

## Effects of Refrigeration, Cooking, and Freezing on *Sarcocystis* in Beef from Retail Food Stores

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**ABSTRACT:** *Sarcocystis* organisms in ground bovine hearts survived storage at refrigeration temperatures for 3 days. Dogs fed this meat became infected and passed sporocysts in their feces. Ground beef from a small local grocery store was fed raw to dogs, and ground beef from a supermarket was fed as raw, rare, medium, and well-done hamburger patties. All dogs fed raw and rare meat became infected and passed sporocysts. Ground beef from a supermarket was fed raw to dogs on the day of purchase and meat from the same batch was fed to other dogs after it had been frozen for 7 days. Only those dogs fed unfrozen meat became infected and passed sporocysts.

Workers recently have found that *Sarcocystis*-infected meat obtained fresh from abattoirs and ingested by dogs, cats, humans, or coyotes results in the development of coccidian stages in the intestine and elimination of sporocysts and/or oocysts in the feces (Rommel et al., 1972; Heydom and Rommel, 1972; Mahr, 1973; Fayer and Leek, 1973; Rommel and Heydom, 1972; Fayer, 1975). Although 22,194 carcasses of cattle and sheep were condemned at slaughter in the United States in 1971-73 because of sarcosporidiosis and eosinophilic myositis (a loss of over \$6.7 million),<sup>1</sup> most carcasses harboring cysts of *Sarcocystis* show no gross signs of infection and therefore pass inspection. Indeed, in three surveys in the United States, 75 to 98% of the cattle examined at slaughter were found to be infected with *Sarcocystis* (Levine, 1973). The experiments described herein were undertaken to determine whether *Sarcocystis*-infected beef obtained at slaughter would remain infectious after refrigeration, whether beef obtained from retail stores contained infectious *Sarcocystis* organisms, and whether such organisms remained infectious after cooking and after freezing.

### Materials and Methods

In three of four experiments, tissue fluid expressed from meat samples was found to contain bodies that could not, in all samples,

be positively identified as *Sarcocystis* zites although they were similar in size and shape. The beef was fed to 28 5- to 17-month-old coccidia-free beagles. These dogs had never previously eaten raw meat and, except for the time of infection, were fed dry pelleted dog food. Dogs were housed in individual cages and fecal samples collected daily from each animal were examined microscopically for the presence of oocysts and sporocysts.

The first experiment was conducted to determine whether *Sarcocystis* organisms would survive storage at refrigeration temperatures for several days. Eight dogs were divided into four groups of two. Several bovine hearts were obtained from a local abattoir and ground in a commercial meat grinder, and part of this ground meat was fed within 4 hr of slaughter to Group 1. The rest of the ground heart was refrigerated, and part was fed to Group 2 at 24 hr, to Group 3 at 48 hr, and Group 4 at 72 hr.

The second experiment was conducted to determine whether *Sarcocystis* organisms were still viable and infective in meat sold by a retail store. Six dogs were divided into two groups of three. Three pounds of lean ground beef were purchased daily for 5 days from a small local grocery store, and 1 pound was fed to each of the dogs in Group 1. Dogs in Group 2 received the normal dry food ration.

The third experiment was conducted to determine the effect of cooking on viability and infectivity of the organisms. Eight dogs were divided into four groups of two. Eight pounds of lean ground beef were purchased daily for

<sup>1</sup> Calculated from whole carcass condemnations due to sarcosporidiosis and eosinophilic myositis (a possible result of sarcosporidiosis) in Federal Meat and Poultry Inspection Statistical Summary for 1971, *ibid.* 1972, *ibid.* 1973, and estimating value of cattle at \$500 and sheep at \$50.

5 days from a large supermarket in the Maryland suburbs of Washington, D. C. This meat was formed into 16 uniform ½-pound patties with the aid of a hamburger press. Patties were divided into four groups of four. Meat for Group 1 was not cooked; meat for the other groups was oven cooked at 400 F (204.4 C), until it was either rare, medium, or well done. Criteria for determining rare, medium, and well-done meats included color and temperature of the meat at the center of the patty. Rare patties were red, medium were pink, and well done were brown. The temperature in the rare patty was 100–128 F (37.8–53.3 C), that in the medium was 140 F (60 C), and that in the well done was 160–166 F (71.1–74.4 C). Temperature was recorded on a Honeywell Brown Elektronik potentiometer<sup>2</sup> with a heat-shielded thermistor cable inserted into the center of two patties in each group. Patties were removed from the oven when they reached the desired temperature. Each day, two raw patties were fed to each dog in Group 1, two rare patties were fed to each dog in Group 2, two medium patties were fed to each dog in Group 3, and two well-done patties were fed to each dog in Group 4.

