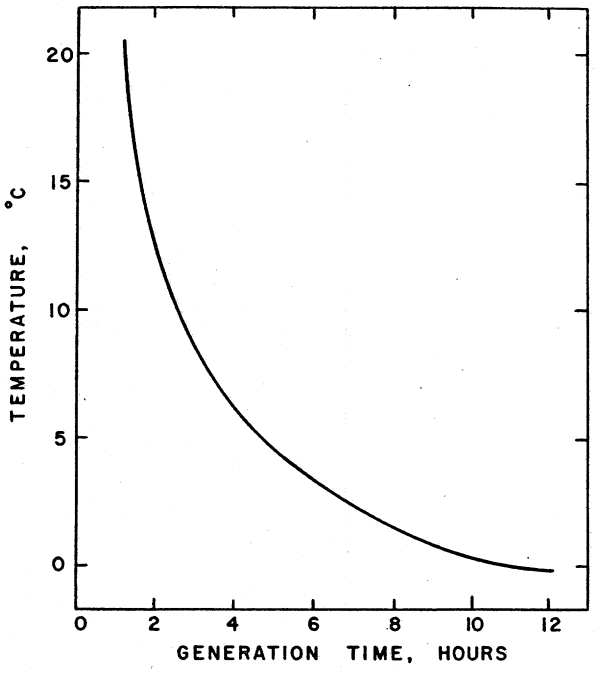

Fig. 1 — Effect of temperature on generation time of slime forming bacteria. Adapted from Ingram [6].

storage times. However, some of the psychrophilic microorganisms with which we are concerned have their lower growth limits at about −7°, not a good temperature for fresh meat preservation. If, then, we can exercice the best of sanitary controls and maintain temperatures in the range of −2° to 0°, we may expect a useful shelf life of 5 or 6 days. This is not often achieved, but it is possible, and the means for its achievement are well understood by competent food technologists everywhere. One factor often neglected in this area is the necessity for rapid chilling of the hot carcases. An efficient beef chill room should be capable of reducing the internal round temperature of a 250 kg carcass to below 5° in 30 hours. Even better performance than this is possible and is desirable.

Antibiotics and Pasteurization

Several methods have been proposed for controlling microbial growth which would allow us to display prepackaged meat at temperatures of about 0° and still achieve a substantially increased shelf life. One of these methods, the use of antibiotics, has stimulated a good deal of study and is frequently proposed. Antibiotics have enjoyed a limited success in treating poultry and fish, and it is therefore natural to expect that their use for extending the shelf life of prepackaged meats should be advocated. The requirements for an acceptable antibiotic for food uses are that it have no medical significance, that it be active against a broad spectrum of microorganisms, and that it be completely harmless when consumed by humans. Furthermore, in order to prevent building up a resistant flora in the processing plant, the antibiotic must be applied in such a manner that it only comes into contact with products leaving the plant. I have not heard of any antibiotic that fulfills all these requirements, and I have considerable doubt that any will be found. The same considerations also apply to other chemical antimicrobial agents.

Another method which has great promise, however, is heat pasteurization. This is already used, although not usually so expressed, in the practice in the United States of slicing and packaging smoked meats on so-called "aseptic" lines. Here the temperature of the smokehouse effectively destroys the heat sensitive microorganisms, and very little recontamination occurs during slicing and packaging.

A more interesting application of pasteurization is the Missouri "Roasteak". This unique product is prepared by heating various large beef cuts in an oven to an internal temperature of 43°, chilling in a refrigerator, slicing and wrapping. The resulting steaks can be rapidly prepared for eating on a broiler or grill and have a good shelf life at either refrigerator or freezer temperatures [7]. This system of precooking meat to about 43° (Missouri studies showed that precooking to 49° resulted in an organoleptically inferior product), combined with real aseptic packaging, is one worthy of more commercial attention than it has received. It is a method that should be particularly applicable to the large scale production of frozen steaks, and to meats intended for restaurant or institutional preparation.

