TEXTURE FORMATION IN SEMI-DRY FERMENTED SAUSAGES: A REPRODUCIBLE PROCESS?

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Background

Dry (fermented) sausages are one of the most important groups of meat products. In 1998 production of raw dry sausages in the EU was 689,000 tons (Fisher, 1995). Main producers in Europe are Germany, Italy, Spain, France and Hungary. In The Netherlands production was 33,400 tons in 1996 (14% of total cured meat products excluding bacon). Dry sausages can be classified on several bases (Incze, 1990). Traditionally, dry sausages in Europe are manufactured with little or no sugar added. Since the second half of the last century fermented sausages have been manufactured with at least 0,3-3% carbohydrates added. These compounds are converted to primarily lactic acid by fermentation of (mainly added) lactic acid bacteria, which reduce the pH within a few days. The modern types of fermented dry sausage can be divided in two groups. Sausages that are long-ripened over 4 weeks (leading to a firm texture with mildly acidic, salty taste) and semi-dry sausages short ripened for between 7 and 28 days depending on the product diameter and less intensively dried (with a strongly acidic, salty, mild taste and a softer texture). Semi-dry fermented sausages (SDFS) have become very popular in Northern-Europe an the United States in the past 30 years.

The basic ingredients of SDFS are lean meat (pork and/or beef, and sometimes cooked rind), pork backfat, salt, sugars and spices (pepper, often cardamom, coriander, garlic). Blood can be added to intensify the colour of the cured sausage. An antioxidant (sodium ascorbate or ascorbic acid) is often added to help stabilise the colour and assist in preventing the formation of lipid peroxydes. Starter preparations such as a mix of lactic acid bacteria and *Micrococcaceae* are often used. Manufacture can be divided in three stages. In the sausage preparation period raw materials and ingredients are comminuted to form a batter. This mix is stuffed into casings. In the fermentation period (starting at a temperature of about 25°C) colour formation, acidification and gelation take place. In the subsequent ripening period in a climate room (reduced temperature, gradually lowered relative air humidity and decreased air circulation speed) the sausages are further dried and flavour development proceeds. Besides taste, colour and safety the textural characteristics of the sausage are important aspects of consumer acceptance. The formation of an adhesive bond between particles and the development of a firm structure are an important aspect of the quality of SDFS and are subject to variation. Consumers respond negatively to variation in quality. The major changes in structure take place in the first 48 hours, when meat is transformed into sausage. In this period pH declines, leading to the gelation of myofibrillar proteins. After gelation, drying is the additional factor affecting binding and rheological properties.

Approaches to consider an automatic control of the ripening process have been based on measurements of water and salt transfer (Daudin et al., 1992), of a_w-values (Stiebing and Rödel, 1992), of pH (Verlinden and Spriet, 1994), of weight losses (Kottke et al., 1996), and on sensory-related properties besides texture (Curt et al., 2002).

Objectives

The aim of this preliminary study was to assess and/or demonstrate the variation in texture occurring in SDFS, if products are repeatedly manufactured under pilot-plant conditions taking care in controlling as good as possible the materials/process factors known by professionals to affect final product texture. This kind of information is urgently needed, to provide reliable data to eventual designers of future (automatic) control strategies for fermentation and ripening processes of SFDS.

Methods

Spread over a period of 15 months fourteen batches of SFDS were produced according to a standardised manufacturing procedure, applying the same product formulation. The formulation was (in % w/w): pork shoulder (31.8), beef (27.8), pork backfat (27.8), ground cooked rind (7.9), nitrite containing salt –99.4%NaCl+0.6%$NaNO_2$- (2.7), pork blood (0.8), dextrose (0.8), ground white pepper (0.33), sodium-ascorbate (0.05) and starter preparation LS25® (Gewürzmüller, Stuttgart) (0.02). Pork shoulders and backfats were selected every 4-5 months by project workers in the slaughterline and 24h pm in a co-operating Dutch plant which guaranteed that the offered meats over this period were from genetically closely related gilts, fattened on the same diets. The granulated rind was obtained from the same meat provider and manufactured according to a strictly standardised procedure. For the beef homogenous lots of selected meats were stored at –30°C for a maximum period of about 9 months; pork materials were stored at the same temperature. Batters (batches of 12.6 kg) were made by using tempered meats (about –4°C), rind (approximately +5°C) and backfat (-18°C). Pork meat, beef and rind were cut in a 60 litres Laska bowl chopper with 6 (freshly sharpened) knives, pre-cooled with ice. The meat was chopped at medium high speed for 90s and meanwhile starter preparation, blood, sodium ascorbate, dextrose and pepper were added. The machine was stopped and pork backfat was distributed over the mix. Then the mix was chopped further at medium high speed for 80s and finally 20s, after the addition of salt. The batters were de-aerated in a 200 l vacuum bowl with a double mixing arm. Mixing under vacuum was done for 90s, in this period at fixed times the arm was operated twice for 15s. Final batter temperature was approximately –3°C. The batter was stuffed in cellulose fibre casings with a Handtmann VF50 machine using a 28 mm filling tube. The stuffing pressure was between 30 and 35 bar, at the prescribed speed. The casings (diameter 58 mm) were pre-soaked in hand-warm water. The filling process was restrained by hand by a professional who also bound the sausage with a string. Fresh sausages weighed about 1 kg. Fermentation and ripening were performed in an Alpas Monopol cabinet with an intermittent air speed between the sausages varying between 0.2 and 0.8 $m.s^{-1}$. Process details are in Table 1. During this process, variations in temperature were ± 0.2°C and in R.H. ± 2%. After 3 days, smoke was applied for 5 min using an Alpas smoke generator.

