FRANKFURTERS FORMULATED WITH OIL BULKING AGENTS AS FAT REPLACERS

A.M. Herrero[1]*, C. Ruiz-Capillas[1], P. Carmona[2] and F.Jiménez-Colmenero[1]

[1] Instituto de Ciencia y Tecnología de Alimentos y Nutrición (ICTAN-CSIC). Madrid, Spain.

[2] Instituto de Estructura de la Materia (CSIC). Madrid, Spain.

Abstract –Proximate composition, processing loss and texture were analysed in frankfurters containing oil bulking agents based on polysaccharide gels as pork backfat replacers. A Raman spectroscopic study was also performed to determine meat protein structural changes induced by the reformulation process. Normal (NF-) and low fat (LF-) frankfurters were formulated with pork backfat (NF-PF and LF-PF) or olive oil bulking agent with dextrin (NF-A/D and LF-A/D) or inulin (NF-A/I and LF-A/I) as animal fat replacer. Processing loss and hardness values decreased in both normal and low fat samples when oil bulking agents where used as pork backfat replacers. These modifications were more pronounced when the oil bulking agent contained inulin. Enhancement of β-sheet structure was found in both normal and low fat reformulated frankfurter (NF-A/D, NF-A/I, LF-A/D and LF-A/I), especially in NF-A/I. This structural characteristic in meat proteins may be associated with specific processing loss and textural characteristics of frankfurters

Key Words – Raman spectroscopy, Meat protein, Texture

I. INTRODUCTION

One of the most important aspects in the development of healthier meat products concerns reformulation processes based on the replacement of animal fat with another fat whose characteristics are more in line with health recommendations [1]. In this regard, strategies have recently been proposed for incorporation of healthy oils in a gel-like matrix to form oil bulking agents (in which this new ingredient acts as an animal fat replacer) [2]. This process could offer new possibilities for improving the fat content of meat products. Polysaccharides, used either individually or in combination, can be used to create a variety of gel structures which may be suitable for immobilizing oil droplets and thus to act as oil bulking agents.

The possibilities of improved development of these healthier meat products depend on a better understanding of the complex relationship between the structure of their components and their technological characteristics. In that regard, Raman spectroscopy offers potential as a tool to understand this relationship, given its numerous advantages: it is non-invasive, it is capable of simultaneously providing structural information on the different components of the foods, and it requires only minimal amounts of sample [3-4].

The aim of this work was to examine quality changes in terms of technological and structural properties (using Raman spectroscopy) in healthier frankfurters formulated using olive oil bulking agents based on polysaccharide gels as animal fat replacers.

II. MATERIALS AND METHODS

Preparation of olive oil bulking matrices based on polysaccharide gels.

These olive oil bulking agent (A) were prepared according to Herrero et al. [2] by mixing sodium alginate (1%), $CaSO_4$ (1%), sodium pyrophosphate (0.75%) and dextrin (D) (2.25%) or inulin (I) (2.25%) with water (40%) in a homogenizer (Thermomix TM 31, Vorwerk España M.S.L., S.C, Madrid) to obtain the oil bulking agents A/D and A/I respectively. Each matrix was prepared in duplicate.

Preparation of frankfurters.

Different frankfurters were prepared as reported in Table 1: control normal-fat (NF-PF) and low-fat (LF-PF) formulated with meat and pork backfat (PF); four reformulated samples in which the pork backfat was replaced by an equal amount of oil bulking agent A/D or A/I to formulate normal (NF-A/D, NF-A/I) and low (LF-A/D, LF-A/I) fat

frankfurters. Frankfurters were prepared in duplicate according to Herrero et al. [4].

Table 1. Formulation (g) of frankfurters*.

Samples	Meat	Pork backfat	Olive oil bulking agent		Water
			A/D	A/I	
NF-PF	63.0	21.0	-	-	13.2
LF-PF	63.0	9.0	-	-	25.2
NF-A/D	63.0	-	32.5	-	1.7
LF-A/D	63.0	-	14.0	-	20.2
NF-A/I	63.0	-	-	32.5	1.7
LF-A/I	63.0	-	-	14	20.2

*Additives added to all samples: 2.0 g/100 g NaCl; 0.30 g/100 g sodium tripolyphosphate; 0.012 g/100 g sodium nitrite; 0.5 g/100g flavoring. *Frankfurters nomenclature: normal (NF-) and low fat (LF-) formulated with pork backfat (NF-PF and LF-PF) or olive oil bulking oil with dextrin (NF-A/D and LF-A/D) or inulin (NF-A/I and LF-A/I) as fat replacer.

Proximate analysis and processing loss

Moisture and ash contents of the frankfurters were determined [5] in triplicate. Protein content was measured in triplicate with a LECO FP-2000 Nitrogen Determinator. Fat content was evaluated in triplicate [6]. Processing loss of frankfurters (expressed as % of initial sample weight) occurring after heat processing and chilling overnight at 2 ºC was calculated in sextuplicate.

