Use of Microbiological Criteria for Raw Meats

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1. Introduction. The purpose of microbiological criteria for foods (including raw meats) within the framework of the FAO/WHO Food Standards Programme (Codex Alimentarius Commission, which has a membership of 117 countries) is to protect the health of the consumer by providing safe, sound and wholesome products, and to meet the requirements of fair practices in trade.

The FAO/WHO working groups (1, 2, 3) considered microbiological criteria for foods and defined them as: standards, specifications and guidelines - as applying respectively to (a) Codex standards, (b) Codes of Practice, and (c) situations where neither (a) nor (b) exist.

A microbiological standard is a mandatory criterion and wherever possible it should contain limits only for pathogenic microorganisms of public health significance in food.

A microbiological end-product specification is intended to increase assurance that the provisions of hygienic significance in the Code have been met. It may include microorganisms which are not of direct public health significance.

A microbiological guideline is applied at the establishment of a specified point during or after processing to monitor hygiene. It is intended to guide the manufacturer and is not intended for official control purposes.

These working groups present a continuous mechanism for providing expert advice on the development and inclusion of microbiological criteria in the Codex codes and standards where they are shown to be justified.

The FAO/WHO Working group convened in Geneva in 1979 (3) considered particularly the microbiological criteria for raw meats, for which a Code of Practice exists (CAC/RCP 11-1976). This paper reflects the opinion of the above-mentioned group of experts.

2. Epidemiology of meat-related diseases. Chilled and frozen meats are important commodities in international trade. At the same time these meats have been incriminated in the transmission of foodborne and some zoonotic diseases. This paper deals with only those agents of foodborne disease which are in texts on food microbiology as "food poisoning" bacteria and do not include the agents of such foodborne diseases as brucellosis and tuberculosis.

Epidemiological data implicate meats as sources of microbe-associated infections and intoxications (table 1). Of the microorganisms causing the most important types of foodborne illness, Clostridium botulinum, Staphylococcus aureus, Clostridium perfringens and Salmonella spp. occur in or on the live animal. However, not all outbreaks of foodborne illness caused by these organisms are of animal origin, e.g. animal strains of S. aureus are not commonly enterotoxigenic. C. botulinum is relatively rare in or on raw meat but its spores survive curing and mild heat processes and their germination and outgrowth can and must be controlled by adequate curing, heat processing and/or temperature during storage. S. aureus occurs more frequently on pork than on beef carcasses, but in low numbers. It competes poorly with the normal microbial flora of raw meat and constitutes a health hazard only when a process, e.g. curing, minimizes this competing flora. C. perfringens is ubiquitous, can be demonstrated in very low numbers on most commercial carcasses, and does not multiply under normal commercial refrigeration conditions. Its spores survive curing but their germination and outgrowth are readily inhibited in cured products. They also survive milk heat processes and are able to grow well in cooked meats if the temperature after cooking remains suitable for growth. The occurrence of C. perfringens on the carcass cannot be controlled by any known means. Salmonella spp. may be present in the gut and on the skin of a proportion of animals exhibiting no symptoms of salmonellosis and hence remain undetected by ante-mortem inspection. They may be transferred to the carcass surface during slaughter (6).

Hence any of these microorganisms may be present on carcass meat at the end of the slaughter line. Figures for percentage carcass contamination are variable and are influenced by many factors including species, age, husbandry practice, feeding, transport, lairage and the care taken in slaughtering procedures. Obviously the figures are also influenced by the sampling technique.

Meat and the environment in which it is handled and stored might also be contaminated by food-poisoning organisms introduced by humans, domestic pets and raw pet food, birds, rodents and insects.

The prevalence of the various types of foodborne diseases in several countries is shown in Table 2.

The majority of outbreaks attributable to meats appear to result from mishandling during preparation for consumption (7, 8). Although control of clinical salmonellosis in animals has been achieved, most attempts to eliminate food poisoning by control of animal husbandry or of slaughter, butchering and distribution have proved to be unsuccessful and the potential for food poisoning from raw meats would seem to be high.

3. Existing and/or proposed national microbiological criteria for raw meats. The information which was received by WHO in 1978 from eight countries (Canada, Denmark, France, New Zealand, Sweden, Czechoslovakia, Finland and Poland) showed that six of them have criteria containing limits for aerobic plate count (APC), indicators (E. coli, faecal coliforms, faecal streptococci, anaerobic sulphite reducing bacteria) and pathogens (S. aureus, C. perfringens and Salmonella). In contrast, Poland's standard requires only the absence of Salmonella and S. aureus in a sample of specified size, while New Zealand has limits only for APC. Amongst the countries using indicator organisms, there appears to be no conformity as to which tests are considered appropriate. Thus, limits for coliforms, faecal coliforms, Escherichia coli, faecal streptococci and anaerobic sulphite-reducing bacteria are variously used. Where pathogens are included, Salmonella spp. are considered appropriate by all countries but one. Clostridium perfringens and S. aureus appear in a number of criteria.

