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Growth performance of weaned pigs fed different levels of starfish meal

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ABSTRACT

Starfish meal (SM) was fed in different concentrations to 4952 piglets from 6 kg to assess the effect on animal performance when fed under commercial conditions. Performance was evaluated at low (L-SM), medium (M-SM) and high (H-SM) SM-levels compared with fishmeal (FM). The experimental period was divided into three two-week phases. Pigs received 5, 7.5 and 100 g/kg SM, and 50 g/kg FM in phase 1. In phase 2, SM and FM were halved. In phase 3, all pigs received the same diet without SM to study compensatory growth. Similar ADG and ADFI was found for pigs fed FM and L-SM in all phases. The ADG of pigs was significantly lower when feeding diets with M-SM and H-SM compared with FM and L-SM in both phase 1 and 2 ($P < 0.001$), and the ADFI of L-SM-fed pigs was greater than for pigs fed M-SM and H-SM in phase 1 ($P = 0.015$), whereas in phase 2, the ADFI of pigs receiving M-SM and H-SM was significantly lower compared with the other two treatments ($P < 0.001$). In phase 3, pig growth was similar on all treatments. M-SM and H-SM gave compensatory growth in phase 3. Piglets can be fed 50 g/kg SM with good results, but greater inclusion levels may cause growth reduction.

1. Introduction

A growing world population and rising incomes are expected to lead to an increased demand for protein sources in the coming decades (Van der Spiegel et al., 2013). Starfish meal (SM) can be a new protein source in animal feed. Aggregations of starfish are considered a pest in Denmark because they predate commercially grown mussels. Therefore, starfish are caught to prevent high losses in mussel yield.

Previous research has demonstrated the potential of feeding weaned pigs diets with SM in pilot-scale experimental settings (Nørgaard et al., 2015; Sørensen and Nørgaard, 2016). Chemical analyses have shown a high protein quality for SM with amino acid profiles comparable to fishmeal (FM) (Nørgaard et al., 2015). FM is frequently used in animal feed and is considered a high quality protein source (Ponce and Gernat, 2002). Furthermore, an experiment with a low number of pigs has proven the feasibility of using SM in weaned pigs (Sørensen and Nørgaard, 2016). Sørensen and Nørgaard (2016) found that growth rate was maintained when substituting 50 g FM/kg for 50 g SM/kg. Including SM at 100 g/kg, however, resulted in reduced growth. It was hypothesized that high calcium (Ca) levels in SM, generating a high Ca:P ratio, could have negatively affected phosphorus (P) digestibility and absorption when feeding 100 g/kg SM (Sørensen and Nørgaard, 2016). Correspondingly, in pigs fed 100 g/kg SM, serum levels were low for P and high for Ca compared with pigs fed FM and 50 g SM/kg (Sørensen and Nørgaard, 2016).

Abbreviations: AA, amino acids; ADFI, average daily feed intake; ADG, average daily gain; CGI, compensatory growth index; CP, crude protein; DM, dry matter; FCR, feed conversion ratio; FM, fish meal; H-SM, high level starfish meal; L-SM, low level starfish meal; M-SM, medium level starfish meal; SM, starfish meal

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The study by Sørensen and Nørgaard (2016) was performed with individually housed pigs in clean and hygienic experimental facilities. Extended research with additional SM levels under commercial conditions will add validation to the use of SM as a potential feedstuff in pig feed. It is expected that there is a limit to the amount of SM that can be added to the diet without reducing growth. However, in cases where available protein sources are already limited, for example in organic pig farming, it would be useful to include a high amount of SM. Therefore, it would be advantageous to evaluate a feeding strategy that allows for inclusion of a high amount of SM during the early part of the growing period. Compensatory growth may be a way to overcome the consequence of P deficiency as a result from the high inclusion of SM in pig feed. Pigs fed diets deficient in a certain nutrient are known to have accelerated growth after changing to a diet sufficient in nutrients. This has been termed compensatory growth (Madsen and Bee, 2015).

In this study, the effect of feeding different SM levels on pig growth was evaluated in commercial conditions. Additionally, compensatory growth in pigs was assessed by removing SM from the diet in the late experimental period.

