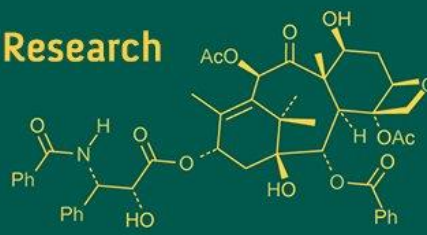
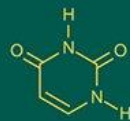
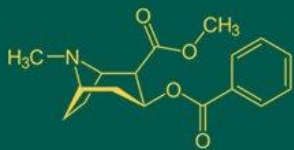


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693

ISSN Online: 2617-4707

NAAS Rating (2026): 5.29

IJABR 2026; 10(6): 40-52

www.biochemjournal.com

Received: 17-03-2026

Accepted: 19-04-2026

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Productive performance of large white Yorkshire sows managed on diet containing fermented soybean meal

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6a.8553>

Abstract

Pig husbandry is an important component of livestock farming in India, particularly among tribal communities in the North Eastern states. In recent years, there has been increasing interest in optimizing feed efficiency and sow productivity through nutritional interventions. The study was undertaken to evaluate the effects of Fermented Soybean Meal (FSBM) on the performance of Large White Yorkshire (LWY) sows during late gestation and lactation, involving 18 sows along with their litters under farm conditions of Mizoram. The animals were randomly divided into three groups (Control, T1 and T2) to nullify the effects of sire and parity. The control group was fed a basal diet containing unfermented soybean meal, while the treatment 1 (T1) and treatment 2 (T2) groups were supplemented with 50% and 100% FSBM, respectively, from day 80 of gestation until weaning (28 days). The study revealed significantly ($p < 0.05$) higher average body weight (ABW) of piglets on day 28 of age and a significantly ($p < 0.05$) improved overall Average Daily Gain (ADG) from the 1st to the 4th week of lactation in the treatment groups compared to the control group. Numerical improvements were also observed in several parameters, including ADG of piglets, milk yield of sows and average daily feed intake during lactation. Mortality rates during the study period were lower in the FSBM-supplemented groups, with 15.91% in the control (C), 10.78% in T1, and 9.07% in T2. Overall, the findings suggest that FSBM may serve as a promising dietary supplement for improving sow productivity and piglet performance during late gestation and lactation.

Keywords: Large white Yorkshire sows, productive performance, fermented soybean meal, pregnancy, oxidative stress, feeding

Introduction

The livestock sector is a major contributor to India's economy, with pig farming emerging as one of the most profitable enterprises due to its rapid turnover, suitability for small and marginal farmers. It also has significant potential to generate sustainable income and economic opportunities for new entrepreneurs and individuals from less privileged backgrounds. According to the 20th Livestock Census (2019) [35], India possesses a pig population of 9.06 million, accounting for about 1.69% of the total livestock population. In contrast to the national decline in pig numbers, the North-Eastern region (NER) of India recorded a notable increase in pig population, reflecting the socio-cultural and economic importance of pig rearing in the region. Pork is widely consumed in the NER, particularly among tribal communities, where pig farming forms an integral part of their culture and lifestyle for ages. (Kumaresan *et al.*, 2007; Payeng *et al.*, 2013) [29, 42]. Owing to their high reproductive efficiency, rapid growth rate, efficient feed conversion ability, and higher dressing percentage, pigs contribute substantially to meat production in the region. Despite its potential, optimizing sow productivity remains crucial for the success of pig farming. A key challenge is the metabolic stress experienced during late gestation and lactation, which leads to oxidative stress that impacts reproductive performance and piglet health, with effects that may persist until weaning (Berchieri-Ronchi *et al.*, 2011; Li *et al.*, 2021) [7, 9]. This condition reduces litter size, litter weight, and overall litter growth (Zhang *et al.*, 2020) [67] and lowers feed intake during lactation, resulting in negative energy balance, greater body condition loss, and reduced milk yield (Dima *et al.*, 2009) [16]. Therefore, dietary strategies aimed at enhancing antioxidant supply during gestation are essential to mitigate oxidative damage and improve sow performance and are regarded as a cost-effective approach in Intensive pig farming practice.

(Cottrell *et al.*, 2015; Li *et al.*, 2021) ^[13]. Fermented soybean meal (FSBM) has gained Significant attention in recent years for its potential benefits in animal nutrition. Historically, soybean meal had been a vital source of plant-based protein in livestock feed, especially for pigs, however, its utilization is limited by anti-nutritional factors such as trypsin inhibitors and lectins, which reduce nutrient digestibility and growth performance. (Lambo *et al.*, 2023; Grant, 1989) ^[20]. Fermentation of soybean meal through microbial processes has been shown to reduce anti-nutritional factors while enhancing nutrient digestibility and feed efficiency in pigs (Czech *et al.*, 2021; Yuan *et al.*, 2017) ^[14, 66]. Overall, microbial fermentation is an effective approach for reducing anti-nutritional components in feed ingredients (Chi *et al.*, 2016) ^[9]. In view of the above findings, the current experiment was conducted to study the productive performance of Large White Yorkshire Sows managed on diet containing fermented soybean meal.

Materials and methods

Location and period of study

The study was carried out in the Piggery Unit of the Instructional Livestock Farm Complex, Department of Livestock Production and Management, College of Veterinary Sciences & Animal Husbandry, Central Agricultural University, Selesih, Aizawl, Mizoram, India. The study was conducted for six months from December, 2023 to May, 2024.

Experimental design and dietary treatment groups

For the purpose of the study, a total of 18 gestating Large White Yorkshire Sows (1st to 4th parity) were utilized. All the sows were identified individually and divided into three groups of 6 sows in each group, viz., Group 1 (Control), Group 2 (T1) and Group 3 (T2), in such a way that the effect of sire and parity is nullified. All the experimental animals were fed with standard rations prepared as per NRC (2012) ^[41] specification by using conventional feed ingredients. Sows of Group1 were fed the basal diet containing unfermented soybean meal (conventional SBM) and served as the control group. Feed containing fermented soybean meal (FSBM) @ 50% and 100% were fed to the sows of Group 2 (T1) and Group 3 (T2), respectively. All the sow were fed at the restricted feed (3.25 kg/sow/day) required during the gestation period (day 80 of gestation till

Farrowing) and the 1st week of the lactation (0-7 days). Ad-libitum feed was fed from the 2nd week of lactation till weaning (8-28 days) and thereafter, 4- 5 kg of feed per day per sow depending upon the body condition from weaning till the next heat, with free access to water throughout the study period. Gestating sows were housed in individual concrete stalls (0.55 × 2.25 m) and shifted to farrowing pens 1 week before parturition, where they remained in farrowing crates (1.8 × 2.25 m) with slatted flooring, guard rails, and heated creep areas until weaning at 28 days, after which they were shifted to dry and pregnant sow pen. Routine management practices, including teeth clipping, navel cord cutting, iron injections and deworming were carried out as per standard procedure, and sick animals were treated promptly. The experimental study was conducted for a period of approximately 70days.

