Open Access

Check for updates

Research Article

Journal of Veterinary and Animal Sciences

ISSN (Print): 0971-0701, (Online): 2582-0605

https://doi.org/10.51966/jvas.2024.55.4.680-687

Early lactational performance and serum biochemical profile of crossbred cows supplemented with maize and soy lecithin during late gestation

Athira Rajan[1], S. K. George[1*], K.Ally[1], Sajith Purushothaman[1], V. L. Gleeja[2] and V. Babitha[3]

[1]Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy, Thrissur- 680 651, [2]Department of Statistics, College of Veterinary and Animal Sciences, Mannuthy, Thrissur- 680 651, [3]Department of Veterinary Physiology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur- 680 651, Kerala Veterinary and Animal Sciences University, Kerala, India.

Citation: Athira R., George S. K., Ally K., Sajith P., Gleeja V. L. and Babitha V. 2024.Early lactational performance and serum biochemical profile of crossbred cows supplemented with maize and soy lecithin during late gestation. *J. Vet. Anim. Sci.* **55** (4):680-687

Received: 05.02.2024 Accepted: 06.06.2024 Published: 31.12.2024

Abstract

A feeding experiment of 145 days was carried out in crossbred cows to assess the effect of supplementation of maize and soy lecithin during late gestation on early lactational performance and serum biochemical profile. Fifteen crossbred dairy cows in eighth month of pregnancy were selected from Cattle Breeding Farm, Thumburmuzhy. The animals were divided into three groups (T1, T2 and T3) of five animals each and were fed with concentrate mixture (CP-20 per cent and TDN- 68 per cent) and green grass (ICAR, 2013) throughout the experimental period of 145 days. The T2 group was supplemented with maize (500 g/day) and T3 was supplemented with soy lecithin (210 g/day) from eighth month of gestation until the date of calving. The experimental diets offered to animals in T2 and T3 were isocaloric. Milk production was higher (P<0.05) in the group supplemented with maize (17.1 kg/d) compared to T1 (15.43 kg) and T3 (15.09 kg), while the milk composition remained similar in all the groups. Dietary treatments had no effect (P>0.05) on the serum biochemical parameters such as serum glucose, cholesterol, total protein, calcium and phosphorous. The study revealed that supplementation of energy in the form of ground maize during late gestation significantly improved the early lactational performance of crossbred cows.

Keywords*: Energy, maize, soy lecithin, milk production, serum biochemical parameters*

Nutrition and reproduction are two critical factors that have significant impact on the production efficiency of dairy cows. The transition period in dairy cows includes three-weeks prepartum and three weeks after calving (Doepel *et al*., 2002). During the early stages of lactation, dairy cows require more energy than that could be obtained from the common dietary sources to maintain themselves and to produce milk. This imbalance results in a negative energy balance for the cow, which can make her more vulnerable to metabolic disorders such as ketosis. To achieve high levels of milk production during this critical period, dairy cows often need to tap their body reserves. Therefore, it's crucial to provide them with appropriate nutrition during the prepartum period to ensure sufficient body reserves at the time of calving.

**Corresponding author: sherin@kvasu.ac.in, Ph.9961452523*

Feeding strategies during the prepartum period play a vital role in enhancing the performance of dairy animals in subsequent lactation cycles. To minimise metabolic stress while mobilizing body reserves, the most effective approach is to increase the energy density of the ration. This strategy helps to ensure that cows have the energy they need to support both maintenance and milk production, reducing the incidence of metabolic disorders and promoting optimal milk production.

Dairy cow diets typically contain large amounts of carbohydrate and fat-based feedstuffs as major sources of energy (Schroeder *et al*., 2004). For dairy cows, cereal grains like maize are primarily used as source of energy and in cereal grains most of the digestible energy comes from the starch (Ali *et al*., 2012). Around 80 per cent of maize produced is used as a feed ingredient worldwide. Various fat sources including soy lecithin, (a mixture of phospholipids such as phosphatidylcholine, phosphatidylethanolamine, and phosphatidylinositol) can also be used as dietary energy source in dairy cows (Pena *et al*., 2014) due to its elevated fat content (99.9%) and gross energy value (7780 kcal/kg). Soy lecithin, being an emulsifier and viscosity regulator can function as dispersing agent and can be easily mixed with the diet. The metabolic changes and lactational performance of dairy animals fed energy supplemented diets, depends on the form in which energy is offered. Therefore, present study was conducted to assess the effect of supplementation of maize and soy lecithin during late gestation on early lactational performance and blood biochemical profile in crossbred dairy cows.

