INFLUENCE OF pH VALUE AND RELATIVE HUMIDITY ON DRYING OF FERMENTED SAUSAGES

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SUMMARY

The effect of pH value and relative humidity on the drying process of fermented sausage was examined. For this purpose we produced raw fermented sausages with various amounts of sugar and glucono-delta-lacton (0-15 g) to vary the rate and extent of acidulation. The pH values varied between 8.0 and 4.5 and the relative humidity values between 90 and 75%. During the 28 days of ripening, the pH value, water activity, consistency, water and salt content of the core and edge zone, as well as the weight loss were investigated. At lot drying velocities, with a relative humidity of 90%, the water release was not influenced by the pH value. The lower the pH during the ripening, the more rapid moisture could be removed by lowering the relative humidity in the chamber. An increase of water binding at pH values below 5.0 was not found. It is important to adjust the drying velocity to the course of the pH value in order to prevent faulty products.

INTRODUCTION

Raw sausage that is matured for a long period of time undergoes a microbial influenced fermentation and flavour process which is called ripening. During this fermentation, the water content must be reduced constantly. This can be achieved by adjusting the relative humidity, temperature, air circulation and ripening time. The adjustment of the relative humidity (%RH) has to be closely correlated to the water activity (aw value) of the microbial ripening process of formulation and additives; however, the effects of air humidity and air circulation have been sparsely investigated (Townsend et al., 1983; Stiebing and Rüdel 1987a, 1987b). The degree of fluctuation of air velocity within the air conditioned smoking chambers was surprising (<0.1 m/sec). In order to prevent the manufacture of faulty products it is very important to lower the relative humidity during the first ripening period. The a_w value on the outer surface is suitable to characterize the course of ripening. We have investigated the effect of different pH values on the drying process, what climate conditions are necessary, and what humidity differences between raw sausage and chamber humidity are necessary to prevent faulty products and to save energy while ripening.

MATERIAL AND METHODS

To answer these questions we produced raw sausage in which each batch contained one third of beef, pork and pork back fat. Each kilogram of raw sausage was sliced with 28 g of nitrite curing salt, 0.5 g Na-ascorbate, 3.5 g spices and O.S 9 starter-cultures (duploferment, firm Müller). Also added were various amounts of sugar (0-15 g glucose and lactose) or glucono-delta-lactone (0 15 g Gdl), and to one batch lactic acid was also added. The frozen meat and the pork back fat were comminuted (size 2-3 mm), filled in fiber casings (diameter 60 mm) and placed into an air conditioned smoking chamber. The humidity adjuster was switched on after the humidity in

climate	90 %	86 %	82 %	75 %
	Number of ripening days			
●	7	7	7	7
⊙		7	3	18
○		7		21
▽			7	21
▼				28

Fig. 1: Variation of the relative humidity

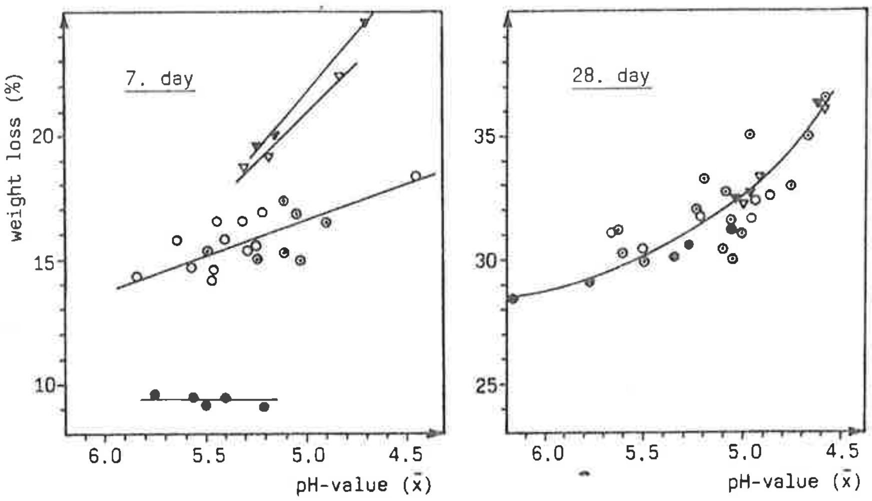

Fig 2: Influence of the relative humidity and pH value on the weight loss (symbols see figure 1)

