Animal Reproduction Science 205 (2019) 70–77

Contents lists available at ScienceDirect

Animal Reproduction Science

journal homepage: www.elsevier.com/locate/anireprosci

Effects of post-insemination energy content of feed on embryonic survival in pigs: A systematic review

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ARTICLE INFO

Keywords:
Feed intake
Progesterone
Embryonic loss
Conceptus
Gestation
Swine

ABSTRACT

The feeding of diets with greater energy content than that needed for body maintenance following mating is believed to reduce embryonic survival in pigs. In swine operations, therefore, feed intake is often restricted during the first and second week of pregnancy to reduce embryo mortality. There is thought to be a relationship between feeding diets that result in energy intake that is greater than that needed for body maintenance and embryonic death. This relationship is associated with lesser than typical progesterone (P4) concentrations when feeding diets with greater energy content due to increased hepatic clearance. There is no consensus, however, as to whether feeding should be restricted during early pregnancy to avert this possible detrimental effect. Thus, the aim of this systematic review is to assess the effect in sows and gilts of feeding diets with different energy contents post-mating on embryonic survival, evaluating when possible, the relationship of a greater energy intake and P4 concentrations on embryonic survival. An electronic search was conducted of the *PubMed, Science Direct, Scopus, Web of science, and Scielo* databases during June 2018. A total of 109 articles were retrieved, and of these, only 16 articles were selected after applying the selection criteria. There was no negative effect of a greater feed intake than that needed for body maintenance after breeding in 75% of the experiments. Results from 35% of the experiments indicated feeding early pregnant sows a diet with greater energy content than that needed for body maintenance resulted in augmented embryonic death. In 66.7% of the experiments, in which there was assessment of P4 concentration, there was no negative effect of feeding after farrowing a diet with greater energy than that needed for body maintenance. In conclusion, it appears that restricted feed intake in early pregnancy is no longer relevant when there are modern prolific dam lines utilized in swine production enterprises because dietary energy of as great as 54 MJ ME/day had no detrimental effect on embryo survival.

1. Introduction

There is still no consensus whether feed intake should be restricted in pork production enterprises following breeding to reduce

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https://doi.org/10.1016/j.anireprosci.2019.04.005
Received 6 February 2019; Received in revised form 3 April 2019; Accepted 15 April 2019
Available online 16 April 2019
0378-4320/

embryonic death. The feeding of diets with greater energy content than that needed for body maintenance during early pregnancy has been reported to have deleterious effects (Den Hartog and Van Kempen, 1980; Jindal et al., 1996; De et al., 2009), while results from other studies indicate there is no negative effect (Pharazyn et al., 1991; Gerritsen et al., 2008; Quesnel et al., 2010), and in some studies there have been beneficial effects (Condous et al., 2014; Che et al., 2015).

The majority of embryonic death occurs during the second and third weeks of gestation (Bazer and Johnson, 2014). During this period, embryos undergo a series of morphological changes before attaching to the endometrium, therefore, uterine secretions have an important function in early conceptus development (Geisert and Schimitt, 2002). Progesterone (P4), in turn, has very important functions in the establishment and maintenance of pregnancy in domestic mammalian species. These effects occur due to the stimulation of the uterine glandular epithelium to synthesize and secrete a plethora of biological molecules (e.g., nutrient transport proteins, mitogens, cytokines, enzymes, growth factors) collectively known as histotroph which is essential for conceptus growth (Bazer and Johnson, 2014). Thus, fluctuations in P4 concentrations may impair endometrial functionality, resulting in embryonic loss (Szymanska and Blitek, 2016).

