INCIDENCE OF FISH-OIL FATTY ACIDS IN AUSTRALIAN HAM AND EFFECTS ON RANCIDITY DEVELOPMENT DURING FROZEN STORAGE.

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ABSTRACT
Fatty acid analysis of manufactured Australian hams showed that there was large variation in the fatty acid composition between samples and that greater than half the samples contained some level of FOFA (fish oil fatty acids), as indicated by the presence of C22:5 and C22:6 fatty acids. To determine the propensity of these ham samples to produce rancid odours during 12 week of frozen storage, the samples were divided into three categories based on the level of unsaturated fatty acids and the presence of FOFA. Although the level of FOFA was low for ham samples containing FOFA (<0.5%), it was sufficient to cause rancid odour to develop after seven weeks of frozen storage. In contrast, ham samples that contained a low level of unsaturated fatty acids and no FOFA did not develop rancid odour during twelve weeks of frozen storage.

BACKGROUND:
Fish oils, either directly or through fishmeal, have been incorporated in pig feeds for decades to provide energy and for their Vitamin A and D levels. However, fish oils are characteristically high in unsaturated fatty acids and incorporation of them by pigs into their own fatty tissues can lead to a greater susceptibility of the fat from these animals to oxidise and produce fish-off odours (Coxon et al., 1986; Hertzman et al., 1988). The level of FOFA in pork fat is characterised by the level of C22:5 and C22:6 fatty acids (Hertzman et al., 1988).

The problem of rancidity development in pork fat containing fish oil fatty acids seems to be a greater problem in cured products, such as bacon, than in uncured fresh pork. It has been reported that bacon containing FOFA may produce rancid fishy flavours after 3-4 months storage at -20^{0}C (Coxon et al., 1986). In contrast, uncured pork containing FOFA shows no sign of rancidity after 6-9 months storage at the same temperature (Coxon et al., 1986; Hertzman et al., 1988).

This research resulted from a sporadic problem at a meat processing plant where frozen sliced ham was developing rancid odours after only 5-6 week of storage. At that time, there were also reports of a similar problem with frozen sliced salami (pepperoni).

OBJECTIVE: Hence this research was carried out to determine if FOFA could be detected in commercial ham products and if detected what effect it has on the development of rancid odours in the product during 12 week of frozen storage at -20^{0}C.

MATERIAL AND METHODS:
Sample selection: Samples of chilled vacuum packaged sliced shoulder ham were obtained within 48 hours of manufacture from a commercial processing plant on two different production days. The samples were analysed for fatty acid composition to determine unsaturated to saturated fatty acids ratio (M+P)/S ((mono-unsaturated+polyunsaturated)/saturated and the presence of FOFA as indicated by the level of C22:5 and C22:6 fatty acids.
Treatments: The samples to be evaluated for frozen storage stability were divided into the following three groups based on their propensity to oxidise: **1)** Low (M+P)/S ratio (<1.4) and No FOFA; **2)** High (M+P)/S ratio (>1.4) and No FOFA; and **3)** High (M+P)/S ratio (>1.4) plus FOFA. The average (M+P)/S and FOFA levels for the three treatments were **1)** 1.39 and 0.00%, **2)** 1.78 and 0.00% and **3)** 1.56 and 0.19%, respectively.
Frozen Storage: Four samples from each category were divided into seven lots (200g), placed in oxygen permeable bags (which is similar to the commercial storage procedure for this product) and frozen at –20^{0}C. The samples were analysed initially and then every 1-2 weeks over a 12-week period for rancidity development using TBARS analysis and a trained sensory odour panel.
Analysis: *Fatty Acid Analysis* Fat from the different ham samples was analysed for fatty acid composition. The fat samples were methylated using sodium methoxide, extracted into hexane and analysed by gas chromatography (Bannon et el., 1984). The method used ensured that the fatty acids normally in fish oils (C22:5 and C22:6) were identified.
Sample Preparation: At each sampling period, the ham samples were removed from the freezer and the fat and lean were diced into 1mm cubes with a sharp knife for all subsequent analysis. Prior to analysis, the fat and lean were mixed in their natural proportions (1 part fat: 3 parts lean).
TBARS Analysis: Samples were analysed in duplicate for each sample for each time interval using the distillation method of Cervantes and Robles-Martinez (1984) which prevent further oxidation occurring during analysis.
Sensory Odour Analysis: Rancid odour was assessed using a trained sensory panel who were trained using fresh and rancid ham samples. For this analysis, duplicate 20 g samples were heated in a 300ml-sealed bottle at 60^{0}C for 30 minutes. Panellists were asked to score the intensity of rancid odour on an eight point scale where 1= No rancid odour to 8=Extremely high rancid odour.