Texture Profile Analysis (TPA)

Six cylindrical cores (20 x 20 mm) from each formulation were axially compressed to 40 % of their original height. Hardness, cohesiveness, springiness and chewiness were calculated according to Herrero et al [4].

FT-Raman spectroscopic analysis.

Various Raman spectra were used for reference: heated pork backfat (PF) and polysaccharide matrices with olive oil (A/I and A/D). Heating was performed in a water bath at 70 ºC for 30 min. Spectra of frankfurters formulated according to Table 1 were also measured. Spectroscopic measurements were performed according to Herrero et al. [4].

Statistical analysis.

Analysis of variance (ANOVA one way) was carried out to evaluate the statistical significance ($P< 0.05$) of the effect of frankfurter formulation using Statgraphics Plus version 5.0.

III. RESULTS AND DISCUSSION

Proximate analysis and processing loss

Proximate analysis of frankfurters (Table 2) was consistent with the formulation (Table 1).

Processing loss of frankfurters ranged from 13.07 to 22.70 % (Table 2), with the highest processing loss values occurring in LF-PF, the sample with the highest level of water added. Values were lowest in normal fat samples formulated with A/D and A/I as animal fat replacers (NF-A/D and NF-A/I). Ranges of processing loss for frankfurters between 10 and 20 % have been reported [7]. Frankfurters reformulated with oil bulking agents, both normal (NF-A/D, NF-A/I) and low (LF-A/D and LF-A/I) fat, showed a significant processing loss decrease than their respective counterpart (NF-PF or LF-PF) formulated with animal fat (Table 2).

Table 2 Proximate analysis (%) and processing loss (PL, %) of frankfurters.

Samples*	Moisture	Fat	Protein	Ash	PL (%)
NF-PF	60.54 ± 0.24^{b}	20.38 ± 0.35^{a}	16.17 ± 0.54^{a}	2.90 ± 0.06^{c}	14.67 ± 0.68^{d}
LF-PF	71.70 ± 0.15^{a}	9.90 ± 0.31^{b}	16.05 ± 0.46^{a}	2.79 ± 0.05^{c}	22.70 ± 1.32^{a}
NF-A/D	60.57 ± 0.18^{b}	19.77 ± 0.29^{a}	14.99 ± 0.49^{a}	4.42 ± 0.02^{a}	13.81 ± 0.65^{e}
LF-A/D	72.13 ± 0.27^{a}	9.59 ± 0.22^{b}	15.46 ± 0.56^{a}	3.49 ± 0.01^{b}	18.95 ± 0.92^{b}
NF-A/I	60.86 ± 0.16^{b}	19.65 ± 0.36^{a}	15.23 ± 0.45^{a}	4.35 ± 0.02^{a}	13.07 ± 0.66^{e}
LF-A/I	71.88 ± 0.19^{a}	9.79 ± 0.30^{b}	15.36 ± 0.54^{a}	3.57 ± 0.04^{b}	17.60 ± 0.87^{c}

*Nomenclatures of samples are explained in Table 1. Means ± standard deviation. Different letters in the same column indicate significant differences ($P<0.05$).

Texture Profile Analysis (TPA)

TPA parameters are shown in Table 3. Textural behaviour was affected by formulation. All normal fat samples (NF-PF, NF-A/D and NF-A/I) presented the highest ($P<0.05$) hardness values, with the highest ($P<0.05$) values occurring in NF-A/D and NF-A/I. Reformulated frankfurters, both normal (NF-A/D, NF-A/I) and low (LF-A/D and LF-A/I)) fat, presented higher ($P<0.05$) hardness and chewiness than their respective normal- or low-fat counterparts made with pork backfat (NF-PF and LF-PF) (Table 3). Springiness was highest

(P<0.05) in all samples reformulated with olive oil bulking agents. Cohesiveness values were similar (P>0.05) in all samples. Our results are consistent with reports by some other authors, who have indicated that frankfurters reformulated using oil in a konjac glucomannan matrixh or with pre-emulsified oils as animal fat replacers showed greater firmness [7-10]

Table 3 Textural profile analysis (TPA) parameters of frankfurters.

