



The Impact of Feeding Non-defatted Silkworm Pupae Meal on Haemato-biochemical and Oxidative Stress Parameters of Crossbred Cattle Calves

Qazi Shehriyar Sahib¹, Haidar Ali Ahmed², Abdul Majeed Ganai², Gowher Gull Sheikh³, Ifla Aafaq⁴, Javid Farooq², Imran Ahmad Ganai⁵, Zubair Ahmed Akhoun⁵

10.18805/IJAR.B-5357

ABSTRACT

Background: The expenses on feed alone accounts around 55-60% to the total rearing cost of ruminants. In present time where the cost of feed is very high, it is very difficult to minimize the cost of production. Among feed ingredients, animal protein is quite expensive, thus, it is the need of the hour to unearth different unconventional feed resources to supply the nutrients to livestock and also for the profitability and sustainability of livestock sector. Among various important unconventional animal protein sources, silkworm pupae meal is one among them. The current study aimed to assess the effect of feeding non-defatted silkworm pupae meal on health status of crossbred calves.

Methods: Fifteen crossbred, female calves (30-40 days old, 35.21±2.72 kg body weight) were selected and equally distributed in a random manner to three treatments viz., control (CON), treatment-1 (TRT-25) and treatment-2 (TRT-50). In CON group, fish meal was added as an ingredient in concentrate mixture @10%, while in the treatments TRT-25 and TRT-50, fish meal was replaced with SWPM at the levels of 25% and 50%, respectively. A 90-days feeding trial was carried out to determine the effect of feeding SWPM on health status of calves.

Result: The haemato-biochemical parameters viz., Hb, PCV, RBC's, WBC's, blood glucose, ALT, AST, BUN, serum creatinine and A:G ratio revealed non-significant difference ($p>0.05$) between the treatment groups, while the values of total protein, albumin and globulin showed significant difference ($p\leq 0.05$) between the treatment groups. The results of oxidative stress parameters viz., SOD, GPx, Catalase and MDA revealed non-significant differences ($p>0.05$) between treatment groups. Hence, the study concluded that inclusion of SWPM upto 50% level in the calf starter ration had no adverse effect on the health status of crossbred calves.

Key words: Blood biochemistry, Crossbred calves, Hematology, Oxidative stress, Silkworm pupae meal.

INTRODUCTION

Prewaned calves are raised under a variety of feeding programs with a wide variation in housing and environmental conditions. Numerous studies have been carried out on calf starter, but major emphasis is laid to explore the role of intake of calf starter in an early weaning programme (Kertz *et al.*, 1979). Calves can be weaned early by promoting early intake of dry feed, by feeding of pre-starters along with milk or by feeding calf starter (Quigley *et al.*, 1994). The process during which calves transition from their neonatal dependence on nutrients supplied from milk to nutrients supplied from solid feed (cereal grains and hay) is of substantial financial importance to the producer. Development of rumen is an important physiological challenge for young ruminants (Gupta *et al.*, 2016) and this transition results in colossal metabolic ramifications to calf growth rate, for the reason that tissues must lean onto glucose supplied from milk to the metabolism of short-chain fatty acids as key energy substrates (Baldwin *et al.*, 2004). In pre-weaned dairy calf, solid feed intake (especially high carbohydrate diet) invigorates rumen microbial proliferation and volatile fatty acid production, eventually initiating rumen development (Suarez *et al.*, 2006; Gupta *et al.*, 2016).

Calves upto 3-4 months of age cannot synthesize all the essential amino acids, thus calf starter must contain a

¹Department of Animal Husbandry, Kishtwar, Jammu-182 204, Jammu and Kashmir, India.

²Division of Animal Nutrition, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shuhama, Alusteng, Srinagar-190 006, Jammu and Kashmir, India.

³Mountain Livestock Research Institute, Manasbal-193 504, Jammu and Kashmir, India.

⁴Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shuhama, Alusteng, Srinagar-190 006, Jammu and Kashmir, India.