Feeding diets with an energy content that is greater than that needed for body maintenance is known to affect P4 concentration (Musser et al., 2004). This effect on P4 concentrations occurs because greater feed intake likely increases hepatic blood flow, leading to augmented P4 catabolism (Mattos et al., 2017). To avoid this detrimental effect, in pork production operations, feed intake and thus energy intake is often restricted following breeding to maximize embryo survival. Nevertheless, there is no consensus as to whether this feed management regimen remains relevant with use of the modern pig genotypes. Thus, the aims of the present research were to systematically review the effects on sows and gilts of feeding allowance post-mating on embryonic survival, evaluating, when possible, the relationship between the feeding of amounts of energy relative to those needed for body maintenance and P4 concentrations on embryonic loss.

2. Materials and methods

2.1. Research strategy

A comprehensive literature search was conducted using the approaches described by Palencia et al. (2017). For this purpose, two scientific investigators (Leal DF, Muro BBD) individually performed an electronic-based search for peer-reviewed studies using the *PubMed*, *Web of Science*, *Science Direct*, *Scopus*, and *SciELO* databases during June 2018. The following terms were used: feed intake, progesterone, embryonic loss, conceptus, early gestation, and swine, forming six combinations between them (e.g., feed intake and progesterone and swine, feed intake and embryonic loss and swine, feed intake and conceptus and swine, feed intake and early gestation and swine, feed intake and progesterone and early gestation and swine, feed intake and progesterone and conceptus and swine), with the aim being to assess the results reported in as many articles as possible. During the search, filters were used if available for each database, thus, only research articles conducted with pigs were chosen.

2.2. Selection of studies

To conduct the assessment of the research results that have been published in the area of interest, studies in which there was evaluation of the effect of feed allowance on pig embryonic survival or on litter size were selected. Studies in which there was inclusion in the analyses the effect of post-breeding feeding allowance on the concentration of P4 and metabolic hormones, on gene expression and secretory uterine proteins were selected. Although there was no date restriction as to when the publications occurred, only articles written in English were used. No restriction was imposed regarding how dietary energy was expressed, hence, articles in which energy was expressed as megajoules (MJ), kilocalorie (Kcal) or megacalories (Mcal) of metabolisable energy (ME), digestible energy (DE) and net energy (NE) were all considered in the assessments. There was no restriction on parity; therefore, studies where there were gilts and sows utilized were included in the assessments of research in the area of interest. The selection criteria were reviewed and thoroughly discussed by all researchers whenever such considerations were deemed necessary.

2.3. Quality criteria

For evaluating the quality of the articles selected, the same methodologies were applied as previously described by Palencia et al. (2017). Scores 1 (partially adequate) or 2 (adequate) were assigned for each specific scientific criteria. The purpose of the application of quality criteria were used to ensure the scientific quality of the articles selected. The following parameters were used:

(i) Randomization: randomized studies were assigned a score of 2, while non-randomized studies or those in which there was not a clear description regarding randomization in the text received a score of 1.
(ii) Control group: studies in which there was a control group were assigned a score of 2 and those where there was no indication that there was inclusion of a control group in the text were assigned a score of 1.
(iii) Breed or genetic line: studies for which there was a description of breed or genetic line, were assigned a score of 2 and those in which there was no indication of breed or genetic line were assigned a score of 1.
(iv) Age and weight: studies for which there was a description of age and weight of animals were assigned a score of 2 and those where there were no values provided for age and weight were assigned a score of 1.
(v) Housing and management: studies for which there was a description of housing and management parameters were assigned a

Table 1
Retrieval of articles from each database when using the combination of keywords.

Database	Search	Keywords[a]						Total
		1	2	3	4	5	6	
PubMed	Total number	29	6	5	62	7	0	109
	Selected number	6	1	1	3	0	0	11
	Repeated number[b]	0	0	0	3	3	0	6
Science Direct	Total number[b]	263	185	60	77	41	26	652
	Selected number	1	0	0	0	0	2	3
	Repeated number[b]	4	0	2	3	2	0	13
Web of Science	Total number	6	4	1	9	1	0	21
	Selected number	1	0	0	1	0	0	2
	Repeated number[b]	0	0	0	0	1	0	1
Scielo	Total number	0	0	0	0	0	0	0
	Selected number	0	0	0	0	0	0	0
	Repeated number[b]	0	0	0	0	0	0	0
Scopus	Total number	31	5	4	34	2	0	76
	Selected number	0	0	0	0	0	0	0
	Repeated number[b]	4	1	1	4	1	0	11
Number of articles selected for review[c]								16

