International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM June 2024, 15(6): 01-07 **Article** AR5346

Research Article *Natural Resource Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2024.5346

Effect of Dietary Addition of Fennel (*Foeniculum vulgare*) Seed on Growth Performance, Haemato-Biochemical Profile and Faecal Microbiota of Kankrej Calves

M. M. Pawar[1], S. S. Patil[1], Y. M. Gami[2], S. S. Patel[3], S. H. Raval[4], C. P. Modi[1] and J. R. Patel[1]

[1]Dept. of Animal Nutrition, [2]Livestock Research Station, [3]Dept. of Veterinary Microbiology, [4]Dept. of Veterinary Pathology, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Sardarkrushinagar, Gujarat (385 506), India

Open Access

Corresponding mahespawar@gmail.com

0000-0002-0797-3580

ABSTRACT

The experiment was conducted during the month of February and March, 2023 at Livestock Research Station, Kamdhenu University, Sardarkrushinagar, Gujarat, India to evaluate the effect of dietary addition of fennel (*Foeniculum vulgare*) seed on growth performance, haemato-biochemical profile and faecal microbiota of Kankrej calves. Eighteen Kankrej calves were randomly divided into three treatment groups, viz. Basal diet (control), Basal diet+5 g animal^{-1} day^{-1} of fennel seed powder supplementation and Basal diet+10 g animal^{-1} day^{-1} of fennel seed powder supplementation for a period of 60 days. Results revealed that there was numerically higher body weight gains were observed in groups fed 5 and 10 g of fennel seed daily than the control, the difference was statistically not significant (p>0.05) among the treatment groups. The mean faecal counts ($\log_{10}$ cfu g^{-1} in fresh faeces) of lactobacillus were increased, while coliform were reduced in groups fed 5 and 10 g of fennel seed daily as compared to control group. There was no effect (p>0.05) on the haemoglobin, haematocrit, total erythrocytes count and total leucocytes count among the treatment groups. No difference (p>0.05) was found in serum levels of total proteins, albumin, globulin, urea, triglycerides, cholesterol, ALT and AST concentrations among the treatment groups. It may be concluded that dietary fennel seed powder supplementation in calves improved growth performance and had beneficial effect on faecal microbiota with higher faecal lactobacillus count and lower faecal coliform count. Fennel seed supplementation did not affect haemato-biochemical profile of calves.

KEYWORDS: Blood biochemistry, calves, faecal microbes, fennel seed, growth

***Citation* (VANCOUVER):** Pawar et al., Effect of Dietary Addition of Fennel (*Foeniculum vulgare*) Seed on Growth Performance, Haemato-Biochemical Profile and Faecal Microbiota of Kankrej Calves. *International Journal of Bio-resource and Stress Management,* 2024; 15(6), 01-07. HTTPS://DOI.ORG/10.23910/1.2024.5346.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 03rd April 2024 RECEIVED in revised form on 04th June 2024 ACCEPTED in final form on 14th June 2024 PUBLISHED on 20th June 2024

1. INTRODUCTION

India is an agriculture-based country and livestock are the most important and essential sub-division of our economy contributing 4.11% Gross Domestic Product and 25.6% of total Agriculture Gross Domestic Product (Anonymous, 2020). Livestock is playing pivotal role in accelerating the rural economy and ultimate sustainable livelihood for 70% population in rural areas. As per 20th Livestock Census, cattle population in India was 192.49 millions (Anonymous, 2019). With the total milk production of 230.58 million tonnes during 2022–23, India ranks 1st in the world in terms of total milk production (Anonymous, 2023). Indigenous cattle in India are robust, resilient and are particularly suitable to the climate and environment of their respective breeding tracts (Srivastava et al., 2019). In Indigenous cows, calves are necessary to keep cows in milk production. Moreover, calves are the future replacement stock of the herd. The calves have to be nourished well in their early phases of life as the development rate is accomplished right from the day of conception (Solanki et al., 2022; Sorang et al., 2023). In calves, morbidity and mortality rates are high between day one and six months of life. The addition of antibiotics to animal feeds has been widely used to promote growth performance, the feed conversion rate, product quality and animal health (Wu et al., 2020). However, injudicious use of antibiotics results in microbial resistance to drugs in calves (Credille et al., 2024; Fossen et al., 2024). Recently, use of various phytogenic feed additives as alternative to feed antibiotics to improve animal performance and health has been tried in livestock animals (Pawar et al., 2021; Saini et al., 2022). The beneficial effects of phytogenic feed additives in livestock animals' performance may be associated with their positive effect on intake (Devi et al., 2022; Modi et al., 2022) and nutrient digestion (Fahim et al., 2022) or their characteristics as antibacterial, antioxidative, and immunity stimulation (Pawar et al., 2019; Hashemzadeh et al., 2023).