2. Material and methods

All animal experimental procedures were carried out in accordance with the Danish Ministry of Justice, Act no. 474 of May 15, 2014 concerning experiments with animals and care of experimental animals and license issued by the Danish Animal Experiments Inspectorate, Ministry of Food, Agriculture and Fisheries, the Danish Veterinary and Food Administration.

2.1. Animals and housing

A total of 4952 Landrace/Yorkshire × Duroc piglets (6.3 ± 0.8 kg; equal sex ratio) were housed in mixed sex groups with castrated males immediately after weaning. Pigs were placed in 11 identical rooms. Each room had 16 pens (2.4 m × 4.8 m). Two adjacent pens shared a feed dispenser; henceforth, these are termed double-pen. The number of pigs per pen was between 23 and 34 according to the number of weaned piglets available, but similar among treatments. The number of pigs per pen was balanced for each room. Temperature in the rooms was controlled at 23 °C at the start of the experimental period and was gradually decreased to 21 °C at the end of the experimental period. The CO_2 level was controlled at a maximum of 3200 ppm. The flooring of pens was made up of one third concrete and one third slatted floor.

2.2. Dietary treatments

Within each room, pens were assigned to one of four dietary treatments (n = 22 double-pens/treatment): fishmeal control diet (FM) and low (L-SM), medium (M-SM) and high (H-SM) SM diets. The experimental period was divided into three phases of two weeks each. During the first two weeks of the experimental period, i.e. phase 1, pigs were fed diets containing 50 g/kg FM and 50, 75 or 100 g/kg SM, respectively (Table 1). In week 3–4, i.e. phase 2, the amount of FM and SM was halved for each treatment, resulting in 25 g/kg FM and 25, 37.5 and 50 g/kg SM, respectively (Table 2). In week 5–6, i.e. phase 3, all pigs received the same diet without SM. Diets were formulated to meet pigs' minimum requirements for all nutrients according to the Danish recommendations for weaned piglets (Tybirk et al., 2016). In both phase 1 and 2, two premixes were used supplementing vitamins, minerals, amino acids and enzymes to optimize diets. In both phases, one premix was adapted to fit the H-SM diet with its high calcium content, while the other premix was adapted to fit the FM control. Premixes contained potato protein concentrate as a carrier compound. Moreover, in phase 1, premix also contained soya concentrate. Eighteen tonnes of starfish were caught with a specialised starfish purse serine in Limfjord, Denmark, in April 2015. Starfish, both the solid and leaked liquid phase, were minced and subsequently dried at an FM processing plant to a water content of 86 g/kg. Dried starfish were ground into meal. All diet ingredients were mixed on farm and fed in meal form directly after mixing using high-precision equipment (Agrisys AirFeed, Herning, Denmark).

2.3. Experimental protocol

Pigs were weaned between 24 and 27 days of age. Experimental treatments were started at day 0 of weaning and lasted 6 weeks. Pigs were distributed to the pens according to body weight to obtain uniform-sized pigs in each pen. Pens that shared the same feed dispenser both had pigs at the same size. There was permanent access to water and diets. Leftover feed was vacuumed out and weighed before transition to a new diet. Feed samples were taken from the pens weekly and stored in a freezer (−20 °C) for posterior nutrient analyses. Feed samples were pooled per week and per treatment. Pigs were weighed by pen on day 0, 14, 28 and 42 of the experimental period. Average daily gain (ADG), feed conversion ratio (FCR) and average daily feed intake (ADFI) were determined. Diarrhoea incidence was assessed by visual judgement and treated according to veterinary advice. Pens with high prevalence of diarrhoea were treated with antibiotics (Doxx-Sol) in the drinking water. It was not possible to apply antibiotics to drinking water to separate pens within a room, hence treatment of pens had to be applied to an entire room. Individual pigs were treated for diarrhoea with antibiotic injections (Borgal).

2.4. Chemical analyses

Chemical analyses for dry matter (DM), crude protein (CP), crude fat, Ca, P and amino acids (AA) were performed in duplicates on feed samples from the phase 1 and 2 diets. Dry matter content was analysed by oven drying at 103 °C for four hours (European