A very promising possibility for the future is the use of ionizing radiation in doses of about 100,000 to 150,000 rads to pasteurize prepackaged meat. Such doses are very effective against pseudomonads, although less so against lactobacilli [8], and temperature control is just as important as for an unpasteurized product. At the present time, radiation pasteurization is likely to be too costly, but it suggests future possibilities that will certainly deserve our attention.

The best method of preserving prepackaged meat is, of course, freezing. When properly done, all the deleterious effects of microbial growth are circumvented, except for the activity of extracellular enzymes which may have been secreted by microorganisms that grew prior to freezing. Some of these enzymes will continue to act, and bacterial lipases will hydrolize meat fats at −29° or lower [1]. The introduction of a pasteurization step into the preparation of frozen meat, similar to the "Roasteak" system described above, will inactivate some enzymes whose activity we would like to avoid. Aside from this effect, however, freezing when combined with good packaging and temperature control, can relieve the meat industry of all concern for spoilage within rather broad time limits.

Microbiological Safety

There is a considerable degree of concern for the microbiological safety of prepackaged meat, whether fresh or frozen, and to assure the public of a safe meat supply, many regulations have been formulated by our several countries [9]. The basis for concern about the safety of prepackaged meat is, of course,

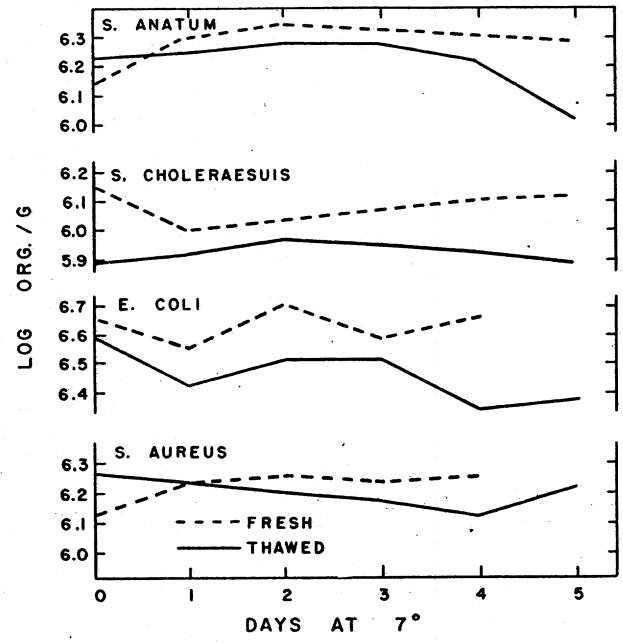

Fig. 2 — Growth of bacteria of public health significance in fresh and thawed meat [11].

the knowledge that meat may sometimes harbor pathogenic or toxigenic microorganisms. I would like to discuss this possibility briefly and to point out some of the principles involved.

In Figure 2 are indicated the growth curves for two species of *Salmonella*, a toxigenic strain of *Staphylococcus*, and the common indicator organism, *Escherichia coli*. These curves were determined by performing daily counts on meat samples stored at 7°, which had received heavy inoculations of the organisms in question [11]. In no instance was there any significant growth at 7°, a temperature quite a bit higher than our suggested optimum of −2° to 0° for prepackaged meat storage. Ingram [6] has reviewed similar data for food poisoning bacteria. Two other toxigenic organisms also deserve some attention. These are *Clostridium perfringens* and the various types of *Clostridium botulinum*. Both of these are anaerobic organisms and do not, as a rule, grow in the packages used for prepackaged meat. However, since some anaerobic packaging materials are used, such as Cryovac for aging beef loins and metal foil for frozen meat, they must be considered. Neither of these organisms will grow at the temperature with which we are concerned except for the strain of *C. botulinum* known as Type E, which will produce toxin at 3.3°. Fortunately, it will not grow very well on meat substrates and is seldom if ever found in association with meat. Nevertheless, vigilance is required by meat packers to assure its continued absence from meat and meat products.