At fixed process times various chemical and microbiological analyses were performed. Moisture losses, pH- and a_w-values were recorded and intermediate and final products were judged by a especially trained sensory panel. At pre-determined time intervals after batter manufacture, uniaxial compression tests were performed with an Adamel Lhomargy DY-20B instrument. Cylinders excised from the core (height 20 mm, diameter 19.5 mm; tempered at 15°C) were compressed with a speed of 50 $mm.min^{-1}$. Force-time curves were recorded. From these stress at fracture, strain at fracture (ln of the ratio between initial and ultimate height at fracture) and compression modulus ($stress.strain^{-1}$ at small deformation; strain= 0.05) were derived. At least 7 successfully sampled cylinders per sausage were measured.

Sensory assessments comprised cohesiveness of slices, hardness and firmness. Cohesiveness of slices (thickness of 2 mm) was judged by lifting a slice and gently shaking it. Hardness can be described as the force needed to break the sample between the molars. Chewed is once only and a score between soft and hard is given. To assess firmness an entire sausage is compressed between two hands radially and a score between soft and firm is given. For the sensory parameters scales from 0 to 10 were applied.

Results and discussion

Table 2 summarises the major observations on the process and the produced sausages which appear specifically of relevance to structure/texture formation. Despite a careful standardisation of both product formulation and control of the manufacturing process, considerable fluctuations of the various measured parameters were observed. Separate statistical analyses were performed to assess whether certain known variations had significantly affected the measured outcome. Variation in beef stock had no effect on the rheological data, nor on the decreases in time of the pH-values. Sausages in which pH decreased below 5,00 within 24h, did not show different rheological data after 9 process days compared to batches with pH_{24} values above this pH-level. Product batters with relatively low temperatures at stuffing (border level arbitrary set at –3.5°C), did not show differences between rheological measurement data after 9 process days, nor on the sensory assessed values compared with products showing temperatures at stuffing above the given level. Products which showed a weight loss of 20% in less than 9.5 days, did not show differing rheological measurement data after 9 process days, compared to data of the products showing inferior drying rates. The colder batters at stuffing (temperatures below the arbitrary set level of –3.5°C) did not show a differing acidification pattern as the warmer products at stuffing, nor did this measurably affect the time at which a weight-loss of 20% was obtained. Overall, the major sources causing the considerable variations still remain unclear.

In conclusion, the observed variations were greater than expected. A better control of the major sources causing such variations appears of prime importance, if adequate control strategies for SFDS processing are to be designed. A first study aiming to determine the contribution of single processing factors to the formation of an SFDS structure during the initial sausage preparation stage and in particular during the period of acid formation and protein gelation, was a multifactorial study involving dispersion modelling (Van 't Hooft, 1999). Subsequent studies appear indicated now to focus more on the ripening process.

Pertinent literature

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Acknowledgements

The authors gratefully acknowledge the enthusiastic interest in the work and the skilled assistance of Hanne L.M. Tjeerdsma-van Bokhoven, Annette A.M. Spanjer and Gert Keizer. This study was partly financed by Senter at The Hague.

Table1. Climate conditions during fermentation and ripening

	Temperature (°C)	Relative Humidity (%)
Day 0	25	96
Day 1	23	93
Day 2	20	90
Day 3	18	86
Day 4-14	16	82

Table 2 Overview of measured values

	Mean ± S.D.
Batter temperature (°C) at stuffing (n=13)	-3.0 ± 1.00
Acidification	
pH_{24h} (n=11)	5.10 ± 0.338
pH_{48h} (n=14)	4.60 ± 0.109
pH_{216h} (n=12)	4.59 ± 0.057
Weight-loss of 20% reached after estimated number of days (n=14)	9.3 ± 1.01
Rheological measurement data after 9 process-days	
Stress (kPa); (n=14)	96.4 ± 26.43
Strain (-); (n=14))	0.95 ± 0.057
Compression Modulus (kPa); (n=14))	192 ± 53.2
Sensory observation data after 9 process-days	
Cohesiveness slices (n=11)	6.0 ± 1.14
Hardness (by biting) (n=11)	5.4 ± 0.83
Firmness (by hand compression) (n=11)	5.2 ± 1.10