DURATION OF PLANT ANTIOXIDANT DISTRIBUTION IN N-3 FATTY ACID-RICH DIETS: EFFECT ON FAT PEROXIDATION IN PORK AND PROCESSED PRODUCTS

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Abstract. The introduction into pig feed of lipids high in n-3 fatty acids (FA) makes it possible to increase the proportion of these FA in the meat. The combined addition to the feed of vitamin E and plant antioxidants (PA) reduces risks of unsaturated fatty acid peroxidation in the meat. The aim of this work will be to quantify the peroxidation of the fatty acids in dry cured hams from animals between 50 and 110 kg of body weight receiving n-3 FA (7.5 g C18:3 n-3 and 80 mg of vitamin E /kg of feed) with more or less PA: 2kg/t feed for 2 months (batch PA2) or 4kg/t for the last 10 days (batch PA4) and one batch without any PA. With the PA input, the quantity of malondialdehyde (MDA), a marker of fatty acid peroxidation, decreases in the fatty tissue of the ham ($p<0.05$) and in the lean ($p<0.005$). The effect on peroxidation reduction is identical between PA2 and PA4. It therefore appears that the PA input into feed for a short period (10 days) makes it possible to reduce FA peroxidation as effectively as throughout the whole duration of the C18:3 n-3 input.

I. INTRODUCTION

Adding linseed, a source of n-3 fatty acids (FA), to pig feed considerably increases the fatty acid content of the meat and processed products (1). The nutritional value of these products is increased not only by the presence of these n-3 fatty acids, judged to be good for health, but also very often, by a reduction in saturated fatty acids (SFA) (2). The addition of vitamin E and plant antioxidants (PA) to the feed greatly reduces the risk of peroxidation of polyunsaturated fatty acids (PUFA) and preserves the sensorial qualities of dry cured products enriched with FA n-3(3).

The PAs (very often polyphenols) make it possible to regenerate the action of vitamin E (4). The first aim of the study is to know if the PA should be introduced in the feed at the same time that AG n-3. The second is to determine if a shorter PA's distribution time enable to protect AG n-3 in processed pork products.

II. MATERIALS AND METHODS

24 castrated boars, divided into 3 batches of 8, after attaining 50 kg of live weight and for a period of 2 months, received an identical diet enriched in FA n-3 via the introduction of extruded linseed (Tradi-Lin®). The overall lipid content was 3.6 % providing 7.5 g of C18:3 n-3 (ALA) / kg of feed and 80 ppm of vitamin E. One batch received this diet with no PA addition (batch PA0). Another batch received this diet supplemented with PA (2kg/ tonne of feed; batch PA2). The last batch received the PA0 diet for 50 days then a diet containing PA (4kg/tonne) during the last 10 days before slaughter (batch PA4). The animals in individual pens received feed *ad libitum* with a record of consumptions and a weighing each week. At slaughter, adipose tissue (AT) was sampled from the back for determination of the total lipids and analyses of the fatty acids by gas chromatography (GC). Dry sausages and dry cured hams were made from the meat from these animals. The drying process lasted for 12 weeks for the sausages and 7 months for the hams. Lipids and fatty acid composition were measured on the whole sausage, on the whole slice of ham and on the lean and the fat of the ham. The fatty acid profile was made as well as the measurement of the MDA (malondialdehyde, representing the FA peroxidation) by HPLC following the protocol reported by Mairesse *et al*, (3). The results are tested by global variance analysis with the diet effect as principal factor then they are compared in pairs using the Bonferonni test.

III. RESULTS AND DISCUSSION

a) Fatty acid composition

The feed consumption and growth performance of the pigs are identical among the diets.

The total lipid content of the adipose tissue of the back is 66 % for batches PA0 and PA2 and 70 % for PA4 (NS effect). The lipid contents of the dry cured sausages are 39 % for PA0, 41 % for PA2 and 43 % for PA4; these values are not different from each lot because of the individual variations. Before drying the lipid content was around 20 %.

