EXTENSION OF REFRIGERATED SHELF LIFE AND INHIBITION OF PATHOGENIC BACTERIA IN FRESH AND VACUUM PACKAGED POULTRY BY SORBIC ACID AND POTASSIUM SORBATE

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INTRODUCTION

Spoilage due to microbial growth in freshly processed and vacuum packaged poultry is a concern of the industry. The initial contamination level greatly influences the refrigerated shelf life of these products (Arafa and Chen, 1977; Brune and Cunningham 1971). Reviews by Barnes (1976), Brune and Cunningham (1971), Mountney (1976), and Walker and Agres (1956) have stated the importance of Pseudomonas spp. in causing spoilage of aerobically stored poultry at refrigerated temperatures. The use of vacuum packaging has minimized the spoilage due to the growth of aerobic psychrotrophs (Clark and Lentz, 1969; Sander and Soo, 1978). However, refrigerated vacuum packaged meats are sucseptible to spoilage caused by microorganisms capable of anaerobic refrigerated growth such as lactobacilli and Enterobacter (Pierson et al., 1970; Newton and Gill, 1978). Pathogenic bacteria such as Salmonella spp. and Staphylococcus aureus, are also capable of growth in vacuum packaged poultry. The purpose of this paper is to review the applications of sorbic acid and potassium sorbate on fresh and vacuum packaged poultry for the purpose of extending refrigerated shelf life and suppressing the growth of pathogenic bacteria on these products.

DISCUSSION

The use of sorbic acid to preserve fresh poultry was first reported by Kaloyereas, et al. (1961). These authors found flaked ice containing sorbic acid and glycol diformate was effective for preserving fresh poultry. Perry et al. (1964) reported that a two step process of acid hydration and application of a 7.5% sorbic acid spray in a 70:20:10 propylene glycol, water and glycerine mixture at 71°C markedly retarded spoilage of fresh, dry packed poultry stored at 7°C. In that study, control poultry showed evidence of spoilage in 5 days while the treated poultry parts did not exhibit evidence of spoilage until 18 days of storage at 7°C. These authors also determined that sorbate treatment did not impair poultry flavor. There was also evidence that microorganisms were unable to develop a greater tolerance for sorbic acid. Perry et al. (1964) also stated that sorbic acid used alone had limited value due to its low water solubility.

The first use of water-soluble potassium sorbate to preserve fresh poultry was recently reported by our laboratory (Robach and Ivey, 1978). In this study, fresh poultry breasts were dipped in a solution containing either 0,2.5, 5.0 or 10% potassium sorbate for one minute. In addition to shelf life studies, another group of fresh chicken breasts was dipped in a suspension of three strains of Salmonella spp. prior to being dipped in one of the sorbate solutions. Determination of sorbate concentration was performed at all 4 dip levels. The 2.5% dip left an average residue of 0.05% sorbic acid, the 5% dip left 0.13% sorbic acid and the residue of the 10% dip was 0.32% sorbic acid. Inhibition data indicates that the use of a potassium sorbate dip significantly reduced the total number of viable bacteria as related to the control parts after 4 and 8 days of 6°C storage. The use of a 5 or 10% sorbate dip significantly reduced the number of viable Salmonella when compared to the controls throughout a 7 day storage at 10°C.

A related study at Kansas State University reported on the use of a potassium sorbate dip on fresh chicken drumsticks, thighs and breasts (Cunningham, 1979). In this study, the use of 10% sorbate dip for 30 seconds doubled the shelf life of drumsticks held at 4°C over the control shelf life. The results obtained are depicted in Table 1.

Table 1:

Shelf-life of Drumsticks at 4°C	
% sorbate dip	Day off odor detected
0	10 ± 0.5
2.5	13 ± 0.5
5.0	14 ± 0.5
7.5	16 ± 0.5
10.0	20 ± 0.5

Additional studies using breasts and thighs indicated that parts dipped for 30 seconds in sorbate solutions, drained, and then baked had similar tendencies scores (Shear Press) and moisture retention scores (Carver Press) regardless of the concentration of the sorbate dip. Sensory data indicates tast panel members could not distinguish between those parts dipped in 5 or 10% sorbate and those dipped in distilled water. Parts dipped in a 15% solution were scored lower than the controls in all four (flavor, tenderness, juiciness, and acceptability) sensory categories.

