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Performance and diarrhoea in piglets following weaning at seven weeks of age: Challenge with *E. coli* O 149 and effect of dietary factors

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ABSTRACT

Four dietary factors (*ad libitum* versus feed restriction, control versus protein restriction at *ad libitum* feeding, control versus inclusion of lupin as a protein source at *ad libitum* feeding, and control versus extra vitamin E at *ad libitum* feeding) were tested in four separate experiments for the effect on diarrhoea. To introduce a diarrhoea-like condition, half of the piglets were challenged with an *E. coli* O 149 dose of 1×10^8 colony forming units on days one and two after weaning (day of weaning = day zero). All piglets were susceptible since the dams were tested mono-zygotic susceptible to the attachment site of *E. coli* O 149 in the intestines. Each of the four experiments included 32 piglets from 4 sows. The design was a 2×2 factorial with dietary factor and *E. coli* O 149 challenge as the two factors, each at two levels. The piglets were housed individually during the experiment which lasted for 10 days from weaning at 7 weeks of age. The daily recordings included feed intake, weight and faecal score (from 1 = solid and cloddy to 6 = watery and yellow). Faeces from days 1 to 4 were tested for *E. coli* strains. In addition, blood was sampled and serum was analysed for antibodies to *E. coli*, IgG and IgM. Generally the *E. coli* challenge had no effect on growth and feed intake whereas faecal score and number of faecal haemolytic bacteria increased and faecal dry matter decreased. Feed restriction decreased the weight gain while faecal characteristics were unaffected. An analysis including all four experiments revealed that a feed intake of less than 200 g during the first day after weaning seems to be associated with a relatively high incidence of a post-weaning diarrhoea-like condition. Protein restriction decreased faecal score and increased faecal dry matter while weight gain tended to decrease. Inclusion of lupin affected neither weight gain nor faecal characteristics. Extra vitamin E did not affect weight gain while faecal dry matter decreased, and faecal score and number of faecal haemolytic bacteria increased. The dietary treatments had no effect on the measured immunoglobulins. In conclusion, the studied dietary factors could not alleviate a diarrhoea-like condition and at the same time maintain the growth rate. Furthermore, the results indicate that performance can be improved if piglets achieve a daily feed intake of at least 200 g during the first day after weaning.

1. Introduction

Many piglets have a poor and variable growth rate associated with a low and variable feed intake after weaning. Furthermore, piglets have an increased susceptibility to enteric pathogens that may cause diseases among which "weaning diarrhoea" is the most common. Weaning diarrhoea usually occurs after a 3–4-day latency period and peaks around one week after weaning. Weaning diarrhoea is a multifactorial problem, and the clinical symptoms may be linked to a combination of different factors such as low feed intake during the first week after weaning, low hygiene, insufficient ventilation, low age at weaning, low piglet live weight at weaning, and a high number of piglets per pen (Madec et al., 1998).

Weaning diarrhoea is also a problem in organic pig production (S. Bak, personal communication) although organically produced piglets are relatively old at weaning

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(at least seven weeks in Denmark). Due to restrictions in the use of medication in organic pig production, other tools that may reduce weaning diarrhoea are needed. Therefore this study will focus on four dietary-based tools, i.e. feed restriction, protein restriction, inclusion of lupin in the diet and inclusion of extra vitamin E in the diet.

The matter of feed restriction is controversial since low feed intake may cause intestinal malfunction and damage (Spreeuwenberg et al., 2001; McCracken et al., 1999), but despite this, restricted feeding is commonly used as an approach to reduce weaning diarrhoea in Denmark (Jørgensen et al., 2000) and elsewhere (Lainea et al., 2004). Potentially, restrictive feeding may prevent piglets, which have not eaten significant amounts during the first one to two stressful days, to engorge on the weaning diet if it is available ad-lib. An engorgement might lead to digestive upset. Also the optimal level of dietary protein at weaning is somewhat controversial. Low-protein diets are commonly used to reduce weaning diarrhoea (Callesen, 2004), and have been shown to reduce the frequency of diarrhoea, however, at the expense of growth performance (Eggum et al., 1987).

