# EFFECT OF SPICES AND SALT ON FERMENTATION OF LEBANON BOLOGNA-TYPE SAUSAGE

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## ABSTRACT

Spices and different concentrations of NaCl added to sausage mixtures are shown to affect the course of fermentation during manufacture of Lebanon bologna. A mixture of nine spices used in Lebanon bologna formulation enhanced fermentation of these sausages. Sterile or nonsterile spices enhanced fermentation to the same extent. Similar stimulatory effects of spice were observed when sausages were prepared by natural flora fermentation or by addition of starter culture (a mixture of *Pediococcus cerevisiae* and *Lactobacillus plantarum*). Increasing concentrations of NaCl from 1 to 7% resulted in an inhibition of fermentation with an attendant decrease in lactic acid production. Use of less than 2% NaCl resulted in poor texture in the sausage. Sausages containing 7% NaCl showed very little fermentation in the absence of spices and showed enhanced fermentation when spices were added. From the standpoint of fermentation, texture, color and palatability, sausages containing 2 and 3% NaCl were the best. Generally, formation of cured meat pigment, using either nitrite or nitrate, and texture of the sausages were related to the degree of fermentation attained during processing.


## INTRODUCTION

ALTHOUGH FERMENTED SAUSAGES, such as Lebanon bologna, summer sausage, and pepperoni, represent a significant portion of the variety of meat products available to the consumer, the significance of the various factors important to their production has not been completely elucidated. In order to develop a better understanding of these factors, we studied the effects of the nonmeat ingredients on the fermentation process and final product quality.

Spices and salt play important roles in sausage production besides their obvious function as flavor components. Since ancient times, both have been regarded as food preservatives. Antioxidant properties of spices have been reported, and a number of spices have been found to be effective in retarding rancidity during frozen storage of ground pork and beef (Dubois and Tressler, 1943), ground pork (Chipault et al., 1956), and pork sausage (Atkinson et al., 1947). Antimicrobial activity of spices has been demonstrated (Fabian et al., 1939; Corran and Edgar, 1933; Webb and Tanner, 1945; Dold and Knapp, 1948; Bullerman, 1974; Beuchat, 1976). The responses of different microorganisms to a given spice varied considerably, with cloves, cinnamon, and mustard having the most inhibitory effect on a variety of microorganisms.

Salt is the most common and the most important nonmeat ingredient of sausage. Its functions include flavoring, preservation, and production of the proper texture by solubilization of meat proteins. The tolerance of different species of microorganisms toward salt varies over a wide range of concentrations. Some microorganisms are inhibited by salt concentrations of less than 1%, while others can grow in saturated brines. Lactic acid producing bacteria, important in fermented foods, are reported to be fairly tolerant of salt and some are even stimulated by low concentrations (Irvine and Price, 1961).

Lebanon bologna, a fermented heavily smoked and spiced all-beef sausage originally produced in the Lebanon Valley area of Pennsylvania, was chosen as a model system for the study of fermentation processes in meat. In the traditional method of Lebanon bologna manufacture using nitrate as the curing agent, fermentation is produced by natural microflora present in ground meat. Some manufacturers are now using lactic acid starter cultures to achieve fermentation with nitrate and/or nitrite for curing.

The preparation of Lebanon bologna (Palumbo et al., 1973), the microbiology of the process (Smith and Palumbo, 1973), and the role of nitrite and nitrate in fermentation and cured meat color formation in Lebanon bologna (Zaika et al., 1976) have been reported. We now report the effect of salt and spices on the course of fermentation of Lebanon bologna prepared with a commercial starter culture containing *Lactobacillus plantarum* and *Pedicoccus cerevisiae*.

## EXPERIMENTAL

### Preparation of Lebanon Bologna

The sausages were prepared essentially as described by Palumbo et al. (1973).

**Spices.** The spice mixture used in the sausage formulation was prepared from commercially available spices (referred to as regular spices) according to the following concentrations:

| | |
|---|---|
| black pepper | 25.0g |
| nutmeg | 12.5g |
| allspice | 12.5g |
| red pepper | 6.2g |
| cloves | 6.2g |
| cinnamon | 6.2g |
| ginger | 6.2g |
| mustard | 6.2g |
| mace | 0.2g |

A similar mixture was prepared using purified spices (Griffith Laboratories, Inc., Union, NJ). Total aerobic plate counts were determined on APT agar (Difco) incubated 3 days at 25°C. The count was $10^4$/g for the regular spice mixture and less than 100/g for the purified spice mixture.

