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Economic evaluation of therapeutic diet formulated for Foot and Mouth Disease (FMD) infected crossbred calves

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ABSTRACT

The study aimed to evaluate the economics involved in the formulation of a therapeutic diet for Foot and Mouth Disease and its impact on the convalescence period. A total of 22 Holstein Friesian crossbred male calves (10-12 months) were considered in which 4 calves were of Control (CON) and 18 calves of treatment groups. The treatment group animals namely, Therapeutic Diet-1 (TD-1), Therapeutic Diet-2 (TD-2), and Therapeutic Diet-3(TD-3) were infected with the FMD virus. The therapeutic diet was fed to calves in the morning and *ad lib.* hybrid Napier green fodder in the afternoon. The experiment was carried out for 42 days. At the end of the experiment, animals gained 18.73, 19.67, 19.10 and 19.42 kg body weight in CON, TD-1, TD-2 and TD-3 groups respectively. Body weight gain between the groups was non-significant. The total cost of feeding inclusive of both therapeutic diet and green fodder was ₹546.24, 523.43, 521.56 and 509 respectively. Cost per kg body weight gain was also calculated. The cost per kg body weight gain was non-significant among the groups; being highest in the CON group compared to infected groups. It can be concluded from the present study that during FMD infectious conditions, the therapeutic diet feeding either mash or cooked (with or without CNS) not only helped in regaining the body weight quickly but also reduced the feeding and treatment cost.

Keywords: Body weight, Crossbred calves, Customized nutrient supplement, Economics, Foot and mouth disease, Therapeutic diet

Foot and Mouth Disease (FMD) is an infectious disease of viral origin caused by the *Apthovirus* of Picornaviridae family. The disease is mainly endemic in India and other Asian countries affecting the cloven-footed domestic animals (Ding *et al*. 2013). FMD is characterized by elevated body temperature, vesicles on tongue, muzzle, snout, nose, teats and inter-digital space of hoof that results in off feeding and lameness (Teifke *et al*. 2012). Disease transmission occurs through contaminated air, water, feed, livestock movement and trade. FMD is a major impediment to the progress of the Indian dairy sector. The farm level economic loss was USD 3159 million (INR 221,110 million) at 2015-16 constant prices (Govindaraj *et al.* 2021). India has more than 500 million FMD susceptible animals and is experiencing a loss of more than ₹20,000 crore/annum (about 3.5 billion USD) directly, of which, loss in milk production accounts for 80% of total loss (Annual Report DFMD 2017-18).

During FMD, animals are unable to consume feed and fodder due to lesions developed inside the mouth leading to progressive loss of body weight and decrease in milk production. Farmers have been using several alternate traditional approaches to ensure optimal feed intake by the affected animals based on their experiences and perceptions. Chopped green fodder is fed in place of dry fodder as the latter pierces the oral lesions causing pain. Therefore, nutrition has been supplemented by changing the physical form of the diet in field conditions. Traditional FMD treatment included cleaning the lesions with a natural soda ash solution, while some communities administered honey or even finger millet flour to the lesions (Gakuya *et al*. 2011).

Nutrients are considered important for the effective immune response (Bertoni *et al*. 2015). Thus, tailor-made diets prepared scientifically taking into consideration the nutritional requirements of the clinically affected animals, would not only ensure adequate nutrient supply but also assure enough consumption, especially if prepared in a physical form compatible with the inflammatory condition of the mouth. Such a modified diet, as a part of the clinical nutrition approaches for the dietary management of clinically ill animals, is often termed a therapeutic diet (TD). In this direction, we have attempted to make a therapeutic diet that contains high protein with different physical farms (mash and cooked form) fulfilling the needs of the satiety centre of the affected animal and evaluate it economically from the perspective of Indian dairy farmers to withstand the economic loss and improve animal health.

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MATERIALS AND METHODS

The experiment was conducted at the Animal Experimentation Station, Yelahanaka, Bengaluru of Indian Veterinary Research Institute, Hebbal, Bengaluru, Karnataka, India. A total of 22 Holstein Friesian crossbred male calves (10-12 months old) which had no previous FMD infection and vaccination were used in the study. The calves were de-wormed, kept under quarantine for 4 weeks and acclimatized. All animals were seronegative (virus neutralization VN titer of ≤8) for FMDV structural antigens (OIE 2017). The experimental protocol was approved by the Institutional Animal Ethics Committee (IAEC) and Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Ministry of Fisheries, Animal husbandry and Dairying, Government of India.

Housing of animals and experimental design: During the experimental period, the animals were kept in the bio-containment (BSL III) facility. The air circulation and temperature were automatically controlled throughout the experiment. All the cleaning and feeding was done by solely dedicated workers during the experimental period. Proper hygienic conditions with strict bio-security measures were followed throughout the experiment. The calves were divided into four dietary groups with six animals in three treatment groups, viz. Therapeutic diet-1(TD-1), Therapeutic diet-2(TD-2) and Therapeutic diet-3(TD-3) and four animals in CON (Control) adopting a completely randomized design. The therapeutic diet (TD) is prepared in the form of Total Mixed Ration (TMR) containing different ingredients which are locally available (Table 2). This therapeutic diet was offered in mash form in Control and TD-1 group. However, the same therapeutic diet was offered in the cooked form in TD-2 and TD-3 along with CNS (Table 1).

