Nutrition of Sows and Boars

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CONTEXT

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INTRODUCTION

Traditionally, the influence of nutrition on the breeding animal has been considered as a simple input – output relationship, with such indices of performance as the number of piglets reared per sow per year being adequate. Nowadays, the considerations of nutrition are more complex and must not only take account of the effects of nutrition on performance, but also of how nutrition impacts on animal welfare, environmental pollution, manure management, health status and product quality. Animal nutrition has therefore become an integrated and pro-active science which reflects the totality of reproduction and related production functions.

One of the major achievements in pig production over the last thirty years has been the improvement in sow productivity from about 16 to 22 piglets reared per sow per year (Table 1.1). Interestingly, this achievement has not come about by large increases in the number of piglets born alive per litter, but more by improvements in nutritional knowledge and dietary formulation, management, husbandry, housing and stockmanship, as well as a better understanding of the healthcare needs of the animal. A contributory factor has been the reduction in weaning age. A major benefit has been a greater understanding of the nutritional physiology of the pig that has allowed specific strategies to be adopted and applied in the different conditions under which sows and boars are kept; that is, it allows customisation of nutritional needs for individual herd or animal circumstances.

Table 1.1 Changes in sow performance during the last 30 years (MLC)

	1970	*1975*	*1980*	*1985*	*1990*	*1995*	*1999*
Litters/sow/year	1.9	2.0	2.18	2.25	2.23	2.25	2.25
Piglets born alive/litter	10.3	10.4	10.3	10.4	10.7	10.8	11.0
Piglet reared/sow/year	16.3	17.5	19.8	20.9	21.1	21.6	22.0
Annual sow disposals (%)	-	33.9	35.9	38.1	40.0	42.6	42.0
P_2 at 100 kg (mm)	-	22	19	14.5	13.0	11.5	11.0
FCR in feeding herd (g/g)	3.8	3.4	2.9	2.8	2.70	2.58	2.61

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THE PRE-BREEDING GILT

Introduction

One of the major achievements in pig production over the past thirty years has been the improvement in sow productivity, from about 16 to 22 piglets reared per sow per year (Table 1.1). However, genetic selection for lean tissue growth may have inadvertently influenced the breeding potential of the sow through a reduction in body fat content and appetite. Thus, the modern sow, which has a higher mature body weight, is expected to have a higher annual sow productivity but is more vulnerable to nutritional mismanagement than animals of 20 to 30 years ago. Kerr and Cameron (1995) showed that the reproductive performance of sows, manifest as litter size and litter weight both at birth and weaning, was lower in lines selected for low daily feed intake or high lean feed conversion efficiency. There was also a reduction in the farrowing rate of such sows. Interestingly, the gilts had lower body weight and backfat at both mating and farrowing, as well as reduced feed intakes in lactation. This suggests that the body condition of the gilt at selection and mating is of prime importance to long-term productivity and the nutritional factors that influence these must be known.

There is also concern about the high culling rate and high mortality of modern hyper-prolific sows, especially in the early parities. Sows without adequate reserves are unable to sustain high levels of productivity and evidence suggests that the average sow replacement rate in many countries is 40-45%. Of the animals culled within the first two parities, some 50% failed to come into oestrus and conceive. In addition, 10% were culled because of leg problems. In comparison, sows in the past were extremely robust and less sensitive to nutritional extremes but with a lower expectation of performance. The proper feeding and management of the replacement gilt is therefore critical if she is to maintain good reproductive performance. Good litter size at birth is determined by ovulation rate, fertilisation rate and embryo survival, and it is also necessary to examine the role of nutrition on these key components.

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ENERGY: RESPONSES AND REQUIREMENTS

Introduction

Unlike other nutrients, energy is derived from several chemical constituents of the diet, namely carbohydrate, protein and lipids. These energy-yielding components are required for many different biological functions. During oxidation they fuel all metabolic processes and result finally in heat loss from the animal or work carried out. If not oxidised and lost from the body, the energy in carbohydrates, protein and lipids may become incorporated into the body tissue, predominantly as protein and fat in the growing and breeding animal, as conceptus and products of conception in the pregnant animal, or as milk in the lactating animal.

