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Quality Control in the Meat Industry

by

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By quality control is sometimes understood quality tests on an end product of a manufacturing process. However, the main tools of a quality control system should obviously be controls of all raw materials, monitoring the various steps in processing and manufacturing in order that uniform end products of the desired quality may result. Inspection of the finished product should only serve to verify that all the other parts of the quality control system have performed satisfactorily.

Feed-back

The total quality control system in the meat industry includes a check of the raw material, primarily animals or meat, various production aids, packaging material, etc. However, the processors' check on these will have only limited significance for end product quality unless appropriate feed-back to suppliers is arranged. As an obvious case, one may mention the grading of slaughter animals. When for instance animals are bought on live markets, the buyer has limited influence as regards the quality of the carcasses and the meat. Conversely, especially for pigs, elaborate systems have been set up, whereby sophisticated grading of the carcasses takes place based on back-fat and side-fat measurements, leanness, weight, etc. As an isolated activity, this grading will only help manufacturers channel the various carcasses to those uses for which they are best suited. Much more important is it that the pig producers be informed of the quality findings, i.e. the grades, in order that they may take appropriate steps in their production methods to see to it that the quality of their animals is improved.

Specifications

Closely related to a feed-back mechanism is, of course, the need for the processor to specify his wishes. This will apply not only to suppliers of animals and meat, also in many cases to suppliers of spices, food ingredients, additives, packaging material, etc. As regards many of these supplies, the manufacturer himself is likely to have limited facilities for testing them, e.g. the quality of spices, the physical characteristics of packaging films, etc. Therefore, a quality control system should to a great extent rely on specifications for what is required of the various suppliers. Where such exist, the supplier, who often is particularly well equipped for testing his own products, will be able to guarantee that the processors' specifications are adhered to, and the latter need carry out only cursory checks to verify that specifications are being met.

Payment systems

Some supplies, primarily live animals and meat raw material, cannot be of a uniform, guaranteed quality. Biological variations must be taken into account. However, a financial incentive for supplying a superior grade of animals will often make the suppliers more aware of the buyers' need and may at times even offset additional costs which may be involved in producing a superior product, e.g. leaner pigs, fattier beef cattle.

In Denmark, for instance, pigs are graded on the rail with the so-called KSA probe measurement which computes an index for per cent meat in the side. Provided that certain weight limits are adhered to, suppliers are presently (Jan. 1983) paid a premium of about Dkr. 0.10 (DM 0.03) for each per cent of meat over 53 and up to 58 per cent. Similarly, a deduction of about Dkr. 0.20 is made for each per cent meat under 53 down to 46%. Presently, considerations are being given to the incorporation into the KSA probe of an optical probe which might provide an index for meat quality. This is still in the experimental state, one reason being that the optical probe will probably be useful only for detecting PSE pigs, hardly for the determination of DFD characteristics. More important, however, there is as yet no sure way to ascertain whether a PSE condition is due to factors which may be controlled by the producer or possibly to factors such as transport, lairage, race-ways in slaughtering plants, stunning, etc., i.e. factors beyond the producers' control. Therefore, a considerable amount of work is indicated before negotiations between suppliers and slaughtering plants could even be initiated to determine what should be the deductions or premiums for meat quality traits as indicated by the probe. In case this were agreed upon, one would need to spell out in monetary terms according to an optical probe index what these should be.

Contracts

In order to secure as closely as possible the type of raw material, e.g. animals, which are required by a manufacturer, the latter may go one step further and enter into formal contracts with producers. This is known in many food industries, e.g. vegetable production for canning or freezing, sugar beet growing, poultry production, etc. In these cases, the manufacturer specifies in great detail how he wishes the product to be produced, may often supply seeds, breeding stock, veterinary service, agricultural consultancy, etc. A detailed specification is written up in contract form as an agreement between producer and processor. In Denmark, two companies, Irma, Inc., and Antonius, Inc., have worked out such contracts for the production of what is considered a superior type of pig meat. They specify a higher weight than that generally supplied in Denmark, require a three cross breed, etc. Some details of one such contract is given in ill. 1.

Etiological considerations

In the past, meat animal producers and meat processors were mainly guided by such factors which will influence quantity or quality of the finished product. Over and above this, every farmer probably is naturally inclined to take good care of his animals' welfare. Also, this is generally believed to result in higher productivity. Lately, consumers have also become interested in details regarding the prior history of meat animals. Some consumers insist on positive asssurance that the animals have been raised under conditions which are generally considered humane. In the Netherlands, for instance, regulations have been worked out for supplying a special type of pig, where certain restrictions are placed on housing, bedding, space per animal, etc. In France, a similar system exists under the so-called "Qualité France", a public

organisation which specifies both for calves, cattle and poultry various production conditions which must be adhered to in order that the meat may be designated "Label". Some of these concern animal welfare, some require traditional practices, e.g. milk feeding calves, etc. The "Label" requirements also give details as regards manufacturing and the finished product. Meat products guaranteed to be produced under these conditions appeal to a certain segment of consumers. Some of the specifications may, of course, result in objectively assessible superior taste or other organoleptic qualities, etc., while others will only be an assurance to the consumer that the animal has been raised and the product has been produced under etological conditions of which he approves.