[a] 1. Feed intake and progesterone and swine 2. Feed intake and embryonic loss and swine 3. Feed intake and conceptus and swine 4. Feed intake and early gestation and swine 5. Feed intake and progesterone and early gestation and swine 6. Feed intake and progesterone and conceptus and swine.
[b] Articles already retrieved within or among databases.
[c] Final number of articles after applying the selection criteria.

score of 2 and those for which there was no description provided in the manuscript text were assigned a score of 1.

(vi) Parity: studies for which parity was reported were assigned a score of 2 and those for which parity was not reported were assigned a score of 1.

(vii) Amount of feed intake: studies for which the daily amount of feed intake was reported as kg/d were assigned a score of 2 and those studies where amount of feed intake was based on maintenance requirements were assigned a score of 1.

3. Results

The results from each database through keyword combination are included in Table 1. There were a total of 109 references accessed of which 88.0% were excluded because the subject of the research was: effects of different patterns of feeding on ovarian follicular development and fertility, increased nutrition in mid or late gestation, nutritional manipulation prior to breeding, or as a result of articles being reviews or book chapters. One article (De et al., 2009) was excluded because there was reporting of the same data as part of another study (Xu et al., 2010). These two manuscripts were the original articles that resulted from one larger study and the latter was included in the present systematic review of the data as result of the more comprehensive nature of the data reported in this manuscript. The use of the databases *Science Direct* and *Web of Science* resulted in addition of the results from five articles, while the other studies accessed using these databases were also accessed as a result of using *Scopus*. The use of the *Scielo* database did not result in retrieval of any results when considering the parameters used for the present study. After applying the selection criteria, 16 articles were selected for assessments of the effects of dietary energy intake on embryonic survival in pigs.

From 16 studies, there were 75% in which there were reports of no negative effect of feeding diets with greater energy content than that needed for body maintenance during early gestation on embryo survival. In some of these studies, there were no beneficial effects reported and, in 25% of the studies, feeding early pregnant sows a diet with an energy content greater than that needed for body maintenance resulted in increased embryonic death. Although there was no restriction on date of publishing, the year of publication of these selected studies ranged from 1983 to 2015. Of the four experiments, where results indicated there were negative effects of feeding diets with an energy content that was greater than that needed for body maintenance, three of these were published more than 25 years ago. Regarding parity, 75% of the experiments that were selected for the present systematic review were conducted with gilts while in two other studies there was assessments of response in multiparous sows and in the other two studies, there were assessments with both sows and gilts.

In Table 2, there is presentation of scores resulting from assessments with the present systematic review of the literature according to the quality criteria utilized. There was the greatest score (14 points) for 50% of articles, and the least score (11 points) with only one article (Pharazyn et al., 1991). In all studies selected, animals were assigned to treatments at random. In all of the studies reported in the selected papers, there was inclusion of a control group. Complete information regarding breed or genetic line was included in 93.8% of the articles as a part of this systematic review. Age and weight were reported for the research conducted in 81.3% of the articles while housing and management parameters were detailed for 50% of studies included in the present systematic review. The commencement of feeding regimens varied among trials, starting at the onset of estrus, after the first insemination, 24 h after the first detected estrus or 3 days after the first insemination. Day 0 of pregnancy in the majority of trials was considered as 24 h

Table 2
Scores for each scientific criteria of articles selected.