The efficiency with which energy is used depends upon the source of the energy, with the gross energy yield from lipid at 39.7 MJ/kg being higher than that from protein (23.6 MJ/kg) or carbohydrate (17.5 MJ/kg). However, not all of this energy is available to the animal and this has prompted the development of systems of energy evaluation of feedstuffs, such as the digestible energy (DE), metabolisable energy (ME) or net energy (NE) value of the feed. The DE system is the most widely used and is the energy currency used in this book to evaluate energy responses and requirements. Similarly, predication equations have been developed, which allow the energy content of the feed to be determined from the chemical analysis of the feed ingredients or the feed (for example Noblet, 1996).

Energy is perhaps the most limiting chemical nutrient, since it is needed to fuel all metabolic processes within the body. Indeed, if energy is limited, even if all other nutrients are provided at the correct level, the animal cannot perform to its genetic potential for growth or reproduction. It is therefore important that the animal's response to energy is clearly understood and that its energy needs are well defined.

Responses to energy

PREGNANCY

Energy is required during pregnancy for two main purposes: for maintenance,

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PROTEIN AND AMINO ACIDS

Introduction

Protein is generally taken as nitrogen content of the diet x 6.25, (the assumption is made that 100g of protein contains 16g of nitrogen). However, the source of protein is also important because, for optimal performance, it must provide adequate amounts of the various essential amino acids. The response to dietary protein will vary depending on the amino acid balance and other factors attributed to the animal or the environment.

In recent years there has been greater attention to preparing the gilt, during the rearing phase, for its future role as a breeding animal. This has been done in the knowledge of the lowered fat content and substantially higher lean content of modern gilts compared with animals in the 1970s. Thus, specific nutritional systems have been developed to ensure that the animals have adequate body reserves at first mating to prepare them for a successful breeding life (see Chapter 2).

It is also recognised that modern breeding pigs make considerable growth during their early breeding life. In addition, the nutritionist is also charged with considering protein nutrition to a background of reducing nitrogen pollution of the environment.

Pregnancy

The protein needs of pregnancy are for maintenance, deposition of reproductive tissue, especially conceptus tissue and for maternal gain. The latter may be pregnancy anabolism associated with the catabolism of body reserves in the previous or subsequent lactation or true growth if the sow has still to reach mature body weight.

Normal, healthy piglets can be produced when the sow is given a protein-free diet (Pond, 1969). The sow is able to buffer the developing foetuses from

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* The contribution of T.A. Van Lunen to this chapter is gratefully acknowledged

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MINERALS

Minerals are important constituents of an animals diet; they have many diverse physiological roles within the body, from regulatory to structural functions. The intensification of pig rearing has led to the need for mineral supplementation in diets as confinement restricts access to soil and forage and limits the animal's sources of dietary minerals. Throughout the reproductive process, minerals are required to support a range of activities including maintenance, cell enlargement and multiplication, and for various secretions as well as immune enhancement, but in terms of specific actions the interaction between mineral supplies and reproduction often remains obscure. Evidence is only exposed when the dietary supply is marginally adequate and changeable. Actual requirements in the breeding pig are hard to establish; most estimates are based on a minimum level required to prevent a deficiency symptom. However, the role of minerals in reproduction is often underestimated and the involvement of specific minerals at different periods of the reproduction cycle has been suggested in Figure 5.1.

