New Formulations for Low-Fat Frankfurters and its Effect on Product Quality

M. A. LURUEÑA-MARTÍNEZ, I. REVILLA and A. M. VIVAR-QUINTANA*

Area of Food Technology, University of Salamanca, E.P.S of Zamora, Zamora, Spain,
*E-mail: avivar@usal.es

Abstract: The effects of reducing fat level (9% and 12%), substituting pork fat with olive oil and adding locust bean/xanthan gum on emulsion stability, jelly and fat separation, cook loss, and hardness of frankfurters were investigated and compared with control sample elaborated with 20% of fat content. Results showed that addition of locust bean/xanthan gum produced a significant increase in hydration/binding properties, characterised by lower cook losses, increasing yield, better emulsion stability and lower jelly and fat separation. The substitution of fat pork by olive oil did not affect these parameters. Multivariate comparison between elaborated low-fat products and commercial frankfurters (normal and low-fat) were carried out using a factorial analysis. Results showed that addition of locust bean/xanthan gum results in products similar to commercial frankfurters with higher fat contents.

Keywords: xanthan; locust bean; olive oil, multivariate analysis; commercial frankfurters

INTRODUCTION

Low-fat meat products are desirable as they contain less calories and this positive effect could be further enhanced by substituting the added animal fat with vegetable oils as olive oil.

However, the role of fat is an important consideration in any formulation because it plays a major role in the texture, juiciness and flavour of comminuted meat products. Fat is vital in the rheological and structural properties of meat products and in the formation of a stable emulsion. Technological aspects associated with the processing of low-fat meat products include problems with texture, flavour and mouthfeel [1]. Approaches used to minimise problems related to fat reduction include the use of different systems like increasing the other raw materials (lean and/or water) or addition of fat substitutes. Fat substitutes are the most used [2] and within this group the most effective are hydrocolloids. Many studies have been carried out on hydrocolloids and their application in comminuted products, but galactomanan (as locust bean) and xanthan gum have received less attention. On the other hand, olive oil is the most important oil in Spain and its consumption has beneficial effects on human health [3, 4]. Therefore, the use of olive oil in meat products to replace animal fat could be beneficial to health. Regarding the above mentioned, the objective of this study was to evaluate the effect of using a mixture of locust bean/xanthan gum and replacing pork backfat with olive oil on the stability and quality characteristics of reduced and low-fat frankfurters.

Finally, a modification in production process generates some changes in properties of the final product that can be identified through chemometric modelling. Multivariate statistical analysis has proved its usefulness in the detection of both the most significant changes induced by different factors and those factors which best differentiate the samples. Then, this could be an interesting tool to find relationships between the experimental parameters and to establish differences among samples. In this case, factor analysis was applied to determinate if the low-fat frankfurters can be differentiate from the most representative commercial frankfurters.

EXPERIMENTAL

Samples manufacture. Four different frankfurter formulations (Table 1), about 3 kg each, were prepared in two separate trials from different meat sources. Fresh lean pork, pork backfat and pork dewlap were obtained from local meat-processing plants and frozen at –20°C until used. Also, olive oil (0.4°; Carbonell, Córdoba, Spain) was used. Meat and fat were thawed slowly (24 h, 4°C) to a temperature 0°C. Olive oil was frozen at –20°C the day before manufacture and tempered at 20°C for 30 min to reach –6°C in order to increase the oil viscosity.

Raw materials were chopped and ingredients were added in a bowl cutter (Talsa T-2473) in the following order: First, soy protein (SUPRO 500, Proanda, Sevilla, Spain) was added with a third of the ice (low speed). Lean, phosphates (Proanda) and salt 99.4% sodium chloride with 0.6% sodium nitrite (Merck, Germany) were added with a further third of the ice to facilitate protein solubility and produce the emulsion (chopped at high speed). Fat (or olive oil) was added with the rest of the ice. All ingredients were mixed until a homogeneous mass was formed. Finally, the other ingredients were added (low speed and temperature under 10°C): sodium lactate (Panreac, Barcelona, Spain); sodium ascorbate (Panreac); dextrose (D(+)Glucose, Merck); hickory smoke (Proanda); potato flour (Proanda); locust bean/xanthan gum commercial mix (Premigum XME-54, Premium Ingredients S. L., Murcia, Spain).

