ANTIMICROBIAL EFFECTS OF LIQUID SMOKES IN MECHANICALLY DEBONED TURKEY MEAT

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SUMMARY

Liquid smoke preparations from ether extracts of smoke condensates from 20 different woods were screened for antimicrobial activity in culture media. The most (i.e. birch, Douglas fir sap and hickory) and least (i.e. mesquite) inhibitory liquid smokes were tested in raw patties of mechanically deboned turkey meat (MDTM) against growth of total aerobes, enterobacteriaceae, lactics and pseudomonads during aerobic storage at 4°C. Initial product pH was in the range of 6.33 to 6.57. The control treatment had the highest pH, while liquid smoke addition to MDTM caused slight decreases in pH. Product pH increased during storage reflecting increases in microbial growth. Generation times ranged from 0.38 days for controls to 1.70 days for product treated with birch liquid smoke. They were also variable with types of microorganisms. Ether extracts from liquid smoke condensates of birch, hickory and Douglas fir sap in decreasing order, were more inhibitory against bacterial growth in MDTM than mesquite derived liquid smoke.

INTRODUCTION

Certain studies have indicated inhibition of microbial growth with liquid smoke, while others found liquid smoke ineffective (Erdman et al. 1954; Eklund et al. 1982). Liquid smoke, has been antimicrobial in fermented and other sausages. The antimicrobial activity of smoke condensates may vary depending on type of food, microorganisms, wood, conditions of smoke generation, extent of liquid smoke refinement, amount of liquid smoke used, product pH, and other chemicals added to the food.

Studies in our laboratory have generated liquid smoke condensates from several woods and spices and tested the chemical, flavoring and antimicrobial properties of their extracts (Maga 1986; Maga and Fapojuwo 1986; Sofos and Maga 1988; Boyle et al. 1988). Some of these studies have screened for antimicrobial activity of ether extracts of smoke condensates in culture media against various microorganisms. The most inhibitory ether extracts were obtained from liquid smokes derived from the sap of Douglas fir and birch woods, while mesquite derived extracts have consistently shown no antimicrobial activity at similar pH values and concentrations.

This study examined the activity of ether extracts from liquid smokes on growth of various microorganisms in aerobically packaged and refrigerated patties of mechanically deboned turkey meat.

EXPERIMENTAL METHODS

Batches (500 g) of mechanically deboned turkey mt,t (MDTM) were mixed with 1% (5 g) salt (sodium chloride) and 20 ml of ether extract of liquid smoke (0.2%) + 30 ml of distilled water in a Kitchen Aid mixer at low speed for two minutes. Meat patties (30 g) were then formed and packaged in a retail-type, tray-pack consisting of a styrofoam tray overwrapped with permeable, all purpose food film. The packages were stored at 4°C and subjected to intermittent lighting to simulate retail display conditions.

At time intervals samples were analyzed for pH and numbers of enterobacteriaceae (VRB agar, 30°C, 24hr), pseudomonads (BHI agar + antibiotics, 20°C, 48 hr), lactics (MRS agar anaerobically, 20°C, 48 hr) and total aerobes (pc agar, 20°C, 48 hr).

The study consisted of five treatments, including a control and four types of liquid smoke ether extracts derived from birch, Douglas fir sap, hickory and mesquite wood samples.

The liquid smokes were generated in the laboratory by combustion of wood samples in an all-glass laboratory generator consisting of a two-holed, 500 ml round bottom flask (Maga 1986; Maga and Fapojuwo 1986).

The microbial growth curves determined were used to estimate generation times and lag phase of each group of microorganisms examined (Rosenow and Marth 1987). The study was replicated twice, and data on generation time and lag phase were analyzed by analysis of variance and Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Growth of microorganisms in MDTM during storage at 4°C is presented in Figures 1-4. The total aerobic plate counts (Fig.1) for control (non-liquid smoke) samples

Table 1. Influence of liquid smokes (0.2%) on the lag time (days) of various microorganisms during storage of mechanically deboned turkey meat at 4°C.

