Influence of sodium chloride, sorbic acid and potassium sorbate on weight losses and gas production in emulsified meat products.

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Introduction

Salt (sodium chloride) is a common non-meat ingredient in many processed meat products. In addition to its antimicrobial influence, salt also affects product flavor and the functionality of the muscle proteins (Sofos, 1984). In emulsified meat products, salt extracts and solubilizes myofibrillar proteins during the mechanical action of chopping. These proteins form a matrix which surrounds the fat and other ingredients. Upon heating the protein gel binds the ingredients and gives products of high yield and acceptable texture (Schmidt et al., 1981; Sofos, 1983). Meat formulations with inadequate concentrations of salt are of reduced binding ability which results in unacceptable yield, texture and flavor. In addition, the shelf-life of these products is shortened (Sofos, 1985a; Madril and Sofos, 1985; Whiting, 1984a,b; Whiting et al., 1984).

Consumption of salt, however, is considered a major source of sodium in the human diet, and sodium intakes have been associated with incidence of hypertension in sensitive individuals (Anonymous, 1980; Kolari, 1980). Cured meat products are considered major sources of sodium in the human diet and various health and regulatory authorities have suggested reduction or elimination of added sodium and salt in processed foods, including meat products. Sodium labeling of various foods is gaining support and may become mandatory in the future. Thus, there are incentives for meat processors to seek ways for reduction of salt levels in meat products, or for the development of acceptable formulations with minimum levels of sodium for individuals that will benefit from such diets.

Sorbates, including sorbic acid and potassium sorbate, are widely used antimicrobial agents in food formulations around the world (Sofos and Busta, 1981; 1983; Lueck, 1976; 1980). The action of sorbates involves inhibition of yeasts, molds, as well as several bacterial species (Sofos et al., 1986). The use of sorbates in meat products is limited. In the United States their only approved use in meats is as inhibitors of molds on the surface of dry sausages. Recent studies, however, demonstrated the effectiveness of sorbates as inhibitors of *Clostridium botulinum* in various meat formulations (Sofos et al., 1979; Robach and Sofos, 1982; Sofos and Busta, 1981). It was, thus, proposed that the levels of 0.26% potassium sorbate, or 0.20% sorbic acid, could be used as antibotulinal alternatives to presently used levels of nitrite in cured meat products.

Recent studies in our laboratory have shown that, in addition to antimicrobial activity, potassium sorbate improved the cooking yields of beef-pork and turkey formulations with certain levels of sodium chloride (Sofos, 1985b; 1986). Inclusion of potassium sorbate in the meat formulation had no major influence on product pH, while sorbic acid reduces pH of meat products (Sofos, 1981). Decreased pH values are desirable from an antimicrobial standpoint, but they may be detrimental to product binding.

The objectives of these experiments were to study the influence of varying levels of sorbic acid, potassium sorbate, and their combination, on pH, weight losses, and spoilage in beef-pork formulations processed with and without varying levels of salt (sodium chloride).

Materials and Methods

Treatments: Three levels of salt (0, 1.2 and 2.4%), sorbic acid (0, 0.1 and 0.2%), and potassium sorbate (0, 0.13, 0.26%) were tested in various combinations to yield a total of 12 treatments. Each level of sorbic acid and potassium sorbate was tested with 0% and 1.2% salt. The study also included treatments with 1.2% and 2.4% salt, and a combination of 1.2% salt - 0.1% sorbic acid - 0.13% potassium sorbate (Table 1).

Table 1. Treatments and pH values of raw and cooked emulsions.

Sodium chloride:	2.4	1.2	—	—	—	—	—	1.2	1.2	1.2	1.2	1.2
Sorbic acid:	—	—	—	0.10	0.20	—	—	0.10	0.20	—	—	0.10
Potassium sorbate:	—	—	—	—	—	0.13	0.26	—	—	0.13	0.26	0.13
Raw product pH	6.02^{cd}	6.07^{d}	5.99^{cd}	5.68^{b}	5.44^{a}	5.94^{c}	6.03^{cd}	5.74^{b}	5.49^{a}	5.98^{cd}	6.03^{cd}	5.72^{b}
Cooked product pH	6.25^{cd}	6.28^{d}	6.23^{cd}	5.97^{b}	5.71^{a}	6.15^{c}	6.17^{cd}	5.99^{b}	5.74^{a}	6.22^{cd}	6.24^{cd}	5.96^{b}

Three replicates. Means in the same line with different superscript letters were significantly different ($P<0.01$).