Materials and methods

Fifteen crossbred cattle at eighth month of pregnancy selected from cattle breeding farm, Thumburmuzhy formed the experimental subjects for the study. The animals were divided into three groups (T1, T2 and T3) of five animals each and were offered with concentrate mixture (CP- 20 per cent and TDN- 68 per cent) and green grass (ICAR, 2013) throughout the experimental period of 145 days. T2 was supplemented with maize (500 g/day) and T3 was supplemented with soy lecithin (210 g/d) from eighth month of gestation until the date of calving and the rations T2 and T3 were isocaloric. Ingredient compositions of concentrate and green grass fed to the three experimental groups are given in Table 1. Clean drinking water was made available *ad libitum* to all animals throughout the experiment. The animals were maintained under identical conditions of feeding and management throughout the experimental period.

Daily milk yield and fortnightly milk composition was recorded. Milk samples were collected from individual animals and analysed for fat (IS:1224.1977), solids not fat (IS:10083.1982) and milk urea nitrogen (IS:1479.1960). Blood samples were collected at the start of experiment, after three weeks, one week after calving and towards the end of the study for the analysis of cholesterol, total protein, glucose, phosphorous and calcium (AOAC, 2016) by semiautomatic analyser using standard kits. The feed and fodder samples were analysed for proximate composition as per AOAC (2016). Data obtained on the various parameters were analysed statistically as per Snedecor and Cochran (1994) by analysis of variance (ANOVA) technique.

Table 1. Ingredient composition of compounded feed mixture used in the experiment

Ingredient	Percentage composition
Maize	12
Corn gluten fibre	15
Coconut cake	15
Alfalfa residue pellet	11
Rice polish	9
Tapioca starch waste	4
Black gram husk	14
Deoiled rice bran	17
Calcite	1.5
Salt	1
Mineral mixture	0.5
Total	**100**

Results and discussion

The per cent chemical composition of concentrate mixture and green grass fed to experimental animals is shown in Table 2.

Table 2. Chemical composition[1] of the rations fed to experimental animals(%)

Parameter	Concentrate	Green grass
Dry matter	90.81±0.18	17.98±0.16
Crude protein	20.64±0.30	10.21±0.18
Ether extract	3.04±0.10	2.01±0.11
Crude fiber	8.07±0.19	30.63±0.44
Total ash	9.87±0.20	9.98±0.31
Nitrogen free extract	58.32±0.37	47.6±0.50
Acid insoluble ash	1.69±0.03	1.33±0.04
Calcium	0.87±0.02	0.56±0.03
Phosphorus	0.52±0.04	0.25±0.02
Neutral detergent fiber (NDF)	30.31±0.52	62.15±0.50
Acid detergent fiber (ADF)	15.14±0.35	41.07±0.20

[1]Values expressed on DM basis, average of six values

Milk production

Energy supplementation during gestation can influence the milk production during subsequent lactation (Janovick and Drackley, 2010). The fortnightly average daily milk production of treatments T1, T2 and T3 recorded in the present study are given in Table 3. The average milk production of experimental animals maintained on three experimental rations T1, T2 and T3 were 15.43±0.31, 17.10±0.44 and 15.09±0.36 kg, respectively. Milk production was significantly higher in maize supplemented group compared to the animals fed control diet or a diet supplemented with soy lecithin.

In a study conducted by Minor *et al*. (1998), it was observed that providing Holstein cows with a high non-fibre carbohydrate diet for 19 days prior to calving led to a significant increase (P<0.05) in milk production, with the treated group yielding more (P<0.05) milk (34.8 kg/day) compared to the control group (32 kg/day). Processing techniques of energy sources such as cereals also influence the milk production in dairy cows. Dann *et al*. (1999) in dairy cows noticed that replacing cracked corn using steam-flaked corn in the prepartum diet increased the fermentability of the non-fibre carbohydrate and tended to increase milk yield. It was opined that; elevated milk production arises from either one or a combination of the following factors: 1) enhanced synthesis of microbial protein 2) Increased levels of propionate (a precursor for glucose production) 3) improved post-ruminal starch digestion or 4) increased utilisation of bypass protein. Moreover, enhanced liver production of glucose and the uptake of glucose and amino acids by the mammary gland are likely responsible for the observed increase in milk production when dietary ruminal carbohydrate availability is raised (Theurer, 1996). Santos *et al*. (2003) conducted a study in dairy cows by adding conjugated linoleic acid (CLA) in the diet during the transition period and also during early lactation. The study revealed that cows supplemented with CLA showed a tendency to produce an additional 3 kg of milk per day on comparison with un supplemented animals. This finding is consistent with the results obtained in various other similar studies (Van Knegsel *et al.*, 2005; Reis *et al*., 2012; Higgs *et al*., 2013 and Roche *et al*., 2013), which collectively demonstrated that increasing the inclusion of fat and starch-based dietary energy sources had a positive impact on milk production in dairy cows.

