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Evaluation of silkworm pupae meal based calf starter diet on the performance of crossbred cattle calves

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ABSTRACT

The present experiment was conducted to evaluate the palatability, growth and economics of the silkworm pupae meal (SWPM) feeding, replacing fish meal (FM) in cattle calves. Crossbred cattle calves (15) around one-month of age were selected for the study and were divided into three equal groups (n=5) viz., T_0 (100% FM), T_1 (75% FM: 25% SWPM) and T_2 (50% FM: 50% SWPM). To estimate the growth parameters fortnightly, a growth trial of 90 days was conducted, and a digestibility trial of 7 days was conducted at the end of experiment. The results revealed non-significant differences between the experimental groups in DMI, OMI, periodical body weight, body weight gain, average daily gain (ADG) (g/d), feed conversion ratio (FCR), feed conversion efficiency (FCE) (%), digestibility coefficients of dry matter (DM), organic matter (OM) and crude protein (CP). Significant differences were observed in digestibility coefficients of crude fibre (CF), ether extract (EE) and nitrogen free extract (NFE) between the groups. The digestible nutrients intake revealed significant difference only in CPI (g/d) with higher values in T_0 followed by T_1 and T_2, but non-significant differences were observed in DDMI, DCPI and TDNI. The economics of feeding showed a decrease in the feed cost and feeding cost per kg body weight gain with increased inclusion of SWPM. Thus, it is concluded that costly FM can be replaced upto 50% level by SWPM without any adverse effect on feed intake, growth and nutrient utilization of crossbred cattle calves.

Keywords: Crossbred cattle, Digestibility, Economics, Fish meal, Growth, Silkworm pupae meal

The problem with fish meal (FM) is that it is costly and locally not available in sufficient quantities, thereby limiting the profitability of a dairy farm. Moreover, following the escalating costs, commonly used protein sources like FM are not ecologically or economically sustainable, and several traditional protein sources are forecasted to be short in supply within the next ten years mainly due to the increasing human population and unfavourable climatic situations (Barona *et al*. 2010). The ease of possibility of its adulteration with other low-quality ingredients, e.g., fish bones, sand, sawdust, further limits its future inclusion in the calf ration (Ali 1995). Among the other low-cost and economically and ecologically sustainable alternative sources of protein ingredients for livestock ration, silkworm pupae meal (SWPM) provides an excellent source, not only of an unconventional feed ingredient but of converting waste into wealth.

The principal by-product of silk factories obtained after the reeling process i.e., wounding off silk thread from the cocoon, is silkworm pupae (SWP) (Valerie *et al*. 2015). The UT of Jammu & Kashmir produces 1000MT of silk cocoons annually accounting for 60% of amount required by local reeling industries, which accounts for 600MT of silkworm pupae as a complete waste (Economic Survey 2017). Among various unconventional feed resources, SWP is one of the top-class protein source containing around 65-75% of crude protein. The dry cocoon weight of SWP is around 60% and has decent quantity of proteins and essential fatty acids (Rao 1994). It is an affordable and cheap ingredient, which is rich in both protein and fat in comparison to fish meal (Bhuiyan *et al*. 1989). Apart from containing high amount of protein and essential fatty acids, SWP contains a decent amount of crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), calcium (Ca), phosphorus (P), methionine and lysine (Habib and Hasan 1995). Despite of its high propensity to be used as a calf starter, as well as excellent quality at cheapest rate, there is no reported study evaluating its use in formulation of calf starter diets. The present study was undertaken to evaluate the growth and physical parameters of crossbred cattle calves fed with graded levels of SWPM.

MATERIALS AND METHODS

Healthy crossbred cattle calves (15; 30-40 days old) maintained at Mountain Livestock Research Institute

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(MLRI), Manasbal, J&K, India were chosen for the study. The calves were randomly distributed in three groups of five animals each, with average body weight of 37 kg.