⁵Division of Clinical Veterinary Medicine, Ethics and Jurisprudence, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shuhama, Alusteng, Srinagar-190 006, Jammu and Kashmir, India.

Corresponding Author: Qazi Shehriyar Sahib, Gowher Gull Sheikh; Department of Animal Husbandry, Kishtwar, Jammu-182 204, Jammu and Kashmir, India; Mountain Livestock Research Institute, Manasbal-193 504, Jammu and Kashmir, India. Email: gull2217@gmail.com, qazi.sahib14@gmail.com

How to cite this article: Sahib, Q.S., Ahmed, H.A., Ganai, A.M., Sheikh, G.G., Aafaq, I., Farooq, J., Ganai, I.A. and Akhoun, Z.A. (2025). The Impact of Feeding Non-defatted Silkworm Pupae Meal on Haemato-biochemical and Oxidative Stress Parameters of Crossbred Cattle Calves. Indian Journal of Animal Research. 1-6. doi: 10.18805/IJAR.B-5357.

Submitted: 18-03-2024 **Accepted:** 30-07-2024 **Online:** 17-01-2025

good quality protein source. In India, many of the organized farms or farmers have adopted the practice of weaning calves at or above 3 months of age and include animal protein (especially fish meal) in the starter diet. The importance of fish protein is due to its high biological value protein (Tiwari *et al.*, 2023), but the quality of fish meal is very much variable and availability is uncertain (Islam, 1993; Nazneen, 1995). In addition, fish meal is often adulterated with other ingredients, e.g. fish bones, sand, sawdust (Ali, 1995). So, alternate feed ingredients should be utilised to replace the costly fish meal. In the present experiment as an alternate to costly fish meal, SWPM was used at graded levels in the starter ration, to assess its effect on haemato-biochemical and oxidative stress parameters of crossbred cattle calves.

MATERIALS AND METHODS

Animal source

A total of fifteen healthy crossbred, female calves (30-40 days age) maintained at Mountain Livestock Research Institute (MLRI), Manasbal, SKUAST-K, Srinagar, were selected for the study. The trial animals were evenly divided in a random manner into three groups of five animals each viz., control (CON), treatment-1 (TRT-25) and treatment-2 (TRT-50), animals belonging to each treatment had average live weight of 35.21 ± 2.72 kg. The experiment was conducted from July to September, the average temperature during the experimental period was 20.8°C and the maximum temperature inside the shed was 24.7°C .

Experimental design and diets

The experimental design was CRD. The dietary treatments were control (CON), treatment-1 (TRT-25) and treatment-2 (TRT-50). In CON group, fish meal was added as an animal protein source in concentrate mixture at the level of 10%, while in treatment groups TRT-25 and TRT-50 groups fish meal was replaced by SWPM at the levels of 25% and 50%, respectively. The proximate composition of the experimental rations are presented in Table 1. The experiment was for a period of 90 days. The experimental animals were fed ration which constituted of chaffed green fodder (maize and sorghum), paddy straw and concentrate mixture individually in equal amount in the morning (08:00 am) and evening

hours (04:00 pm) as per nutrient requirements of calves by ICAR (2013).

Haemato-biochemical studies

The estimation of haemoglobin (Hb g/dl) and packed cell volume (PCV %) was executed by using Drabkin's solution and haematocrit tubes, while RBC and WBC counts was accomplished using haemocytometer. The blood glucose was evaluated after collection of blood by using Accu-Chek instant Glucometer. The estimation of ALT, AST, BUN, Creatinine, Total protein, Albumin and Total cholesterol was done by utilizing commercial diagnostic kits acquired from Span diagnostics limited, Surat, Gujarat, India. Globulin was estimated by subtracting albumin from total protein content and the A:G ratio was calculated by dividing albumin and the globulin concentrations.

