R. Bras. Zootec., 51:e20210122, 2022
https://doi.org/10.37496/rbz5120210122

Non-ruminants
Full-length research article

Revista Brasileira de Zootecnia

Brazilian Journal of Animal Science
e-ISSN 1806-9290
www.rbz.org.br

Prepartum supplementation of soybean oil as an energy source for sows and their litters

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Received: June 22, 2021
Accepted: February 14, 2022

How to cite: Santos, M. C.; Vier, C. M.; Lu, N.; Orlando, U. A. D.; Almeida, L. M.; Maiorka, A. and Oliveira, S. G. 2022. Prepartum supplementation of soybean oil as an energy source for sows and their litters. Revista Brasileira de Zootecnia 51:e20210122.
https://doi.org/10.37496/rbz5120210122

ABSTRACT - The objective of this study was to evaluate the effect of pre-farrowing lipid supplementation for three days on performance parameters of sows and piglets and the survival rate of litters. Four hundred hyperprolific sows were randomly distributed in blocks according to their body condition score, weight, and parity order. Three levels of soybean oil were added on top at the time of feed supply and compared to the control treatment. The levels were: 250 mL, 500 mL, and 1,000 mL, in addition to the control that contained only the crude fat present in the feed (5.04%). Sows were weighed and evaluated for their body condition score at the beginning and end of the lactation period, and their piglets were weighed at birth, after 24 h, and at weaning to determine colostrum yield of the sow and daily weight gain of piglets during the lactation period. Survival rate of litters was also evaluated. Weight loss of gilts decreased linearly as the level of supplemented oil increased. The other parameters evaluated were not affected by treatments, suggesting that the supplemented soybean oil was used for growth rather than milk production of gilts. Additionally, it had no effect on the performance of multiparous females. Under the experimental conditions of this study, soybean oil supplementation for gilts in the first three days before farrowing decrease their weight loss but does not change their body condition score, colostrum yield, and performance and survival of their litters.

Keywords: colostrum yield, gilts, lipids

1. Introduction

As the highest fetus growth occurs in the final third of pregnancy, sows need high energy input during this period to meet such high demand. If this demand is not supplied through the diet, energy will be obtained through the catabolism of body fat and protein, which can cause weight loss and decreased body condition and delay the reproductive cycle (Chen et al., 2019).

In the final days of pregnancy, there is a decreased food intake due to the physical restriction caused by the increased volume of the uterus. This does not significantly affect colostrum production and body condition of sows, although it does make it impossible to deposit more lipids in the colostrum and milk (Thodberg and Sørensen, 2006; Farmer and Quesnel, 2009).

To compensate for the decreased intake in the final days prior to farrowing proposed by Chen et al. (2019), lipid supplementation during this period can reduce weight loss in sows, increase the amount of fat in colostrum and milk, and decrease weaning intervals. In addition, the amount and type of fatty acid offered may affect the composition of colostrum and milk in terms of immunoglobulins and fatty acids, improving survival rate and weight gain in piglets (Jin et al., 2017).

Other studies (Pettigrew, 1981; Laws et al., 2018) evaluated whether a diet with higher energy concentration during the period prior to farrowing could influence sow performance between parity and weaning, which yielded positive results such as increased fat concentration in milk, decreased piglet mortality, and lower body condition loss in sows. The study by Pettigrew (1981) is a survey of articles showing vegetable lipids as a viable and positive option for pre-birth energy supplementation.

Therefore, this study analyzed the effects of lipid supplementation in the final three days before farrowing on colostrum yield (CY) and body conditions of sows, in addition to performance and survival of piglets.

2. Material and Methods

This project was approved by the local Animal Ethics Committee in Curitiba, PR, Brazil, case no. 087/2018. The experiment was conducted in the farrowing room of a commercial farm located in Campos Novos, Santa Catarina, Brazil (−27.3894 latitude and −51.21830 longitude), from September to October 2019.

Four hundred hyperprolific Camborough females (Agroceres PIC, Rio Claro, São Paulo, Brazil) with a mean weight of 209.3±30.7 kg were used; they were divided into four treatments with 100 repetitions each. Each animal was considered an experimental unit. Within each treatment, sows were randomly distributed into blocks by weight, body condition score, expected farrowing date, and parity order, and parity orders were divided into three categories for distribution in blocks: 0 (females with no previous farrowing, 71 sows), 1 (females with only one previous farrowing, 92 sows), and 2 (females with more than one previous farrowing, 237 sows). They were housed in individual 1.2-m^2 (2.0 m × 0.6 m) farrowing cages equipped with heated floor boxes to house their piglets from day 111 pre-birth to approximately day 21 post-birth, when the piglets were weaned.