The lipid contents in the fat cover of the ham differ significantly from each other ($p<0.001$) with values

respectively of 62, 61 and 57 % for PA0, PA2 and PA4. This difference is difficult to explain, all the more so as the adipose tissue of the back contained more lipids in the animals from batch PA4. For the lean part, the content is also different ($p<0.02$) with values of 4.7, 4 and 3.6% ($p<0.02$).

The FA composition of the backfat (table 1) shows a higher PUFA percentage in batch PA4 ($p<0.01$), as well as for C18:3 n-3 (ALA) ($p<0.001$) and the long chain derivatives C22:5 n-3 (DPA) ($p<0.05$) and the C22:6 n-3 (DHA) ($p<0.001$); PA4 was different from the other batches for ALA, DHA and total FA n-3.

Table 1 Effect of diets on the fatty acid composition of the backfat (in % of FA identified)

Diet	PA0	PA2	PA4	Rsd	effects
SFA	39.91	39.02	38.86	1.54	NS
MUFA	39.07a	39.96ab	37.50b	1.83	P<0.04
PUFA	21.02a	21.02a	23.64b	1.87	p<0.01
C18:2 n-6	12.85a	12.89a	14.45a	1.24	p<0.02
C18:3 n-3	5.43a	5.49a	6.44b	0.52	p<0.001
C20:5 n-3	0.11	0.12	0.13	0.03	NS
C22:5 n-3	0.21a	0.24a	0.26a	0.03	p<0.05
C22:6 n-3	0.03a	0.03a	0.05b	0.01	p<0.001
n-3	7.03a	7.06a	8.09b	0.63	p<0.004
LA / ALA	2.37a	2.35a	2.24a	0.01	p<0.05

SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid. By lines, means without common letter were significantly affected by dietary treatment ($p<0.05$)

The FA composition of the dry cured sausage at the end of the drying process shows a higher percentage in C18:2 n-6 and in ALA in batch PA4 ($p<0.001$) (table 2). PA4 is also different from PA2. But the effects are not demonstrated for the ALA derivatives as was the case for the A.

Table 2 Effect of diets on the fatty acid composition of dry cured sausages (in % of the FA identified)

Diet	PA0	PA2	PA4	Rsd	effect
SFA	36.38	35.56	36.11	1.21	NS
MUFA	39.00	38.54	37.13	1.79	NS
PUFA	24.62	25.89	26.76	2.77	NS
C18:2 n-6	10.52a	10.86a	12.07b	0.44	P<0.001
C18:3 n-3	4.17a	4.54b	5.01c	0 .17	P<0.001
C20:5 n-3	0.94	1.38	0.89	0.48	NS
C22:5 n-3	0.26	0.29	0.30	0.04	NS
C22:6 n-3	0.03	0.02	0.04	0.02	NS
n-3	8.85	9.59	9.80	1.42	NS
LA/ALA	2.53a	2.39b	2.40b	0.03	P<0.001

The percentage of saturated FA is identical in the fat cover of the slice of ham of the 3 batches (36% of the total FA). That of the PUFA is significantly higher for PA4 ($p<0.06$) with 20 % *vs* 18 % for PA0 and PA2 because of the increase of the C18:2 n-6 ($p<0.05$) and of the C18:3 n-3 ($p<0.06$) in batch PA4.

On the other hand, expressed in quantity, the ALA contents (mg/100g of tissue) are not different between the batches because of lower lipid content in batch PA4 (Fig.1).

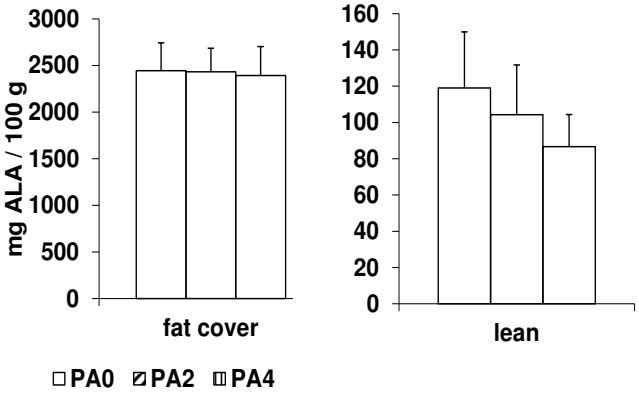

Fig. 1. ALA content (mg/100 g of tissue) in the fat cover and lean of the ham according to treatments.