Immediately after chopping, the batter was mixed under vacuum (60 cm Hg) for 4 min [5]. After that, the batter was stuffed by a piston stuffer (Talsa H262A) into 22 mm diameter cellulose casings (Viscofan, Pamplona, Spain). Frankfurters were handlinked at 15 cm intervals, weighed, heat processed and smoked in a Eller smokehouse (model Unimatic Micro, Eller,) according to the following processing cycle: drying for 15 min at 55°C and 60% relative humidity (RH); smoking for 15 min at 60°C and 75% RH; and steam cooking at 75°C to an internal temperature of 72°C, monitored throughout by thermocouples inserted in the thermal centre of the sausages. The frankfurters were then showered to a temperature of 15°C, and chilled at 2°C overnight. After chilling, the frankfurters were weighed, peeled and vacuum packed (Tecnotrip V220) in pouches of polyethylene, then pasteurised in hot water at 75°C for 45 min, and afterwards cooled in cold running water for 15 min before being stored in the dark at 4°C for subsequent analysis (1st week).

Analysis. For chemical analysis representative samples from each treatment and commercial frankfurters were homogenised and analysed. Percentage fat (ether-extractable), protein and hydroxyproline according to standard AOAC (1990) procedures were determined. Moisture was determined using an infrared (IR) moisture analyser (Sartorius

Table 1. Frankfurters formulations

	Treatments: Percentage of fat and locust bean + xanthan gum			
Ingredient	20/0	12/0.5	9/0.6	Olive/0.5
Lean pork	35	40	45	40
Pork backfat	25	12.5	6.75	7.5
Olive oil	–	–	–	5
Ice	30	37.8	40.55	37.8
Polyphosphate	0.25	0.3	0.3	0.3
Nitrite salt (0.6% sodium nitrite)	1.6	1.6	1.6	1.6
Soya protein	2.65	2	2	2
Potato starch	3.5	2.5	2.5	2.5
Smoke	0.7	0.7	0.7	0.7
Sodium ascorbate	0.05	0.05	0.05	0.05
Dextrose	0.25	0.25	0.25	0.25
Sodium lactate	1	1	1	1
Locust bean/xanthan gum	–	0.5	0.6	0.5

MA100, Gottingen, Germany). All analyses were performed in duplicate.

Study of emulsion analysis was carried out by three methods. The jelly and fat separation was measured as described by Bloukas and Honikel [6]. The mean value of three cans was taken for each treatment.

The measure of emulsion stability was carried out according with the method proposed by Hughes *et al*. [7]. The volumes of total expressible fluid (%TEF) and the percent fat were calculated as follows:

TEF = (weight of centrifuge tube and sample) – – (weight of centrifuge tube and pellet)

% TEF = TEF/sample weight × 100

Cook loss values were determined using the following equation:

% cook loss = (weight before – weight after)/ weight before × 100

Texture of the cooked frankfurters (commercial and elaborated) was determined using a Texture Analyzer (Model XT2i; Stable Micro Systems, England) as described by Ordoñez *et al*. [5]. A 50 mm cylindrical cell was used to compress the frankfurter samples. Ten cores (diameter 2.2 cm; height 1 cm) were cut from each type of and axially compressed to 50% of its original height in a two cycle compression. Force-time curves were recorded at a speed 1 mm/s. The samples were prepared by immersion of the frankfurters in a water bath (15 min, 70°C). This procedure gives information on such attributes as hardness (g), springiness (mm), cohesiveness (dimensionless), gumminess (g), adhesiveness (g × mm) and chewiness (g × mm).

Statistical analysis. The statistical analysis of the data was carried out by factor analysis using principal components and working with standardised data with a view to avoiding the assignation of greater weight or influence to the variables with the highest absolute values. The selection criterion was to choose the number of factors showing an eigenvalue of greater than 1. The factors were subjected to Varimax rotation, which minimises errors and renders the factors orthogonal to one another, thus explaining the maximum variance of the data. Data was analysed by one-way analysis of variance (ANOVA). The statistical significance of each factor considered was calculated at the $\alpha = 0.05$ level using the *F*-test. The LSD Fisher-test was employed to test for statistically significant differences between samples. Statistical analysis was performed using the Statgraphic Plus program for Windows (Manugistics Inc. 1995).

