EFFECT OF DIETARY FAT QUALITY ON THE LIPID QUALITY AND STABILITY OF A CURED AND FERMENTED PORK SAUSAGE

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Introduction

An estimated 50,000 tonnes of oils and fats (mostly sunflower oil) are used annually in fried foods in South Africa (Kock *et al.*, 1997). As a result of regulations relating to quality of edible oils and fats for human consumption (Government Gazette, 1996), approximately 60 % of these oils and fats should accumulate as non-toxic used oils that need to be discarded in an appropriate manner. These non-toxic oils should contain less than 25 % polar compounds and less than 16 % polymerized compounds. They should also have the potential to be used as high energy food sources for animal production (Kock *et al.*, 1997). The aim of this study consequently was to evaluate the effect of the inclusion of such oils in pig diets on the lipid quality and stability of a high value consumer product such as salami.

Materials and Methods

Twenty four Large White gilts weighing ± 32 kg, were randomly assigned to each of four dietary treatments. These consisted of a control diet (CL), a diet supplemented with 3 % fresh sunflower oil (FSO), a diet supplemented with 3 % used sunflower oil (USO) and a diet supplemented with 3 % used sunflower oil plus 200 mg/kg of α-tocopheryl acetate (USOE). Pigs were slaughtered after a 85 day feeding period at an average live weight of ± 100 kg. The left loin including the last three ribs was removed and deboned. Total lipid was extracted from the backfat and muscle (Folch *et al.*, 1957). Fatty acid methyl esters were prepared using methanol-BF3 (Slover and Lanza, 1979) and identified and quantified using a Varian GX 3400 gas chromatograph. A colorimetric method (AOAC nr. 971.30, 1990) was used to determine the α – tocopherol content in backfat and muscle. The lean as well as backfat from the pigs of each dietary treatment was pooled and used to manufacture salami according to good manufacturing practices using a commercial starter culture (Floracarn SL Hansen). Salamis were sampled directly after stuffing, after fermentation and at the end of ripening for pH and stability measurements. Extracted lipids were subjected to testing for thiobarbituric acid reactive substances (TBARS) (Raharjo *et al.*, 1992), peroxide value (PV) (AOAC nr. 965.33, 1990), free fatty acids (FFA) (Pearson, 1968) and total carbonyl compounds (TCC) (Berry and McKerrigan, 1958). Analysis of variance (ANOVA) and the Tukey-Kramer multiple comparison test was used to determine whether measurements from different treatments differed significantly (NCSS, 2004).

Results and Discussion

The backfat and muscle of animals fed sunflower oil contained significantly more linoleic acid (C18:2) and less palmitic acid (C16:0) compared to those receiving the control diet. Dietary supplementation with α-tocopheryl acetate resulted in signifcant increases in the α-tocopherol content of both backfat and muscle (Table 1).

Table 1: Chemical properties and fattty acid composition of gilts in the four dietary groups.

Dietary groups	CL (n = 12)	FSO (n = 12)	USO (n = 12)	USOE (n = 12)	Sign.
Properties of backfat					
C16:0 (%)	21.24 ± 1.70^{b}	19.55 ± 2.02^{a}	19.61 ± 1.18^{a}	18.89 ± 1.89^{a}	*
C18:0 (%)	11.14 ± 0.90	10.17 ± 1.29	10.94 ± 1.66	10.32 ± 1.60	NS
C18:1 (%)	36.47 ± 1.00^{b}	32.35 ± 1.47^{a}	31.82 ± 1.80^{a}	32.03 ± 0.99^{a}	***
C18:2 (%)	18.65 ± 2.69^{a}	27.42 ± 4.15^{b}	27.39 ± 3.56^{b}	28.26 ± 3.07^{b}	***
α-tocopherol (µg/g)	8.36 ± 2.41^{a}	8.29 ± 2.48^{a}	6.91 ± 2.06^{a}	24.16 ± 7.61^{b}	***
Properties of muscle:					
C16:0 (%)	22.42 ± 0.79^{b}	21.11 ± 0.94^{a}	21.64 ± 0.81^{a}	20.97 ± 0.99^{a}	*
C18:0 (%)	11.39 ± 0.65	11.61 ± 0.68	11.57 ± 0.59	11.70 ± 0.78	NS
C18:1 (%)	37.14 ± 2.18^{b}	35.86 ± 2.23^{a}	34.69 ± 2.59^{a}	33.48 ± 2.06^{a}	*
C18:2 (%)	12.99 ± 2.07^{a}	15.64 ± 2.36^{b}	16.96 ± 1.58^{b}	17.17 ± 2.55^{b}	*
α-tocopherol (µg/g)	1.92 ± 0.66^{a}	1.97 ± 0.58^{a}	1.48 ± 0.89^{a}	4.77 ± 1.23^{b}	***

Sign. = Significance level; NS = Not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