The phytogenic feed additives, fennel (*Foeniculum vulgare*) seed supplementation in livestock shown to promote the growth performance and health of young animals (Kargar et al., 2021; Nowroozinia et al., 2022; Ansari et al., 2024). Fennel is an aromatic plant belonging to the Apiaceae family. Anethole and limonene are the main phytochemicals of fennel (Noreen et al., 2023). The fennel seeds have aroma (due to essential oils such as fenchone, trans-anethole, estragole, and limonene), antioxidant and anti-inflammatory (due to flavonoids, essential oils, phenolic acids, hydroxycinnamic acids, coumarin, and tannin), estrogenic (due to photoanethole and dianethole) and antimicrobial (due to 1, 3-benzenediol, oleic acid, undecanal, linoleic acid, 5-hydroxy-furanocoumarin, and 2, 4-undecadienal) properties (Barrahi et al., 2020; Jadid et al., 2023; Kaveh et al., 2023). Mitra and Mukherjee (2010) previously showed that fennel seed cures gastrointestinal disorders such as indigestion, flatulence, and diarrhea. Also, it was reported that fennel seed regulate the appetite and improve hyperlipidemia, mainly by influencing the expression of insulin and leptin receptors (Zakernezhad et al., 2021). Moreover, recently the encapsulated essential oil and aqueous extract from fennel seeds had shown considerable reduction in the blood glucose content (Zolkepli et al., 2022). Recent studies have shown that dietary supplementation of fennel seed in growing animals improved feed intake, growth performance, lipid profile and gut health (Kargar et al., 2021; Ansari et al., 2022; Ansari et al., 2024) We hypothesized that feeding of fennel seed powder would improve growth performance and beneficial faecal microbiota in calves. Therefore, the present study was carried out to investigate the effect of dietary addition of fennel (*Foeniculum vulgare*) seed on growth performance, haemato-biochemical profile and faecal microbiota of Kankrej calves.

2. MATERIALS AND METHODS

The present study was conducted at Livestock Research Station, Sardarkrushinagar, Gujarat, India which is located in semi-arid region of North Gujarat, India having latitude of 24.32' North and longitude of 72.31' East and at an elevation of 189 meters above the mean sea level. This experiment was carried out during the month of February and March, 2023. The experimental protocol was approved (No. VETCOLL/IAEC/2021/17/PROTOCOL-03) by the Institutional Animal Ethics Committee. Eighteen Kankrej calves were randomly divided into three treatment groups, viz. T_1: Basal diet (control), T_2: Basal diet+5 g animal^{-1} day^{-1} of fennel seed powder supplementation and T_3: Basal diet+10 g animal^{-1} day^{-1} of fennel seed powder supplementation. The experiment was conducted in a completely randomized design and consisted of 10 days of adaptation period and 60 days of experimental feeding. Representative samples of feeds and fennel seed powder were analyzed for chemical composition (Anonymous, 2007).

The body weight of each calf was recorded at the beginning (0d) and thereafter at fortnightly intervals during the experimental feeding. Rectal faecal samples were collected at the beginning (0d), 30th and 60th day of experimental feeding to determine the faecal microbial populations of *Lactobacilli* and coliforms. Bacterial populations were enumerated by serial 10-fold dilutions (10^{-1} to 10^{-8}) with the total volume of 10 ml including 1 g homogenized faeces and 9 ml normal saline (0.9% NaCl) and plated in triplicate onto selective media-MRS agar for *Lactobacilli* (Himedia); EMB agar,

Levine (Himedia), for coliforms (Sharma et al., 2017). The agar plates were incubated aerobically at 37°C for 24 hr. Colonies on the agar plates were counted as colony-forming units (CFU) per g faeces and then converted to $\log_{10}$ cfu g^{-1}. At the end of experimental feeding (60th day) blood samples from jugular vein were collected from each calf in the sterilized vials with and without anticoagulant. The fresh blood samples were analyzed for haemoglobin, haematocrit, total erythrocytes and leucocytes count using automatic analyzer. The serum samples were analyzed for glucose, total proteins, albumin, urea, triglycerides, cholesterol, alanine amonotransferase (ALT) and aspartate aminotransferase (AST) using commercial diagnostic kits.

