PHYSICOCHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF NEW FORMULATIONS OF DRY-FERMENTED SAUSAGES

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Abstract – Seven formulations of dry-fermented sausages (DFS) were elaborated using different proportions of lean meat, pork backfat, oleic sunflower oil, sodium chloride, potassium chloride and flavouring. Instrumental and sensory characteristics of each formulation were evaluated through instrumental and sensory analyses. Results showed that instrumental texture and colour parameters were not affected by partial substitution of sodium chloride with potassium chloride. But, they were significantly affected by fat level, oleic sunflower oil and by flavouring. Furthermore, it was found that healthier DFS formulation with good acceptability can be manufactured by replacing 30% of sodium chloride with potassium chloride and adding flavouring (garlic and pepper) and 3% of sunflower oil.

Key Words – dry-fermented sausage, flavouring, texture, colour, NaCl, KCl
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I. INTRODUCTION

Dry-fermented sausages (DFS) are important traditional meat products that are largely daily consumed in many parts of the world. Actually, manufacturing these products requires large amounts of sodium chloride (NaCl) and pork backfat, for which excessive intake has been linked to several human health problems such as hypertension and cardiovascular diseases. So, reducing salt and fat in these kinds of products could benefit human health. However, these reductions in DFS can provoke microbiological, technological and sensory problems, especially because these two components play critical functions during DFS manufacture. For example, salt is used since prehistoric times for food preservation. Also, it has a flavour enhancer function which increases the intensity detection of flavour and aroma. On the other hand, fat is involved in the texture and aroma of these kinds of products. For example, high fat content leads to softer and darker products [1] and higher levels of lipolysis and lipid oxidation which are very important for the production of volatile compounds, and thus for the final product sensory attributes such as flavour and aroma [2]. However, many strategies can be used to reduce NaCl and/or fat during dry-fermented sausage manufacture, such as replacing NaCl and pork backfat, respectively, by other kinds of salts and sources of fat. Thus, this study aimed to evaluate the effect of a combined substitution of salt and pork backfat, respectively, by potassium chloride (KCl) and oleic sunflower oil (SFO) and the impact of adding flavouring (garlic and pepper) on the instrumental and sensory attributes of different DFS formulations.

II. MATERIALS AND METHODS

DFS manufacture

As shown in Table 1, seven different formulations of DFS with three replicates were elaborated.

Table 1 Details of experiments giving all the formulations of dry-fermented sausages manufactured

Samples	Animal fat (%)	SFO (%)	NaCl (%)	KCl (%)	flavouring: Garlic powder (g/kg)	flavouring: Black Pepper (g/kg)
S1	21	0	2.8	0	0	0
S2	21	0	2.8	0	0.5	2
S3	21	0	2.0	0.8	0.5	2
S4	7	0	2.8	0	0.5	2
S5	7	3	2.8	0	0.5	2
S6	7	0	2.0	0.8	0.5	2
S7	7	3	2.0	0.8	0.5	2

For each formulation, about 30 DFS were manufactured as per the following procedure. Raw pork meat was purchased from a local distributor (DISTRIPORC, Clermont-Ferrand, France). When the pork meat was delivered, the water content, pH and water activity (a_w) of the pork lean were verified. The pork shoulder was then defatted and cut into small parallelepipeds. For each formulation, the corresponding amount of defatted pork shoulder and backfat was weighed, ground to 6 mm diameter, and mixed with the corresponding amount of NaCl, KCl, a set of additives and a mid-acidification kinetic starter culture (MF55, Biovitec, Lissieu, France) prepared at 100 kg/L concentration and added at 10 g/kg. Each meat batter was added with dextrose (5 g/kg), potassium nitrate (0.3 g/kg), potassium erythorbate (0.5 g/kg), black pepper (2 g/kg, except experiment S1), garlic powder (0.5 g/kg, except experiment S1) and finally the starter solution (10 g/kg). Note that incorporation of 3% total matter (TM) oleic SFO (previously stored at -2°C) into products of experiments S5 and S7 (Table 1) required prior preparation of an emulsion with lean pork meat and the addition of 1% TM wheat plant fibres (WF200, Rettenmaier & Son, Rosenberg, Germany) to bind the batter and minimize further oil loss in liquid form. Then, for each formulation, the meat batter was stuffed into 50 mm-diameter collagen casings. The raw sausages (450 g and 20 cm in length) were then plunged in *Penicillium nalgiovensis* solution to cover their surface during the drying stage. All products were steamed for 4 days at 24°C and 70% relative humidity (RH), then dried for 25 days at 13°C and 70% RH in the same ripening room.

