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Influence of genotype and feeding strategy on pig performance, plasma concentrations of micro nutrients, immune responses and faecal microbiota composition of growing-finishing pigs in a forage-based system

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ABSTRACT

In free-range pig production it is important to reduce the input of nutrients from supplementary feed to reduce nutrient leaching and improve the resource efficiency of the system. A promising development might be to encourage foraging behaviour of the pigs. However, very little is known about pigs' ability to take advantage of direct foraging to cover their nutritional needs and how this interacts with breed and affects robustness. Pig performance, plasma concentration of micro nutrients, immune response and faecal microbiota composition were studied in 72 growing pigs (34 to 105 kg live weight) of either a traditional (Tamworth × (Landrace × Yorkshire)) or a 'modern' crossbreed (Duroc × (Landrace × Yorkshire)) fed a pelleted diet as supplementary feed either according to recommendations (NORM), or restrictedly with (RES+) or without (RES–) a supplementary vitamin and mineral mixture. The pigs 'strip grazed' a diverse pasture with a grass–clover mixture and forage herbs (338 m^2 pig^{-1}) and root chicory (34 m^2 pig^{-1}). The results revealed that a 33% reduction in feed allowance of a pelleted diet reduced daily gain with up to 25% but improved conversion of supplementary feed into live weight with up to 15%. There were no significant differences in pig performance between RES+ and RES–. The two breed combinations responded similarly to the reduction in feed allowance with regard to growth performance and feed conversion. Across feeding strategy, the traditional crossbred had 20% lower daily weight gain and used 25% more supplementary feed per kg live weight gain compared to the 'modern' crossbreed. Omitting a mineral and vitamin premix to the diet had no consistent effects on plasma concentration of minerals but the plasma concentration of α-tocopherol and retinol were significant lower in RES– pigs compared to RES+ and NORM pigs. Plasma 25-D_3 was significant lower in October than in September. The immune response and microbial composition showed few and inconsistent differences between treatments. In conclusion, this study indicated that direct foraging in a diverse range area contributed significantly to the nutritional supply of pigs fed restrictedly with supplementary feed. There are indications that the mineral content of the premix is not needed in a forage-based free-range system but cautious need to be taken with regards to the vitamin A, D, E supply.

1. Introduction

Among consumers in Europe and other parts of the world there is an increasing interest in high-value pork positioned with regard to animal welfare (Krystallis et al., 2012). Free-range pig production is considered more animal friendly by the consumers. However, outdoor production of growing-finishing pigs on pastures as described by Halberg et al. (2010) has a major drawback in terms of high nitrate leaching (Eriksen et al., 2006a, 2006b). This is to a large extent related to high stocking density combined with large input of nutrients from the supplementary feed (Eriksen et al., 2006a, 2006b). The use of supplementary feed is often higher in free-range compared to indoor systems for growing pigs due to a poorer feed conversion.

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A way to reduce the nutrient input might be to encourage the pigs to find a larger part of their food directly from range areas and thereby increase the nutrient re-cycling in free-range systems (Hermansen et al., 2004; Quintern and Sundrum, 2006). It is well-known that non-lactating sows can cover a large part of their energy and protein requirements by foraging grass-clover (Rivera et al., 2001; Fernández et al., 2006) and a daily grass intake of 3.7 kg DM has been reported (Sehested et al., 2000). Data on growing-finishing pigs are scarce but in general growing pigs have a lower capacity to digest forages. A daily herbage intake of 0.5 kg DM has been observed in young European wild boar grazing pastures in a semi-extensive production system (Hodgkinson et al., 2009), Iberian heavy pigs grazing natural pastures (Rodríguez-Estévez et al., 2009, 2010) and in growing pigs grazing cultivated ryegrass and alfalfa pastures (Riart, 2002). However, the herbage intake of growing-finishing pigs depends on the level of supplementary concentrate (Edwards, 2003; Stern and Andresen, 2003).

Direct foraging in the range area has the potential to provide an important contribution to the vitamin and mineral supply, in addition to the contribution to energy and protein requirements (Edwards, 2003) as also indicated in pregnant sows (Fernández et al., 2006). In practice, in addition to the contribution of minerals in the major dietary ingredients, the animals' requirement of minerals and vitamins are fulfilled through dietary supplementation of commercially produced micronutrients. However, this practice is debated with regard to organic farming, and there is a lack of information on the actual requirement for micronutrients of growing pigs housed in alternative systems such as free-range systems with access to forage areas.

Access to forage area is further of interest in terms of animal health and immune response. Potential forage plants are rich in components such as dietary fibres with immunoregulatory properties (Wismar et al., 2010). Inclusion of chicory roots into diets for pigs has e.g. been shown to benefit the gut health and the resistance of the pigs towards certain infectious diseases (Mølbak et al., 2007; Thomsen et al., 2007).