The experimental data generated were analysed by ANOVA using the statistical software program SPSS. Data of the growth performance and haemato-biochemical parameters were analysed using one-way ANOVA. Data for faecal *Lactobacilli* and coliforms were analysed using two-way ANOVA. The difference between the means was declared significant at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Chemical composition

The chemical composition of feeds and fennel seed used in experimental feeding of Kankrej calves is given in Table 1. The content of crude protein was 20.56, 6.78 and 3.56% in concentrate feed, hybrid Napier fodder and jowar hay, respectively. The contents of dry matter, crude protein, ether extract, crude fiber, nitrogen free extract and ash in fennel seed powder were 93.76, 9.38, 9.76, 18.21, 49.68 and 12.97%, respectively. Similarly, Noreen et al. (2023) reported content of dry matter, protein, fat and fiber in fennel seed was 93.7, 9.5, 10.0 and 18.5% fiber, respectively.

Table 1: Proximate composition of feeds and fennel seed

Composition (%)	Concentrate mixture	Hybrid Napier	Jowar hay	Fennel seed
Dry matter	90.10	16.56	78.43	93.76
Crude protein	20.56	6.78	3.56	9.38
Crude fibre	6.58	25.4	37.58	18.21
Ether extract	4.15	1.72	0.96	9.76
Total ash	7.05	7.77	6.56	12.97
NFE	61.66	58.33	51.34	49.68

3.2. Growth performance

The data of effect of fennel seed supplementation on growth performance of Kankrej calves is given Table 2. The final body weights of Kankrej calves were 66.92, 68.55 and 67.80 kg in T_1, T_2 and T_3 groups, respectively. No significant difference was observed in final body weights among the dietary treatment groups. The overall body weight gain was 25.86, 27.77 and 26.90 kg in T_1, T_2 and T_3 groups, respectively. Though, numerically higher body weight gain was observed in T_2 and T_3 than the control, the difference was statistically not significant ($p>0.05$) among the treatment groups. Earlier studies also reported improved weight gain in dairy calves supplemented with fennel seeds (Saeedi et al., 2017; Kargar et al., 2021; Nowroozinia et al., 2022; Ansari et al., 2022; Ansari et al., 2024). Phytochemical compound with estrogenic activity play important roles in skeletal muscle and bone growth (Nowroozinia et al., 2022), improve glucose uptake into muscle cells and provide long-lasting anabolic conditions (Saeedi et al., 2017; Hajalizadeh et al., 2019), modulate the immune responses, and are anti-inflammatory (Nowroozinia et al., 2022).

Table 2: Effect of fennel seed supplementation on growth performance (kg) of Kankrej calves

Age in days	Dietary groups			SEm	*p* value
	T_1	T_2	T_3		
Initial	41.05	40.78	40.90	3.145	0.999
15	47.48	47.05	47.25	3.074	0.972
30	53.83	53.85	54.23	3.110	0.851
45	60.62	61.92	61.83	2.785	0.904
60	66.92	68.55	67.80	3.073	0.856
BW gain (kg)	25.86	27.77	26.90	0.579	0.430

3.3. Faecal microbiota

The data pertaining to faecal microbial counts are shown in Table 3. The faecal lactobacillus counts ($\log_{10}$ cfu g^{-1} in fresh faeces) at 60th day and overall average were increased in T_3 group followed by T_2 group as compared to the control group, while the faecal coliform counts ($\log_{10}$ cfu g^{-1} in fresh faeces) at 60th day and overall average were numerically reduced in T_3 and T_2 groups as compared to T_1 group. However, the faecal lactobacillus and coliform counts were statistically not significant ($p>0.0.5$) among the dietary groups. Anwar et al. (2009) found that fennel essential oils had extensive antibacterial activity against particularly *E. coli*. Ghiasvand et al. (2021) reported that essential oil of fennel reduced *E. coli* population in the intestines of broiler chickens.

