ENHANCING SOW PERFORMANCE AND WELFARE BY CHOICE OF DIETARY ENERGY SUBSTRATES

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Abstract: Diet formulations and feeding strategies for breeding sows are currently based on requirements for total energy to meet the needs of maintenance, maternal growth, reproduction and lactation. This approach takes no account of the chemical form in which the energy is supplied. There is growing evidence that supply of energy from specific substrates at key times in the reproductive cycle can have beneficial effects on both performance and welfare of the sow. The inclusion of increased fibre in the pre-mating diet has been shown to significantly increase litter size. High fibre diets give continued benefit throughout pregnancy, since the consequent prolonged feeding time, gastro-intestinal distension and metabolic state can ameliorate feelings of hunger of the feed-restricted sow. This can reduce the development of stereotypic oral behaviours, aggression and vice, and thus improve sow welfare. Inclusion of long chain n-3 fatty acids in the diet prior to service can increase litter size. When fed in late pregnancy, these essential fatty acids may also enhance piglet viability and post-natal growth. It can be concluded that, in future nutritional strategies, the specific sources of energy rather than just the total amount supplied need to be considered to optimise sow performance.

Keywords: sow, nutrition, energy, fibre, n-3 fatty acids

Classical approaches to sow nutrition

Correct nutrition of the breeding sow is important in optimising all aspects of reproductive performance. Early research focussed on the absolute requirements for food (both energy and protein) in gestation and lactation, and demonstrated the importance of maintaining sows in good body condition during pregnancy for piglet birthweight and adequate milk yield, and preventing condition loss of young sows during lactation for good rebreeding interval and subsequent litter size. As a result of such empirical studies, factorial mathematical models have been developed to predict the requirements of sows under different conditions. Such models can calculate the daily energy, protein and mineral requirements to meet the needs of maintenance, maternal growth, reproduction and lactation. Whilst calculation of protein needs has for many years taken account of the composition of the protein, in terms of its balance of individual amino acids (reviewed by Pettigrew, 1995), estimates of energy needs have been less sophisticated. Diet formulations and feeding strategies for breeding sows are currently based around the requirements for energy expressed as joules (or calories) of energy (ARC, 1981; NRC, 1998; BSAS, 2003). This approach takes no account of the chemical form in which the energy is supplied. However, there is growing evidence that supply of energy from specific substrates at key times in the reproductive cycle can have beneficial effects on both performance and welfare of the sow.

Feeding fibre for improved litter size

After initial research on absolute levels of nutrient over the cycle, studies then focussed more closely on key times in the reproductive cycle which seemed to be particularly influenced by feed level. Classical experiments on the role of dietary energy level on litter size in the sow have demonstrated that a high energy intake prior to service (flushing) can increase ovulation rate (e.g. Beltranena et al., 1991), whilst a reduced level of energy in the period after service can improve embryo survival in young sows (Jindal et al., 1997). More recent studies have shown that the level of feed given before service can also affect the quality of embryo produced and its ability to successfully develop and implant. Ashworth et al. (1999) demonstrated that the level of feed given prior to service actually had a bigger influence on embryo survival than the level of

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feeding post service, and subsequent studies have investigated the mechanisms underlying this effect. By comparing the endocrinology of gilts fed at maintenance (M) or 3xM, it was shown that 3M feeding resulted in increased insulin and IGF-I concentration in the blood, lower mean oestradiol and progesterone concentrations and an increased number of LH pulses in the pre-ovulatory period. These differences were associated with production of an ovulatory population of oocytes which were of higher quality, as assessed by maturity after in vitro incubation (Ferguson et al., 2003a). A subsequent study sought to differentiate between the possible dietary mechanisms, by selectively altering only one component of the diet designed to influence each mechanism (Ferguson et al., 2003b). Thus gilts were fed either a M diet supplemented with starch or protein equivalent to the increment provided by the 3M diet, or a diet high in fibre designed to increase steroid clearance. The results showed no benefit to the starch or protein supplement, but a clear benefit from the high fibre diet incorporating 50% unmolassed sugar beet pulp (SBP), which increased embryo survival by 7%. This effect was studied in more detail in a subsequent experiment (Ferguson et al., 2003b, 2004a), in which gilts were slaughtered at both day 19, to examine oocyte quality, and at day 28, to examine embryo survival, with measurement of the associated endocrinology. The results showed that the high fibre diet again increased embryo survival and that this was linked with better oocyte quality, as indicated by a higher proportion of oocytes which developed to blastocyst stage when cultured in vitro. This outcome was associated with an increased frequency of LH pulses, higher follicular oestradiol prior to ovulation and higher blood progesterone during the critical implantation period (Ferguson et al., 2004b).

