The Effects of Garlic, Coriander and Paprika on Microbiological and Sensory Characteristics of Beef Frankfurters

Rand A. Al-Assaf* and Basem M. Abdullah **

ABSTRACT

Nine different frankfurter formulations were prepared, involving garlic, coriander and paprika, used either singly or in combination. These included two controls, one with no added spices and the other with black and white pepper only, which were also present in all the experimental formulations. After cooking, the frankfurters were stored at 4°C for up to 48 days and tested at intervals to determine their microbial content as evaluated by Aerobic Plate Count (APC). Effects of storage on colour, flavour, juiciness and overall acceptability were also determined.

Results indicated that during storage, APC remained virtually static for the first 13-20 days before increasing by at least 6.0 log10 units by the 48th day. Not only did the added spices have no discernible effect on microbial growth in the sausages, but their contribution to the initial microbial load resulted in a shorter product shelf-life, when judged on microbiological basis.

Upon examination at the 21st day by the sensory panel, there were few significant differences between the product formulations. However, it was found that coriander and paprika together had an adverse effect on all four sensory characteristics and, when garlic was also present, panel scores were significantly lower (P < 0.05) for juiciness and overall acceptability. None of these effects were evident at the 7th day of storage.

Keywords: Frankfurter, Garlic, Coriander, Paprika, Microbiology, Sensory.

1. INTRODUCTION

Microbial growth during storage is one of the main factors affecting the quality of meat products, leading to spoilage and hence economic losses. However, such foods are also susceptible to off-flavour development as a result of chemical changes. To overcome these problems, there is a need for low-cost preservation systems that can provide both microbiological and chemical stability (Cheah and Gan, 2000).

While spices are currently added to foods simply as flavouring agents, many spices and their oils have been found to possess antimicrobial activity (Davidson et al., 1983). In paprika, the antimicrobial compound is capsaicin (Cowan, 1999), while that of garlic, which has been recognized for many years, is mainly allicin. This substance is absent from intact garlic, but is generated from a precursor, alliin, through enzymatic hydrolysis, when garlic tissue is damaged (Shim and Kyung, 1999). Various studies have demonstrated such antimicrobial activity (Shelef et al., 1980; Saleem and Al-Delaimy, 1982; Naganawa et al., 1996; Kumar and Berwal, 1998; Arora and Kaur, 1999; O’Gara et al., 2000; Ross et al., 2001; Yin et al., 2002; Yin and Cheng, 2003). Generally, spices are inhibitory to a range of aerobic bacteria, more specifically, garlic and onion were active against

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Clostridium botulinum, Bacillus subtilis, and Staphylococcus aureus, while pepper was shown to inhibit Escherichia coli in sausages (Huhtanen, 1980).

Flavour and colour are two critical quality criteria for meat products that affect both consumer acceptance and product shelf-life (Yu et al., 2002). Garlic products, in particular, have a number of applications, including the flavouring of soups, meats and salad dressings, and the preparation of garlic bread. Garlic powder is used commercially in the manufacture of sausages (Parry, 1969). Coriander seed and its extracts are also used in various kinds of sausage, especially bologna and wiener. Paprika has a bright red colour and an extremely mild flavour, it is widely employed as a colourant for items such as processed meats, snack foods, sauces, gravies and salad dressings (Tainter and Grenis, 1993).

The objectives of this study were to evaluate the effects of garlic, coriander and paprika on microbial populations and on the colour, flavour, juiciness and overall acceptability of beef frankfurters during chill storage.

2. MATERIALS AND METHODS

Preparation of Frankfurters

The formulations used were similar to those of previous studies (Resurreccion and Reynolds, 1990; Al-Shuibi and Al-Abdullah, 2002), and for each one, a 10 kg batch of material was prepared. The ingredients included Australian beef, ice-water (18.75%), potato starch (3%), soya protein (1.85%), sodium tripolyphosphate (0.6%), salt with nitrite (1.75%), sodium ascorbate (0.05%), white pepper (0.75%) and black pepper (0.25%). Fresh garlic, powdered coriander and powdered paprika were obtained from a local market and added at concentrations of 1%, 2% and 2%, respectively. Nine different formulations were prepared and, where required, the spices were added either singly or in combination. Two control formulations were also included, one with no added spices, and another containing only black and white pepper, which were also present in all the experimental batches. The nine formulations are shown in Table (1).