**Starter culture method.** Beef was ground through a 3/32 in. plate and divided into 2-kg batches. The sausages were prepared according to the formulation given in Table 1. All sausages were prepared with the addition of 2% glucose and 2% sucrose. Starter culture (Lactacel MC, Merck and Co., Inc., Rahway, NJ) containing both *Lactobacillus plantarum* and *Pediococcus cervisiae* was added at a level of 0.1%.

**Natural microflora method.** Beef ground through a 3/4-in. plate was mixed with 3% NaCl, aged for 10 days at 5°C, and then ground through a 3/32-in. plate. The aged meat was divided into 2-kg batches and mixed with 2% glucose, 2% sucrose, 200 ppm $NaNO_3$, and 0.8% spice mixture (if used).

**Processing of sausages.** In order to facilitate analysis, the sausage mixtures were stuffed into 55 mm moisture impermeable fibrous casings (Union Carbide Co.) and the sausages were incubated for 4 days at 35°C.

### Analytical methods

Determination of pH, titratable acidity (expressed as percent lactic acid), cured meat pigment, and nitrite concentration during 4 days of fermentation of the sausages was carried out as described previously (Zaika et al., 1976).

Evaluation of the flavor, texture and firmness of the sausages was carried our informally by experienced laboratory personnel by comparison with sausages prepared by the formulation developed by Palumbo et al. (1973) in our laboratory.

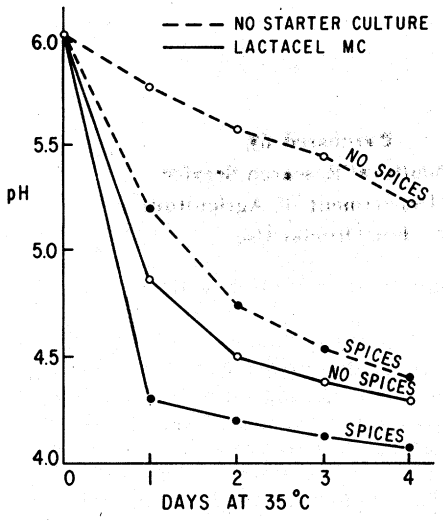


*Fig. 1—Effect of spices on changes in pH during fermentation of Lebanon bologna prepared with and without starter culture (sausage Series A).*

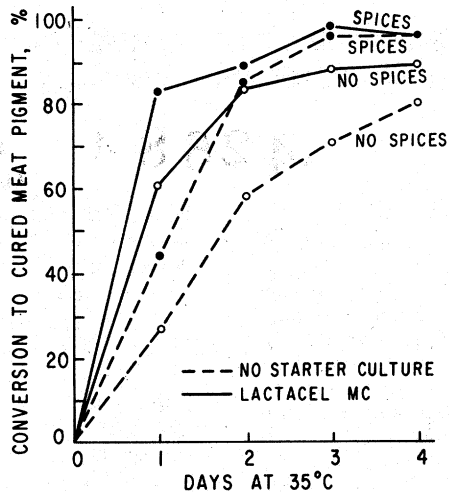


*Fig. 2—Effect of spices on formation of cured meat pigment during fermentation of Lebanon bologna prepared with and without starter culture (sausage Series A).*

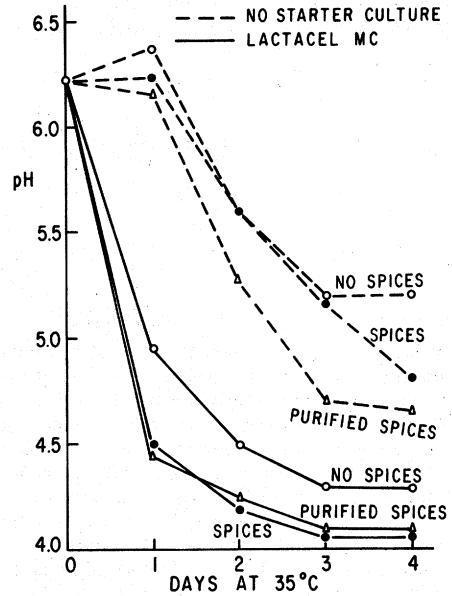


*Fig 3—Effect of regular and purified spices on changes in pH during fermentation of Lebanon bologna prepared with and without starter culture (sausage Series B).*