A total of 5,250 piglets from the treated sows were evaluated, which were housed together with their sows in farrowing crate. After the first day of life, piglets were evenly distributed among the sows under the same treatment and date of birth, with each sow having 10 to 16 piglets for all the treatments, depending on parity order, number of viable teats, and last lactation performance.

Temperature in the farrowing room was controlled by opening and closing the curtains, with a mean of 25.6±7 °C.

Sows were fed the standard farm diet based on Rostagno et al. (2017) (Table 1), administered through an automated feeding system. Fresh water was supplied *ad libitum* in bowl-type troughs throughout the experimental period.

Quantities of feed supplied followed a decreasing order until the day of farrowing, with 3.0 kg on day 111 pre-farrowing, 2.5 kg on day 112, and 2.0 kg on day 113 per day for each sow (first parity and multiparous), which was discontinued on the farrowing day. The feed used contained 5.04% crude fat.

Refined soybean oil (SO) was added to the control feed in quantities of 250 mL (T250), 500 mL (T500), and 1,000 mL (T1000), resulting in the supply of 628 g, 878 g, and 1,378 g of crude fat, respectively, over the three-day period. The control was feed without SO addition, with only the crude fat already present in the formula, resulting in the supply of 378 g of crude fat. The oil was added to the diet in an on-top system at the time of feeding. With the amount of crude fat already present in the feed, each treatment presented the following crude fat calculated values: control: 5.04%, T250: 8.37%, T500: 11.7%, and T1000: 18.4%.

Piglets were evaluated for survival, stillbirths, and daily weight gain (DWG) only during lactation. Animals were weighed at birth, after 24 h (to obtain the CY of the sow), and at weaning (to measure DWG). Survival was calculated as:

[(Live animals per sow at the end of lactation period/Total animals uniformed per sow) × 100].

Table 1 - Ingredients and calculated nutritional composition of the experimental diet

Ingredient	Content (g/kg)
Corn	615.1
Soybean meal (45% crude protein)	268.0
Offal flour	30.0
Poultry fat	20.0
Sugar	20.0
Yeast	5.0
Dicalcium phosphate	7.0
Calcitic limestone	11.0
Common salt	6.0
Lysine	6.8
DL-Methionine	1.2
Threonine	1.8
Tryptophan	0.3
Vitamin premix[1]	1.2
Mineral premix[2]	2.0
Choline chloride 60	1.3
Kaolin	3.3
Calculated nutritional composition	
Crude protein (%)	20.68
Fat (%)	5.03
Linoleic acid (%)	1.91
Linolenic acid (%)	0.08
Lysine (%)	1.42
Methionine (%)	0.42
Methionine + cysteine (%)	0.75
Threonine (%)	0.95
Tryptophan (%)	0.27
Metabolizable energy (MJ/kg)	13.02

[1] Provides per kg of complete feed: vitamin A, 12,870 IU; vitamin D3, 2,600 IU; vitamin E, 85.8 IU; vitamin K3, 5.2 mg; vitamin B2, 12.87 mg; vitamin B12, 52 mcg; pantothenic acid, 42.9 mg; nicotinic acid - B3, 57.2 mg.
[2] Provides per kg of complete diet: Se, 0.45 mg; Mn, 34.9 mg; Cu, 15.39 mg; Fe, 182.03 mg; Zn, 135 mg; I, 0.310 mg.

Colostrum yield was obtained through the methodology described by Devillers et al. (2004), determined by the sum of the colostrum intake of each piglet in the litter (SCI), in which:

$$SCI: -217.4 + 0.217 \times t + 1861019 \times BW24h/t + BW0h \times (54.80 - 1861019)/t) \times (0.9985 - 3.7 \times 10 - 4 \times tfs + 6.1 \times 10 - 7 \times tfs^2),$$

in which BW0h = weight of each piglet at birth; BW24h = weight of the piglet 24 h after birth; t = interval between first and second weighing, fixed at 1,440 min (24 h × 60 min); and tfs = time to first colostrum intake, fixed at 30 min.

Sows were weighed before farrowing and at weaning to evaluate weight variation during that period. Variation in body condition of sows was determined by measuring body condition score when entering the maternity period and after the lactation period using a caliper based on a scale from 1 to 20, with an indication of body condition as thin (9 to 11), ideal (12 to 15), or fat (16 to 18) (Knauer and Baitinger, 2015).

