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Evaluation of feeding fat rich diets to Large White Yorkshire sows on feed intake and digestibility of nutrients#

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Abstract

The present study was conducted at Centre for Pig Production and Research, Mannuthy using eighteen gestating Large White Yorkshire (LWY) sowsfrom 75th day of gestation to 42nd day of farrowing to evaluate the effect of supplementing rendered fat at two different levels on intake and digestibility of nutrients. Experimental animals were grouped into three dietary treatments of six animals each following the completely randomized design. Control diet (C) was formulated as per NRC, 2012 (3300 kcal ME/kg feed and 18 per cent crude protein (CP). Other two dietary treatments were prepared by supplementation of control diet with rendered fat at five (SF5) and ten (SF10) percent levels. All sows were received experimental diets from 75th day of gestation to four weeks after farrowing and were maintained on farm rations up to 42nddday of farrowing. The weekly average daily dry matter intake (DMI)of Control and SF5 diets were higher (p<0.05) than SF10 at most weeks of recording during the experimental periods. Higher digestibility (p<0.05) of CP was observed in dietary treatment SF5 and lowest in SF10 with CP digestibility of Control group statistically similar to other two groups. Supplemented diets (SF5 and SF10) however showed a higher digestibility (p<0.05) of ether extract and nitrogen free extract than control groups. Based on the overall results of present study, it could be concluded that supplementation of rendered fat at ten per cent level resulted in lower DMI.

Keywords: *Digestibility, dry matter intake, rendered fat, LWY sows*

Pigs are prolific breeders and have one of the highest feed conversion efficiencies making swine farming highly profitable (Haridas *et al*., 2023). Ensuring adequate dietary energy during maternity is vital component of nutritional programmes associated with swine farming. A surge in body energy demands usually occurs from last one third of gestation (McPherson *et al*., 2004) to lactation (Zhang *et al*., 2020). Meeting of maternal energy needs depended on ability of sows to mobilize the energy from offered diets and intake of energy could be enhanced by increasing energy density of ration using appropriate supplements (van den Brand, 2000). Kongkeaw *et al*. (2022) had reported improvement in energy

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density of feed with supplementation of fat. Apparent total tract digestibility of lipids was known to increase with age of animals and these improvements are more evident with animal fats than vegetable oils (Kerr *et al*., 2015). Enhancing the energy density of maternal diet during late gestation and subsequent lactation was attempted in present study by use of rendered fat supplementation at two levels of *viz.,* five and ten per cent levels and its effect on intake and digestibility of nutrients were investigated.

Materials and methods

Eighteen multiparous Large White Yorkshire (LWY) sows (parity between two to five) maintained at Centre for Pig Production and Research, Mannuthy that screened positive for pregnancy after 70 days of breeding using ultrasonic pregnancy detector (Draminski, Poland) were used for present study. Animals were grouped into three using completely randomized design (CRD) *viz.,* Control, SF5 and SF10 having six replicates in each group. Control diet (C) was formulated as per NRC, 2012 (3300 kcal ME/kg feed and 18 per cent crude protein). Other two dietary treatments were prepared by supplementation of control diet with rendered fat at five (SF5) and ten (SF10) per cent levels. Experimental animals were fed with one of the three dietary treatments from 75th day of gestation to four weeks after farrowing and were maintained on farm rations up to 42nd day of farrowing (until weaning) there after. Diets used in present study are shown in Table 1.

Table 1. Dietary treatments given to experimental animals

Group	Experimental Treatment
Control	Gestational and lactation diet (NRC, 2012) with 3300 kcal ME/kg diet and 18 % CP
SF5	Control + 5 % excess energy using rendered fat (3465 kcal ME/kg diet and 18 % CP)
SF10	Control+ 10 % excess energy using rendered fat (3630 kcal ME/kg diet and 18 % CP)