These indications of improved oocyte quality and embryo survival in controlled experiments with gilts were subsequently tested in a large scale commercial farm trial with 260 sows (Ferguson et al., 2003c). Sows were fed either conventional cereal-based diets, or high fibre diets formulated by inclusion of 20% SBP for the last two weeks of lactation and 40% SBP during the period from weaning to service. All sows then received the same standard commercial diet from service until farrowing. Feeding the high fibre diet in the period prior to service resulted in an extra 0.9 piglets per litter. This result corroborated an earlier finding in Danish farm trials, where inclusion of 10% SBP in lactation diets in combination with 20% SBP in gestation diets resulted in an extra 0.5 piglets born alive (Sørensen, 1992, 1994). Whilst the Danish work indicated a requirement to increase dietary fibre in both gestation and lactation, a more recent Dutch study with a 2x2 factorial design found that only increased fibre in the gestation diet was beneficial for litter size, again giving an increase of 0.5 piglets (van der Peet-Schwerling et al., 2003). It is relevant to note that it was the gestation diet that was fed between weaning and service, supporting evidence for the effect of fibre during this critical time. The extent to which fibre sources other than SBP can give the same benefit is still uncertain. A review by Reese (1997) concluded that the majority of fibre sources studied gave litter size increases of 0.5-0.7 piglets when NDF intake was above 450g/day, although a similar response was obtained with wheat straw at a lower NDF level of 368 g/day. However, other work has not always shown litter size benefits from high fibre diets and a clearer understanding of the mechanism involved in the beneficial effect of SBP is needed to clarify the optimal level and type of fibre for sow diets.

Feeding fibre for improved sow welfare

Whilst the beneficial effect on litter size appears to result from fibre in the pre-ovulatory diet, the use of a high fibre diet has longer term benefits for the sow when fed throughout pregnancy. Public concern about confinement of sows in stall and tether systems has been stimulated by the high incidence of abnormal behaviour shown by these animals, and in particular the repetitive bar biting and chain chewing behaviours classified as stereotypes. Research into the causation of these behaviours demonstrated that their occurrence was strongly related to the level of feed received by the animals, and that feeding level actually had more influence than housing system. Loose-housed sows on low feed levels developed more stereotyped behaviour than confined sows on high feed levels (Terlouw et al., 1991). Whilst a higher level of feeding can prevent stereotypes, this can give rise to other problems of obesity and farrowing difficulty, and is not economic for production. Research has therefore focussed on other ways of alleviating the problem of chronic hunger in the pregnant sow. Providing sows with straw bedding can prevent development of stereotypies, even at low feeding levels, through offering a way to express foraging behavior more naturally (Spoolder et al., 1995). However, use of straw bedding is incompatible with many housing systems because of cost and slurry management considerations. An early experiment demonstrated that, rather than providing a full bed of straw,
giving a small amount of straw in the feed trough or even incorporating the straw chopped up within the feed could be partially effective in reducing stereotypies (Fraser, 1975). Subsequent work confirmed that increasing the level of dietary fibre could reduce stereotypy development, even in unbedded systems (see review by Meeuwer-Slaauw et al., 2001). High fibre diets prolong feeding time, give greater gastro-intestinal distension, produce more heat of fermentation and a more uniform blood glucose and insulin level across the day (Vestergaard, 1997; de Leeuw et al., 2004). These different effects combine to ameliorate feelings of hunger of the feed-restricted sow, and reduce levels of activity and oral behaviour.

