
EFFECT OF DIET ON THE BEHAVIOUR AND WELFARE OF PIGS.

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ABSTRACT

The behaviour and hence the welfare of pigs can be affected by a number of factors related to their diet and the way that that diet is presented. When diets are fed at levels below the voluntary feed intake capacity of the pig (for example in the case of gestating sows) hunger can have a profound effect on behaviour. Problems arise because the diet of the commercial domestic pig is so different from that of its ancestor the wild pig. Whereas the wild pig's diet is low density, low dry matter concentration (around 20-25%) and high in crude fibre the commercial sow's diet is high in dry matter (85-90%) with a crude fibre content of less than 10% and frequently less than 5%. In the last 15 years it has become apparent that feeding sows on high density, low fibre diets has a profound and negative effect on their behaviour and welfare and that conversely, providing sows with more bulky diets can have very positive effects on their wellbeing.

When pigs are fed *ad libitum* on diets that apparently satisfy their nutrient requirements diet related behaviour problems can still arise. In this case the composition of the diet may influence the behaviour of the pig. Diet components can influence the incidence of vices in intensively kept grow-finish pigs, such as biting of tails, ears, or flanks. Imbalances in the diet can influence feed intake and resting behaviour. Diet composition can also affect the time that the pig spends eating and its demand for water, and hence time spent drinking. When feeding and drinking points are limited, changes in demand for access to feeders or drinkers may have an influence on behaviour. At best these changes will result in animals eating out of synchrony with their circadian rhythms and in particular eating and drinking during what should be their resting period. In other circumstances they cause considerable disruption to the behaviour of the individual or group. In the worst situations the available resources for feeding and drinking may be so limited that the pig's requirements cannot be accommodated thereby compromising their welfare.

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Introduction

Traditionally, nutritionists formulated diets to meet the perceived nutrient requirements of the animal. Most of these requirements were established by considering the nutrient demands for specific functions, usually derived under experimental conditions. These values were then combined using a factorial approach to derive an overall food allowance. Feed allowances aimed to optimize biological performance under commercial conditions. Only in recent years has nutritional research started to consider the effect that diet may have on the behaviour and welfare of the animal. The quantity and quality of the feed and the physical and social environment in which it is presented to the animal all affect feeding behaviour. Some ways in which these interact are outlined schematically in Figure 1.

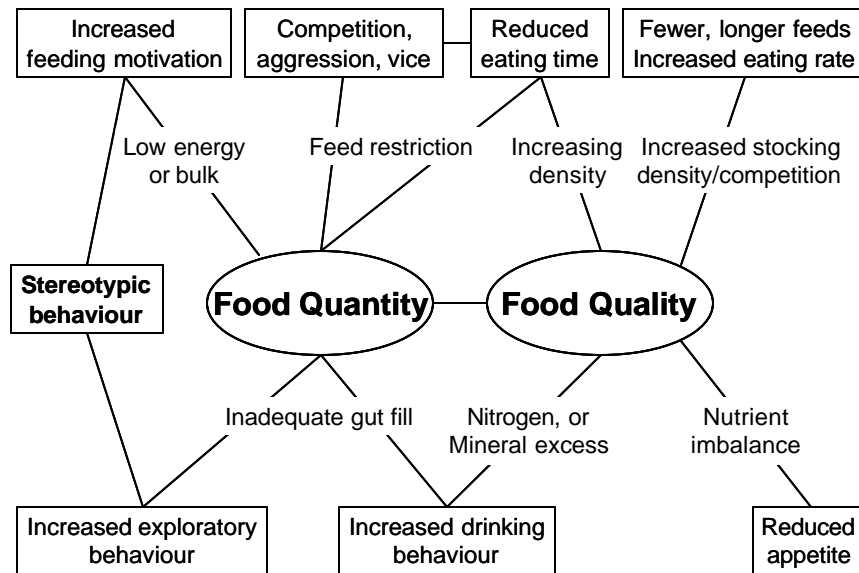


Figure 1. Some effects of food quality and quantity on pig behaviour.