Table 2:

% sorbate dip	Sensory Evaluation Scores			
	Flavor	Tenderness	Juiciness	Acceptability
0	6.21a	6.10a	6.25a	6.10a
5	6.20a	6.15a	6.20a	6.15a
10	6.10a	6.10a	6.15a	6.10a
15	5.00b	5.22b	5.18b	5.21b

[a]Scores with different letters in the same column differ significantly at p>0.01

Based on the results of the two previous laboratory studies using broiler parts, our laboratory undertook a plant scale study. We went into a processing plant in Maryland to evaluate the use of a 5% potassium sorbate dip to extend refrigerated shelf life of whole ice packed broilers (Robach, 1979). We determined that a 5% sorbate dip for 30 seconds left an average residue of 0.12% sorbic acid based on the weight of the carcass. In this study we monitored the psychrotrophic plate count and the Pseudomonas count on the outside of the carcass (breast swab) and inside the cavity (cavity swab). The effect of 5% sorbate dip on the total psychrotrophic count of whole broiler stored at 3°C indicated a doubling of refrigerated shelf life. Spoilage odors were noted on the control birds at 10 days, when the counts approached 10^7cells/cm_2. Off odors from the sorbate treated birds were not noticed until the 19th day of 3°C storage. Members of the genus Pseudomonas were the predominant bacteria present at the time of spoilage in both the sorbate treated and the control broilers.

In order to more fully study the effects of a 5% sorbate dip on fresh poultry, two additional plant trials in Georgia and Mississippi were run by our laboratory (To and Robach, 1980a). In these tests, the refrigerated shelf life of ice packed broilers with and without sorbate treatment was studied. In addition, broilers were also inoculated with Staphylococcus aureus and Salmonella to determine the efficacy of a 5% sorbate dip on the control of these two important food poisoning bacteria. The use of a 5% sorbate dip extended the refrigerated shelf life of ice packed broilers from 7 days for the controls to 14 or 15 days in both plant studies. These data confirmed all the earlier data from our laboratory and others. The 5% sorbate dip also markedly suppressed the growth of Salmonella inocuulated onto the surface of the broilers. Sorbate also effectively suppressed the growth of S. aureus on fresh broilers. These data indicate that a 5% sorbate dip not only can extend broiler shelf life but also can control the growth of Salmonella and S. aureus.

The use of vacuum packaging poultry products to supress the to supress the growth of Pseudonomonas and related psychrotrophic spoilage bacteria has only recently been reported (Arafa and Chen, 1975, Sander and Soo, 1978; Bailey et al., 1979). Based on our earlier work with fresh poultry and the work of Pierson et al., (1979) using sorbate in vacuum packaged bacon we ran a cooperative study with Louis-Rich, Inc., a large processed turkey manufacturer (Robach et al., 1980b). In this study we evaluated the effect of 0.20% sorbic acid on the refrigerated shelf life of two vacuum packaged cooked turkey products. One was a skin-on natural breast muscle product and the other a turkey breast sliced luncheon meat product containing coarsely ground breast meat. Preliminary studies at 10°C indicated that 0.2% sorbic acid was an effective use level in both the breast and luncheon meat products. We then employed plant production and distribution procedures to run our refrigerated shelf life studies. Sorbate reduced the psychrotrophic counts of the sliced turkey luncheon meat stored at 4°C. The controls developed a putrid off odor after 21 days of storage. No off odors in the sorbate samples were detected throughout the 56 day storage period. Some pink color formation was noticed after 28 days of storage. Sorbate also effectively extended the shelf life of the whole breast product. Off odors first appeared from the control products at 21 days whereas the sorbate product did not exhibit any off odors throughout the 56 day storage at 4°C. Louis-Rich, Inc. conducted sensory evaluation data using triangular comparison tests. These data indicated that there were no significant differences between the control and sorbate treated products. This study indicates that the use of at least 0.1% sorbate can depress microbial growth and delay odor formation in vacuum packaged poultry stored at 4°C.

In a related study, the effect of sorbate on the growth of enteropathogenic Escherchia coli, Salmonella, and S. aureus was studied using vacuum packed, cooked turkey products (To and Robach, 1980b). The products were processed at Louis-Rich, Inc. at the same time the shelf life products were processed. The turkey products were inoculated with the appropriate bacterial cultures, vacuum packaged and stored at 15°C for 10 days. The results show the inhibition of Salmonella, S. aureus and E. coli on vacuum packed, sliced, turkey luncheon meat by sorbic acid was significant. Control samples inoculated with either Salmonella of E. coli gave off odors after 6 days of storage when the counts were approaching 10^9 cells/g. After 8 days of storage these samples had a distinct spoilage odor. The samples inoculated with S. aureus lost their firm texture after 8 days storage when the counts reached 10^8 cells/g. In contrast, the sorbate treated product effectively inhibited the growth of all three pathogens throughout the 10 day storage at 15°C. None of the packages in the sorbate treated lots exhibited off odors in the 10 day test.