Table 1

CHANGE IN NUMBER OF BACTERIA IN CELLOPHANE-PACKAGED MEAT BEFORE AND AFTER FREEZING, AS DETERMINED BY INCUBATING PETRI DISHES AT DIFFERENT TEMPERATURES

Sample	*20° Aerobes*	*20° Lipase formers*	*37° Aerobes*
	Log number of organisms		
Before freezing	3.1	2.3	3.6
After 12 weeks at −18°	3.9	2.7	3.1

Considerable doubt still exists as to the survival of bacteria in frozen meat and their growth in thawed meat. This is due in part to the fact that, in early studies showing rapid death on freezing, counts were determined by incubation of petri dishes at 37°. Under these circumstances the mesophilic organisms only were counted and they often showed markedly decreased numbers. In Table 1 are shown the results obtained in our laboratory [10] in a study of frozen pork which was held for 12 weeks at −18°. Bacterial counts were determined by incubating petri dishes at both 37° and 20°. The apparent increase at 20° is probably not real and may result from the break up of clumps by

freezing. However, the results indicate that the numbers of psychrophilic microorganisms in meat are not likely to be reduced by freezing and that strict sanitation is highly important for the successful preparation of prepackaged frozen meat products.

Another important matter is the advisability of refreezing thawed meat. Somehow the impression has been gained that this is an inherently dangerous practice. Table 2 shows the growth of a psychrophilic bacterium inoculated

Table 2

GROWTH OF A PSYCHROPHILIC BACTERIA IN FRESH AND THAWED MEAT

	Log no. organisms/gram	
Days at 7°C	*Fresh*	*Thawed*
0	6.2	6.1
1	6.3	6.2
2	7.0	6.3
3	8.5	6.6
4	—	7.5
5	—	9.0
6	—	—

into meat and held at 7° both without freezing and after thawing [11]. It can be seen that there was no tendency whatever for the thawed meat to support growth better than the unfrozen meat. When this result is considered along with the growth rates of food poisoning bacteria shown in Figure 2, it can be seen that there is no reason to suppose that thawed meat would be any more dangerous from a public health standpoint than unfrozen meat. In fact, the practice of shipping certain meat cuts in the frozen state and marketing them as the thawed product is used very successfully in the United States. It has the advantage of keeping the meat at a temperature where no microbial growth can occur during the distribution process, thus minimizing the eventual bacterial population.

CONCLUSION

In summary I should like to emphasize the following points :

1. A high degree of sanitation from the moment of slaughter, and strict maintenance of low temperatures should result in prepackaged meat that will keep very well for periods up to 5 or 6 days.

2. Antibiotics are not likely to prove useful for extending the shelf life of prepackaged meat because the broad spectrum antibiotics useful for meat

preservation are more valuable for medical purposes and should be reserved for such uses.

3. Pasteurization by heat or irradiation can be very useful and should be developed by further research.

4. A combination of sanitation and temperature control can prevent meat from being a source of food poisoning. This applies equally to fresh meat and to thawed meat.

5. Freezing represents the best all-around method now available for prolonged preservation of prepackaged meat.

REFERENCES

[1] ALFORD, J.A. and PIERCE, D.A. (1961). *J. Food Sci.* **26**, 518-524.
[2] AYRES, J.C. (1951). *Iowa State Coll. J. of Sci.* **26**, 31-48.
[3] BROWN, A.D. and WEIDEMANN, J.F. (1958). *J. Appl. Bacteriol.* **21**, 11-17.
[4] HALLECK, F.E., BALL, C.O. and STIER, E.F. (1958). *Food Technol.* **12**, 197-203.
[5] HANSEN, N.H. (1960). *Suppl. Bull. Inst. d. Froid*, 251-261.
[6] INGRAM, M. (1951). *Proc. Soc. Appl. Bacteriol.* **14**, 243-260.
[7] KORSCHGEN, B.M. *et al.* (1963). *Univ. of Mo. Res. Bull.* 825.
[8] NIVEN, C.F. Jr. and CHESBRO, W.R. (1956-57). *Antibiot. Ann.*, 855-859.
[9] O.E.C.D. Document 68 (1964).
[10] SULZBACHER, W.L. (1950). *Food Technol.* **4**, 386-390.
[11] SULZBACHER, W.L. (1952). *Food Technol.* **6**, 341-343.