Oxidative stress parameters

The activity of superoxide dismutase (SOD) was measured in hemolysate by an iodophenyl nitrophenol phenyl tetrazolium chloride modified method (RANSOD Kit, Randox, UK). The glutathione peroxidase (GPx) activity was evaluated by Paglia and Valentine's method in whole blood, using RANSEL Kit (Randox, UK), while the catalase activity was subjected to hemolysate according to Aebi's method. The quantification of serum malondialdehyde (MDA) was performed in serum by thiobarbituric acid method, for which reactive substances were quantified with thiobarbituric acid as peroxidation index.

Statistical analysis

The experimental data was evaluated by one-way ANOVA (SPSS Software, Base 23.0, for MacOS). The statistical equation used were as following:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where;

Y_{ij} = Parameter under analysis ij .

μ = Overall mean.

T_i = Effect due to treatments on the parameter under analysis.

e_{ij} = Experimental error for ij on the observation.

The significance of mean difference was tested by Duncan's New Multiple Range Test (DNMRT). The significance

Table 1: Proximate composition of experimental rations.

Proximate principle (%DMB)	Concentrate mixture			Roughage	
	CON	TRT-25	TRT-50	Paddy straw	Green roughage
Crude protein	23.70	23.73	23.75	2.88	7.50
Crude fibre	6.48	5.32	5.01	31.23	23.80
Ether extract	4.78	5.01	5.33	1.46	2.36
Nitrogen free extract	48.14	50.51	50.81	44.70	56.56
Total ash	16.90	15.43	15.10	12.67	8.53

Groups: CON- Control, TRT-25- Treatment group fed with 2.5% SWPM, TRT-50- Treatment group fed with 5.0% SWPM.

of data was considered at $p \leq 0.05$. The data is presented in the table as mean, SEM and p-values.

RESULTS AND DISCUSSION

The dietary treatments showed no significant effect ($p > 0.05$) on Hb (g/ dl) and PCV (%) levels (Table 2). The concentration of RBC's also did not disclose any significance ($p > 0.05$) up to 60 days of experiment, but at 90th day the results revealed significant difference ($p \leq 0.05$) where the values of TRT-50 were higher as compared to CON group (Table 2). The WBC count showed significant difference ($p \leq 0.05$) on 30th day in which higher values were detected in groups incorporated with SWPM (TRT-50 and TRT-25) as opposed to CON group and from 60 days onwards non-significant difference ($p > 0.05$) was observed between treatments (Table 2). The haematological framework is the most sensitive index to assess the health and pathological changes (Zhou *et al.*, 2009). The assay of blood indices has endorsed to be a valuable approach for analysing the health status of farmed birds/animals as these indices provide consistent information on metabolic disorders and stress status in an experimental setting (Bahmani *et al.*, 2001). From the present experiment it is evident that the hematological parameters remain unchanged; so, it specifies that replacement of fish meal with silkworm pupae meal had no antagonistic effects on the normal physiology of animals. The diet with different quantities of silkworm meal up to 100% level enhanced growth, hematological and physiological performance of

cat fish was reported by Olaniyi and Babasanmi (2013). The values observed for all treatments suggest the nutritional sufficiency of all diets with no malnutrition status (Church *et al.*, 1984). The RBC count showed non-significant differences ($p < 0.05$) among treatments and the values were in normal range as reported by Bhuiyan (1998). These observations correlated with the health of the birds and no mortality was observed in the study as well. The values of RBC's increases in association with superior quality protein in disease free animals was reported earlier (Ullah *et al.*, 2017). These results also coincided with the results of Ijaiya and Eko (2009b) who reported blood sugar, packed cell volume, white blood cell, red blood cell, haemoglobin showed no significant differences ($p < 0.05$) among the dietary treatment means when fish meal was replaced with silkworm caterpillar meal at 25%, 50%, 75% and 100% inclusion levels.

The existent study did not divulge any significant effect ($p > 0.05$) on blood glucose (mg/ dl) levels of experimental animals fed SWPM, presented in Table 3. The results of total protein, albumin, globulin and total cholesterol differ significantly ($p \leq 0.05$) between the treatment groups, showing the higher values for the treatment groups fed 5.0% of SWPM (TRT-50) followed by the animals fed 2.5% of SWPM (TRT-25) and then the control (CON) group. The A:G ratio did not show any significant difference ($p > 0.05$) between treatments. Data of liver function tests (ALT and AST) showed no significance ($p > 0.05$) between treatments (Table 3). The kidney function tests (BUN and creatinine)

Table 2: Hematological parameters of experimental animals.

