PROBLEMS ASSOCIATED WITH THE TRANSPORTATION OF FRESH MEAT

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INTRODUCTION

During the past two days we have discussed many physical and chemical processes of meats. Many of these processes occur while meat is being transported. During much of the time from slaughter of an animal to consumption meat is in transit between distribution points in the marketing channel. It is the responsibility of the transportation industry to deliver meat to areas where demanded. To transport 31.5 billion pounds of meat each year is a tremendous job. Most of this meat is shipped in the fresh state. The transportation industry is vitally interested in research and information on ways to maintain fresh meat quality in order to improve its service to the meat industry.

TRANSPORTATION EQUIPMENT

There are a number of choices of containers and refrigeration systems available to transport fresh meats from packers to markets. Our marketing system for meat requires delivery of a few pounds or several million pounds per order. New transportation systems are needed, such as the booming air freight service predicted by tomorrow's jumbo jets (---C-5A's, B-747's and L-500's). These planes which you have probably seen photos of will be capable of carrying around 107 tons of cargo. Such planes will accommodate 10-, 20-, and 40-foot van containers or 24 of the 88 x 125-inch pallets (the standard size pallet of the airline industry). This is over twice the cargo carried by B-707 jets. Advantages of shipping by air are: (1) Speed-reduce days to hours. Fast sea freighters require 5-1/2 days to go from New York to European ports. Air service would be about 8 hours. (2) Direct service. Direct from the packinghouse to the distribution center. (3) Reduce number of handlings which can be a big factor in maintenance of meat quality. These advantages for transporting fresh meats might eventually offset the high cost of air-freight transportation (present rate from New York to Paris is 18 cents per pound for lots of 2200 pounds). The Maritime Transportation Research Board of the National Academy of Sciences recently reported that they expect air transportation to dominate movement of perishable commodities by the next decade.

Present methods for transportation of fresh meat include many types of containers that are available in a number of sizes. Air-cargo containers have a capacity for a few hundred pounds. Jumbo rail cars can haul over 85,000 pounds of carcass beef. In a flexible marketing system, such as we have in this country, the container used for transportation of fresh meat must transfer from one mode of transportation to another with the minimum amount of effort and time. Refrigeration is the principle means of maintaining quality of fresh meat during transit. Let us look at some of the systems that are now available for the transport of fresh meat.
First, refrigeration by a mechanical system. This system is essentially the same for rail cars and for truck-trailer equipment. The container is cooled by a mechanical refrigeration unit which consists of a compressor, evaporator coils, and air supply. Location of the refrigeration unit varies from one manufacturer to another and with the size of the equipment. About 80-85% of our meat supply is transported by truck-trailer containers rather than by rail cars with mechanical refrigeration units.

Second, refrigeration by ice-bunker rail car. This type of car obtains refrigeration from bins which hold ice and a fan system to circulate air over the ice and through the load. These cars are rapidly going out of existence. No new units are being built. However, there are many units in service today. Last year a leading mid-west railroad, which had a fleet of about 1,000 rail cars in service for the transport of fresh meat, reported that 75% of their cars were ice bunkers.

Third, refrigeration by liquid gas systems. These systems obtain refrigeration from the free expansion of an inert gas such as liquid carbon dioxide or nitrogen. They are in use mainly in truck-trailer containers. These gases, which are by-products of the missile program, have found use in about 3600 units in the United States. In order to accomplish free expansion of these gases, a gas must be free of moisture or the nozzles freeze up. As the gas passes through the container it will pick up moisture from meat; this moisture leaves the container through emergency valves. Last March an 80,000 pound test shipment of fresh beef from a midwestern packing house to a southern city used liquid nitrogen as a refrigerant. Over 6,000 pounds of liquid nitrogen were utilized in 115 hours. The free expansion of this quantity of nitrogen would amount to more than 89,000 cubic feet of nitrogen passing through the container. Shrinkage of fresh meat under these conditions remains to be determined.

The refrigerating effect is the primary reason for using these gases. Modification of the atmosphere within the container to be different from the composition of gases found in air may appear to be of secondary importance. However, control of the atmosphere may have a significant role in maintenance of quality characteristics of meat. Here is an area where persons engaged in the development of quality-control methods for meat can help the transportation industry.

CONTROL OF ATMOSPHERE

Workable systems of atmospheric control have been developed for refrigerated containers. At this time, much of the information on the value of atmospheric control to maintain meat quality during transit is available only from manufacturers of these systems. As more of these systems to modify the atmosphere come into use the effect of modified atmospheres on meat quality will have to be evaluated. Since atmospheric control aims to create the ideal environment for fresh meat to reduce losses caused by bacterial spoilage and shrinkage, the possibilities are certainly worthy of investigation. As long as equipment for the transportation of fresh meat does not maintain optimum narrow temperature ranges (30± 2°F) there is justification to investigate the use of atmospheric control in transportation systems as an aid to maintain quality of meat.
Three main types of atmospheric control systems are in use in transportation units. First, the type where liquid nitrogen provides the only source of refrigeration. Promoters of this system claim the nitrogen blanket reduces surface spoilage from aerobic bacteria and that meat has less shrinkage because there are no refrigeration plates to increase the tendency for moisture loss from meat.