Silk worm pupae meal formation: The pupae were collected from the local silk factory where they are otherwise treated as waste. The pupae were carried to the farm as such. It is pertinent to mention that the pupae were procured at minimal cost as the local factory disposes them out as a waste material, secondary to silk production. After procurement, silkworm pupae were first sun dried to reduce the moisture content and then grinded prior to formulation of rations for feeding to experimental animals. About 150 kg of pupae were bought and around 118 kg of SWPM was finally prepared which was stored in the feed store at ambient temperature and fed to the selected calves for a period of 90 days in graded levels, as per the already designed experiment for the study.

Experimental design and diets: The design of experiment was CRD. The dietary treatments were control (T_0), treatment-1 (T_1) and treatment-2 (T_2). In T_0, FM was added as an ingredient in concentrate mixture @ 10%, while FM was replaced at the levels of 25% and 50% by SWPM in T_1 and T_2 groups, respectively. All the feed ingredients and experimental rations were analysed for proximate composition (AOAC 2005) and mineral estimation viz., calcium and phosphorous (Talpatra *et al.* 1940). The diets offered to the experimental animals were iso-nitrogenous and iso-caloric, and formulated as per Indian Council of Agricultural Research recommendations (ICAR Research Databook 2013). The ingredient composition of the diet fed to the experimental animals is presented in Table 1. All the animals were fed same basal ration which constituted of chaffed green fodder (maize and sorghum), paddy straw and compounded concentrate mixture individually in equal divided doses in the morning (8:00 h) and evening hours (16:00 h) as per nutrient requirements of calves by ICAR (2013). Daily feed intake (dry matter) was recorded by subtracting the residue (dry matter) left by the animals from feed offered to the animals during 90-days study period.

Table 1. Ingredient composition of concentrate mixture used in experimental trial

Ingredient	Treatment[1]		
	T_0	T_1	T_2
Maize	45	45	45
Wheat bran	10	10	10
Mustard oil cake	10	10	10
Soyabean	22.5	22.5	22.5
Fish meal	10	7.5	5
Silkworm pupae meal	0	2.5	5
Mineral mixture	2	2	2
Salt	0.5	0.5	0.5
Total	100	100	100
%CP	23.70	23.73	23.75

[1]T_0 group contains 100% of fish meal in concentrate mixture, [1]T_1 group contains 75% of fish meal and 25% of silkworm pupae meal in concentrate mixture and [1]T_2 group contains 50% of fish meal and 50% of silkworm pupae meal in concentrate mixture. CP, crude protein.

Growth studies, digestion trial and economics of feeding: Body weight of the experimental animals were recorded for two consecutive days and the average body weight was considered as initial body weight for feeding experiment and then periodically body weight was recorded at fortnightly intervals. To know the actual effect of the diet, fortnight body weight gain, ADG (g/d), FCR and FCE (%) were calculated. At the end of the feeding experiment, a digestion trial of 7 days was conducted. Feeding economics was determined based on cost of experimental feed, average feed consumed and weight gain by the experimental animal.

Statistical analysis: The data generated in the experiment were analyzed by one way ANOVA, using, SPSS Software, Base 23.0 (SPSS Inc. Chicago, USA). The effects were considered to be significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

Chemical composition of experimental feeds and silkworm pupae meal: The chemical composition of the diet fed to the experimental animals is presented in Table 2. The chemical composition of SWPM is in harmony with Panda (1968), Choudhry *et al.* (1990), Ahamad *et al.* (2000) and Sheikh *et al.* (2005).

Feed consumption and body weight gain: The results of DM intake (g/d) and body weight gain did not show any significant different ($p>0.05$) between the treatment groups (Table 3). The average daily gain (g/d), FCR and FCE (%) also did not show any statistical difference ($p>0.05$), but were obviously improved in SWPM supplemented groups (Table 3). The improvement in body weight parameters of the treatment groups supplemented with silkworm pupae meal might be due to presence of substantial amount of critical amino acids like lysine (5.5%) and methionine (3.3%) in SWPM and thereby higher retention of nitrogen (Sengupta *et al.* 1995). The improved body weight gain of silkworm pupae meal supplemented treatment groups could also be due to presence of some unidentified growth factors which might accelerate the growth rate (Wijayasinghe and Rajaguru 1977, Horie and Watanabe 1980, Gowda 1996). The improvement might also be attributed to the composition of SWPM which contains vitamins like thiamine, riboflavin, pyridoxal, ascorbic acid, folic acid and minerals like calcium, phosphorus and iron that makes silkworm pupae further nutritive (Koundinya and Thangavelu 2005) and simulate mineral supplementation effects, much required in the growing calves.