Parameters	Days	CON	TRT-25	TRT-50	SEM	p value
Haemoglobin (g/dl)	0	8.44	8.50	8.52	0.07	0.912
	30	8.76	8.76	8.86	0.09	0.893
	60	8.92	8.94	9.18	0.10	0.586
	90	9.08	9.42	9.54	0.12	0.335
	Mean	8.80	8.91	9.03	0.08	0.610
Packed cell volume (%)	0	25.32	25.50	25.56	0.22	0.912
	30	26.28	26.29	26.58	0.27	0.893
	60	26.76	26.82	27.54	0.32	0.586
	90	27.24	28.26	28.62	0.38	0.335
	Mean	26.40	26.72	27.08	0.26	0.610
RBC's ($\times 10^6$ mL)	0	5.46	5.52	5.40	0.04	0.611
	30	5.70	5.82	5.94	0.04	0.071
	60	6.18	6.22	6.40	0.05	0.266
	90	6.48 ^a	6.52 ^{ab}	6.86 ^b	0.06	0.013
	Mean	5.95	6.02	6.15	0.04	0.139
WBC's (cells/mL)	0	5244.20	5242.80	5234.40	31.02	0.992
	30	5704.40 ^a	6241.00 ^b	6259.00 ^b	81.37	0.001
	60	6697.20	6816.20	6958.80	62.99	0.251
	90	7416.60	7630.60	7628.80	73.76	0.426
	Mean	6265.60	6482.65	6520.25	50.74	0.076

Values with different superscripts between the treatments differ significantly ($P \leq 0.05$).

Groups: CON- Control, TRT-25- Treatment group fed with 2.5% SWPM, TRT-50- Treatment group fed with 5.0% SWPM.

RBC- Red blood cells, WBC- White blood cells.

also showed non-significant differences ($p>0.05$) between treatment groups (Table 3). The blood biochemistry is significant to assess the animals' health status (Lumeij, 2008) and are further implemented to estimate the safety of different feed ingredients. Recent investigations with laying hens have not confirmed any effect from partial, or complete alternative of soybean meal in diets with either pupae meal, or black soldier fly larvae meal (Lalev *et al.*, 2023; Ullah *et al.*, 2017; Marono *et al.*, 2017). The results of liver function tests (ALT and AST) were in harmony with Ullah (2016) who

reported that on partial or complete replacement of soybean meal by silkworm meal (up to 0.05%) had no effect on liver enzymes. Numerically similar values of uric acid and creatinine confirmed unchanged rate of protein catabolism and confirmed normal kidney functioning. Some researchers (Ullah, 2016; Marono *et al.*, 2017; Bovera *et al.*, 2018; Kim *et al.*, 2020), also confirmed lack of any effect from the inclusion of black soldier fly larvae or pupae meals on protein metabolism. Gugolek *et al.* (2021) reported that the inclusion of SWPM in the diets of rabbits have shown

Table 3: Changes in biochemical parameters of experimental animals.

Parameters	CON	TRT-25	TRT-50	SEM	<i>p</i> value
Blood glucose (mg/dl)	60.34	60.57	61.11	0.27	0.545
Total protein (g/dl)	6.14 ^a	6.51 ^b	6.91 ^c	0.08	<0.05
Albumin (g/dl)	2.37 ^a	2.52 ^b	2.71 ^c	0.04	<0.05
Globulin (g/dl)	3.77 ^a	3.99 ^b	4.20 ^c	0.05	<0.05
A:G ratio	0.63	0.63	0.65	0.008	0.669
Total cholesterol (mg/dl)	72.31	79.39	80.00	1.00	<0.05
Liver function tests					
ALT (units/L)	25.08	23.66	26.45	0.86	0.446
AST (units/L)	34.46	34.89	34.95	0.21	0.625
Kidney function tests					
BUN (mg/dl)	14.99	14.97	14.92	0.06	0.928
Creatinine (mg/dl)	1.49	1.50	1.50	0.006	0.874

Values with different superscripts between the treatments differ significantly ($P\leq 0.05$).