Handling the Raw Materials

The frankfurters were prepared at a local meat factory. Frozen beef flank meat was thawed for two hours, coarsely ground and then blended for three minutes in a bowl chopper. At this stage, the ice-water, phosphate, sodium ascorbate, and salt and nitrite were all added and the mixture was then chopped for another two minutes before adding the black and white pepper, garlic, coriander and paprika, as required. The material was chopped for a further two minutes. Finally, the soya protein and starch were incorporated, with chopping for three more minutes. After a total chopping time of 10 minutes, the temperature of the meat blend was 15°C. The material was then stuffed into cellulose casings, 10 cm long x 1.5 cm diameter, using a stuffer.

Cooking and Storage

Each batch of frankfurters was cooked in a steam oven as follows:
1. The frankfurters were heated to 55°C, which was achieved within 30 minutes.
2. The oven temperature was increased to 76°C and the frankfurters reached this temperature within two further hours. They were held at 76°C for five minutes.

After cooking, the frankfurters were removed from the oven and cooled to 20°C by spraying them with cold water. They were then transferred to a refrigerator for storage at 4°C in a normal atmosphere.

Determination of Moisture, Fat and Protein

Five samples were taken for analysis from each formulation. The methods of Berg and Kolar (1991) were used, involving an Infratech meat analyzer (Tecator 1265, Sweden).

Microbiological Analysis

For microbial counts, 10 grams of frankfurter representative sample were removed aseptically from each formulation and homogenized in 90 ml of 1.5% peptone water, using a stomacher. Then, serial ten-fold dilutions were prepared in peptone water, as required, and
the following counts were obtained according to Cook (1991):

**Aerobic Plate Count (APC):** This utilized Plate Count Agar (Lab M, UK) and the pour-plate method. Plates were incubated at 35°C for 48 hours. Counts were obtained at 0, 3 and 6 days, and then at approximately weekly intervals up to 48 days of storage.

**Enterobacteriaceae:** The medium was Violet-Red-Bile-Glucose Agar (Scharlau Chemie, Spain), used as pour-plates that were incubated at 37°C for 24 h. Typical isolates were confirmed by a fermentative reaction in a glucose medium and a negative oxidase test, as described by the ICMSF (1978). Tests were carried out after 28 days of storage to allow recovery of any heat-damaged cells. All analyses were carried out in triplicate.

**Sensory Evaluation**

From each formulation, 10 frankfurters were taken and cooked in an electric grill (Lider, Turkey) at approximately 90°C for 15 minutes. The cooked sausages were examined by 15 panellists chosen from the staff of the Department of Nutrition and Food Technology at the University of Jordan. The panellists were of both sexes and from different age groups. Each one was asked to taste the samples separately, without making any comparison, and evaluate them for colour, flavour, juiciness and overall acceptability, the last-mentioned being according to a nine-point hedonic scale (Larmond, 1991).

Samples were taken after seven and 21 days of storage and evaluated on each occasion in a single session involving virtually the same panellists. Between individual samples, the panellists were given portions of bread and water to neutralize the taste of the previous sample.

**Statistical Analysis**

Analysis of variance for a complete, randomized, split-plot design was used in designing this study. The experimental data were analyzed by means of the Statistical Analysis System (SAS) package. The significance of differences between mean values (P < 0.05) was determined with Duncan’s Multiple Range Test (Littell et al., 1991).

### 3. RESULTS AND DISCUSSION

**Moisture, Fat and Protein Content**

Results are shown in Table (1). The moisture content ranged from 42.1 to 47.0%, fat from 25.7 to 31.4% and protein from 12.3 to 15.0%. Frankfurters containing garlic and paprika showed significantly higher moisture content than the other formulations and a lower fat content. On the other hand, those with garlic and coriander or no spices at all had significantly less moisture and a higher fat content. Protein content was the highest for garlic alone and the lowest for the product containing all the spices. In all cases, the moisture and protein content were within the range specified in the Jordanian standards for emulsion-type sausages (JS 816 / 1996), i.e. a maximum of 65% for moisture and a minimum of 12% for protein. However, the fat content was higher than the specified maximum (25%).