Liquid Smoke	Total aerobes	Pseudo-monads	Lactics	Entero-bacteriaceae
Control	2^b	2^b	2^b	$<2^c$
Mesquite	2^b	2^b	2^b	$<2^c$
Hickory	4^a	4^a	2^b	2^b
Douglas fir sap	4^a	4^a	4^a	2^b
Birch	4^a	4^a	4^a	4^a

Means (two replicates) in the same column with different superscript letters are significantly different (P<0.05).

Table 2. Influence of liquid smokes (0.2%) on the generation time $(days)^{-1}$ of various microorganisms during storage of mechanically deboned turkey meat at 4°C.

Liquid smoke	Total aerobes	Pseudo-monads	Lactics	Entero-bacteriaceae
Control	0.50^b	0.38^b	0.84^b	0.83^{bc}
Mesquite	0.50^b	0.55^{ab}	0.81^{bc}	0.83^{bc}
Hickory	0.63^a	0.57^a	0.92^{ab}	1.01^b
Douglas fir sap	0.50^b	0.55^{ab}	0.67^c	0.76^c
Birch	0.69^a	0.70^a	1.04^a	1.70^a

Means (two replicates) in the same column with different superscript letters are significantly different (P<0.05).

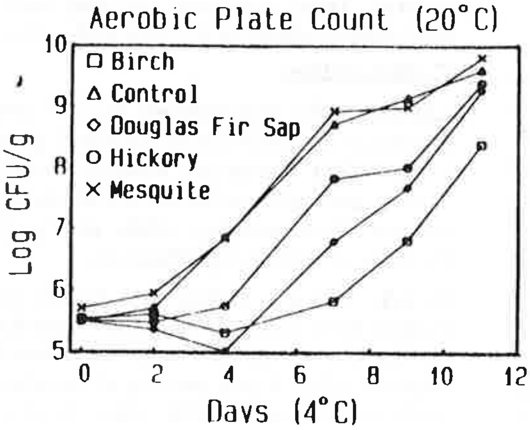

Fig. 1. Total aerobic plate counts in mechanically deboned turkey meat.

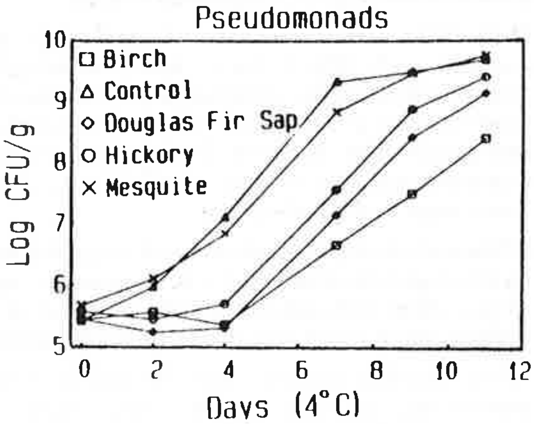

Fig. 2. Pseudomonads counts in mechanically deboned turkey meat.

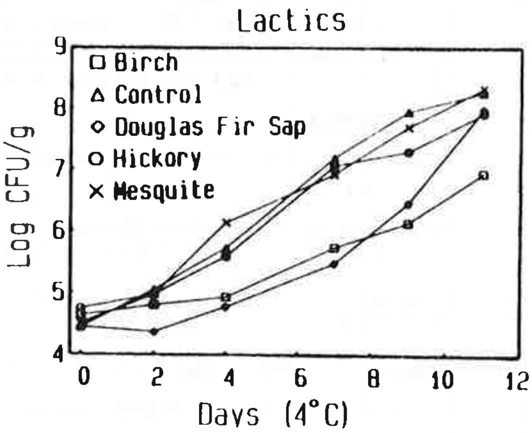

Fig. 3. Lactic acid producing bacterial counts in mechanically deboned turkey.