Table 1. Experimental design

	CON	TD-1	TD-2	TD-3
FMD Infection+	No	Infection	Infection	Infection
Physical form	Mash	Mash	Cooked	Cooked
CNS ++	–	–	–	+

Note: + A bovine-derived FMDV serotype O/IND/R2/75 was inoculated with 1.0×10^4 50% bovine tongue infectious dose (BTID50) of the virus by intra-dermo-lingual route and the animals were observed for FMD lesions in the foot and mouth after 24 hours after the infection; ++Customized Nutrient Supplement (CNS): Salt, Copper sulphate, Zinc sulphate, Manganese sulphate, Sodium selenite, Chromium chloride, Sodium bicarbonate at the rate of 85, 125, 80, 1, 2, 707 g respectively. The supplementation was added @ 2 g/kg of concentrate placed in the mouth before concentrate feeding in the morning.

Feeding of animals: The calculated quantity of the therapeutic diet (1.5% body weight) was fed to individual calves in the morning. This therapeutic diet contained 95, 19, 7, 95, 5, 1, 56, 12% of DM, CP, EE, OM, TA, AIA, NDF and ADF respectively. Further, the diet had 2.90 Mcal ME/ kg. After complete consumption of TD, *ad lib.* hybrid Napier green fodder *(Pennisetum glaucum × Pennisetum purpureum)* chaffed to 2 inch size was offered. This fodder contained 15, 14, 4, 86, 14, 4, 75, 39% of DM, CP, EE, OM, TA, AIA, NDF and ADF respectively. The experiment was conducted for 42 days.

Cost of therapeutic diet: The feeding cost was calculated for each calf based on the consumption of TD during the whole experimental period. The cost of TD arrived at based on the prevailing market prices of all the feed ingredients. Keeping the percentage of ingredients in view (Table 2), the cost per kg TD was ₹36.53/kg. Further, the cost of CNS (keeping the lab grade salt rates in view) was ₹3.5/5 g making it ₹147/calf for the whole experimental period. Similarly, the cost of hybrid Napier green fodder was considered as ₹4/kg.

Table 2. Proportion of ingredients and the rate

Ingredient	Ingredient (%)	Rate
Ragi straw, ground	10	11
Crushed maize	14	21
Ragi (Finger millet)	14	32
Crushed wheat	6	30
Jaggery	8	56
Groundnut cake (GNC)	26	38
Wheat bran	15	22
Vegetable oil	4	115
Mineral mixture	2	180
Common salt	0.50	10
Sodium bicarbonate	0.50	60

To estimate the economics of therapeutic diet feeding in the FMD infected animals in comparison to non-FMD infected animals, the body weight gain and cost of feeding during the experiment was considered. Therefore, the total cost of feeding per unit kilogram (kg) body weight was calculated. The data were analyzed using one way ANOVA (Analysis of Variance) single factor as per the standard statistical analysis.

RESULTS AND DISCUSSION

Table 3 represents the relative economics of therapeutic diet (TD) feeding to the infected animals. The table reveals that at the end of the experiment, animals gained 18.73, 19.67, 19.10 and 19.42 kg body weight in CON, TD-1, TD-2 and TD-3 respectively. Body weight gains between the groups were non-significant. The FMD non-infected group (CON) has relatively less body weight gain in comparison to FMD infected group. Among the infected group TD-1 marginally had higher body weight gain compared to the other two FMD infected groups. The probable reason could be due to higher TD intake compared to other two groups. Lower TD intake in TD -2 and TD -3 was mainly because of water content in the diet by virtue of cooking, which quickly fulfilled the satiety of the animal. Further, the total dry matter intake as per the body needs was fulfilled by green fodder intake. The therapeutic diet in the infected group helped calves quickly to regain their

Table 3. Economics of therapeutic diet feeding in FMD infected and non-infected groups

Particular	CON	TD-1	TD-2	TD-3
(a) Initial Body weight (kg)	121.25±28.02	125.83±11.47	120.50±10.23	124.50±14.40
(b) Final body weight(kg)	139.98±27.55	145.50±10.65	139.60±11.46	143.92±12.40
(c) Body weight gain (kg):b-a	18.73±1.83	19.67±3.33	19.10±3.52	19.42±2.35
(d) Therapeutic Diet (TD) consumed (kg)	11.08±2.21	10.46±0.97	10.29±0.85	9.59±0.86
(e) Cost of TD (₹)	404.84±80.58	382.20±35.58	375.81±31.05	350.22±31.26
(f) Green fodder consumed (kg)	35.35±2.40	35.31±3.00	36.44±2.47	39.76±1.35
(g) Cost of green fodder (₹)	141.40.00±9.60	141.23±12.02	145.75±9.90	159.04±5.40
(h) Total Cost of feeding (₹):e+g	546.24±80.56	523.43±44.23	521.56±32.39	509.00±34.47
(i) Cost/kg body weight gain (₹/kg):h/c	29.15±5.09	26.61±16.15	27.31±12.35	26.23±6.55
(j) Customized Nutrient Supplement(CNS) (₹)	_	_	_	147.00
(k) Medicine savings (₹/kg)	_	15.6	16.1	15.8

