„Conformity of water activity values of dry sausages at the end of ripening“

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Introduction

Decisive factors for the suppression of foodborne disease agents as well as for microbial stability of dry fermented sausages are pH and a_w values (Gareis et al., 2010; Matagaras et al., 2015).

However, fermentation processes alone are not enough for the shelf-life of fermented meat products (FMP). Their importance as an obstacle to the growth of undesirable microorganisms is limited, both in terms of their effectiveness and in terms of time. During the ripening of sausages, the most important and most stable barrier begins to emerge - low level of water activity, a_w. Low a_w values also stabilize heat-treated dry sausages.

The a_w value as an important shelf-life indicator is influenced by the addition of NaCl (i.e. nitrite curing salt mixture), fermentation, but above all by the drying process. The speed of the drying process is determined by the external and internal diffusion of water in the product. Diffusion is dependent on the difference of the water content gradient between the product and its surroundings (relative air humidity in the chamber and activity of the water in the sausage), the type of technological packaging used, the surface quality of the products, the air flow velocity and the air temperature in the chambers. However, the internal water diffusion is also influenced by the composition of the product (meat/fat ratio), the pH value, the degree of chopping of the work („grain“ size) and its uniformity, the mixing of the work and the quality of the chopping process. What reduces the internal diffusion of water and therefore its transport to the product surface? It can be the high fat content, chopping of the work into a very fine grain and the fat film that covers the pieces of meat created during chopping. The basic prerequisite for FMP drying is the difference between the ambient air humidity and the product moisture on the one hand and the difference in moisture between the core of the product and its edge layer on the other.

Certain principles must be observed when drying FMPs, as the goal is to obtain a quality standard product. On the one hand, the operating economy requires drying as quickly as possible in order to achieve the lowest possible operating costs. On the other hand, the drying process must be gentle with respect to the product properties. In the case of FMP, a gradual drying process is absolutely essential. It is necessary to ensure a uniform drainage of water from the center of the product to its surface, where water molecules evaporate into the surrounding air.

Since the relative air humidity (RAH) in the environment, where drying is carried out, is lower than a_w of sausages, water evaporates from the surface layer of sausages. This increases the

salt concentration in this outer layer. The difference between the water content of the core of the product and its edge must be equalized and therefore water diffuses from the center of the product to the surface. The outer surface layer of sausages always has lower water content than the center. It can be said that FMPs are dried from the inside out. The rate of water evaporation from the surface of the products shall be adapted to the rate of water diffusion from the center to the outer zone. If moisture is removed from the sausage surface faster than diffusion inside the product is sufficient, the result will be a ring formation (Feiner, 2006).

The intensity of water evaporation on the salami surface is increased by high air temperature, high air flow velocity and low RAH. Conversely, the drying process slows down the temperature decrease, the low air flow velocity and the RAH increase. These parameters must therefore be suitably set so that drying takes place economically but, on the other hand, does not lead to hardening of the surface zone of the products and thus to the formation of a ring.

The ripening of FMPs is currently taking place in air-conditioned chambers. The external parameters (air temperature, RAH, air flow velocity) in the chambers should be determined so that drying is neither too fast nor too slow and therefore does not allow the growth of undesirable moulds, yeasts or bacteria on the product surface.

The objective of the submitted work was to determine the a_w values of the “Poličan” sausage at the end of the ripening process and to compare the conformity of the measured values obtained from samples from various places in the ripening chambers Mauting. Sampling was carried out at one industrial meat processor in the Czech Republic.

Fig. 1: Illustrative photo: ripening climatic chamber MAUTING KMD CrossFlow. The aim of the designers and manufacturers of air-conditioned chambers is to ensure intense water loss during the drying of sausages without causing a ring formation or other defects. The uniformity of drying throughout the chamber is also important.

Material and methods

Samples of Poličan 500g product were taken as 1 whole piece of sausage from total 3 different places of the ripening chamber Mauting and at the given place always from the upper and lower floor of the smoking trolley (size of the trolley in m - 1x2x1) within the one production batch (total of 6 pieces). The first sampling site was the closest to the entrance of the ripening chamber and the other two sites were selected so that they were as far away as possible from the first sampling site and at the same time represented the volume of the measured batch. All pieces of sausage were labelled and taken to the laboratory to measure a_w.