Recently considered criteria (2) have embodied the International Commission on Microbiological Specifications for Foods approach, i.e. the use of 2- and 3-class attribute sampling plans. A number of the above-mentioned countries failed to specify the number of samples to be taken or a sampling plan.

Just as there is considerable variation in the tests employed, there are also wide discrepancies in the limits set for a particular test. For example, the limits for APC vary by at least 100-fold. Similar differences occur in limits for indicator organisms and pathogens.

Although the extent of enforcement of these criteria is not known, it appears that few are mandatory.

4. The relevance of microbiological criteria to raw meat. A microbiological criterion should adequately distinguish between acceptable and unacceptable batches of foods and thus help to protect the health of the consumer.

Pathogens. Microbial food-poisoning associated with the consumption of meat results mainly from inadequate cooking and/or improper post-cooking handling at the point of preparation for consumption. With the possible exception of Salmonella, the microorganisms of public health significance in meats (Clostridium botulinum, Staphylococcus aureus, Clostridium perfringens) are part of the normal microflora of live animals. Further, given present methods of animal husbandry and meat processing, the occurrence of Salmonella and these other pathogens in raw meat is unavoidable and will not be prevented by the application of codes of hygienic practice. Also the extreme variability of distribution of pathogens such as Salmonella in meats prevents the establishment of practical sampling plans and it is thus impossible to check for absence of Salmonella in meats with any reasonable confidence.

It was concluded that limits for pathogenic microorganisms should not be used in microbiological criteria for raw meats, as they would not help to protect the consumer. The examination of meats for Salmonella could be useful for epidemiological purposes.

Indicator organisms. The determination of the indicator organisms, like Enterobacteriaceae, coliforms and E.coli, which are conventionally used in the evaluation of food hygiene appears to have little relevance in microbiological criteria for raw meats. There is no direct relationship between the occurrence of such organisms and the presence or absence of pathogens and such an assumption could give an illusion of safety where a real hazard exists (10, 11). Also, the level of indicator organisms in meat does not relate to the storage life of meat products.

It was concluded therefore that indicator organisms should not be used in microbiological criteria for raw meats.

Aerobic plate count (APC). There is an established relationship between total count and storage life of raw meats under carefully defined conditions, e.g. packing, gaseous atmosphere and time-temperature conditions during storage. Hence, an APC determination is of value to the processor for predicting the expected storage life of a particular product when distributed under known conditions. This could be of commercial importance but has no relevance to health and any limits established would depend on marketing requirements.

With chilled meats the only point at which APC can be used to evaluate the hygienic conditions under which meat is produced is at the abattoir. However, the perishability of chilled raw meats renders virtually all microbiological findings retrospective. Following chilling, the microbial population is continuously changing in number and type. This is influenced by the conditions of storage and distribution. At a point remote from processing, i.e. where a microbiological end-product specification would be applied, there is no way of distinguishing between the contribution of microorganisms from processing practices and that from subsequent growth during distribution. This makes it difficult to conceive how the application of an APC limit to chilled raw meats at a point remote from the processing plant would reflect adherence to a code of practice.

Processing conditions, quite independent of the level of hygiene, may profoundly influence the numbers of microorganisms present in the end-product. For example, the aging of meat in vacuum packs results in the growth of lactic acid bacteria. Also meat may be tenderized by holding for short periods e.g. 1 day at temperatures of up to 15°C or for longer periods e.g. 7-10 days near 0°C. In both instances substantial microbial growth may occur even when this is done under conditions in compliance with codes of hygienic practice. For these reasons it is not possible to propose APC limits to be used in guidelines or specifications for chilled meats.

After freezing the microbial population in meat is reasonably stable but will tend to decrease during storage. Thus the problems discussed above in respect to chilled meats are not applicable when the product is frozen but will apply when it is thawed and then kept chilled.

A guideline incorporating an APC limit involving a sufficiently large number of samples could be established for a particular product produced under specific conditions but this requires data correlating hygienic conditions with microbial numbers. Such criteria may be useful at the producer level and at a national level. However, because of differences in meat processing practices throughout the world, it is impossible to specify a total count limit for use in microbiological criteria.

In the light of these conclusions, reference was made to the attempt in the USA to control hygienic practices in the production of minced meat by microbiological standards. Limits were imposed on APC and E.coli at retail sale. The programme was abandoned as unsuccessful for the following reasons (12):

1. Results of the programme showed no clear evidence that the application of standards had the overall effect of improving hygiene in retail meat markets.
2. There was no evidence of a significant change in the number of bacteria found in ground meat and it was concluded that there was probably no significant change in quality.
3. No evidence was obtained that the use of the standards reduced foodborne disease.
4. The programme was believed to mislead the consumer in the expectation of receiving minced meat with a lower bacterial content and thus of improved quality and which was less liable to cause illness or spoil readily.
5. Analysis of the cost/benefit ratio indicated that the costs were not justified, because the expected benefits, namely significant lowering of the bacterial content and reduction of the risk to public health, were not demonstrated.