Moreover, Gende et al. (2009) reported that fennel essential oil exhibits considerable antibacterial action due to its active component, anethole, which was shown to be particularly abundant in the oil of fennel (92.7%). Barrahi et al. (2020) found that fennel (*Foeniculum vulgare*) seed essential oil was efficient against a variety of microbes, including bacteria, yeast, and fungal strains. The presence of soluble fibre in fennel seeds acts as prebiotics in caecum and colon. Prebiotics in the caecum and colon are readily fermented by beneficial bacteria such as lactobacillus which produce

Table 3: Effect of fennel seed supplementation on faecal microbiota of Kankrej calves

Attributes	Dietary groups			Period average	SEm	*p* value		
	T_1	T_2	T_3			T	P	T×P
Lactobacillus (log_{10} cfu g^{-1} of fresh faces)								
Initial	7.75	7.77	7.76	7.76	0.023	0.552	0.328	0.845
30 day	7.91	7.94	7.98	7.94	0.107			
60 day	7.78	7.84	8.11	7.91	0.234			
Average	7.81	7.85	7.95	7.87				
SEm±	0.086	0.089	0.232					
Coliform (log_{10} cfu g^{-1} of fresh faces)								
Initial	7.91	7.94	7.98	7.94^{C}	0.107	0.725	0.011	0.950
30 day	7.81	7.59	7.61	7.67^{B}	0.230			
60 day	7.54	7.36	7.39	7.43^{A}	0.177			
Average	7.75	7.63	7.66					
SEm±	0.149	0.206	0.255					

^{ABC}Means with different superscripts in a column differed significantly (p<0.05)

antimicrobial agent and metabolic compound, which may have bactericidal action against gram negative bacteria (Ohland and MacNaughton, 2010).

3.4. Haemato-biochemical profile

The effect of fennel seed supplementation on haemato-biochemical parameters of Kankrej calves is shown in Table 4. There was no effect (p>0.05) on the haemoglobin, haematocrit, total erythrocytes count and total leucocytes count among the treatment groups. No difference (p>0.05) was found in serum levels of total proteins, albumin, globulin, urea, triglycerides, cholesterol, ALT and AST concentrations among the treatment groups. In line with the present findings, no effect on blood glucose concentrations was observed in previous study (Fahim et al., 2022). On the contrary, the increase in plasma glucose concentration was reported by other studies (Mahmoud et al., 2020; Moosavi-Zadeh et al., 2023). In the present study, the lack of fennel seed effect on blood concentrations of total proteins, albumin, globulin and urea may imply that no alterations in the demand and competition for amino acids occurred and, in turn, shows no challenge to hepatic synthesis of albumin or globulin, required to sustain nutrient transportation and normal immune function (Kargar et al., 2018).

Cholesterol and triglycerides are 2 main indicators of lipid metabolism, and their concentrations are highly associated with health and diminished early mortality in calves (Renaud et al., 2018). In our study, there was no effect of fennel seed supplementation on blood cholesterol and triglycerides in calves, however, other studies reported increased (Ansari et al., 2022) and decreased blood triglycerides in dairy calves (Lakhani et al., 2019). The ALT

Table 4: Effect of fennel seed supplementation on haemato-biochemical profile of Kankrej calves

Parameters	Dietary groups			SEm	*p* value
	T^1	T_2	T_3		
Haematological parameters					
Haemoglobin (g dl^{-1})	8.52	8.45	8.33	0.160	0.906
Hematocrit (%)	21.23	19.80	18.93	0.592	0.293
TEC (10^6 μl^{-1})	12.83	11.67	11.97	0.247	0.131
TLC (10^3 μl^{-1})	13.08	14.27	13.03	0.414	0.413
Blood biochemical parameters					
Glucose (mg dl^{-1})	60.72	62.06	62.95	61.91	0.774
Total protein (g dl^{-1})	5.39	5.50	5.51	5.46	0.085
Albumin (g dl^{-1})	2.78	2.83	2.85	2.82	0.116
Globulin (g dl^{-1})	2.60	2.67	2.66	2.65	0.140
Urea (mg dl^{-1})	8.45	8.47	8.30	8.40	0.833
Triglycerides (mg dl^{-1})	19.84	16.31	17.30	17.82	0.935
Cholesterol (mg dl^{-1})	87.84	85.26	84.81	85.97	2.338
ALT (U l^{-1})	26.59	23.76	23.38	24.58	1.891
AST (U l^{-1})	107.45	106.20	110.31	107.99	2.451