RESULTS:
Fatty Acid Analysis:
The fatty acid values summarised in Table 1. show that a high percentage of the samples contained some fish oil (as indicated by the presence of C22:5 and C22:6 fatty acids) and that there was a large variation in the amount of unsaturated fatty acids as shown by the (M+P)/S ratio. The levels of C22:5 and C22:6 fatty acids in the hams samples were relatively low (0.06% to 0.27%) compared to those previously reported in pork fat with fishy odours (0.47% and 1.49%) (Coxon et al., 1986). The presence of fish oil fatty acids in the ham fat is not unexpected since the feeding of fishmeal and cooking oil that has been used for cooking fish, is not uncommon in Australia. Similarly, the variation in fatty acid composition is not surprising since a range of fats and oils varying in composition from fairly saturated beef tallow to highly unsaturated vegetable oils are included in pig feed as an energy source.

TBARS Values and Rancid Odour Scores of Ham during Twelve Weeks Frozen Storage.
The TBARS analysis of frozen ham samples showed that, with all three groups, the TBARS remained fairly constant for the first seven weeks of frozen storage and then increased rapidly from then on (Fig 1). After twelve weeks frozen storage the two treatments with the high (M+P)/S ratios had the highest TBARS values.

The trend in results for the sensory odour scores during frozen storage were different to that obtained with the TBARS analysis (Fig. 2). The samples with low (M+P)/S ratios (Group 1) had low odour scores initially and the scores did not change over the twelve weeks of frozen storage. The samples with high (M+P)/S ratios but no fish oil fatty acids (Group 2) had slightly higher odour scores initially, the values varied over the twelve week storage time but did not show any systematic increase. In contrast, the samples with high (M+P)/S ratios and fish oil fatty acids (Group 3) had low odour scores initially and the odour scores increased progressively with increasing frozen storage time from a score of 3.8 at week zero to 5.5 at week 12. Hence, it would appear that the fish oil fatty acids are more susceptible to oxidation and that they produce much more odorous compounds than the other fatty acids when they oxidise.

SUMMARY

The fatty acid analysis of the ham samples showed that a high percentage of the samples had some level of FOFA present indicating that fishmeal or fish-oil had been fed to pigs at some time during production. Although this level of FOFA in the fat is only about one third of that reported in the literature for pig fat with fish odour, it appears to be sufficient to cause rancid odour development in the fat during frozen storage. There was a large variation in the level of unsaturated fatty acids in the fat of the ham samples independent of the presence of fish oils. This indicates that there is a similar large variation in the composition of the fat in the pigs' diets (which could range from saturated fats such as beef tallow to highly unsaturated vegetable oils such as cannola oil). The higher level of unsaturated fatty acids did not appear to affect the rancid odour development in the fat during frozen storage as much as the presence of the FOFA. Importantly, the samples with the low level of unsaturated fatty acids showed no change in rancid odour during the twelve weeks of frozen storage.

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Table 1. Fatty acid composition of different ham samples taken from two different days of production.