Ingredients: Lean (5% fat) ground beef and pork trimmings (55% fat) constituted the meat formulation. The frozen (<1 month) meats were ground twice through a 0.95 cm plate. The pH of beef was 5.75-5.95 and of the pork trimmings 6.15-6.25. Other common ingredients included water (20%), dextrose (0.5%), corn syrup solids (0.5%), white pepper (0.25%), nutmeg (0.0625%), sodium erythorbate (0.03%), and sodium nitrite (0.01%).
Processing: Equal amounts (200 g) of beef and pork trimmings were mixed with the other ingredients for 10 seconds on speed two and 20 seconds on speed five of a Kitchen Aid Mixer (model K45SS, Hobart Co., Troy, OH). The formulations were then chopped and comminuted in a horizontal blade bowl cutter (Sunbeam Le Chef Food Processor) for two 20-second intervals to a temperature of less than 15°C. The finely chopped mixtures were then extruded with a hand-operated stuffer into three large (30 x 105 mm) and ten small (16 x 150 mm) test tubes. The product in the tubes was cooked in a 50°C water bath by gradually increasing its temperature to 75°C. Final internal product temperature was 70°C. Before cooking, the small tubes were inoculated with *Clostridium sporogenes* spores. After cooking, the inoculated tubes were capped with a sterile mixture of paraffin and mineral oil to achieve anaerobic conditions and to indicate production of gas during product storage. The large tubes were used for determination of weight losses and pH.
Inoculum: Spore suspensions of *C. sporogenes* P.A. 3679 were prepared according to the procedure of Santo Goldoni et al. (1980). The raw emulsions in the small tubes were inoculated through a syringe with one ml of a

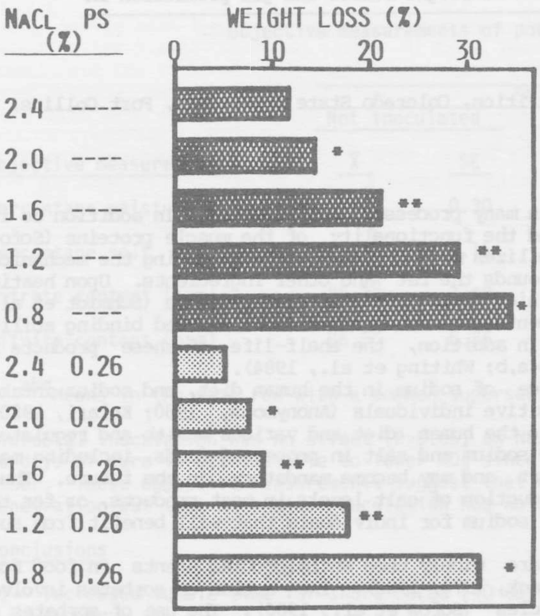

Fig. 1. Effect of salt (NaCl) levels (%) and potassium sorbate (PS) on weight losses during cooking of an emulsified meat product (from Sofos, 1985b). Asterisks indicate significant differences between pairs of means (three replicates).

heat activated (80°C, 15 min) spore suspension. The injected inoculum was diluted to yield 1000 spores/g of emulsion.

Weight Losses: Cooking losses were determined by draining and collecting the separated material from each large tube immediately after heating. The volume of total material and fat collected were measured. The tube contents were weighed before and after thermal processing and cooling. Cooking losses were expressed as percent weight losses, total volume (ml) losses per 100 gram raw material and fat volume (ml) losses per 100 gram raw material.

pH Determination: Raw and cooked emulsion pH values were determined on a blend of 10 g emulsion with 90 ml distilled, deionized water with a Corning pH meter.

Product Spoilage: Inoculated product in small test tubes was stored for abuse at 27°C and monitored daily for gas production.

Replication and Statistical Analysis: All the treatments of the study were replicated three times on three different occasions with meat from different animals. The results were analyzed by analysis of variance and significant differences among treatment means were determined with the LSD procedure.

