# Effect of fat and sodium reduction on instrumental and sensory characteristics of liver paste

Van Leuven I.[1], Goemaere O.[2], Steen L.[2], Dirinck P.[1] and Paelinck H.[2]

[1]Laboratory for Flavour Research, Catholic University College Ghent,
[2]Laboratory for Food Chemistry and Meat Technology, Catholic University College Ghent,
K.U.Leuven Association, Belgium

*Abstract*— **The objectives of this study were to evaluate the effect of fat and sodium reduction on the volatile composition and the textural characteristics of spreadable liver paste and to compare these instrumental results with sensory data. A control product and a reduced fat and sodium liver paste were analysed by instrumental analyses (gas chromatography-mass spectrometry (GC-MS) analysis, texture profile analysis (TPA), rheology and emulsion stability analysis) and descriptive sensory analysis. Instrumental and sensory data were statistical processed by analysis of variance (ANOVA) and correlated using Spearman's correlation coefficient. Results indicated a tremendous loss of texture and structure in the fat and sodium reduced liver paste compared to the control product. Spearman's correlation coefficient showed that the sensory attributes 'hardness', 'watery' and 'grainy' highly correlated with most of the instrumental textural characteristics.**

*Keywords*— **fat and sodium reduction, sensory analysis, instrumental texture.**

## I. INTRODUCTION

Several studies have shown the link between a high daily intake of fat and sodium and the increased risks for several health problems such as cardiovascular disease, certain types of cancer and overweight [1-2]. Processed meat products often contain large amounts of fat and sodium. Therefore the pressure on the meat companies to develop healthier products is rising. However fat and sodium (salt) play important roles in flavour, textural properties, water holding capacity and the overall acceptance of the product. Reducing the fat and salt level of food products without affecting product quality is of crucial importance to the food industry and requires profound research. Several studies [3-4] illustrate the effect of sodium reduction or fat reduction in some meat products (e.g. cooked sausages or frankfurters, hams, fermented sausages, beefburgers, salami) but few deal with the combined effect of fat and sodium reduction.

Spreadable liver paste, a typical Belgian emulsified meat product, is a standard example of a product with a high fat and sodium content. The Belgian meat industry is highly interested on the production of a low fat and sodium liver paste with similar sensory properties as the traditional one. Therefore, the objectives of this work were to evaluate the effect of fat and sodium reduction, respectively 40 % and 30 % reduction, on the aroma and textural properties of spreadable liver paste.

## II. MATERIALS AND METHODS

### *A. Production of spreadable liver paste*

The spreadable liver pastes were processed in the pilot plant of the research group 'Technology and Quality of Animal Products' (KAHO Sint-Lieven).

The liver paste products were prepared with the following raw materials: liver (30 g/100 g), bleached adipose tissue (40 g/100g for the control; 23 g/100 g for the fat and sodium reduced liver paste) and the broth obtained by bleaching the adipose tissue (30 g/100g for the control; 51 g/100 g for the fat and sodium reduced liver paste). The concentration of the salt and all the other additives and spices were calculated on the basis of total raw materials. The used amounts of sodium chloride were 18 g/kg for the control and 12 g/kg for the fat and sodium reduced liver paste.

The spreadable liver paste was produced by first separately pre-chopping and salting the raw liver in a bowl cutter (Stephancutter UM12, Germany). The prechopped liver was stored at 4°C until further processing.

Before the actual liver paste manufacture, the adipose tissue was scalded at 100°C during 20 min. Then the scalded hot adipose tissue, together with the broth, was cut and mixed during 5 min. in the cutter. Afterwards (when the temperature reaches 51°C), the (pre-salted) fine grounded liver was added together with the remaining spices and additives. All of the ingredients were mixed in the cutter during 3 min. at low speed and 70% of vacuum. This batter is subsequently, filled into cans, cooked at 76°C (core temperature 72°C) in a cooking chamber and finally cooled to 4°C to obtain the final product.

*B. Texture Profile Analysis (TPA)*

The texture of the liver paste was evaluated using TPA, as described in the work of [5]. Three cans of liver paste per batch were axially compressed to 40% of their originally height. A double compression cycle test was performed using a loadcell of 100 N and a cylindrical probe (diameter 6 mm) with a speed of 100 mm/min. The following texture parameters were obtained: hardness (IH), cohesiveness (ICo), springiness (IS), gumminess (IG), chewiness (IC), adhesiveness (IA).