	% Fatty Acids (Production Day 1)								% Fatty Acids (Production Day 2)								
Fatty Acid	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9
C14:0	1.43	1.64	1.34	1.36	1.46	1.54	1.50	4.16	1.24	1.13	1.63	1.68	1.39	1.37	1.60	1.50	1.65
C16:0	22.75	26.94	22.47	24.27	23.15	24.53	24.50	23.44	23.31	22.79	25.62	26.68	24.86	22.86	24.04	21.80	24.33
C16:1	2.08	3.29	3.11	2.53	2.76	2.69	2.42	2.42	2.12	1.96	4.90	2.83	2.74	2.25	2.06	3.12	3.04
C18:0	11.34	12.77	9.89	12.63	10.30	11.66	13.99	8.97	12.32	13.17	10.34	14.62	12.95	11.05	12.08	11.24	11.20
C18:1	40.28	43.78	42.43	45.16	45.26	44.85	40.13	40.76	47.69	47.10	46.68	37.52	44.21	41.15	41.19	45.52	43.82
C18:2	17.51	5.13	14.97	7.87	11.43	8.86	10.46	14.29	8.17	9.07	4.29	10.12	8.41	16.85	14.68	9.95	10.05
C18:3	1.20	0.35	1.13	0.74	0.79	0.62	0.88	1.11	0.72	0.73	0.34	0.82	0.79	1.11	0.99	0.96	0.81
C20:0	0.36	0.55	0.42	0.51	0.40	0.37	0.40	0.85	0.49	0.54	0.42	0.35	0.49	0.43	0.32	0.80	0.51
C20:1	0.80	0.84	0.78	1.04	0.87	1.07	0.94	0.73	1.03	1.03	0.82	0.72	0.81	0.71	0.75	0.64	0.91
C22:0													0.13	0.15	0.15	0.14	0.13
C22:5				0.10	0.10	0.06	0.13	0.13	0.19	0.11		0.17	0.21	0.06	0.09	0.18	0.12
C22:6					0.19		0.11		0.13	0.09		0.27	0.18			0.13	0.06
(M+P)/S	1.72	1.27	1.83	1.48	1.74	1.53	1.36	1.59	1.61	1.60	1.50	1.21	1.44	1.73	1.56	1.71	1.55

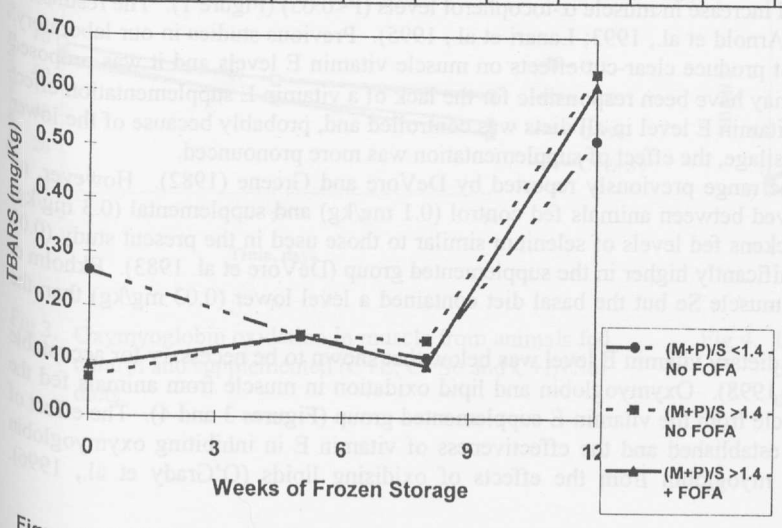

Figure 1. TBARS values during 12 weeks of frozen storage.

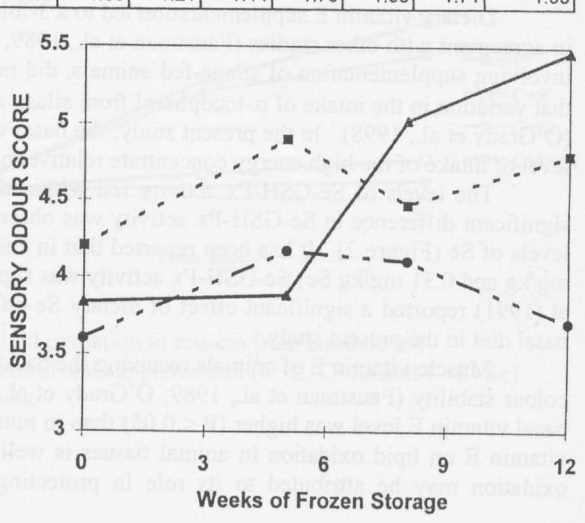

Figure 2. Odour score during 12 weeks of frozen storage