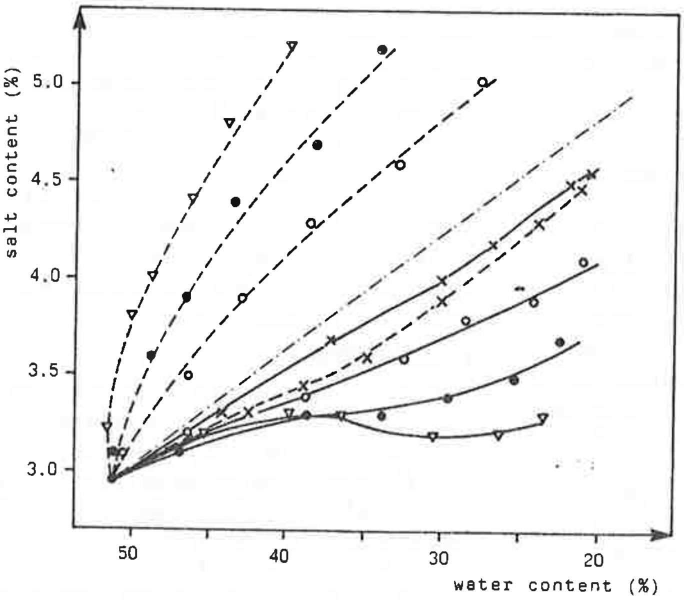

Fig. 3: Influence of the pH value (▽ pH 5.6, • pH 5.3, o pH 4.9, x pH 4.5) on the water and salt content in the core (---) and edge (—) zone (climate No.2: 7 da ys 86 %, 3 days 82 %, 18 days 75 %)

For clarity, the following present data on four batches only, each with a different course of pH value, namely for the ripening process without sugar (pH 5.6), B g sugar (pH 5.3), 12 g GdL (pH 4.9) and 12 g GdL and 8 g lactic acid (pH 4.5). The listed pH is the mean of pH values measured ln the first ripening week. The sausage with a pH value of 4.5 had a very wet surface when cut due to an intensive acidulation and a crumbly structure without formation of gel. Smell and taste were not acceptable.

Figure 3 shows the influence of the pH value on the water and salt content in the core and close to the surface of the sausage. The salt content of the core and edge zone should theoretically increase with further drying as shown by the dotted and pointed line. During sausage ripening, however, salt migrates (Rödel and Hofmann, 1982).

the chamber had increased, due to water release of the raw sausage (after 5 hours).

Five different climate-conditions were examined in which the relative humidity was changed between 90 and 75% in order to reach different drying velocities. The average air velocity was 0.5 m/sec during the second week. On the third day of ripening, the sausages were slightly smoked.

During the 28 days of ripening the following parameters were investigated: pH value, aw value (electrolyte probe, Novasi-na), consistency (sample cylinder 12.8 x 10 mm, thrust-graduation 74% at 20°C, firm Instron), and water and salt content of the core and edge zone as well as the weight loss of the sausages. The core and edge zones were divided in such a way so that the relation of core and edge remained constantly 50:50.

RESULTS AND DISCUSSION

The consistency of the sausage increased continuously as the pH value declined (down to 4.6). There was no difference between the batches with GdL and sugar, except that the batches with GdL showed a faster increase in the consistency due to a quicker acidulation. At a pH value of 4.5 no gel was formed. In this case, 12 g of GdL and 8 g of lactic acid per kilogram had been added.The structure was very crumbly and the surface when cut, was very moist due to the great amount of free water.

The influence of the pH values (mean value measured on 1st, 3rd and 7th ripening day) on the weight loss in different air conditions is presented in figure 2 for the 7th and 28.th days of ripening. The water release at lot drying velocities (relative humidity 90%) was not influenced by the pH value during the first week. The lower the pH during the week of ripening, the more rapidly moisture could be removed by lowering the relative humidity in the chamber. The effects of different relative humidities was not visible after 28 days ripening, since all sausages were exposed to the same relative humidity (75%) after 7 and 10 days, respectively, but it was in the first ripening week.

As the water content decreased, the salt content in the edge zone increased from 2.9 to 3.3%. In the batch with a pH value of 5.6 the salt content did not increase further even though the water content declined further from 40 to 24%. The lower the pH value, the more the salt content increases in the edge zone. After 28 days of ripening, (the outmost points in figure 3), the differences in the salt content of the edge zone with 3.3 to 4.5% are very high, the differences in the water content with 23.5 to 21% only small. The process in the core zone is always mirror-like to the process in the edge zone. The lower the pH value, the less salt migrates in the core zone at equal water content. The salt content in the core was 3.4% at a water content of 40% and a pH value of 4.5, in contrast to a 5.2% salt content at a pH value of 5.6 and the same water content. However, in the pH range between 5.8 and 4.9 the final salt content in the core zone only decreased slightly from 5.2 to 5.0%. Only the sample with a pH value of 4.5 had a distinctly lower salt content. In contrast, core water content decreased with pH from 41 to 21%. Compared with the small pH-dependent fluctuations of the water content in the edge zone, this is a very strong effect. The evaporation of water from the edge zone is only slightly influenced by the different pH values but strongly influenced in the core zone.