The interrelationships are often complex and as a consequence the outcome of dietary manipulation is not always easy to predict. However, this paper will argue that pig managers should consider the nutrition and management of the pig in a holistic and evolutionary context. An important subtext to this discussion is that we need to consider all the components of gut fill (feed, water and consumed bedding) and the impact of diet on factors such as meal duration and eating speed when trying to understand the relationship between diet, feeding motivation and behaviour. By doing this, they are more likely to be able to predict outcomes and modify pig behaviour in a way that maintains performance and at the same time safeguards the animal's welfare.

This paper will exemplify this approach by considering two specific cases, the effect of diet on stereotypic behaviour in gestating sows and the possible involvement of dietary salt in tail biting in growing-finishing pigs.

Look backwards to look forwards!

We may have domesticated and selectively bred the pig but it still retains most of the behavioural repertoire that it developed for survival in its evolutionary past. The diet fed to domestic pig is very different from that consumed by their ancestral wild counterparts. Wild pigs are opportunistic feeders and will consume a very wide range of plant material (Massei *et al.* 1996). Vegetation makes up approximately 93% of the annual diet by volume (Taylor *et al.* 1997) and is supplemented with invertebrates and carrion, when the pigs can find them (Schley *et al.* 2003).

Finding food occupies a considerable amount of the wild pig's time. Wild pigs spend between 25% and 59% of their time foraging and feeding (Teilland 1986). Similarly, Mauget (1981) reported that wild boar spend 25% of their time foraging and feeding, although the proportion may reduce considerably when food is plentiful. This is in contrast with lactating domestic sows who spent 4.0-5.5% of their time feeding (de Passille *et al.* 1989) increasing to 5.4-8.3% when fed using a sow operated dispenser (Burke *et al.* 2000).

An important characteristic of the wild pig's diet is that it has a low density, low dry matter concentration (around 20-25%). Furthermore, the dry matter contains a high proportion of crude fibre. In controlled studies, the neutral-detergent fibre (NDF) concentration of diets selected by wild pigs ranged from 139 to 767 g NDF / kg of organic matter (van Wieren 2000). The wild pig's diet is in marked contrast to that of commercial sows. Generally, commercial sows are fed diets that are high in dry matter (85-90%) with a crude fibre content of less than 10% and frequently less than 5%. Do these changes that we have imposed on the diets of sows matter? For a long time we didn't think they did, but in last 15 years it has become apparent that feeding sows on high density, low fibre diets has a profound and adverse effect on their behaviour and welfare and that conversely, providing sows with more bulky diets can have very positive effects on their wellbeing.

Feed intake and feeding motivation.

One of the Five Freedoms (DEFRA 2003) states that animals should have '*freedom from hunger and thirst - by ready access to fresh water and a diet to maintain full health and vigour*'. In the case of pregnant sow this is a contentious issue. A vast amount of research has been undertaken to determine the nutrient requirement of the sow and this has been used in the derivation of feeding recommendations (e.g. National Research Council 1998; Close *et al.* 2000). However, when sows are group housed not only their nutrient requirements, but also their feeding motivation, must be considered. A feature of commercial pig keeping that has caused great concern among the consuming public, and animal behaviourists, is the development of stereotypic behaviour. This apparently motiveless, repetitive behaviour is indicative of poor welfare.

Initially, the sham chewing and bar biting exhibited by stall-housed sows was put down to the frustration that was caused by keeping them in a barren environment that did not allow them to fulfill their normal behavioural repertoire. This interpretation had to be revised when workers at Edinburgh (Appleby *et al.* 1987) demonstrated that stereotypic behaviour in confined gilts could be almost completely 'turned off' by increasing their feed intake from 1.25 to 4.00 kg/day. Pigs fed 1.3 times their maintenance requirement were still unsatisfied in terms of their feeding motivation (Lawrence *et al.* 1988; Lawrence *et al.* 1989a; Lawrence *et al.* 1993). It was shown that recommended feed intakes represented only 60% of the amount of feed that pigs would choose to eat if offered feed *ad libitum*. As a consequence animals were motivated to feed for up to 19 hours of the day (Lawrence *et al.* 1989b). It became apparent that hunger rather than inactivity was the factor contributing most to the sow's sense of frustration.