Instrumental colour measurements

Colour was recorded using a spectro-colorimeter Konica Minolta CM 2500d (Japan) in CIELAB system (D65-10°-L*a*b*-d/8 SCE). The instrument was calibrated at 0 (in the air) and with white standard (n°7009694). Colour was measured on the top of DFS slices. The colour data represented in this paper are the average of 15 local measurements performed on the slices.

Texture profile analysis

Hardness and cohesiveness of DFS were first evaluated objectively through texture measurements performed on non-frozen 30×20×50 mm parallelepiped samples extracted from 29-day-old DFS. A TA.XT Plus universal texture analyzer (Stable MicroSystems Ltd., Surrey, England) was used to perform the texture profile analysis (TPA) test (Bourne, 2002) at room temperature. Each texture measurement was performed in 6 replicates.

Sensory analysis

DFS quality was also evaluated through a sensory analysis performed by 29 assessors with the objective of comparing consumer-panel acceptability of each formulation. Scoring was carried out by the 29 assessors, using a structured scoring scale (0–10). Eight samples were presented to the assessors. The first sample corresponded to the control formulation “S2’’and was designed only to habituate the assessors to the tasting task. The other 7 formulations corresponding to the 7 DFS formulations were presented to the judges in random order, and only their sensory evaluation results were analyzed statistically. Four DFS acceptability criteria were studied: appearance, texture, taste and aroma

Statistical analysis

Analysis of variance (ANOVA) was established to assess the effect of each factor - time, fat content, salt content, flavouring and the interaction between salt and fat (animal fat or SFO) - on each variable measured in this study. Post-hoc procedures were used when a significant effect was found ($p < 0.05$). Multiple comparisons among means were examined by the Tukey test to determine the level of significance between groups.

III. RESULTS AND DISCUSSION

Instrumental measurements

Results for instrumental lightness (L*) (least-squares means) are shown in Table 2. Both the fat level and flavouring had a significant effect on lightness (L*). As expected, the 21% animal fat formulations (Experiments S1 to S3) showed higher L* values than the other formulations (Experiments S4 to S7). Several studies have reported significantly higher L* values when fat level was increased in different kinds of DFS [3]. Concerning redness (a*), the highest values were obtained for the 7%-animal fat formulations without 3% oleic SFO (Experiments S4 and S6) followed by the 7%-animal fat formulations with 3% oleic SFO, thus highlighting a very highly significant effect of fat content on a* values ($p < 0.001$). This can be attributed to a higher myoglobin concentration in these products with higher amount of lean meat compared to the 21%-

animal fat formulations (Experiments S1 to S3). Yellowness (b*) values were also affected by the fat level and adding of SFO. Higher b* values were obtained for the 21%-animal fat formulations followed by the 7%-animal fat formulations with 3% oleic SFO, probably as a result of a higher unsaturated fatty acid content which would make them prone to oxidation and thus to colour changes [3].

Table 2 Instrumental colour measurement of each DFS formulation

Instrumental colour measurement			
Samples	a*	b*	L*
S1	9.2 ± 1.4^{a}	9.6 ± 0.8^{ab}	41.7 ± 4.8^{b}
S2	9.8 ± 0.8^{a}	9.7 ± 1.0^{b}	45.8 ± 2.5^{bc}
S3	9.9 ± 1.1^{a}	9.7 ± 1.7^{b}	47.2 ± 1.9^{c}
S4	12.2 ± 1.3^{b}	8.6 ± 1.4^{a}	36.0 ± 5.0^{a}
S5	11.5 ± 1.0^{ab}	9.6 ± 1.7^{ab}	35.3 ± 2.3^{a}
S6	12.6 ± 1.5^{b}	8.4 ± 1.4^{a}	34.2 ± 4.5^{a}
S7	11.9 ± 1.3^{ab}	9.5 ± 1.3^{ab}	34.4 ± 4.0^{a}
Significant factors ($p < 0.05$)	Fat SFO	Fat SFO	Fat Flavouring