Meat inspection

Compared to other food industries, the meat industry is in the special situation that much of the activities of a slaughtering plant and a meat processing facility are supervised in considerable detail by a veterinary inspector, most often a trained veterinarian or a person under the supervision of one. Quite elaborate official systems exist for this purpose, often exceeding in cost and manpower what even a well organized factory can be expected to deploy for its own quality control system. Therefore, it may be useful to consider to what extent this system may supplement or replace the processor's own quality control system.

Meat inspection probably originated because man had the experience that certain animal diseases were transferable to man. Obvious problems were trichinellosis, tuberculosis, brucellosis, cysticercosis, etc. It seemed important to make certain that animals to be used for food were not afflicted with these diseases, and an official control was set up to make certain, especially through post-mortem inspection of each carcass, that any animal showing signs of any of these diseases or other diseases detectable in this way was condemned and not used for human consumption. While, as it is mentioned below, the veterinary inspection system has since been given many other inspection duties, the verification of absence of disease among the animals brought to slaughter or on the slaughter line is still considered its primary function and that function to which most of its efforts are directed.

However, it is well-known that in recent years, veterinary science has found reason to reevaluate the role of meat inspection. Grossklaus (1982b) mentions that among the various zoonoses, which are relevant in this connection, mainly tuberculosis, cysticercosis and trichinellosis are detectable, cf. ill. 2. However, in many countries, e.g. the Federal Republic of Germany and Denmark, those diseases have been eliminated. As seen from the illustration, other zoonoses, primarily salmonellosis and toxoplasmosis could be, and sometimes are, transferred through the meat and afflict man. However, they are normally not detectable by the veterinary inspection. Thus, this inspection gives limited or no assurance that they will not be present in the finished product.

Veterinary authorities, but probably hardly the general public, are well aware of these facts. They do, of course, not mean that traditional meat inspection should be done away with. Consumers have a deeply felt aversion against the mere thought that they might eat meat from a diseased animal. To assure these consumers - and few consumers would want it any different - convential meat inspection is indicated. However, according to Grossklaus (1982a), the above facts may suggest that certain modifications take place in the actual execution of meat inspection and the deployment of veterinary personnel simply to make certain that a very valuable and well educated human resource is utilized to the best advantage for society.

Recently, the EEC has introduced some draft meat hygiene proposals where for instance the inspection of every carcass in a poultry slaughtering plant might be replaced by a strict inspection of the flocks at the place of production, etc. Other changes are also being proposed, cf. also Grossklaus (1982a) and Goodhand (1982).

Animal health problems

Both during ante-mortem and post-mortem inspection, several animal diseases, some of which have little or no meat inspection significance, may be detected. It seems that a valuable by-product of the veterinary inspection could be that information about the occurrence, extent, severity, etc., of these diseases could be transmitted back to the producer. Such steps are, of course, only possible in rather closed systems, where information regarding each animal can be transmitted back to the producer, i.e. systems, where each animal is identified all the way from producer to post-mortem inspection. Thus, in Danish pig production, where this applies, certain information about diseases found in the course of meat inspection is transmitted back to the producer, normally through the means of the weekly financial statement from the slaughtering plant to the supplier. However, veterinary specialists are today studying this subject to see if it could be considerably extended and possibly combined with some direct advisory work to the meat producer in order that maximum use may be made of all information which can be obtained from the veterinary inspection system. Assistance in this regard could be of considerable economic value since animal diseases represent a significant economic factor in animal production. Such a procedure might also in some way pave the way for including a closer inspection of the animal on the farm, as referred to above, in meat inspection as such.

Hygiene inspection

The veterinary inspection system, which probably originally was introduced as a means of preventing a diseased animal from being used for human consumption, for obvious reasons soon was given the task of controlling also hygienic aspects of the slaughtering process, meat processing and the end products. It seemed obvious that it as a public inspection system should ascertain not only that animals were not diseased, e.g. contained patogenes due to animal diseases, but also that the meat was not contaminated with microorganisms - or viruses - which might be introduced as contaminations during the slaughtering, during processing or storage and which could also be disease provoking in man or cause putrification of the products. Thus, the meat inspection function was extented to include a general control of hygienic aspects of the slaughtering and manufacturing plants and processes.

The primary purpose of this additional function was, of course, to safeguard against disease. No clear distinction, however, was made between patogenes and spoilage organisms. Therefore, the responsibilities of the veterinary meat control soon was made to cover not only such hygienic aspects which might lead to disease among consumers but all aspects of hygiene within the slaughtering facility or meat processing plant, many of which are of an aesthetic nature only.