In subsequent studies, the Edinburgh workers used operant conditioning techniques to determine the degree of hunger that gilts were experiencing (Lawrence *et al.* 1988; Lawrence *et al.* 1989a). Operant conditioning requires the animal to do work (like operating a lever) to obtain a reward (in this case food). The extent of motivation can be determined by making the animal do increasing amounts of work in order to obtain the same reward. This approach was also used by Hutson, (1991), who came to the quite staggering conclusion that sows on restricted diets (normal commercial feed allowances) would sustain an energy deficit to more food. That is to say, they would expend more energy working to get food that they obtained back from the food reward. These results were very dramatic and challenged the way that nutritionists had been looking at the sow's feed requirements.

Nutrient requirements or feed requirements?

In order to understand why this situation had occurred we need to look at the way in which nutritional science got overtaken by changes in sow housing. Until the 1950's sows had generally be kept in groups either with some access to pasture, or in housing systems that included bedded sleeping areas. In the 1960's Lucas, Lodge and Elsley pioneered low level feeding for sows (which became the basis of the ARC (1967) Nutrient Requirements of Pigs). They found that the productivity of sows could be maintained or even improved be feeding much lower levels of feed than had been the practice up until that time. They also showed that apportioning more of the sow's feed intake to the lactation period and less to the gestation period improved the overall utilisation of energy. As a result there followed a decade of nutritional studies that redefined the nutritional requirement of the sow, or more particularly the energy and protein requirements of the sow for maintenance and reproduction. Most of the studies conducted at that time were undertaken using individually fed sows that were group housed in straw bedded yards. Under those conditions there were no obvious, adverse, effects on sow behaviour. The problem arose when the industry went on to adopt confinement housing systems (sow stalls). Two important factors had been overlooked. First, although the commercial diets used to feed confined sows met the sow's requirement for energy and protein, they did not satisfy her hunger or her need for gut fill. Secondly, the move from group housing systems to sow stalls usually resulted in the sow being deprived of bedding material. Nutritionists and managers alike had only seen straw bedding as providing comfort and thermal insulation, they had not appreciated that it also satisfied behavioural needs (for exploration and manipulation) and provided the sow with the opportunity to satisfy her need for gut fill. As a consequence, sows housed in confinement and fed on high density diets may have their nutritional requirements met but at the same time suffer serious welfare abuse because their needs for gut fill are not satisfied.

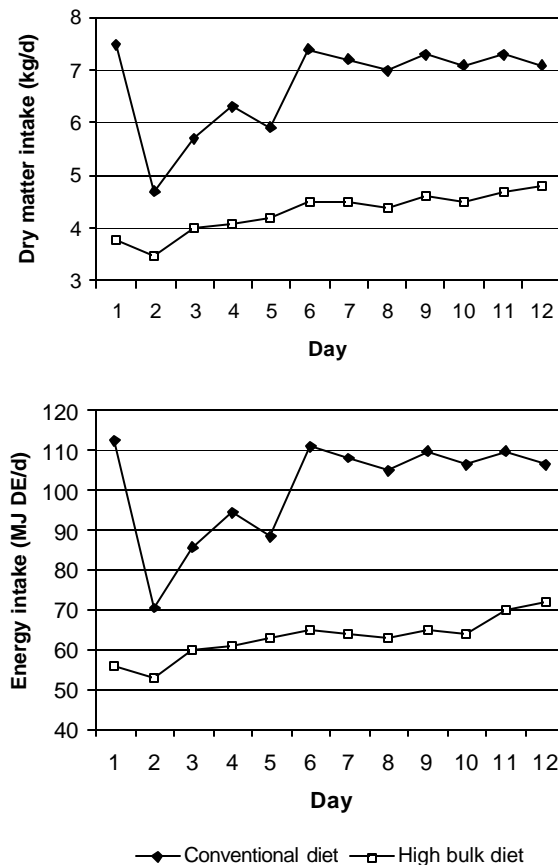


Figure 2. Dry matter and energy intake of pregnant sows fed a conventional diet *ad lib.* or 2.5 kg of a conventional diet plus *ad lib.* soaked, unmolassed, sugar beet pulp. (Hodgkiss 1998).

