Summary

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This thesis describes research on the essential-fatty acid supply of weanling piglets. Vertebrates require dietary sources of essential fatty acids. The polyunsaturated fatty acids (PUFAs), linoleic acid (LA, C18:2 n-6) and α-linolenic acid (ALA, C18:3 n-3) are considered the parent compounds of the n-6 and n-3 families of PUFAs, respectively. The products of desaturation and elongation arachidonic acid (AA, C20:4 n-6) and eicosapentaenoic acid (EPA, C20:5 n-3), are the precursors for eicosanoids, which play an important role in the immune response. Eicosanoids produced from n-3 PUFAs generally have effects opposite to those elicited by eicosanoids synthesized from n-6 PUFAs. Due to the competition between n-3 and n-6 PUFAs for the desaturase and elongase enzymes, the net response to eicosanoids depends on the amounts and on the ratio of n-3 and n-6 PUFAs present in the diet.

Weanling piglets are prone to the development of the so-called post-weaning syndrome which is related to a by low feed intake and is associated with atrophy of the villi, inflammation of the gut and depressed performance. To investigate the influence of PUFAs on the post-weaning syndrome, the fatty acid supply and status of piglets from birth to two weeks after weaning was measured first. In addition, the fatty acid composition of erythrocyte membranes, liver fat and lymph nodular fat tissue was determined. It was found that between weaning and one week post weaning there was no difference in the status of n-3 and n-6 PUFAs as based on their concentrations in erythrocyte membranes and tissues. Weaning was associated with a drop of plasma total cholesterol, HDL cholesterol and phospholipid concentrations as well as a decrease in heparin-released plasma lipoprotein lipase activity. The changes in plasma lipid metabolism around weaning are explained by the decrease in fat intake immediately after weaning. It was concluded that this study does not point at a lowering of the status of n-3 and n-6 PUFAs in piglets at the stage around weaning. However, it is stressed that the outcome of this study is determined by the essential-fatty acid status of the sows and the fatty acid compositions of the commercial lactation diet, creep feed and weaner diet that were used.

In a second experiment, the effect of supplemental n-3 PUFAs and the ratio of n-3:n-6 PUFAs on small intestinal morphology and growth performance was investigated. Weanling piglets (n = 360) were fed diets with different levels of ALA, the levels being 0.22, 0.47, 0.77 and 1.13 % of metabolizable energy. The experimental diets were formulated by the addition of various amounts of linseed oil at the expense of corn oil. Intakes of ALA above 0.22 energy% tended to increase growth during the first two weeks post weaning and tended to reduce feed conversion during the first week: the average increase in weight gain was 9% and the decrease in feed conversion was 14%. Increasing amounts of ALA in the diets stimulated the desaturation and elongation into EPA and DHA and the incorporation of these fatty acids into erythrocyte membranes. The requirement of ALA by weanling piglets to display maximum growth is not known, but this study indicates that it may be above 0.22 energy %. The piglets showed a post-weaning decrease in total cholesterol, HDL cholesterol and phospholipids, but the intake of various amounts of linseed oil did not influence the concentration of plasma lipids.

The third experiment addressed the question whether in weanling piglets the feeding of EPA, in the form of fish oil, would be more beneficial as to growth performance and gut integrity than the feeding of ALA in the form of linseed oil. Weaner diets were formulated that contained two levels each of either fish oil or linseed oil. The fish-oil diets on average increased post-weaning growth by 27%, when compared with the linseed-oil diets, but this increase did not reach statistical significance. Feed intake was not affected by the experimental diets. There was no systematic influence of diet on the villus:crypt ratio of small intestinal mucosa. The highest villus:crypt ratio was seen with the control diet having a n-3:n-6 ratio of 0.1, and the lowest ratio was found in the piglets fed the linseed-oil diet with a n-3:n-6 ratio of 0.3. The diets containing fish oil produced higher n-3:n-6 ratios in erythrocytes, liver fat, storage fat and lymph nodular fat than did the diets containing linseed oil and having similar n-3:n-6 ratios. It is concluded that dietary fish oil might positively affect growth of weanling piglets, this effect not being mediated by counteracting the weaning-induced decrease in villus height.