Hygiene regulations

It is quite obvious that a meat inspection system, normally operated by government, - regional or national, - will take steps to draw up specifications as regards its functions. Detailed instructions generally exist as regards ante- and post-mortem inspection procedures. Similarly, regulations as regards hygiene conditions were considered necessary and promulgated. Such specifications have been worked out in great detail over the years and are today generally a somewhat complex set of rules

pertaining to all aspects of factory construction, water supply, waste disposal, workers clothing, meat storage conditions, working procedures, etc. However, it has been expressed, i.e. by Hans Jørgen Bendixen (1982), Chief of the Veterinary Service in the EEC in Brussels, that many of these regulations may fail to relate closely to what is actual important, viz. the hygienic quality of raw material as well as the finished product and limiting contamination with harmful organisms during the manufacturing process.

Thus, quite elaborate regulations have been enforced lately in many countries, i.e. in the UK, where the introduction of the EEC Fresh Meat Directive led to very considerable modifications of existing slaughtering plants in order that they might meet the EEC requirements as regards hygiene. However, the Meat Research Institute in Langford, England, see Ingram and Roberts (1976), found the results quoted in ill. 3. Various slaughtering facilities, some not qualifying for EEC approval and some in complete compliance, were examined microbiologically. Several days' visits to plants, of which some were classified as visually very good seen from a hygienic point of view, and some found poor, revealed that there was no real difference in microbiological contamination of the meat between the two types of plants. Many similar observations have been made.

However, generally, in meat hygiene regulations, e.g. EEC Fresh Meat Directives (CEC, 1975), much attention is paid to the physical standards of the plants. Findings such as those indicated in ill. 3 show that these factors have at best very limited significance for actual product hygiene. Many such stipulations are actually based on very general and conventional assumptions as regards proper hygiene, and few on actual investigations as regards contamination sources, etc. Private companies have used the same approach, e.g. ill. 4, which shows a guideline used by a major UK food processing company.

It is obvious that much time and effort may be used in verifying compliance with such stipulations. The situation is further complicated by the fact that they are often objectively controllable; thus an inspector or quality control officer may easily verify whether walls or floors are cracked, glass thermometers are used, faucets are hand operated, knife sterilizers are installed, etc., etc. It is much more difficult day in and day out to make certain that machines, utensils, walls and floors are adequately cleaned, if correct temperatures are maintained, whether wash bowls are used consistently, if knives are appropriately sterilized, etc., etc. Actually, it is difficult and not often attempted to determine what is adequate, correct, consistent, appropriate, etc. Thus, whoever controls a meat plant is often left with a set of easily controlled non-essentials and a multitude of ill-defined essentials. Therefore, an inspector may easily resort to controlling mainly or only the former.

The above is mentioned not to suggest that this type of hygiene supervision should be dispensed with. It is quite obvious that consumers expect their foods to be prepared in plants which have clean, preferably washable walls, with equipment made of stainless steel, workers properly clothed, using microbiologically safe water, etc. etc. The presence of a veterinary inspector to ascertain that all such requirements are met is undoubtedly a welcome assurance for the public. Nevertheless, it is probably useful to remember that consumers have the same expectations with regard to other than meat foods, e.g. vegetables, fish, bread, dairy products, beverages. However, generally less stringent and less resource intensive public inspection systems exist here, e.g. in plants producing canned vegetables, fresh cooked crab meat, mayonnaise, etc., although significant health hazards exist in such plants.

Special hygiene problems exist in some meat plants with particularly demanding processing procedures, e.g. hot boning, packaging ground meat in controlled atmosphere, etc. Such operations generally require such close hygienic control that manufacturers have had to introduce their own microbiological surveyance system over and above the veterinary inspection system. In some cases, there may be an overlap between the two systems. Besides, official food and veterinary inspectors generally have an excellent training in food microbiology. It is not inconceivably that their expertise could be utilized in the execution of such systems.

The Commission for the European Communities, CEC, is fully aware of the need for improved microbiological monitoring of the hygienic status of meat plants and has worked on finding suitable microbiological methods for this purpose, cf. CEC (1979).

Chemicals monitoring and inspection systems

Society today faces several food safety risks in that a great many agricultural chemicals are used in the form of pesticides, herbicides, veterinary pharmaceuticals, etc. etc. Because of the very nature of their use, these are often very active chemicals, most of them quite toxic or considered undesirable, e.g. anabolic (growth promoting) preparations. Also, new knowledge about microbiological toxins, primarily mycotoxins, has made society realize that there is a certain risk that our foods are contaminated with such substances. Finally, pollution, industrialization, etc., result in many chemicals getting into our meats, and it is hardly conceivable that such contaminants can be totally avoided in industrialized societies. Most societies have built up elaborate analytical food control systems in an attempt to safeguard against the occurrence of these phenomena or at least to monitor their occurrence and enable authorities to suggest corrective steps. Generally, very sophisticated chemical analyses are involved. However, rarely can feed-back to the source of contamination be arranged. This is a very unsatisfactory situation since such feed-back would be a very valuable means of reducing such occurrences. A few cases are known where a feed-back was possible, e.g. the existence of penicillin in milk supplies and the occurrence of ochratoxin in pigs. In these cases, penalties could be and have been invoked on the suppliers, and corrective steps were immediately taken. In other cases, only general data regarding the level of contamination in a country exist and only very general preventive steps are possible. In this, some naivity occurs. Thus, the public's concern as regards these contaminants often leads to a decision that an increased number of analyses are to be carried out. However, if a reasonably satisfactory number of samples are analysed, they may for instance disclose that the content of lindane in 0.5% of all cases exceeds 1 ppm in kidney fat when the legal limit may be 2. An increased number of analyses will give very close to the same result, albeit with a slightly higher degree of accuracy. The expenditure in resources for the additional analytical work may be very high but will be of no value when it comes to rectifying the situation or assuring the public against lindane. Obviously, the public interest is not really served by such increased analytical activity until feed-back of the results to the source of contamination can be organized.