References	A	B	C	D	E	F	G	Total
Dyck and Strain (1983)	2	2	2	1	2	2	2	13
Pharazyn et al. (1991)	2	2	2	2	2	2	2	14
Dyck (1991)	2	2	1	1	2	2	1	11
Cassar et al. (1994)	2	2	2	1	2	2	2	13
Jindal et al. (1996)	2	2	2	1	2	1	2	12
Jindal et al. (1997)	2	2	2	1	2	1	2	12
Soede et al. (1999)	2	2	2	1	2	2	2	14
Virolainen et al. (2004)	2	2	2	2	2	2	2	14
Virolainen et al. (2005)	2	2	2	2	2	2	2	14
Xu et al. (2010)	2	2	2	1	2	1	1	12
Quesnel et al. (2010)	2	2	2	2	2	2	2	14
Hoving et al. (2011)	2	2	2	2	2	2	2	14
Hoving et al. (2012)	2	2	2	2	2	2	2	14
Athorn et al. (2013)	2	2	2	2	2	2	2	14
Condous et al. (2014)	2	2	2	1	2	2	2	13
Che et al. (2015)	2	2	2	1	2	2	2	13

A. Randomization: 2 for randomized study and 1 for non-randomized study or was not clearly presented at the text; B. Control group: 2 for study that used control group and 1 for study that not used control group or was not clearly presented at the text; C. Breed or genetic line: studies that mentioned breed or genetic line received a score of 2 and those that did not mention it received a score of 1; D. Housing and Management: 2 for studies that described housing and management and 1 when it was not mentioned or was not clear at the text; E. Parity: trials that characterized dams as nulliparous, primiparous and multiparous received a score of 2 and those that did not received a score of 1; F. Age and weight: studies that mentioned age and weight received a score of 2 and those that did not mention it received a score of 1; G. Amount of feed intake: studies in which the daily amount of feed intake was clearly shown received a score of 2 and those that did not clearly demonstrated it score 1.

after the onset of standing estrus. In only three articles was there inclusion of backfat thickness data, and in two of these experiments reported in these articles there was inclusion of loin muscle depth.

The data for effect of feeding regimen post-breeding on embryonic survival, P4, metabolic hormones and gene expression are reported in Table 3. The effect of feeding relatively larger amounts of energy on P4 concentration was evaluated in 56.3% of the studies and in 66.7% of these studies it was reported that there was no detrimental effect.

The interaction among feeding allowance and concentrations of important regulatory hormones was evaluated in 18.8% of the studies. In general, amounts of metabolic hormones and uterine proteins increased as amount of energy in the diet increased.

4. Discussion

Results from a number of studies indicate the importance of nutrition in swine reproductive performance. For example, nutrition is well-known to affect the secretion of important regulatory hormones, resulting in enhanced ovarian follicular and embryonic development and, consequently, in the number and homogeneity of size of piglets born. Consequently, there is never ending consideration in swine production of the quantity of feed provided during early pregnancy to maximize embryonic survival. Although this topic has been addressed for more than 6 decades (Heap et al., 1967), it remains unresolved because contradictions still exist whether feed should be restricted following breeding.

In the majority of studies, results indicate there is no detrimental effect of feeding diets with energy content greater than that needed for body maintenance on embryonic survival. Rather, the feeding gilts shortly after breeding diets with energy content as great as 50 MJ DE (Quesnel et al., 2010) or 54MJ DE (Virolainen et al., 2004) had no negative effect on embryo development. This result is inconsistent with results from earlier studies in which the feeding of gilts diets containing 32.5 MJ DE (Jindal et al., 1996, 1997) or 29.4 MJ ME (Dyck and Strain, 1983) resulted in lesser embryonic survival.