Preparations of fermented soybean meal

Fermentation of soybean meal was done as per standard procedure described by Lambo *et al.* (2024) ^[30] with some modifications. For fermentation, distilled water was added to the grounded soybean (SBM) at a rate of 700 ml/kg and cooked at 65-121 °C for 30 minutes by using a pressure cooker. The cooked SBM was naturally cooled down to room temperature. After that, cooked soybean meal was simultaneously inoculated with *Saccharomyces cerevisiae* (Sacye® forte, Brihas Animal Health, 1x1020 CFU/gm) with the dose rate of 1gm per kg of soybean meal and *Aspergillus oryzae* MTCC 3107 (HiMedia) (3 × 107 CFU/gm) in the proportion of 1 gm per kg of soybean meal. Thereafter, SBM was kept in an incubator at 37 °C for 24 hours for fermentation. After being incubated for 24 hours, fermented soybean meal (FSBM) was mixed with *Lactobacillus acidophilus* (Inlife group, 5x109 CFU/capsule) with the dose rate of 1 capsule per kg of soybean meal which was again incubated at 37 °C for 96 hours in a tightly packed container to maintain the anaerobic condition. After the completion of fermentation, fermented soybean meal was dried in a hot air oven at 50°C-60°C for 72 hours, up to 10% moisture content. After cooling, the pH of fermented soybean was measured (4.5 pH was achieved) with a pH meter by following a procedure described by Abdel *et al.* (2023) ^[1]. Finally, fermented soybean meal was packed and stored in the fridge for further use. The nutrient composition of SBM and FSBM used in the experiment are shown in Table 1

Table 1: Proximate composition of soybean meal (as per DM% basis)

Particulars	Soybean meal	Fermented soybean meal
Dry matter (%)	88.80	89.90
Crude Protein (%)	44.50	50.41
Total Ash (%)	6.1	7.88
Crude Fiber (%)	4.28	3.25
Ether Extract (%)	0.71	1.36
Digestible Energy (DE)(Kcal/kg) (calculated)	2939.05	3523.67

Procurement of feed ingredients and preparation of compounded feed for experimental animals The feed ingredients such as maize, soyabean meal, groundnut cake (GNC), wheat bran, Di- calcium phosphate (DCP), soya oil, DL methionine, L-lysine, mineral mixture and salt were procured from Aizawl, Mizoram. They were then estimated for proximate principle analysis by following standard

procedure (AOAC, 2000) ^[6] in the Department of Animal Nutrition, C.V.SC & A.H, CAU, Selesih, Aizawl. Standard rations for the animals were then prepared as per NRC (2012) ^[41] specification in the Feed Processing Unit, Department of Animal Nutrition, C.V.SC & A.H, CAU, Selesih, Aizawl. The composition of formulated rations and their estimated nutrient contents are presented in Table 2 and 3, respectively.

Table 2: Composition of ration used in the experiment

Ingredients	Gestation ration (unfermented SBM)	Lactation ration (unfermented SBM)	Gestation ration (50% FSBM)	Lactation ration (50% FSBM)	Gestation ration (100% FSBM)	Lactation ration (100% FSBM)
Maize (kg)	71	69	71	69	71	69
Soybean meal (kg)	17	18.3	8.5	9.15	0	0
Fermented Soybean (kg)	0	0	8.5	9.15	17	18.3
GNC (kg)	3.7	6	3.7	6	3.7	6
Wheat bran (kg)	4.5	2	4.5	2	4.5	2
DCP (kg)	0.3	0.3	0.3	0.3	0.3	0.3
Soya oil (kg)	1	1.8	1	1.8	1	1.8
Lysine (kg)	0.1	0.2	0.1	0.2	0.1	0.2
Methionine (kg)	0.1	0.1	0.1	0.1	0.1	0.1
Min- mixture (kg)	2	2	2	2	2	2
Salt (kg)	0.3	0.3	0.3	0.3	0.3	0.3
Total (kg)	100	100	100	100	100	100

Table 3: Estimated nutrient contents of different ration used in the experiment

Nutrient contents	Gestation ration (Unfermented SBM)	Lactation ration (Unfermented SBM)	Gestation ration (50% FSBM)	Lactation ration (50% FSBM)	Gestation ration (100% FSBM)	Lactation ration (100% FSBM)
Dry matter (%)	88.75	88.74	88.81	88.82	88.89	88.9
Energy (DE) (Kcal/kg)	3221.05	3256.82	3267.84	3307.19	3314.63	3357.56
Crude Protein (%)	15.16	15.5	15.64	16.02	16.12	16.54
Crude Fibre (%)	3.01	3.08	2.85	2.92	2.7	2.75
Ether Extract (%)	3.31	3.26	3.37	3.32	3.42	3.38
Total Ash (%)	2.56	2.49	2.93	3.16	2.86	2.82
Lysine (%)	0.6	0.68	0.6	0.68	0.6	0.68
Methionin e (%)	0.26	0.28	0.26	0.28	0.26	0.28
Calcium (%)	0.66	0.67	0.66	0.67	0.66	0.67
Phospho- rus (%)	0.73	0.71	0.73	0.72	0.73	0.42

Parameter recorded were as follows

Average Daily Feed Intake (ADFI) of sow

Feed consumption of sows was recorded on a daily basis during the entire study period. ADFI was determined by subtracting the residual feed from the feed provided after making corrections for the dry matter content of the feed.

Body Condition Score (BCS) of sow

Body Condition Score (BCS) of the sow was assessed with finger and hand pressure on the sow's body, particularly areas where the only tissue between the skin and bones is fat tissue, which include the ribs, backbone, H^o bone and pin bones on the 80 days of gestation, day of farrowing, and day of weaning. A condition score from 1 to 5 was assigned to each sow based on the ease or difficulty of detecting bones at various pressure points as per the BCS system by Coffey *et al.* (1999) ^[12]. Assessment of Sow Body Condition as mentioned by Coffey *et al.* (1999) ^[12] is presented table 4.

Table 4: Relationship between BCS and back fat level

Condition score	Approx. Level of Back Fat (inches)	Condition
1	<0.6	Emaciated
2	0.6-0.7	Thin
3	0.7-0.8	Ideal
4	0.8-0.9	Fat
5	>0.9	Overly fat

Gestation period of sow

Gestation period of each sow was recorded during the study period.

Number of born dead piglets and mummified fetuses

Number of born-dead and mummified were observed and recorded at the time of farrowing.

Litter size and litter weight at birth and weaning

Litter size and litter weight at birth and weaning were observed and recorded at the time of farrowing and weaning.

Body weights of piglets at weekly interval

The body weight of the piglets was taken in the morning by using an electronic platform weighing balance (capacity 30 kg) from birth to the date of weaning (day 28) at a weekly interval (at day 0, 7, 14, 21, and 28).

Average daily gain (adg) of the piglets till weaning

The average daily gain (ADG in grams) was calculated by subtracting the initial body weight from the final body weight of a particular period. The average daily gain was calculated by using the following formula:

$$R = \frac{W2 - W1}{T2 - T1} \times 1000 \text{ g}$$

Where,

R=Average Daily Weight Gain (ADG) (in grams) W1=Initial body weight in kilograms

W2=Final body weight in kilograms T1=Initial age in days

T2=Final age in days

Milk yield of sow during lactation

Milk yield of sows was determined on the basis of an increase in litter weight, assuming that piglets needed 4 litres of milk per kg body weight gain (Close & Cole, 2001) ^[11]. This procedure was done on a weekly basis during lactation to estimate the week-wise milk yield of sow. Body weight of

dead piglets during the experiment period was taken into account to determine the milk yield of sow.

Weaning to Service Interval (WSI) of Sow

After weaning of the piglets, sows were observed for onset of post weaning estrus with the help of a boar observing behavioral signs of estrus, standing heat and weaning to estrus intervals (WSI) were recorded accordingly.

Mortality rate (%) and causes of mortality

Mortality of the piglets was recorded from day of farrowing till 4th week postpartum. Animals that died during the experiment were sent for postmortem examination in the Department of Veterinary Pathology, College of Veterinary Sciences & Animal Husbandry, Central Agricultural University, Selesih, Aizawl, Mizoram, and causes of mortality were recorded.

Mortality rates were calculated by using the following formula

$$\text{Mortality rate (\%)} = \frac{\text{Number of deaths during the period}}{\text{Total number of animals at the beginning of the period}} \times 100$$

Data collected from the study were subjected to statistical analysis using IBM SPSS version-27.0 software and Chi-square test (X²) for meaningful and accurate comparison and interpretation (Snedecor and Cochran, 1994) [50].