A study by Hodgkiss (1998) provides some insight into the problem. In her study, pregnant sows were fed for 12 days, either *ad libitum* on a conventional wheat soya based diet, or on 2.5 kg per day of the conventional diet (calculated to be adequate to meet their nutrient requirements) but also given the opportunity to consume as much of a high bulk feed as they wanted. The bulky feed used was unmolassed, sugar beet pulp, soaked in 4 parts water to 1 part dried sugar beet pulp (Figure 2).

Another important observation in this study was the difference in water consumption per unit of dry matter (Table 1). When offered unrestricted access to both feed and water, the pig will maximise its feed intake within its capacity for gut fill consistent with consuming sufficient water to maintain its homeostatic balance (Yang *et al.* 1981). However, when the diet is rationed the pig will consume additional water to satisfy its need for gut fill (Barber *et al.* 1991; Barber 1992). This effect was apparent in the Hodgkiss study. When the feed intake was limited the sows increased their DM:water ratio to 1:6.0. When they were fed *ad libitum* the ratio was 1:3.2 or 3.4. This compares well with the value of 1:3.2 recorded for *ad lib.* fed growing pigs by Barber (1992).

Table 1. Water consumption per unit of dry matter of gestating sows fed different diets. (Hodgkiss 1998).

Feed	Dry Matter : Water ¹
2.5 kg conventional diet	1 : 6.0
Conventional diet <i>ad lib.</i>	1 : 3.2
2.5 kg conventional diet + soaked sugar beet pulp <i>ad lib.</i>	1 : 3.4

¹ Water value includes water associated with the feed components as well as water consumed from drinkers.

From the forgoing we can propose models to explain the observed relationship between diet and behaviour in sows. If the sow is fed a low density (high bulk) diet (typical of a wild pig) feeding motivation is driven by the energy requirement of the sow (Figure 3). Water is consumed to maintain homeostasis and the requirement for gut fill is easily satisfied. Indeed on very bulky diets it is unlikely that the sow's desire to consume energy is ever satisfied.

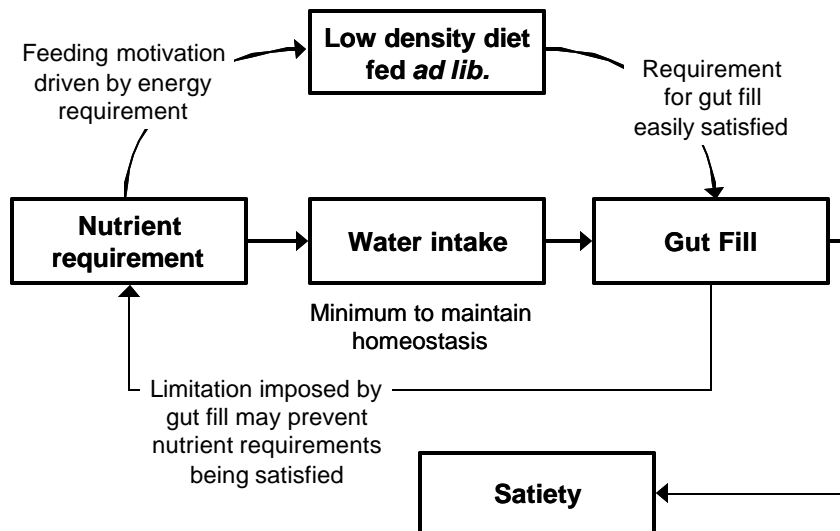


Figure 3. Model of feeding motivation in sows fed a low density diet *ad libitum*.

If the sow is fed *ad libitum* on a typical commercial, high density diet, the requirement for energy and protein for production can be easily satisfied (Figure 4). Feeding motivation comes from lack of gut fill and

is not terminated by a glucostatic feedback, as sows attempt to accrue substantial fat deposits during gestation to support the following lactation. From an evolutionary point of view this is a logical process. It would be unlikely that wild pig would either have access to or be able to eat enough bulky food to support maximum milk yield. Therefore, the deposition of fat reserves would improve the chances of their piglets surviving. If we now consider a situation in which the sow is fed a high density diet, but rationed to permit only a modest increase in fat during gestation the picture is more complex (Figure 5). In this case feeding motivation is driven by a desire to satisfy the requirement for gut fill. In the absence of sufficient food, additional water will be consumed. Additionally, if edible bedding material is available this will also be consumed. In the absence of edible bedding feeding motivation cannot be satisfied and as a consequence is redirected as stereotypic behaviour. The implication of this is that nutritionists now have to think not only about satisfying the nutritional requirements for maintenance and production, but also consider how they can produce diets that will satisfy the animals feeding motivation.

