REPLACEMENT OF PORK BACK FAT BY FUNCTIONAL GELLED EMULSION IN BOLOGNA SAUSAGE: TEXTURAL AND RHEOLOGICAL PROPERTIES

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Abstract – Emulsion gels (EG) were used to replace partial or total pork back fat (PB) in bologna sausage. EG were made with soybean oil, soy protein isolate, chia flour, inulin, carrageenan, sodium caseinate, and sodium tripolyphosphate and analyzed using shear force, texture profile analysis and dynamic rheological measurements. Sausages prepared with different gelled emulsions had greater hardness, gumminess, chewiness and shear force ($p<0.05$), and less cohesiveness and resilience than the control formulations. Batters of reduced-fat sausages presented elastic modulus lesser than no reduced-fat sausages ($p<0.05$). Treatments with addition EG and PB had values of the elastic modulus close to control formulation.

Key Words – emulsion gel, meat products, TPA, elastic modulus, shear force

I. INTRODUCTION

The substitution of backfat with vegetable oils in liquid form is highly challenging to improve the health properties of meat products, especially, emulsified meat products, since the mere substitution has an adverse effect, especially in texture properties, on the desirable quality properties for such foodstuffs [1]. Due that, new techniques as gelled emulsion for structuring liquid oils have been studied. An emulsion gel is defined as an emulsion with a gel-like network structure and mechanical properties similar to that of a solid [2]. Inulin and chia flour are added in foods as healthier and more functional ingredients, being consistently labelled as dietary fiber. The aim of this work was to evaluate the effect of the substitution partial or total of pork back fat by functional gelled emulsions on the textural and rheological properties of bologna sausage.

II. MATERIALS AND METHODS

Two treatments based on the protein source in the emulsion gels were elaborated: EG1 contained 5% Soy protein isolate (SPI), 1% sodium caseinate (CAS), 0.75% carrageenan, 0.5% sodium tripolyphosphate and 1% inulin. EG2 was made with 2.5% SPI, 2.5% chia flour and the same amount of the other ingredients added in EG1. In addition, both treatments were made with 51% soybean oil and 41% distilled water. The main steps to obtain emulsions gels were: heating of SPI and CAS with distilled water followed of adding of carrageenan, inulin, and sodium phosphate and mixing in GRINDOMIX GM 200 homogenizer (Retsch, Amsterdam, The Netherlands) at 10,000 rpm for 4 min. The oil was added gradually to the mixture of water, protein, and other components and homogenized for another 4 min. The samples were then vacuum packed in plastic containers and heated at 90°C for 30 min to gel the emulsion. Afterwards, they were stored in a refrigerated chamber at 2°C. Low-fat Bologna sausages were prepared according to the process described by Felisberto *et al.* [1].

Six treatments were evaluated: FC1 (20% of pork back fat-PBF); FC2 (10% of PBF); F1 (10% of PBF and 14% EG1); F2 (14% of EG1); F3 (10% of PBF and 14% EG2); and F4 (14% of EG2) containing 63% of pork meat, 2% of NaCl, 0.25% of sodium tripolyphosphate, 0.015% of sodium nitrite and 0.05% of sodium erythorbate. The sausages were analyzed regarding: Instrumental texture profile of the samples was performed using a TA-xT2i texturometer (Texture Technologies Corp., Scarsdale, NY) [3]. Oscillatory rheological tests were performed according to the methodology previously used [4]. The analysis was performed in duplicate. Experiment was conducted in duplicate. Data were evaluated by analysis of variance (ANOVA). When statistically significant differences were found, Tukey's test was performed at 5% significance level ($p<0.05$) using SPSS (version 17, SPSS Inc., Chicago, IL, USA).

III. RESULTS AND DISCUSSION

Sausage texture properties were affected by the substitution of pork back fat by gelled emulsions, as well as the pork back fat reduction (Table 1). The elasticity of FC1 did not differ from F1, F2, F3 and F4 ($p>0.05$), but was higher than that of FC2. The F1 treatment had the highest hardness value ($p<0.05$), possibly due to the fact that these sausages were formulated with EG1 (gelled emulsion with higher G') and also had the same fat content that FC1.