Measurements were performed in the laboratory of the processor on the AquaLab device (manufacturer Decagon Devices, Inc. 2365 NE Hopkins Ct. Pullman, WA 99163 USA). A sample of the sausage to be measured was cut in half and a slice of round shape with a thickness of up to 1 cm corresponding to the shape of the instrument dish (4 cm dish diameter) was cut from the center and the a_w value of the product was then measured. The sample from the center of the sausage was cut and measured twice in total, and the average of these two measurements was calculated. Thus, within one measurement day, 6 resulting a_w values were generated for one production batch of sausage. The a_w value measurements were carried out from March to August 2018. The results of individual measurements were recorded in tables and statistically evaluated.

In June the correctness of a_w value was verified by sending a control sample of the sausage Poličan 500g to The State Veterinary Institute Jihlava. In agreement with the SVI Jihlava, the a_w value was measured on the same day, in the case of the first sample in the processor's laboratory on the Aqualab device (deviation ± 0,003), in the case of the second sample in the SVI Jihlava on the Novasina device (deviation ± 0,003). Measured a_w values in the processor's laboratory: 0,914, measured a_w value in the SVI Jihlava: 0,912.

All a_w values were compared mutually by the ANOVA statistical method, taking into account two factors - sampling site and floor. First, a_w values were compared mutually taking into account each factor separately and then in combination of both factors simultaneously. A value of $P \leq 0,05$ was considered statistically significant.

Results and discussion

All measurements are recorded in the table and relate to individual samples of “Poličan” 500g sausage. It is the following data for the batch produced: date of manufacture (filling), date of a_w measurement, total ripening time of the product (from filling to the end of ripening), designation and dimensions of Mauting ripening chamber, size of the batch produced and results of partial a_w measurements from individual sites of the ripening chamber and floors of the smoking trolley.

The total ripening period ranged from 19 to 24 days. For all 4 batches measured, measured a_w values were less than 0,927 (calculated with an deviation of device measurement of ± 0,003) and therefore meet the legislative requirement (a_w max. 0,93) and the products could be released for packaging.

The measured a_w values ranged from 0,885 to 0,921. The highest variance of values was recorded for the batch produced on March 22 (0,885-0,921), the lowest for the batch produced on June 8 (0,910-0,919). Statistical evaluation of the results revealed that in the case of comparison a_w values taking into account a separate first factor (sampling site), the value of P = 0,9009, i.e. the differences between a_w values within individual measuring sites are statistically insignificant.

When comparing the measured a_w values with the application of the second factor (the smoking trolley floor), the value of P = 0,0838, which means that the differences between a_w values within the individual floors were also statistically insignificant. However, according to the value of P it is obvious that this second factor (the smoking trolley floor) had a greater effect on the a_w value than the first factor, i.e. the site in the chamber where the sausage sample was taken (0,0838 vs. 0,9009).

In the case of comparison of individual a_w values taking into account both factors (sampling site, smoking trolley floor) in mutual interaction, the value of P = 0,9709 came out, i.e. the resulting differences were also statistically insignificant.

Fig. 2: Illustrative photo: Not only the inlet of air-conditioned air but also its outlet play a role for a uniform and efficient process of sausage drying. The picture shows installations that extract air from the chamber into the air conditioning unit located on the right wall, manufacturer MAUTING KMD CrossFlow.

For a dry meat product Poličan, the conformity of the water activity values at the end of the ripening process (i.e. drying) was determined. The legislation of the Czech Republic limits the allowed maximum a_w value of dry sausages to 0,93 (Decree No. 69/2016 Coll.).

Sampling was performed at the time when the products were in the MAUTING ripening air-conditioned chambers. The aim of the MAUTING air-conditioned chambers manufacturer is to achieve the same temperature value, RAH and air flow velocity values throughout the space of the chamber and to allow uniform drying of the placed sausages. The conforming

microclimate is essential for achieving the shortest possible drying time without surface drying of products (ring) or, on the contrary, their moulding (Feiner, 2006). Due to the uniform drying at all sites in the chamber, even a_w values are achieved for the product.

