Effects of Fat Content and Heat Treatment on the Chemical and Sensory Characteristics of Canned Luncheon Meat

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ABSTRACT

Canned luncheon meat made from beef and poultry was prepared with either a low (about 9%) or high (about 16%) fat content and subjected to heating at 105, 115 or 121°C, which were designed to give an F value of about 3.4. After heat processing and storage of cans at 30°C for 14 days, no viable microbes were recovered from any of treatment products. Proximate chemical composition showed that low-fat group had a significantly higher \( p < 0.05 \) moisture content and a lower protein content than the corresponding high-fat products, while pH values ranged from 6.59 to 6.61 and were not significantly different for the treatments. There was no clear distinction between low- and high-fat products with regard to oxidative rancidity, little effect of either fat content or treatment temperature on protein denaturation. Low-fat formulation, heated at 105°C, was the best in relation to sensory characteristics, microbiologically safe and shelf-stable.

Keywords: Fat Content, Heat Treatment, Luncheon Meat, Chemical Properties, Sensory Evaluation.

INTRODUCTION

Canned luncheon meat is an emulsion-type, cured meat product that is sterilized by heat and has a shelf-life of about three years at ambient temperature (Standard, 1998). It is a popular food item in many countries and it is also used in ‘fast food’ (Al-Bachir and Mehio, 2001). The basic raw material is either beef or poultry in chopped or comminuted form and additional ingredients may include spices, soya protein, starch, nitrite, salt, ascorbate, and phosphate (Abdullah, 2007). The quality of luncheon products is strongly influenced by the temperature, time of processing and fat content of the meat. If too severe, heat treatment can cause denaturation of protein and changes in product appearance, water-binding capacity and tenderness (Pena-ramos and Xiong, 2002). The fat content is of similar importance and, depending on the degree of lipid oxidation, may lead to discoloration, increased drip-loss and an adverse effect on product flavor (King and Harris, 1982). Thermal processes tend to promote lipid oxidation by disrupting cell membranes and releasing pro-oxidants, thereby inducing the development of ‘warmed-over’ flavor (Morrisey et al., 1998; Andreo et al., 2003).

According to consumer perception, flavor is the most important quality characteristic of meat, but production of those components that are responsible for the typical aroma and flavor of the cooked product is a complex process. Among the chemical intermediates observed were alpha-dicarbonyl compounds, alpha-amino ketones and flavor volatiles, such as pyrazines, oxazoles, thiopheres, thiazoles and other heterocyclic sulfur...
compounds (Love, 1994).

Meat can be contaminated with foodborne human pathogens and is a highly perishable type of food, heat treatment of the canned product is essential in relation to its safety and stability, and must be sufficient to ensure that no microbiological hazard arises during storage (Ostoga et al., 2002). The efficacy of the treatment depends on a number of factors, such as the time and temperature of heating play an important part (Kautter et al., 1992).

The purpose of the present study was to compare the influence of three different heat treatments for luncheon meat products containing either a low or high fat-content on the product quality, and the survival of both aerobic and anaerobic spore-forming bacteria.

MATERIALS AND METHODS
Luncheon meat manufacture

Used meat in this study, were mechanically deboned poultry meat, chicken breast and thigh, and flank of beef. To provide formulations with a ‘low’ (about 9%) and ‘high’ (about 16%) fat content, the amounts of meat were adjusted by trial and error, and confirmed by proximate analysis. All ingredients included in the two formulations are shown in Table 1.

<table>
<thead>
<tr>
<th>TABLE (1):Composition of low- and high-fat luncheon formulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredient</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>MDPM*</td>
</tr>
<tr>
<td>Lean beef 65% **</td>
</tr>
<tr>
<td>Lean beef 85% ***</td>
</tr>
<tr>
<td>Chicken breast</td>
</tr>
<tr>
<td>Chicken thigh</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Starch</td>
</tr>
</tbody>
</table>

*MDPM: mechanically deboned poultry meat
** Contains 35% fat
*** Contains 15% fat

The products were prepared at a local meat factory, using frozen meat tempered to –3°C. After flaking, the different meats were mixed for 10 min in the required proportions and then processed at low speed in a mechanical chopper (Sydelman, Stuttgart, Germany) for four minutes, while water, soya protein, tripolyphosphate, ascorbate, salt, and sodium nitrite were added. Metal cans of 7.3 cm diameter and 20.65 cm in height were filled with the emulsion to a weight of 850 g, using piston-type filler (Hema DM60CB, Quimper Cedex, and France). The cans were double-seamed under a vacuum of 0.033 mbar.