Samples*	Hardness (N)	Springiness (mm)	Cohesiveness (dimensionless)	Chewiness (N×mm)
NF-PF	27.64 ± 0.40^{b}	6.66 ± 0.06^{b}	0.68 ± 0.03^{a}	121.9 ± 1.3^{c}
LF-PF	22.43 ± 0.52^{d}	6.69 ± 0.02^{b}	0.69 ± 0.01^{a}	98.9 ± 3.5^{e}
NF-A/D	28.46 ± 0.26^{a}	6.95 ± 0.04^{a}	0.69 ± 0.00^{a}	132.5 ± 1.2^{a}
LF-A/D	24.69 ± 0.52^{c}	6.97 ± 0.05^{a}	0.70 ± 0.01^{a}	117.3 ± 0.8^{d}
NF-A/I	29.83 ± 0.70^{a}	6.93 ± 0.07^{a}	0.69 ± 0.00^{a}	144.1 ± 1.2^{a}
LF-A/I	24.67 ± 0.19^{c}	7.01 ± 0.05^{a}	0.69 ± 0.00^{a}	121.3 ± 1.1^{c}

*Nomenclatures of samples are explained in Table 1. Means ± standard deviation. Different letters in the same column indicate significant differences (P<0.05).

FT-Raman spectroscopic analysis

The 800-1800 cm^{-1} spectral region was analysed to determine how meat protein structure was affected by changes resulting from reformulation. To that end, the corresponding spectrum of the heated polysaccharide gel oil bulking agent (A/D or A/I) was subtracted from the reformulated frankfurters by zeroing the bending =CH band located close to 1267 cm^{-1}, which is attributed to lipid molecules. Similarly, the heated pork backfat spectrum was subtracted from the frankfurters made with animal fat following the same criteria, in order to eliminate any spectral influence of lipids in this region (800-1800 cm^{-1}). The Phe ν-ring band located near 1003 cm^{-1} was used as an internal standard to normalize the spectra as it has been reported to be insensitive to the micro-environment [3-4]. The visible bands were assigned according to the literature [3-4].

The amide I band (1620 -1720 cm^{-1}) was used to study the structural changes occurring in the meat protein when pork backfat was replaced with olive oil polysaccharide matrices in the formulation (Fig. 1). This band includes mainly C=O stretching and, to a lesser extent, N-H in-plane bending of peptide groups [3-4]. The frequency changes in this Raman band were mainly indicative of changes in the secondary structure and variations in local environments of meat proteins. In general, the highest frequency values corresponded to normal fat frankfurter, both control and reformulated (NF-PF, NF-A/D and NF-A/I) (Fig. 1). Of these normal-fat samples, frequency upshifting

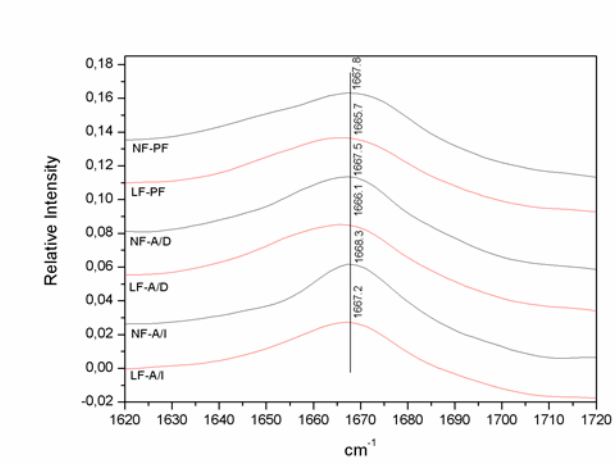

Figure 1. Raman spectra in the 1620-1720 cm^{-1} region from frankfurters. Nomenclatures of samples are explained in Table 1.

particularly from 1667.8 to 1668.3, was observed in frankfurters reformulated using the olive oil bulking agent with inulin (Fig. 1). This fact could be related to changes in the meat protein in terms of more β-sheet structure content in NF-A/I. A comparison of the amide I band of LF-PF and reformulated frankfurters (LF-A/D and LF-AI) revealed a shift of the absorption maximum from 1665.7 to 1666.1 cm^{-1} in LF-A/D and from 1665.7 to 1667.2 cm^{-1} in LF-A/I (Fig. 1). These spectral changes are indicative of alterations in meat protein structure consisting of increased β-sheet structure content due to the use of these olive oil bulking agents as animal fat replacer in the low fat frankfurters. As in the normal fat samples, this

change was more pronounced when the oil bulking agent content inulin.

The observed changes in meat protein secondary structure due to reformulation were accompanied by modifications in the processing loss and texture. Other authors have reported a similar correlation in meat batters prepared with different lipids as fat replacers [8, 11].

IV. CONCLUSION

The structural characteristics of meat proteins seem to play an essential role in some technological properties of frankfurters. Replacement of pork backfat with olive oil bulking agents produces an enhancement of β−sheet structure accompanied by decreased processing loss and stronger textural characteristics, specifically hardness, springiness and chewiness.

This relationship could lead to scientific and technological insights that would help to improve the development of healthier meat products in terms of lipid content and lipid profile.

ACKNOWLEDGEMENTS

This research was supported by projects AGL2010-19515, AGL2011-29644-C02-01, and Consolider-Ingenio 2010:CARNISENUSA (CSD2007-00016).

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