Significantly higher pH values in salami were observed in the USO group and lower pH values in salami of the USOE group compared to the CL and FSO groups at the end of fermentation and drying (Table 2). This can possibly be ascribed to the negative effect of oxidation products (transferred from the used oil to the meat), on starter growth, or to the more conducive environment created for starter growth by α-tocopherol. This pH difference was, however, not large

enough to induce significant differences in weight loss from salamis in the different treatment groups. Although salami usually contains nitrite (an antioxidant), oxidative differences were observed in salami made from meat of the different treatments. Salami made from the meat of pigs receiving the sunflower oil supplemented diets had significantly higher FFA and TCC contents than salami made from meat of the CL diet throughout the manufacturing process. No significant differences were, however, observed between the FSO, USO and USOE groups in terms of FFA and TCC at any point of manufacture. The same significant trend was observed with PV's except that salami manufactured from the USO treatment had a significantly higher initial PV than salami manufactured from the other sunflower oil treatments. It would seem that FFA production (lipolysis), peroxide formation (oxidation products of FFA) and carbonyl formation (oxidation products of peroxides) are related to lipid unsaturation and that oil quality and α-tocopherol level had little effect on these values. Contrary to FFA content, PV and TCC content TBARS values were significantly influenced by dietary oil quality and α-tocopherol level towards the end of the manufacturing process of salami. At the end of the drying period, the TBARS values of the salami from the CL and USOE groups were well below the critical value of 1.0 considered to be the cut-off point in terms of rancid tastes, while salami from the FSO and USO groups exceeded this value.

Table 2: Lipid stability in salami after manufacture (Day 0), fermentation (Day 2) and drying (Day 21).

	Treatments:					
Parameter:	**Day**	**CL(n=12)**	**FSO(n=12)**	**USO(n=12)**	**USOE(n=12)**	**Sign.**
Weight loss (%)	2	1.54	1.89	1.71	1.83	
	21	**21.56**	22.04	**21.67**	21.83	-
pH	0	5.77 ± 0.01	5.77 ± 0.01	5.78 ± 0.01	5.76 ± 0.02	NS
	2	5.18 ± 0.02^{b}	5.19 ± 0.01^{b}	5.24 ± 0.02^{c}	5.07 ± 0.07^{a}	***
	21	4.75 ± 0.02^{b}	4.76 ± **0.03**^{b}	**4.78 ± 0.01**^{b}	**4.68** ± 0.09^{a}	***
Free Fatty Acids (%)	0	1.91 ± 0.42^{a}	2.19 ± **0.33**^{b}	2.29 ± 0.17^{b}	2.31 ± 0.37^{b}	*
(g oleic/100g total fatty acids)	2	2.70 ± 0.34^{a}	3.07 ± 0.18^{b}	2.95 ± 0.48^{b}	3.33 ± 0.40^{b}	**
	21	4.41 ± 0.34^{a}	**5.04 ± 0.26**^{b}	**4.86** ± 0.38^{b}	**5.12 ± 0.47**^{b}	***
Total carbonyl compounds	0	11.90 ± 1.99^{a}	14.74 ± **1.97**^{b}	14.53 ± 3.39^{b}	14.79 ± **3.27**^{b}	*
(mmol/kg lipid)	2	13.06 ± 17.01^{a}	17.01 ± 2.63^{b}	17.43 ± 1.73^{b}	15.99 ± 2.26^{b}	***
	21	13.42 ± 1.17^{a}	**15.31 ± 2.74**^{b}	15.82 ± 1.88^{b}	**16.42 ± 2.73**^{b}	*
Peroxide value	0	5.72± 2.20^{a}	11.18 ± **2.79**^{b}	15.01 ± 3.17^{c}	12.01 ± 3.84^{b}	***
(milliequiv. peroxide/kg fat)	2	6.11 ± 1.08^{a}	17.14 ± 5.67^{b}	18.80 ± 7.26^{b}	18.61 ± 6.09^{b}	***
	21	8.28 ± **2.43**^{a}	**13.10 ± 5.79**^{b}	14.45 ± 6.70^{b}	**14.53** ± 5.51^{b}	*
TBARS value	0	0.05 ± 0.03	0.05 ± 0.02	0.05 ± 0.02	0.04 ± 0.02	NS
(mg molonaldehyde/kg meat)	2	0.09 ± 0.05	0.08 ± 0.03	0.10 ± 0.03	0.09 ± 0.01	NS
	21	**0.48 ± 0.35**^{a}	**1.22** ± 0.30^{b}	1.14 ± **0.24**^{b}	**0.40** ± 0.38^{a}	***

Sign. = Significance level; NS = Not significant; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

Conclusions

This research indicated that high levels of polyunsaturated fatty acids and oxidized oils in the diets of pigs had a negative effect on lipid stability of high value products like salami. It was, however, demonstrated that dietary supplementation with α-tocopheryl acetate may be efficient in retarding oxidative rancidity in salami manufactured from fatty tissue originating from animals fed oxidized oils or feed rich in polyunsaturated fats.

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