Groups: CON- Control, TRT-25- Treatment group fed with 2.5% SWPM, TRT-50- Treatment group fed with 5.0% SWPM.

ALT- Alanine transaminase, AST- Aspartate aminotransferase, BUN-Blood urea nitrogen.

Table 4: Average oxidative stress parameters of experimental animals.

Parameters	Days	CON	TRT-25	TRT-50	SEM	<i>p</i> value
Superoxide dismutase (IU/g Hb)	0	1746.12	1752.43	1743.09	20.44	0.985
	30	1889.15	1900.29	1935.14	14.56	0.436
	60	2209.52	2255.07	2353.33	40.44	0.358
	90	2579.31	2595.62	2603.25	24.17	0.929
	Mean	2106.03	2125.86	2158.69	16.93	0.472
Glutathione Peroxidase (IU/g Hb)	0	309.53	308.51	308.78	3.97	0.995
	30	316.11	318.49	321.05	2.85	0.804
	60	328.69	329.93	335.21	3.17	0.705
	90	334.66	338.90	343.49	3.99	0.698
	Mean	322.25	323.96	327.13	2.83	0.801
Catalase (k/g of Hb)	0	13.75	13.76	13.73	0.06	0.986
	30	14.10	14.08	13.85	0.19	0.868
	60	14.21	14.15	13.70	0.22	0.637
	90	14.88	14.31	13.64	0.25	0.127
	Mean	14.23	14.07	13.73	0.14	0.364
Lipid peroxidase MDA (μ mol/L)	0	2.13	2.14	2.13	0.04	0.998
	30	2.25	2.16	2.12	0.03	0.449
	60	2.34	2.18	2.09	0.05	0.128
	90	2.44	2.21	2.09	0.06	0.106
	Mean	2.29	2.17	2.11	0.04	0.217

Values with discrete superscripts between the treatments differ significantly ($P\leq 0.05$).

Groups: CON- Control, TRT-25- Treatment group fed with 2.5% SWPM, TRT-50- Treatment group fed with 5.0% SWPM.

MDA- Malondialdehyde.

an increase in the concentration of plasma albumin, while the total plasma protein levels remained unaffected. Same results were reported by Nandeesh *et al.* (1998) and Tona *et al.* (2006). Previous researches have demonstrated that the presence of total protein in blood is directly linked to the amount of available protein in the diet (Gasco *et al.*, 2019). In the present study, concentration of albumin and globulin both increased in response to SWPM incorporation.

The present experiment revealed non-significant effect ($p>0.05$) on oxidative stress parameters *viz.*, SOD, GPx, Catalase and MDA, of experimental animals fed SWPM, presented in Table 4. The values showed improved results by incorporating the SWPM in the ration of crossbred calves. Minimal work has been carried out on using silkworm pupae meal as a feed constituent in calf starter ration and especially on oxidative stress parameters of calves. The results of SOD and MDA showed disagreement with the findings of Ji *et al.* (2015), who revealed that high dietary silkworm pupae meal levels significantly decreased hepatic SOD activity and increased MDA content, showing that the diets containing higher silkworm pupae levels induced oxidative stress and lipid peroxidation and return to damage the hepatopancreas.

CONCLUSION

The verdict of the current experiment revealed that SWPM can be incorporated upto 50% replacing fish meal without manifesting any ill effect on haemato-biochemical and oxidative stress parameters of crossbred cattle calves. Thus, SWPM shows potential to replace costly fish meal as animal-based protein in the calf starter diets. Further studies are suggested on incorporation of SWPM as feed ingredient in calf starter ration for longer duration.