The fourth experiment was conducted to determine the effect of freezing on the viability and infectivity of the organisms. Six dogs were divided into three groups of two. Four pounds of lean ground beef were purchased daily for 5 days from a large supermarket. Each day, 1 lb. of ground beef was fed to each dog in Group 1 and the remaining 2 lb. placed in the freezer section of a refrigerator. Each 2-lb. package of ground beef was thawed 7 days after freezing and 1 lb. was fed to each dog in Group 2 for 5 successive days. Dogs in Group 3 were fed only dry pelleted feed.

### Results

**EFFECT OF STORAGE AT REFRIGERATION TEMPERATURE (EXPERIMENT 1):** Dogs were fed ground meat within 4 hr of slaughter and after refrigeration for 24, 48, and 72 hr. Beginning 15–18 days after the infective meat was fed, all eight dogs passed sporulated *Sarcocystis* sporocysts.

<sup>2</sup> Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may be suitable.

**INFECTIVITY OF GROUND BEEF FROM GROCERY STORE (EXPERIMENT 2):** All three dogs fed ground beef began to pass sporulated sporocysts in their feces 19–21 days after the initial feeding of ground beef. None of the three dogs fed the normal dry food ration passed such stages.

**EFFECT OF COOKING ON INFECTIVITY OF ORGANISMS (EXPERIMENT 3):** All dogs fed raw or rare patties began to pass sporocysts 16–17 days after the initial feeding. None of the dogs fed medium or well-done patties passed such stages within 25 days after the initial feeding.

**EFFECT OF FREEZING ON INFECTIVITY OF ORGANISMS (EXPERIMENT 4):** Both dogs fed raw unfrozen ground beef began to pass sporulated sporocysts in their feces 15–16 days after the initial feeding. Neither the two dogs fed ground beef from the same batches, but frozen for 1 week, nor the two dogs fed dry pelleted food passed such stages within 22 days after the initial feeding of thawed ground beef.

### Discussion

Because of the high percentage of cattle infected with *Sarcocystis* and the present findings that indicate that viable, infectious organisms are present in fresh beef sold in retail stores (Exps. 2–4), the potential for transmission of *Sarcocystis* to humans and their pets by fresh beef clearly exists.

Five of six German investigators who ate *Sarcocystis*-infected raw beef or raw pork seasoned with onions and spices passed sporocysts in their feces beginning 9–17 days later (Rommel and Heydorn, 1972). One suffered a severe influenzalike infection with fever and mild diarrhea. The others were asymptomatic. Ingestion of meat containing greater numbers of organisms, ingestion of larger quantities of infected meat, or ingestion of meat containing other species or strains of *Sarcocystis* could significantly alter the degree of pathogenicity.

*Toxoplasma gondii*, a protozoan parasite pathogenic for many animals, including man, is closely related to *Sarcocystis* and has also been found in cattle, swine, and sheep in the United States and other countries (Levine, 1973). Transmission to man by means of undercooked meat was strongly suggested

when patients in a hospital in France where such meat was given for therapeutic purposes became infected (Desmonts et al., 1965) and in the U. S. where five medical students who had eaten hamburgers at the same time and place concurrently suffered acute lymphadenitic toxoplasmosis (Kean et al., 1969). The finding that cats and certain other Felidae produce oocysts after ingesting *Toxoplasma*-infected mice and that these oocysts infect all birds and mammals tested and, circumstantially, humans (Miller et al., 1972) suggests that the feeding of raw or undercooked meat to pets may result in human infection as a result of contact with organisms from pet feces. Although we do not know yet whether *Sarcocystis* sporocysts from dogs or cats are infectious to humans, conceivably, transmission from pets could occur similarly.

Both freezing and cooking appear to reduce the infectivity of *Toxoplasma* and *Sarcocystis*. Dubey (1974) found that *Toxoplasma*-infected mice that had been stored at  $-9$  and  $-20$  C for as little as 3 hr were not infectious for cats. Jacobs et al. (1960) found that the viability of *Toxoplasma* organisms in mouse brain decreased after 1 hr at 113 F (45 C) and was lost after 30 min at 122 F (50 C) and 10–15 min at 132.8 F (56 C). Similarly, the effect of cooking decreases infectivity of *Sarcocystis*-infected meat. Gestrich (1974) fed cats bovine diaphragm stored at 35.6 F (2 C) for 14 days and heated to different temperatures. All cats fed meat heated to 113 F (45 C) for 5–6 min passed sporocysts, as did one of four cats fed meat heated to 131–140 F (55–60 C) for 6 min. No cats fed meat heated to 149–158 F (65–70 C) for 10 min passed sporocysts. Gestrich also found that of two groups of cats, one fed fresh meat and the other fed meat that had been stored at  $-20$  C for 3 days, the latter group passed no sporocysts. These results are closely paralleled and substantiated by the results obtained in the present study, and together they indicate that *Sarcocystis* organisms remain infective for long periods of time and that proper cooking or freezing may be effective controls.

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