Results and Discussion

Recent studies in our laboratory indicated that potassium sorbate improved the cooking yields of comminuted meat formulations with varying salt levels (Sofos, 1985b; 1986). The data of Figure 1 demonstrate the influence of potassium sorbate in reducing cooking losses of a canned, comminuted beef-pork product heated to 70°C. Potassium sorbate reduced weight losses at salt levels of 0.8, 1.2, 1.6, 2.0 and 2.4%. Its effect, however, was significant at 0.8, 1.2, 1.6 and 2.0% salt (Fig. 1). This observation is important, because it indicates that addition of potassium sorbate in meat products can be of economic significance. Furthermore, potassium sorbate could be valuable in facilitating reduction of salt levels though its influence on cooking yield and through its action as an antimicrobial agent (Sofos, 1985b). These observations can also be useful in elucidating the exact mechanisms through which chemicals such as phosphates improve binding in meat products.

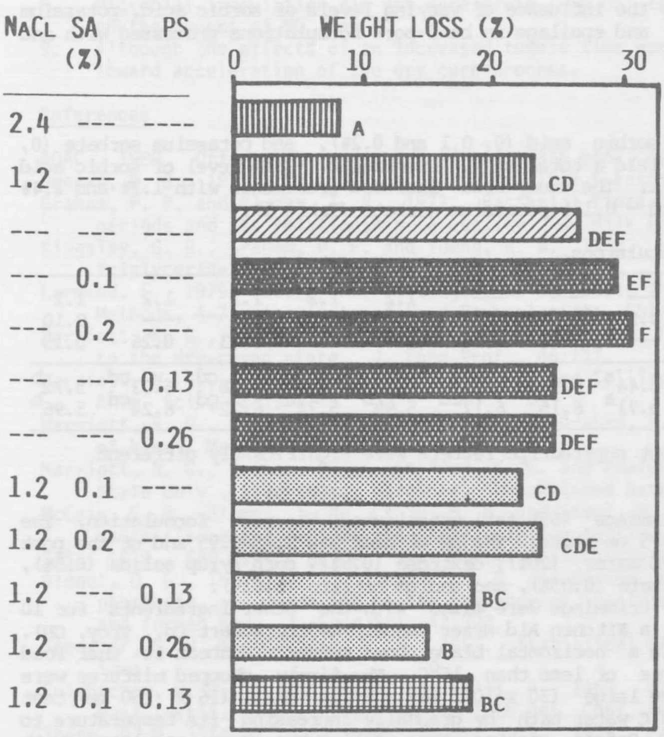

Fig. 2. Effect of different salt (NaCl), sorbic acid (SA) and potassium sorbate (PS) levels (%) on weight losses during cooking of an emulsified meat product (Three replicates; different letters indicate significance at P<0.01).

The present study was designed to determine whether sorbic acid would have the same influence as potassium sorbate on weight losses during cooking of a low salt, beef-pork, comminuted meat product. In addition, the influence of potassium sorbate and sorbic acid on product pH and shelf-life were evaluated. It has been reported (Sofos, 1981) that sorbic acid can reduce the pH of meat products by 0.2–0.3, while potassium sorbate has no major influence on product pH. A lower pH is detrimental to emulsion stability, while it favors antimicrobial activity and the action of several food preservatives (Sofos and Busta, 1981). The study was also designed to examine whether a smaller amount of sorbic acid and potassium sorbate, and their combination, would be influential in reducing cooking losses and extending shelf-life.

As indicated above, the pH values of the raw and cooked meat formulations were basically unaffected by potassium sorbate (Table 1); while sorbic acid reduced pH values significantly (P<0.01). The combination of sorbic acid (0.1%) and potassium sorbate (0.13%) had an intermediate effect on pH.