RESULTS AND DISCUSSION

Jelly and fat separation, cook loss and emulsion stability are indicative of hydration/binding properties. Jelly and fat separation of the batters, (Table 2), was directly correlated to the locust bean/xanthan gum content with the highest levels of jelly and fat separation occurring in the controls. Jelly and fat separation of batters after heating was lowest in the higher locust bean/xanthan gum samples (0.6%) which means that the addition of this gum improves the water binding capacity of batter. Frankfurters prepared with olive oil had no significant differences in jelly and fat separation to those made with the same animal fat content.

Regarding emulsion stability, the presence of locust bean/xanthan gum caused a decrease in total expressible fluid (%TEF), statistically significant for the low-fat frankfurters. No significant differences were recorded when olive oil was added to the meat emulsion.

Results for the cook losses indicated that the addition of locust bean/xanthan gum had favourable

Table 2. Effect of fat and locust bean/xanthan gum level on quality properties of frankfurters

Treatment	% Jelly/fat separation	% TEF	Cook losses	Hardness
20/0	1.16^{c}	0.55^{b}	6.51^{c}	2060.0^{b}
12/0.5	0.67^{b}	0.43^{b}	1.56^{a}	2178.4^{b}
9/0.6	0.29^{a}	0.12^{a}	3.54^{b}	2171.1^{b}
Olive/0.5	0.63^{b}	0.43^{b}	1.74^{a}	1653.5^{a}

$^{a–c}$different letter means differences statistically significant at $\alpha = 0.05$

influence and caused a decrease in cook loss. The highest cook loss was in the control frankfurters (6.51%), while the lowest levels were in the low-fat frankfurters (9/0.6). Reducing the fat content of the frankfurters from 12% to 9% caused a significant increase in cook loss, but this was always lower than for the control sample. The addition of olive oil did not produce significant differences in cook losses compared with frankfurters made with the same content of animal fat.

No significant changes in hardness were recorded in the reduced fat frankfurters due to the replacement of fat by water when locust bean/xanthan gum was added to the emulsion. Olive oil addition together with fat reduction caused a significant decrease in hardness which could be due to the fact that monounsaturated fat has lower hardness at high temperature.

Multivariate analysis

Commercial frankfurters are characterised by its different composition and textural properties that makes difficult to establish correlations or classifications of the product, because it varies with the parameter considered. In this way, factor analysis, that is a method of multivariate analysis, is very useful because this method considers all parameters and samples together, it linearly transforms one set of variables into another set of fewer variables (factors) that conserve all the information of the original set, searches for associations among the variables, and is able to detect natural groups present in the samples when they are represented in the plain described by the calculated factors took two by two. After factor analysis of physico-chemical and textural parameters measured in ten commercial and four experimental frankfurters, four factors with an eigenvalue greater than unity were obtained, overall accounting for 87.3% of the total variance (Table 3). Since the factors were subjected to varimax rotation it can be assumed that the variables associated with the same factor are also more or less correlated with one another.

Factor 1, accounting for the 35.4% of the total variance was associate mainly with physico-chemical parameters and one textural property, cohesiveness. Moisture and fat are inversely correlated in this factor revealing that reduction in fat content is accompanied by increasing moisture level, remaining protein content constant. The high loading of %fat reveals that the major source of variability was due to the different fat content, because samples included normal and low-fat frankfurters. The positive correlation with cohesiveness points out that the higher the fat percentage the higher the cohesiveness of the frankfurter.

The factor 2 explained the 24.3% of total variance and grouped variables related with texture, especially with sample hardness. This fact shows that changes in formulations direct affects the hardness of frankfurters.