As Grossklaus (1982a) mentions, it is conceivable that more on farm inspection might serve as a measure of reducing some of these risks.

The HACCP concept

Under the auspices of WHO, a group of microbiologists discussed the so-called Health Analysis Critical Control Point concept, especially as regards food hygiene, see WHO (1982). The group considered that so many factors are often included in a food hygiene inspection system that even an elaborate control organization may well be the victim

of having to inspect so many factors that important ones are neglected or even overlooked. Early, food hygiene inspection probably concentrated on a few aspects which were considered of particular importance. However, the systems have gradually built-up, and now, as indicated above, constitute very comprehensive programs. Thus, it seemed useful to study, preferably by microbiological monitoring, the whole manufacturing process in order to identify those points where contamination of health significance is most likely to occur. If this is done, one will generally arrive at some key points, the so-called critical control points, where major efforts should be made to monitor product or process closely and where there may be a need for more detailed specifications as regards for instance cleaning frequency, temperature, etc.

This concept, of course, need be applied not only to official hygiene controls. It is equally important to apply it to a manufacturing concern's own hygiene monitoring systems. Thus, ill. 4 indicated a small part of a monitoring system of a major food processing concern. It is easy to see that many of the factors may be of some significance when it comes to the general aesthetic requirements to a factory, but are of little or no significance when it comes to food safety and wholesomeness. If, however, a microbiological flow sheet survey is carried out at that shown in ill. 5, critical points are quickly identified.

One useful concept is also the "Pareto" principle, i.e. accepting that the major dangers of contamination are always in the fewest points. Therefore, the major preventive effort need be focused on few points, cf. Cichy, Nicholas and Zabrik (1982).

Such concerns have, of course, not been overlooked by the various hygiene, veterinary or quality control systems. Thus, the CEC produced (CEC, 1979) report on microbiological monitoring methods might be used in meat plants in work aimed at identifying critical control points.

While the HACCP concept originated with food microbiology, it should, of course, by no means be limited thereto. It may well be equally important to identify points where risks of other types of contamination, e.g. chemicals, filth, etc., exist, or where risk of adverse effect on quality exists.

Non-essential targets

In connection with the identification of critical control points must eventually come also the determination and subsequent elimination of not essential control points, i.e. criteria which at one time may have been important or may have been thought important but where a closer examination reveals that they are non-essential and where the control may eventually be relaxed or discontinued in the light of experience or closer study.

As an example, in the EEC Fresh Meat Directive and in other related EEC directives, a requirement is made that wrapping, i.e. placing meat in the package, often a film immediately in touch with the meat, and packaging, i.e. placing the wrapped meat into an outer carton, must take place in separate rooms. This requirement is presumably based on an assumption that cartons may introduce either microbiological contamination, e.g. mould spores or physical impurities, e.g. dust, into rooms where unprotected meat surfaces are exposed. However, both Australian and Danish studies, see Husband, Johnson and Muhl (1975) and Simonsen (1979) have demonstrated that the introduction of cartons into a meat cutting room causes no such contamination. Further, especially where modern wrapping and packing machinery is in use, there are practically no technical means of making such arrangements that the requirements are adhered to. Since the requirement is unnecessary, it seems that it should be repealed, especially

since even token arrangements for adhering to the stipulation are very expensive and adherence is often not enforced.

Some stipulations may be totally unnecessary or even counterproductive. Thus, the EEC so-called Fresh Poultry Meat Directive requires facilities for lairage of diseased animals and emergency slaughter facilities for poultry slaughtering plants, even in countries where for many years the custom has been never to bring such animals to the slaughtering plants.

Similarly, the EEC so-called third country directive stipulates for slaughtering plants, exporting to the EEC, that all animal pens at the plant be roofed. In Australia, this becomes unnecessary because of the favourable climatic conditions and undesirable because the livestock, which has never been under roof before, becomes frightened and start fighting when so laired.

Tolerances

In many laws and regulations regarding meat inspection and meat hygiene, various absolute limits are introduced. Thus, the State of Oregon in the USA, at one time maximum microbiological limits existed for fresh meat appearing anywhere in the trade. However, the experience was that these limits were often exceeded by meat which was perfectly acceptable while meat in poor condition could well be within the limits. Further, it turned out that authorities often had to prosecute retail dealers who had no ways of influencing the bacteriological condition of their merchandise and no means of verifying that the limits were being adhered to, cf. Winslow (1975). Because of the resulting, seemingly very arbitrary, prosecutions and absence of any benefit, the rules were eventually repealed. Today, it is widely accepted, e.g. recommended by the FAO and WHO, that microbiological limits should be considered as guidelines, not as standards. Yet, as listed by Weir (1982), numerous such standards exist.