TEC: Total erythrocytes count; TLC: Total leucocytes count; ALT: Alanine amonotransferase; AST: Aspartate aminotransferase

and AST in liver and other tissues such as skeletal muscles are main indicators of tissue damage or dysfunction. In the present study, blood concentration of ALT and AST was not affected by treatment indicating no adverse effect of fennel seed supplementation in calves. These variations in findings among the experiments might be due to variations in experimental design, species, diet compositions, doses supplemented, and physiological stage of experimental animals.

4. CONCLUSION

Dietary fennel (*Foeniculum vulgare*) seed powder supplementation in calves improved growth performance and had beneficial effect on faecal microbiota with higher faecal lactobacillus count and lower faecal coliform count. Fennel seed supplementation did not affect haemato-biochemical profile of calves.

5. REFERENCES

Anonymous, 2007. Official methods of analysis, 18th edn. Association of Official Analytical Chemists, Gaithersburg. Available at www.aoac.org Accessed on 2nd June, 2023.

Anonymous, 2019. Basic animal husbandry statistics. Department of Animal Husbandry and Dairying. Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. Available at https://dahd.nic.in/documents/statistics/livestock-census Accessed on 5th February, 2024.

Anonymous, 2020. Food and Agriculture Organization, 2020. Food outlook, biannual report on global food markets. Italy, Rome. Available at https://www.fao.org/home/en. Accessed on 15th February, 2024.

Anonymous, 2023. Basic animal husbandry statistics. Department of Animal Husbandry and Dairying. Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. Available from https://dahd.nic.in/sites/default/filess/BAHS2023.pdf Accessed on 20th February, 2024.

Ansari, M., Kargar, S., Eslami, M.A., Falahati, R., Albenzio, M., Caroprese, M., Zamiri, M.J., Kanani, M., 2022. Potential benefits of early-life supplementation of liquid feed with fennel (*Foeniculum vulgare*) seeds or oregano (*Origanum vulgare*) leaves on growth, health, and blood metabolites in Holstein dairy calves. Journal of Dairy Science 105(8), 6639–6653.

Ansari, M., Kargar, S., Falahati, R., Kanani, M., Ghaffari, M.H., 2024. Effects of pre-weaning supplementation with fennel seed powder in two terms on growth performance, health status, and blood metabolites of Holstein dairy calves. Animal Feed Science and Technology 308, 115861.

Anwar, F., Ali, M., Hussain, A.I., Shahid, M., 2009. Antioxidant and antimicrobial activities of essential oil and extracts of fennel (*Foeniculum vulgare Mill.*) seeds from Pakistan. Flavour and Fragrance Journal 24(4), 170–176.

Barrahi, M., Esmail, A., Elhartiti, H., Chahboun, N., Benali, A., Amiyare, R., Lakhrissi, B., Rhaiem, N., Zarrouk, A., Ouhssine, M., 2020. Chemical composition and evaluation of antibacterial activity of fennel (*Foeniculum vulgare* Mill) seed essential oil against some pathogenic bacterial strains. Caspian Journal of Environmental Sciences 18(4), 295–307.

Credille, B., Berghaus, R.D., Jane Miller, E., Credille, A., Schrag, N.F., Naikare, H., 2024. Antimicrobial metaphylaxis and its impact on health, performance, antimicrobial resistance, and contextual antimicrobial use in high-risk beef stocker calves. Journal of Animal Science 102, skad 417. doi: 10.1093/jas/skad417.

Devi, N.S., Vidyarthi, V.K., Zuyie, R., 2022. Performance of broilers on dietary supplementation of black cumin (*Nigella sativa*) seed during monsoon season. International Journal of Bio-resource and Stress Management 13(7), 718–724.

Fahim, N.H., Kholif, A.E., Azzaz, H.H., 2022. Fennel and ginger improved nutrient digestibility and milk yield and quality in early lactating Egyptian buffaloes. Annals of Animal Science 22(1), 255–270.