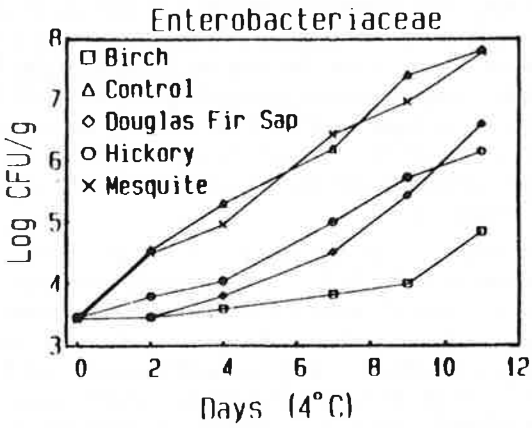

Fig. 4. Enterobacteriaceae counts in mechanically deboned turkey meat.

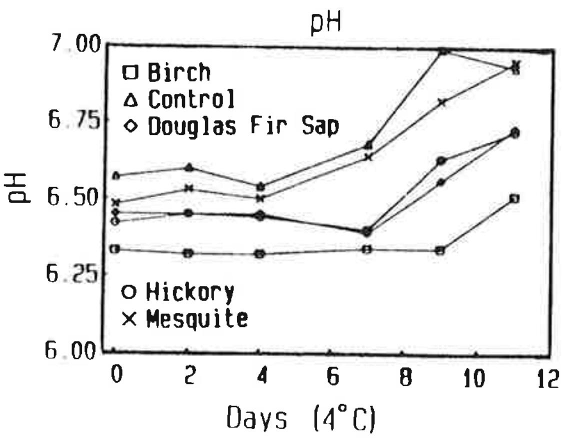

Fig. 5. Changes in pH of mechanically deboned turkey meat.

exceeded the level of 10^8 colony forming units (CFU) per gram in seven days of refrigerated storage.

Most of the aerobic bacteria belonged to the group of pseudomonads (Fig.2). Lactic acid producing bacteria (Fig.3) and enterobacteriaceae (Fig.4) counts showed a slower rate of increase due to the aerobic environment and the pH of the products. Their counts in the control treatment exceeded the level of 10^8 CFU/g, or were still lower, after 11 days of storage.

Of the various liquid smokes tested, mesquite wood had no effect on microbial growth. In its presence, growth of all types of microorganisms tested was almost identical to control samples formulated without liquid smoke.

Of the other liquid smokes, hickory showed antimicrobial activity against total aerobic plate counts (Fig.1), pseudomonads (Fig.2) and enterobacteriaceae (Fig.4), but had no effect against lactics (Fig.3). In contrast, birch and Douglas fir sap were inhibitory against all microorganisms tested.

Changes in product pH during storage (Fig.5) reflected the rate of microbial growth, since control and mesquite treated patties exceeded the pH value of 6.5 within seven days of storage, while, hickory, birch and Douglas fir sap treated samples did not exceed the pH of 6.5 until 9 or 11 days of storage at 4°C. The relative antimicrobial activities of the various liquid smokes are also demonstrated by the lag and generation times presented in Tables 1 and 2.

The extent of the lag phase and the generation times demonstrate the lack of antimicrobial effectiveness of mesquite liquid smoke. Of the other liquid smokes birch appeared to be more effective against the various microorganisms than hickory and Douglas fir sap. Liquid smoke from Douglas fir sap was more effective in extending the lag phase than the generation time (Tables 1 and 2). Actually Douglas fir sap was less inhibitory than hickory and birch. Studies with culture media indicated that Douglas fir sap liquid smoke was the most inhibitory of twenty different woods tested (Boyle et al. 1988). In this study, however, product containing liquid smoke from birch wood had a lower pH (6.33) than products with hickory (6.42) and Douglas fir sap (6.45) liquid smokes. Thus, this lower pH may have contributed to birch liquid smoke being detected as the most inhibitory.

CONCLUSION

Liquid smoke preparations used in poultry meat may contribute to inhibition of microbial growth and product preservation. Variations, however, exist in antimicrobial activity among liquid smokes, with mesquite showing no antimicrobial activity, while others (birch, hickory, Douglas fir sap) being inhibitory.

Results of such studies may be useful in developing poultry meat sausages and other products of improved quality, flavour and shelf-life. Additional studies should evaluate other liquid smokes at varying concentrations; study combinations with other food ingredients; test activity against various other microorganisms; and, determine smoke fractions responsible for microbial inhibition and flavoring effects.

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