Result and discussion

The mean ($\pm$ SE) Average daily feed intake (ADFI) (in kg) of

LWY sow during gestation (from 80 days of gestation to day of farrowing) at weekly interval are presented in Table 5. Statistical analysis of the data revealed non-significant ($p > 0.05$) difference in ADFI during different weeks of late gestation among the groups. The feed intake of sows during gestation is essential for maintaining their health and ensuring proper fetal development. Sow should neither be too fatty nor too lean during gestation. Restricted feeding of sows is helpful to prevent excessive weight gain during gestation, which reduces complications during farrowing and lactation including occurrence of mastitis, metritis and agalactia syndrome (Whittemore and Kyriazakis, 2006) [62]. This approach helps in maintaining an optimal body condition score (BCS), improves fertility, and supports better milk production, Ampode *et al.*, (2023) [3], all of which contribute to the sow's overall health and reproductive performance. As 2/3 of the fetal development takes place during last trimester of gestation; higher level of feed intake during last month of pregnancy resulted in high birth weight of piglets (Reddy D.V., 2001) [44]. Gestating sow feeding schedule of 2.25-2.50 kg during day 0 to 27, 2.50-2.75 kg during day 28 to 83, 3.00-3.35 kg during day 84 to 112, 2kg during day 113 to last day of gestation and Nil or 1kg feed on the day of farrowing is proven to be beneficial (Anon, 2005) [4]. The overall feed intake of sows (on restricted feed) in the present study is in line with the study of Shang *et al.* (2024) [48], who reported that sows (Large White $\times$ Landrace) in both the fermented Soybean hulls (FSH) treatment and control group had a feed intake (restricted) of 3.0 kg/day during late gestation. During the present study, sows were managed on restricted diet as per the feeding schedule of Anon, (2005) [4] with minor variation depending upon the body conditions of the sows.

Table 5: Mean ($\pm$ se) average daily feed intake (kg) of LWY sows during the last trimester of gestation under different treatment and control groups

Time period	Groups			Overall	p-value
	C	T1	T2		
1st week (Day 80-86 of gestation)	3.26 $\pm$ 0.01	3.25 $\pm$ 0.02	3.25 $\pm$ 0.01	3.25 $\pm$ 0.01	0.93
2nd week (Day 87- 93 of gestation)	3.25 $\pm$ 0.02	3.24 $\pm$ 0.01	3.26 $\pm$ 0.01	3.25 $\pm$ 0.01	0.94
3rd week (Day 94-100 of gestation)	3.25 $\pm$ 0.02	3.26 $\pm$ 0.02	3.25 $\pm$ 0.01	3.25 $\pm$ 0.01	0.75
4th week (Day 101- 107 of gestation)	3.24 $\pm$ 0.01	3.25 $\pm$ 0.01	3.25 $\pm$ 0.02	3.25 $\pm$ 0.01	0.93
5th week (Day 108 of gestation till day of farrowing)	2.53 $\pm$ 0.02	2.53 $\pm$ 0.01	2.52 $\pm$ 0.02	2.52 $\pm$ 0.01	0.92
Overall	3.11 $\pm$ 0.05	3.12 $\pm$ 0.06	3.10 $\pm$ 0.05	3.25 $\pm$ 0.01	0.99

The mean ($\pm$ SE) Average daily feed intake (ADFI) (in kg) of LWY sow from 1st week to 4th week (weaning) of lactation at weekly interval and for overall period are presented in Table 6. The mean ($\pm$ SE) ADFI (in kg) of LWY sows during the 1st to 4th weeks (weaning) of lactation at weekly intervals for Control, Treatment 1 (T1) and Treatment 2 (T2) in the present study were 3.11 $\pm$ 0.02, 3.12 $\pm$ 0.02 & 3.13 $\pm$ 0.01; 5.54 $\pm$ 0.78, 5.78 $\pm$ 0.55 & 5.90 $\pm$ 0.47; 5.83 $\pm$ 0.48, 6.03 $\pm$ 0.39 & 6.23 $\pm$ 0.35 and 5.62 $\pm$ 0.63, 5.83 $\pm$ 0.48 & 6.1 $\pm$ 0.51, respectively. The overall ADFI from the 1st to the 4th week (weaning) of lactation for Control, Treatment 1 (T1) and Treatment 2 (T2) were 5.03 $\pm$ 0.45, 5.19 $\pm$ 0.17 and 5.34 $\pm$ 0.29, respectively. Statistical analysis revealed no significant differences in ADFI during the 1st, 2nd, 3rd and 4th weeks of lactation, as well as in the overall ADFI from the 1st to 4th week of lactation among the groups. However, numerical increase in ADFI during the 2nd, 3rd and 4th weeks was observed in sows reared under the T1 and T2 groups (fed diets containing FSBM) compared to those in the control group. During lactation, sows' feed intake is gradually increased to

meet their rising nutritional needs, which Enhances milk yield and the weight of piglets at weaning. It is often suggested that sows should be fed based on the size of their litter. Sow with an average litter size of 11 at birth should be provided with 1- 2 kg of feed on the first day of lactation and the amount should be gradually increased by 0.5 kg daily until the target feed of 7kg (Target feed: 1.5 + (0.5 $\times$ litter size). Thereafter, 7kg per day during the rest of lactation (Anon, 2005) [4]. Whittemore and Kyriazakis, (2006) [62] state that sows have a reduced appetite on the first day after farrowing due to the stress of delivery and the physiological changes associated with lactation. At this stage, they usually consume 1-2 kg of feed, but feed intake can increase by approximately 1 kg per day, reaching 6-7 kg by the end of the first week, as sows require more energy for milk production and recovery. To help sows gradually adjust to the increasing nutritional demands of lactation, it is recommended to raise feed intake by 0.5 kg daily. A reduction in feed intake may occur after 21 days of lactation as milk yield decreases. This gradual adjustment ensures optimal energy and nutrient supply for

milk production and the sow's recovery from the physiological stress associated with pregnancy, farrowing, and early lactation. The lack of significant differences in ADFI observed in the present among the groups during the 1st, 2nd, 3rd, and 4th weeks of lactation in LWY sows was consistent with the findings of Huang *et al.* (2020) [22], who observed no significant difference ($p=0.98$) in ADFI of sows (Landrace $\times$ Yorkshire) throughout lactation between the treatment groups (fed a diet containing 5% fermented soybean fiber (FSF diet)) and the control group (fed a diet without supplementation of FSF). Similar findings were observed by Jurgens *et al.* (1997) [24], where supplementation with dry yeast (*Saccharomyces cerevisiae*) during gestation and lactation did not improve sows' feed intake. Lambo *et al.* (2024) [30] mentioned that feeding FSBM helps to maintain the gut health in sows. However, the numerical increase in sows' ADFI observed in the present study during the 2nd, 3rd and 4th weeks aligns with the observations of Tan *et al.*

(2020) [53] and Wu *et al.* (2021) [63]. Tan *et al.* (2020) [53] found that adding 10 g/kg yeast extract to LWY sows' diets increased their feed intake during lactation. Wu *et al.* (2021) [63] noted that the average daily feed intake of lactating (Yorkshire $\times$ Landrace) sows fed diets containing 100 and 200 mg/kg SI (Soybean Isoflavone) and APS (Astragalus Polysaccharide Mixture) in the form of powder (GC100 and GC200, respectively) was significantly higher ($p<0.05$) than that of the control group (GC). Although no significant differences in ADFI were observed among the groups during the 1st to 4th weeks of lactation, the inclusion of FSBM might have increased feed palatability, digestibility, improve nutrient utilization and absorption due to enhanced gut morphology, alleviation of gut disorders, and overall improvement in sow health which might have helped in higher milk production in sows, as reflected in improved growth rate of suckling piglets.