In a second type of atmospheric control system, trailers use liquid nitrogen along with a mechanically refrigerated unit. At present, this system seems to have better temperature control than systems where nitrogen is used alone. The amount of nitrogen required is less than for systems where nitrogen must also provide adequate refrigeration.

A third type of trailer using atmospheric control is a system whereby refrigeration is again obtained from a mechanical unit, but a specified amount of oxygen is removed and the atmosphere is supplemented with certain amounts of nitrogen, carbon dioxide, or other gases. One of the manufacturers of trailers is conducting tests to determine whether certain combinations of these gases might reduce shrinkage and bacterial losses from meat during transit and retain other desirable quality characteristics.

Maintenance of the modified atmosphere during shipping requires a gas-tight trailer. The problem of leakage is difficult to overcome. Differences in pressure inside and outside the trailer as it moves through mountain areas can force the modified atmosphere out through any leaks in the trailer, then at low elevations oxygen enters the trailer through the same leakage spots.

Our Division, Market Quality Research, of the U. S. Department of Agriculture is sponsoring some work on the effects of atmospheres made up of various concentrations of carbon dioxide and nitrogen upon properties of refrigerated meat. This research is under contract with the Research Center of the Meat Industry, Helsinki, Finland. Dr. M. S. Pohja is in charge of this investigation. Results from this study should indicate the potential of controlled atmospheres over air to retain meat quality. Keeping qualities of loin muscles of beef are being studied. Atmospheres are modified to contain varied amounts of nitrogen or carbon dioxide within a test cabinet which maintains temperatures of 32°F ± 2°F and relative humidity at 95% ± 2%. So far only a limited number of tests have been completed. They have reported that in 40% carbon dioxide, the keeping time for fresh meat is around 26 days. Significant improvements in keeping quality of meat stored in 90 or 95% nitrogen have not been noted. Total bacterial counts of meat stored in nitrogen and in air were similar, but growth of anaerobes was accelerated in the nitrogen atmosphere. Bacterial population of meat stored in 40% carbon dioxide was considerably smaller than that of meat stored in air and growth of anaerobes was inhibited.

Changes in surface fat composition, as measured by peroxides, aldehydes, and free fatty acids were about the same for samples stored in 90% nitrogen and in air. The content of free fatty acids in surface fats were greater in the 95% nitrogen atmosphere than in air. These changes in fat composition were greater for samples stored in 40% carbon dioxide than for meat stored in air.
Certainly until more information is available to fully evaluate the use of modified atmospheres to increase shelf life of fresh meat, other methods to maintain meat quality in transit must be utilized to their best potential. Particularly important are those which help to control growth of microorganisms during transit.

CONTROL OF MICROORGANISMS

We know that the cut surface of meat provides an excellent medium for the growth of microorganisms. Many researchers have found that the shelf life of fresh meat products is inversely proportional to the initial population of microorganisms on the surfaces of meat. Without microscopic counts in a laboratory, the initial load of microorganisms on meat surfaces is difficult to determine. The only safe procedure is to follow proper handling practices throughout all operations dealing with fresh meat. The following precautions should be taken:

1. **Maintain proper temperatures.** At some of the best establishments chilling of carcasses is at 21° to 25°F with an air-flow rate of 3 to 6 ft/sec. When the surface of a meat carcass is near freezing the interior of the carcass is cooled to about 38°F. Subsequent cooling and temperature equilization should continue in store rooms where the ambient temperature is not lower than 30°F.

   Recommended temperatures for the transport of beef vary tremendously depending on who makes the recommendation. In actual practice the shipping temperature is always a compromise between economics and the scientific ideal. An encouraging trend is evident toward lower temperatures and narrower temperature ranges in recent transport recommendations.

   During distribution of fresh meat to wholesale or distribution outlets, temperature may increase abruptly with little opportunity to recool. Temperatures within the container sometimes vary 15 to 20 degrees. A good refrigerating unit should have sufficient capacity to absorb the heat entering the container through the floor, walls, and roof under severe operating conditions and to maintain satisfactory temperatures within the container. Unfortunately, parts of a load sometimes may be inadequately refrigerated if the chilled air is not distributed evenly inside the container.

   During the short transits from wholesale to retail outlets, meat is vulnerable to extreme temperature variations because it is in small lots. Transportation equipment, although probably capable of maintaining a cool environment, must be opened and closed frequently for deliveries. Training of personnel responsible for distribution of fresh meat to wholesale or to retail outlets is vital if temperature increases are to be kept to a minimum.