Sows were fed twice daily (10 AM and 3 PM) throughout the experimental period as per guidelines (NRC, 2012). Sows were allowed to feed for one hour and refusals if any, were collected, weighed and moisture content were estimated daily to arrive at dry matter intake (DMI) of animals. The quantity of feed offered was reviewed once in every two weeks based on the DMI of sows. A digestibility trial of three days duration was conducted before farrowing after thirty days from start of feeding trial by total collection method in all sows included in study. Feed offered, refusals and faeces voided were weighed during the collection period and pooled samples were mixed thoroughly to make representative sub samples that were analysed as per the methods described in Association of Official Analytical Chemists (AOAC, 2016) to arrive at chemical composition of feed and faecal samples. Apparent digestibility coefficients and digestible nutrients were calculated from the data generated.

Statistical analysis of data collected on various parameters of study was done using One Way Analysis of Variance (ANOVA). Means were compared with Duncan's Multiple Range Test. Comparisons were done as per Snedecor and Cochran (1994) and using Statistical Product and Service Solutions (SPSS) (Version 24.0).

Results and discussion

Weekly average daily dry matter intake (DMI) of experimental animals maintained on three dietary treatments were recorded for a period of twelve weeks (six weeks each, before and after farrowing) and are presented in Table 2 and illustrated in Fig. 1. The DMI from first to twelfth week increased from 1.99 to 4.39 kg in Control, 1.98 to 4.38 kg in SF5 and 1.81 to 4.27 kg in SF10 groups, respectively. A trend of lower DMI for a brief period before and after farrowing was observed in all animals during course of experiment. The DMI measured during last six weeks of pre-farrowing period varied significantly ($p<0.05$) among different among treatment groups except during the two weeks prior to farrowing. The DMI was also measured during the post-farrowing period for six weeks and it varied significantly ($p<0.05$) during the first, second and sixth week after farrowing among treatment groups. Sows maintained on Control and SF5 showed higher ($p<0.05$) DMI than SF10 during all the weeks, where differences in DMI were recorded. Lokhande (2020) had reported higher weekly average gestational feed intake (3.09 to 3.81 kg) than present study (1.90 to 2.22 kg) during three weeks prior to farrowing. However, weekly average lactational feed intake (1.85 to 4.29 kg) reported for the period of six weeks after farrowing was lower than that recorded in present study (2.13 to 4.39 kg). Tripura *et al*. (2021) had reported weekly average gestational feed intake (2.94 to 3.78 kg) during three weeks prior to farrowing and a weekly average lactational feed intake (2.24 to 4.40kg) for the period of six weeks after farrowing. Results of present study agreed with earlier observations, that sows showed a lower feed intake during gestation exhibited a higher feed intake during lactation (Mallmann *et al*., 2018; Mallmann *et al*., 2019). Further, present study agreed partially with the observation that lactation feed intake was not influenced by energy supplementation as similar intakes were recorded in Control and SF5 treatment groups (Quiniou *et al*., 2008; Shelton *et al*., 2009); but contradicted the above observation due to a lower feed intake by dietary treatment SF10. Findings of present study agreed with observations of Rosero *et al*. (2012), who reported increased DMI when energy was supplemented at five per cent levels and also with Jin *et al.* (2018), who reported a reduction in DMI when energy was supplemented at ten per cent levels. Results revealed an increased intake from farrowing to weaning and were in agreement with findings of Cabezon *et al*. (2016) and Cabezon *et al*. (2017) that maternal feed intake increased during lactation *viz.,* from farrowing to weaning in sows.