Table 3 shows the values of three textural parameters (hardness, cohesiveness and elasticity) measured by TPA-testing. Regarding hardness, the highest values were obtained for the 7%-animal fat formulations (Experiments S4 to S7) compared to the 21%-animal fat formulations (Experiments S1 to S3), thus highlighting a highly significant effect of fat content on final DFS texture ($p < 0.001$). Also, adding vegetable oil (Experiments S5 and S7) clearly modified DFS texture, making them harder probably due to the use of wheat fibre during oleic SFO preparation or/and to higher weight losses during drying. Comparing Experiment S2 vs. Experiment S3 and Experiment S4 vs. Experiment S6 highlights a very limited impact of using KCl as NaCl substitute on DFS hardness. On the other hand, not adding flavouring (garlic and pepper) was detrimental to final DFS hardness (Experiment S1), probably due to under-acidification during the fermentation stage that led to visibly poor slice ability. Regarding cohesiveness, slightly lower values were obtained for the 21%-animal fat formulations (Experiments S2 to S3) than the 7%-animal fat formulations (Experiments S4 to S7). Nevertheless, statistical analysis found a significant effect of fat content ($p < 0.01$) but no significant effect of adding SFO, salt content or type of salt on final product cohesiveness. Regarding elasticity, analysis found the same patterns as for cohesiveness, i.e. slightly lower values for the 21%-animal fat formulations (Experiments S1 to S3) than the 7%-animal fat formulations (Experiments S4 to S7), but with statistical analysis indicating a highly significant effect ($p < 0.001$) of animal fat content on elasticity value. There was no visible or statistically significant effect of salt content, type of salt or adding SFO on DFS elasticity. Expect for hardness, our results were in good accordance with those of [3].

Table 3 Texture profile analysis of each DFS formulation

Instrumental texture measurement			
Samples	Hardness (N)	Cohesiveness	Elasticity
S1	37.6 ± 4.3^{a}	0.58 ± 0.02^{ab}	0.76 ± 0.004^{a}
S2	58.2 ± 5.4^{bc}	0.58 ± 0.03^{ab}	0.77 ± 0.003^{a}
S3	54.6 ± 3.9^{b}	0.56 ± 0.04^{a}	0.76 ± 0.003^{a}
S4	72.6 ± 6.1^{de}	0.60 ± 0.02^{b}	0.80 ± 0.008^{b}
S5	81.5 ± 6.2^{ef}	0.61 ± 0.02^{b}	0.81 ± 0.004^{b}
S6	67.7 ± 6.0^{cd}	0.61 ± 0.03^{b}	0.81 ± 0.005^{b}
S7	85.0 ± 8.5^{f}	0.60 ± 0.04^{b}	0.80 ± 0.002^{b}
Significant factors ($p < 0.05$)	Fat SFO Flavouring	Fat	Fat

Sensory analysis

Results for sensory analysis are shown in Fig.1. Except for formulations S1 and S6, the products of all other formulations were judged acceptable. In these formulations, acceptability scores for most of the criteria lay between 5.5 and 6.5/10. The products that scored highest on all the criteria corresponded to formulation S7 which contains (NaCl 2% + KCl 0.8% + animal fat 7% + SFO 3% + flavouring) and formulation S5 which contains (NaCl 2.8% + animal fat 7% + SFO 3% + flavouring), with slightly higher acceptability scores than for the control formulation (S2) which contains (NaCl 2.8% + fat 21% + flavouring). As reported previously, formulation S1 which corresponds to (NaCl 2.8%+ fat 21% + non flavouring) was considered mediocre with lower scores for appearance, texture, taste and aroma between 3.7 and 4.7/10 and for the formulation S6 which contains (NaCl 2% + KCl 0.8% + fat 7% + flavouring) which scored low on aroma.