Table 6: Mean ($\pm$ se) average daily feed intake (kg) of LWY sows from 1st to 4th week of lactation under different treatment and control groups

Time period	Groups			Overall	p-value
	Control	T1	T2		
1st week (1-7 day)	3.11 $\pm$ 0.02	3.12 $\pm$ 0.02	3.13 $\pm$ 0.01	3.12 $\pm$ 0.01	0.66
2nd week (8-14 day)	5.54 $\pm$ 0.78	5.78 $\pm$ 0.55	5.9 $\pm$ 0.47	5.74 $\pm$ 0.33	0.91
3rd week (15-21 day)	5.83 $\pm$ 0.48	6.03 $\pm$ 0.39	6.23 $\pm$ 0.35	6.03 $\pm$ 0.22	0.78
4th week (22-28 day)	5.62 $\pm$ 0.63	5.87 $\pm$ 0.46	6.1 $\pm$ 0.51	5.86 $\pm$ 0.29	0.81
Overall	5.03 $\pm$ 0.45	5.19 $\pm$ 0.25	5.34 $\pm$ 0.29	5.19 $\pm$ 0.17	0.70

The mean ($\pm$ SE) Body Condition Score (BCS) of LWY sow during gestation (day 80), day of farrowing and weaning (28 days) are presented in Table 7. The mean ($\pm$ SE) BCS of LWY sow during gestation (day 80), day of farrowing and day of weaning in Control, Treatment 1 (T1) and Treatment 2 (T2) were 3.00 $\pm$ 0.26; 3.33 $\pm$ 0.34 & 3.17 $\pm$ 0.31; 3.50 $\pm$ 0.23, 3.83 $\pm$ 0.17 & 3.67 $\pm$ 0.21 and 2.50 $\pm$ 0.22, 2.83 $\pm$ 0.16 & 2.67 $\pm$ 0.21, respectively. Statistical analysis revealed non-significant differences in BCS of sow during gestation (day 80), day of farrowing and weaning (day 28). Body Condition Score (BCS) of a sow refers to the proportion of fatty material relative to non-fatty components in the sow's body. Young and Aherne, (2005) [65] stated that BCS serves as an essential management tool for producers to improve production efficiency, monitor pig health, and assess their nutritional status and is measured by subjective (manual body scoring) and objective methods (Sow caliper, Flank to flank & Renco Lean Meater). Anupam *et al.* (2019) reported that BCS scores range from 1 to 5, with BCS 1 indicating extreme emaciation and BCS 5 representing severe obesity. A BCS of 3 reflects optimal body condition, where reproductive performance in sows is maximized. According to their study, the BCS at farrowing should range from 3.0 to 4.0 for optimal reproductive performance and decrease to 2.5 to 3.5 at weaning as sows mobilize energy reserves, leading to weight loss during lactation. This weight loss may also be influenced by litter size, with larger litters requiring greater energy expenditure. Furthermore, BCS in sows is directly influenced by body weight gain and loss, as it reflects the sow's nutritional status and overall health. During pregnancy, the weight gain of sow is closely related to feed intake. It is generally recommended that sows should gain between 25.0 and 30.0 kg during gestation (Lavery *et al.*, 2018) [31], receiving 3.25 kg/day of feed from the 86th to the 112th day

of gestation and 2 kg/day from the 113th to the 114th day of gestation (NRC, 2012) [41] to support maternal and conceptus growth. Whittemore and Kyriazakis, (2006) [62] reported that under ad libitum conditions, the daily feed intakes of lactating sows may range from 3 to 12 kg, but most sows rarely exceed 6.5 kg during lactation, and a lower feed intake can lead to a loss of up to 20 kg (i.e., approximately 10% of their BW) of maternal body weight. Excessive weight loss leads to a body condition score below the optimal 2.5 at weaning, which results in reduced conception rates, longer weaning-to-oestrus intervals, and a higher risk of shoulder lesions during nursing. The BCS of sows at day 80 of gestation recorded in the present study is in agreement with the findings of Maes *et al.* (2004) [37], who reported that sows in three herds (A: 400 sows, B: 300 sows, and C: 250 sows) had different body condition scores (BCS) at 80 days of gestation: 2.96, 3.36, and 3.32, respectively. Herds A and C were fed the same commercial meal twice a day, while herd B was fed pellets once a day. Present observation of the body condition score (BCS) at the day of farrowing and weaning were also in accordance with the observation of Shen *et al.* (2011) [49] and Huang *et al.* (2020) [22]. Shen *et al.* (2011) [49] observed that supplementation of sows with *Saccharomyces cerevisiae* fermentation products throughout the whole gestation period did not affect gestational back-fat thickness change. They mentioned that body weight and back-fat thickness (BFT) of sows during gestation and lactation were similar between two treatments (sows fed a basal diet with 12.0 g of fermentation product [(SCFP- *Saccharomyces cerevisiae* fermentation product) /day for 5 days before breeding through gestation and 15.0 g of fermentation product /day through lactation) and control sows fed a corn-soybean meal basal diet without supplementation]. Huang *et al.* (2020) [22] reported that inclusion of fermented soybean fiber (FSF) in gestation and

lactation diet of sow (Landrace × Yorkshire) had no effect on body weight or back-fat thickness gain on day 109 of gestation and at the day of farrowing and at weaning ($p>0.05$). In contrast to the present findings, Wang *et al.* (2018)^[60] reported that the back-fat loss of sows (Yorkshire × Landrace) fed 15% Fermented Mixed Feed (FMF-40% corn, 40% soybean meal, and 20% wheat bran) was significantly lower ($p<0.05$) than that of sows fed the control diet. The back-fat was measured on the days of parturition and weaning. The present findings showed that feeding fermented soybean meal (FSBM) to sows minimized the significant loss of body condition at farrowing and weaning. Although no significant differences were found between the treatment and control groups, sows from T1 and T2 had a

higher numerical body condition score compared to those from Control. This improvement might be due to the beneficial effects of FSBM, which might reduce anti-nutritional factors in the diet, provides Beneficial bioactive peptides and digestive enzymes, probiotics and antioxidants, leading to higher feed intake of sows during lactation, promoting a positive energy balance, thereby, reducing body condition loss and contributes to improved milk production. The difference in sow body condition particularly body weight and back-fat thickness, observed by the earlier studies compared to the present findings may be due to the variations in breed, parity, lactation feed intake and the management practices.

Table 7: Mean ($\pm$ Se) body condition score of LWY sows during gestation (day80) and day of farrowing and weaning under different treatment and control group

Time period	Control	T1	T2	Overall	p-value
Gestation (Day 80)	AB	AB	AB	3.16 $\pm$ 0.16	0.92
Day of farrowing	B	B	B	3.63 $\pm$ 0.11	0.52
Day of weaning	A	A	A	2.66 $\pm$ 0.11	0.52
Overall	3.00 $\pm$ 0.16	3.33 $\pm$ 0.16	3.17 $\pm$ 0.17		
p- value	0.03	0.03	0.04		

The mean ($\pm$ SE) gestation period (days) of LWY sows in Control (C), Treatment (T1) and Treatment (T2) are presented in the Table 8. Statistical analysis showed non-significant difference in gestation period (days) of LWY sows among the groups. The gestation period observed in the present study aligns with the findings of Sasaki and Koketsu, (2007)^[47], who reported that the average gestation length of sows (Large White Yorkshire × Landrace) on commercial farm was approximately 115 days, with individual lengths ranging from 105 to 125 days. They noted that about 70% of farrowing events occurred between 114 and 116 days, indicating minimal variability in gestation length among sows. Although gestation length varied among individual sows, it did not change with parity. Sows were more likely to have a gestation length similar to that of their previous gestation at any parity. They also stated that the high repeatability of gestation length also indication of sow-to-

sow variation had a considerable influence on the total gestation length variation. The similarity in gestation periods observed in the present study might be associated with the comparable litter sizes, as no significant variations ($p>0.05$) in litter size were found between the treatment and control groups. According to Imboonta *et al.* (2012)^[23], sows with a lower total number of piglets born had longer gestation periods compared to those with larger litters. They mentioned that sows with smaller litters gestated 0.24 days longer ($p<0.05$) than those with larger litters. They further noted that sows with litters of 12 or more had a shorter gestation length compared to sows with smaller litters. This could be attributed to the larger placentas of sows with larger litters producing higher levels of estrogen, which initiates parturition, contributes to shorter gestation lengths when present in greater quantities (Dziuk, 1991)^[17].