However, the current study did not observe any improvement in milk yield during early lactation with the supplementation of fat in the prepartum diet. These results are consistent with the findings of Alexander *et al*. (2002), in dairy cows with prepartum lipid supplementation having no impact (P>0.05) on milk production measured at 30, 60, and 90 days post calving.

Milk composition

Significant variation is often reported in the gross composition of milk produced by cows offered different supplemental feeds and the changes in the milk composition is associated, particularly in relation to the fatty acid profile of the diet (Magan *et al*., 2021). Table 4, 5 and 6 provides detailed information about the milk composition, encompassing parameters such as fat content, solids excluding fat, and milk urea nitrogen collected from experimental animals at fortnightly intervals.

The average milk fat content of experimental animals fed on the three experimental diets T1, T2 and T3 were 3.44±0.03, 3.5±0.03 and 3.72±0.03 per cent, respectively. Notably, during the first two weeks, the cows supplemented with soy lecithin during late gestation, had a higher (P<0.05) fat content in milk compared to the other groups. However, during the later days of early lactation, there were no substantial differences in fat content among the groups. This aligns with the findings of Ryan *et al.* (2003), in dairy cows, observing similar milk fat content during the initial four weeks of lactation, irrespective of the dry period diet provided with or without a concentrate mixture. Similarly, Mendoza *et al*. (2019) conducted a study, to examine the impact of increasing the level of non-fibrous carbohydrates (by including cracked corn) in the prepartum diet of Holstein cows and found no significant disparities in milk fat concentration among the various treatment groups.

The average milk SNF content (per cent) of experimental animals fed on the three experimental diets T1, T2 and T3 were 8.08±0.02, 8.1±0.05 and 7.96±0.05,

Table 3. Fortnightly average milk production[1] of dairy cows maintained on experimental ration

Fortnight	Daily milk production (kg)			P value
	T_1	T_2	T_3	
1	14.14±0.61	15.02±0.42	13.11±0.40	0.052^{ns}
2	16.16^a±0.44	17.70^b±0.52	14.91^a±0.38	0.003
3	16.20^a±0.37	18.21^b±0.56	15.51^a±0.42	0.003
4	16.17^a±0.48	18.00^b±0.52	16.19^a±0.54	0.041
5	15.57^a±0.35	17.79^b±0.39	15.52^a±0.25	0.001
6	15.16^a±0.28	16.82^b±0.35	15.25^a±0.22	0.002
7	14.64^a±0.33	16.14^b±0.27	15.12^a±0.30	0.012
Mean±S.E.	15.43^a±0.31	17.10^b±0.44	15.09^a±0.36	0.003

[1]Mean values are based on five replicates with S.E.; $^{a-b}$Mean of different treatment having different alphabets as superscripts within a row differ significantly (P<0.05), ns- non significant (P > 0.05)

respectively. Likewise, Suksombat and Chullanandana (2008) also observed similar SNF content in the milk of Holstein cows supplemented either with soybean oil or rumen-protected conjugated linoleic acid at a rate of 150 g per animal per day. Similarly, beef cattle (Banta *et al*., 2011), supplemented with linoleic and midoleic sunflower seeds at specific rates during mid to late gestation, had no significant changes in milk SNF levels (9 per cent) during early lactation. Furthermore, Mendoza *et al*. (2019) assessed the impact of increasing non-fibrous carbohydrates by incorporating cracked corn at various levels in the prepartum diet of Holstein cows and found no notable differences in milk SNF concentration. In essence, these studies collectively suggest that dietary interventions, such as supplementation with specific oils or grains, did not significantly influence the SNF content in milk, consistent with the findings of this study.