Organic pig production is subject to regulations regarding sources of feedstuffs which results in great interest in testing protein sources that may be an alternative to non-organically grown soya beans. One of these alternatives may be lupin which is readily available and although low in sulphur-rich amino acids has a relatively high protein content. In addition lupin may have the potential to reduce intestinal *E. coli*, since it is rich in galactose, a substrate for galactane, which has been shown to reduce the number of intestinal *E. coli* (Mathew et al., 1993).

Vitamin E is important for development of and maturation of the immune system and vitamin E deficiency has been found to predispose pigs to *E. coli* infection (Ellis and Vorhies, 1976), which may lead to weaning diarrhoea, whereas dietary supplementation with vitamin E resulted in improved cellular and humoral immunity in pigs (Jensen et al., 1988; Hayak et al., 1989).

The effects of dietary factors on spontaneous weaning diarrhoea are difficult to study because of low or variable incidences of this disease. Therefore controlled *E. coli* challenge models have been used in order to simulate the outbreak of this condition (Madec et al., 2000; Melin et al., 2000). The experimental models of porcine post-weaning *colibacillosis* have used a combination of different strains for piglet inoculation (Madec et al., 2000) as well as a single pathogen strain (Melin et al., 2000).

The objective of this study was to determine the effect of four selected dietary factors on a potential reduction in severity of weaning diarrhoea in piglets, which were weaned at 7 weeks of age to simulate this condition in organic pig production.

2. Materials and methods

2.1. Animals

The piglets were from the herd at the Research Centre Foulum. The herd has the specific-pathogen-free (SPF) health status according to the Danish SPF system (i.e. free from toxigenic *Pasteurella multocida*, *Sarcoptes scabei* var. *suis*, *Haematopinus suis*, *Brachyspira hyodysenteria*, and *Actinobacillus pleuropneumoniae* serotype 1,2,3,4,5,7,8,9,10, but reinfected with *Mycoplasma hyopneumoniae*). The herd is not organic, but age at weaning met the requirements for organic pig production. Only sows tested homozygote carriers of the dominant gene encoding for intestinal F4 fimbriae receptors (Jørgensen et al., 2004) were used as dams while the sires were not tested. Regardless of genotype, however, the density of intestinal receptors for *E. coli* F4 adhesion is variable (Rasschaerta et al., 2007). The sows were not vaccinated against *E. coli*. However, *E. coli* vaccination is permitted in organic pig production. The piglets were weaned at 7 weeks of age to simulate this condition in organic pig production.

Piglets were treated for diarrhoea if they had a faecal score of 5 or more (see below) and appeared apathetic and not interested in their surroundings.

2.2. Experimental design

Four separate experiments were conducted each testing the effect of one of the four dietary factors, i.e. feed restriction, protein restriction, inclusion of lupine in the diet and inclusion of extra vitamin E in the diet. Each experiment was designed as a 2×2 factorial block design with dietary factor (two levels) and challenge with *E. coli* (inoculation with *E. coli* suspension or buffer) as the factors. The housing facility allowed handling of one block of 16 piglets at each time. Each block consisted of eight littermate piglets from each of two sows. For each dietary factor two blocks were used. Two piglets were allocated to each of the four factorial subgroups within each litter. Thus for each dietary factor, 32 piglets originating from four sows and allocated to the four subgroups in two blocks were used. During allocation of the piglets their weights were taken into consideration in order to control weight variation between subgroups. The experimental period was 10 days.

2.3. Dietary factors

The feed used in the feed restriction experiment was obtained from a commercial feed supplier while the other diets were produced at Research Centre Foulum. The composition of the diets is outlined in Table 1. The feed ingredients met the requirements for organic pig production.

2.3.1. Feed restriction

The control piglets had *ad libitum* access to the feed while the experimental piglets were fed restrictively starting with a daily allowance of 400 g feed on day 1 (first 24 h), gradually increasing by 40 g per day to 800 g feed on day 10 of the experiment. Half the daily restricted ration was fed in the morning and half in the afternoon. The feed used in this experiment was a commercial diet, thus the composition deviates from the control diet used in the other experiments.

2.3.2. Protein restriction

The dietary content of barley was increased at the expense of the protein rich ingredients, thus the control diet included 167 g (20.1% crude protein), while the low-protein diet included 94 g (12.0% crude protein) digestible protein per kg.