COMPARISON OF MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*) FERMENTED SAUSAGES WITH MORE COMMON SALAMI PRODUCTS FROM PORK AND BEEF

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Introduction

Whaling has a long tradition in some countries. Whale meat is still consumed in certain countries and regarded as a special and traditional treat. Minke whale hunting is today recommended by Norwegian Authorities due to its high abundance. Most whale recipes describe simple processing (http://www.80dager.no/hval) involving frying the meat as a steak. In Norway processing of Minke whale meat into fermented sausage has not been widely commercially exploited. No publication exists on the quality of this product compared to products produced in accordance with the "Norwegian Salami Technology". The aim of this study was to compare Minke whale salami with more common Norwegian fermented sausages produced from pork and beef-pork.

Materials and Methods

Minke whale meat was collected late June at the end of the catching season. The meat was vacuum-packed and frozen until the fermented sausages were produced in mid-September. Frozen pork and beef meat were used, and salami minces were produced according to standard production routines (Skjelkvåle *et al.*, 1974). A standard recipe (for pork) is given in Table 1. Smoking was carried out on the 3rd day after production. All recipes had the same initial protein, fat and water content. The starter culture was Biocarna ferment CXK (Danisco, Denmark) containing *Staphylococcus carnosus, Staphylococcus xylosus* and *Lactobacillus sakei.* The fermentation kinetics were recorded with continuous pH loggers (L, Table 2) inserted in the raw batters at 20°C. The fermentation is thus accelerated, since the temperature was not reduced. The acid production was calculated from logger and titration data. Lag time, maximum production rate of lactic acid as well as ripening due to base production ($pH = ae^{bt}$, where b is a measure of base production and a is a constant) were calculated. The sausages were withdrawn at intervals during the fermentation and their pH and moisture loss determined. The fermented sausages were produced three times with three different batches of raw materials. The sausages were removed from the chamber after approx. 30% weight loss, vacuum-packed and kept at 4°C until analysed approx. 3 weeks later
(-40°C and 20 weeks for GC-MS). **Water activity,** a_w, was measured at 25°C (± 1°C) after about 2-hrs equilibrium (AquaLab model CX-2, Decagon Devices Inc., Pullman, Washington, USA). **Organic acids** were analysed by HPLC as described by Skeie *et al.* (1997). **Accelerated rancidity** was induced in sausage slices, covered by a transparent film, using fluorescent light for 17-20 days before thiobarbituric acids were analysed in accordance with Tarlagdis *et al.*, (1960). **GC-MS**: Static headspace was measured on samples (headspace to sample 1:2) preheated to 50°C. GC was performed with an Agilent Technologies 6890 N, in combination with an Autospec Ultima (Micromass, Manchester,UK) mass spectrometer with EBE geometry, operated in EI mode at 70eV. The column (CP-WAX 52 CB, 30 m, ID 0.32 mm and DF 0.50µm) was run at 200°C. The results are reported as number of compounds identified (in % of total numbers). **Statistics:** Minitab version 14 (Minitab Inc., Pennsylvania, USA) was used for one-way ANOVA, for testing for equal variances (Bartlett's test) and for descriptive statistics.

Results and Discussion

The recipes (Table 1) were all with pork back fat as the major fat source. The lean meat originated from three different species. The general pattern of pH change involves first a lag phase, thereafter a decline in pH to a minimum value followed by an increase in pH. No arrest in base production during the ripening phase was observed, *i.e.* during logging pH increased exponentially post-acidification. The average pH drop was 1 unit using 0.7% sugar (Table 2). Whale meat tended towards the lowest drop ($pH_{min} - pH_{init}$). This suggests that whale meat has a higher buffer capacity than beef-pork or pork. The evaporation of water tended to be highest for pork meat. This appears due to pork's lower ability to bind water, as reflected in the moisture loss. Most common lag times were 20-27 hrs. Longer lag times were observed for one of three batches of whale and beef-pork. This is evident from the significantly larger standard deviation for lag time of the sausages from these two species (Table 2). This might be due to difficulties in establishing the lactic acid bacteria as the dominant bacteria. Once established, the acid production stopped at a final value of about 11 - 12 gram of lactic acid *per* kg of the initial wet weight (Table 2). The acid production rate was highest in the pork meat. The glucose level dropped to 0.1-0.3ppm in the final products (not shown). Only the whale sausage contained a substantial, but variable among batches, amount of acetic acid. With respect to the other organic acids analysed *i.e.* citric, orotic,