In such a manner, in view of the great variety of raw meats in international trade covered by the Codex Code of Hygienic Practice for Fresh Meat, and also of the large differences in the technology and microbiology of similar meats in different regions, the establishment of microbiological criteria for these products is recognized as impracticable. Furthermore, for the reasons given above, it appears that no benefit would result in respect of public health from the application of such criteria.

The final report of the above-mentioned working group was approved. The 16th Session of the Codex Committee on Food Hygiene (1979) came to the following conclusions concerning the use of microbiological criteria for raw meats:

1. Raw meats are important sources of Salmonella, Clostridium perfringens and Staphylococcus aureus, all of which are commonly incriminated in outbreaks of foodborne diseases.
2. Most foodborne diseases attributed to the consumption of meats are a consequence of inadequate cooking of the products and/or improper handling of the products after cooking.
3. The prevalence of Salmonella in raw meats is more likely to reflect the incidence of Salmonella in the live animal prior to slaughter than adherence to a code of hygienic practice.
4. The eradication of Salmonella from raw meats cannot be achieved by the imposition of microbiological criteria on the finished product, but only by the elimination of Salmonella from the live animal prior to slaughter or by an approved post-slaughter treatment to kill these microorganisms.
5. If eradication of Salmonella from the live animal proves impracticable and if a large proportion of the world's raw meat and poultry production is not to be condemned by the imposition of severe microbiological criteria, human salmonellosis from these sources may need to be controlled by effective consumer education in the cooking and handling of raw meat products.
6. Staphylococcus aureus and C. perfringens occur commonly, but in low numbers, on raw meats. Neither grows on chilled meats and they normally constitute a hazard only after substantial multiplication on cooked and mishandled products. Therefore microbiological criteria including these organisms seem not to be justified.
7. Estimation of the number of indicator organisms in meats does not appear to reflect adherence to a code of hygienic practice, or to indicate presence or absence of pathogens. Hence criteria based on indicator organisms are not justified for raw meat.
8. For some raw meats under particular situations APC obtained from a large number of samples may serve to monitor hygienic practices and to predict potential shelf life. However, variations in technology and microbiology between products and processes in different regions and even in different abattoirs make their use in criteria inadvisable.
9. The example of raw meat has shown that the establishment of microbiological criteria for raw foods in general cannot serve the purpose of protecting the health of the consumer when the main source of pathogenic organisms is the raw food itself and when processing does not include steps which will eliminate or substantially reduce numbers of these organisms.

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TABLE 1. FOOD POISONING AND SALMONELLA INFECTIONS: A SUMMARY OF THE TYPES OF FOOD IMPLICATED IN GENERAL AND FAMILY OUTBREAKS IN ENGLAND AND WALES (1969-1976)[a]

Food implicated	Presumed causal agent									
	Salmonella		Clostridium perfringens		Staphylococcus aureus		Other bacteria		All bacterial agents	
	No.	%	No.	%	No.	%	No.	%	No.	%
Meat	74	26.4	226	71.8	68	50.8	4	5.1	372	46.1
Poultry	141	50.4	79	25.0	35	26.1	0	-	255	31.6
Other foods	65	23.2	10	3.2	31	23.1	74	94.9	180	22.3
Total	280	100.0	315	100.0	134	100.0	78	100.0	807	100.0

a - Modified from Vernon & Tillett (4), Vernon (5) and Hepner (personal communication)

TABLE 2. FOODS ASSOCIATED WITH OUTBREAKS OF FOOD POISONING IN CANADA, THE UNITED STATES OF AMERICA, ENGLAND AND WALES, AUSTRALIA AND JAPAN[a]

	Canada 1973-1975		USA 1973-1975		England & Wales 1973-1975		Australia 1967-1971		Japan 1968-1972	
	No.	%	No.	%	No.	%	No.	%	No.	%
Meat	444	30.8	268	22.3	131	6.7	10	20.8	-	-
Poultry	137	9.5	60	5.0	103	5.3	11	22.9	-	-
Fruits and vegetables	111	7.7	39	3.3	-	-	-	-	-	-
Bakery foods	95	6.6	35	2.9	-	-	-	-	-	-
Fish and shellfish	84	5.8	112	9.3	10	0.5	6	12.5	1 270	35.4
Chinese foods	77	5.4	36	3.0	48	2.5	-	-	-	-
Salads	41	2.9	68	5.7	-	-	-	-	-	-
Dairy foods	36	2.5	42	3.5	32	1.6	-	-	-	-
Beverages	29	2.0	30	2.5	-	-	-	-	-	-
Eggs	3	0.2	-	-	-	-	-	-	-	-
Other foods	129	9.0	170	14.2	10	0.5	6	12.5	1 113	31.0
Unknown foods	254	17.6	339	28.3	1 623	82.9	15	31.3	1 203	33.6
Total	1 440	100.0	1 199	100.0	1 957	100.0	48	100.0	3 586	100.0

[a] From Todd (9)

- Not reported