**Microbiological Changes**

For most of the frankfurter formulations, strains of Enterobacteriaceae were not detected, and only in two cases, formulations B and F in Table (1), were levels of < 100 per gram were found (data not shown). Thus, the cooking process was marginally effective in eliminating these organisms and the results suggest that none of the raw materials used was highly contaminated.

The APCs over the storage period are presented in Fig (1) and are expressed as log$_{10}$ colony forming units (CFU) per gram of test material. The counts showed little difference initially between the formulations, except that the one without any spices was much less contaminated. It is clear, therefore, that the added spices contributed significantly to the microbial load of the processed frankfurters. Buckenhuskes (1997) reported APCs from ground, untreated paprika, coriander, white pepper, black pepper and garlic of $2.4 \times 10^5$, $1.3 \times 10^6$, $1.0 \times 10^7$, $6.1 \times 10^6$ and $5.0 \times 10^4$ per gram, respectively. Many of the
organisms present are known to be spore-forming bacteria, such as *Bacillus cereus* and *Clostridium perfringens* (Kneifel and Berger, 1994) and, being more heat-resistant than vegetative cells, the spores are unlikely to have been destroyed by the cooking process used in the present study.

During storage of the frankfurters, counts remained relatively static for the first 13-20 days, before increasing, by at least six log_{10} units, by the 48th day. The longest delay in growth was observed with frankfurters containing no added spices, indicating that the spices themselves had no discernible inhibitory effect on the microbial growth in the sausages.

Spices, usually, contain high levels of bacteria and often are treated with sterilizing agents to reduce bacterial loads (Hui, 1992; Vij *et al.*, 2006). When APCs exceeded 6.0 log_{10} CFU per gram, the microbiological condition of the product was considered unacceptable (Riettle *et al.*, 1991). In the absence of any spices, this occurred by the 34th day, while all the other formulations attained such a level by the 27th day. Again, the spices had no obvious inhibitory effect on the organisms present and, because of their contribution to the initial microbial load, the inclusion of spices in the different frankfurter formulations resulted in a shorter, rather than a longer, shelf-life. These findings are contrary to those of earlier works, referred to above (Kneifel and Berger, 1994; Riettle *et al.*, 1991) which was mainly concerned with the effects of different spices on bacterial cultures tested under laboratory conditions. Unlike the study of Huhtanen (1980), garlic had no effect on the microbial growth in the sausage formulations studied here.

**Sensory Evaluation**

Results of the sensory tests carried out on days 7 and 21 of storage are given in Table (2). The control formulation without any spices was omitted from the analysis, since it was considered to be at a disadvantage from the sensory viewpoint.

Samples taken at the 7th day showed no significant differences between the formulations for any of the sensory characteristics studied. On 21st day, however, coriander and paprika together had an adverse effect on product colour, flavour, juiciness and overall acceptability. When garlic was also present with these two spices, panel scores were significantly lower for juiciness and overall acceptability, but colour and flavour were unaffected. None of these effects appeared to be related to the content of moisture or fat (Table 1). Regarding flavour, Ahn *et al.* (2002) noted that relatively small differences between treatments could be difficult for panelists to detect, especially at high levels of ‘warmed-over’ flavour.

**4. CONCLUSIONS**

1. Storage of frankfurters at 4°C led to an increase in APC, but only after the 13th day in all cases.
2. None of the added spices had any practical antimicrobial effect.
3. The microbiological condition of the spices had a critical effect on the shelf-life of chill-stored frankfurters by reducing the time at which unacceptable counts were obtained. Therefore, only spices with the highest microbiological quality should be used in product manufacture.
4. The cooking process at 76°C should have been sufficient to avoid any hazard from the growth of pathogenic Enterobacteriaceae in the frankfurters, but would not eliminate spore-forming bacteria.
5. At 21st day, prior to extensive microbial growth, there were few differences between any of the formulations containing added spices with respect to sensory characteristics. Only formulations containing coriander and paprika together gave significantly lower sensory scores at this stage.
6. Because there was little difference in microbial levels or sensory scores between the spice formulations at 7th day, it is evident that any of them could be used commercially for sausages manufacture, provided that appropriate ‘best before’ limits are observed.
Table (1)
Moisture, fat and protein content of the frankfurters.