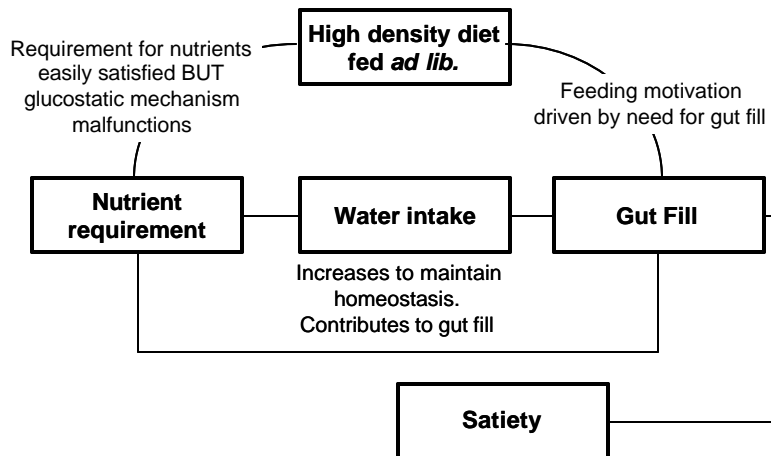


Figure 4. Model of feeding motivation in sows fed a high density diet *ad libitum*.

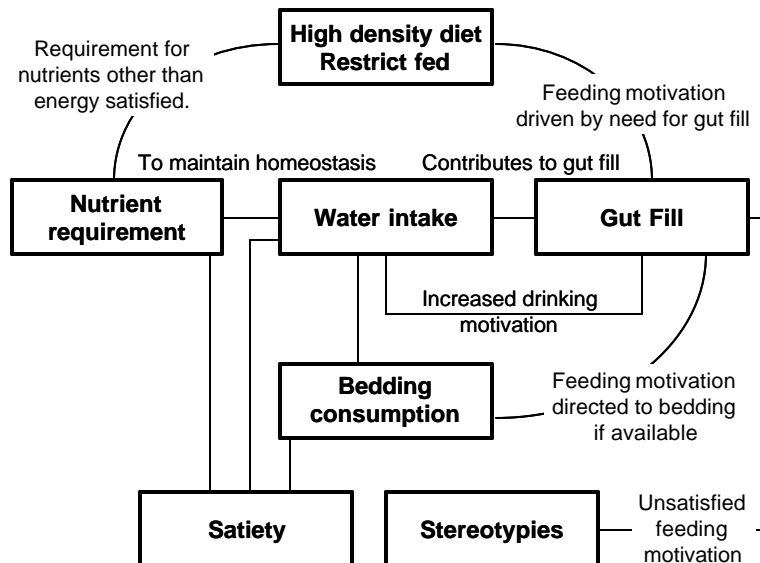


Figure 4. Model of feeding motivation in sows fed a restricted quantity of a high density diet.

Higher fibre diets for sows.

A number of studies have examined the effect of feeding lower density diets. These have been reviewed by Meunier-Salaun et al. (2001). They concluded that the incorporation of fibre in diets to increase bulk, without changing the daily dietary energy supply, resulted in: -

- At least a doubling of eating time,
- A 20% reduction in feeding rate,
- A 30% reduction in operant response in feed motivation tests,
- A reduction of 7-50% in stereotypic behaviour,
- A decrease in general restlessness and aggression.

While a reduction of stereotypic behaviour would be seen as indicating some improvement in the welfare of confined sows the greatest benefits might accrue when sows are group housed. The high levels of feeding motivation cause restlessness in group housed sows. The high feeding motivation frequently results in aggression, particularly around feeding stations. Commercial producers in the UK have found that feeding diets containing 20-30% dried sugar beet pulp is very effective in reducing the incidence of non-feeding visits to Electronic Sow Feeders and that these diets also reduce sow activity levels. An additional benefit of feeding high fibre diets in gestation is that they increase the size of the gastrointestinal tract. This in turn enables greater voluntary feed intake by the sow in the following lactation.