To further study whether the intake of fish oil would have positive effect on growth performance of weanling piglets, in a feeding trial with 480 piglets diets without fish oil or with either 13 or 22 g fish oil/kg were fed. Fish oil was added to the diets at the expense of the corn-oil component. The diets were fed ad libitum from weaning until 14 days post weaning. Fish oil feeding did neither affect feed intake nor weight gain and feed conversion efficiency. The fatty acid composition of erythrocyte membranes reflected fish oil consumption and pointed at inhibition of LA desaturation and elongation by fish oil feeding. Piglets fed the diets with fish oil had higher erythrocyte-membrane concentrations of EPA and lower concentrations of AA while LA contents were not affected. It is concluded that, under the conditions of this study, the addition of fish oil to a weaner diet adequate in ALA did not enhance growth performance, faeces consistency and body condition of weanling piglets. However, at weaning piglets already had a high status of n-3 PUFAs which might have masked any effect of fish oil in the weaner diet on growth performance.

In the fifth experiment, weaned piglets were used to determine the effect of fish oil in the diet on the clinical response to an infection with a pathogenic *Escherichia coli* O149:K91:K88. The piglets were divided into two groups of 8 animals each. One group was fed the control diet containing 5% corn oil. The test piglets were fed a diet with 0.5% corn oil and 4.5% fish oil. Piglets were orally infected with the challenge strain on days 6 and 7 after weaning. The experimental period lasted 14 days, during which no piglets died. Feed intake and weight gain, faecal and condition score.s were measured daily. Faecal samples were collected for bacteriological analysis. Blood samples were taken for analysis of the fatty acid composition of erythrocyte membranes. The average daily feed intake and average daily gain after infection tended to be higher in the test group than in the control group. The faecal excretion of O149:K91:K88 tended to be lower for the test than control piglets. This experiment indicates a possible positive effect of fish oil on the clinical response in weaned piglets to a pathogenic *E. coli*. The outcome of this study is not in agreement with the second feeding trial using diets fortified with fish oil and showing a lack of effect of fish oil on growth performance. The piglets in that feeding trial were kept in a relatively clean environment which might explain the lack of effect of fish oil.

The experiments described may be interpreted in that the addition of n-3 PUFAs to the weaner diet may be beneficial, but only when the piglets have a low status of n-3 PUFAs at weaning. Thus, a literature review was made to identify the factors determining the fatty acid status at weaning. The fatty acid composition of fat mobilized by the sow and that of the lactation diet influence the fatty acid composition of the sow's milk which then determines the fatty acid status of piglets at weaning.

The risk to develop post-weaning disorders and post-weaning feed intake are negatively related. To put the potential beneficial effects of the fatty acid composition of the weaner diet in perspective the final experiment was done. In an attempt to increase post-weaning feed intake, piglets were fed diets with increasing water contents. An increase in the water content of the diet was found to raise dry matter intake, total water intake and body-weight gain in a dose-dependent fashion. When the magnitude of the effect on feed intake seen in this study is compared with that in the previous studies using diets with different fatty acid compositions, it follows that the effect of PUFAs is relatively small.

Conclusions and implications

This thesis has focussed on the dietary provision of PUFAs to weanling piglets in relation to growth performance and small intestinal integrity. The status of n-3 and n-6 PUFAs in piglets at weaning might determine their susceptibility to the development of post-weaning disorders. In agreement with this statement, it was found that fish oil, which is rich in EPA, tended to have a positive effect on the clinical response in weanling piglets to a pathogenic *E. coli*. It is suggested that the status of n-3 PUFAs at weaning relates to the risk of post-weaning growth

depression and development of diarrhoea. The status of PUFAs at weaning is determined by the fatty acid status of the sow and the fatty acid composition of the weaner diet. Depending on the fatty acid status of the piglet at weaning, there may be no change of the status after weaning in spite of the low feed intake. The requirement of ALA by weanling piglets to display maximum growth is not known, but it may be above 0.22% of metabolizable energy. Dietary fish oil might positively affect growth of weanling piglets, with low status of n-3 PUFAs, this effect not being mediated by counteracting the weaning-induced decrease in villus height. However, the addition of fish oil to a weaner diet adequate in ALA and fed to weanling piglets with high status of n-3 PUFAs
may not enhance growth performance, faeces consistency and body condition. When put in perspective, it is concluded that the potential beneficial effect of the fatty acid composition of the weaner diet, at least under practical situations, may only be marginal and certainly is much smaller than that obtained by measures that raise post-weaning feed intake.