As a better system may be referred to the USA where veterinary authorities are expected also to verify certain chemical compositional aspects of meat products. Thus, the meat control system must for many cured meat products verify that they do not contain more than a certain percentage of moisture, normally so that on a green weight basis the finished product must not have undergone a weight increase. When a moisture limit is given, the US regulations generally accept that a manufacturer cannot control moisture content with very great accuracy and accepts a certain variation above the specified limit. Thus, for instance for cooked canned ham and ham like products in cans, the rule is that no more than 8% by weight may have been gained in curing this allowing for jelly cook-out in the can. However, it is realized that curing meat is not a very accurate process, and certain tolerances are given as illustrated in ill. 6.

Other authorities require that limits given in official regulations be absolute limits which means that industry and trade would have to maintain a considerable margin to make certain that no violations are ever found. However, this is difficult to enforce since both industry, trade and the controlling authorities will be inclined to expect that a deviation of say 1 or 2^{o}C, 1 or 2% in weight, etc., is a violation so small that no prosecution or other action should take place. In all such cases, it seems better to provide a tolerance in the wording of the law in order that all cases may be dealt with at the same degree of discretion.

One less convincing way of providing for a tolerance is seen in the EEC Regulation on the permitted water content of chicken. As a means of controlling this parameter, one may carry out a chemical determination of moisture and protein in the finished

product. The actual amount of permissible water in grammes is then determined by the following formula:

$$3.82 \times bP_1 + 59$$

Here, "b" is the protein content in per cent and "P_1" the net weight of the frozen bird.

If the water content exceeds that determined by that formula, the amount of excess water represents the degree of violation. However, it is rarely realized that in the formula itself is included a quite generous tolerance, approximately 2.5% absolute because of biological variations between birds and even flocks. However, when excess water is found in small amounts, using the above formula, both industry, trade and inspectors are inclined to conclude that the violation is insignificant and no procecution should take place. They overlook that a considerable tolerance has already been included. It probably would have been better to use a formula in which no tolerance were included and then accept as satisfactory any result which did not exceed the limit with more than 2.5% absolute. In that way, the system would be much more understandable for all concerned and the formula would have represented a more realistic target for those monitoring water chilling in the poultry plants. (It should be mentioned that the EEC Regulation also provides for a method of analysis, whereby the permissible amount of water in the meat is determined in relation to the amount of fat-free dry matter present in the meat).

Food poisoning data

Since the primary purpose of both meat inspection and hygiene control is to safeguard the wholesomeness of meat products, it seems obvious that one point of departure could be to examine the cases and sources of food poisoning and from these determine what regulatory action is indicated based on the identification of critical control points.

Ill. 7 shows a list of reported and diagnosed cases of food-borne disease in Canada in 1976, from Health and Welfare Canada (1980).

Foster (1981) gives in a similar table, reproduced in ill. 8, the situation in the USA.

Both suggest that the present days' concern about chemicals in foods may be exaggerated. Also, that the major number of food poisonings are due to Salmonella or Staphylococci or other bacteria. Only a very close control of the carefully identified critical control points will bring about a reduction of these outbreaks. It is characteristic that most causes of these outbreaks are due to defective food handling in the food distribution system or in the home. In considering these data, one need to keep in mind that microbiological intoxications normally result in acute disease while the toxic effect of other chemical components often is accumulating, with a long term effect.

On-line control

As mentioned earlier, while analytical or microbiological examinations are indicated for the identification of, and control at, critical points, it is obvious that in the day to day inspection, more attention need be given to the control of such factors as temperature, residence time, brine composition, etc., i.e. indirect indicators of proper hygiene and quality. Specifications as regards such parameters should, however, be based on actual determination of the extent to which each point is a critical one.

In the EEC Fresh Meat Directive, for instance, it is required that the core temperature of chilled meat must be less than +7°C before the meat can be shipped. This stipulation seems neither necessary nor practical in modern meat chilling where very low air temperatures are used. Thus, in pig chilling, where very cold, much below freezing, temperatures are used, the carcasses may be adequately chilled when the surface is -1°C and the center temperature of the hams is still 20°C. All heat which need be removed from that carcass has been removed. Chilling it any further in the chillers may cause undesired surface freezing and surface condensation when the carcass is eventually removed from the chiller. Adherence to the Directive's stipulation may thus result in a decreased keeping quality of the carcass over and above the disadvantage of having lost a day in the chillers and having these tied up for an extra 20 hours. However, such considerations are not always easily understood and need be considered closer in a collaboration between technologists and regulating authorities.

Instruction of personnel

Generally, in meat plants, a very considerable effort may go into controlling that hygienic equipment and procedures are used. However, since the level of hygiene in reality depends mainly on the working habits of the workers involved, it is likely that some resources could better be used in educating workers as regards hygienic principles and motivating them for observing these.