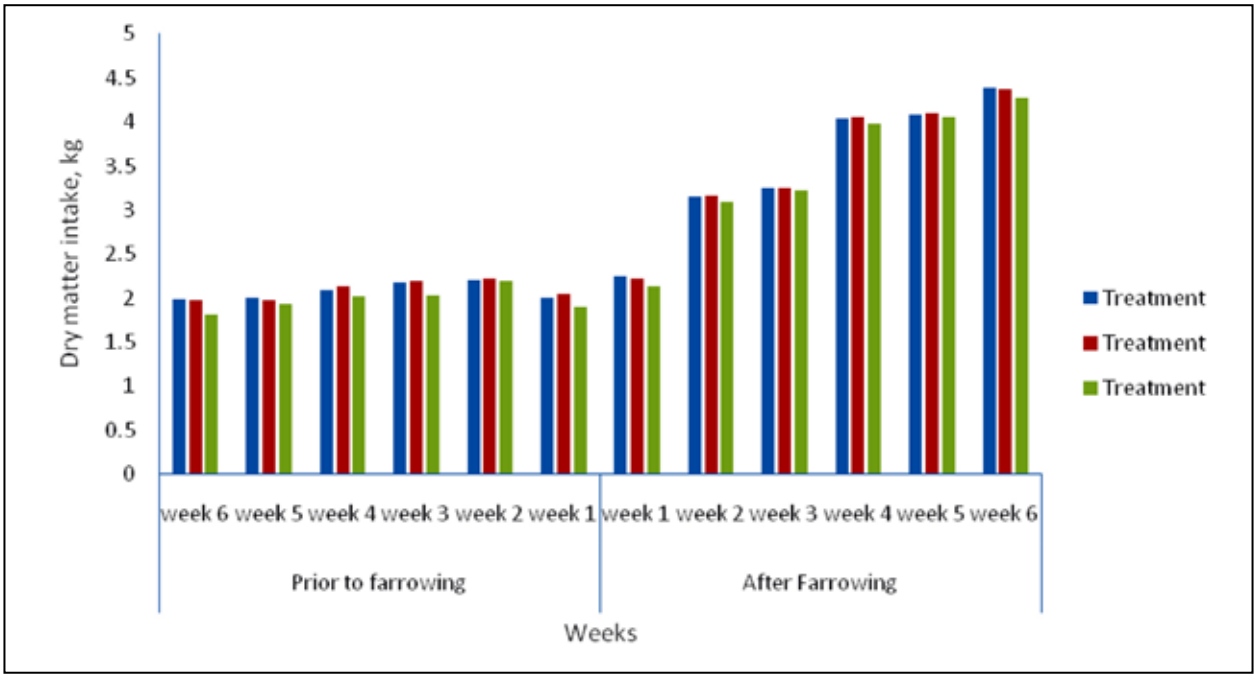

Fig. 1. Weekly average daily dry matter intake of sows maintained on three dietary treatments, kg

Table 2. Weekly average daily dry matter intake of sows maintained on three dietary treatments, kg

Stage	Weeks	Dietary treatments[1]			p value
		Control	SF5	SF10	
Six weeks prior farrowing	6	$1.99^{a} \pm 0.01$	$1.98^{a} \pm 0.03$	$1.81^{b} \pm 0.02$	0.000^{*}
	5	$2.01^{a} \pm 0.01$	$1.98^{ab} \pm 0.03$	$1.93^{b} \pm 0.02$	0.029^{*}
	4	$2.10^{a} \pm 0.02$	$2.14^{a} \pm 0.01$	$2.02^{b} \pm 0.03$	0.002^{*}
	3	$2.18^{a} \pm 0.01$	$2.20^{a} \pm 0.01$	$2.04^{b} \pm 0.03$	0.000^{*}
	2	2.21 ± 0.01	2.22 ± 0.01	2.20 ± 0.02	0.664^{ns}
	1	$2.00^{a} \pm 0.02$	$2.05^{a} \pm 0.01$	$1.90^{b} \pm 0.02$	0.000^{*}
Six weeks after farrowing	1	$2.25^{a} \pm 0.01$	$2.22^{a} \pm 0.02$	$2.13^{b} \pm 0.02$	0.000^{*}
	2	$3.15^{ab} \pm 0.01$	$3.17^{a} \pm 0.01$	$3.10^{b} \pm 0.03$	0.031^{*}
	3	3.25 ± 0.01	3.26 ± 0.00	3.22 ± 0.02	0.162^{ns}
	4	4.04 ± 0.02	4.05 ± 0.01	3.98 ± 0.03	0.097^{ns}
	5	4.09 ± 0.01	4.10 ± 0.02	4.06 ± 0.02	0.191^{ns}
	6	$4.39^{a} \pm 0.03$	$4.38^{a} \pm 0.05$	$4.27^{b} \pm 0.02$	0.044^{*}