Milk urea nitrogen (MUN) is correlated with dietary nitrogen and is commonly used to monitor feeding

Table 4. Fortnightly milk fat content of experimental group(%)

Fortnight	Dietary treatments			P value
	T1	T2	T3	
1	$3.38^{a}\pm0.08$	$3.52^{a}\pm0.07$	$3.86^{b}\pm0.17$	0.034
2	3.48±0.07	3.54±0.07	3.80±0.17	0.151^{ns}
3	3.52±0.08	3.42±0.06	3.70±0.22	0.382^{ns}
4	3.46±0.10	3.44±0.09	3.66±0.18	0.449^{ns}
5	3.32±0.07	3.50±0.06	3.70±0.19	0.129^{ns}
6	3.40±0.07	3.48±0.05	3.64±0.14	0.242^{ns}
7	3.50±0.10	3.62±0.08	3.70±0.14	0.467^{ns}
Mean ±S.E.	3.44±0.03	3.5±0.03	3.72±0.03	0.264^{ns}

[1]Mean values are based on five replicates with S.E.; ns- non significant,[a-b]Mean of different treatment having different alphabets as superscripts within a rowdiffer significantly (P<0.05)

Table 5. Fortnightly milk SNF content of experimental group(%)

Fortnight	Dietary treatments			P value
	T1	T2	T3	
1	8.17±0.09	8.19±0.09	8.15±0.05	0.942^{ns}
2	8.08±0.06	8.28±0.05	8.13±0.09	0.170^{ns}
3	8.10±0.07	8.10±0.07	7.99±0.06	0.442^{ns}
4	7.99±0.08	8.01±0.06	7.92±0.06	0.618^{ns}
5	8.03±0.12	7.91±0.12	7.82±0.06	0.374^{ns}
6	8.06±0.09	7.96±0.13	7.80±0.05	0.219^{ns}
7	$8.12^{a}\pm0.09$	$8.24^{b}\pm0.08$	$7.93^{a}\pm0.05$	0.041
Mean± S.E.	8.08±0.02	8.10±0.05	7.96±0.05	0.076^{ns}

[1]Mean values are based on five replicates with S.E.; ns- non significant,[a-b]Mean of different treatments having different alphabets as superscripts within a row differ significantly (P<0.05)

Table 6. Fortnightly milk urea nitrogen concentration of experimental animals(mg/Dl)

Fortnight	Dietary treatments			P value
	T1	T2	T3	
1	11.9±0.09	12.01±0.08	11.99±0.05	0.590^{ns}
2	11.99±0.08	12.19±0.08	12.20±0.06	0.104^{ns}
3	12.25±0.03	12.31±0.05	12.31±0.04	0.490^{ns}
4	12.32±0.03	12.38±0.04	12.41±0.03	0.197^{ns}
5	12.39±0.04	12.55±0.07	12.46±0.06	0.189^{ns}
6	12.5±0.05	12.74±0.07	12.58±0.07	0.060^{ns}
7	12.58±0.07	12.81±0.05	12.70±0.07	0.094^{ns}
Mean ± S.E.	12.28±0.10	12.43±0.11	12.38±0.09	0.444^{ns}

[1]Mean values are based on five replicates with S.E.; ns- non significant

programs to achieve environmental goals (Aguilar *et al*., 2012). The average MUN content (mg/dL) of experimental animals on the three experimental diets T1, T2 and T3 were 12.28±0.1, 12.43±0.11 and 12.38±0.09, respectively.

Elevated MUN levels (>18 mg/dL) indicate either an increase in protein intake or a deficiency of rapidly fermentable carbohydrates in the diet (Melendez *et al*., 2000). Similar to the findings of this study, Alexander *et al.* (2002) also concluded that adding lipids as a supplement before calving had no effect (P>0.05) on MUN levels measured at 30, 60, and 90 days post-calving. Similarly, Guo *et al*. (2007) revealed that the feed given during the transition period had no impact on the concentration of MUN (P>0.05). These outcomes were in line with those of Mendoza *et al*. (2019), in Holstein cows offered various levels of non-fibrous carbohydrates by introducing cracked corn into the prepartum diet. However, in contrast to these findings, Fontoura *et al*. (2021) observed a linear decrease (P<0.05) in MUN levels in dairy cows when deoiled soy lecithin was supplemented at different levels (0, 0.12, 0.24, and 0.36 per cent DM) in a basal diet containing palm fat.