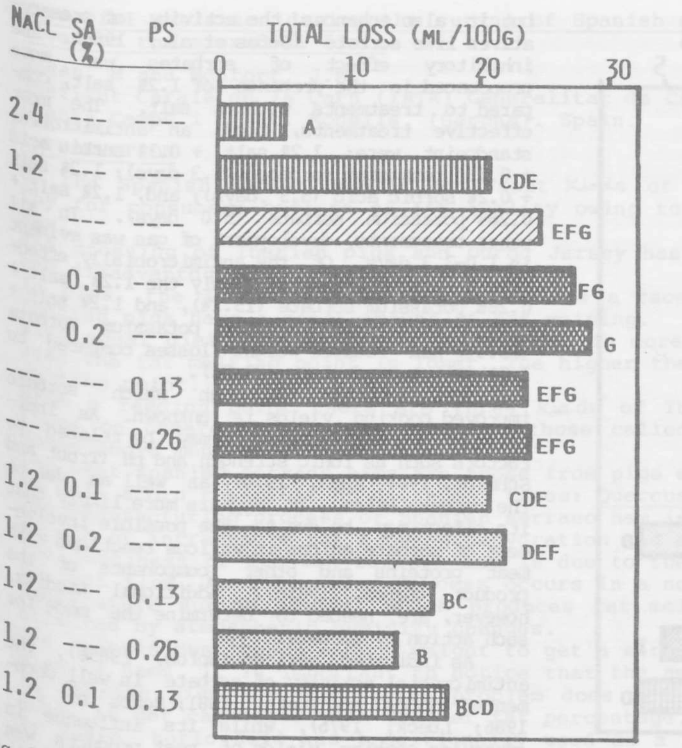

Fig. 3. Effect of different salt (NaCl), sorbic acid (SA) and potassium sorbate (PS) levels (%) on total material separated (ml/100 g) during cooking of an emulsified meat product (Three replicates; different letters indicate significance at P<0.01).

These major decreases in pH were very influential on product weight losses and shelf-life.

The average weight loss of the three replicates in the control treatment with 2.4% salt was 8.1% (Fig. 2). In the absence of salt the weight loss was significantly (P<0.01) higher (26.6%). The treatment with 1.2% salt had an average weight loss of 23.2%, which was significantly (P<0.01) higher than that of the control (2.4% salt) treatment, but not significantly different than the treatment without salt. These results confirm previous findings, by indicating that a reduction of presently used salt levels by 50% results in comminuted meat products of very low cooking yields (Sofos, 1983a; 1985a,b; Madril and Sofos, 1985; Puolanne and Terrell, 1983a,b; Whiting, 1984a,b).

Formulations with sorbic acid (0.1 and 0.2%) in the absence of salt demonstrated weight losses even higher than the treatment without salt. This is attributed to the reduction in pH caused by presence of sorbic acid in the formulation. In treatments without salt, potassium sorbate (0.13 and 0.26%) resulted in weight losses similar to the treatments without and with 1.2% salt. These results indicate that in meat formulations without salt, sorbic acid reduces pH and, thus, it increases weight losses during processing, while potassium sorbate has no influence on cook yield.

The weight losses of treatments with 1.2% salt were not reduced with presence of 0.1 or 0.2% sorbic acid in the formulation. Considering, however, the lower pH (Table 1) of treatments with 1.2% salt + sorbic acid compared to the product with 1.2% salt and no sorbic acid, it appears that any positive influence of the sorbate ion on yield was negated by the lower pH of these treatments. Potassium sorbate improved cooking yields when tested in combination with salt (1.2%), especially at the 0.26% level. The 1.2% salt + 0.26% potassium sorbate combination had significantly (P<0.01) lower cooking losses than the 1.2% salt treatment, but higher than the 2.4% salt treatment. The combination of 1.2% salt + 0.1% sorbic acid + 0.13% potassium sorbate had weight losses similar to the treatment of 1.2% salt + 0.13% potassium sorbate. The pH of this treatment, however, was lower and this improved its shelf-life compared to the treatment with only 0.13% potassium sorbate or salt (1.2%).

The data on total material and fat separated during cooking also demonstrate the importance of salt and higher pH on product binding, and the positive influence of potassium sorbate in reducing the extent of product losses during cooking (Fig. 3 and 4).

Spoilage of products inoculated with *C. sporogenes* spores was influenced by pH, salt level, sorbic acid and potassium sorbate (Fig. 5). In the control treatment with 2.4% salt, gas production was detected (swelling) in an average of 2.7 days at 27°C. With 1.2% salt, gas was first detected in 1.3 days, while in the absence of any salt, spoilage was even more rapid (1 day). Production of gas was delayed in the presence of sorbic acid and potassium sorbate, both in the absence and presence of salt. The delay in gas production was longer with increasing level of sorbate. Sorbic acid appeared to be slightly more effective than potassium sorbate. Sorbic acid treatments, however, were of lower pH. A lower pH, not only delays microbial growth,

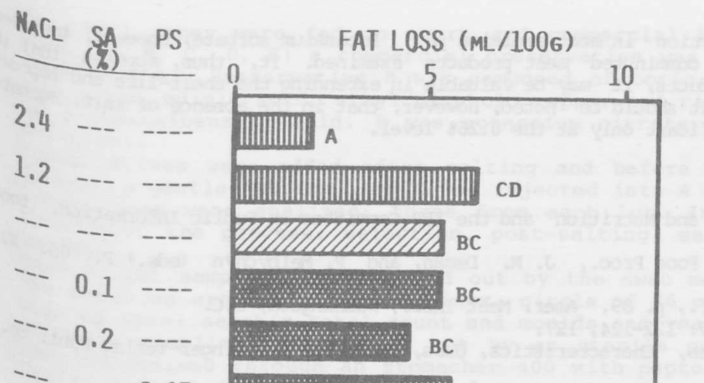

Fig. 4. Effect of different salt (NaCl), sorbic acid (SA) and potassium sorbate (PS) levels (%) on fat separated (ml/100 g) during cooking of an emulsified meat product (Three replicates; different letters indicate significance at P<0.01).