Self control

Since workers today often understandably object to too much control, supervision, having their performance measured by others, etc., it is likely that consideration must be given to systems whereby workers or groups of workers are given the tools of monitoring their own performance as regards quality attributes of the product they produce, including production hygiene, and recognition for superior performance.

Automated controls

In modern meat operations, automated controls are often relied on, e.g. controls of smoke ovens, steam cooking cabinets, retorts, etc. Many foremen and production managers feel reassured that human errors have thus been eliminated. However, mechanical, systematic errors may easily have been introduced at the same rate. Thus, in for instance steam cooking cabinets, very uneven temperature distribution and heat transmission rates due to differences in steam-air ratio are rather the rule than the exception. Also, thermometers, thermostats and thermographs need to be calibrated very frequently to make certain that they actually indicate or maintain the conditions desired.

Objective and sensoric measurements

The meat research literature abounds with suggestions for various chemical or physical methods which are assumed to be useful indexes of meat quality. Scientists seem to have an obsession with such objective methods because they seem accurate. However, where they are assumed to measure quality, as experienced by the consumer, one will have to keep in mind that the consumers perception of quality is what matters. Many chemical or physical quality indexes do not satisfy this criterion to the necessary extent and they may sometime fail completely. One must also be aware of changing preferences in the trade or among consumers. Thus, in Danish pig grading, the occurrence of slight of lean (insufficiently developed loin muscle) in the mid-fifties resulted in a decision for a major change in the grading system, i.e. the introduction of the side-fat measurement, because it became clear that grading on back-fat measure-

ments only failed to reveal some very fat carcasses. Incidentally, because of the system of feed-back of grading results to the producers, the problem was subsequently eliminated.

Cases also exist where one for the purpose of sausage formulation etc. wishes to measure potential for water binding, collagen content, potential colour formation, etc. and routine methods for these purposes have been developed. However, these methods are reliable only to a certain extent. Especially for certain unforeseen types of raw material they give unrealiable results.

Because of the difficulty of applying objective measurements, there has been a tendency to stress the use of very elaborate sensoric measurements. However, these are hardly useful as on-line measurements., since the operation of taste panels, etc., is cumbersome. Besides, however, while taste panels can be trained to produce very reproducable results, they very often develop standards of their own and do not reflect the reaction of the trade or the consumer. On the other hand, an experienced person's subjective evaluation of freshness or taste may often prove surprisingly realiable.

Specifying quality

One very perplexing thing in quality control is to determine what quality should be. A well-known example is that of beef grading in the USA. The official grading and the preference in the trade emphasizes as desirable a high degree of marbling. Consumers, however, seem to have changed their preferences and pay less attention to marbling. Tastewise there is no reason for insistence on marbling but difficulties in changing customs in the trade has led to an impasse in negotiations regarding grade revisions.

A somewhat similar situation may exist with regard to discussions regarding pig meat quality. Scientific institutions have been very concerned about PSE and DFD meat and try to develop objective methods for the identification of these conditions. However, in so far as consumers are concerned, comparatively little reaction to these deviations from average pork quality has been reported. In reality, these are probably quality characteristics to which the meat industry need to pay considerable attention but which are of limited importance for the consumer.

When discussing the difficulties of setting standards for quality, one may mention a very interesting case which developed in one major US meat packing company some years back. The company was loosing market share in the sliced bacon trade. Elaborate investigations were carried out. It finally turned out that the quality and appearance of the sliced bacon was actually determined and controlled by the foremen in the bacon smoking department. For reasons which are easily understood, they had a preference for a rather heavily smoked, strongly flavoured bacon with a rather high salt content. Among American consumers, however, preference had changed to a very mild cure with very little smoke flavour. Once this was realized and the product was changed to correspond to the preference of the majority of the consumers, the company's market share started to improve.

End product inspection

Most companies will include in their quality control some kind of end product inspection, e.g. cutting sessions where samples from the previous day's production of canned meats are opened and sampled. Hopefully, these sessions should reveal nothing but ascertain that the quality control system has performed satisfactorily. It is very important that such sessions be as comprehensive as possible. Not only the product but also the package and possibly the outer carton should be evaluated at such occasions.

Also, it is useful if someone actually monitors the cooking characteristics of a product. Such sessions may have a very important additional advantageous effect in that they may serve to make executives and sales personnel aware of the exact nature and characteristics of the firm's product. Therefore, in the organization of such sessions, deliberate attempts should be made to make certain that relevant persons are present. Many food companies run into the difficulty that top management is so concerned with problems related to labour, sales volume, investment, etc., etc., that they overlook the most important factor in the operation of the company, i.e. how consumers perceive the quality of its products.

Incubation tests

Especially for canned goods there is a tradition for an incubation test. It is assumed that when one or a few cans are incubated, any case of underprocessing will be revealed by swelling of the cans. Firstly, one need not only observe the appearance of the can but actually open it because many cases of spoilage are not associated with gas formation. More important, however, it need to be kept in mind that the chances of finding underprocessed cans are very slim unless very large samples are included. For instance, if 0.1 per cent unsatisfactory cans are to be detected with a probability of 0.95, about 3000 cans need be tested. The ICMSF has developed sampling plans for such testing and reference need be made to these, see International Commission on Microbiological Specifications for Foods (1974).