Table 8: Mean ($\pm$ Se) gestation period (days) of sows under different treatment and control groups

Parameters	Groups			Overall	p- value
	Control	T1	T2		
Gestation period (DAYS)	115.5 $\pm$ 0.84	115.17 $\pm$ 0.41	114.83 $\pm$ 0.4	115.16 $\pm$ 0.14	0.18

The mean ($\pm$ SE) number of born dead and mummified fetuses in LWY sow at the time of farrowing are presented in Table 9. The mean ($\pm$ SE) number of born dead and mummified fetuses in LWY sows in Control, Treatment 1 (T1) and Treatment 2 (T2) were 1.67 $\pm$ 0.42, 1.33 $\pm$ 0.42 & 1.17 $\pm$ 0.31 and 1.17 $\pm$ 0.75, 1 $\pm$ 0.6 3 & 0.83 $\pm$ 0.75, respectively. Statistical analysis revealed non-significant differences in the number of born dead and mummified fetuses at the time of farrowing among the groups. Whittemore and Kyriazakis, (2006)^[62] reported that embryo and fetal death are often associated to irregular returns to estrus, and is usually related to disease invasions. Infective agents, such as mycotoxins, reproductive tract infections, parvovirus, Aujeszky's disease, and Leptospira can cause uterine infections, vulval discharges

resulting in embryo Loss, giving irregular return to estrus (often between 23 and 40 days), fetal death, mummified fetuses, reduced litter size, stillbirths, and abortions. Furthermore, Pasteurella, E. coli, and Corynebacterium may enter through the vagina and disrupt the reproductive tract, causing painful urination, cystitis, and abortion. Lefebvre, (2015)^[32] observed that fetal mummification may occur after 35-40 days of pregnancy, once the skeleton has formed, with 70% of cases linked to management, nutrition, and environmental factors and 30% caused by infections. Factors like parity, litter size, uterine capacity, environmental temperature, mycotoxins are associated with mummification (Van de *et al.*, 2003)^[58]. Borges *et al.* (2005)^[8] found that larger litters (over 12 piglets) had a 14.5-fold higher chance

of mummification compared to smaller litters ($p < 0.05$). This finding may be Associated with a failure of the uterus to maintain a favorable environment for fetal growth and survival. According to Wu *et al.* (1998) [64], uterine length in sows with and without mummified fetuses is equivalent. However, sows with mummified fetuses tend to have larger litters (more fetuses), suggesting that uterine space is more likely to influence fetal death and eventually mummification, particularly in the last trimester of gestation, when the fetal growth rate increases significantly. Present findings of number of born dead and mummified fetus were in accordance with the observation of Huang *et al.* (2020) [22], who reported that inclusion of a fermented soybean fiber diet (FSF diet) in the pregnant sows (Landrace $\times$ Yorkshire) diet had no significant effect in the number of stillbirths for the FSF group versus the control (stillbirth; 1.8 for FSF vs. 2.0 for control). Similar results were reported by Tan *et al.* (2020) [53] in dietary supplementation with different amounts of yeast extract (0, 2.5, 5, and 10 g/kg YE treatments) in multiparous LWY sows from day 85 of gestation to day 21 of lactation, observing no significant difference ($p > 0.05$) in the number of

stillborn and mummified piglets. In contrast to the present results, Song *et al.* (2017) [51] mentioned that supplementation of sows (LWY $\times$ Landrace) with 4% SSDDGS (Saccharomyces cerevisiae refermented sorghum dried distiller's grains with solubles) significantly reduced the litter stillbirth rate ($p < 0.05$) as compared to the control. Fermented soybean enhances reproductive performance in sows through improved nutrient availability, phytoestrogenic activity and support for uterine health (Ren *et al.*, 2001) [46]. The link between estrogen, uterine glycogen, and reproductive success is well established, supporting the role of FSBM in reducing stillbirths and improving farrowing outcomes. However, the absence of a significant difference in the number of stillborn or mummified fetuses between the fermented soybean treatment group and the control group observed in the present study could be due to several influencing factors. These might include the treatment duration, the quantity of fermented soybean used, or other environmental and genetic variables that affect fetal development. To ascertain the present findings, further study on inclusion of fermented soybean in sow diet with more number of sows might be helpful.

Table 9: Mean ($\pm$ Se) number of born dead and mummified fetuses at the time of farrowing under different treatment and control groups

Parameters	Groups			Overall	p-value
	Control	T1	T2		
Number of born dead	1.67 $\pm$ 0.42	1.33 $\pm$ 0.42	1.17 $\pm$ 0.31	1.39 $\pm$ 0.21	0.65
Number of mummified fetus	1.17 $\pm$ 0.75	1 $\pm$ 0.63	0.83 $\pm$ 0.75	1.00 $\pm$ 0.16	0.72

The mean ($\pm$ SE) litter size (numbers) and litter weight (kg) of LWY piglets at birth (day 0) and weaning (day 28) in the present study are presented in Table 10. The mean ($\pm$ SE) litter size (numbers) and litter weight (kg) of LWY piglets at birth (day 0) and weaning (day 28) in Control, Treatment 1 (T1) and Treatment 2 (T2) were 11 $\pm$ 0.54, 11.17 $\pm$ 0.6 & 11.33 $\pm$ 0.76; 9.33 $\pm$ 0.61, 10 $\pm$ 0.85 & 10.33 $\pm$ 0.67; and 14.52 $\pm$ 0.81, 14.81 $\pm$ 1.05 & 15.04 $\pm$ 1.22; 53.62 $\pm$ 3.47, 59.6 $\pm$ 5.19 & 65.39 $\pm$ 4.53, respectively (Table 10). Statistical analysis revealed non-significant differences in litter size and litter weight at different age (0, 7, 14, 21, 28 days) among the groups. The present study findings of litter size and litter weight (kg) at birth were in agreement with the findings of Rehfeldt *et al.* (2007) [45], Wang *et al.* (2016) [61], Wang *et al.* (2018) [60] and Luo *et al.* (2021) [36]. Rehfeldt *et al.* (2007) [45] found that supplementation of soybean flavonoid to the sow's (Landrace) diet had no effect on the litter size, litter birth weight, and piglet birth weight. Wang *et al.* (2016) [61] reported that the inclusion of fermented soybean meal (FSBM) in the gestation diet of sows (Landrace $\times$ Yorkshire) had no effect ($p > 0.05$) on litter size, litter weight, average piglet weight at birth. Wang *et al.* (2018) [60], reported that supplementation of 7.5% fermented mixed feed [(FMF-fermentation of 40% corn, 40% soybean meal (SBM), and 20% wheat bran with *B. subtilis* (3×10^8 cfu/g), *E. faecium* (108 cfu/g)] in sow (Landrace $\times$ Yorkshire) diet does not show any tendency to improve the performance of sows and their progeny. Luo *et al.* (2021) [36] reported that replacing SM with FSBM (fermented with *Aspergillus oryzae* and *Lactobacillus reuteri*) in the sow (Landrace) diet had no effect on the litter size, alive litter size, litter weight at birth and the birth weight of piglet ($p > 0.05$). In contrary to the present findings, Ren *et al.* (2001) [46] reported that the feeding soy isoflavones daidzein to late pregnant sows could enhance the