Factors that may have influenced the final a_w value of the samples during the control measurements included manufactured batch volume, total ripening time, dimensions and type of ripening chamber, choice of sampling site as well as the floor of the smoking trolley. However, as the statistical calculations confirmed, the effect of the given factors, e.g. sampling site or the smoking trolley floor, on the resulting a_w value proved to be insignificant. It is obvious that the temperature, RAH and air flow velocity in all spaces of the MAUTING climate chambers were correctly adjusted and the products could be dried as evenly as possible.

Another factor that was not examined during the measurement but could affect the measured a_w values of the products, was the state of filling the chamber with smoking trolleys of products. With a filled chamber it is not possible to expect the same air flow at different sites in the space. A completely different air flow velocity will be measured under the nozzles supplying conditioned air to the chamber and another will be measured in the middle of the full rows of smoking trolleys or in the middle of the smoking trolley with hanging products. In cooperation with the technology supplier, the manufacturer must strive for optimum adjustment of the chambers in terms of air flow (fan power, adjustment of supply air flaps), monitor the development of microclimate in the chambers several times a day and adapt the regime in the chambers to detected conditions (amount of sausage on trolleys, change of site during the production cycle, etc.) (Kameník, 2011).

Plšek (2008) carried out extensive analyzes focused on determination of FMP weight loss during ripening as part of his diploma thesis entitled “Technology of dry meat products production”. He always monitored four smoking trolleys placed in 4 different sites in the chambers and he also took samples from three floors of each trolley. The author found out the FMP weight loss by weighing individual pieces of sausage. Based on the results, Plšek (2008) concluded that there was a statistically very significant difference in the weight of sausages between the three floors of the smoking trolley and the effect of placing the trolleys in the chambers on the amount of FMP weight loss was proved.

Based on the results of the above mentioned diploma thesis, it would be logical to expect, in addition to the difference in weight of the sausages at different placement in the chamber, different a_w values for the products. This assumption has not been confirmed through this work. Only statistically insignificant differences were found by comparing the measured a_w values for all sausages with regard to the sampling site and the smoking trolley floor. However, the analyzes performed by the above mentioned author Plšek were carried out in a different production plant than the one in which the measurements were carried out, and therefore, of course, also in differently adjusted and possibly constructed climatic chambers than the MAUTING climate chambers.

Conclusion

Current air-conditioned chambers for the ripening of dry sausages can ensure relatively uniform drying and balanced values of water activity of final products even in industrial conditions. The study proved, that even in an area of 462 cubic meters, the differences between a_w values of sausage on the 19th day of ripening were statistically insignificant. The good results of sausage ripening, however always reflects, besides quality equipment, also the experience of the manufacturer. Preparation of semi-finished products (in this case individual pieces filled with a work) begins with the selection and treatment of meat and lard, continues with the selection of suitable technology for the preparation of sausage work and ends with its filling into technological packaging. These stages of production are as important to the quality of the final products as subsequent ripening.

Table: Values a_w and additional data to the measured batches of the product „ Poličan 500g“

Measurement data of the batches	**Date of production**	22.3.2018	6.4.2018	19.4.2018	8.6.2018
	Date of measurement	11.4.2018	24.4.2018	9.5.2018	28.6.2018
	Total maturation time (days)	21	19	21	21
	Air-Conditioned chambers KMD Mauting	C1	C2	C1	C1
	Dimensions of the chamber (m)	21,5x6x3,5	22x6x3,5	21,5x6x3,5	21,5x6x3,5
	Batch size (kg)	2337	3634	4005	4034
	a_w (two measurement average)				
Place of sampling	**1 – upper floor**	0,903	0,905	0,910	0,919
	1 - bottom floor	0,900	0,903	0,909	0,910
	2 - upper floor	0,921	0,906	0,914	0,919
	2 – bottom floor	0,916	0,903	0,902	0,911
	3 – upper floor	0,891	0,902	0,916	0,916
	3 – bottom floor	0,885	0,898	0,919	0,916

Note: This article was written as an extract from the article from the attestation work of MVDr. Blanka Čurdová "Conformity of water activity values at the end of dry sausages ripening".

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