## RESULTS & DISCUSSION

THE CHARACTERISTIC FLAVOR of a given type of sausage depends to a large extent on the spices used in its formulation. Our spice formulation consists of nine spices: black pepper, nutmeg, allspice, red pepper, cloves, cinnamon, ginger, mustard and mace. In our previous research on Lebanon bologna, we noticed that when spices were omitted from the sausage formulation, less fermentation was obtained, even with the use of starter culture, than in sausages containing spices. To investigate the effect of spices on fermentation, sausages (Series A, Table 1) were prepared from fresh meat with or without the addition of the spice mixture and starter culture, Lactacel MC. The results are shown in Figures 1 and 2. In sausages from which both the spice mixture and the starter culture were omitted, there was little fermentation (Fig. 1). The pH decreased from 6.0 to only 5.2 after 4 days at 35°C. With spices alone, the decrease in pH was almost as large as with starter culture alone. Addition of both spices and starter culture to the sausage mixture resulted in very rapid fermentation and the lowest final pH of 4.1.

In these sausages, as well as in those from other experiments, the development of cured meat pigment paralleled the production of acid. The most rapid formation of cured meat pigment was in sausages containing both spices and starter culture (Fig. 2). Series A sausages were prepared with 1000 ppm $NaNO_3$ as the curing agent; however, similar results were obtained with sausages prepared with 78 ppm $NaNO_2$ instead of $NaNO_3$. We have previously reported (Zaika et al., 1976) that satisfactory Lebanon bologna with good cured meat color can be prepared using nitrite alone.

Since spices are known to be heavily contaminated with micro-organisms, the possibility that these may contribute to fermentation of Lebanon bologna was investigated. Sausages (Series B, Table 1) were prepared without spices, with regular spices and with purified spices either with or without the addition of starter culture. Microbiological analysis of the purified spice mixture indicated that the total bacterial count was less than 100/g compared to a count of approximately $10^4$/g for the regular spice mixture. Changes in pH during the fermentation of these sausages are shown in Figure 3. These results suggest that the enhanced fermentation in the spice-containing sausages, both in the presence and in the absence of starter culture, was not due to microbial contaminants in spices, since the regular and the purified spices behaved similarly. In an experiment using starter culture, regular spices sterilized by autoclaving gave the same enhancement of fermentation as did unsterilized spices.

*Table 1—Formulation of sausages prepared by the starter culture method*

| Sausage series | NaCl (%) | $NaNO_2$ (ppm) | $NaNO_3$ (ppm) | Spices (%) | Lactacel MC (%) |
|---|---|---|---|---|---|
| A | 3 | – | 1000 | 0 or 0.8[a] | 0 or 0.1 |
| B | 3 | – | 200 | 0 or 0.8[a,b] | 0 or 0.1 |
| C | 3 | 78 | – | 0–1.6[b] | 0.1 |
| D | 0-4 | 78 | – | – | 0.1 |
| E | 3-7 | 78 | – | 0 or 0.8[b] | 0.1 |

[a] Regular commercial spices
[b] Purified spices

The effect of spices in Lebanon bologna prepared by the traditional method, which involves fermentation by microflora naturally present in ground meat, was also investigated. Sausages were prepared by the natural flora fermentation method with regular spices, purified spices, or without spices. As in the previous example with starter culture, the results of this experiment (Fig. 4) show that purified spices gave the same enhancement of fermentation as did the regular spices. Development of cured meat color during fermentation of sausages by natural microflora is shown in Figure 5, which is a composite of several experiments. In each case 200 ppm $NaNO_3$ was used as the curing agent. Conversion to cured meat pigment was better and proceeded at a faster rate in spice-con-

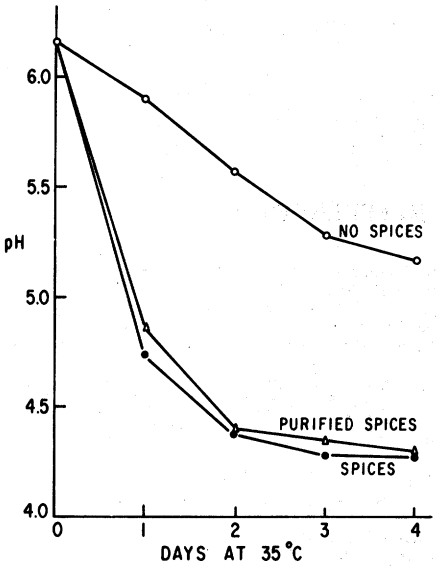


*Fig 4—Effect of regular and purified spices on changes in pH during fermentation of Lebanon bologna by natural flora.*

