EVALUATION OF SCALING EFFECTS ON PHYSICO-CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF RAW FERMENTED SAUSAGES

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Abstract – Agroscope implements methodologies for challenge tests and considers if results of trials with raw fermented sausages in smaller scale productions are transferable to industrial scale production. Three parameters were investigated: I) two different sized fermentation chambers II) three different sizes of production scale (industrial vs. pilot vs. lab) and III) different sausages-diameters. Samples were analyzed after 0, 1, 3, 7, 16, 28 days on physico-chemical parameters and microbial growth. Chamber size did not influence pH curves. Weight loss was slightly accelerated in industrial scale, but physico-chemical and microbiological characteristics were similar. The different equipment in the three scales seemed to not affect physico-chemical and microbiological characteristics. A smaller sausage-diameter accelerated the drying process and thus changed characteristics of final product.

Key Words – challenge test, food safety, raw sausage production, scaling effects

I. INTRODUCTION

Agroscope plans to construct a new Biosafety Level 3 pilot plant for fermented milk and meat products. In preparation for future challenge tests the influence of production scale, fermenting conditions, chambers and product diameters of fermented raw sausages on physico-chemical and microbiological parameters were tested.

II. MATERIALS AND METHODS

Raw material and a standard recipe were provided by industry. For all trials the starter culture BITEC LK-30 (containing *Staphylococcus carnosus*, *Kocuria varians* and *Lactobacillus sakei*) and a spice mixture containing 1.1% potassium nitrate were used. Equal number of sausages were ripened in the industry chamber (81 m^3 fermenting for 3 days, 499 m^3 drying for 25 days) and in Agroscope chamber (1.41 m^3 for 28 days) under the same conditions to test chamber size effect. For comparison of different scales a pilot scale production with 40 kg of raw material and a lab scale production with 20 kg were made with different equipment corresponding to each production scale. To evaluate the influence of diameter, sausages from pilot scale were stuffed in two different casing sizes (45 mm and 75 mm). Sausages from pilot and lab scales were ripened at Agroscope and analyzed after 0, 1, 3, 7, 16 and 28 days on pH value, weight loss, water activity and moisture. For detection of lactic acid bacteria MR Agar (Biolife, I-Milano) and for detection of *Staphylococcus* and *Kokuria* MS Agar (Biolife, I-Milano) were used and incubated at 26 and 37 °C for 48 hours according to Comi *et al.* [1] (only 10 g sample instead of 25 g).

III. RESULTS AND DISCUSSION

The pH values seemed to be not affected by the different chamber sizes (Table 1). Only after day 1 pH of sausage in Agroscope chamber was significantly lower ($p<0.05$). The weight loss in industrial chamber was significantly higher ($p<0.05$) during the whole process, but effective differences were small. The final products had similar moisture contents (391 vs. 389 g/kg drying loss) and water activities (0.911 vs. 0.912). The microbial growth on the selected media were comparable in yield. Although there is a big difference in the chamber-dimensions (1:57 for fermentation and 1:354 for drying) the quality of the final products was almost the same, but drying process was slowed down in Agroscope chamber. The acidification process was similar for all three scales (Figure 1). After day 7 the raw fermented sausages with 45 mm diameter increased in pH faster which led to a higher final pH (pH 5.32 vs. pH 5.26, $p<0.05$). This could be explained by higher surface to volume ratio and the smaller diameter as moulds could better penetrate the whole sausage and accelerate the breakdown of lactic acid [2]. After 16 and 28 days there were no significant differences ($p<0.05$) in weight

loss between the three scales (75mm). Smaller diameter led to significantly higher weight loss after 16 and 28 days ($p<0.05$). Water activity decreased in a similar way for all scales. The sausages with smaller diameter dried faster which explains the more intense drop of water activity.