*Mean values between different treatments groups did not differ significantly.

body weight and also surpass the weight gain compared to the non-infected group. Although direct references are not available to discuss our study, we attempt here to make an indirect relation with available studies involving a change in the physical form of diet and supplementations. Ranjan *et al*. (2016) attempted by offering a soft diet like gruel containing whole rice, broken flour, finger millet flour and jaggery animals started taking feed gradually from the 3rd day and cows regained their milk yield up to normal (pre-infection level) in 25–35 days. Further, by topical application of paste (finger millet flour and honey) to the mouth lesions, the animals healed quickly. During FMD outbreaks, a paste made from five Sirumalai banana fruits and 25 ml Amanakku oil is beneficial in treating FMD when administered orally for three days (Rajkumar *et al.* 2014). The sick goats were fed with a fistful of rice gruel in 100 ml of water with salt and boiled to make it as porridge to ensure optimal feed intake (Devaki *et al.* 2021)

Our findings are in accordance with that of Choi *et al*. (2018), who found that combining antiviral medications orally and supplementary therapy with vaccines synergistically increased antiviral activity and prevented bodyweight loss in FMD pigs. Similarly, Li *et al*. (2009), found no significant difference in body weight between the mice with orally administered *Rhizoma Atractylodis Macrocephalae* (RAM) extract and the control mice administered with saline solution.

The total cost of feeding inclusive of both therapeutic diet and green fodder was ₹546.24, 523.43, 521.56 and 509 respectively. The total cost of feeding was non-significant among the groups. The feeding cost was highest in CON group due to the higher intake of both TD and green fodder. Among the infected groups, the cost was high in the TD-1 group and it was almost comparable with TD-2 group. Both these groups had similar intake of TD and green fodder. The cost of feeding in TD-3 group was low because of higher body weight gain. Cost per kg body weight gain was calculated as ₹29.15, 26.61 27.31 and 26.23 respectively. The cost per kg body weight gain was non-significant among the groups. The cost per kg body weight gain was highest in CON group compared to infected groups. Among the infected groups, the cost was similar for TD-1 and TD-3 group as they had similar body weight gain whereas the cost was marginally higher for TD-2 due to lesser body weight gain. The higher cost/kg body weight gain in CON group could be due to higher TD intake as reflected in the table. The higher TD was mainly due to the absence of any lesions in the non-infected group. Results are in agreement with Ghosh *et al.* (2010) who observed that the feed cost per kg body weight gain in crossbreed calves was 42.94% lower in the treatment group (receiving garlic extract supplementation) in comparison with control group. The garlic extract supplementation in the calf's diet increased growth and other performance significantly (Ghosh *et al.* 2010). Further, the cost per body weight gain would be highest (₹34) for TD-3 group if we include the cost of Customised Nutrient Supplement (CNS) which was worked out to be ₹147 per calf for the whole experiment. The CNS supplement used in the experiment was laboratory-grade which is usually higher compared to normal feed grade. The extra cost due to CNS inclusion in the TD-3 group might have helped in quicker healing of mouth lesions leading to normal intake of TD which further enhanced the body weight gain. The body weight gain on supplementation of CNS did not differ significantly which is in agreement with Jacometo *et al.* (2015) who reported that the effects of organic trace minerals supplementation during growth of the neonatal calf had no significant difference in body weight gain. Further, Arthington *et al*. (2015) also report that injectable trace minerals (ITM) had no impact on BW gain in performance of pre and post-weaned Brangus-crossbred beef calves.

Treatment cost is another burden to the farmer in the FMD outbreak in addition to milk production loss. The treatment involves the administration of antibiotics and antipyretics along with potassium permanganate ($KMnO_4$) for washing lesions and liquid paraffin for topical application. The cost of such treatment would involve ₹307 per calf if they were to be treated in the above conditions. This amount has been derived based on the cost of treatment on antibiotic, antipyretic, potassium permanganate and liquid paraffin at the prevailing market prices. Our table indicates that ₹15.6, 15.1, and 15.8 per kg body weight towards the treatment, would be reduced if the animal recovers quickly. So this has been witnessed even in our experimental animals due to quick recovery and no secondary or maggot infestation due to conduction of experiment in bio-containment (BSL III) facility.

It can be concluded from the present study that during FMD infection, the therapeutic diet feeding either mashed or cooked (with or without CNS) not only helped in regaining the body weight quickly but also reduced the feeding and treatment cost.

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