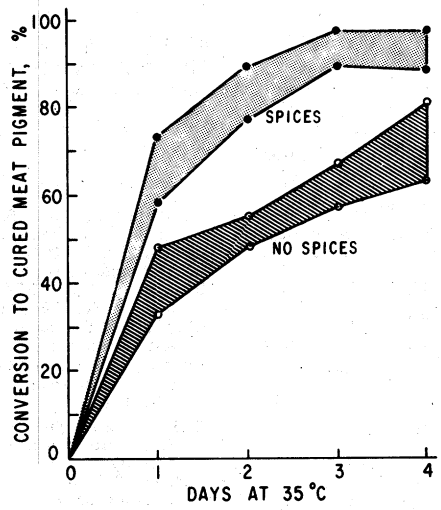


*Fig. 5—Effect of spices on formation of cured meat pigment during natural flora fermentation of Lebanon bologna in presence of 200 ppm added $NaNO_3$.*

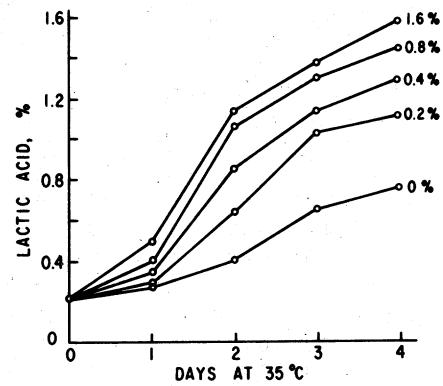


*Fig. 6—Effect of spice concentration on production of lactic acid during fermentation of Lebanon bologna (sausage Series C).*

taining sausages than in sausages prepared without spices. Generally, an acceptable cured meat color was produced in sausages without spices after 4 days of fermentation.

Although we are unable to offer a satifactory explanation for the stimulatory effect that spices have on fermentation of Lebanon bologna, all our experiments suggest that some chemical constituent of one or more of the spices used in our formulation may be involved. Previously, Corran and Edgar (1933) suggested that black pepper contains a yeast stimulant. Wright et al. (1954) showed that a number of spices at low levels, namely caraway, cardamon, cinnamon, ginger, mace, nutmeg and thyme, exhibited marked promoting effects on gas production in yeast-sugar suspensions, as well as in more complex media.

Although the amount of spice mixture normally used in our sausage formulation is 0.8%, the effect of spice concentration of 0–1.6% on titratable acidity was examined (sausage Series C, Table 1). Titratable acidity, expressed as % lactic acid, increased with increasing spice concentration, the greatest increase in acidity was produced by the first increment of spices used (Fig. 6).

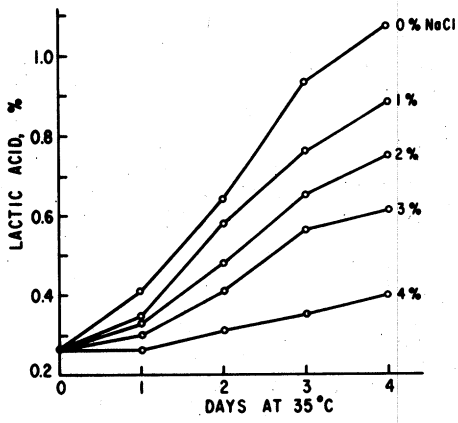


*Fig. 7—Effect of NaCl concentration on production of lactic acid during fermentation of Lebanon bologna prepared with starter culture but without spices (sausage Series D).*

Some aspects of the effect of salt on the preparation of Lebanon bologna by the natural microflora method have been reported previously (Palumbo et al., 1973; Smith and Palumbo, 1973). We conducted experiments to study the effect of salt on fermentation using the starter culture organisms *Lactobacillus plantarum* and *Pediococcus cerevisiae*. *P. cerevisiae* apparently grows well in solutions containing up to 5.5% salt and poorly in concentrations of salt up to 10% (Frazier, 1958). *L. plantarum* was reported to grow in soy sauce containing 10% NaCl (Yoshii and Kato, 1966). Sausages (Series D, Table 1) were prepared with 0, 1, 2, 3 and 4% NaCl, using Lactacel MC starter culture but no spices. Figure 7 shows the changes in titratable acidity during 4 days of fermentation of these sausages. Increased amounts of NaCl inhibited fermentation and decreased lactic acid production. Using 78 ppm $NaNO_2$, conversion to cured meat pigment was 85% or better in sausages containing up to 3% NaCl; in sausages containing 4% NaCl, it was only 70%, accompanied by a slower disappearance of $NaNO_2$.

A certain amount of NaCl is necessary for the production of sausage having the proper texture. Sausages containing 2–4% NaCl and starter culture had a good firm texture. Use of less than 2% NaCl resulted in poor texture. From the standpoint of texture, flavor and fermentation, sausages containing 2 and 3% NaCl were the best.