These inconsistent outcomes could be, in part, a result of continuous genetic selection, leading to greater prolificacy of sows from which there are larger litters when compared to sows in pork production operations 25 years ago. The sows of present pork production enterprises appear to respond differently to metabolic perturbations. The greater productivity of these sows results in the need for greater nutritional requirements of modern crossbred lines and as a consequence there is also need for more strategic nutritional management. Research results indicating these needs have been reported by Quesnel et al. (2010) where gilts of the experimental groups were selected based on litter size for more than ten generations. The sows in this study produced three more piglets than the control line (Large White) and had four or five more corpora lutea. Another important consideration is the effects of the advances in nutrition (e.g., diets formulated using the optimal protein concept, inclusion of dietary fiber, use of different dietary energy sources), and housing environment as well as improved stockmanship practices and use of technologies on furthering contemporary sow productivity and embryo survival. These factors likely contribute to the lack of a detrimental effect of feeding diets with energy contents greater than that needed for body maintenance than what has been traditionally recommended during early pregnancy.

Of the studies assessed in conducting the present systematic literature review, the negative effect of feeding these diets has only been reported in one relatively recent study. Xu et al. (2010) noted that gilts fed 53 MJ DE had lesser embryo survival rates compared

Table 3
Main features and the effects of feed allowance on embryonic survival, reproductive and metabolic hormones, gene expression and uterine proteins of the articles selected.

Author	A	B	C	D	E	F	G	H	I	J
Dyck and Strain (1983)	Gilt	L 28; HI 31	11.76 MJ ME/kg	L 1.5 kg/day or HI 2.5 kg/day	30-35	No	None	−10.4%	NE	NE
Pharazyn et al. (1991)	Gilt	L 12; HI 12	12.2 MJ DE/kg	L 1.6 x ME or HI 2.6 ME	28	Yes	None	NS	NS	NE
Dyck (1991)	Gilts	L 49; HI 52	12.56 MJ DE/kg	L1.25 kg/day or HI 2.5 kg/day	30; 60	No	None	NS	NE	NE
Cassar et al. (1994)	Gilt and sow (2nd)	L 45; HI 46	22.2 MJ DE/day or 36.0 MJ DE/day	NE	9-11; 25	No	None	NS	NE	NE
Jindal et al. (1996)	Gilt	L 43; HI 43	12.5 MJ DE/kg	L 1.9 kg/day or HI 2.6 kg/day	28	Yes	None	−18.7%	↓	NE
Jindal et al. (1997)	Gilt	L 26; HI 26	12.5 MJ DE/kg	L 1.5 x ME† or H 2 x ME†	3-5; 11-12; 28	Yes	IGF-1; uterine proteins	−12.3%	↓	↑ Uterine proteins
Soede et al. (1999)	Gilt	L 53; HI 53	12.1 MJ ME/kg	L 2.5 kg/day or H 4 kg/day	5; 7-16	No	Estrogens (uterine flushing)	NS	NE	↑ Uterine proteins and Estrogens
Virolainen et al. (2004)	Gilt	L 8; HI 8	13 MJ DE/kg	L 2.1 kg/day or HI 4.3 kg/day	34	Yes	None	NS	NS	NE
Virolainen et al. (2005)	Sow (2nd-11th)	L 6; HI 6	13 MJ DE/kg	L 2 kg/day or HI 4 kg/day	35	Yes	None	NS	NS	NE
Xu et al. (2010)	Gilt	L 18; M 18; HI18	13.4 MJ DE/ kg	L 0.6 x ME‡ or M 1.2 x ME‡ or HI 2 x ME‡	12; 25; 35	Yes	IGF-I; Leptin; Gene expression	−15.6%	↓	↑ IGF-I, insulin, leptin and GH; ↑ embryonic genes
Quesnel et al. (2010)	Gilt	L 13; HI 15	12.5 MJ ME/kg	L 2 kg/day or HI 4 kg/day	27	No	None	NS	NE	NE
Hoving et al. (2011)	Gilt and sow (2nd)	L 49; HI 47	12.0 MJ ME/kg	L 2.5 kg/day or HI 3.25 kg/day		No	None	↑ Litter size (+2 piglets)	NE	NE
Hoving et al. (2012)	Sow (2nd)	L 13; HI 18	12.0 MJ ME/kg	L 2.5 kg/day or HI 3.25 kg/day	35	Yes	IGF-I; Insulin	NS	NS	NS
Athorn et al. (2013)	Gilt	L 12; HI 12	13.2 MJ DE/kg	L 1.51 kg/day or HI 2.78 kg/day	10	Yes	None	+15.0%	↑	NE
Condous et al. (2014)	Gilt	L 23; HI 23	13 MJ DE/ kg	L 1.37 kg/day or HI 2.6 kg/day	25	No	None	+10.6%	NE	NE
Che et al. (2015)	Gilt	L 16; HI 16	H 14.2 or L 12.5 MJ DE/kg	2 kg/day	35; 55; 90	Yes	Gene expression.	+13.4%	NS	↑ Luteal genes