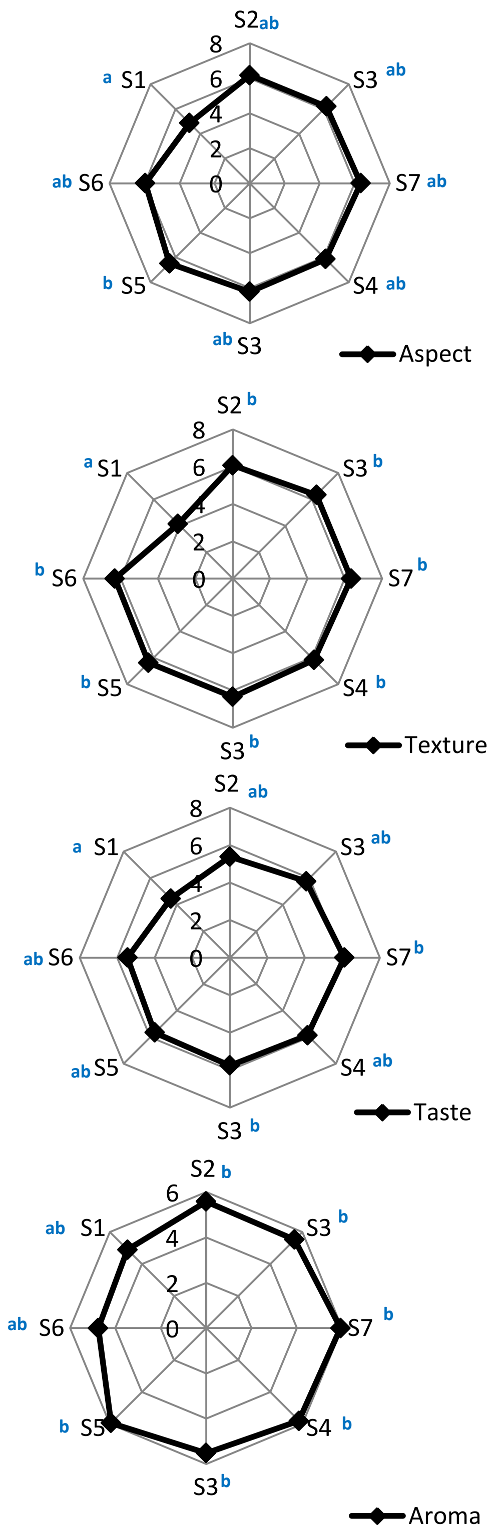

Fig 1 Acceptability of aspect, texture, aroma, and taste of the dry-fermented sausages of Table 1

There are several reasons for the large gap in acceptability of the non-flavoured formulation. Actually the absence of flavouring, especially of black pepper limited the acidification process, with a strong impact on final DFS texture and aroma.

Note that in all low salt and flavoured formulations, the flavour of the sausages was always found salty enough, or even too salty. This can be explained by the fact that garlic and pepper probably act a saltiness enhancer function, as the assessors made very frequently associated items such as “too salty and spicy».

IV. CONCLUSION

The present results clearly indicate that healthier DFS with good appearance (colour and aspect), texture and acceptability can be manufactured by replacing 30% of NaCl with KCl and using 3% oleic SFO, on the condition that flavouring was added (garlic and pepper). However, further flavouring solutions must be tested to take into account the eating habits corresponding to the other countries.

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REFERENCES

1. Muguerza, E., Fista, G., Ansorena, D., Astiasaran, I., & Bloukas, J. G. (2002). Effect of fat level and partial replacement of pork backfat with olive oil on processing and quality characteristics of fermented sausages. Meat Science 61(4): 397-404.
2. Corral, S., Salvador, A., & Flores, M. (2013). Salt reduction in slow fermented sausages affects the generation of aroma active compounds. Meat Science 93(3): 776-785.
3. Mora-Gallego, H., Serra, X., Guàrdia, M. D., & Arnau, J. (2014). Effect of reducing and replacing pork fat on the physicochemical, instrumental and sensory characteristics throughout storage time of small caliber non-

acid fermented sausages with reduced sodium content. Meat Science 97(1): 62-68.