b) Measurement of the MDA in the processed products

The quantity of MDA (Fig. 2) found in the dry sausages is lower for the batches receiving the PA compared to the batch receiving no PA ($p<0.01$). PA4 is the batch with the lowest MDA content, but this difference is not significantly different from PA2 because of considerable individual variations between the sausages. So the peroxidation is lower whilst the percentage of FA n-3 is higher in this batch.

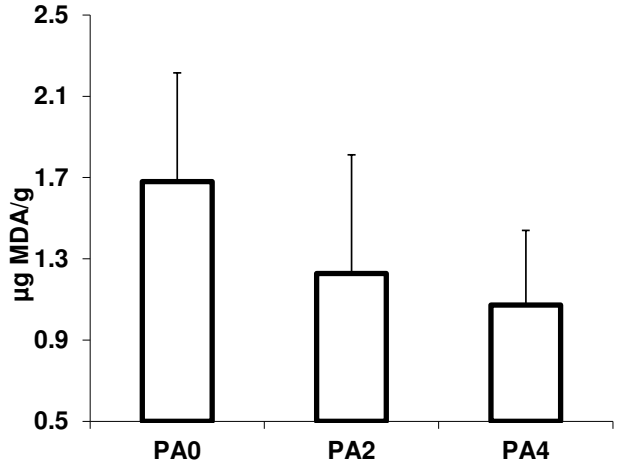

Fig. 2. Comparison of the MDA content (µg/g) in the dry cured sausages according to the origin of the diets

For the fat tissue in the ham, the MDA content is lower in the batches that received PA ($p<0.05$). For the lean part, it is also lower ($p<0.005$) and the effect is more marked, batches PA2 and PA4 being different (threshold of 5%) from the batch without PA (Fig. 3).

These results on the processed products confirm the interest of enriching high ALA content diets with antioxidants (3).The absence of any significant difference between the batches with PA shows that the effectiveness of these antioxidants regarding FA peroxidation is more or less identical. As the quantities and duration of distribution were different between batches PA2 and PA4, it therefore does not seem necessary to provide PA throughout the period when the diet was enriched with FA n-3, but simply during the last days of the animal's life. In this study, 10 days of distribution seem sufficient to obtain a protective effect.

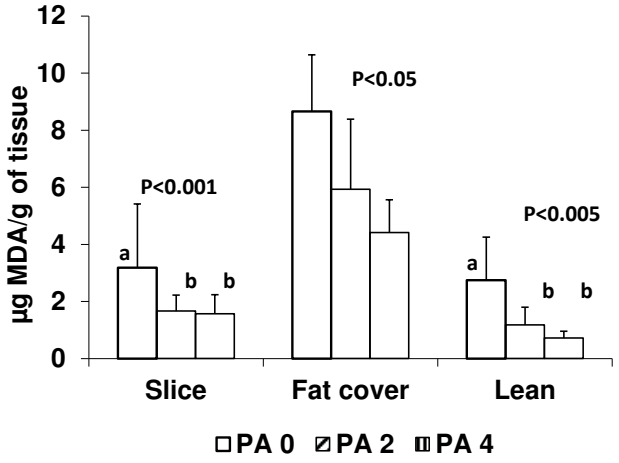

Fig. 3 MDA content (µg/ g of tissue) in the fat and lean of the ham according to treatments

IV. CONCLUSION

In presence of PUFA in the feed, the addition of PA is efficient to reduce peroxidation on pork and processed products. The protective effect demonstrated on dry cured products with a short drying period is confirmed on products with a moderately long drying process (7 months). Short-term PA supplementation of the feed seems sufficient to protect against PUFA peroxidation.

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