Ethics approval

The experimental animals were handled as per approved trial protocol regulations of the Institutional Animal Ethics Committee of SKUAST-Kashmir.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- Ali, M.S. (1995). Effect of replacement of fishmeal by soyabean meal on the performance of broilers. M.Sc. Thesis. Department Poultry Science. Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Bahmani, M., Kazemi, R. and Donskaya, P.J.F.P. (2001). A comparative study of some hematological features in young reared sturgeons (*Acipenser persicus* and *Huso huso*). *Fish Physiology and Biochemistry*. 24: 135-140.
- Baldwin, R.L., McLeod, K.R., Klotz, J.L. and Heitmann, R.N. (2004). Rumen development, intestinal growth and hepatic metabolism in the pre and post-weaning ruminant. *Journal of Dairy Science*. 87: 55-65.
- Bhuiyan, M.Z. (1998). Complete replacement of fish meal by full fat soybean and supplementation of lysine and methionine to broilers. Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Bovera, F., Loponte, R., Pero, M.E., Cutrignelli, M.I., Calabrò, S., Musco, N., Vassalotti, G., Panettieri, V., Lombardi, P., Piccolo, G. and Di Meo, C. (2018). Laying performance, blood profiles, nutrient digestibility and inner organs traits of hens fed an insect meal from *Hermetia illucens* larvae. *Research in Veterinary Science*. 120: 86-93.
- Church, J.P., Judd, J.T., Young, C.W., Kelsay, J.L. and Kim, W.W. (1984). Relationships among dietary constituents and specific serum clinical components of subjects eating self-selected diets. *American Journal of Clinical Nutrition*. 40(6): 1338-1344.
- Duncan, D.B. (1955). Multiple Range and Multiple F Test. *Biometrics*. 11: 1-24.
- Gupta, S.K., Singh, P., Shinde, K.P., Lone, S.A., Kumar, N. and Kumar, A. (2016). Strategies for attaining early puberty in cattle and buffalo: A review. *Agricultural Reviews*. 37(2): 160-167. doi: 10.18805/ar.v37i2.10741.
- Gupta, M., Khan, N., Rastogi, A. and Varun, T.K. (2016). Nutritional drivers of rumen development: A review. *Agricultural Reviews*. 37(2): 148-153. doi: 10.18805/ar.v37i2.10740.
- Gasco, L., Dabbou, S., Trocino, A., Xiccato, G., Capucchio, M.T., Biasato, I., Dezzutto, D., Birolo, M., Meneguz, M., Schiavone, A. and Gai, F. (2019). Effect of dietary supplementation with insect fats on growth performance, digestive efficiency and health of rabbits. *Journal of Animal Science and Biotechnology*. 10: 1-9.
- Gugolek, A., Kowalska, D., Strychalski, J., Ognik, K. and Juśkiewicz, J. (2021). The effect of dietary supplementation with silkworm pupae meal on gastrointestinal function, nitrogen retention and blood biochemical parameters in rabbits. *BMC Veterinary Research*. 17(1): 1-14.
- ICAR. (2013). *Agricultural Research Data Book*. Indian Council of Agricultural Research, New Delhi. India.
- Ijaiya, A.T., Eko, E.O. (2009b). Effect of replacing dietary fish meal with silkworm (*Anaphe infracta*) caterpillar meal on growth, digestibility and economics of production of starter broiler chickens. *Pakistan Journal of Nutrition*. 8(6): 845-849.
- Islam, M.A. (1993). Use of Marine and Shrimp Waste in Broiler Diet. M.Sc. Thesis, Department of Poultry Science. Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Ji, H., Zhang, J.L., Huang, J.Q., Cheng, X.F. and Liu, C. (2015). Effect of replacement of dietary fish meal with silkworm pupae meal on growth performance, body composition, intestinal protease activity and health status in juvenile Jian carp (*Cyprinus carpio* var. *Jian*). *Aquaculture Research*. 46(5): 1209-1221.
- Kertz, A.F., Prewitt, L.R. and Everett, J.P. (1979). An early weaning calf program: Summarization and review. *Journal of Dairy Science*. 62(11): 1835-1843.
- Kim, D.W., Kim, S.R., Choi, K.H. and Nho, W.G. (2020). Effect of dietary supplementation of silkworm powder on laying performance, egg quality, blood characteristic and egg storage stability in laying hens. *Resources Science Research*. 2(1): 47-57.