Table 3. Factor loading matrix after Varimax rotation

	Factor 1	Factor 2	Factor 3	Factor 4
Adhesiveness	–*	–	–	-0.820
Cohesiveness	0.476	0.4430	–	0.616
%Collagen	–	–	0.9643	–
%Collagen/%protein	–	–	0.7254	-0.444
Hardness	–	0.939	–	–
Springiness	–	-0.277	–	0.7522
Gumminess	–	0.948	–	–
%Fat	0.976	–	–	–
%Fat/%protein	0.934	–	-0.330	–
%Moisture	-0.983	–	–	–
Chewiness	–	0.979	–	–
%Protein	–	–	0.772	0.392

*values lower than 0.25 are not shown

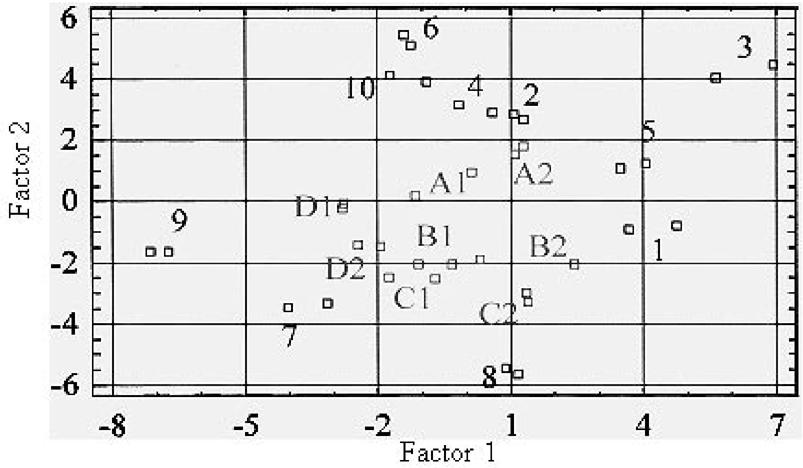

Figure 1. Sample distribution in the plain described by factors 1 and 2

Variables associated with Factor 3 (15% of total variance) were parameters related to protein content, because they remained more or less constant in the different formulations.

Finally Factor 4 was associated to adhesiveness, cohesiveness and springiness and with protein level, revealing that increasing collagen level and decreasing the protein content, the obtained product had less adhesiveness and springiness.

After analysis of obtained factors, the plot of the samples on the plane described by the two first factors was carried out (Figure 1). In this plot two groups of commercial frankfurters were observed, one of them included the low-fat frankfurters (group 1: numbers 7, 8 and 9) characterised by its lower fat percentage and hardness, an the other included the normal frankfurters (group 2: numbers 1, 2, 3, 4, 5, 6 and 10) revealing that factor analysis was able to detect the presence of groups among the samples studied.

Experimental frankfurters (A, B, C and D) constituted a third group of samples, situated between the two groups of commercial frankfurters because they have similar hardness than the normal frankfurters but with lower fat content. Within this group control frankfurters (A1 and A2) with positive coordinates in the factor 1, were closer to the group 2 due to the higher fat percentage, meanwhile frankfurters with olive oil (D1 and D2) with negative values in factor 2, were closer to group 1 due to the lower hardness of these samples.

CONCLUSIONS

The use of locust bean/xanthan gum was an effective additive for the reduced and low-fat frankfurters, because it increased the hydration/binding properties without affect the textural properties, and when pork fat is substituted by olive oil only a decrease in hardness is detected.

On the other hand, factor analysis revealed that experimental frankfurters are closer to the in the range of commercial frankfurters achieving its textural properties but with lower fat content.

References

[1] Keeton J.T. (1994): Meat Sci., **36**: 261.

[2] Giese J. (1994): Food Technol., **46**: 100.

[3] Tuck K.L, Hayball P.J. (2002): J. Nutr. Biochem., **13**: 636.

[4] Visioli F., Galli C. (1998): J. Agric. Food Chem., **46**: 1292.

[5] Ordoñez M., Rovira J., Jaime I. (2001): International J. Food Sci. Technol., **36**: 749.

[6] Bloukas J.G., Honikel K.O. (1992): Meat Sci., **32**: 31.

[7] Hughes E., Cofrades S., Troy D.J. (1997): Meat Sci., **45**: 273.