Serum biochemical profile

Cows when offered with an energy dense ration during the pre-calving period generally mobilises more body reserves during early lactation to achieve a favourable metabolic profile by altering the various serum biochemical parameters (Nielsen *et al*., 2010). Serum biochemical profile of dairy cows observed during the present study is depicted in Table 7. Statistical analysis of the data revealed that there was no significant difference in serum glucose concentrations between treatment groups at any stage of the experiment. Respective, serum glucose levels (mg/dL) of the animals fed with T1, T2 and T3 were 60.64±2.00, 62.8±2.72 and 58.47±1.30 at the beginning of the study and 64.17±1.75, 68.58±1.87 and 67.37±2.12 three weeks after the initiation of the experiment However, Valiente *et al*. (2018) reported elevated serum glucose levels 20 days before calving in Angus cows. Serum glucose levels (mg/dL) for animals receiving treatment diets T1, T2 and T3 were 55.39±1.84, 61.09±2.45 and 58.37±2.29 respectively after one week of calving and the values remained similar among the treatment groups.

Much like the findings in the present study, Kim and Suh (2003) reported no differences (P > 0.05) in glucose concentration during late pregnancy and early lactation in Holstein cows offered feed with varying energy levels. Gutierez *et al*. (2009) also observed no improvement (P > 0.05) in plasma glucose concentration in cows after peripartum supplementation with saturated fat, unsaturated fat, or propylene glycol. Furthermore, when supplementing dry rolled corn during late gestation in cows that were fed low-quality forage, no significant effects on plasma glucose concentration were observed (Tanner *et al*., 2020), aligning with the findings observed in this study.

Dietary treatments had no influence (P > 0.05) on serum cholesterol concentrations throughout the experiment. Serum cholesterol levels (mg/dL) of animals in treatment groups T1, T2 and T3 were 114.74±2.69, 109.84±2.15 and 113.65±3.39 respectively three week after initiation of feeding trial and the values (mg/dL) were 108.91±3.86, 107.94±3.17 and 108.49±3.74 respectively one week after calving. Seifi *et al.* (2005) examined changes in energy-related biochemical metabolites in dairy cows during the transition period and found that serum cholesterol concentrations came lowest level (1.89 mmol/L), seven days after parturition and then began to rise gradually (3.2 mmol/L) at day 21 postpartum as observed during this study. The results obtained during the present experiment disagrees with the observations of Van Knegsel *et al*. (2007) in multiparous cows, offered with glucogenic, lipogenic or a mixed diet during late gestation. Cows provided with glucogenic diets had lower (P < 0.05) serum cholesterol levels on comparison with those offered a lipogenic or mixed diet during the pre and postpartum period.

Total protein content in the serum of the experimental dairy cows were similar (P>0.05) among the groups both during the prepartum and postpartum phases of the study. Serum total protein levels (g/dL) in T1, T2 and T3 before calving were 7.46±0.28, 7.47±0.15 and 7.55±0.33 respectively and the respective values observed one week after calving were 7.24±0.22, 7.19±0.34 and 7.2±0.15. Chen *et al*. (2022) conducted studies in cows by feeding a low-energy density diet (1.36 Mcal NEm /kg DM), a medium-energy density diet (1.53 Mcal NEm /kg DM) or a high-energy density diet (1.67 Mcal NEm/kg DM) using corn silage during the last 45 days of gestation and concluded that prepartum energy supplementation had no effect on serum total protein concentration. Contrary to this, during the final 28 days of gestation, Keady *et al*. (2001) assessed the impact of supplementing grass silage-based diet with concentrate mixture (5kg/day) and found that the level of serum total protein was higher (P > 0.05) in the concentrate supplemented group.

Transition period in dairy cows is associated with multiple hormonal and metabolic changes causing variations in the serum concentration of macro minerals (Fadlalla *et al*., 2020). Serum calcium levels (mg/dL) for treatments T1, T2 and T3 before calving were 9.39±0.28, 9.11±0.11 and 9.27±0.20 respectively and the respective values observed (mg/dL) one week after calving were 7.82±0.1, 7.99±0.08 and 7.94±0.12. Statistical analysis of the data revealed no significant difference in serum calcium levels between treatment groups.