In this study we hypothesised that in a forage-based system pigs fed restrictedly with supplementary concentrate would need less concentrate per kg live weight gain and further they would show improved gut health as indicated by changes in faecal microbial composition compared to pigs provided with concentrates according to recommendations.

Free-range production combined with the use of pigs of a traditional genotype has been suggested as a way to produce high-value niche-market pork (Talbott et al., 2003). Pigs of a traditional genotype are generally characterised by inferior feed efficiency (Kongsted et al., 2011; Leenhouwers and Merks, 2013) and therefore less profitable and ecological sustainable in production systems with high input of concentrated feed. However, due to their lower potential lean tissue growth rate, pigs of a traditional breed are likely to be under less metabolic stress when provided feed traditionally considered as poor quality feed (Edwards, 2003; Wood et al., 2004). It is likely that pigs of a traditional breed are able to consume a higher quantity of bulky feeds compared to pigs of a 'modern' breed as breeding for leanness and improved feed efficiency has selected for reduced appetite (Kelly et al., 2001). Finally, breed-related differences have been observed for health and immune response to environmental stressors. Merlot et al. (2012) found that a pigs of a slow-growing local breed was less susceptible to environmental stressors than pigs of a fast-growing breed. All of this together could indicate that pigs of a traditional breed may be more suitable for a system based on foraging in a range area compared to pigs of a more 'modern' fast-growing genotype.

In the current study we hypothesised that compared to modern fast-growing pig genotypes, the performance of pigs of a traditional genotype will be less impaired by restricted access to supplementary concentrate in a diverse forage-based system and further the traditional genotype will reveal enhanced robustness in terms of immune- response and intestinal microbial composition.

The objective of the present study was to investigate the effect of pig genotype (expected to differ in growth rate), feeding strategy (high or low concentrate allowance), and inclusion or withdrawal of vitamin and micromineral premix on animal performance, mineral and vitamin status, immune response and faecal microbial composition of growing-finishing pigs in a forage-based system.

2. Materials and methods

2.1. Animals, experimental design and treatments

A total of 72 female growing-finishing pigs with an average live weight of 33.7 kg (SD=2.8 kg) and an average age of 88 days were included in an experiment carried out at Aarhus University, Denmark, from August to October 2012. All pigs were born and raised on the same conventional indoor pig farm until three weeks before the start of the experimental feeding, when they were introduced to two paddocks, one for each breed combination, to become familiar with an electric fence and outdoor life. After one week in these training paddocks, the pigs were moved to the experimental paddocks to get familiar with the paddocks and to be accustomed to the forage crops before introduction of three different feeding strategies approximately two weeks later (day 0). The experimental design was factorial, with three feeding strategies, two genotypes and three replicates, i.e. a total of 18 groups, each including four pigs. The two genotypes used (DYL and TYL) were the progeny of Landrace × Yorkshire (LY) sows sired by either a Duroc (D) or Tamworth (T) boar. Within each genotype the pigs were divided in three blocks on the basis of live weight, and within each block they were randomly allocated to one of three feeding strategies. The pigs were not snout ringed. All pigs were fed an organic complex pelleted diet formulated to provide all nutrients, except vitamins and micro-minerals, according to the Danish recommendations for growing-finisher pigs (Anonymous, 2010). All pigs were daily fed 1.8 kg of pelleted diet from until the experimental feeding began at day 0. One feeding strategy (NORM) fulfilled the Danish energy recommendations for indoor housed pigs (Anonymous, 2010) plus 15% as recommended by Edwards (2003) for the higher activity level of free-ranging pigs. Two alternative feeding strategies (RES+ and RES–) provided approximately 80% (day 0–28) and later 50% (day 28–66) of the NORM feed allowance. The pelleted diet used in treatment NORM and RES+ contained a supplementing vitamin–micromineral premix. This is standard procedure in organic and conventional pig production in Denmark. The feeding treatment RES– resembled the feed mixture used in the two other treatments except that no supplementing vitamin–micromineral premix was added. The compositions and results of the chemical analyses of the pelleted diets are shown in Table 1.

2.2. Experimental paddocks and paddock management

The 18 experimental paddocks were arranged in a line. The paddocks were divided in three blocks with six adjacent paddocks within each block. Each of the six combinations of genotype and feeding were randomly allocated to one of six paddocks within each block. Each paddock measured in total $13 \times 125\ m^2$ and provided an area of $13 \times 104\ m^2$ sown in spring 2011 with a mixture containing 77% grass–clover and 23% forage herbs. The grass clover mixture contained 10% white clover (*Trifolium repens*),