For cooking purposes, a separate retort was used for each heat treatment (Stock automat SAM 1300-5-HU-TT, Neumunster, Germany). The required treatment temperatures were 105, 115 and 121°C respectively and the cooking process had an F value in each case of about 3.4. Thermocouples (Stock CTF9008, Neumunster, Germany) were used to monitor the coldest parts of the can and the water surrounding the cans, which was heated by steam injection. Temperature, pressure and heating time in the retorts were controlled and, after each cooking process, the cans were cooled by water.
Proximate analysis and pH measurement

Moisture, fat and protein were determined with a Tectator Meat Analyzer (Tecator model 1256, Foss Tecator, Hoganas, Sweden), as described by Berg and Kolar (1991).

For pH measurement, 10 g of sample and 90 ml of distilled water were blended for 30 sec in a stomacher (AES 3500, Combourg, France). The pH value of the homogenate was determined electrometrically and in duplicate using a pH meter (WPA, Cambridge, UK), (Egan et al. 1981).

Oxidative rancidity and protein denaturation

To determine the degree of oxidative rancidity, the method for thiobarbituric acid reactive substances (TBARS) was used. Tests were also carried out on the uncooked materials. Values were expressed as mg malonaldehyde / kg of sample by multiplying the sample absorbance reading at 532 nm by a factor of 7.8 (Faustman et al., 1992; Egan et al., 1981).

Protein denaturation, both before and after heat treatment, was determined by measuring total volatile nitrogen (TVN). After blending in a stomacher (AES 3500, Combourg, France), 0.5 g of each sample was transferred to a digestion tube with 20 ml of H2SO4 and a digestion tablet. The tube was heated at 420°C for 45 min on a block digester and then removed and allowed to cool. Following the addition of NaOH, the tube was attached to a distillation unit with a collecting flask containing 25 ml of 4% boric acid solution. At the end of the distillation process, the flask was removed and five drops of methyl red indicator were added. The distillate was titrated with 0.1 M HCl until a gray-colored end-point was reached. Values for total volatile nitrogen (TVN) were expressed as mg Nitrogen/100 g sample (Egan et al. 1981).

Microbiological analysis

Two cans of each treatment product were taken for analysis. From the contents of each can, 10 g were blended with 90 ml of sterile peptone water in a stomacher (AES 3500, Combourg, France) and ten-fold dilutions prepared in 9 ml amounts of peptone water. Duplicate pour-plates were prepared from each dilution, using Reinforced Clostridial Agar (Prodilab, Barcelona, Spain) and incubated at 35°C for 40 – 48 hours in an anaerobic jar containing a gas-generating sachet (Prodilab, Barcelona, Spain). The plates were then examined for microbial colonies.

The pour-plate method was also used for organisms capable of aerobic growth. The medium was Nutrient Agar (Prodilab, Barcelona, Spain) and plates were incubated in air at 35°C for 48 hours (Kautter et al. 1992).

Sensory evaluation

Samples from each treatment were sliced, randomized and presented to a trained sensory panel at a single session. The 15 panelists were chosen from employees of the participating meat manufacturing company and came from different departments. They were of both sexes and different ages, and were asked to assess each sample separately without comparing with other samples. The panel used a 9-point hedonic scale on which 9 was ‘like extremely’ and 1 was ‘dislike extremely’ (Larmond, 1991). Samples of the six products were evaluated for color, flavor, odor, juiciness and overall acceptability. Between samples, panelists were given a glass of water to cleanse the mouth.

Statistical analysis

The data were analyzed using a standard package (SAS, 1997). A complete randomized design was used to analyze the data by analysis of variance. Differences between means were determined with the least significant difference and Duncan’s Multiple Range tests. Pearson’s correlation coefficients were used to determine any inconsistencies in panel scores and the degree of correlation between the sensory characteristics studied.
RESULTS AND DISCUSSION

Proximate composition, pH and microbial survival

Data given in Table 2 show that the low-fat product treated at each of the three temperatures (A – C) had a significantly higher moisture content ($p < 0.05$) than the high-fat version subjected to the same temperatures (D – F), and these results agreed well with the results obtained by (Abdullah, 2007) who worked on canned luncheon meat formulations as affected by different raw meat sources. The values obtained for the former group were slightly higher than the maximum of 65% specified in the Jordanian Standard for luncheon meat(Standard 79, 1998) but those of the latter were below this figure. Both treatment groups were within the specified maximum of 25% for fat content. Although between-group differences were relatively small, the low-fat group was significantly lower in protein and Pearson’s correlation coefficient confirmed the relationship ($r = 0.92893, p < 0.0001$).

