Investigation of salt diffusion during the salting of ham

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Abstract: Excessive consumption of salt causes many diseases, including high blood pressure and as a result, contributes to the development of further cardiovascular system disease. In most countries around the world, salt intake is above the WHO guideline daily intake. In Hungary, on average, we consume twice as much salt as recommended. Based on these, significant changes are needed in food technology and recipes. To avoid excessive salt intake Hungary has joined the European Union's community program for salt reduction.

The aim of this study was to investigate the salt content and the salt diffusion in Mangalitsa ham during the curing. The ham was cut at 3 points (C. Cushion, FC. Fore Cushion and BE. Butt End). The salt content of BE was generally higher than the other two areas (C, FC). The differences can explain by the difference in the thickness of the pieces of meat and fat. The salt content in the different areas did not exceed the maximum value required in the Codex Alimentarius Hungaricus.

Keywords: salinity, salt reduction, salt diffusion,

Introduction:

Curing is one of the oldest preservation method. It is based on the migration of sodium chloride (NaCl) to the meat. The traditional curing technology is also widely used by the modern food industry, and today it is almost the same to the method used centuries ago. The aim of curing is to increase the shelf life, to create the right taste and color, and to increase the enjoyment value and digestibility.The NaCl results in physico-chemical and biochemical changes in meat (Gil et al.,1999). The NaCl enhances shelf-life, flavour, juiciness and tenderness of the products (Carcel et al., 2007).

Pork meat curing can be conducted by immersion of meat tissues in NaCl brines, which is known as brine curing procedure. It is used in several countries by small processors for certain pork cuts. Pickle cure usually gives a product with a milder flavor than dry curing and requires less labor (Pearson and Gilett, 1996).

The migration of NaCl from the brine to the meat matrix is normally quite slow therefore curing process is often complemented with tumbling and injecting of the meat: a mechanical

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treatment, which causes cellular disruption of the meat tissue (Gou et al., 2003, Bedinghaus et al., 1992).

The food industry is currently under pressure from the Food Standards Agency (FSA) to deliver reductions in the salt intake of the population through the introduction of lower salt levels in processed foods (Gilbert & Heisler 2004 in same issue). High salt intake increases the risk of poor health, including cardiovascular disease, high blood pressure. Reducing the salt content to maximum 6 g per day would help to reduce these health problems (Swales 2001).

According to a WHO study in 2009, 181 of the 187 countries in the world consume more salt than the recommended 5g / day. Data from 2009 show that salt intake in Hungary was 14,8 grams per day for adults (Fig 1.) (Trieu et. al., 2015).

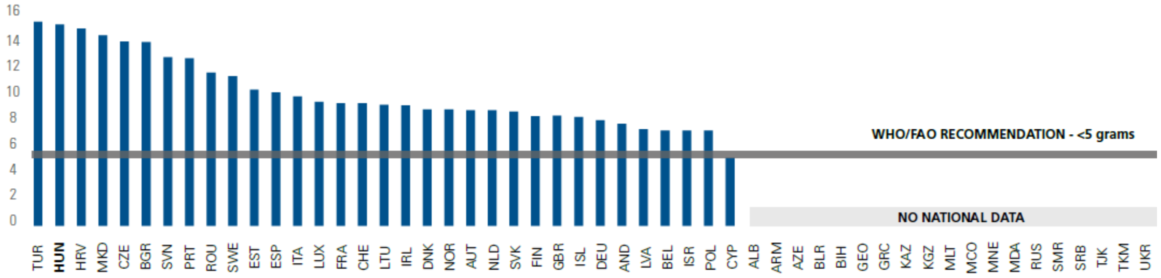

Figure 1: Salt intake (grams) per person per day for adults in the european region from individual country based surveys (WHO 2009)

Based on these data, Hungary has also joined the European Union's community program for salt reduction. The aim of the program is to shape a substantial part of the product range in all EU member states in a compatible way. The aim in Hungary is to reduce the salt content of the food groups most consumed by the Hungarian population by 16% in the coming years.

The aim of this work was to to produce ham of the quality required by the Codex Alimentarius Hungaricus and to study the salt diffusion of the product during the salting and aging process.

Materials and Methods:

Experiment

Mangalitsa ham obtained from a local slaughterhouse were used for investigations. Ham was dry salted with 10% by weight of the meat and placed in a controlled atmosphere storage room. The salting took 21 days. On day 21, I removed the salt from the ham and I hanged it back in the same atmosphere storage room. This part lasted until day 45. After that the ham was smoked on beech wood at about 40°C.