Similarly, Augustine (2008) reported that there were no notable distinctions in the calcium concentration among lactating cows supplemented with energy in the form of ground maize (1 kg/day) or protected fat (100 g/day). Serum phosphorous levels (mg/dL) also remained similar among the groups before calving and the values

Table 7. Serum biochemical parameters of experimental animals

Parameter	Weeks	Dietary treatment			P value
		T1	T2	T3	
Glucose (mg/dL)	Initial	60.64±2.00	62.8±2.72	58.47±1.30	0.373^{ns}
	After 3 weeks	64.17±1.75	68.58±1.87	67.37±2.12	0.283^{ns}
	One week after calving	55.39±1.84	61.09±2.45	58.37±2.29	0.230^{ns}
	End of trial	66.99±1.65	65.87±2.53	62.68±2.65	0.421^{ns}
Cholesterol (mg/dL)	Initial	120.86±5.84	119.37±3.11	124.44±3.08	0.689^{ns}
	After 3 weeks	114.74±2.69	109.84±2.15	113.65±3.39	0.452^{ns}
	One week after calving	108.91±3.86	107.94±3.17	108.49±3.74	0.982^{ns}
	End of trial	147.94±4.56	150.48±4.67	143.49±1.85	0.465^{ns}
Total protein (g/dL)	Initial	7.34±0.19	7.24±0.17	7.4±0.28	0.869^{ns}
	After 3 weeks	7.46±0.28	7.47±0.15	7.55±0.33	0.968^{ns}
	One week after calving	7.24±0.22	7.19±0.34	7.20±0.15	0.989^{ns}
	End of trial	7.46±0.17	7.49±0.02	7.54±0.09	0.873^{ns}
Calcium (mg/dL)	Initial	9.32±0.17	9±0.22	9.49±0.24	0.287^{ns}
	After 3 weeks	9.39±0.28	9.11±0.11	9.27±0.21	0.662^{ns}
	One week after calving	7.82±0.10	7.99±0.08	7.94±0.12	0.486^{ns}
	End of trial	9±0.22	9.25±0.08	9.18±0.28	0.712^{ns}
Phosphorous (mg/dL)	Initial	6.72±0.31	6.69±0.42	6.1±0.16	0.324^{ns}
	After 3 weeks	5.5±0.20	5.82±0.19	5.52±0.32	0.589^{ns}
	One week after calving	6.51±0.25	6.31±0.14	6.35±0.24	0.791^{ns}
	End of trial	6.66±0.37	6.35±0.18	6.41±0.25	0.720^{ns}

were 5.5±0.2, 5.82±0.19 and 5.52±0.32 respectively and the observed values (mg/dL) one week after calving were 6.51±0.25, 6.31±0.14 and 6.35±0.24 respectively. In dairy cows, during the last four weeks of gestation, Keady *et al*. (2001), explored the effects of supplementing a grass silage-based diet with a concentrate mixture (5 kg/day) and noticed no variation in serum phosphorus concentration among the treatment groups. Similarly, Augustine (2008) observed comparable phosphorus concentrations in lactating crossbred cattle supplemented with either ground maize (one kg/ day) or protected fat (100g/ day).

Conclusion

Supplementation of energy as ground maize to cross bred dairy cows during late gestation significantly improved the early lactational performance without altering the serum biochemical profile.

References

Aguilar, M., Hanigan, M.D., Tucker, H.A., Jones, B.L., Garbade, S.K., McGilliard, M.L., Stallings, C.C., Knowlton, K.F. and James, R.E. 2012. Cow and herd variation in milk urea nitrogen concentrations in lactating dairy cattle. *J. Dairy Sci.* **95**: 7261-7268.

Alexander, B.M., Hess, B.W., Hixon, D.L., Garrett, B.L., Rule, D.C., McFarland, M., Bottger, J.D., Moss, G.E. and Simms, D.D. 2002. Influence of prepartum fat supplementation on subsequent beef cow reproduction and calf performance. *Professional Anim. Scientist*. **18**: 351-357.

Ali, M., Weisbjerg, M.R., Cone, J.W., Van Duinkerken, G., Blok, M.C., Bruinenberg, M. and Hendriks, W.H. 2012. Postruminal degradation of crude protein, neutral detergent fibre and starch of maize and grass silages in dairy cows. *Anim. Feed Sci. Technol*. **177**: 172-179.

AOAC [Association of Official Analytical Chemists]. 2016. Official Methods of Analysis of AOAC International. (20th Ed.). Association of Official Analytical Chemists, Washington D. C., U. S. A. 1885p.

Augustine, R. 2008. Energy supplementation on production performance of cows under field condition. *M. V. Sc*. thesis, Kerala Agricultural University, Thrissur, 83p.

