

Advances in the control of *Trichinella spiralis*

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Communications

Food scientists are presently communicating with parasitologists and both groups are communicating with the industry, regulatory agencies and the consumer to develop improved methods for the detection and control of *Trichinella spiralis*. The number of scientific publications on *T. spiralis* in the United States has increased substantially in the last five years and Symposia entitled "Control of *Trichinella spiralis* in meat" and "Foodborne parasites of man: Their threat to the public health", were held at annual meetings of the Institute of Food Technology in 1982 and 1984, respectively. These symposia provided not only a forum for scientific debate but also enriched the literature with a summary of the "state of the art" concerning the importance of *Trichinella spiralis* and its control. In 1983, a book "Trichinella and Trichinosis", which was edited by W.C. Campbell, was published. A new book "Advances in Meat Science" has just been written and should be released in 1985. Chapter 2, "Parasitic Organisms", will provide the scientific community with the current results of research on a number of parasites, in addition to information of life cycles and epidemiology of the organisms (Murrell et al. 1985).

The National Pork Producers Council formed a Trichinae-Safe Pork Task force in 1982 and is encouraging implementation of methods for the control and elimination of *Trichinella spiralis* in pork. These methods include the enzyme-linked immunoassay (ELISA), and the pooled digestion technique for detection; irradiation, cold or heat for destruction of encysted larvae; and education of the consumer and the pork producer. They have established the year 1987 as a target for the elimination of that parasite from pork in the United States (Dudley, 1982; Anon., 1983). The trichinoscope method is not being considered for use because its accuracy is estimated at 50 percent (Miller, 1985). The National Live Stock and Meat Board is cooperating with the other segments of industry and has funded research at the Gerling Laboratory in California to develop procedures for cooking pork to a uniform internal temperature in microwave ovens. They have also funded the Iowa State University to evaluate the effectiveness of the cooking procedures recommended by the Gerling Laboratory for the destruction of *T. spiralis* during microwave cooking. The American Meat Institute has indicated that some of their members, representing the meat packing industry, are prepared to cooperate in the field testing of promising techniques for the detection of *Trichinella spiralis*.

Research

Epidemiological studies are underway by scientists in the Agricultural Research Service (Murrell, 1984) that will establish the current incidence of *T. spiralis* in swine, and will help to characterize the mode of infec-

tion of the animals. These studies include defining the role of rats in the transmission of trichinellosis and the development of regional surveillance programs based on new serological testing procedures. Research has been carried out successfully to develop a rapid ELISA procedure which will be used to identify infected swine by sampling their blood ante or postmortem (Leighty, 1982, 1985). Scientists in Dr. Murrell's laboratory have recently used monoclonal antibody technology to purify the secretory antigen for use in a test which is 95 % effective in detecting *T. spiralis* in swine (Anon., 1984).

Scientists in Dr. Leighty's laboratory, who began pioneer work on the development of an immunoassay for this purpose in 1971, have field tested their immunochemical procedure for detecting *T. spiralis* in swine. Their assay can be completed in 25 minutes, is highly sensitive and specific and can examine large numbers of whole blood samples in a relatively short time. This immunochemical procedure has been reviewed by an international panel of experts who concluded that the "data are scientifically sound and it clearly demonstrates that this assay is capable of yielding reliable, reproducible results within and among competent laboratories". The use of the ELISA by certified laboratories has been authorized.

Research for control of *T. spiralis* infection of swine through vaccination is underway by Dr. D.K. Murrell of the USDA and Dr. R. Rapic, Zagreb, Yugoslavia. Vaccines will be prepared using live irradiation attenuated larvae and larval excretory-secretory products (Murrell, 1984). The vaccination program, when successful, can be utilized in the specific areas of the country where swine trichinosis may be localized.

Research to ensure destruction of *T. spiralis* in cooked and uncooked meat by heat, cold and control of water activity is also continuing. The influence of various cooking methods on the destruction of *T. spiralis* in fresh pork was described by Kotula, 1982; Kotula et al., 1982, 1983; Zimmermann and Beach, 1982; Zimmermann, 1983. A thermal death curve describing the cooking temperature and time necessary to destroy the larvae was reported by Kotula et al. 1983. The USDA regulations (1960) provide refrigeration temperatures and holding times needed to inactivate the larvae in the temperature range of -15 to -28,9°C. Further research on the influence of temperatures between -17,8 and -6,7°C is being conducted at the Iowa State University. Murrell (USDA) is presently studying the resistance of sylvatic strains of *T. spiralis* to freezing temperatures. Brake et al. (1984) reported that 10 to 30 Krad were needed to eliminate the infectivity of the larvae. The Food and Drug Administration recently approved the irradiation of pork using up to 100 Krad for the destruction of trichinae (Anonymous, 1985). Terrell et al. (1982) and Childers et al. (1982) reported research on the influence of salts and nitrites on *T. spiralis* larvae in pork sausage. Lotzsch and Associates (1974, 1977) published a series of research articles describing the use of water activity as an index of the destruction of *T. spiralis* larvae in hams and sausage meat products. It is anticipated that the results of these research efforts will lead to improved and more cost effective procedures for the inactivation of trichinae in pork.