birth weight of male piglets. They mentioned that ingestion of daidzein by the sow could alter the expression of estrogen receptor beta (ER β) in the newborn piglets which influences fetal growth associated with higher Type 1 insulin-like growth factor receptor (IGF-1R) gene expression in skeletal muscle. Cho *et al.* (2011) [10] reported that fermentation of soybean increased the content of soybean isoflavones (SIFs) as the form of aglycones, which comprises different form such as genistein and daidzein. Shen *et al.* (2011) [49] mentioned that sows treated with Saccharomyces cerevisiae fermentation product (SCFP) throughout gestation and lactation period tended to have increased litter weaning weight compared with sows in the control group. Zhang *et al.* (2020) [67], also observed that the litter size (total born) and numbers of piglets born alive were significantly ($p < 0.01$) greater in the sows (Landrace $\times$ Yorkshire) fed diet supplemented with *B. subtilis* PB6 (BS) group than those in the control (without *B. subtilis* PB6) group. Wang *et al.* (2018) [60] observed that feeding 15% FMF to sows increased ($p < 0.05$) the weaning weight and weight gain of litters. Luo *et al.* (2021) [36] observed heavier litter weight on the 14th day after birth in 4% FSBM and 6% FSBM (fermented with *Aspergillus oryzae* and *Lactobacillus reuteri*) supplemented in Landrace sows than that of the control ($p < 0.05$). Furthermore, the weight of litter was heavier in the 4% FSBM group than that in the control ($p < 0.05$) on the 21st day after birth. Their findings suggest that FSBM supplementation can improve litter weight at different stages of growth. Non-significant differences in litter size and litter weight at birth (0 day), 1st week, 2nd week, 3rd week and 4th week observed in the present study between treatment (T1 and T2) and Control group could be due to difference in quality of soybean, percent of FSBM in diet, environmental conditions or the duration of the supplementation.

Table 10: Mean ($\pm$ se) litter size and litter weight of LWY piglets under different treatment and control groups

Days / Parameters	Groups			Overall	p- value
	Control	T1	T2		
Litter size (no.)					
At birth	11±0.54	11.17±0.60	11.33±0.76	11.16±0.36	0.94
Day 7	10.17± 0.83	10.5±1.02	10.83±0.83	10.50±0.49	0.87
Day 14	9.83±0.79	10.17±0.91	10.5±0.76	10.17±0.45	0.85
Day 21	9.5±0.67	10±0.85	10.33±0.67	9.94±0.40	0.72
Day 28	9.33±0.61	10±0.85	10.33±0.67	9.88±0.40	0.61
Litter weight (kg)					
At birth	14.52±0.81	14.81±1.05	15.04±1.22	14.79±0.56	0.94
Day 7	23.08±1.94	25.14±2.55	26.51±2.18	24.91±1.26	0.56
Day 14	33.70±2.72	36.64±3.71	38.87±3.05	36.40±1.80	0.53
Day 21	44.16±2.91	48.96±4.19	52.79±3.71	48.64±2.15	0.27
Day 28	53.62±3.47	59.6± 5.19	65.39 ±4.53	59.53±2.6	0.29

The mean ($\pm$ SE) average body weight (kg) of LWY piglets at birth (day 0) to day 28 (weaning) at weekly interval are presented in Table 11. The mean ($\pm$ SE) of body weight (kg) of LWY piglets at birth (day 0) and day 28 in Control, Treatment 1 (T1) and Treatment 2 (T2) were 1.320 $\pm$ 0.03, 1.32 $\pm$ 0.04 & 1.33 $\pm$ 0.03 and 5.74 $\pm$ 0.15, 5.96 $\pm$ 0.19 & 6.32 $\pm$ 0.16, respectively. Statistical analysis revealed non-significant differences in average body weight at birth (day 0,) day7, day 14 and day 21 among the groups ($P \geq 0.05$). However, significant ($P \leq 0.05$) increased average body weight (ABW) of piglets were found at day 28 in the treatment 2 (T2) group as compared to the control (C) and treatment 1 (T1) groups. The results of the average body weight (ABW) of piglets supplemented with fermented soybean observed in the present study were in accordance with the findings of Luo *et al.* (2021) [36], they reported that replacing soybean meal (SM) with fermented soybean meal (FSBM), fermented with *Aspergillus oryzae* and *Lactobacillus reuteri*, in the diet of sows (Landrace breed) had no significant ($p > 0.05$) difference in the ABW of piglets at birth (0 day). However, it significantly improved the ABW of piglets on the day of weaning (21 days), compared to the control group ($p < 0.05$). In their research, the average ABW of piglets at birth was recorded as 1.57 $\pm$ 0.11, 1.58 $\pm$ 0.88, 1.54 $\pm$ 0.07, and 1.55 $\pm$ 0.11 kg for control, 2%, 4%, and 6% FSBM-supplemented groups, respectively. They recorded ABW at weaning

(day 21) as 4.57 $\pm$ 0.30, 5.53 $\pm$ 0.29, 6.03 $\pm$ 0.28, and 5.65 $\pm$ 0.34 kg for the same groups, respectively. Wang *et al.* (2018) [60] reported that supplementing sows (Yorkshire $\times$ Landrace) with 7.5% and 15% Fermented Mixed Feed (FMF) consisting of 40% corn, 40% soybean meal (SBM), and 20% wheat bran did not affect body weight gain of suckling piglets in the treatment groups compared to the control, but they recorded significantly increased ($p < 0.05$) individual piglet weight at weaning (day 21). They mentioned the average body weight of piglets at birth 1.27 kg, 1.26 kg, and 1.34 kg, and at weaning (day 21) 5.93 kg, 5.94 kg, and 6.45 kg for the control, 7.5% FMF, and 15% FMF groups, respectively. Data of ABW in the present study under different groups reveals that fermentation might have increases the aglycone form of SIFs in FSBM, which in turn reduced oxidative stress during gestation and lactation, thereby enhancing the milk production resulting in better growth of nursing piglets of sows fed FSBM as compared to the control group. In sow, milk production started to decline after 3rd week of lactation (Whittemore and Kyriazakis, 2006) [62] which was also observed in the present study (Table no.13). However, incorporation of FSBM might have helped to sustain the milk production even in 4th week of lactation, which might cause significantly higher body weight in nursing piglet on day 28 (T2) as compared to piglets under control group.

Table 11: Mean ($\pm$ se) body weight (kg) of LWY piglets under different treatment and control

Age	Groups				p-value
	Control	T1	T2	Overall	
Day 0 (At birth)	1.320 $\pm$ 0.03	1.32 $\pm$ 0.04	1.33 $\pm$ 0.03	1.32 $\pm$ 0.14	0.99
Day 7 (1st week)	2.27 $\pm$ 0.08	2.39 $\pm$ 0.09	2.45 $\pm$ 0.07	2.37 $\pm$ 0.12	0.25
Day 14 (2nd week)	3.43 $\pm$ 0.11	3.60 $\pm$ 0.14	3.71 $\pm$ 0.12	3.58 $\pm$ 0.11	0.26
Day 21 (3rd week)	4.65 $\pm$ 0.13	4.89 $\pm$ 0.16	5.11 $\pm$ 0.14	4.88 $\pm$ 0.10	0.08
Day 28 (4th week)	a	ab	b	6.02 $\pm$ 0.09	*

(*) Significant ($p < 0.05$)

The mean ($\pm$ SE) ADG (g) of LWY piglets from 1st to 4th week of age and for the overall ADG are presented in Table 12. The mean ($\pm$ SE) ADG (grams) of LWY piglets at 1st week, 2nd week, 3rd week and 4th week for Control, Treatment 1 (T1) and Treatment 2 (T2) in the present study were 134.89 $\pm$ 8.1, 146.21 $\pm$ 8.61 & 155.7 $\pm$ 6.29; 169.85 $\pm$ 8.49, 169.67 $\pm$ 10.36 & 176.73 $\pm$ 9.44; 174.83 $\pm$ 8.24, 182.42 $\pm$ 9.54 & 194.91 $\pm$ 8.99 and 150.81 $\pm$ 9.06, 152.02 $\pm$ 8.62 & 174.29 $\pm$ 9.43, respectively. The overall ADG from birth to day 28 of age for Control, Treatment 1 (T1) and Treatment 2 (T2) were 157.34 $\pm$ 4.32, 162.41 $\pm$ 4.71 & 175.17 $\pm$ 4.36, respectively.