   Recommendations for temperature control are: (1) Maintain specified temperatures in all warehouses and distribution points. (2) Demand transportation equipment that can maintain desired temperatures with minimum fluctuation. (3) Improve packages and packaging techniques to eliminate or reduce delays of meat in the marketing channel.
2. Maintain sanitary conditions throughout the entire marketing channel. Sanitation, of course, is to reduce initial load and control growth of microorganisms on fresh meat.

3. Allow for air circulation around carcasses. Free circulation of air is another way to help control growth of microorganisms by keeping meat surfaces dry.

4. Prevent undue exposure of chilled carcasses to warm air. When warm air hits a chilled carcass moisture condenses on the surface of the meat. This film of water promotes microbial growth. Condensation can be prevented by refrigerating the loading and unloading areas, precooling the transport vehicle, and minimizing the handling of meat during marketing.

5. Ship only thoroughly chilled meat carcasses. Several questions arise when this subject is mentioned. Can carcasses be chilled effectively during transit? What conditions and what systems would be necessary to accomplish this chilling? Would it be possible to go one step further and age beef in transit? Certainly more research is needed to provide the information that would indicate whether these are practical objectives for the future.

MEAT HOOK AND RACK PROBLEM

There are a number of little problems associated with transportation of fresh meat which a little thought and ingenuity would appear capable of eliminating. One of these is the "hook and rack" problem. It seems a small problem, but it is an expensive one for the shipper who transports fresh meat and a constant distribution headache. Metal hooks and racks were designed to help maintain carcass quality by permitting adequate circulation of air around carcasses and prevent crushing. Hooks and racks pile up at certain distribution centers around the country and are usually needed elsewhere. The expense of hook and rack replacement and return of these items to points for re-use is quite a problem. I accompanied a shipment of fresh meat to Germany. We ended up with a large supply of steel hooks. To return these hooks to the U.S.A. in the shipping van meant taking up space which could be used to increase the return cargo of good German beer. This problem could be solved by use of an inexpensive type of material such as nylon cliplocks in place of hooks. The extruded aluminium floors in many new refrigeration trailers and staggered loading of boxed meat helps to minimize the use of wooden racks.

CRITICAL PROBLEM AREAS

Before concluding, I would like to mention the critical problem areas associated with transportation of fresh meat as defined by the Committee on Transportation of Perishable Foods of the Maritime Transportation Board for the National Academy of Sciences. This work was sponsored by the Transportation and Facilities Research Division of the U.S.D.A. These critical problem areas are: handling and loading; container design; pre-cooling; and packaging. In these areas all persons working with meats can contribute toward solution of problems to benefit meat transportation.
Better handling and loading require study of transport schedules to minimize the cost of the system, obtain clearer definition of how to maintain needed shelf-life and minimum meat inventory. Much more information is needed on the time profiles of a transportation system and how these influence product quality. The key word in better handling practices seems to be "DON'T". That is, don't handle, don't load the product any more times than necessary.

This brings up the second critical problem area--container design. Containerized shipping can certainly reduce handling. Development and improvement of designs of transportation systems require data on the condition of meat at incremental times during transport in a given system. Data on transportation damage, its cost, and why it occurs are needed to effectively evaluate a transportation system. Allowable tolerances in the environment within the shipping vehicle, so that the desirable quality of fresh meat can be maintained, need to be clearly established. Much more can be learned about the effect of humidity and special atmospheres on meat quality. There is a need to define benefits of optimum humidity ranges and of special atmospheres singly or in combination along with proper temperature control.

Pre-cooling is an often neglected factor. The packer may leave this problem to the shipper, the shipper assumes the packer will take care of pre-cooling the meat while he assures adequate pre-cooling of the van prior to loading. Adequate cooling of meat by the packer and adequate refrigeration to accomplish cooling during transport could both be improved. More knowledge on pre-cooling requirements for fresh meat in terms of speed and retention of optimum quality as well as data on temperatures of meats during a variety of pre-cooling, loading, and transportation operations will help to resolve this problem.

Packaging of meat for transport is likely to become an increasingly critical problem. As we move away from shipment of whole carcasses to cuts prepared and packaged by the packer, all the problems presently associated with packaging of meats at the retail level will be encountered. Meat cuts will need proper protection during distribution to provide adequate sanitation, prevent shrinkage, and to maintain optimum color and other quality attributes. In addition such packaging must consider the size and shape to best utilize container space, facilitate handling, and allow needed ventilation. Development and improvement of new techniques to preserve fresh meat quality and to reduce bacterial loads--such as sterilizing lamps or radiation might help to meet packaging requirements for transport of prepackaged cuts of meat.

Finally, I am confident these problems associated with transportation of fresh meats will be solved. Particularly, as researchers recognize that methods to maintain fresh meat quality must include those that function successfully during the time meat is in transit.

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