Because of the reduction in stereotypic activity brought about by increased fibre levels in the diet, Dutch Legislation (Varkensbesluit 1994) requires that sow diets must contain at least 140g crude fibre/kg. More recently the EU have recognised the welfare problems associated with hunger in gestating sows and the latest welfare regulations (Council Directive 2001/88/EC) state that: -

'All dry pregnant sows and gilts must be given a sufficient quantity of bulky or high fibre food as well as high energy food to satisfy their hunger and need to chew'.

Can we feed sows *ad libitum* using high fibre diets?

There would be considerable advantages for producers if sows could be fed high fibre diets *ad libitum*. Such an approach would enable sows to be group housed in relatively cheap structures and without the investment in Electronic Sow Feeders. Including a proportion of high fibre materials in diets can reduce voluntary feed intake as the data in Table 2 demonstrates.

Table 2. Voluntary feed intake, by gestating sows, of diets containing fibrous raw materials (after Brouns *et al.* 1995).

	Inclusion level (g/kg)	DE (MJ/d)	Feed Intake (kg/d)	Crude fibre (g/d)
Sugar beet pulp	650	18	2.3	294
Straw	360	42	6.4	1029
Oat husks	370	58	7.7	1088
Malt culms	460	52	6.8	624
Rice bran	610	52	7.6	1485
Wheat bran	670	54	7.1	590

Bulk can be provided by a range of materials. In dry feeding systems sugar beet pulp pellets appear to be the most effective. When sows are fed using liquid feeding systems, wet sugar beet pulp, maize silage or corn cob mix (CCM) can be incorporated in the diet and is effective in increasing bulk and reducing hunger. The problem with a number of these fibre sources is that they either make mechanisation of sow

feeding difficult (e.g. whole crop silages), or they make the diet very expensive. However, where it is available at an acceptable cost, the incorporation of unmolassed sugar beet pulp into diets could make it possible to feed gestating sows *ad libitum*. In a recent study (Whittaker *et al.* 2000), sows were fed either a conventional (13.1 MJ/kg) diet at 2.2 - 2.4 kg/day from an electronic sow feeder, or were fed *ad libitum*, from hoppers, a diet containing 600g/kg unmolassed sugar beet pulp. In this study, there were no significant differences in any of the parameters of sow reproductive performance measured nor were there any significant effects on sow body condition. This suggests that diets containing sufficiently high levels of unmolassed sugar beet pulp could be used to feed sows on an *ad libitum* basis during gestation without compromising productivity. However, in this study the average feed intake of the sugar beet pulp diet was 4.1 kg per sow per day, so the economics of developing a sow housing and feeding system based on such an approach will need careful consideration.

Nutrition and tail biting.

The second example of an interaction between diet and behaviour that will be considered is the involvement of nutrition in vices such as tail biting. In intensively kept grow-finish pigs, biting of tails, ears, or flanks is a fairly common occurrence. This vice is not only a major welfare concern but also leads to serious economic loss. Performance of bitten pigs is reduced and the tissue damage that ensues frequently leads to infection. Abscesses in the spine, a frequent sequel to tail biting, often result in the condemnation of whole carcass. Even superficial scratching and bruising can result in the downgrading of carcasses. Even if this were an infrequent event it would still be a welfare issue. However, biting is rarely isolated to one or two pigs. Once the problem starts it can spread rapidly and reach epidemic proportions.

Despite the economic and welfare importance of this subject it is one that has been little researched. One reason for this is that outbreaks cannot be predicted and hence alternative treatments cannot be imposed. A number of different factors may be involved in the aetiology of any one outbreak. A recent case control study in England (Moinard *et al.* 2003) has identified some of the risk factors for tail biting on commercial units. Adding straw in the creep area once or more per day decreased the risk of tail biting 10-fold. Keeping grower pigs on partially or fully slatted floors rather than solid floors, using a feeding system with five or more grower pigs per feed space and imposing a stocking density during the growing phase of 110 kg/m² or greater each increased the risks of tail biting.