HI. High feed level; M. Moderate feed level; L. Low feed level; MT. maintenance (Some experimental group names used here do not correspond to those used in the original articles, they were adapted to facilitate comprehension); NE. Not specified; †. Energy requirement calculated in the basis of BW $Kg^{.75}$; ‡: (DEm = 110 Kcal $BW^{0.75}$; BW: body weight + 1/2 expected total pregnancy weight gain); A. Parity; B. Number of animals per group; C. Dietary energy content; D. Mean feed intake; E. Mean day of gestation at slaughter; F. P4 evaluation; G. Additional evaluation (metabolic hormones, gene expression and uterine proteins); NS. Not Significant; H. Ratio (%) of embryonic survival between high level of feeding groups and control groups; I. Effect of high level of feeding on P4 concentration; *J*. Effect of high level of feeding on metabolic hormones, gene expression and uterine proteins.

with gilts fed 32 MJ DE; however, there should be consideration that gilts fed 32 MJ DE had the greatest embryo survival rate at day 35 of pregnancy indicating diets containing about 32 MJ DE that were fed shortly after breeding had no deleterious effects on embryonic survival.

Backfat thickness is an objective indicator of body condition and metabolic status in pigs. It is considered to be positively related to leptin concentrations (Robert et al., 1998), which, in turn, has an important function in mediating the effects of nutritional status on reproduction (De et al., 2009). There were, however, only three articles that were assessed in the present systematic review of the literature where there was information regarding backfat thickness. Because this parameter can have significant effects on reproduction values for this variable should be ascertained when conducting future experiments in which there is evaluation of the interaction of nutrition and reproduction to avoid possible confounding factors in conducting research endeavors.

As previously emphasized in this manuscript, there were 50% of the experiments that were assessed with this systematic review in which there was detailed information provided concerning housing and management. Comprehensive data related to these factors should be provided when reporting results in future studies to ensure that studies are conducted in a totally controlled environment because ambient conditions can markedly affect reproduction. For example, heat stress is associated with a reduction in concentration of circulating P4 in pregnant gilts and also effects embryonic development (Lucy and Safranski, 2017).

Nutritional status can influence the secretion of both reproductive (Hazeleger et al., 2005) and metabolic hormones (Lucy, 2008). With respect to a majority of previous studies, there was no detrimental effect reported. When gilts were fed 54 MJ DE or 27 MJ DE following insemination, there were significant differences in P4 concentration only at days 9 and 12 of pregnancy and there was no negative effect on embryonic survival among groups (Virolainen et al., 2004).

There should also be consideration that there is a post-prandial decrease in P4 concentration with systemic P4 concentrations decreasing 3–4 ng/mL approximately 1 h after feeding and returning to basal values (27.6 ± 1.5 ng/mL; day 14 of pregnancy) 4–5 h after feeding (Hoving et al., 2017). This decrease in circulating P4 2–3 h after feeding was also reported in gilts on day 5 of pregnancy. Gilts fed diets with an energy content that 1.2 times that of maintenance had 5.5 ng/mL greater systemic P4 concentrations compared with gilts fed diets that containing 2.4 times the maintenance recommendations. Interestingly, gilts with greater systemic P4 (> 20 ng/mL) on day 5 of pregnancy had a lesser embryo survival (62%) compared to gilts with < 20 ng/mL in which there was a 75% embryo survival rate (Athorn et al., 2011).