[1]Mean of six values with SE, $^{a-b}$ * Means with different superscript within row differ significantly ($p<0.05$), ns – Non significant ($p>0.05$)

Chemical composition of feed samples is presented in Table 3. The three dietary treatments Control, SF5 and SF10 had 90.36, 90.24 and 90.45 per cent of dry matter (DM) respectively. The DM content of experimental diets was within the range of 88.12 to 92.55 per cent reported for sows earlier by Thiruveni (2003). The crude protein (CP) content in present study ranged from 18.18 to 18.28 per cent. The CP values in maternal diets of swine ranged from 17.90 to 18.06 per cent (Thiruveni, 2003). The ether extract (EE) content in present study ranged from 5.95 and 9.71 per cent. Values of EE obtained in the present study were higher than those reported by previous studies which could be due to use of rendered fat as a key ingredient in present study. The EE values obtained in current study agreed with values reported by Thiruveni (2003) that ranged from 3.90 to 16.56 per cent. Lokhande (2020) had reported EE values ranging from 3.18 to 3.96 per cent earlier. The crude fibre (CF) values of three experimental rations ranged from 3.64 to 3.91 per cent. Thiruveni (2003) had reported higher CF values ranging from 8.19 to 9.09 per cent in swine diets and Lokhande (2020) had reported CF values that ranged from 2.86 to 3.10 per cent in sow feeds earlier. The above differences could be attributed to difference in ingredient composition of experimental rations. The total ash (TA) values of experimental rations ranged from 4.55 to 4.70 per cent. Experimental diets in present study were formulated with 1.7 percent mineral mixture and salt. Higher values of TA

that ranged from 12 to 12.92 per cent were reported in diets formulated with unsalted fish having higher silica as ingredient (Thiruveni, 2003). Values of TA had ranged from 4.35 to 4.60 per cent in experimental diets formulated with 2 percent mineral mixture and salt (Lokhande, 2020). The Nitrogen Free Extract (NFE) values of three experimental rations ranged from 63.73 to 67.41 per cent. Lokhande (2020) had reported NFE values ranging from 70.09 to 70.50 per cent. The acid insoluble ash (AIA) values of three experimental rations ranged from 0.73 to 0.74 per cent. Elanchezhian (2013) had reported AIA values ranging from 1.05 to 6.63 per cent in grower diets and 0.93 to 6.52 per cent in finisher diets.

Chemical composition of faecal samples collected during digestibility trial is presented in Table 4. Faecal matter had DM content of 35.07, 34.97 and 35.74 per cent for dietary treatments Control, SF5 and SF10, respectively. The DM composition of faecal matter in sows were much higher than 16.61 to 20.08 per cent previously reported by Thiruveni (2003) and the DM content in present study were more in range with those reported earlier by 30.17 to 32.14 per cent (Tripura, 2018). The CP values of faeces ranged from 15.17 to 17.46 per cent. The CP values in faeces of sows ranged from 18.71 to 20.39 per cent (Tripura, 2018). The ether extract (EE) values of faeces ranged from 16.19 to 21.55 per cent. Values of EE obtained in the present study were higher probably due to the use of rendered fat as a key ingredient in all the formulation of experimental rations. Tripura (2018) reported EE values in faeces ranging from 4.57 to 5.22 per cent earlier. The CF values in faeces ranged from 8.85 to 9.33 per cent in present study. Tripura (2018) reported CF values in faeces ranging from 7.74 to 8.58 per cent. The NFE content of faeces ranged from 30.83 to 37.31 per cent in present study and were closer to values (26.92 and 38.50 per cent) reported earlier with feeding of rendered fat to sows (Thiruveni, 2003). Tripura (2018) reported NFE values in faeces ranging from 45.71 to 50.20 per cent. The TA content of faeces ranged from 21.31 to 22.00 per cent and the AIA ranged from 10.17 to 10.66 per cent in the present study. Higher values of TA in faeces 33.36 to 35.16 per cent and AIA 23.06 to 27.05 per cent were reported earlier (Thiruveni, 2003). Saseendran (2016) had reported a TA content of 18.99 per cent in faeces while feeding rendered fat to pigs.