In addition to these environmental factors, it has often been speculated that nutritional inadequacies or imbalances might contribute to the condition. In human subjects, there is considerable evidence that specific nutrients can be linked to mood (Rogers 2001). In farm animals the impact of specific imbalances and/or deficiencies on behaviour is harder to establish, however, there is evidence of a link between tryptophan levels and pig behaviour (Seve 1999). Increasing dietary tryptophan has been shown to increase brain tryptophan and serotonin concentration in rats (Fernstrom *et al.* 1971) and has been shown reduce the preference of pigs for blood and to increase sleeping behaviour in pigs (McIntyre *et al.* 2002). However, increasing tryptophan in the diet also depresses feed intake (Baranyiova 1996; Henry *et al.* 1996).

In pigs, the biting vices often lead to blood injuries and once such injuries have occurred there is a rapid escalation in abnormal behaviour with more and more animals being attracted to the bloody wounds and engaging in biting. For this reason, it has often been speculated that tail biting may indicate either a disruption in the acid base balance of the diet, or a specific deficiency of salt (Fraser 1987b). Although pigs only require around 0.2% salt (NaCl) in their diet for maximum weight gain, salt is often included in the diet at 0.5%. Although there has been little research evidence to support such an hypothesis, many nutritionists will attempt to overcome tail-biting problems by adjusting the salt content of the diet, increasing it to 0.75 or 1.0%. There are many anecdotal accounts of adjustment of dietary salt levels curtailing biting events. Unfortunately, these do not tell us much, as biting can stop as quickly as it starts and in many of these on-farm situations, the problem would probably have resolved without any intervention. Never the less, recent studies indicate that dietary salt consumption can affect the behaviour of the pig and this in turn may have an influence on biting behaviour.

Tsourgiannis et al., (2002) looked at the effect of salt supplementation in a unit with a history of tail biting. The pigs were housed in straw-bedded pens so the environment was not as barren as in many commercial units. The diet fed on the unit contained 0.5% salt. The treated animals had additional salt (equivalent to 1% extra NaCl per kg feed) spread on the solid floor of the lying area on two occasions per day at a three-hour interval. The behaviour of the pigs was studied and it was found that the pens of pigs that had salt spread on their lying area indulged in significantly less biting behaviour (Table 3). It might have been expected that, if the pigs were salt deficient, spreading salt on the floor of a bedded pen would increase the foraging behaviour. This in turn might divert them from tail biting. However, in this study there was no significant difference in the time spent on other behaviours.

Table 3. Effect of providing additional salt on the incidence of biting by growing-finishing pigs.

	Control (0.5% salt in the diet)	Supplemented (equivalent to 1.5% salt in the diet)	SED
Bites	171	78	13.5*
Drinking	130	127	2.1
Standing	188	199	8.1
Feeding	357	339	13.1
Lying	3959	3938	14.9
% of total bites	68.8	31.3	

In a second study, Tsourgiannis and his colleagues (unpublished data) fed pigs *ad libitum* on liquid diets (1 part food to 2.5 parts water). The two diets fed contained either 0.25 or 1% added salt. The behaviour of the pigs was monitored for two weeks using time lapse video. The results (Table 4) show that biting behaviour was greater in both groups in the first week (immediately after the pigs were grouped and penned) but in both weeks was significantly lower on the higher salt diet.

Table 4. Effect of dietary salt level on biting behaviour by growing pigs

Week	Biting incidence (per pig per week)		SED
	Low salt (0.25%)	High Salt (1.0%)	
1 st week	10.3	6.6	1.76*
2 nd week	5.1	2.4	1.03*
Over All	6.7	4.6	0.9*

Because it is not possible to set up conditions that will initiate a tail-biting episode, researchers have looked for a behavioral model that might provide insight into this subject. One approach has been to use a rope chews as a surrogate for pig's tails (Day *et al.* 1996). The rope model can be impregnated with blood, salt or other blood components to measure changes in the chewing motivation of pigs. It has been shown that chewing of a rope is reinforced if it is impregnated with a nutrient substrate, like sucrose (Day *et al.* 1996). Similarly, pigs can be given different diets and the amount of behaviour directed at rope chews can then be compared. Using this model Fraser (1987a) found that a major reduction in the energy:protein ratio in the diet increased the attraction to blood but McIntyre and Edwards, (2001) failed to confirm this finding. Using this model, Tsourgiannis et al., (2003b) investigated the effect that dietary salt content had on the chewing behaviour that liquid-fed growing pigs directed at rope chews soaked in saline or clean water.