During the first 31 days every 3 days was measured the salt content of 4 randomly selected ham. Thereafter, every 7 days I measured the salt content until day 52, then I measured every 14 days.

NaCl content determination

The determination of the amount of NaCl diffused into the meat was carried by titrating chloride anions in sample solutions with silver nitrite using the Mohr method as described by Volpato et al. (2007). The ham was cut at 3 points (1. Fore Cushion (FC), 2. Cushion (C), and 3. Butt End (BE)) from the skin to the free surface of the meat, approx. 5 * 5 centimeters in area (Fig 2.). Each slice of meat was cut into 5 equal sized pieces: 3 meet and 2 fat. This way I was able to follow up the salt content on the surface, in the centrum and in the fat.

Figure 1. Test holes on the ham

Statistical analysis

Numerical results of NaCl content were analyzed using IBM SPSS 23.0 software. Statistical analysis was performed by variance analysis (ANOVA). The investigated factors were meat layer (surface, centrum, fat) and test holes (FC, C, BE). Difference was considered to be statistically significant at $p<0.05$. Analysis of variance (ANOVA) along with Tukey post hoc test was used to compare the NaCl content of samples.

Results:

Based on the measurements, it can be concluded that the increase in the salt content was significant mainly during the first stage of the experiment, during the salting. Figure 2 shows, that the salt content on the surface is typically the highest on the BE. The FC. and C. have approximately the same salt content. Significant changes was found between tha salt content in C. and BE. On the 14th day of the experiment, the salt content on the surface of each sampling points reached the permitted (Codex Alimentarius Hungaricus) 5,00%.

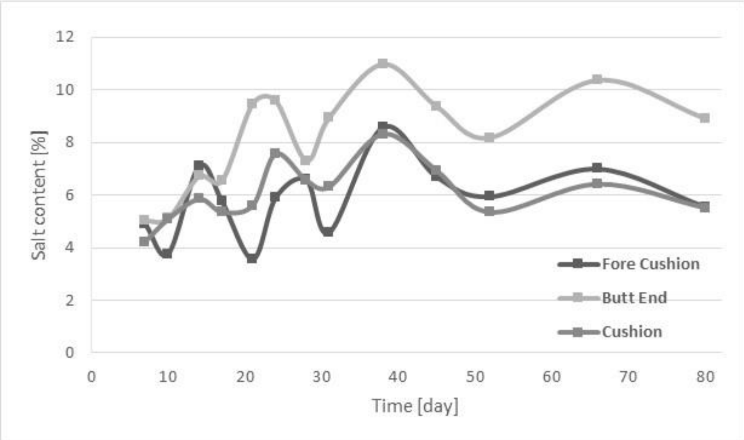

Figure 2. Change in salt content of meat surface

The salt content in the centrum is shown in Figure 3. In this layer was most significant the increasing of the salt content. The salinity only showed slight increasing to day 21, but after that it was higher. Between days 31 and 45, salinity increased in the centrum by an average of 2.08%. The salt content of the BE. in the centrum also exceeds that of the other two studied areas. The ANOVA and the TukeyHSD test did not show the significant difference among the three areas. In this layer the salt content reaches the limit of 5,00% by weight at the latest.

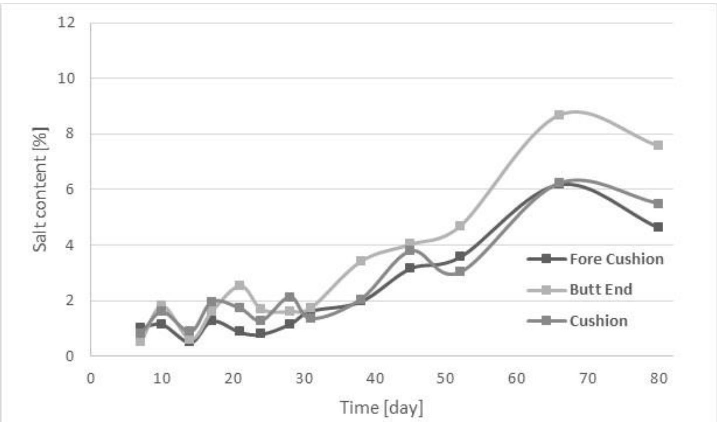

Figure 3. Change in salt content of meat centrum

In the case of fat layers, the change in salinity is significantly slower than in the surface and in the core. It shows Figure 4. In the first two parts of the experiment, the salinity increase of the fat is minimal. However, during the ageing process after smoking, the salt content increased to a greater extent. This is especially noticeable in the case of the C. However, there was no significant difference in the salt content in this layer.