*C. Rheology*

Rheological measurements were performed using an AR2000ex stress controlled rheometer (TA instruments, New Castle, US) equipped with a 40 mm crosshatched parallel plate-plate system. The gap between the plates was set to 1000 µm. Oscillation experiments were conducted at 4°C. All the rheological measurements were performed at least in duplicate. The length of the linear viscoelastic region (LVR) of liver paste was determined by performing a stress sweep between 1 and 10000 Pa at 1 Hz. Storage modulus (G'), loss modulus (G") and phase angle (δ) were obtained directly from the software (Rheology Advantage, TA version 5.7, UK). The complex modulus (rigidity) was calculated using the following formula: $G^* = \sqrt{(G')^2 + (G'')^2}$

*D. Emulsion Stability Analysis*

The emulsion stability of the liver paste products were quantified based on the procedure described in [6]. 30 g of the raw liver paste batter was poured in a pre-weighted centrifuge tube. The sample was heated in a cooking chamber for 30 min. at 70°C and centrifuged at 6000 rpm for 3 min. The supernatant, consisting of a mixture of water and fat, and the centrifuge tube with the remaining pellet were weighted separately. The percentage of total expressible fluid (TEF) was determined by the following formula:

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

% TEF = TEF/sample weight x 100

*E. Simultaneous Steam Distillation-Extraction-Gas Chromatography-Mass Spectrometry (SDE-GC-MS) profiling*

The volatiles of spreadable liver paste samples were isolated by SDE. This extraction technique was already successfully used for meat volatiles [7-8]. For each paste sample duplicate isolations of volatiles were performed.

Analysis of the different SDE extracts was performed using a HP 6890 gas chromatograph coupled to a HP 5973 MSD mass spectrometer (Agilent Technologies, Santa Clara, CA, USA) as described in the work of [7]. The SDE-GC-MS concentrations of the volatile compounds, expressed as ng/g paste, were calculated by relating the peak area of the paste volatile to the peak area of undecane as internal standard. The results should be considered as semi-quantitative.

*F. Descriptive Sensory Analysis*

Three production batches of paste samples were sensorially evaluated for 3 aroma ('odour intensity', 'liver-like' and 'spicy'), 2 taste ('taste intensity' and 'salty') and 4 textural ('creamy', 'hardness', 'watery' and 'grainy') attributes. The twelve panelists had to score on a 100 mm-unstructured score line which was scaled from 0 to 100 mm as fixed points. The panelists assessed the reduced fat and sodium paste against the control product for all the attributes.

*G. Statistical analysis*

Instrumental and sensory data were statistical analysed by analysis of variance (ANOVA). A correlation between sensory attributes and instrumental textural parameters was made using Spearman's correlation coefficient (ρ) (SPSS 17.0 (SPSS Inc., Chicago, IL, USA)).

## III. RESULTS

*A. TPA, Rheology and Emulsion Stability Analysis*

A large significant ($p < 0.001$) decrease in TPA-values is noticed (Fig. 1 a,b) when comparing the control and the fat and sodium reduced liver paste. These measurements illustrate a great loss of texture and structure of the reduced liver paste. Quantification of the rheological parameters confirms this result (Fig. 1c). Determination of the emulsion stability (Fig. 1d) additionally reveals poor physical constancy and could possibly reduce the shelf-life of the product.

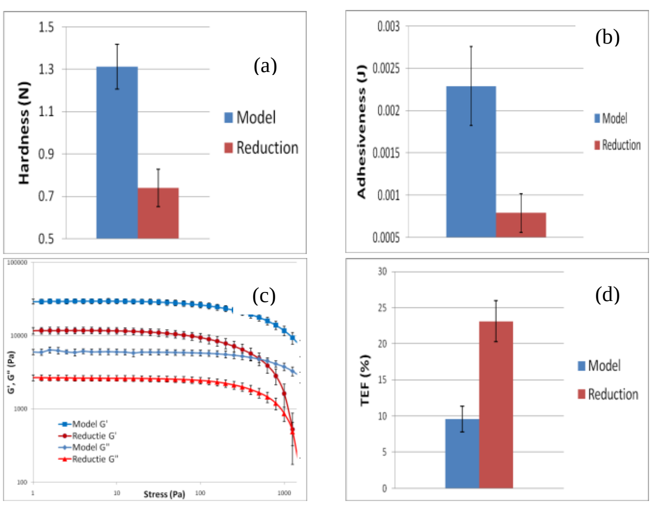


Fig. 1 Instrumental textural parameters of a fat and sodium reduced liver paste and a control product: (a,b) differences in IH and IA values, (c) elastic modulus G' and viscous modulus G" vs. oscillatory stress amplitude (f = 1 Hz) ,(d) change of the emulsion stability measured as the %TEF.

*B. SDE-GC-MS profiling*

The main difference between the volatile composition of the reduced fat and sodium paste and that of the control product was the level of terpenes, added to the liver paste to enhance the flavour of the product. The reduced fat and sodium paste was characterised by a significant ($p < 0.05$) higher level of monoterpenes (e.g. α-fellandrene, δ-3-carene and α-terpinene) and terpenoids (or oxygen containing terpenes, e.g. linalool, 1-terpinen-4-ol, α-terpineol, cis- and trans-sabinene hydrate), and a significant ($p < 0.01$) lower level of sesquiterpenes than the control product.

*C. Descriptive Sensory analysis*

A decrease of the fat and sodium content in liver paste resulted in a significant ($p < 0.001$) increase of the sensory attributes 'watery' and 'grainy', and a significant ($p < 0.05$) decrease of the attributes 'spicy', 'taste intensity', 'salty', 'creamy' and 'hardness'.

*D. Correlation between sensory and instrumental data*

Table 1 gives an overview of the correlation between sensory and instrumental textural data.