Data were previously checked for normality (Shapiro-Wilk) and homogeneity of variance (Levene's test) and subjected to analysis of variance (ANOVA) considering blocks and using the Glimmix procedure of the SAS statistical package (Statistical Analysis System, version 9.3). Variables were analyzed according to the following mathematical model for a complete randomized block design:

$$Y_{ij} = \mu + \beta_i + \varepsilon_{ij},$$

in which, Y_{ij} = observation j of experimental unit subjected to treatments i, μ = general constant, β_i = effects of adding SO to diets, and ε_{ij} = random error associated to each observation.

Orthogonal, linear, and quadratic contrasts were performed considering treatment and parity order as fixed effects and parity date as a random effect. Results were considered significant with less than 5% significance.

3. Results

There was a difference between treatments for weight variation in first-parity females, with linear improvement according to increased levels of SO supplementation (P<0.05; Table 2). The other performance parameters, CY, and performance of multiparous females showed no influence of the treatments (P>0.05; Table 2).

Treatments had no influence on the performance of sows or piglets at birth nor on standardization, weaning, and survival rate (P>0.05; Table 3).

Table 2 - Physical performance and colostrum yield of nulliparous and multiparous sows that underwent pre-birth lipid supplementation during lactation

	Females 1st parity				SEM	P		Females ≥ 2nd parity				SEM	P	
	Control	T250	T500	T1000		L	Q	Control	T250	T500	T1000		L	Q
Sow weight (kg)														
Day 111	206.8	208.3	201.4	208.9	6.00	0.84	0.69	238.3	239.5	238.5	238.9	2.99	0.84	0.81
Weaning	176.6	169.6	181.6	187.1	5.71	0.05	0.95	216.2	212.0	218.6	214.6	3.31	0.95	0.73
Variation	−31.1	−40.6	−20.5	−25.6	5.01	0.05	0.95	−21.8	−33.5	−19.4	−27.2	4.19	0.90	0.98
Body score[1]														
Day 111	14.2	15.2	14.0	15.0	0.47	0.49	0.96	14.3	14.0	14.2	14.2	0.21	0.87	0.67
Weaning	12.2	11.6	12.6	13.3	0.50	0.10	0.53	13.3	13.4	13.8	13.6	0.23	0.25	0.11
Variation	−1.9	−3.7	−1.3	−1.9	0.42	0.10	0.53	−0.9	−0.6	−0.4	−0.6	0.18	0.25	0.11
Colostrum yield (kg)	3.80	3.45	3.52	3.86	0.25	0.70	0.20	4.20	4.43	4.01	4.14	0.14	0.39	0.86

T250: 628 g of fat supply in three days; T500: 878 g of fat supply in three days; T1000: 1,378 g of fat supply in three days.
L - linear, Q - quadratic; SEM - standard error of the mean.
[1] A caliper was used to evaluate the score, which was based on a scale from 1 to 20, with an indication of the female's body condition that could be thin (9 to 11), ideal (12 to 15), or fat (16 to 18) (Knauer and Baitinger, 2015).

Table 3 - Performance at birth and weaning of sows (nulliparous and multiparous) and piglets during the experimental period

	Females 1st parity				SEM	P		Females ≥ 2nd parity				SEM	P	
	Control	T250	T500	T1000		L	Q	Control	T250	T500	T1000		L	Q
Female performance at farrowing														
Born alive (n)	13.4	12.5	13.6	13.8	0.80	0.54	0.70	14.7	14.9	14.6	15.3	0.40	0.26	0.54
Stillbirths (n)	1.3	1.5	1.3	1.7	0.20	0.35	0.74	1.6	1.7	1.9	1.6	0.10	0.95	0.15
Piglet weight														
Birth (kg)	1.3	1.3	1.2	1.3	0.05	0.69	0.18	1.3	1.2	1.2	1.3	0.03	0.83	0.48
24 h after birth (kg)	1.4	1.3	1.2	1.3	0.06	0.89	0.08	1.4	1.3	1.3	1.3	0.03	0.62	0.70
Uniformity (kg)	1.4	1.4	1.3	1.4	0.06	0.50	0.19	1.4	1.4	1.3	1.4	0.04	0.55	0.22
Weaning (kg)	5.3	5.3	5.4	5.0	0.19	0.16	0.33	5.8	5.6	5.6	5.7	0.08	0.26	0.18
DWG (g)	225.1	216.7	229.6	202.3	0.08	0.08	0.26	260.3	248.8	252.6	255.1	0.04	0.65	0.11
Survival (%)	94.2	85.7	89.6	90.0	3.60	0.61	0.27	90.1	89.3	89.9	89.6	1.67	0.88	0.89

T250: 628 g of fat supply in three days; T500: 878 g of fat supply in three days; T1000: 1,378 g of fat supply in three days.
DWG - daily weight gain; L - linear, Q - quadratic; SEM - standard error of the mean.