Digestibility coefficient of nutrients, nutritive value of experimental rations and plane of nutrition: No significant difference ($P>0.05$) was observed in the apparent digestibility of dry matter, organic matter, crude protein, but the apparent digestibility of crude fibre, ether extract and nitrogen free extract showed significant difference ($P \leq 0.05$) in the groups of calves fed diets containing SWPM when matched to the control group (Table 4). These

Table 2. Chemical composition of experimental feeds and feed ingredients

Attribute	DM	OM	CP	EE	CF	NFE	TA	AIA	Ca	P
Maize	89.96	96.57	11.08	4.47	6.78	74.24	3.43	1.32	0.16	0.39
Wheat bran	87.43	96.07	14.00	3.03	4.43	74.61	3.92	1.48	0.26	0.88
MOC	91.4	93.19	26.83	8.31	6.52	51.53	6.80	3.53	0.10	0.12
Soybean	90.2	95.12	42.58	13.18	7.37	31.98	4.88	1.36	0.25	0.78
Fish meal	100.0	77.34	50.50	16.9	5.90	4.04	22.66	0.91	6.38	3.54
Silkworm pupae meal	79.31	83.79	51.58	19.23	3.85	9.13	16.21	1.75	0.96	0.78
Green fodder	29.00	91.47	7.50	2.36	23.80	56.56	8.53	3.82	0.78	0.57
Paddy straw	91.40	87.33	2.88	1.46	31.23	44.70	12.67	8.78	0.52	0.13
Experimental feeds (Concentrate mixtures)										
T_0	94.74	83.10	23.70	4.78	6.48	48.14	16.90	1.46	2.76	1.32
T_1	92.42	84.57	23.73	5.01	5.32	50.51	15.43	1.08	2.16	1.07
T_2	90.63	84.90	23.75	5.33	5.01	50.81	15.10	1.04	1.94	0.79
Total mixed ration (TMR)										
T_0	55.30	88.12	13.98	3.33	16.87	53.19	11.88	2.88	1.57	0.87
T_1	54.37	88.71	13.99	3.42	16.41	54.14	11.29	2.72	1.33	0.77
T_2	53.65	88.84	14.00	3.55	16.28	54.26	11.16	2.71	1.24	0.66

Mineral mixture consisted of Vitamin A - 7,00,000 IU, Vitamin D_3 - 70,000 IU, Vitamin E - 250 mg, Nicotinamide - 1000 mg, Co - 200 mg, Cu - 2000 mg, I - 325 mg, Fe - 1500 mg, Mg - 6000 mg, Mn - 1500 mg, K - 100 mg, Na - 5.9 mg, S - 0.72%, Zn - 15 g, Ca - 25% and P – 12.75%.

Table 3. Feed consumption and body weight gain

Parameter	T_0	T_1	T_2	SEM	p value
Initial BW	37.83	37.15	37.62	2.85	0.996
Final BW	59.89	60.65	62.72	3.28	0.945
Fortnight gain in weight	3.68	3.92	4.18	0.11	0.187
ADG (g/d)	251.76	261.11	278.89	7.33	0.311
DMI (g/d)	1737.30	1717.61	1708.76	38.55	0.954
FCR	7.57	7.24	6.66	0.28	0.415
FCE (%)	14.82	15.42	16.28	0.49	0.473

Values having different superscripts between the groups show significant difference ($P \leq 0.05$).

results are in concordance with the findings of Sheikh and Sapcota (2010). The better retention might be due to improved digestion, absorption and assimilation of dietary protein. The protein utilization efficiency of feed increased with increase in inclusion levels of SWPM in the diets, which indicates better protein utilization and improved essential amino-acids availability in the SWPM (Ijaya and Eko 2009b). Non-significant difference ($P>0.05$) was found statistically in DCP (%) and TDN (%) values between the groups, but comparatively higher values were witnessed in groups supplemented with SWPM than that of control group (Table 4).