Table 1 Spearman's correlation coefficient (ρ) between instrumental and sensory textural characteristics of a control and a fat and a sodium reduced liver paste

| *ρ*[a] | *creamy* | *hardness* | *watery* | *grainy* |
|---|---|---|---|---|
| **IH** | 0.302* | 0.775*** | -0.686*** | -0.718*** |
| **ICo** | 0.496*** | 0.768*** | -0.640*** | -0.731*** |
| **IS** | 0.353** | 0.623*** | -0.528*** | -0.574*** |
| **IG** | 0.401** | 0.798*** | -0.702*** | -0.731*** |
| **ICh** | 0.404*** | 0.801*** | -0.699*** | -0.730*** |
| **IA** | 0.254* | 0.655*** | -0.629*** | -0.615*** |
| **TEF** | -0.385* | -0.853*** | 0.798*** | 0.757*** |
| **LVR** | 0.248* | 0.699*** | -0.626*** | -0.582*** |
| **G*** | 0.290* | 0.737*** | -0.639*** | -0.609*** |
| **δ** | -0.277* | -0.656*** | 0.638*** | 0.554*** |

a: statistical significance for $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***)

Statistical analyses showed good correlations ($-1 < \rho < +1$) between instrumental and sensory textural data. From the 4 sensory textural attributes, the attributes 'hardness', 'watery' and 'grainy' were highly correlated with the instrumental textural parameters. Sensory 'hardness' correlated highly positively with all TPA parameters (IH, ICo, IS, IG, ICh and IA), 'LVR' and 'G*'. A high negative correlation was found between sensory 'hardness' and 'TEF' and 'δ'. The sensory attributes 'watery' and 'grainy' correlated in an opposite way as sensory 'hardness' with the instrumental textural parameters.

## IV. DISCUSSION

TPA and rheological measurements showed a tremendous loss of structure/texture of the fat and sodium reduced liver paste compared to the control product. The reduction also led to a significant decrease of the emulsion stability. Salt has the ability to dissolve proteins which contribute to structure, water holding capacity and physical stability of meat products [9]. In emulsified meat products, such as frankfurters, the dissolved proteins form a film around the fat particles and so prevent the fat from escaping the meat matrix during cooking [10]. Therefore salt has a great influence on the overall product quality and consumer acceptance. Fat plays also an important role in this: it creates a certain body and contributes to juiciness, mouthfeel and spreadability of the product [11]. In the work of [12], they concluded a loss of juiciness, poor texture and an unacceptable flavour when 20% of fat was reduced in frankfurters.

The small differences in the GC-MS compositions reflect in the sensory results which were not significant for the attribute 'odour intensity'. A significant ($p < 0.05$) low score was obtained for the attribute 'spicy' for the reduced fat and sodium liver paste. This can be due to the low level of sesquiterpenes in this reduced product.

## V. CONCLUSIONS

As fat and sodium reduction of, respectively 40 % and 30 % in this liver paste mainly resulted in textural changes, improving the textural characteristics will be necessary. Therefore, the effect of (partial) replacing sodium by potassium, adding fat replacers or modifying some process parameters (e.g. chopping time, process temperature) on sensory and instrumental textural attributes will be further investigated.

## ACKNOWLEDGMENT

This work was supported by Flanders' FOOD and the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT-Vlaanderen).

## REFERENCES

1. ADA reports (2005) Position of the American Dietetic Association: Fat Replacers. J Am Diet Assoc 105:266–275
2. Karppanen H, Mervaala E (2006) Sodium Intake and Hypertension. Progress in Cardiovascular Diseases 49 (2):59-75
3. Carrapiso A (2007) Effect of fat content on flavour release from sausages. Food Chem 103:396-403
4. Ruusunen M, Puolanne E (2005) Reducing sodium intake from meat products. Meat Sci 70:531-541
5. Bourne M (1976) Texture profile analysis. Food Technol 32(7):62-66
6. Hughes E, Cofrades S, Troy D (1997) Effects of fat level, oat fibre and carrageenan on frankfurters formulated with 5, 12 and 30% fat. Meat Sci 45(3):273-281
7. De Winne A, Dirinck P (1997) Effect of feeding high vitamin E levels to pigs on the sensory and keeping quality of cooked ham. J Agric Food Chem 45:4309-4317
8. Dirinck P, Van Opstaele F, Vandendriessche F (1997) Flavour differences between northern and southern European cured hams. Food Chem 59:511-521
9. Desmond E (2006) Reducing salt: A challenge for the meat industry. Meat Sci 74:188-196
10. Pearson A, Dutson T (1997) Advances in meat research. Blackie Academic & Professional, London
11. Jiménez-Colmenero F, Cofrades S, López-López I et al. (2010) Technological and sensory characteristics of reduced/low-fat, low-salt frankfurters as affected by the addition of konjac and seaweed. Meat Sci 84(3):356-363
12. Atughonu A, Zayas J, Herald T, Harbers L (1998) Thermo-rheological properties and cooking yield of sausage-type products as affected by levels of fat and added-water. J Food Quality 21:129-143