Banta, J.P., Lalman, D.L., Owens, F.N., Krehbiel, C.R. and Wettemann, R.P. 2011. Effects of prepartum supplementation of linoleic and mid-oleic sunflower seed on cow performance, cow reproduction, and calf performance from birth through slaughter, and effects on intake and digestion in steers. *J. Anim. Sci.* **89**: 3718-3727.

Chen, H., Wang, C., Huasai, S. and Chen, A. 2022. Effect of prepartum dietary energy density on beef cow energy metabolites, and birth weight and antioxidative capabilities of neonatal calves. *Sci. Rep.* **12**: p.4828.

.Dann, H.M., Varga, G.A. & Putman, D.E. 1999. Improving energy supply to late gestation and early postpartum dairy cows. *J. Dairy Sci*. **82**: 1765-1778.

Doepel, L., Lapierre, H. and Kennelly, J.J. 2002. Peripartum performance and metabolism of dairy cows in response to prepartum energy and protein intake. *J. Dairy Sci.* **85**: 2315-2334.

Fadlalla, I.M.T., Omer, S.A. and Atta, M. 2020. Determination of some serum macro element minerals levels at different lactation stages of dairy cows and their correlations. *Sci. Afr*. **8**: 00351.

Fontoura, A.B.P., Rico, J.E., Davis, A.N., Myers, W.A., Tate, B.N., Gervais, R. and McFadden, J.W. 2021. Effects of dietary deoiled soy lecithin supplementation on milk production and fatty acid digestibility in Holstein dairy cows. *J. Dairy. Sci.* **104**: 1823-1837.

Guo, J., Peters, R.R., and Kohn, R.A. 2007. Effect of a transition diet on production performance and metabolism in periparturient cows. *J. Dairy Sci*. **90**: 5247-5258.

Higgs, R.J., Sheahan, A.J., Mandok, K., Van Amburgh, M.E. and Roche, J.R. 2013. The effect of starch-, fiber-, or sugar-based supplements on nitrogen utilization in grazing dairy cows. *J. Dairy Sci.* **96**: 3857-3866.

ICAR [Indian Council of Agricultural Research]. 2013. Nutrient Requirements of Animals-Cattle and Buffalo. (3rd Ed.). Indian Council of Agricultural Research, New Delhi, 59p.

IS: 1479. [Indian standards Institution]. 1960. Methods of test for Dairy Industry, Part-1. Rapid examination of milk. Indian Standards Institution, New Delhi, 31p.

IS: 1224. [Indian Standards Institution]. 1977. Determination of fat by Gerber's Method part 1. Milk (First Revision). Indian Standards Institution, New Delhi, 10p.

IS: 10083. [Indian Standards Institution]. 1982. Method of test for determination of SNF (Solids- Not- Fat) in milk by the use of the lactometer. Indian Standards Institution, New Delhi, 4p.

Janovick, N.A. and Drackley, J.K. 2010. Prepartum dietary management of energy intake affects postpartum intake and lactation performance by primiparous and multiparous Holstein cows. *J. Dairy Sci.* **93**: 3086-3102.

Keady, T.W.J., Mayne, C.S., Fitzpatrick, D.A. and McCoy, M.A. 2001. Effect of concentrate feed level in late gestation on subsequent milk yield, milk composition, and fertility of dairy cows. *J. Dairy Sci*. **84**: 1468-1479.

Kim, I.H. and Suh, G.H. 2003. Effect of the amount of body condition loss from the dry to near calving periods on the subsequent body condition change, occurrence of postpartum diseases, metabolic parameters and reproductive performance in Holstein dairy cows. *Theriogenology*. **60**: 1445-1456.

Magan, J.B., O′ Callaghan, T.F., Kelly, A.L. and McCarthy, N.A. 2021. Compositional and functional properties of milk and dairy products derived from cows fed pasture or concentrate-based diets. *Compr. Rev. Food Sci. Food Saf.* **20**: 2769-2800.

Melendez, P., Donovan, A. and Hernandez, J. 2000. Milk urea nitrogen and infertility in Florida Holstein cows. *J. Dairy sci*. **83**: 459-463.

Mendoza, A., Wijma, R., Piñeyrúa, J.M. and Cavestany, D. 2019. Carbohydrate source offered in the prepartum diet did not affect postpartum metabolic status or milk yield in dairy cows. *Animals*. **13**: 289-2296.

Minor, D.J., Trower, S.L., Strang, B.D., Shaver, R. and Grummer, R.R. 1998. Effects of non-fibre carbohydrate and niacin on periparturient metabolic status and lactation of dairy cows. *J. Dairy Sci*. **81**:189-200.