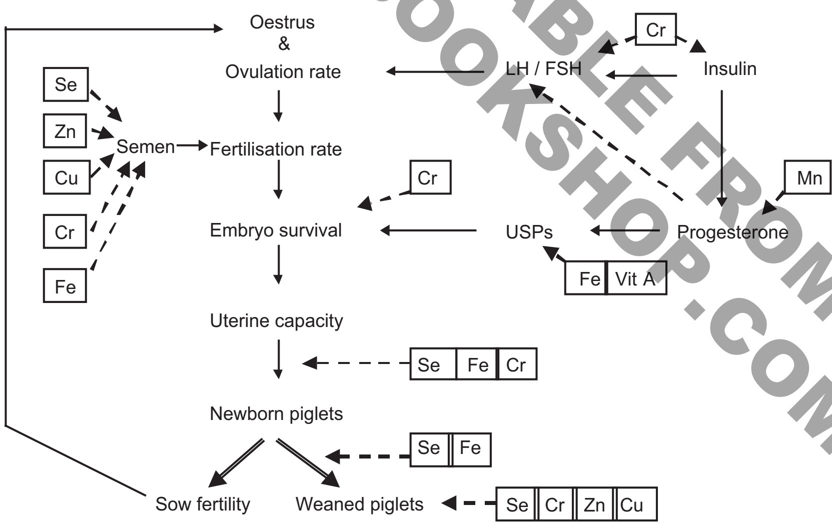

Figure 5.1 The role of trace elements in sow reproduction (Close, 1999)

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VITAMINS

Introduction

Vitamins are dietary organic compounds, which are required in very small amounts and are essential for the normal metabolism, growth and health of animals. Thirteen different vitamins have been defined and there are at least six additional compounds that may have a vitamin-like activity for some species. Many vitamins function as co-enzymes or pro-hormones; others have specific roles as components of specialized tissues or precursors of essential biochemical processes; some have important functions as antioxidants.

While the pig has a metabolic requirement for all vitamins, it is able to synthesise some of them either through the action of micro-organisms in the hind gut or by the action of the adrenal glands (Christensen, 1980). It is not clear what proportion of the vitamin products synthesised in the hind gut is beneficially absorbed and whether any becomes available by coprophagy. Sorrell *et al* (1971) suggested that some B-group vitamins can be absorbed from the colon. If the pig has access to its faeces, it might benefit from the intestinal vitamin synthesis by coprophagy. Similarly, the adrenal glands manufacture vitamin C as ascorbate in normal, healthy pigs over 14 days old unless they are under stress (Brown, 1984.)

Daily dietary supplementation of most vitamins is therefore essential for pigs of all ages, since no reliance can be placed on microbial manufacture. The absence of adequate amounts of any vitamin may lead to symptoms of clinical deficiency although, in most cases, the first signs are a reduction in performance. All feed ingredients contain a range of vitamins, although both the amounts and their bioavailability and bioactivity may be extremely variable (Christensen, 1980). The vitamin content will vary between different food types and individual foods can show large differences within a food type.

The contribution of Michael Putnam to this chapter is gratefully acknowledged

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WATER PROVISION

Introduction

Water is involved in virtually all body functions and it comprises almost 70% of the adult animal's body mass. An animal can lose practically all its fat and over half its protein and yet live, while a loss of one-tenth of its body water will result in death (Maynard, Loosli, Hintz and Warner, 1979). Furthermore, the daily turnover rate of water within the body is greater than that of any other substance; 200 ml/l or 120-130 ml/kg body weight per day in growing pigs (Yang, Howard and McFarlane, 1981). Despite this, the water requirements of the pig have been given scant attention by researchers. To limit the discussion in this chapter to a consideration of water 'requirements' would be to perpetuate a failing that has been inherent in most reviews of nutrient requirements. Water is not just another nutrient, it fulfils other functions and has special significance beyond nutrition. Its importance is often underestimated both in experimental and practical settings and not only by nutritionists but also by building designers, veterinarians and commercial pork producers. It is frequently, but wrongly, assumed that if the pig has access to a supply of water, it will neither limit nor modify its performance. This is not the case since many of those intractable problems of poor performance in the commercial piggery which are attributed to 'the environment' or 'the food' actually have their genesis in an inadequate, inappropriate or contaminated water supply. Furthermore, many nutritional studies in which unusual or unexpected results have been obtained have been compromised by inappropriate water provision.

The aim in this chapter is to consider the interactions of water with other aspects of nutrition and management and to suggest ways in which the researcher and the producer should approach the subject of water provision to breeding animals.