pyruvic, succinic, formic, uric and propionic, only succinic acid was present above 0.5 g/kg in the raw batter, but was later metabolised by the bacteria (Table 2). The slowest production of base equivalents took place in the beef-pork sausages. This increase in pH during ripening is generally regarded as important for flavour development (Toldra, 2002). The final pork sausages were all accepted according to the Norwegian salami standard and were not regarded as oxidised (not shown). However, the accelerated test for oxidation induced extensive oxidation in all products. Most pronounced oxidation was present in Minke whale sausage due to its high myoglobin content. The gas chromatographic run differentiated between the three samples (Table 2). The most frequent aldehyde in the headspace of the whale sausage was decanal that originates from lipid degradation.

Conclusion

Salami sausage characteristics of Norwegian salami and Minke whale sausages had largely the same fermentation characteristics. The Minke whale sausage would benefit from slightly more sugar in order to obtain the same pH drop as in the more traditional salamis. The largest variation in lag time and amount of acetic acid produced was observed for the whale material. Minke whale has a high base production capacity that might be utilized to optimise flavour development. The shelf life of the sausage is limited due to its high amount of the pro-oxidant myoglobin even when pork back fat is used as fat source.

Table 1: A standard pork sausage recipe.

Raw materials/ingredients	Amount (g)
Pork 6% fat	7,570
Pork back fat	2,000
Ascorbic acid	5
NaCl	100
Salt (0.6% $NaNO_2$)	220
Spices incl. garlic	30
Starter culture	10
Glucose	70
Sum	10,000

Table 2: Kinetic and flavour characteristics of the sausages (S=sausage; Raw batter=RB; L=logger data obtained on RB). The standard deviations given are the standard deviations of different productions. Significantly different mean values ($p<0.05$) are indicated with letters a, b and c. The letters x, y reflect data with unequal variances ($p<0.05$).

	Whale	Pork	Pork-beef
Initial pH-RB	5.68±0.14	5.60±0.15	5.56±0.04
Minimum pH	4.71±0.13	4.51±0.11	4.44±0.10
a_w-S	0.905±0.005	0.891±0.014	0.904±0.008
Moisture loss(%)-S	30.9±1.7	31.6±2.5	30.6±1.7
Lag phase(hrs)-L	38^{x} ±12	23^{y} ±4	27^{x} ±9
Acid production-doubling time (hrs)-L	$7.1^{a,b}$ ± 1.0	5.3^{a} ±1.1	8.0^{b} ±0.7
Base eqv.*(1/hr)-L	0.012^{a} ± 0.002	0.012^{a} ± 0.002	0.0072^{b}±0.002
Lactic acid(g/kg) RB⇒S	8.4⇒11.0±2.1	5.0 ⇒11.4±0.9	5.4 ⇒12.1±0.5
Acetic acid (g/kg) RB⇒S	0.16⇒1.2^{x}±0.7	0.0⇒0.19^{y}±0.03	0.0⇒0.22^{y}±0.03
Succinic acid (g/kg) RB⇒S	0.66^{a}⇒0.09±0.03	0.60^{a}⇒0.14±0.05	0.96⇒0.12±0.04
TBARS* (mg/kg) RB⇒S	0.8⇒22.8^{a}±2.1	0.9⇒6.7^{b}±0.8	0.3⇒11.4^{c}±0.2
GC-MS**-% acids	64	35	47
GC-MS-% aldehydes	27	18	Not identified
GC-MS-% alcohols	Not identified	18	24

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