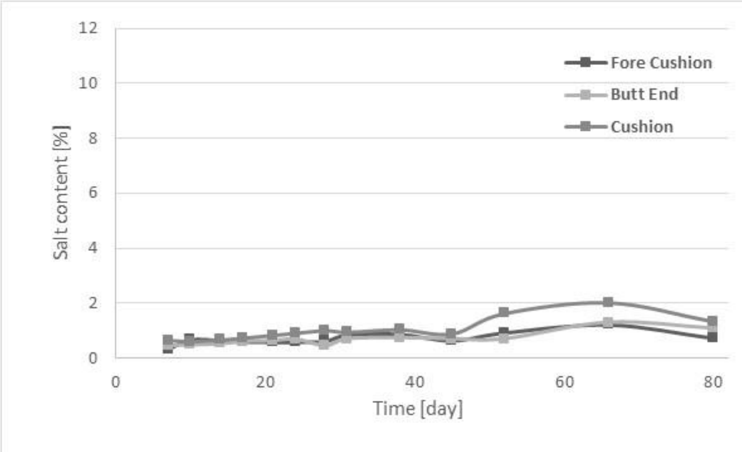

Figure 4. Change in salt content of fat

Figure 5 shows the change in salinity of all sampling points and layers. The salinity was the highest for all samples at day 66. In the case of a FC., the absorption of salt is most variable, since the differences in salinity between the surface and inner layers fluctuate. However, by the end of the experiment, the salt content in the meat layers was almost equalized. The initial difference of about 3.80 % by weight between the surface and the centrum was below 1% by day 80. Nevertheless, in the case of bacon layers, the opposite is true.

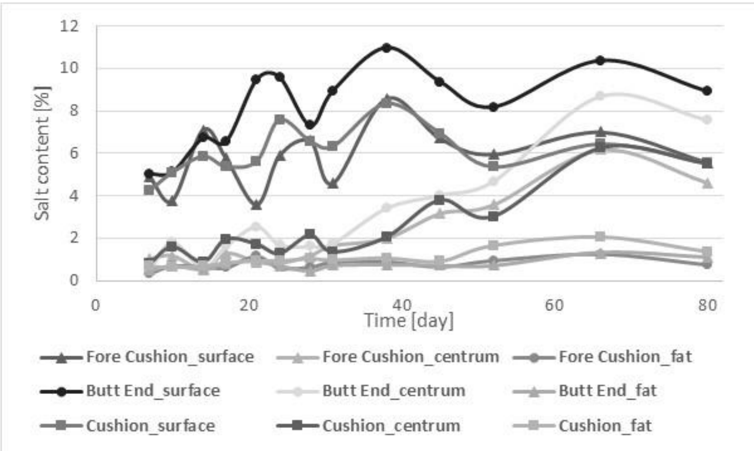

Figure 5. Change in salt content of ham

The average salt content of the meat layers of the hams on day 80 was 5.24%. However, when examined together with the fat layers, the average salt content of the FC. was 3.66%, which is a significant difference. It can be explained by the migration of the water content of the ham. During the salting process, the hams still have a high moisture content, so diffusion occurs mainly in the surface layer. During aging, the humidity of the surface layer is significantly reduced by moving air, so that the salt migrates to the inner layers and the moisture to the surface. Because salt is a non-fat soluble compound, the bacon layers have a lower salt content and a significantly slower diffusion. It can be stated that the thickness of the meat and fat layers plays an extremely important role in the formation of the salinity of each ham part. The thicker the layer of meat, the more moisture the area holds, allowing it to absorb more salt and to absorb more quickly.

On day 80, the average salt content of the FC. is 3.66%, the average salt content of BE. is 6.00% and that of the C. is 5.49%. Based on the measured data, the average salt content of the whole ham can be inferred, which is 4.71%. That is, the salt content of the examined ham corresponds to the salt content of 5.00% as defined in the Codex Alimentarius Hungaricus.

Conclusion:

In my research I used ham production technology and regularly measured the salt content of the ham during the 80-day experiment. Based on these, it was possible to conclude the salt diffusion of the samples. The differences between the different areas of the ham can be explained by differences in the thickness of the layers of meat and fat. The salt content of BE. was typically higher than FC. and C. On BE. the fat layer is thinner, this way the difference can be explained.

At the beginning of the experiment, the salinity of each layer of meat was very different, absorbed salt was concentrated on the surface. During aging, significant increase in salt content began in the centrum. It can be explained by the significant loss of water in the sample. By the end of the experiment the salinity of the examined meat layers was almost completely equalized.

Based on the results it can be stated that the applied salting and aging technology can satisfy with the maximum salt content specified in the Codex Alimentarius Hungaricus.

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