Quality assurance programs

Especially the Food and Drug Administration (FDA) and the Department of Agriculture (USDA) in the USA have accepted that a complete system of control of quality, wholesomeness and safety is, indeed, a very complex one. It is clear that manufacturers themselves through organized production quality control look after many aspects thereof and that it would hardly be possible to arrange for official control to monitor all parameters. It is for this reason that these two organizations are encouraging so-called total quality control systems which - when they satisfy certain criteria - can be accepted by the authorities as supplementing and partly replacing inspection and control activities of the government. When one considers the resources necessary for a total quality assurance program, it seems obvious that there is a need to make maximum use of the efforts by all concerned in a coordinated fashion, i.e. primarily government and industry systems. The USDA system is today operating in about 100 meat plants, and is said to have resulted in considerable savings both to industry and government. A brief review of the government's requirements and an outline for an industry quality assurance system are given by Golomski (1982).

Also, the FDA is organizing an industry quality assurance assistance programme, IQAAP, cf. Majorack (1982).

Maintaining quality

Many may feel that quality is a certain, fixed characteristic and can and even should be specified for once and all. An interesting example may be mentioned. Cooked ham in the American market some 40 years was a whole ham with an ample layer of fat. Today, a cooked ham for the US market is completely free of visible fat. It consists of pieces of muscle which have been stitch-pumped and massaged, e.g. tumbled, and are then reassembled. The product is normally cooked within 24 hours after the hams are cut up. Even up to 15% comminuted meat is permitted in the product provided its addition is not visible. Some may consider this a very inferior product compared to that of 40 years ago. However, the former could not be sold today. If it were

acceptable at all, its price would be considerable above the prevailing price for cooked ham, simply because the production cost would be much higher. Many deplore such a development which is not unique; the quality of many other meat products has undergone a similar change. However, it is difficult to argue that a product, which is sold and accepted by consumers, should be prohibited. One may on the other hand suggest that product standards should be established to protect against such gradual changes and that alternative designations and labelling should be used for modified products.

Dialogue between veterinary control, quality control, and meat science

Above are mentioned cases where either official control or company quality control verifies parameters which are non-essentials in so far as product wholesomeness, safety or quality is concerned. Obviously, this is done with an eye to protecting the interest of consumers. In order that controls may adequately serve this purpose, it seems that one would encourage a dialogue and a very close collaboration between both veterinary meat control, quality control, meat science and consumers. Such a constant dialogue may make controlling bodies more aware of the parameters which need be monitored and of those which may not be essential. Conversely, it may well make industry better aware of areas of wholesomeness or safety concern and make research organizations better aware of the day to day problems confronting the meat industry or prescribed by consumers.

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MJ/LBP

A contract for the production of "Antonius" pig meat provides for an average monthly delivery of 20 "Antonius" approved pigs, evenly divided over the four weeks. Additional deliveries must be agreed with "Antonius", Inc. The crosses may be either Landrace/Yorkshire/Hampshire or Landrace/Yorkshire/Duroc. The carcass weight must be 79 to 90 kg, as compared to the usual 60 to 70 kg for pigs for Danish Wiltshire bacon production and most other pig meat trade in Denmark.

The pigs must be produced in cooperation with an agricultural consultant (name indicated in contract) and a veterinarian (name indicated in contract). The producer must conduct at least quarterly efficiency checks as regards his production or have extended production control as specified by the National Committee for Swine-Breeding and Production.

The pigs must be fed optimally according to existing standards and norms; the "Antonius" company may request analyses of any ready-made feed concentrate mixtures for pigs above 30 kg and until they are slaughtered. The company assumes all costs related to such analyses.

The producer must record all use of medicine, and the veterinarian must make at least one monthly visit. The veterinarian issues a quarterly report which is submitted to the "Antonius" company regarding the herd's health records, medicine use, etc.

In cases of an increasing number of remarks regarding disease by the meat control in the slaugtering plant, the producer and the veterinarian must contact the company in order that corrective steps may be decided upon.

The "Antonius" company may at any time on the basis of results of meat inspection, use of medicine in the production or other circumstances, which make the finished product unsuited for the company's purpose, exclude a producer for a period.

The contract may be terminated on a 3 months' notice.

Ill. 1. Summary of contract between the "Antonius" company and a pig producer.

Zoonosis	Occurrence in Animal	Diagnosed at Meat Inspection	Public Health Relevance
Salmonellosis	+ + +	(+)	+ + +
Toxoplasmosis	+	-	+ + +
Cysticercosis+	+	+ +	+ + +
Trichinellosis	(+)	+ +	+ + +
Q-Fever	+	-	+ + +
Leptospirosis	+ +	-	+
Listeriosis	(+)	-	+
Sarcosporidiosis	+ + +	+ +	?
Tuberculosis	-	+ + +	+ + +
Brucellosis	-	+	+ + +
Certain viral infections	?	-	?

Ill. 2. Zoonoses important in meat hygiene. After Grossklaus (1982b).