- Lalev, M., Mincheva, N., Hristakieva, P., Ivanova, I. and Oblakova, M. (2023). Effect of inclusion insect meals in feed on performance, blood biochemical and immune parameters of layer hens. *Bulgarian Journal of Agricultural Science*. 29(5): 938-945.
- Lumeij, J.T. (2008). *Avian Clinical Biochemistry*. In: *Clinical Biochemistry of Domestic Animals* (6th Edition). Academic Press, San Diego. pp. 839-872.
- Marono, S., Loponte, R., Lombardi, P., Vassalotti, G., Pero, M.E., Russo, F., Gasco, L., Parisi, G., Piccolo, G., Nizza, S. and Di Meo, C. (2017). Productive performance and blood profiles of laying hens fed *Hermetia illucens* larvae meal as total replacement of soybean meal from 24 to 45 weeks of age. *Poultry Science*. 96(6): 1783-1790.
- Nandeesh, M.C., Shikanth, G.K., Varghese, T.J., Keshavant, P. and Shetty, H.P.C. (1998). Influence of silkworm pupae based diets on growth, organoleptic quality and biochemical composition of catla-rohu hybrid. *Aquaculture Research in Asia. Management Techniques and Nutrition*. Pudoc press, Wageningen. pp. 211-220.
- Nazneen, T. (1995). Economic feasibility of feeding broiler offals as replacement of fishmeal on the performance of growing pullets up to sexual maturity. M.Sc. Thesis. Department of Poultry Science. Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Olaniyi, C.O. and Babasanmi, G.O. (2013). Performance characteristics of African Cat fish (*Clarias gariepinus*) fed varying inclusion levels of silk worm pupae (*Anaphe infracta*). *Bangladesh Journal of Animal Science*. 42(1): 76-80.
- Quigley III, J.D., Bernard, J.K., Tyberend, T.L. and Martin, K.R. (1994). Intake, growth and selected blood parameters in calves fed calf starter via bucket or bottle. *Journal of Dairy Science*. 77(1): 354-357.
- Sua' rez, B.J., Van Reenen, C.G., Gerrits, W.J.J., Stockhofe, N., van Vuuren, A.M. and Dijkstra, J. (2006). Effects of supplementing concentrates differing in carbohydrate composition in veal calf diets: II. Rumen development. *Journal of Dairy Science*. 89: 4376-4386.
- Tiwari, M., Bordoloi, P.L. and Barooah, M.S. (2023). Quality evaluation of fish powder developed from labeo bata, a minor carp of Assam. *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DR-2057.
- Tona, G.O., Togun, V.A. and Oladele, B.A. (2006). Effect of different levels of cocoa bean shell on the haematological characteristics of mature cocks. *Proceedings of 11 Annual Conference of Animal Science Association, Ibadan, Sept*, pp. 35-37.
- Ullah, R., Khan, S., Khan, N.A., Mobashar, M., Sultan, A., Ahmad, N. and Lohakare, J. (2017). Replacement of soybean meal with silkworm meal in the diets of white leghorn layers and effects on performance, apparent total tract digestibility, blood profile and egg quality. *International Journal of Veterinary Health Science and Research*. 5(7): 200-207.
- Ullah, R. (2016). Replacement of soybean meal with silkworm meal (*Bombyx mori*) in poultry ration. Dissertation The University of Agriculture, Peshawar, Pakistan.
- Zhou, X., Li, M., Abbas, K. and Wang, W. (2009). Comparison of haematology and serum biochemistry of cultured and wild Dojo loach *Misgurnus anguillicaudatus*. *Fish Physiology and Biochemistry*. 35: 435-441.