Fossen, J.D., Campbell, J.R., Gow, S.P., Erickson, N., Waldner, C.L., 2024. Antimicrobial resistance in *Enterococcus* isolated from western Canadian cow-calf herds. BMC Veterinary Research 20(1), 6.

Gende, L.B., Maggi, M.D., Fritz, R., Eguaras, M.J., Bailac, P.N., Ponzi, M.I., 2009. Antimicrobial activity of *Pimpinella anisum* and *Foeniculum vulgare* essential oils against Paenibacillus larvae. Journal of Essential Oil Research 21(1), 91–93.

Ghiasvand, A.R., Khatibjoo, A., Mohammadi, Y., Akbari Gharaei, M., Shirzadi, H., 2021. Effect of fennel essential oil on performance, serum biochemistry, immunity, ileum morphology and microbial population, and meat quality of broiler chickens fed corn or wheat-based diet. British Poultry Science 62(4), 562–572.

Hajalizadeh, Z., Dayani, O., Khezri, A., Tahmasbi, R., Mohammadabadi, M.R., 2019. The effect of adding fennel (*Foeniculum vulgare*) seed powder to the diet of fattening lambs on performance, carcass characteristics and liver enzymes. Small Ruminant Research 175, 72–77.

Hashemzadeh, F., Rafeie, F., Hadipour, A., Rezadoust, M.H., 2023. Effect of adding a phytogenic-rich herbal mixture to diet on the expression pattern of some insulin hormone metabolism-related candidate genes

of heat-stressed fattening Afshari-Shal lambs. Animal Production Research 12(1), 25–37.

Jadid, N., Widodo, A.F., Ermavitalini, D., Sa'adah, N.N., Gunawan, S., Nisa, C., 2023. The medicinal Umbelliferae plant Fennel (*Foeniculum vulgare* Mill): Cultivation, traditional uses, phytopharmacological properties, and application in animal husbandry. Arabian Journal of Chemistry 16(3), 104541.

Kargar, S., Mousavi, F., Karimi-Dehkordi, S., 2018. Effects of chromium supplementation on weight gain, feeding behaviour, health and metabolic criteria of environmentally heat-loaded Holstein dairy calves from birth to weaning. Archives of Animal Nutrition 72(6), 443–457.

Kargar, S., Nowroozinia, F., Kanani, M., 2021. Feeding fennel (*Foeniculum vulgare*) seed as potential appetite stimulant to newborn holstein dairy calves: Effects on meal pattern, ingestive behavior, oro-sensorial preference, and feed sorting. Animal Feed Science and Technology 278, 115009.

Kaveh, R., Naghmachi, M., Motaghi, M.M., Amirmahani, F., Danaei, M., 2023. Antibacterial and antioxidant activities and anticancer effects of fennel seeds (*Foeniculum vulgare*) against lung cancer cells. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences 93(2), 311–316.

Lakhani, N., Kamra, D.N., Lakhani, P., Alhussien, M.N., 2019. Immune status and haemato-biochemical profile of buffalo calves supplemented with phytogenic feed additives rich in tannins, saponins and essential oils. Tropical Animal Health and Production 51, 565–573.

Mahmoud, A.E.M., Rahmy, H.A.F., Ghoneem, W.M.A., 2020. Role of caraway, fennel and melissa addition on productive performance of lactating Frisian cows. Pakistan Journal of Biological Sciences 23(11), 1380–1389.

Mitra, S., Mukherjee, S.K., 2010. Ethnomedicinal usages of some wild plants of North Bengal plain for gastro-intestinal problems. Indian Journal of Traditional Knowledge 9, 705–712.

Modi, C.P., Patil, S.S., Pawar, M.M., Chaudhari, A.B., Chauhan, H.D., Ashwar, B.K., 2022. Effect of cumin (*Cuminum cyminum*) seed supplementation on production performance, nutrient digestibility and haemato-biochemical profile of Mehsana goats. Indian Journal of Animal Sciences 92(7), 887–891.

Moosavi-Zadeh, E., Rahimi, A., Rafiee, H., Saberipour, H., Bahadoran, R., 2023. Effects of fennel (*Foeniculum vulgare*) seed powder addition during early lactation on performance, milk fatty acid profile, and rumen fermentation parameters of Holstein cows. Frontiers in Animal Science 4, 1097071.