Based on above data, apparent total tract digestibility coefficients of nutrients were calculated (Table 5). Digestibility coefficient of DM for dietary treatments Control, SF5 and SF10 were 80.11, 81.98 and 80.97 per cent, respectively. The DM digestibility among the three dietary treatments was comparable and statistically similar. Tripura *et al*. (2021) had reported that digestibility coefficient of DM ranged from 85.19 to 85.93 per cent in pregnant sows. Liao and Veum (1994) had reported higher DM digestibility, ranging from 86.60 to 88.10 per cent in pregnant gilts. An increased DM digestibility when diets were supplemented with rendered fat was observed during earlier studies (Thiruveni, 2003; Elanchezhian, 2013). The CP digestibility among dietary treatments Control, SF5 and SF10 were 83.40, 84.95 and 81.76 per cent, respectively. Highest CP digestibility ($p<0.05$) was observed in dietary treatments SF5 and lowest in groups SF10 with CP digestibility of Control group statistically similar to other two groups. Lokhande (2020) had reported that CP digestibility ranged from 90.72 to 93.56 per cent in pregnant sows. Elanchezhian and Ally (2020) had reported a lowered digestibility of CP when maize was progressively replaced with rendered fat. Higher values of CP digestibility coefficient (86.27 to 88.10 per cent) than the present work was observed with a trend of increase in digestibility of CP with graded increase in rendered fat supplementation (Thiruveni, 2003) contrary to observations of present experiment that documented a lower digestibility for dietary treatment SF10.

The EE digestibility in dietary treatments Control, SF5 and SF10 were 45.88, 58.86 and 57.75 per cent, respectively. Higher ($p<0.05$) EE digestibility was observed in dietary treatments SF5 and SF10 and lowest in Control. Reis *et al.* (2000) had noted that an increased dietary level of fat up to a threshold level would stimulate pancreatic lipase and depress amylase activity. A trend in increased digestibility ($p<0.01$) of EE was also observed with graded increase in rendered fat supplementation (Thiruveni, 2003), corroborating with higher digestibility

Table 3. Chemical composition* of three experimental rations fed to sows, %

Parameters	Dietary treatments		
	Control	SF5	SF10
Dry matter	90.36	90.24	90.45
Crude protein	18.18	18.28	18.22
Ether extract	5.95	8.60	9.71
Crude fibre	3.91	3.73	3.64
Total ash	4.55	4.67	4.70
Nitrogen free extract	67.41	64.72	63.73
Acid insoluble ash	0.74	0.73	0.74

*On dry matter basis except DM

Table 4. Chemical composition of faecal samples* of sows maintained on three dietary treatments, %

Parameters	Dietary treatments		
	Control	SF5	SF10
Dry matter	35.07	34.97	35.74
Crude protein	15.17	15.27	17.46
Ether extract	16.19	19.63	21.55
Crude fibre	9.33	8.89	8.85
Total ash	22.00	21.51	21.31
Nitrogen free extract	37.31	34.70	30.83
Acid insoluble ash	10.66	10.36	10.17

*On dry matter basis except DM

Table 5. Apparent digestibility coefficients of nutrients of three experimental rations, %

Parameters	Dietary treatments[1]			p value
	Control	SF5	SF10	
Dry Matter	80.11 ± 1.18	81.98 ± 0.39	80.97 ± 0.43	0.251
Crude protein	83.40^{ab} ± 0.99	84.95^{a} ± 0.32	81.76^{b} ± 0.41	0.011*
Ether extract	45.88^{b} ± 3.21	58.86^{a} ± 0.89	57.75^{a} ± 0.95	0.001*
Crude fibre	52.55 ± 2.82	57.05 ± 0.93	53.66 ± 1.04	0.222
Nitrogen free extract	89.01^{b} ± 0.65	90.34^{a} ± 0.21	90.79^{a} ± 0.21	0.021*
Organic matter	96.97 ± 0.18	97.17 ± 0.06	96.80 ± 0.07	0.116