The results of their study (Table 5) indicated that the salt content of the diets did not significantly alter the pigs' motivation to chew ropes. Although there were some week-by-week variations there was no significant difference in the amount of chewing behaviour and no convincing evidence that the pigs chose salt impregnated ropes. This data suggests that chewing behaviour directed at a particular substrate is not indicative of the nutritional status of the diet that the pig is being fed. The fact that the pigs fed the low salt diet did not show any preference for a salty rope might be interpreted as evidence that they were not

deficient in salt. This suggests that if salt has a role in affecting biting behaviour it is not because it is satisfying a nutritional inadequacy, but because it alters the time the pig spends on other components of the behavioural repertoire.

Table 5. Chewing behaviour directed at salty or plain ropes by pigs on liquid diets containing 0.25 or 1% added salt.

	High salt diet (1%)		Low salt diet (0.25%)	
	Salty Rope	Plain Rope	Salty Rope	Plain Rope
1 st week	11.38 ^a	9.52 ^b	10.5 ^a	11.14 ^{a,b}
2 nd week	12.38 ^a	10.8 ^b	11.25 ^a	11.54 ^{a,b}
Overall	10.87 ^a	10.47 ^a	11.72 ^a	11.23 ^a

Values with different superscripts differ at P<0.05

Increasing the amount of salt in the pig's diet normally increases water consumption, as the pig needs to increase urination in order to maintain mineral homeostasis. Given unrestricted access to water pigs can tolerate up to 8% salt in their diets (Patience *et al.* 2001). Therefore, it could be anticipated that one of the consequences of pigs being given diets with a higher salt concentration would be that their drinking behaviour would be affected. In the study by Tsourgiannis *et al.*, (2003a) pigs were fed *ad libitum* on liquid diets (1 part food to 2.5 parts water) containing either 0.25 or 1% added salt. Even though there was such a large difference in salt content between the two diets feed intake was not affected. However, during the first week of the study pigs fed 1% salt spent almost three times as much time drinking as pigs fed the low salt diet (Table 6). In the second week of the study the pigs on the high salt diet appeared to become more tolerant of the higher salt inclusion. Although they continued to drink more in total than pigs on the low salt diet, both the duration of drinking and the number of visits they made to drinkers each day was reduced.

Table 6. Average daily drinking duration of individual pigs and visits to the drinkers.

Period	Drinking duration sec/pig/day			Drinking events pig/day		
	High salt (1%)	Low salt (0.25%)	SED	High salt (1%)	Low salt (0.25%)	SED
1 st week	285.0	106.8	32.13***	13.3	6.1	1.437***
2 nd week	246.0	150.0	24.95***	9.9	6.4	0.997***
Over All	262.5	131.8	23.68***	10.6	6.9	0.937***

***(P<0.001)

This observation may help to explain the differential results when salt levels are increased in an attempt to reduce tail biting. If sufficient drinkers are provided and they have an adequate flow rate (600-700ml/min) increasing salt in the diet may have a beneficial effect. However, if drinker numbers and flow rate are inadequate, and there is increased demand for drinker access, high dietary salt levels may increase rather than reduce the incidence of biting behaviour.

Conclusions and implications.

The pig evolved a physiology and behavioural repertoire to cope with the diverse and food poor environment in which it lived. Thus wild pigs devote a great deal of time to foraging and the food that they consume is low in dry matter and high in bulk. In contrast, commercial pigs are generally raised in barren environments and have high density, high dry matter food provided for them. As a consequence their foraging and feeding behaviour is disturbed and this can lead to misdirected behaviour, which can compromise their welfare. Feed formulation needs to consider, not only the nutritional impact of the diet,

but also the impact on pig behaviour in the environment to which the pig is subjected. Only by taking a holistic approach to the problem of nutrition and behaviour will we be able to develop management strategies that maintain both the performance and welfare of the pig.

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