Digestible dry matter intake (DDMI), crude protein intake (CPI), digestible crude protein intake (DCPI) and total digestible nutrient intake (TDNI) were calculated to compute the intake of digestible nutrients. No significant difference ($P>0.05$) in DDMI (kg/d), DCPI (g/d) and TDNI (g/d), but CPI (g/d) showed significant difference ($P \leq 0.05$) was observed in SWPM supplemented groups when compared to the control (Table 4).

Economics of feeding: One of the significant implications of the study was reduction in feed cost and

Table 4. Average digestibility coefficients, nutritive value of experimental rations and intake of digestible nutrients

Attribute	Group			SEM	p value
	T_0	T_1	T_2		
Digestibility of gross nutrients					
DM	65.70	65.80	66.13	0.44	0.931
OM	70.92	71.35	71.61	0.49	0.859
CP	81.88	82.36	82.49	0.32	0.739
EE	62.99^{a}	67.26^{b}	68.66^{b}	0.89	0.012
CF	73.08^{a}	75.26^{ab}	76.94^{b}	0.62	0.023
NFE	67.44^{b}	67.18^{ab}	63.83^{a}	0.73	0.067
Nutritive value of experimental rations					
DCP (%)	11.45	11.52	11.55	0.04	0.659
TDN (%)	64.37	65.42	65.80	0.53	0.559
Intake of digestible nutrients					
DDMI (kg/d)	1.51	1.43	1.50	0.03	0.539
CPI (g/d)	328.25^{b}	323.62^{ab}	320.25^{a}	1.28	0.023
DCPI (g/d)	263.30	250.69	261.72	3.92	0.388
TDNI (kg/d)	1.48	1.42	1.49	0.03	0.520

Values having different superscripts between the groups show significant difference ($P \leq 0.05$).

production cost per kg live weight in the treatment groups supplemented with either 25% or 50% SWPM as compared with control group (Table 5). In T_2 group, the reduction in the feed cost and production cost per kg live weight was lesser than T_1 when compared to T_0 group. The lower production cost was evident from the lower cost per kg of diet and relatively better feed conversation results were shown by SWPM supplemented groups. The feed cost per kg weight gain was found to be on higher side in the control group when compared with the treatment groups supplemented by SWPM. The results are in harmony with the findings of Saikia *et al.* (1971), Reddy *et al.* (1991), Khatun *et al.* (2005), Sheikh *et al.* (2006), Banday *et al.*

Table 5. Voluntary feed intake (DMI), FCR, cost of feeding (₹)/kg gain and % reduction in cost of feeding/kg gain of experimental animals

Attribute	Group		
	T_0	T_1	T_2
Total DMI (kg)	26.55	26.19	25.86
Total gain in body weight (kg)	3.68	3.92	4.18
FCR	7.57±0.50	7.24±0.55	6.66±0.40
Cost of feeding (₹)/kg gain	173.70	156.50	139.51
% reduction in cost of feeding/kg gain	-	9.90%	19.68%

(2008) and Dutta *et al.* (2012), who reported that the incorporation of SWPM in the diets would decrease the cost per kg live weight gain and results in high profit when compared with the control group.

The present findings of the experiment revealed that FM can be replaced successfully by SWPM upto 50% level without any adverse effect on feed intake, nutrient utilization and growth of the crossbred cattle calves. The feeding cost also decreased by increasing the inclusion of SWPM in the diet of calves. The palatability of SWPM could be further increased by addition of molasses or other such feed supplements, keeping the economics of feed in mind. However, further studies using large number of animals for long duration are recommended to ascertain the physiological, productive and reproductive performance of the animals under study and develop a general feeding schedule for inclusion of SWPM in cattle ration.

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