[1] Mean of six values with SE, $^{a-b}$ Means with different superscripts within the same row differ significantly*($p<0.05$)

Table 6. Estimated total digestible nutrients of three experimental rations

Parameters	Dietary treatments			p value
	Control	SF5	SF10	
DCP %	1516.29^{b} ± 17.92	1552.80^{a} ± 5.93	1489.71^{b} ± 7.43	0.006*
DEE %	273.00^{c} ± 19.12	506.22^{b} ± 7.62	560.74^{a} ± 9.18	0.000*
DCF %	205.49 ± 11.02	212.78 ± 3.45	195.33 ± 3.78	0.242
DNFE %	6000.07^{a} ± 44.00	5846.81^{b} ± 13.47	5786.23^{b} ± 13.12	0.000*
TDN %	83.36^{b} ± 1.16	87.51^{a} ± 0.40	87.33^{a} ± 0.45	0.002*
DE, kcal/kg	3667.88^{b} ± 51.02	3850.62^{a} ± 17.60	3842.49^{a} ± 19.79	0.002*
ME, kcal/kg	3521.16^{b} ± 48.98	3696.59^{a} ± 16.90	3688.79^{a} ± 19.00	0.002*

$^{a-c}$ Means with different superscripts within the same row differ significantly* ($p<0.05$)

Assumptions: 1 kg TDN = 4400 kcal DE; ME = 0.96 DE in pigs

of EE observed in dietary treatments SF5 and SF10 of present work. Tripura (2018) had reported that digestibility coefficient of EE was ranged from 55.56 to 59.47 per cent in sows, while Saseendran *et al.* (2017) had reported a digestibility coefficient of EE that ranged from 57.17 to 65.76 per cent. The CF digestibility was 52.55, 57.05 and 53.66 per cent, respectively and it did not vary significantly ($p>0.05$) among treatment diets *viz.,* Control, SF5 and SF10 respectively. Feed rich in CF would increase the rate of passage of ingesta resulting in lowered digestibility of nutrients (Ewan, 2000; Lentle and Janssen, 2008) but such differences in CF digestibility was not observed during present study. Suresh (2003) had reported a lowered CF digestibility that ranged from 27.5 to 32.7 per cent in LWY pigs. The NFE digestibility was 89.01, 90.34 and 90.79 per cent, respectively among dietary treatments Control, SF5 and SF10. Higher NFE digestibility ($p<0.05$) was observed in excess energy supplemented groups (SF5 and SF10) compared to Control. Lower values for digestibility coefficient of NFE (79.52 to 83.31per cent) compared to present work were observed earlier, and a trend in increased digestibility ($p<0.05$) of NFE with graded increase in rendered fat supplementation, corroborating with findings of present study was reported earlier (Thiruveni, 2003). Tripura (2018) had reported that the digestibility coefficients of NFE ranged from 90.31 to 90.73 per cent. Organic matter digestibility was 96.97, 97.17 and 96.80 per cent, respectively among three dietary treatments and no variation was observed among treatments. Estimated nutrient digestibility of experimental rations is presented in Table 6. The calculated TDN values ranged from 83.36 to 87.51 per cent and DE values ranged from 3667.88 to 3850.62 kcal/kg diet. Calculated ME values of experimental rations ranged from 3521.16 to 3696.59 kcal/kg diet.

Conclusion

The present study aimed to evaluate the effect of feeding high energy diet containing rendered fat to LWY sows during late gestation and early farrowing on intake and digestibility of nutrients. The DMI of control and SF5 diets were comparable and sows supplemented with rendered fat at ten per cent levels resulted in lower DMI. Rendered fat supplementation resulted in higher digestibility of EE and NFE than control groups. Further, a higher CP digestibility was also observed in SF5 group. Based on the overall results of present study, it could be concluded that supplementation of rendered fat at ten per cent level resulted in lower DMI.

