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USE OF OTHER PRESERVATIVES TO CONTROL LISTERIA IN MEAT

Since *Listeria monocytogenes* can grow on a variety of processed meat products at refrigeration temperatures (9), a variety of chemicals which destroy or limit the growth of harmful microbes have been tested for the preservation of meat. Many of these compounds are well known and their effects on various bacteria and on meat quality have been thoroughly investigated; others have been introduced recently and are not as well studied. Some compounds are not very potent by themselves but in combination with other preservatives or storage conditions can suppress the growth of foodborne pathogens. Several researchers have developed models which describe the effects of different combinations of preservatives on the growth of *L. monocytogenes* in laboratory media (*2,8,26,31*). Although these models are useful, growth of *L. monocytogenes* in meat nearly always differs from that in culture media.

Sodium chloride (NaCl). NaCl in growth media or foods can be a source of osmotic stress by decreasing water activity (a_w). However, *L monocytogenes* is remarkably salt-tolerant and able to withstand higher salt concentrations than *Salmonella* spp. and *Yersinia* spp. (*13*). In an experiment to determine the antilisterial effects of brine solutions which could be used as dips, *L. monocytogenes* easily survived 6 hours at 10°C in solutions containing 6, 16, or 26% sodium chloride (*15*). *L. monocytogenes* even grew in the 6% brine solution (*15*) and in meat peptone media containing 8% NaCl (*40*). The presence of sodium chloride in growth media also partially protects *L. monocytogenes* from other stresses such as heat in ground pork (*45*), lactocin 705 in minced beef slurry (*41*), and hydrogen peroxide in culture media (*21*).

Although *L. monocytogenes* is halotolerant, salt is a stress and does depress growth rates (*4,40*). In combination with other compounds used in curing meats, NaCl is one factor contributing to the destruction or inhibition of *L. monocytogenes* (*3,8,17,26,31*).

Nitrite. Nitrite alone is also not a very effective antilisterial agent. In turkey slurries (pH6.2), 30 ppm sodium nitrite was unable to inhibit the growth of *L. monocytogenes* at 4 or 25°C (*35*). In beef slurries, 800 ppm was required to inhibit growth of *L. monocytogenes* (*41*). However, as with salt, in the presence of other curing agents (*8,26,31,44*) or lactocin 705 (*41*), nitrite can contribute to the suppression of *L. monocytogenes* at refrigeration temperatures.

Trisodium phosphate (TSP). Trisodium phosphate has been used for decontamination of poultry carcasses (*34*) and can reduce bacterial contaminants by 1-2 logs. Spraying of TSP on beef carcass tissue contaminated with *L. monocytogenes* removed 1.3 log of cells but by the 7th day of cold storage, the remaining bacteria started to grow (*6*). Use of 10% TSP as a 15 sec dip removed only about 39% and 81% of *L. monocytogenes* at 10°C and 4°C, respectively (*5*). In other experiments, in which *L. monocytogenes* was suspended on solutions of TSP, exposure to 8% TSP for at least 10 min was required to reduce bacterial numbers by at least 1 log (*36*). *E.*

coli O157:H7, *Campylobacter jejuni* and *Salmonella typhimurium* were all more sensitive than *L. monocytogenes* to TSP.

Smoke/Liquid Smoke. Smoking of meat and fish is a well known preservation technique and has been shown to inhibit the growth of *L. monocytogenes* (*27,32*). Several experiments have also documented the antilisterial effects of liquid smoke additives. Of 5 Red Arrow smoke products evaluated, CharSol-10 was the most effective against *L. monocytogenes* and reduced viable cells on the surface of beef franks by >99.9% after 72 hours storage at 4°C (*23*). Another product, CharSol Supreme also had potent antilisterial effects in wiener exudate (*7*). Analysis of this product revealed that its active ingredient was isoeugenol and that this compound was more effective in the presence of acetic acid at pH 5.8. Experiments with 7 commercial smoke preparations used in Spain indicated that some were better antilisterial agents than others and that the most potent had higher concentrations of phenols (*37*).

Plant Extracts. A variety of herbs and spices have been tested for their efficacy in suppressing the growth of *L. monocytogenes* in culture media. Plant extracts exhibiting antilisterial activity include: hop extracts (*20*), eugenol (*1,10,11*), pimento leaf (*10,11*), horseradish distillates (*43*), rosemary (*21,30*), cloves (*21,30*), cinnamic acid (*19,33*), furanocoumarins (*38*), and carvacol (*18*). Numerous other plant extracts have been tested but results were not always consistent. (*10,18,21*). Different commercial samples of plant essential oils and different varieties of the same herbs may exhibit differences in antilisterial potency because of varying amounts of critical compounds. Some plant extracts were also found to be effective against *Listeria* spp. in meat including rosemary in ready-to-eat pork liver sausage (*30*), horseradish distillates on roast beef (*43*), and eugenol and pimento leaf of refrigerated cooked beef (*11*). It should be noted that *L. monocytogenes* was usually less sensitive to these extracts in meat (compared to culture media) and sensitivity also varied with fat content of the meat. For hop extracts tested in dairy products, antimicrobial activity was higher in lower fat meats (*20*).

Monolaurin and other monoglycerides. Several monoglycerides (glycerol with one esterified fatty acid) are effective inhibitors of *L. monocytogenes* in culture media (*25,28,29,42*) and in foods. In beef frank slurries (pH 5.0 and 5.5), mono-caprin, monolaurin and coconut monoglycerides, individually all inhibited the growth of *L. monocytogenes* (*42*). These individual compounds were not as effective in turkey frank slurries but combinations of monoglycerides were effective. Brines containing monolaurin and lactate pumped into beef roasts (microwave-ready beef roasts) enabled a greater kill of *L. monocytogenes* during cooking in bags in water baths than brines without monolaurin (*39*). Monolaurin appeared to be a more potent antimicrobial at lower temperatures and pH values (*25,29,42*). Also, planktonic cells of *L. monocytogenes* were more susceptible to monolaurin than cells attached to stainless steel surfaces (*28*).

Chelators (Citrate and EDTA). Chelators, which bind metal ions, are not by themselves lethal to *L. monocytogenes* in the concentrations used in foods (*46*). However, these compounds interact with other preservatives and sometimes aid in suppressing the growth of *L. monocytogenes* in meats (*1,25,31*). In other cases, for example EDTA combined with nisin, the opposite occurs and EDTA reduces the antimicrobial effects of nisin (*46*).

Lysozyme. Hen egg white lysozyme suppressed the growth of *L. monocytogenes* in fresh pork sausage (bratwurst) for 2-3 weeks (*16*).

Sorbate (Sorbic acid). Experiments using culture media revealed that *L. monocytogenes* was more susceptible to sorbate at lower pH (pH 5 vs pH 6) and at lower temperatures (5°C vs 30°C). (24) In beaker sausage sorbate was also a more effective inhibitor of *L. monocytogenes* at lower temperatures (*14*). Fat content of the sausage did not affect the potency of sorbate at 4°C but at 10°C, sorbate was a more effective in sausages containing 67% fat as compared to 22% fat.

Other additives. Minimal inhibitory concentrations of **methyl paraben (p-hydroxybenzoate)** for growth of *L. monocytogenes* in culture media were lower at pH 5 than at pH 6 and at 5°C than at 30°C. Under similar conditions, methyl paraben was a more potent inhibitor of *L. monocytogenes* than sorbate (*24*). **Sodium erythorbate** did not appear to be an effective antilisterial agent in raw or cooked ground beef. (*12*).

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