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APPETITE

Appetite is of major concern in lactation when the heavy requirements of milk production demand that feed intake be of the order of more than three times the level needed in pregnancy. For example, the energy needs of the sow in lactation may be in the order of 80-120 MJ DE/day (Chapter 3), whereas estimates suggest that the voluntary intake of the sow in early pregnancy is between 65-75 MJ DE/day falling to about 54 MJ DE/day at farrowing (Friend, 1971). The latter value is similar to that of 53 MJ DE/day reported by Weldon *et al* (1994) for sows fed *ad libitum* from day 60 of gestation. This is well in excess of the suggested mean requirements of 27-40 MJ DE/day in this review.

It has been proposed that with the selection of growing pigs for the efficient production of lean meat, appetite has been reduced (Cole and Chadd, 1989) and that this may also have consequences for the lactating sow (Cole, 1990). Estimates of the energy requirements of lactating sows that avoid losses of liveweight or maternal body tissue are of the order 80-120 MJ DE/day, representing intakes of 6.0-9.0 kg/day of typical sow feeds. However, feeding strategies generally allow for some small maternal losses. For example, ARC (1981) based requirements on liveweight, weaning age and different levels of milk production with the assumption that sows could lose 175 g/day without serious consequences. Modern targets suggest that the hyperprolific sow can lose 10kg liveweight in lactation without prejudicing subsequent performance.

In examining the appetite of the lactating sow, it is assumed that requirements are set by a number of animal factors which may be modified by environment, and that the level of intake achieved is determined by the ability of the diet to meet those requirements.

The animal

GENOTYPE

The selection of growing pigs for the efficient production of lean meat has selected against appetite (Fowler *et al*, 1976; Cole and Chadd, 1989) (Figure 8.1). Such

* The contribution of P.J. Booth to this chapter if gratefully acknowledged

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DIETS

Introduction

Attitudes to diet construction will vary depending on a number of factors. For example, in a country which is a net importer of animal feeds, great attention will be paid to precise nutrient requirements and least cost formulation strategies. On the other hand, in areas where the main objective is to maximise use of particular materials (e.g. maize and soya), the aim will be to add value to these products and to use the least number of other ingredients.

The pig, being a monogastric animal, does, in many instances, compete with humans for its food supply. However, as the animal matures, it has a greater capacity for dealing with bulky foods than younger pigs.

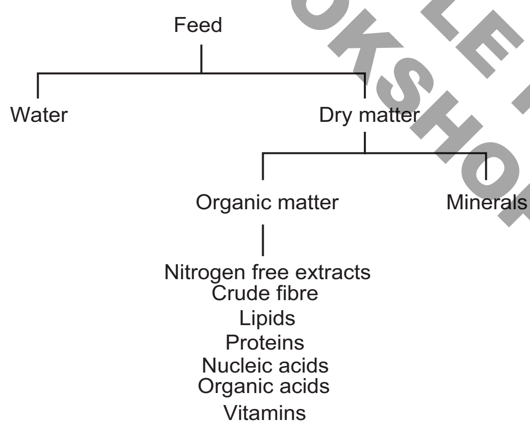

Figure 9.1 The major components of feed ingredients

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MODELLING REQUIREMENTS AND RESPONSES

Introduction

One of the most effective ways of determining the nutrient requirements and responses of farm animals is by simulation models, where the animal is represented by a series of mathematical equations linking genetic, nutritional, metabolic, physiological and environmental phenomena. Several have been described and applied with good success for the growing pig (see Moughan, Verstegen and Visser-Reyneveld, 1995), but it is only in the last years that sufficient information has become available to allow integration into a simulation model to describe and predict the requirements and responses of the sow (Williams *et al*, 1985; Black *et al,* 1986; Mullan *et al*, 1989; Whittemore and Morgan, 1990; Noblet *et al*, 1990, 1997; Walker and Young, 1992; Pettigrew *et al*, 1992a, b; Whittemore, 1995; NRC, 1998).