Table 2 shows that pH values varied only between 6.59 and 6.61, with no significant difference between any of the treatments, and no effect of cooking temperature. The similarity of the values obtained may have been due to the inclusion of phosphate in the formulation and its likely buffering effects. In relation to the heat-resistance of bacterial spores, pH was known to be a key factor and resistance tends to be maximal at around neutral pH (Hersom and Hulland, 1980). Nevertheless, no viable organisms were recovered from any of the samples examined after the cans had been incubated at 30°C, indicating the absence of microbial growth. This finding also suggests that the raw materials used in preparing the luncheon meat were of sound microbiological quality.

### Table (2): Proximate composition and pH values of the luncheon products

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Protein (%)</th>
<th>* pH value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Low fat, 105°C</td>
<td>67.65c</td>
<td>10.80d</td>
<td>12.95d</td>
<td>6.59a</td>
</tr>
<tr>
<td>B Low fat, 115°C</td>
<td>68.60b</td>
<td>9.65e</td>
<td>12.85f</td>
<td>6.61a</td>
</tr>
<tr>
<td>C Low fat, 121°C</td>
<td>69.50a</td>
<td>9.15f</td>
<td>12.90e</td>
<td>6.60a</td>
</tr>
<tr>
<td>D High fat, 105°C</td>
<td>61.20d</td>
<td>15.85c</td>
<td>13.50a</td>
<td>6.61a</td>
</tr>
<tr>
<td>E High fat, 115°C</td>
<td>61.20d</td>
<td>16.20b</td>
<td>13.35b</td>
<td>6.61a</td>
</tr>
<tr>
<td>F High fat, 121°C</td>
<td>60.80e</td>
<td>16.55a</td>
<td>13.25c</td>
<td>6.60a</td>
</tr>
</tbody>
</table>

Each value is the mean of two determinations on each of four samples.

Means with the same superscript letter in any column are not significantly different ($p \leq 0.05$).

* pH values for the uncooked products were: 6.60 (low fat) and 6.55 (high fat).

Oxidative rancidity and protein denaturation

The oxidation of lipid in meat is associated with the development of rancidity and is enhanced by cooking (Pearson and Dutson, 1994; Gandermer, 2002). The process proceeds more rapidly at higher temperatures (Lee, 1975). In this study, TBARS values were used as a measure of oxidative rancidity (Gaebler et al., 2002) are shown in Table 3. Significant differences were observed between some treatments ($p < 0.05$), there was no clear distinction between low- and high-fat products. The highest values for both groups were obtained from
the 121°C treatment, but these were not significantly different from each other (Andreo, 2003). A value of 1.00 was obtained for the uncooked, high-fat material and this was in the range of 1 – 2 mg malonaldehyde / kg that was considered by Kowale et al., (1996) to be indicative of rancidity. However, all three heat treatments yielded values below the threshold.

Table 3 also shows the total volatile nitrogen (TVN) values. Any heat treatment over 80°C could be expected to result in protein denaturation (Fernandez-Martin et al., 2000) and, with one exception (low fat, 115°C), all values were significantly higher (p < 0.05) than those for the uncooked meat, regardless of fat content. The most marked effect for both types of processed product was at 121°C, although all the between-treatment differences were relatively small.

**Sensory characteristics**

The panel scores are shown in Table 4. In relation to product color, there was a consistent difference between the low- and high-fat groups, with higher scores being given to the low-fat products in all cases. Within these categories, however, treatment temperature made little difference and only the high-fat product heated at 105°C gained a significantly higher score (p < 0.05) than others in the same group. While heat-processing is known to have an adverse effect on meat myoglobin (Lee, 1975) the fat content of the formulations studied also had a significant influence on product color.
TABLE (4): Effect of heat treatment on the sensory evaluation of the luncheon products