Statistical analysis showed non-significant differences in ADG at different ages among the groups. However, significant ($p < 0.05$) increase in overall ADG from the 1st to the 4th week was observed in the treatment groups (T1 and T2) compared to the control group. The present observation of ADG in LWY piglets from the 1st to the 4th week of lactation resembles the findings of Luo *et al.* (2021) [36] who reported that supplementing the diet of Landrace sows with 4% FSBM significantly increased the average daily gain of piglets after birth compared to the sows in the control group. However, contradictory results were reported by Demečková

et al. (2002)^[15] and Wang *et al.* (2016)^[61]. Demečková *et al.* (2002)^[15] reported that feeding sows *Lactobacillus* spp.-fermented liquid feed improved sow ADFI but had no effect on piglet growth performance. Wang *et al.* (2016)^[61] revealed that the daily gain of piglets did not differ significantly ($p>0.05$) between the group receiving the FSBM (fermented with *Bacillus subtilis*, *Hansenula anomala* and *Lactobacillus casei*) supplement during gestation and the first 28 days of lactation and the control group. Data of the average daily gain (g) of LWY piglets revealed that FSBM might have enhance nutrient digestibility, increases the bioavailability of

amino acids and essential nutrients, supports gut health through the production of short-chain fatty acids and increases the contents of soybean isoflavone aglycones with high efficacy of biotransformation, which in turn helped to reduced oxidative stress in sows and increased feed intake (Table no. 6). Decreased oxidative stress in both gestation and lactating sow and increase feed intake during lactation as observed in the present study (numerically increased) might enhanced the milk production and contribute to improvement in the average daily gain of suckling piglets under the treatment groups as compared to the control group.

Table 12: Mean ($\pm$ se) average daily gain (g) of LWY piglets from 1st to 4th week of age under different treatment and control groups

Age	Groups			Overall	p- value
	Control	T1	T2		
1st Week (Day 0-7)	134.89 $\pm$ 8.1	146.21 $\pm$ 8.61	155.7 $\pm$ 6.29	145.82 $\pm$ 5.09	0.16
2nd Week (Day 7-14)	169.85 $\pm$ 8.49	169.67 $\pm$ 10.36	176.73 $\pm$ 9.44	172.16 $\pm$ 5.30	0.84
3rd Week (Day 14-21)	174.83 $\pm$ 8.24	182.42 $\pm$ 9.54	194.91 $\pm$ 8.99	184.33 $\pm$ 5.29	0.28
4th Week (Day 21-28)	150.81 $\pm$ 9.06	152.02 $\pm$ 8.62	174.29 $\pm$ 9.43	159.39 $\pm$ 5.26	0.11
Overall	157.34 $\pm$ 4.32a	a	175.17 $\pm$ 4.36b	165.20 $\pm$ 2.59	*

(*) Significant ($p<0.05$)

The mean ($\pm$ SE) weekly estimated milk yield (litre) of LWY sow from 1st week to 4th week (weaning) of lactation at weekly interval in the present study are presented in Table 13. The mean ($\pm$ SE) weekly estimated milk yield (litre) of LWY sow from 1st to 4th week (weaning) of lactation at weekly interval in Control, Treatment 1 (T1) and Treatment 2 (T2) were 38.40 $\pm$ 3.75, 42.99 $\pm$ 5.22 & 47.23 $\pm$ 4.09; 46.76 $\pm$ 5.05, 48.3 $\pm$ 6.37 & 51.96 $\pm$ 5.02; 46.5 $\pm$ 4.82, 51.08 $\pm$ 2.87 & 56.39 $\pm$ 3.72 and 39.41 $\pm$ 2.76, 42.57 $\pm$ 4.93 & 50.42 $\pm$ 3.83, respectively. The overall estimated milk yield (litre) from 1st week to 4th week (weaning) of lactation for Control (C), Treatment (T1) and Treatment (T2) were 42.77 $\pm$ 2.11, 46.23 $\pm$ 2.45 & 51.5 $\pm$ 2.07 and respectively. Statistical analysis revealed non-significant difference in the estimated milk yield (litre) of LWY sow during lactation period among the groups. However, the treatment groups receiving fermented soybean meal exhibited a numerical increase in estimated milk yield compared to the control group. Milk yield in sows is essential for piglet growth and survival, directly influencing weaning weight and litter performance. It is impacted by factors such as litter size, feed intake, and the sow's body condition. According to Whittemore and Kyriazakis, (2006)^[62], larger litters stimulate higher milk yield, while adequate feed intake supports both milk production and the sow's recovery from the physiological stresses of pregnancy, farrowing, and early lactation. They mentioned that a sow nursing six piglets produces 8.5 kg of milk daily, with each piglet consuming 1.4 kg; for eight piglets, the yield is 10.4 kg, with 1.3 kg per piglet; with ten piglets, the yield is 12 kg, and intake per piglet is 1.2 kg; and for twelve piglets, the yield reaches 13.2 kg, with 1.1 kg per piglet. Milk production peaks at around 3 weeks post-partum, with piglets suckling hourly during the first 4 weeks. Afterward, suckling frequency decreases as piglets begin to rely less on milk. Lactation typically ends by 10-12 weeks, as piglets become nutritionally independent. Noblet and Etienne, (1986)^[40] reported that milk production increased significantly ($p<0.01$) as the lactation period was

maximum at day 21 in sows fed with high energy diet and at day 17 in the sows fed with low energy diet. Kakati *et al.* (2019)^[25] reported that the average weekly milk production in LWY sows as 46.51 liters, with peak production occurring at the third week of lactation, a pattern also observed in the present study (Table 13). The numerical increase in estimated milk yield of LWY sows from the 1st to the 4th week, as well as the overall improvement in milk yield observed among the treatment groups, can likely be attributed to the higher average daily feed intake (ADFI) in the groups compared to the control (Table no. 6). This increased feed intake may be a result of the beneficial effects of fermented soybean, which could enhance nutrient availability, improve palatability, and support better metabolic efficiency that contributes to greater milk production of sow during the lactation period. However, the results of the present study contradict the observations made by Wang *et al.* (2018)^[60], who reported that supplementing the diets of Yorkshire $\times$ Landrace sows with 15% Fermented Mixed Feed (FMF), consisting of 40% corn, 40% soybean meal, and 20% wheat bran, significantly ($p<0.05$) enhanced milk yield and increased the IgA content in the milk compared to the control group. Luo *et al.* (2021)^[36] also observed that replacing soybean meal with fermented soybean meal (FSBM), fermented using *Aspergillus oryzae* and *Lactobacillus reuteri*, in Landrace

Sow diets reduced oxidative stress, enhanced colostrum composition (protein, fat, lactose, total solids, SNF, and immunoglobulins) and improved offspring performance. They noted a significant ($p<0.05$) increase in protein and total solids in the colostrum. Wu *et al.* (2021)^[63] also mentioned that the inclusion of a mixture of soybean isoflavones and astragalus polysaccharide (200 mg/kg) significantly enhanced the lactation yield of sows (LWY $\times$ Landrace) compared to the control group. These differences as compared to the present study could be attributed to variations in breeds, environmental factors, or the physiological status of the sows.