The effects of high fibre diets in ameliorating hunger are important not only in preventing development of stereotyped behaviours in confined sows, but also in reducing aggression in group-housed animals. Directive 2001/93/EC requires that all EU member states implement group-housing of pregnant sows by 2013. Many farmers have concerns that group-housing may increase welfare problems, particularly in slatted systems where the level of vulva biting can be as high as 30-50% (van Putten and van der Burgwal, 1990). Detailed studies of this problem have again implicated level of feeding as a contributing factor (Edwards, 1992) and it has been shown that increasing dietary fibre can significantly reduce vulva biting in both transponder feeding systems (Bare, 1991) and in floor feeding systems (Whittaker et al., 1999). The extent to which different levels of fibre diets affect feelings of satiety is still unclear. However, work by Brouns et al. (1995) demonstrated the unique properties of SBP in this respect. When sows were offered high fibre diets ad libitum, high SBP inclusion restricted intake to a far greater extent than all other fibre sources investigated.

Feeding long chain n-3 fatty acids for improved piglet viability

Whilst specifying that a certain proportion of dietary energy should be in the form of non starch polysaccharides (dietary fibre) can benefit litter size and sow welfare, manipulation of other energy substrates may also offer the opportunity to enhance sow performance. Previously, the addition of dietary lipid has been used in the final trimester of pregnancy to improve piglet survival by boosting energy in situations where pigler birthweight has been poor and mortality has been high (reviewed by Pettigrew, 1981). However, results have not always been consistent in less challenging situations. More recently, attention has focussed on the nature of the dietary lipid and, in particular, the specific role of long chain n-3 fatty acids in enhancing piglet viability. These essential fatty acids, such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), are not present in typical pig diets and cannot be readily synthesised by the pig. They must therefore be supplied pre-formed from sources predominately of marine origin (such as fish oil or marine algae). Feeding diets supplemented with fish oil to the pregnant sow can increase levels of DHA in fetal tissues and, in particular, can increase the essential fatty acid content and size of the fetal brain (Rook et al., 1998; Rook et al., 2001a). Feeding vegetable sources of shorter chain precursors in the n-3 fatty acid series, such as linseed oil which is a rich source of α-linolenic acid, was unable to achieve the same result (Rook et al., 2000), confirming the need for pre-formed material. Studies on the level (Rook et al., 2001a) and timing (Rook et al., 2001b) of fish oil supplementation showed that feeding from day 60 of pregnancy produced the same response in fetal tissues as feeding for the whole of pregnancy. When fed from day 60, the optimum inclusion of fish oil was 10g/kg diet, equivalent to 6g/day of EPA and DHA or 0.6% of DE intake. These small scale experiments also gave some indications of improved piglet viability, with reduced time to suckling and increased weaning weight (Rook et al., 2001b). To evaluate such benefits, a large-scale commercial trial was carried out in which 200 sows were fed gestation diets with or without supplementation of 16.5 g salmon oil/kg from post service to farrowing. The supplemented diet resulted in a slight increase in gestation length, but a significant reduction in birthweight by 70g. Despite this effect, survival of piglets between birth and weaning was improved from 88.3 to 89.8% (Rook et al., 2001c).

The benefits of long chain n-3 fatty acids in sow diets may not be restricted to improved piglet viability. Whilst the previous experiments fed diets only after the time of conception, more recent work in America has demonstrated that feeding diets supplemented with protected n-3 fatty acids (the commercial product Fertilium™) during lactation and rebreeding increased litter size by 0.6 piglets (Webel et al., 2003). As well as these further benefits for sow reproduction, there may also be longer term benefits for piglet
growth. Another recent experiment has shown that supplementing lactation diets with DHA from marine algae increased piglet weaning weight, whilst supplementation of late pregnancy diets increased subsequent growth rate of piglets after weaning (Edwards et al., 2003). This latter effect was also indicated in a previous experiment with fish oil supplementation of pregnancy diets (Rooske et al., 2001b), and merits further investigation at a time when the challenges of weaning will be increased by the EU ban on antimicrobial growth promoters.