4. Discussion

Data obtained through lipid supplementation in this study showed that it was efficient to decrease the weight loss of first-parity sows as oil doses increased. This result corroborates that of Laws et al. (2018), who also performed pre-birth lipid supplementation for approximately 10 days. The current study shows that three days, under the experimental conditions previously described, are enough to obtain the same effect. Sows in their first parity are not yet fully developed and direct part of what they consume towards their body growth, not only for milk production as multiparous sows (Piñeiro et al., 2019), which explains the results observed in this experiment.

Chen et al. (2019) evaluated the effect of supplementing a diet that already contained SO in its composition with medium-chain fatty acids or protected polyunsaturated fatty acids during the pre-partum period on the weight loss of sows and reported similar results to those of this present study, with lower weight loss in sows that received supplemented diet.

However, CY was unaffected by lipid supplementation, differing from what was expected based on the studies by Jin et al. (2017) and Farmer and Quesnel (2009), who showed that pre-birth lipid supplementation with SO or fish oil influences the colostrum of supplemented sows.

Parameters related to piglets showed no effect of treatments on performance and survival rate. Most studies also show no evidence of prepartum lipid supplementation affecting the performance of piglets (Pettigrew, 1981; Theil et al., 2011). On the other hand, scientific evidence showed that lipid supplementation tends to increase survival rate (Pettigrew, 1981; Jin et al., 2017; Chen et al., 2019), which was also not observed in this study. This divergent result may have occurred due to genetic differences within each study or because, in this study, piglets already had a good weight at birth (1.3±0.25 kg), which may have directly affected their weight gain and survival rate (Li et al., 2018), making the response margin for any treatment lower.

In the previously mentioned study, Chen et al. (2019) evaluated the effect of medium-chain or polyunsaturated fatty acid supplementation in the prepartum period for sows, also reporting supplementation effects on piglet performance and survival. They concluded that this supply did not change the number of total births, live births, and stillbirths or the weight of the litter at birth, corroborating the findings of the present study. However, in the same study, the DWG of piglets was higher in the group of sows that received diet with a higher amount of polyunsaturated fatty acids, and survival rate was also higher with both polyunsaturated fatty acids and medium-chain fatty acids compared with those of the control group. Such results are in contrast with what happened in this trial, even though both used the same lipid profile. This may have happened because, contrary to those used in the study by Chen et al. (2019), the fatty acids present in the SO used in this study were not isolated, which may have hindered their absorption and use for colostrum synthesis. Additionally, SO is rich in long-chain fatty acids, and the fatty acids used in that study were medium- and short-chain and thus more readily digestible.

The study by Pettigrew (1981), the basis for most studies in this area, compiled the results of 12 experiments with supplementation between 5 and 9% lipids from different sources in the feed for 306 piglets from different females. Supplementation increased the survival rate of piglets by 2.3% but did not significantly change their weight gain until weaning. In the present study, the amount of oil in the diet varied between 3.06 and 16.4%, a larger range than the one evaluated by Pettigrew (1981), but which did not generate similar results. This difference in results may be a consequence of the higher amount of crude fat in the present study, which may have affected the performance of sows and, consequently, of piglets, as shown by Cheng et al. (2020).

5. Conclusions

Soybean oil supplementation at the levels of 6.3, 9.73, and 16.4% in the final three days before farrowing affects the weight loss of first-parity sows during the lactation period, without affecting their colostrum yield, size, weight, daily weight gain of their piglets, total live births, stillbirths, and survival rate of the litter in the same period.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: M.C. Santos, N. Lu, U.A.D. Orlando, L.M. Almeida, A. Maiorka and S.G. Oliveira. Data curation: M.C. Santos, C.M. Vier, N. Lu, U.A.D. Orlando, A. Maiorka and S.G. Oliveira. Formal analysis: M.C. Santos, C.M. Vier and N. Lu. Funding acquisition: A. Maiorka. Investigation: M.C. Santos and L.M. Almeida. Methodology: M.C. Santos, C.M. Vier, U.A.D. Orlando and A. Maiorka. Project administration: M.C. Santos, U.A.D. Orlando and S.G. Oliveira. Resources: M.C. Santos. Supervision: M.C. Santos and S.G. Oliveira. Writing-original draft: M.C. Santos. Writing-review & editing: M.C. Santos, A. Maiorka and S.G. Oliveira.

Acknowledgments

We would like to thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the scholarship granted, and Copercampos and PIC North America for their partnership in the project.

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