The lack of effect on embryo survival in response to a post-prandial decrease in P4 concentration could be a result of a local transfer from the ovarian veins to the uterus, through counter-current and lymphatic pathways. This direct transfer of P4 does not result in hepatic catabolism of this hormone, therefore, there is an increase in the uterine supply of P4 (Athorn et al., 2013). Rather, in some studies P4 concentrations are four times greater in the caudal vena cava compared to the jugular (Athorn et al., 2013; Hoving et al., 2017). Another possibility is that when there is feeding of diets with a relatively greater energy content, there would be expected an increase in the secretion of IGF-I which functions at the ovary to increase the production and/or secretion of P4 and this might counteract the hepatic catabolism of P4 (Athorn et al., 2011).

Metabolic hormones have marked effects on reproductive function because these hormones have a great effect on ovarian follicular growth, ovulation rate, synthesis and release of gonadotropins, steroidogenesis and embryonic development (Prunier and Quesnel, 2000; Lucy, 2008). In general, albeit there have not always been significant effects when studies have been conducted, there is an increasing trend for metabolic hormone concentrations that is associated with amount of energy content in diets of sows and gilts during early pregnancy. There is a similar association for uterine secretory proteins.

Gene expression varied greatly in response to feed intake; however, important developmental genes encoding for proteins such as RBP4 which is considered a candidate gene for litter size and uniformity (Rothschild et al., 2000) and DNMT1, which has an important function in epigenetic regulation of gene expression (Xu et al., 2010), was greater in gilts that were not fed a diet with restricted energy content post breeding.

With the present systematic review, there was an evaluation of whether feeding diets with differing energy content following breeding is detrimental to embryo survival. To address this question, two scenarios must be considered when evaluating the data resulting from the systematic review. One of these scenarios is gilts are normally fed ad libitum for 11–14 days prior to breeding with this feeding regimen occurring to increase ovulation rate; however, continuing with this nutritional management during the period subsequent to ovulation has repeatedly resulted in greater embryonic death as compared to feeding diets with relatively lesser energy content. When data were assessed, when conducting the present systematic review of the literature, feeding gilts more than 32 MJ during early pregnancy was only detrimental for embryo survival in three experiments. In addition, these experiments were conducted more than 20 years ago. Based on these data, the feeding of diets with greater energy content for a short period of time (i.e., "flush" feeding) should be discontinued at onset of estrus because this management has neither a beneficial nor detrimental effect on embryo survival post-insemination. The practice of restricting feed intake during the period following ovulation, therefore, should not be a practice utilized in pork production enterprises.

For sows, the feeding of diets with relatively greater energy content allows for recovering of body condition after lactation, especially first parity sows. Subjecting these females to feed restriction, therefore, negatively effects embryonic development and decreases sow longevity in production enterprises. For sows after piglet weaning, body condition should be individually evaluated and there should be consideration of values for this variable when developing nutritional feeding regimens, bearing in mind that diets with as great an energy content as 39 MJ ME/day do not have a detrimental effect on embryo survival.

5. Conclusion

There is an increasing amount of evidence that was systematically evaluated in the present literature review that indicates post-insemination feed restriction in pork production enterprises should no longer be recommended when there are gilts and sows of contemporary highly prolific genotypes utilized in these enterprises. Providing energy in amounts that are greater than those for maintenance during early pregnancy did not have negative effects on embryo survival for gilts and additionally there are benefits of this feeding regimen for sows in lesser body condition and especially first parity sows. Importantly, this topic warrants further study with contemporary sows and gilts of highly prolific genotypes to further evaluate the findings that have resulted from the present systematic review of the literature.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Acknowledgements

The authors thank CNPq, CAPES, and FAPESP for financial support.

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