Potassium sorbate was also effective on pathogen growth in vacuum packaged turkey breasts. As in the sliced control product, Salmonella and E. coli grew rapidly on the control breasts and reached a maximum of 10 cells/cm^2 in 6 days. In addition to an off odor, on day 8 a pink color developed on the meat surface not covered by skin. Staphylococcus aureus did not grow well on the breast product, only increasing 2 log cycles in 10 days. The use of 0.26% sorbate effectively stopped growth of Salmonella and S. aureus through the 10 day storage period. There was a 2-3 log cycle increase in E. coli numbers after 6 days of 15°C. however, final levels were 3.5 log cycles below those of the controls.

SUMMARY

The results of all the laboragory studies and plant studies indicate that the use of sorbates in fresh and vacuum pakced, cooked poultry can not only markedly extend the refrigerated shelf life of these products, but also it can inhibit the growth of potential food poisoning bacteria. By improving the microbial quality of the product, the processor is giving his consumer the benefit of a better quality, longer lasting product.

REFERENCES

1. Arafa, A.S. and Chen, T.C., 1975. Effect of vacuum packaging on cut-up chickens and in chicken products. J. Food Sci. 40:50.

2. Arafa, A.S. and Chen, T.C., 1977. Characteristics of microorganisms associated with hot-packaged, washed and immersion chilled broilers. Poultry Sci. 56:918.

3. Bailey, J.S., Reagan, J.D., Carpenter, J.A., Schuler, G.A. and Thompson, J.E., 1979. Types of bacteria and shelf life of evacuated carbon dioxide-injected broilers and ice-paced broilers. J. Food Prot. 42:218.

4. Barnes, E.M., 1976. Microbiological problems of poultry at refrigerator temperatures. A review. J. Sci. Fd. Agri., 27:777.

5. Brune, H.E. and Cunningham, F.E., 1971. A review of microbiological aspects of poultry processing. World's Poultry Sci. J. 27:223.

6. Clark, C.S. and Lentz, C.P., 1969. The effect of carbon dioxide on the growth of slime producing bacteria on fresh beef. Can Inst. Food Technol. J. 2:72.

8. Kaloyereas, S., Crown, R.M. and McClesky, C.S., 1961. Experiments on preservation with a new ice-containing glycol diformate and sorbic acid. Food Technol. 15:361.

9. Mountney, G. J., 1976. Poultry products technology (2nd Ed.). Avi Publishing Co., Westport, Ct. 369p.

10. Newton, K.G. and Gill, C.O., 1978. The development of the anaerobic spoilage flora of meat stored at chill temperature. 44:91.

11. Perry, G.A., Lawrence, R.L. and Melnik, D., 1964. Extension of shelf-life of poultry by processing with sorbic acid. Food Technol 18:101-107.

12. Pierson, M.D., Collins-Thompson, D.L. and Ordal, Z.J., 1970. Microbiological, sensory, and pigment changes of aerobically and anaerobically packaged beef. Food Technol. 24:1171.

13. Pierson. M.D., Smoot, L.A. and Stern, N.J., 1979. Effect of potassium sorbate on growth of Staphylococcus aureus in bacon. J. Food Prot. 41:284.

14. Robach, M.C., 1979 Extension of shelf life of fresh, whole broilers using a potassium sorbate dip. J. Food Prot. 42:855.

15. Robach, M.C. and Ivey, F.J., 1978. Antimicrobial efficacy of a potassium sorbate dip on freshly processed poultry. J. Food Prot. 41:284.

16. Robach, M.C. To, E.C., Meydav, S. and Cook, C.F., 1980. Effect of sorbates on microbiological growth in cooked turkey products. J. Food Sci. 45:638.

17. Sander, E.H. and Soo, H.M., 1978. Increasing shelf life by carbon dioxide treatment and low temperature storage of bulk pack fresh chickens packaged in mylon/surlyn film. J. Food Sci. 43:1519.

18. To, E.C. and Robach, M.C., 1980a). Potassium sorbate dip as a method of extending shelf life and inhibiting the growth of Salmonella and Staphylococcus aureus on fresh, whole broilers. Poultry Sci. 59:726.

19. To, E.C. and Robach, M.C., 1980b). Inhibitor of potential food poisoning microorganisms by sorbic acid in cooked, uncured, vacuum packaged turkey products. J. Food Technol. (in press).

20. Walker, H.W. and Ayers, J.C., 1956. Incidence and kinds of organisms associated with commercially dressed poultry. Appl. Microbial. 12:492.