To investigate the possibility that higher levels of NaCl may completely inhibit the activity of the starter culture, sausages (Series E, Table 1) were prepared containing 3, 5 and 7% NaCl. A mixture of the purified spices was added to some of the sausages to see whether or not the stimulatory effect of spices would counteract the inhibitory effect of higher levels of salt. The results of this experiment are summarized in Table 2.

There was very little fermentation in samples containing 5 and 7% NaCl in the absence of spices. With the added spices there was considerable increase in lactic acid production in sausages with 3 and 5% NaCl and a small increase in sausages with 7% NaCl.

In the Series E experiment, 78 ppm $NaNO_2$ was used as the curing agent. Conversion to cured meat pigment was good ($>$84%) in sausages containing 3% NaCl both in the presence and in the absence of spices. At the 5% NaCl level, either with or without spices, and at the 7% NaCl level with spices the color conversion was $\sim$70%. However, in sausages prepared

*Table 2—Effect of NaCl and spices on the properties of Lebanon bologna (sausage Series E) during fermentation at 35°C.*

| | | No spices | | | | Spices (0.8%, purified) | | | |
|---|---|---|---|---|---|---|---|---|---|
| NaCl | Days | pH | Lactic Acid, % | $NaNO_2$ ppm | Color % conversion | pH | Lactic acid, % | $NaNO_2$ ppm | Color % conversion |
| 3% | 0 | – | – | – | – | 6.06 | 0.18 | 49 | – |
| | 1 | 5.40 | 0.25 | 7 | 46 | 4.75 | 0.42 | 6 | 74 |
| | 2 | 4.80 | 0.43 | 7 | 70 | 4.15 | 1.03 | 2 | 81 |
| | 3 | 4.55 | 0.61 | 4 | 79 | 4.10 | 1.24 | 0 | 86 |
| | 4 | 4.44 | 0.75 | 4 | 84 | 4.06 | 1.39 | 2 | 88 |
| 5% | 0 | – | – | – | – | 6.05 | 0.18 | 49 | – |
| | 1 | 5.83 | 0.22 | 19 | 36 | 5.56 | 0.26 | 20 | 41 |
| | 2 | 5.30 | 0.29 | 11 | 54 | 4.63 | 0.50 | 5 | 73 |
| | 3 | 5.25 | 0.32 | 9 | 62 | 4.36 | 0.75 | 3 | 74 |
| | 4 | 4.92 | 0.42 | 8 | 72 | 4.24 | 0.98 | 2 | 73 |
| 7% | 0 | – | – | – | – | 6.05 | 0.18 | 51 | – |
| | 1 | 6.15 | 0.17 | 20 | 32 | 6.14 | 0.17 | 23 | 33 |
| | 2 | 5.80 | 0.23 | 15 | 40 | 5.73 | 0.23 | 16 | 38 |
| | 3 | 5.55 | 0.27 | 10 | 47 | 4.89 | 0.41 | 7 | 66 |
| | 4 | 5.40 | 0.30 | 10 | 56 | 4.64 | 0.54 | 6 | 69 |

with 7% NaCl without spices, color conversion was only 56%. From the standpoint of acid production, texture and color, sausages containing 5% NaCl were satisfactory. The use of 7% NaCl resulted in sausages of borderline acidity with pH values of 4.6–4.8. In our opinion, a fermented sausage should have a pH value of 4.7 or less to assure microbiological safety. Considerations of palatability, as well as potential adverse effects on the health of individuals with high blood pressure, make the use of 5 or 7% NaCl impractical for sausage preparation.

## SUMMARY

FERMENTATION of Lebanon bologna-type sausages containing from 1 to 7% NaCl was studied. Fermentation was inhibited by increasing amounts of NaCl. A mixture of nine spices exerted a stimulatroy effect on fermentation both by Lactacel MC starter culture and by natural microflora. Increased fermentation was not due to microbial contamination of spices.

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Ms received 4/16/77; revised 6/23/77; accepted 6/30/77.

Presented in part at the 36th Annual Meeting of the Institute of Food Technologists, Anaheim, CA, June 6-9, 1975.

The authors express their thanks to Merck and Co., Inc., Rahway, NJ., for their generous gift of starter culture, Lactacel MC; to Griffith Laboratories, Inc., Union, NJ., for generous samples of purified spices; and to Saadia Y. Upchurch for skilled technical assistance.

Reference to brand or firm names does not constitute endorsement by the U.S. Dept. of Agriculture over others of a similar nature not mentioned.