Hygiene Standard

log count per 50 cm^2, average for 25 lambs

Visit	Poor		Intermediate		Excellent	
	A	C	B	D	E	F
1	5.09	4.41	4.66	4.41	3.65	3.47
2	4.57	4.80	4.46	4.15	4.23	3.73
3	4.51	4.48	4.89	4.68	4.38	3.77
4	4.67	4.13	4.09	4.15	4.47	4.40

Ill. 3. Total surface counts on lamb carcasses in UK slaughtering plants, at various sites and visits. The plants were classified according to visual appearance as regards cleanliness and adequacy of premises and equipment as hygienically poor, intermediate or excellent. After Ingram and Roberts (1976).

External	
Are roads well surfaced?	Is surrounding area tidy?
Are roads and drainpipes sound?	Are windows intact?
Are contractors areas tidy?	Is pest control adequate?
Is weed growth adequately controlled?	
Internal	
Are overheads clean and dustfree?	Are glass lamps correctly shaded and clean?
Are service pipes clean and dustfree?	Are service pipes free from drips and condensation?
Are walls sound?	Is tiling intact?
Are sufficient notices posted?	Are notice boards properly constructed and mounted?
Are floor surfaces satisfacory?	Do floors drain readily?
Are drains adequate and clear?	Is there a regular hygiene inspection of the building?
Dry storage area	
Is floor clean?	Is there enough space left between stacks and walls?
Is storage orderly?	Are bins clean?
Are bins closed when not in use?	Are utensils and scales clean?

Ill. 4. Part of a major UK food processor guide for verifying plant hygienic condition.

Position	Count
Table, where large pack is opened	1
Side table	0
Carrier on slicing machine	>300
Knife	0
Rubber conveyor belt	0
Stainless steel belt support	0
Packing machine, edge	18
Holder for product	255

Ill. 5. Total count, obtained with contact plates, containing 0.4% thiosulphates, in a slicing plant for cooked cured meat.

	Canned hams, pork loins	Canned pork shoulder
Zone E	16.3 -	13.6 -
Zone D	13.6 - 16.2	11.7 - 13.5
Zone C	10.9 - 13.5	9.9 - 11.6
Zone B	8.1 - 10.8	8.1 - 9.8
Zone A	- 8.0	- 8.0
Zone Q	10.4 and below	9.5 and below

Ill. 6. Tolerances for import of canned hams and similar canned products in the USA. Shipments are permitted entrance without awaiting analytical results under so-called normal control procedures. Shipments are retained awaiting analyses under tightened control procedures which are implemented when analytical results of previous shipments show the following: (1) one result is in zone D or E, or (2) two consecutive results are in zone C, or (3) more than six consecutive results are in zones B or C. Under tightened control procedures a composite sample of six cans is analysed and the shipment is released if the result is in zone Q. Four consecutive results in zone Q are required to return to normal control procedures. From the USDA Meat and Poultry Inspection Manual.

Etiology	Outbreaks	Cases
MICROBIOLOGICAL		
Staphylococcus aureus	25	520
Salmonella spp.	23	356
Clostridium perfringens	18	598
Clostridium botulinum	2	13
Bacillus cereus	3	17
Other suspect Bacillus spp.	5	13
Shigella sonnei	-	-
Yersinia enterocolitica	-	-
Clostridium perfringens and Staphylococcus aureus	1	5
Suspect fecal streptococci	-	-
Suspect Psudomonas aeruginosa	3	50
Suspect Erwinia sp.	-	-
Suspect mold and yeast	4	12
Microbilogical total	**84**	**1584**
PARASITIC		
Trichinella spiralis	5	37
PLANT		
Mushroom (Lactarius/ Russala sp. and Amanita pantherina) toxin	-	-
Pokeweed (Phytolacca americana) poison	-	-
ANIMAL		
Paralytic shellfish poison	1	13
Scombroid poison	-	-
Suspect insect	-	-
CHEMICAL		
Metals	2	4
Caustic wash	-	-
Pesticide	1	4
Rancidity	2	4
Solvents	2	7
Extraneous matter	-	-
Other chemicals	1	2
Chemicals total	**8**	**21**
Total known	**98**	**1655**
Total unknown	**654**	**3606**
Total	**752**	**5261**

Ill. 7. Number of persons ill in food-borne incidents by specific etiology, 1976. From Health and Welfare Canada (1980).

	Outbreaks	Cases
MICROBIAL AGENTS		
Clostridium botulinum	12	58
Clostridium perfringens	9	617
Bacillus cereus	6	248
Salmonella spp.	45	1921
Shigella spp.	4	159
Staphylococcus aureus	23	1318
Vibrio parahaemolyticus	2	86
Other bacteria	4	59
Hepatitis A (virus)	5	300
Trichinella spiralis (parasite)	7	35
CHEMICAL AGENTS		
Naturally occurring seafood toxins	30	96
Toxic mushroom	1	7
Heavy metal	1	41
Other chemicals	5	19
Total	**154**	**4964**

Ill. 8. Confirmed food-borne diseases, US, 1978. After Foster (1981).