Table 1. TPA analysis (texture profile analysis) and shear force of sausages.

	FC1	FC2	F1	F2	F3	F4
H (N)	10.59±0.46[c]	6.16±0.44[e]	14.41±1.17[a]	8.50±0.65[d]	12.74±0.64[b]	6.90±0.42[e]
S	0.90±0.01[a,b]	0.88±0.02[b]	0.91±0.02[a]	0.91±0.01[a]	0.89±0.02[a,b]	0.90±0.03[a,b]
CO	0.84±0.01[a]	0.83±0.01[a,b]	0.82±0.01[c]	0.83±0.01[b]	0.82±0.01[b,c]	0.83±0.02[b,c]
G (N)	8.80±0.55[c]	4.92±0.69[f]	11.75±0.93[a]	7.04±0.52[d]	10.47±0.49[b]	5.71±0.38 [e]
CH (N	7.92±0.47[c]	4.35±0.60[f]	10.67±0.76[a]	6.39±0.48[d]	9.36±0.48[b]	5.15±0.40[e]
R	0.53±0.01[a]	0.52±0.01[b]	0.50±0.01[b]	0.51±0.01[b]	0.50±0.01[b]	0.51±0.02[b]
SF(N)	2.35±0.01[a]	1.75±0.02[b]	2.55±0.03[a]	1.86±0.02[b]	2.55±0.03[a]	1.67±0.01[b]

Equal letters in the same column are not statistically different ($p > 0.05$). H: Hardness; S: springeness; CO: cohesiveness; G: gumminess; CH: chewiness; R: resilience; SF: shear force; FC1: 20% PBF; FC2: 10% PBF; F1: 10% PBF, 14% EG1; F2: 0% PBF, 14% EG1; F3: 10% PBF, 14% EG2; F4: 0% PBF, 14% EG2.

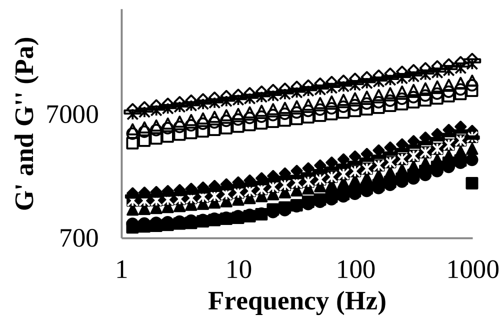

Figure 1. Storage (G'; open symbols) and Loss (G''; closed symbols) moduli as a function of frequency for FC1(◇ ◆) FC2(Δ▲) F1(✱ ✱) F2(○●) F3 (▭ ▬) and F4(□■)

FC2, F2 and F4 presented lower hardness compared to the other treatments, possibly because the substitution of fat wa compensated by the increase of water in the formulations. Sausages elaborated with EG1 (F1 and F2) were firmer and had higher values for chewiness than those elaborated with EG2 (F3 and F4). This result possibly occurred due to the higher G' value of EG1 since the water/protein ratio between F1 and F3 and F2 and F4 was the same. Shear force in sausage was higher for formulations with higher lipid content (FC1, F1 and F3), as well as in instrumental hardness, Table 1. Figure 1 shows the storage (G') and loss (G") modulus of the meat batters. In the frequency range studied, the values of G' were greater than G", characterizing the batters as viscoelastic solids.

It was observed that reduced-fat sausages (FC2, F2, and F4) presented G' lesser than no reduced-fat sausages (FC1, F1, and F3) ($p<0.05$) at 50 Hz. Treatments with addition gelled emulsions and pork back fat (F1 and F3) had values of the elastic modulus close to FC1, demonstrating that the three-dimensional network formed was similar between them, making them with a more solid characteristic than the reduced-fat formulations (FC2, F2 and F4). This result is in accordance with those obtained in the texture profile.

IV. CONCLUSION

This study demonstrated that the reformulation of meat products with restructured vegetable oils and functional ingredients may be a reliable strategy in the reformulation of these products, especially in texture properties, which are greatly affected when the oils are added in their natural form.

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