EFFECTS OF FEED COMPOSITION ON CHEMICAL AND SENSORY CHARACTERISTICS OF PORK LOINS DURING FROZEN STORAGE

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Keywords: pork quality, processed food waste, sensory evaluation, fatty acids, frozen storage.

Background and objectives

Appropriate quality and consistent storage stability of products are important to ensure competitiveness and high consumption of pork. Throu intensive selection for feed efficiency and reduced fatness the Norwegian pig population has become leaner than most breeds elsewhere (Kjos 1995). Lean pigs generally have a higher proportion of unsaturated fat, a feature further accentuated by feeding rations high in unsaturated fat (Wood, 1984). Traditionally, fish meal and offals from fish processing industry have been available and used as supplements in pig feed. The use of "processed food wastes", which include a variety of byproducts from food processing and catering industries, may also contribute to the variation in fatty acids composition of the pigs tissue. High proportions of unsaturated fat causes the fat to be more susceptible to oxidation, w ensuing rancid flavour (Kjos, 1995). Hertzmann (1988) found that the content of the C22:6 docosal hexane fatty acid (DHA) in pork fat is a good indicator of the amount of polyunsaturated marine fat in the feed. Consumer and industry reactions revealed the need for investigation o pig meat quality.

The objective of this study was to chart the quality of pork, and to find quality criteria for controlling the development and securing the quality through the production chain.

Materials and methods

In two periods (August 1995 and January 1996) 177 commercial carcasses (mainly Norwegian Landrace and NL-crosses) were randomly selected (M1)from five slaughterhouses and analysed for chemical and sensory properties (Table 1). In addition, samples from pigs fed special diets were selected: 21 fed 80% or 100% processed food waste (M2) and 15 fed "swill" (M3) which is food waste without prior processing or standardisation in a plant. M. *longissimus dorsi* were cut in chops and wrapped in polyethylene bags before storing at -20 to -25°C. Sensory analysis was preformed by a panel of 9 well trained assessors using a descriptive test (ISO-6554-1985E). The intensity of 16 sensory attributes were evaluated, of which 11 were selected and presented in Figure 1. Loin samples were analysed for ultimate-pH, fatty acid composition and intramuscular fat content. Thiobarbituric acid reactive substances (TBARS) and sensory properties were determined after 1, 4 and 8 months frozen-storage. Statistical analyses were preformed by SAS and Sysdat, and significance differences between any two groups were determined by Student's t- test.

Results and discussion

The overall sensory profile of the random samples stored for 1, 4 and 8 months pork is given in Figure 1. The loins are rated high in tenderness (parameter no.10), and correspondingly low in toughness (11), but rather low in juiciness (9). These parameters were relatively unaffected by length of storage. The low values of intramuscular fat (ave. 1.4%, var. 0.3-3.7%), and low ultimate pH (ave. 5.44, 50% of samples ≤ 5.4), may both contribute to the low juiciness scores. Judging from the flavour and the juiciness of the pork, the recommended intramuscular fat content is 2% (Cheah et al., 1995). Low ultimate-pH values affect the ability to bind water, and thus the economic return for the meat industry. Low pH is associated with the RN-gene in Hampshire breed (Enfält, 1997), but this breed is not represented, and the presence of RN-gene has not been investigated in the Norwegian pig-population. The lower the pH value of the meat is, the faster the fat will hydrolyse (Honkavaara, pers. com., 1995).

As indicated by both sensory panel scores and an internal consumers test, Norwegian pork loins receive overall acceptable meat flavour and odour ratings (3 & 4) initially (1 month), but meat flavour and odour scores decreased significantly during further frozen storage. This deterioration in flavour and odour during storage were accompanied by significant increase in scores for divergent (5 & 6) and rancid (7 & 8) flavour and odour. This was further substantiated by average TBA-values of approximately 200 already after 4 months, which indicate early developing rancidity. This early fat oxidation might be a problem, as "freezer-life" of pork has been set to maximum 6 months in Norway. The degree of rancidity (7 & 8) varied considerably between samples, and some samples were definitely rancid (Intensity 8) even at 1 month storage. Our studies confirm that particularly extreme diets, e.g. waste from fish industry, contain high level of marine fat, will result in high marine fatty acids in fat tissue and deviating flavour and rancidity at an early stage of storage. There were significant differences between abattoirs ($p<0.05$) in the randomly selected samples for the properties meat flavour, and rancid and deviating flavour. Randomly selected samples from one abattoir, and some selected extreme samples from swill-fed pigs in particular, were negatively distinguished, by low meat flavour and high deviating and rancid flavour scores.