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Conflict of interest:

The authors declare that they have no conflict of interest.

References

AOAC [Association of Official Analytical Chemists]. 2016. *Official Methods of Analysis*. (20th Ed.). Association of official analytical chemists, Washington DC, 684p.

Cabezon, F.A., Schinckel, A.P., Leon, Y.L. and Craig, B.A. 2017. Analysis of lactation feed intakes for sows with extended lactation lengths. *Transl. Anim. Sci.***1**: 90-96.

Cabezon, F.A., Schinckel, A.P., Richert, B.T., Stewart, K.R., Gandarillas, M. and Peralta, W.A. 2016. Analysis of lactation feed intakes for sows including data on environmental temperatures and humidity. *Prof. Anim. Sci.* **32**(3): 333-345.

Elanchezhian, N. 2013. Dietary modifications on lipid profile of pigs fed animal fat. *Ph.D* Thesis, Kerala Veterinary and Animal Sciences University, Pookode. 212p.

Elanchezhian, N. and Ally, K. 2020. Replacement of maize by wheat bran on growth, feed efficiency and nutrient digestibility in pigs. *Int. J. Curr. Microbiol. App. Sci.* **9**(5): 2916-2924.

Ewan, R.C. 2000. Energy utilization in swine nutrition. In: Lewis, A.J. and Southern, L.L. (eds.), Swine Nutrition (2nd Ed.). CRC press, Florida, USA, pp. 85-94.

Haridas, P.J., Ravishankar, C., Sumod, K., Rajasekhar, R., Anoopraj, R., Anjitha, G.S., Shashank, S. and John, K. 2023. Detection of porcine parvovirus in domestic pigs in North Kerala. *J. Vet. Anim. Sci.* **54**(3): 840-844

Jin, S.S., Jin, Y.H., Jang, J.C., Hong, J.S., Jung, S.W. and Kim, Y.Y. 2018. Effects of dietary energy levels on physiological parameters and reproductive performance of gestating sows over three consecutive parities. *Asian- Australas. J. Anim. Sci.* **31**: 410-420.

Kerr, B.J., Kellner, T.A. and Shurson, G.C. 2015. Characteristics of lipids and their feeding value in swine diets. *J. Anim. Sci. Biotechnol.* (http://creativecommons.org/licenses/by/4.0) **6** (30):1-23.

Kongkeaw, A., Wichasit, N., Chot, O., Omthonglang, W. and Tartrakoon, W. 2022. Effects of ketogenic diet on growth performance and back fat thickness of finishing pigs. *Khon. Kaen. Agri. J.* **50**(2): 440-447.

Lentle, R.G. and Janssen, P.W.M. 2008. Physical characteristics of digesta and their influence on flow and mixing in the mammalian intestine: A review. *J. Comp. Physiol*.**178**: 673-690.

Liao, C.W. and Veum, T.L. 1994. Effects of dietary energy intake by gilts and heat stress from 3 to 24 or 30 after mating on embryo survival and nitrogen and energy balance. *J. Anim. Sci*. **72**: 2369-2377.

Lokhande, S. 2020. Impact of higher levels of dietary energy supplementation in the performance of sow and litter. *M.V.Sc thesis*, Kerala Veterinary and Animal Sciences University, Pookode, 69 p.

Mallmann, A.L., Betiolo, F.B., Camilloti, E., Mellagi, A.P.G., Ulguim, R. R., Wentz, I., Bernardi, M.L., Goncalves, M.A.D., Kummer, R. and Bortolozzo, F.P. 2018. Two different feeding levels during late gestation in gilts and sows under commercial conditions: impact on piglet birth weight and female reproductive performance. *J. Anim. Sci.* **96**: 4209-4219.