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Color</th>
<th>Flavor</th>
<th>Odor</th>
<th>Juiciness</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Low fat, 105°C</td>
<td>7.8a</td>
<td>7.7a</td>
<td>7.7a</td>
<td>7.9a</td>
<td>7.7a</td>
</tr>
<tr>
<td>B Low fat, 115°C</td>
<td>7.5ab</td>
<td>7.5a</td>
<td>7.4b</td>
<td>7.3b</td>
<td>7.5b</td>
</tr>
<tr>
<td>C Low fat, 121°C</td>
<td>7.5ab</td>
<td>7.6a</td>
<td>7.3b</td>
<td>7.2b</td>
<td>7.3b</td>
</tr>
<tr>
<td>D High fat, 105°C</td>
<td>5.8c</td>
<td>5.0b</td>
<td>5.1cd</td>
<td>5.2c</td>
<td>5.2c</td>
</tr>
<tr>
<td>E High fat, 115°C</td>
<td>4.7d</td>
<td>4.7c</td>
<td>4.9de</td>
<td>5.3c</td>
<td>4.5e</td>
</tr>
<tr>
<td>F High fat, 121°C</td>
<td>4.5d</td>
<td>5.1b</td>
<td>5.5c</td>
<td>4.7cd</td>
<td>4.9cd</td>
</tr>
</tbody>
</table>

* Each value is a mean of 15 assessments.

Means with the same superscript letter in any column are not significantly different ($p \leq 0.05$).

As with color, flavor scores were significantly higher ($p < 0.05$) for the low-fat group, with no significant difference between any of the heat treatments. The lowest score (4.7) was obtained for the high-fat product heated at 115°C. This was significantly different from others in the same group, but the reason is obscure. The main conclusion that can be drawn is that fat content had a critical influence on product flavor, which was rated more favorably in the low-fat group.

Panel scores for odor and juiciness showed a similar distinction between low- and high-fat groups, with the low-fat group yielding higher scores in both cases. The low-fat product heated at 105°C had the highest score for both properties and these were significantly different ($p < 0.05$) from others in the low-fat group. Exactly the same trend was observed for overall acceptability, with all the low-fat products being more acceptable. With a score of 4.5, the high-fat product heated at 115°C was significantly less acceptable ($p < 0.05$) than others in the group.

For all the sensory characteristics studied, the low-fat product heated at 105°C yielded the highest panel scores, which were significant ($p < 0.05$) for odor, juiciness and overall acceptability, but not for color or flavor among the low-fat group. With the latter two characteristics, there was no significant temperature effect.

To determine any inconsistencies among the panelists, Pearson’s coefficients were calculated, relating individual scores and panel means. No significant differences were observed, but there was a significant correlation ($p < 0.01$) between the characteristics studied (Table 5).
TABLE (5): Pearson’s correlation coefficients relating individual scores with panel means and showing the inter-relationship between sensory characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Panelists</th>
<th>Color</th>
<th>Flavor</th>
<th>Odor</th>
<th>Juiciness</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>0.03921*</td>
<td>1.00</td>
<td>0.5371**</td>
<td>0.64323**</td>
<td>0.62591**</td>
<td>0.74221**</td>
</tr>
<tr>
<td>Flavor</td>
<td>-0.01859*</td>
<td>0.5371**</td>
<td>1.00</td>
<td>0.78038**</td>
<td>0.6382**</td>
<td>0.85854**</td>
</tr>
<tr>
<td>Odor</td>
<td>-0.04197*</td>
<td>0.64323**</td>
<td>0.78038**</td>
<td>1.00</td>
<td>0.67987**</td>
<td>0.8079**</td>
</tr>
<tr>
<td>Juiciness</td>
<td>-0.06040*</td>
<td>0.62591**</td>
<td>0.6382</td>
<td>0.67987**</td>
<td>1.00</td>
<td>0.79800**</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>0.03891*</td>
<td>0.74221**</td>
<td>0.85854**</td>
<td>0.8079**</td>
<td>0.79800**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Correlation not significant at the 0.01 level.
** Correlation significant at the 0.01 level.

Conclusion

It would be concluded that the oxidative rancidity of all the luncheon products were less than the threshold level (1 mg malonaldehyde / kg), but a correlation between temperature and TBA was observed and no correlation between the fat content and the TBA value. The luncheon product which had low fat and cooked at low temperature (105 °C) had the highest color, flavor, juiciness, odor and overall acceptability scores. It is, therefore, recommended that to use a combination of low fat luncheon formula and low temperature of sterilization to produce a high quality canned luncheon meat.

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