Table 13: Mean ($\pm$ se) weekly milk production (litre) of LWY sows under different treatment and control groups

Time period	Groups			Overall	p- value
	Control	T1	T2		
1st week	38.40 $\pm$ 3.75	42.99 $\pm$ 5.22	47.23 $\pm$ 4.09	42.87 $\pm$ 2.54	0.38
2nd week	46.76 $\pm$ 5.05	48.3 $\pm$ 6.37	51.96 $\pm$ 5.02	49.00 $\pm$ 3.03	0.79
3rd week	46.5 $\pm$ 4.82	51.08 $\pm$ 2.87	56.39 $\pm$ 3.72	51.32 $\pm$ 2.32	0.23
4th week	39.41 $\pm$ 2.76	42.57 $\pm$ 4.93	50.42 $\pm$ 3.83	44.14 $\pm$ 2.41	0.16
Overall	42.77 $\pm$ 2.11	46.23 $\pm$ 2.45	51.5 $\pm$ 2.07	46.83 $\pm$ 2.20	0.24

The mean ($\pm$ SE) WSI of LWY sow in Control (C), Treatment (T1) and Treatment (T2) are presented in the table 14. The average WSI (days) for the sows in Control, Treatment 1 (T1) and Treatment 2 (T2) were 6.33 $\pm$ 0.55, 5.67 $\pm$ 0.56 and 5.5 $\pm$ 0.43, respectively and statistical analysis revealed non-significant difference among the groups. Most sows experience a period of rapid follicular growth after weaning and return to oestrus within 3-7 days, so ensuring with proper nutrition and minimizing stress during this period is essential for optimizing reproductive success. The length of WSI influences subsequent reproductive performance (Tummaruk *et al.*, 2000) ^[57], and can be used to indicate the fertility in subsequent reproductive cycles (Tubbs and Dyer, 1996) ^[56]. Whittemore and Kyriazakis, (2006) ^[62] mentioned that the weaning age of piglet affects both sow subsequent reproductive performance and piglet viability. Weaning before 21 days is associated with increased number of sows that do not show oestrus within 5 days of weaning, fewer ovulations, and lower embryo survival, partly due to incomplete uterine involution. Weaning after 21 days, however, allows the weaned sow for rapid resumption of estrous cyclicity with the rapid initiation of follicular development under follicle- stimulating hormone (FSH) and with subsequent luteinizing hormone (LH) surge driving the sow into estrus and ovulation. Furthermore, the duration of post-partum anoestrus is affected by environmental, genetic, physiological, and metabolic factors, including breed, nutrition, suckling, rate of uterine involution, follicular development, hormone levels and changes in body weight and energy intake. Thaker and Bilkei, (2005) ^[55] reported that lactation weight losses of sows are inversely related to subsequent reproductive performance of sows. In this regard, Tantasuparuk *et al.* (2001) ^[54] reported that sows with a high body loss during lactation had a significantly ($p < 0.05$) longer WSI compared to sows with medium or low weight loss. The results of the present study are comparable to those reported by Kim *et al.* (2010) and Huang *et al.* (2020) ^[22]. Kim *et al.* (2010) observed no significant difference in the weaning-to-oestrus interval between sows fed yeast culture, and the control group during gestation and lactation. Huang *et al.* (2020) ^[22] reported that inclusion of fermented soybean fiber (FSF) in gestation diet of sows (Landrace $\times$ Yorkshire) had no effect on weaning-to-oestrus interval of sows. In contrast to the present findings, Zhao *et al.* (2022) ^[68] reported that Yeast culture (YC) supplementation improved the weaning-to-oestrus interval of YC sows (Landrace) compared to control sows (5.16 d for YC sows, 6.12 d for control sows) ($p < 0.05$). Non-significant differences in the weaning-to-oestrus interval (WSI) observed in the present study may be attributed to the

lack of variation in body condition score (BCS) during lactation between the treatment and control groups.

Table 14: Mean ($\pm$ se) weaning to service interval (WSI) (days), in sows under different treatment and control groups

Parameters	Groups			Overall	p-value
	Control	T1	T2		
WSI (Days)	6.33 $\pm$ 0.55	5.67 $\pm$ 0.56	5.5 $\pm$ 0.43	5.82 $\pm$ 0.29	0.501

The mortality rate (%) of LWY young pigs from 1st - 4th weeks are presented in table 15a and causes of mortality in table 15b. Out of the 201 numbers of LWY piglets born alive, 23 numbers of piglets died (mortality rate-11.44%) during the experiment period (from birth to 4th week) with mortality rate (%) of 15.91, 10.78 and 9.03 and in Control (C), Treatment (T1) and Treatment (T1), respectively, The highest mortality occurred during the first week of lactation (52.18%), followed by 2nd week (26.08%), 3rd week (17.4%) and 4th week (4.34%). Statistical analysis revealed non-significant ($p > 0.05$) differences in the mortality rate of piglets among the experimental groups. Higher pre weaning mortality than the present study were recorded by Abraham (2001) ^[2] in Landrace up to 28 days of age, Elmaz *et al.* (2008) ^[19] in crossbred (Bulgarian Large White $\times$ Large Black $\times$ Turopolije) up to 43 days of age, Li *et al.* (2010) up to 4- 5 weeks of age, Mondal *et al.* (2012) ^[38] up to 46 days of age, Kielland *et al.* (2018) ^[27] in crossbred (Norwegian Landrace $\times$ Swedish Yorkshire) up to 32 days of age. Lower mortality rates compared to present finding were reported by Ramesh *et al.* (2006) ^[43] in Large White Yorkshire pigs up to 56 days of age and Stamati *et al.* (2006) ^[52] up to 28 days of age. The causes of mortality of LWY young pigs during the period of study were gastroenteritis, pneumonia, emaciated/weak, crushing and sudden death. These observations were comparable with the observations of Kalita *et al.* (2002) ^[26], Hmar (2006) ^[21], Edward & Bartex (2014), Muns *et al.* (2016) ^[39] and Vanlalpianpuia C. (2021). Although no significance differences were found in the mortality rate (%) among the groups in the present study, the numerically reduced mortality rate (%) of piglets under T1 compared to T2 and the Control group may be attributed to diets enriched with fermented soybean. This could have enhanced the immune function of sows, thereby facilitating the transfer of better immunity to piglets through colostrum and milk. Wang *et al.* (2016) ^[61] reported higher growth and lower piglet mortality in sows (Large White Yorkshire $\times$ Landrace) fed fermented soybean compared to sows without fermented soybean.

Table 15: (a) Mortality rate (%) of LWY piglets under different treatment and control groups

Age (Weeks)	Mortality %				
	Groups				
	Control	T1	T2	Overall	p-value
1st	7.57 (5)	5.98 (4)	4.41 (3)	52.18 (12)	0.93
2nd	3.28 (2)	3.18 (2)	3.07 (2)	26.08 (6)	0.96
3rd	3.38 (2)	1.64 (1)	1.58 (1)	17.4 (4)	0.62
4th	1.75 (1)	0	0	4.34 (1)	0.83
Total	15.91 (10)	10.78 (7)	9.07 (6)	100 (23)	0.77
Overall	11.44%				

Overall mortality percentage of piglets during the experiment was 11.44%

{Out of total 201 piglets born alive, 23 piglets died (23/201) x100=11.44

%} Figures in parenthesis indicate the number of piglets died

Table 15: (b) Caused of mortality (%) of LWY piglets under different treatment and control groups

Cause of mortality (%)	Control	Treatment 1	Treatment 2	Overall
Emaciated / Weak (%)	13.04 (3)	13.04 (3)	8.7 (2)	34.78(8)
Gastroenteritis (%)	8.7 (2)	4.35 (1)	8.7 (2)	21.74(5)
Crushing (%)	8.7(2)	8.7 (2)	4.35 (1)	21.74(5)
Sudden dead (%)	8.7 (2)	-	-	8.7(2)
Pneumonia (%)	-	4.35 (1)	-	4.35(1)
Miscellaneous (%)	4.35 (1)	-	4.35 (1)	8.7(2)

Figures in parenthesis indicate the number of piglets died

Miscellaneous causes;1 piglet died due to iron injection and 1 piglet died due to physical injury

Conclusion

In conclusion, dietary inclusion of fermented soybean meal (FSBM) during late gestation and lactation improved piglet Growth performance and survivability during the nursing period, although no marked improvement was observed in body condition score (BCS) and litter performance of Large White Yorkshire pig sows. The present findings suggest that fermented soybean meal (FSBM) may serve as a promising supplementary feed ingredients for improving sow health during late gestation and lactation. However, further scientific research involving large number of sows might be of great help to better understand and fully exploit the potential benefits of FSBM on performance of sow.

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