Conclusion

It can be concluded that, in future nutritional strategies, the specific sources of dietary energy rather than just the total daily supply need to be considered to optimise sow reproduction and welfare. Recommendations for specific dietary fibres and long chain n-3 fatty acids should be formulated to enhance all aspects of sow performance.

POBOLJŠANJE PERFORMANSII DOBROBITI KRMAČA UPOTREBOM RAZLIČITIH ENERGETSKIH SUPSTRATA U ISHRANI

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Rezime

Formulisanje obroka i strategija u ishrani za priplodne krmače se trenutno zasniva na neophodnoj energiji koja se izražava u džulima (ili kalorijama) energije po danu kako bi se zadovoljile potrebe životinje za njeno održavanje, porast, reprodukciju i laktaciju. Ovakav pristup ne uzima u obzir hemijsku formu u kojoj se daje obrok. Međutim, sve je više dokaza koji potvrđuju da snabdijevanje energijom iz određenih supstrata u ključnim momentima u reproduktivnom ciklusu može imati povoljne efekte na performanse i dobrobit krmače. Klasični eksperimenti na temu uloge nivoa energije na veličinu legla krmače su pokazali da visok unos energije pre servisa (ispiranja) može povećati broj ovlacija, dok smanjen nivo energije u periodu nakon servisa može poboljšati opstanak embriona. Novije studije su pokazale da nivo hrane date pre servisa takode može utići na kvalitet proizvedenih embriona i njihovu sposobnost da uspešno razviju i implantacije. Ogledi pokazuju da ovaj efekat može posredovati preko promena u nivou reproduktivnih hormona i njihovim povratnim uticajima na izlučivanje LH. Na isti mehanizam se može uticati uključivanjem povećane količine celuloze u obroku pre parenja, što je dokazano u velikim ogledima u tržišnim uslovima gde je utvrđen signifikantan uticaj na veličinu legla. Korišćenje obroka sa visokim učešćem celuloze ima kontinuirano pozitavan efekat tokom bremenitosti, jer produkćeno vreme ishrane, gastro-intestinalna distenzija i stanje metabolizma koje ovakva ishrana izaziva može uticati na osećaj gladi kod krmače na restrikтивnoj ishrani. To može uticati na smanjenje pojave stereotipnog oralnog ponašanja, agresije i sl. i na taj način poboljša dobrobit krmače. Uključivanje ostalih energetskih supstrata takođe nudi priliku za poboljšanje performansi. Novija istraživanja su pokazala da uključivanje n-3 masnih kiseline dugog lanca u obrok pre servisa može uticati na povećanje veličine legla. Ove esencijalne masne kiseline mogu imati pozitivan uticaj i ulogu u obroci tokom gestacije. Ranije se mast dodavao obroku u finalnom trimestru bremenitosti kako bi se poboljšao opstanak prasadi povećanjem energije u situacijama kada je mortalitet visok. Od skora, dokazana je specifična uloga u oborocima za krmače nakon prašenja dodavanja n-3 masnih kiselina u poboljšanju vitalnosti prasadi uz poboljšan opstanak prasadi u tržišnim uslovima kakvi postoje na velikim farmama. Pozitivni efekti su utvrđeni i kod porast prasadi na sisi kada se n-3 masne kiseline uključe u obroce krmača u laktaciji, iako su dobijeni i suprotni rezultati. Može se zaključiti da u budućim nacionalnim strategijama ishrane se mora uzeti u obzir specifični izvor energije a ne samo ukupna količina obezbedene energije ukoliko je cilj postižanje optimalnih performansi kod krmače.
References