Table 1 Comparison of pH value and weight loss of raw fermented sausages depending on chamber size

	pH (n=3)		Weight loss [%] (n=3)	
day	Agroscope chamber	Industrial chamber	Agroscope chamber	Industrial chamber
0	5.73 ±0.00	5.73 ±0.00	-	-
1	5.36^{a}±0.00	5.39^{b}±0.01	0.00	0.00
3	5.24 ±0.01	5.23 ±0.00	3.56^{a}±0.03	5.54^{b}±0.24
7	5.22 ±0.04	5.16 ±0.01	10.26^{a}±0.25	12.00^{b}±0.15
16	5.20 ±0.02	5.23 ±0.02	17.01^{a}±0.33	17.81^{b}±0.23
28	5.18 ±0.03	5.20 ±0.02	22.33^{a}±0.42	23.22^{b}±0.32

Table 2 Concentration of different microorganism after 28 days

Scale	MR-Agar [cfu/g]	MS-Agar 26 °C [cfu/g]	MS-Agar 37 °C [cfu/g]
Industry	$3.11x10^{8}$	$1.38x10^{5}$	$9.06x10^{5}$
Pilot	$2.65x10^{8}$	$1.41x10^{6}$	$1.73x10^{6}$
Pilot 45mm	$3.00x10^{8}$	$9.74x10^{5}$	$1.49x10^{6}$
Lab	$3.20x10^{8}$	$7.24x10^{6}$	$2.26x10^{6}$

The concentrations of lactic acid bacteria on the different plates (Table 2) was comparable to the ones described by Comi *et al.* [1] and Garriga *et al.* [3].

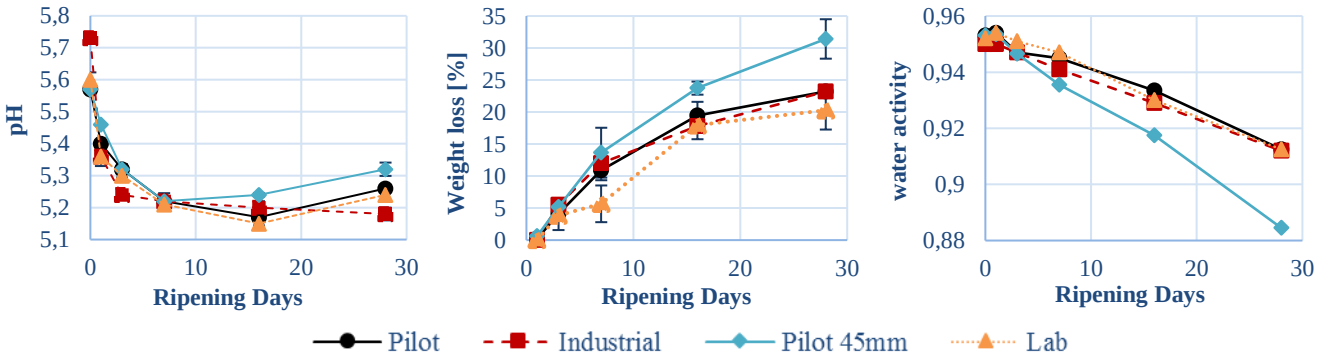

Figure 1. Comparison of pH-value (n=3) (left), weight loss (n=3) (middle) and water activity (n=1) (right) of raw fermented sausages in industrial vs. pilot vs. lab scale during ripening

IV. CONCLUSION

Final physico-chemical characteristics of raw fermented sausages and growth of starter cultures were not affected by chamber size, but drying process was slightly slowed down in the Agroscope chamber. The use of different equipment in the three scales seemed to not affect characteristics of the products. Smaller diameter of sausages accelerated the drying process and thus changed water activity and pH value. This could be explained by a higher surface to volume ratio. This study shows that it should be possible to draw conclusions from a smaller scale to an industrial scale, if recipe, drying parameters in chamber and dimensions of the sausage are equal. A smaller diameter of the sausage led to accelerated ripening. However it would be necessary to confirm the results of this study by another trial.

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