<table>
<thead>
<tr>
<th>Formulation*</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 (no spices)</td>
<td>42.6h</td>
<td>13.9b</td>
<td>31.4a</td>
</tr>
<tr>
<td>A2 (WP and BP)</td>
<td>46.1c</td>
<td>13.5c</td>
<td>27.9de</td>
</tr>
<tr>
<td>B (G)</td>
<td>45.0e</td>
<td>15.0a</td>
<td>28.5c</td>
</tr>
<tr>
<td>C (C)</td>
<td>45.6d</td>
<td>13.3d</td>
<td>27.6ef</td>
</tr>
<tr>
<td>D (P)</td>
<td>46.8b</td>
<td>12.6f</td>
<td>26.4g</td>
</tr>
<tr>
<td>E (G and C)</td>
<td>42.1i</td>
<td>13.3d</td>
<td>30.5b</td>
</tr>
<tr>
<td>F (G and P)</td>
<td>47.2a</td>
<td>13.2e</td>
<td>25.7h</td>
</tr>
<tr>
<td>G (C and P)</td>
<td>44.2f</td>
<td>12.6f</td>
<td>27.4f</td>
</tr>
<tr>
<td>H (G, C and P)</td>
<td>44.0g</td>
<td>12.3g</td>
<td>28.2cd</td>
</tr>
</tbody>
</table>

*WP: white pepper, BP: black pepper, G: garlic, C: coriander, P: paprika. All treatments except treatment A1 contained white and black pepper.
Each value is the mean of two determinations.
Means with the same letter in any given column are not significantly different (P≤0.05).

Table (2)
Effect of storage on the sensory characteristics of frankfurters.

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>Color Storage days</th>
<th>Flavor Storage days</th>
<th>Juiciness Storage days</th>
<th>Overall acceptability Storage days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>21</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>A2 (WP and BP)</td>
<td>7.07a</td>
<td>7.67a</td>
<td>6.87a</td>
<td>6.87a</td>
</tr>
<tr>
<td>B (G)</td>
<td>6.87a</td>
<td>7.47a</td>
<td>7.00a</td>
<td>7.20a</td>
</tr>
<tr>
<td>C (C)</td>
<td>6.93a</td>
<td>7.33a</td>
<td>6.93a</td>
<td>6.40a</td>
</tr>
<tr>
<td>D (P)</td>
<td>7.80a</td>
<td>7.73a</td>
<td>6.93a</td>
<td>7.20a</td>
</tr>
<tr>
<td>E (G and C)</td>
<td>6.93a</td>
<td>6.07a</td>
<td>6.60a</td>
<td>6.33a</td>
</tr>
<tr>
<td>F (G and P)</td>
<td>7.13a</td>
<td>7.27a</td>
<td>7.27a</td>
<td>7.27a</td>
</tr>
<tr>
<td>G (C and P)</td>
<td>7.87a</td>
<td>6.07b</td>
<td>7.27a</td>
<td>6.07b</td>
</tr>
<tr>
<td>H (G, C and P)</td>
<td>6.60a</td>
<td>6.13a</td>
<td>7.47a</td>
<td>6.60a</td>
</tr>
</tbody>
</table>

*Treatments are explained in Table 1.
Each figure is the mean of 15 determinations, where 9 is ‘like extremely’ and 1 is ‘dislike extremely’.
Means with the same letter in any given row for each sensory parameter are not significantly different (P≤0.05).
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الصفات في مكونة البهارات. أما في الفترة المتبعة، تتم تحليل المنتج، وتشمل هذه العملية تحديد كمية 6.0 log 10 أرقام المبايعات بعد أسبوع والموسمية في المنتج، والتأكد منها في 10 أيام. الوحدة، باستثناء الأحداث التي تحدث في المنتج، لا تكون مصممة، بالنسبة إلى الأوبئة كحاسِبة، تسأف الببرة، والبحث، ووضح صفات المنتج، وعندما المنتج، الت_WP-0006/15-240 نموذج، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتحقيق، والتح免责..