Regulations

The Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture routinely evaluates its regulations and revises them as necessary. To aid the industry in the detection and control of *T. spiralis*, the Department has amended the Federal meat inspection regulations to permit additional treatment methods for the destruction of *T. spiralis* in pork products (FSIS, 1985). The amendment expands the range of freezing and heating times for internal product temperature and prescribes drying times for sausages based on sausage diameter, salt content and temperature above 21°C. The drying times for hams and pork shoulders are based on smoking and drying at a range of room temperatures (FSIS, 1983). The FSIS plans to publish a "Procedural outline for verifying the lethality of a process treatment to trichinae" so that competent scientists can carry out additional evaluations for new or modified processes to determine whether such processes destroy the infectivity of the larvae. FSIS now permits use of a "Pooled sample artificial digestion method" which, when carried out by a certified laboratory, will exempt pork carcasses found to be free of *T. spiralis* from prescribed trichina destruction methods.

Conclusions

In the last five years, the research effort associated with *Trichinella spiralis*, has expanded significantly. The incidence of this parasite in swine, as well as its epidemiology in the United States, are being defined. The feasibility of vaccination of suspect hogs is being studied, and acceptable methods for detection include the ELISA and the pooled digestion techniques. The effectiveness of the destruction of the larvae by freezing, cooking and irradiation are being characterized more precisely. The mechanisms are now in place for the control of *Trichinella spiralis* in the United States. The scientific community can now be challenged with the need to develop detection and control measures for other parasites like *Toxoplasma gondii*.

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SECTION 5 - MEAT PROCESSING: FERMENTED PRODUCTS

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production sausage ripening (e.g. the whole process between case filling and the final product), can be clearly divided into two periods :
 1. A first short fermentation period (1-2 days) in which pH drops to its lowest value between 4.5 and 5.0.
 2. A second longer drying period (2-4 wks) in which the sausage loses up to about 50% of its weight and develops full flavour, colour and texture.

Modernization of traditional empirical methods to industrial production has generated research into the biochemistry of sausage ripening (Lilke, 1958). It has also resulted in energy costs up to 5000 kcal/kg of finished product, 3% of which being consumed by air conditioning during drying (Lilke et al., 1983). Less energy consuming systems using brine immersion have been described (Frank et al., 1987).

We do not have the intention to try and review all aspects of sausage ripening and its technology at recent excellent reviews on this subject are available (Beem, 1984)(Lilke, 1985). This paper will totally neglect microbial aspects (e.g. mould growth and mycotoxins) and focus on work carried out in our laboratory in which sausage ripening is studied as an integrated process. Such study requires simultaneous evaluation of several

interrelated dynamic aspects of the complex system of sausage ripening, and their effect on sausage quality. The paper will describe simple mathematical and metabolic models used for such evaluation, in an extension of earlier work published locally (Gawyer, 1981)(Gawyer and Terplakos, 1984) or as abstract (Gawyer, 1982)(Gawyer and Terplakos, 1985).

2. Quality characteristics of dry sausage.

Quality of dry sausage may be defined here as

- a. Shelf life and nutritional safety
- b. Sensory characteristics : texture, colour and flavour.

2.1. Shelf life, nutritional safety and microbiology.

The combination of low pH and low water activity (a_w) prevents growth and toxin production of e.g. *Salmonella* and *Clostridium botulinum* respectively. *Staphylococcus aureus* enterotoxin production is less inhibited by low a_w but is sensitive to desiccation (Lilke and Stokelenburg, 1978). Lactic acid bacteria furthermore produce antimicrobial compounds such as hydrogen peroxide, bacteriocins and proteolysis (Lilke, 1985)(Lilke et al., 1980)(Frank and Fleckmann, 1986). Apart from low pH and a_w , nitrite provides an additional defense against *C. botulinum* toxin and according to Gerasimovic (1978), 50 ppm a_w is sufficient to prevent *S. aureus* development, while starter cultures and desiccation are used. Public health considerations are mainly responsible for the emphasis put on a rapid and reproducible pH drop in dry sausage manufacture. Recent information even suggests that nitrite in dry sausage has little or no effect in controlling organisms such as *Staphylococcus aureus*, *Salmonella* and *Clostridium sporogenes* (Collins - Thompson et al., 1984). Improved chilling and sanitation measures however show the average natural inoculum is likely to contain fewer bacteria than in the traditional production of the past. This may delay fermentation, necessitating a period of pre-curing before stuffing or the use of "starter cultures" or of a bacteriocin. It should be mentioned that, depending on temperature and curing, nitrite may reduce to nitrate, prior to its inhibition by lactic acid production, whereas even with starter cultures, fermentation may be delayed because of the presence of antibiotic substances, from natural sources (Lilke and Penney, 1978) or from antibiotic drug residues (transaminase, bacterial contamination). Starter cultures were initially developed in the U.S.A. using *Lactobacillus* sp., not currently occurring in meat but resistant to lyophilization. Later frozen cultures of *Lactobacillus plantarum* were introduced, showing lower optimal growth temperatures and more akin to the atypical *Lactobacilli* found in traditional sausage (Lilke, 1985). In Europe, where lower fermentation temperatures are common and nitrate salt was more frequently used, rapid lactate production suppressed organisms producing catalase and nitrate reductase, inducing flavour and soiling defects. This resulted in the development of starter cultures containing both *Lactobacilli* and *Streptococci* in Europe. It should be emphasized however that the use of a starter culture is not necessarily associated with a rapid fermentation and vice-versa. Indeed, "acid" starter cultures have to compete with bacteria present in the raw materials and dominance of individual strains determining product characteristics will be affected by many factors. The development of an indigenous meat micro-flora, simultaneous with the