Models may operate at different levels; some are empirical and are based on whole-animal predictive equations developed from experimental data sets, whereas others are mechanistic and deal with individual processes within the body. Mechanistic models deal with the effects of diets and other external variables on processes within the animal and use these to predict whole-animal responses. Thus, depending upon the knowledge available and the level of sophistication, mechanistic models may operate at tissue, cellular or molecular level. Because they operate at a lower level of organisation, these approaches are more flexible and may be expected to predict responses and indeed requirements, over a wider range of conditions.

Many of the models available for sows are a combination of the empirical and mechanistic model and are usually referred to as 'nutrient-partitioning' models. They usually operate on the factorial principle that dietary nutrients may be partitioned between the requirement to maintain the animal in nutritional balance

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THE BOAR

Introduction

Despite the importance of the boar to herd fertility, it has received little attention and is the most neglected animal on the pig unit. Boars are often kept in conditions of poor hygiene in pens that are too small or badly designed and in poor climatic and social environments. The nutrition of the boar has received scant attention. Information relating to the nutritional requirements and responses of the breeding boar is therefore limited and this topic received little mention in the reviews of ARC (1981) and NRC (1988, 1998). Many recommendations have therefore been based on the breeding sow.

If boars are to be reared for breeding purposes, then physical soundness and future reproductive performance are as important as good growth rate. Young boars are normally selected according to an index which includes such characteristics as growth rate, appetite, feed conversion efficiency, lean tissue growth rate, carcass quality and breeding potential. They are normally fed to appetite and it is assumed that this does not prejudice subsequent reproductive capacity. It may however affect their physical ability to perform since the tendency to leg weakness may be exacerbated by high rates of growth and by feeding to appetite (Grondalen, 1974; Hanssen and Grondalen, 1979; Kesel, Knight, Kornegay, Veit and Notter, 1983). Penny and Guise (1989) reported that the annual culling rate of boars in commercial herds is 40 to 60% with the primary reason being excessive weight gain and animals becoming too large. This suggests that the priorities for nutrients and the nutritional requirements of the breeding boar may differ markedly from those bred for meat production or from those of the breeding sow. It is therefore important to establish the nutritional requirements and responses of the breeding boar at the various stages of development, to assess whether nutrition influences sexual development and reproductive capacity, and to make recommendations on appropriate feeding strategies to ensure good reproductive performance.

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PRACTICAL FEEDING STRATEGIES

Introduction

The development of a feeding strategy necessitates the clear identification of objectives by sound scientific principles as a basis for realistic application. This may result in some aspect of the science or practice completely outweighing another or it may result in a compromise between the two. For example, the objective in pig production is to produce saleable pig meat and considerable emphasis is placed on the genetics and nutrition of pigs until slaughter weight. Consequently, little attention has been given to treating the young developing pig as a potential breeding animal. It is fortuitous that the nutrition of pigs for meat is a reasonable, but not necessarily ideal, basis for future breeding and it is likely that reproduction will be optimized in the early stages (e.g. the gilt litter) by more attention being paid to tactics to be adopted around puberty and first mating.

Nutrition may influence reproductive characteristics at many stages of the breeding cycle (for example, Figure 12.1). However, strategies for sow nutrition must imply attention to longer term reproduction. Consequently when examining the influences of nutrition at different stages of the reproductive cycle it is important to consider their effect on the whole breeding lifetime. In this context, body condition and how it is influenced by level and pattern of supply of energy and nutrients is of key importance. Relationships exist between different phases of the reproductive cycle and there are 'carry-over' consequences of nutrition, not only within a parity, for example between pregnancy and lactation, but also between parities. These influences must be considered in the development of appropriate diets and feeding strategies.

Emphasis on body condition may be justified in several ways. For example, support may be sought from the classical work of Hammond (1944) in which he suggested a "priority for nutrients". His theory suggested that the various tissues could be placed in an order of priority for the allocation of energy and nutrients.

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Pages in bold italics indicate summarised information in the keynote section.