Pigs fed food waste (M2) were rated equal to or in lower range of the random sample (M1) for storage stability and most quality parameters, that are likely to vary with content of marine fatty acids in the feed. The pigs fed food waste (M2) appear to have better meat quality than the extreme swill-fed pigs (M3). The pigs fed food waste (M2) were inferior in meat quality, compared to random samples (M1) from the same abattoir, at all sampling times. Pigs feed food waste had a significantly ($P<0.05$) higher meat percentage (58.7 vs. 57.0%), content of "unknown" (not defined) fatty acids (7.0 vs. 3.4%), intramuscular fat (1.8 vs. 1.4%) and tenderness than pigs fed commercial concentrates. On the negative side, pigs fed food waste had significantly ($P<0.05$) lighter meat colour as determined by Hennessy grading system (GP2Q), and a higher divergent and rancid flavour (5.5 vs. 4.3) deemed by sensory analysis after 8 months storage. Commercial concentrates also contain a certain amount of marine fatty acids, as fish meal is normally added, with a recommended maximum level equivalent to 3 g marine fat per kg concentrate. At present the recommended maximum level of food waste is 50% (FEg, net energy), supplemented with a specially composed concentrate. This implies that feeding too large amounts of food waste, containing a high percentage of polyunsaturated fat (ave. 13%,var. 6.0-

20.7%) and marine fatty acids, is likely to result in inferior quality and storage stability. The levels of C22:5 and C22:6 were 0.31% (STD=0.18) and 0.34% (STD= 0.28) respectively. The total level of these fatty acids (0.65%) were higher than the level (0.5%) recommended by Tuominen (pers. com., 1995) to avoid problems related to lipid oxidation. This omega 3-fatty acids give more characteristic, identifiable rancid flavour than other fatty acids (Rødbotten & Holten, 1993). This was also shown in our survey, where C22:5 + C22:6 levels of approximately 3%, resulted in very rapid development of rancid taint. The correlation between the relative content of C22:5 and C22:6 and rancid flavour scores was fairly high (r = 0.7 - 0.8). According to Øverland et al. (1996), fish oil in the feed (3 %) resulted in significant increase ($p<0.001$) in the concentrations of C20:5n-3, C22:5n-3 and C22:6n-3 fatty acids in subcutaneous fat and muscles, and increased off flavour.

The panel also characterized divergent flavour, as e.g. "pig flavour", referred to as the smell of live pigs, piggery and slaughterhouse. Our experience indicates that this unpleasant flavour and odour largely reduces the appetite for pork. The cause and extent should be further investigated.

Conclusions

The composition of the pig feed has a definite influence on fatty acid content in pork fat. The overall proportion of polyunsaturated fatty acids and content of marine fatty acids in the fatty tissue in Norwegian pork, is higher than the levels recommended to avoid quality problems, particularly during frozen storage. The content of C22:5 and C22:6 were 0.6 %, but vary from 0.2 to 3.0%.These fatty acids were found to be a useful indicator of rancidity. The highest values gave extremely rapid development of rancid flavour during storage. Pigs fed food waste (M2) were rated equal to or in lower range of the random sample (M1) for storage stability and most quality parameters, that are likely to vary with content of marine fatty acids in the food waste. A monitoring programme is recommended in order to control the fatty acid composition in the fat tissue, in order to improve Norwegian pork quality. Further use of processed food waste in pig feeding require improved quality of this feed, although economy and environmental considerations may give other short term signals.

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Table 1. Analysis and frozen storage time.

STORAGE-TIME (month)	TYPE OF ANALYSIS
1	Intramuscular fat (IMF)[1], pH[2], TBA, fatty acid composition and sensory analysis
4	TBA and sensory analysis
8	TBA and sensory analysis

[1]Foss Let AOAC976.21 (1979) [2] Orion model SA 720, AOAC 981.12. Ultimate-pH .

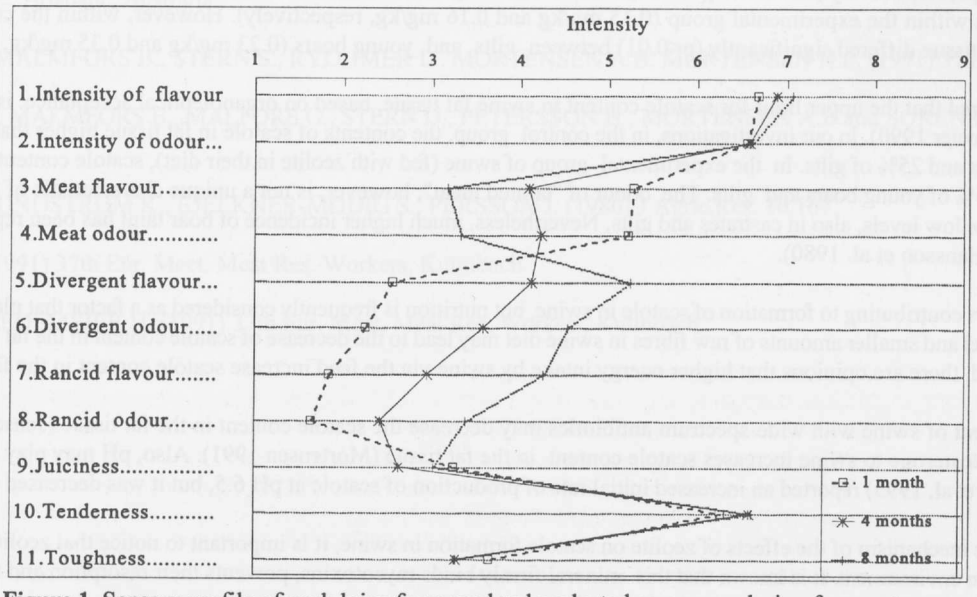

Figure 1. Sensory profile of pork loins from randomly selected carcasses, during frozen storage.
1= Low intensity, 9= High intensity.