The dependency of the migration of the salt on the pH value can be explained as follows: drying increases the salt content in the edge zone and decreases the aw value. At slow drying, water is continuously transported to the surface of the sausage and with it are other soluble substances, for example, salt and sugar. The resulting concentration gradient causes a back-diffusion of ions that occurs faster than the water migration towards the outside, especially at higher pH values and concomitant high water binding of the meat.

The water activity values in the individual zones of the sausages illustrate a dynamic humidity balance. A decrease of the water activity in the edge zone causes a corresponding decrease of the aw value in the core by an exchange of salt and water. Figure 4 shows the changes of t:he water activity in batches with pH values (mean value of the 1st week) of 5.6 (without sugar) and 4.9 (12 g GdL) during ripening. The aw value in the core zone of the batch with a pH value of 4.9 was already less than in the edge zone of the batch with pH 5.6. One could suppose that at a pH value of 5.6 the drying velocity will increase and the aw value will decrease faster than at a pH value of 4.9 since the difference between the relative humidity and the water activity is increasing. However, the drying velocity is not only influenced by the humidity difference and air velocity, but also by the diffusion of the water inside the sausage. At climate conditions causing a weight loss at the 7th day of 14.7% the sausages with a pH value of 5.6 showed a marked hard dry edge, after 21 days some wrinkles and after 28 days of ripening a nonacceptable formation of wrinkles on the surface while the batch with a pH value of 4.9 remained acceptable.

First it seems incomprehensible that the samples with the higher pH value developed a hard dry edge and wrinkles although the aw value in the edge zone dropped slowly. It has to be considered that the examined edge zone does not only include the surface of the sausage, but also the outer 50% of the total sausage. At higher pH values the diffusion of water towards the surface is slower, and therefore the drying loss is lower due to a better water binding of the meat proteins. When the humidity difference is too high between the relative humidity and the humidity of the sausage, the surface of the sausages dries too fast so that water can not diffuse fast enough from the core to the surface. The quick evaporation of water off of the surface also prevents additional salt from diffusing quick enough into the core zone. Due to the very rapid evaporation of water, the salt concentration rises near the surface which causes denaturation of the protein and an encrustation of the surface (hard dry edge). At further drying the core zone shrinks more which causes wrinkles in the surface and cracks in the core. Appropriate air conditions are necessary to prevent dry edge zones. When the humidity is decreased slowly there is no problem to ripen sausages with an even higher pH value since enough time is available for the core water to diffuse into the outer edges.

CONCLUSION

It can be summarized that the evaporation of water is only marginally influenced by the pH value at low drying velocities, while the evaporation of water is accelerated with decreasing pH value at greater relative humidity difference between the sausages and the chamber air. An increase in water binding at pH values below 5.0 was not found. The lower the pH value the more uniform was the drying and the less differences there were in the water and salt content between the core and edge zones. It is important to adjust the drying velocity to the course of the pH value in order to prevent faulty products.

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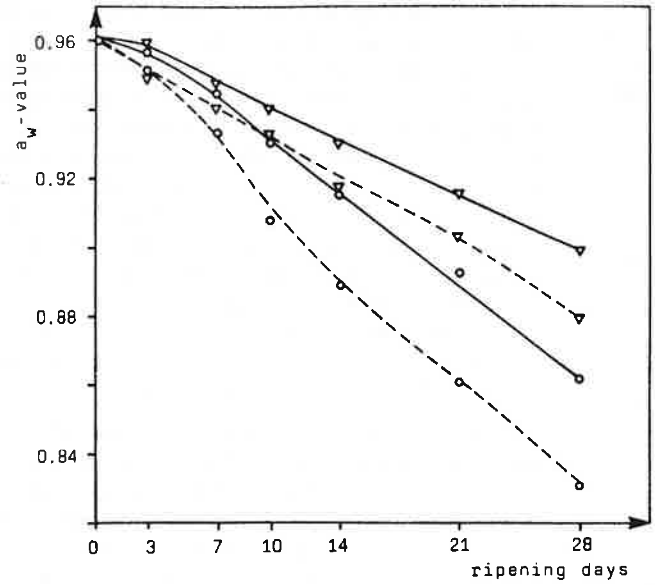

Fig. 4: Influence of the pH value (▽ pH 5.6, o pH 4.9) on the a_w value in the core (——) and edge (- - -) zone