Nielsen, N.I., Hameleers, A., Young, F.J., Larsen, T. and Friggens, N.C. 2010. Energy intake in late gestation affects blood metabolites in early lactation independently of milk production in dairy cows. *Animals*. **4**: 52-60.

Pena, J.E.M., Vieira, S.L., Borsatti, L., Pontin, C. and Rios, H.V. 2014. Energy utilization of by-products from the soybean oil industry by broiler chickens: acidulated soapstock, lecithin, glycerol and their mixture. *Braz. J. Poult. Sci*. **16**: 437-442.

Reis, M.M., Cooke, R.F, Ranches, J. And Vasconcelos, J.L.M. 2012. Effects of calcium salts of polyunsaturated fatty acids on productive and reproductive parameters of lactating Holstein cows. *J. Dairy Sci*. **95**: 7039-7050.

Roche, J.R., Kay, J.K., Rius, A.G., Grala, T.M., Sheahan, A.J., White, H.M. and Phyn, C.V.C. 2013. Short communication: Immediate and deferred milk production responses to concentrate supplements in cows grazing fresh pasture. *J. Dairy Sci*. **96**: 2544-2550.

Ryan, G., Murphy, J.J., Crosse, S. and Rath, M. 2003. The effect of pre-calving diet on post-calving cow performance. *Livest. Prod. Sci.* **79**: 61-71.

Santos, B. G., Perfield II, J.W., Barbano, D.M., Bauman, D.E. and Overton, T.R. 2003. Production responses of dairy cows to dietary supplementation with conjugated linoleic acid (CLA) during the transition period and early lactation. *J. Dairy. Sci*. **86**: 3218-322.

Schroeder, G.F., Gagliostro, G.A., Bargo, F., Delahoy, J.E. & Muller, L.D. 2004. Effects of fat supplementation on milk production and composition by dairy cows on pasture: A review. *Livest. Prod. Sci*. **86**: 1-18.

Seifi, H.A., Mohri, M., Ehsani, A., Hosseini, E., and Chamsaz, M. 2005. Interpretation of bovine serum total calcium: effects of adjustment for albumin and total protein. *Comp. Clin. Pathol*. **14**: 155–159.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods* (8th Ed.). The Iowa state university press, Ames, Iowa, USA. 503p.

Suksombat, W. and Chullanandana, K. 2008. Effects of soybean oil or rumen protected conjugated linoleic acid supplementation on accumulation of conjugated linoleic acid in dairy cows' milk. *Asian-Australas. J Anim. Sci*. **21**: 1271-1277.

Tanner, A.R., Bauer, M.L., Kennedy, V.C., Keomanivong, F.E., Kirsch, J.D., Reynolds, L.P., Stokka, G.L., Rodas-Gonzalez, A., Ward, A.K., Dahlen, C.R. and Neville, B.W. 2020. Influence of corn supplementation to beef cows during mid-to late-gestation: maternal feed intake, body condition, plasma metabolites, and calf growth. *Livest. Sci*. **240**:104-14.

Theurer, C. B. 1996. Steam-flaking improves starch utilization and milk production parameters. *In: Proceedings of Cornell Nutrition Conference for Feed Manufacturers;* Department of Animal Sciences, Cornell University, Ithaca, New York. p. 121-130

Valiente, S.L., Maresca, S., Rodriguez, A.M., Palladino, R.A., Lacau-Mengido, I.M., Long, N.M. and Quintans, G. 2018. Effect of protein restriction of Angus cows during late gestation: Subsequent reproductive performance and milk yield. *Prof. Anim. Sci*. **34**: 261-268.

Van Knegsel, A.T.M., Van den Brand, H., Dijkstra, J., Van Straalen, W.M., Jorritsma, R., Tamminga, S. and Kemp, B. 2005. Effect of dietary energy source on energy balance, production, metabolic disorders and reproduction in lactating dairy cattle. *Reprod. Nutr. Dev*. **45**: 665-688.

Van Knegsel, A.T.M., Van den Brand, H., Dijkstra, J., Van Straalen, W.M., Jorritsma, R., Tamminga, S. and Kemp, B. 2007. Effect of glucogenic vs. lipogenic diets on energy balance, blood metabolites, and reproduction in primiparous and multiparous dairy cows in early lactation. *J Dairy Sci*. **90**: 3397-3409.

■