Noreen, S., Tufail, T., Badar Ul Ain, H., Awuchi, C.G., 2023. Pharmacological, nutraceutical, functional and therapeutic properties of fennel (*Foeniculum vulgare*). International Journal of Food Properties 26(1), 915–927.

Nowroozinia, F., Kargar, S., Akhlaghi, A., Fard, F.R., Bahadori-Moghaddam, M., Kanani, M., Zamiri, M.J., 2022. Feeding fennel (*Foeniculum vulgare*) seed as a potential appetite stimulant for Holstein dairy calves: Effects on growth performance and health. Journal of Dairy Science 105(1), 654–664.

Ohland, C.L., MacNaughton, W.K., 2010. Probiotic bacteria and intestinal epithelial barrier function. American Journal of Physiology Gastrointestinal and Liver Physiology 298, 807–819.

Pawar, M.M., Kamra, D.N., Agarwal N., Chaudhary, L.C., Charturvedi, V.B., 2021. Use of essential oils as feed additive for modulation of rumen fermentation and methanogenesis in buffalo. Animal Nutrition and Feed Technology 21, 49–60.

Pawar, M.M., Kamra, D.N., Chaudhary, L.C., Agarwal N., Charturvedi, V.B., 2019. Nutrients utilization, methane emission, immune function, blood metabolites and performance of buffalo calves fed *Trachyspermum copticum* seed oil. Indian Journal of Animal Sciences 89(1), 63–67.

Renaud, D.L., Duffield, T.F., LeBlanc, S.J., Haley, D.B., Kelton, D.F., 2018. Clinical and metabolic indicators associated with early mortality at a milk-fed veal facility: A prospective case-control study. Journal of Dairy Science 101(3), 2669–2678.

Saeedi, S., Dayani, O., Tahmasbi, R., Khezri, A., 2017. Effect of supplementation of calf starter with fennel powder on performance, weaning age and fermentation characteristics in Holstein dairy calves. Journal of Animal Physiology and Animal Nutrition 101(1), 81–87.

Saini, R., Chhikara, S.K., Sahu, S., Yadav, D.C., 2022. The potential of aloe vera as a herbal feed additive for livestock- A review. International Journal of Bio-resource and Stress Management 13(8), 877–886.

Sharma, A.N., Kumar, S., Tyagi, A.K., 2018. Effects of mannan-oligosaccharides and *Lactobacillus acidophilus* supplementation on growth performance, nutrient utilization and faecal characteristics in Murrah buffalo calves. Journal of Animal Physiology and Animal Nutrition 102(3), 679–689.

Solanki, C.P.S., Lakhani, G.P., Roy, B., Mishra, A., Joshi, S.K., Aharwal, B., 2022. Production performance of Murrah buffaloes under weaning and suckling system of calf management. International Journal of Bio-resource and Stress Management 13(1), 99–105.

Sorang, Z.K., Deka, R.J., Baruah, D.K., Hussain, J., Saikia, G., Shome, A., Kaushik, P., 2023. Effect of supplementation garlic powder (*Allium sativum*) in the growth parameters of Sahiwal calves. International Journal of Bio-resource and Stress Management 14(9), 1313–1320.

Srivastava, A.K., Patel, J.B., Ankuya, K.J., Chauhan, H.D., Pawar, M.M., Gupta, J.P., 2019. Conservation of Indigenous cattle breeds. Journal of Animal Research 9(1), 1–12.

Wu, C.F., Chen, C.H., Wu, C.Y., Lin, C.S., Su, Y.C., Wu, C.F., Tsai, H.P., Fan, P.S., Yeh, C.H., Yang, W.C., Chang, G.R., 2020. Quinolone and organophosphorus insecticide residues in bivalves and their associated risks in Taiwan. Molecules 25, 3636.

Zakernezhad, F., Barati, M., Sanadgol, N., Movahhedi, M., Majd, A., Golab, F., 2021. The association between fennel extract, serum lipid profile, and leptin receptor expression. Basic and Clinical Neuroscience 12(6), 711.

Zolkepli, H., Widodo, R.T., Mahmood, S., Salim, N., Awang, K., Ahmad, N., Othman, R., 2022. A review on the delivery of plant-based antidiabetic agents using nanocarriers: current status and their role in combating hyperglycaemia. Polymers 14(15), 2991.