Mallmann, A.L., Camilotti, E., Fagundes, D.P., Vier, C. E., Mellagi, A.P.G., Ulguim, R.R., Bernardi, M.L., Orlando, U.A.D., Goncalves, M.A.D., Kummer, R. and Bortolozzo, F.P. 2019. Impact of feed intake during late gestation on piglet birth weight and reproductive performance: a dose response study performed in gilts. *J. Anim. Sci*. **97**: 1262-1272.

McPherson, R.L., Ji, F., Wu, G., Blanton Jr, J.R. and Kim, S.W. 2004. Growth and compositional changes of fetal tissues in pigs. *J. Anim. Sci.* **82**: 2534-2540.

NRC [National Research Council]. 2012. *Nutrient Requirements of Swine*. (11th Ed.). National Research Council, Washington, D.C., 420p.

Quiniou, N., Richard, S., Mourot, J. and Etienne, M. 2008. Effect of dietary fat or starch supply during gestation and/or lactation on the performance of sows, piglets' survival and on the performance of progeny after weaning. *Animal,* **2**(11): 1633-1644.

Reis, T.C., Aumaitre, A., Mourot, J. and Peiniau, J. 2000. Effect of graded levels of tallow in the diet on performance, digestibility of fat, lipogenesis and body lipid deposition of the weaned piglet. *Aust. J. Anim. Sci.* **13**(4): 497-505.

Rosero, D.S., vanHeugten, E., Odle, J., Cabrera, R., Arellano, C. and Boyd, R.D. 2012. Sow and litter response to supplemental dietary fat in lactation diets during high ambient temperatures. *J. Anim. Sci.* **90**: 550-559.

Saseendran, A. 2016. Effect of dietary supplementation of lecithin and carnitine on growth in piglets on high fat diet. *M.V.Sc. thesis*, Kerala Veterinary and Animal Sciences University, 86 p.

Saseendran, A., Ally, K., Gangadevi, P. and Banakar, P.S. 2017. Effect of supplementation of lecithin and carnitine on growth performance and nutrient digestibility in pigs fed high-fat diet. *Vet. Wrld*. **10**(2): 149-155.

Shelton, N.W., DeRouchey, J.M., Neill, C.R., Tokach, M.D., Dritz, S.S., Goodband, R.D. and Nelssen, J.L. 2009. Effects of increasing feeding level during late gestation on sow and litter performance. *Kansas. Agri. Exp. Station. Research. Reports*. **10**: 38-50.

Snedecor, G.W. and Cochran, W.G. 1994. Statistical Methods. (8th Ed.) The Iowa State University Press, Ames, 503p.

Suresh, M. 2003. Effect of dietary potassium diformate on growth performance in large white Yorkshire pigs. *M.V.Sc thesis*, Kerala Agricultural University, Mannuthy, 66 p.

Thiruveni, S. 2003. Influence of renedered fat in the diet of large white Yorkshire sows on litter performance. *M.V.Sc thesis*, Kerala Agricultural University, Mannuthy, 114 p.

Tripura, S. 2018. Dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows. *M.V.Sc thesis*. Kerala Veterinary and Animal Sciences University, Pookode, 76 p.

Tripura, S., Shyama, K., Ally, K., Ajith, K.S., Usha, A.P., Tarang, M., Vijaya Raghavendran, S., Mohammed, S.A.V., Lokhande, S. and Sumayya, K.K. (2021). Incorporation of cooked barley residue and spent grapes in the ration of pregnant Large White Yorkshire sows and their piglets. *Trop. Anim. Health Prod.* **53:**1-9.

van den Brand, H. 2000. Energy partitioning and reproduction in primiparous cows: Effects of dietary energy source. *Ph.D* Thesis, Wageningen University, Netherlands, 139p.

Zhang, S., Johnson, J. S., Qiao, M. and Trottier, N.L. 2020. Reduced protein diet with near ideal amino acid profile improves energy efficiency and mitigate heat production associated with lactation in sows (http://creativecommons.org/licenses/by/4.0/), *J. Anim. Sci. Biotech.***11**(4): 1-16.

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