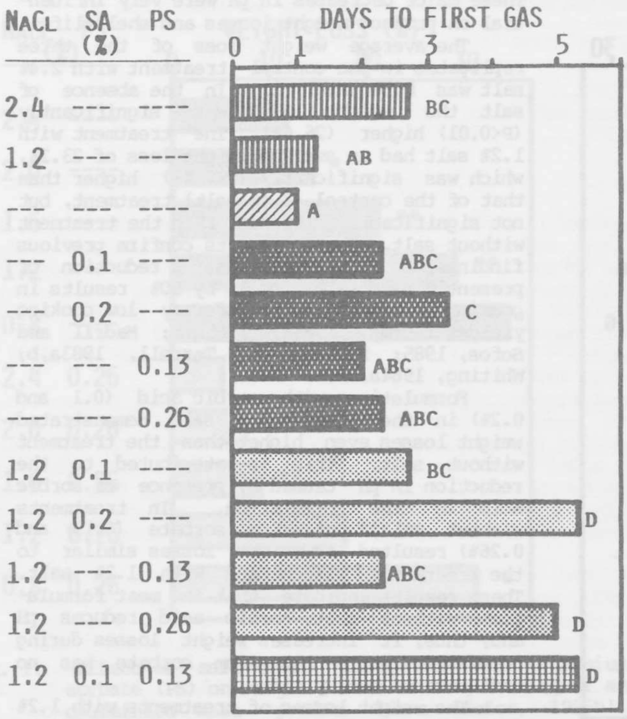

Fig. 5. Effect of different salt (NaCl), sorbic acid (SA) and potassium sorbate (PS) levels (%) on gas production in an emulsified meat product inoculated with Clostridium sporogenes spores (1000/g) and stored at 27°C (Three replicates; different letters indicate significance at P<0.01).

but it also enhances the activity of preservatives like sorbate (Sofos et al., 1986). The inhibitory effect of sorbates was more pronounced in the presence of 1.2% salt, compared to treatments without salt. The most effective treatments, from an antimicrobial standpoint, were: 1.2% salt + 0.1% sorbic acid + 0.13% potassium sorbate (5.3 days); 1.2% salt + 0.2% sorbic acid (5.3 days); and, 1.2% salt + 0.26% potassium sorbate (5.0 days). In all other treatments, development of gas was evident in 1.0-3.3 days. Of the antimicrobially effective treatments, however, only the 1.2% salt + 0.26% potassium sorbate (15.1%), and 1.2% salt + 0.1% sorbic acid + 0.13% potassium sorbate (18.4%) had reduced weight losses compared to 1.2% salt tested alone (23.2%).

The mechanism through which sorbate improved cooking yields is unknown. As indicated by Sofos (1985b), it may be related to factors such as ionic strength and pH (Trout and Schmidt, 1984; Hamm, 1970), as well as due to the sorbate anion. It appears more likely that its effect may be due to the possible involvement of sorbate anions in various reactions with meat proteins and other components of the product (Sofos, 1985b). Additional studies, however, are needed to determine the mode for such action by sorbate.

As indicated earlier (Sofos, 1985b), the antimicrobial activity of sorbate is well documented (Sofos and Busta, 1981; Sofos et al., 1986; Lueck, 1976), while its influence in improving cooking yields of meat products was observed recently. The present study has verified the positive influence of potassium sorbate in reducing weight losses of meat products with certain salt levels. The results have also shown that sorbic acid did not reduce weight losses, because it causes a large reduction in meat emulsion pH. Potassium sorbate, however, improved the cooking yields and the shelf-life of the comminuted meat products examined. It, thus, appears that if sorbate is approved for direct use in meat products, it may be valuable in extending the shelf-life and improving cooking yields of low salt formulations. It should be noted, however, that in the absence of salt, sorbate was ineffective, and that its action was significant only at the 0.26% level.

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