



Evaluation of dietary incorporation of treated waste silkworm pupae meal on nutrient utilization and performance of broiler chicken

AANVI¹, RAMESH KUMAR SHARMA¹, NAZAM KHAN², ANKUR RASTOGI¹,
ANAND KUMAR PATHAK¹ and VIJAY KUMAR SHARMA^{3✉}

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir

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ABSTRACT

The most expensive component in poultry feed formulations is protein of animal origin. Considerable emphasis is placed on exploring alternative protein sources to reduce feeding costs. In this context, the present study evaluated the effect of incorporating ethanol-treated waste silkworm pupae meal (WSWPM-ET) in broiler chicken diets on their production performance, carcass characteristics, immunological responses, and blood-biochemical profile. The proximate composition of WSWPM-ET (on dry matter basis) was as follows: crude protein (CP) $51.97 \pm 0.67\%$, ether extract (EE) $9.23 \pm 0.06\%$, crude fiber (CF) $4.58 \pm 0.28\%$, total ash (TA) $4.89 \pm 0.07\%$, nitrogen-free extract (NFE) $29.31 \pm 0.79\%$, calcium (Ca) $0.23 \pm 0.01\%$ and phosphorus (P) $0.90 \pm 0.01\%$. Notably, the EE content of the untreated sample was 37.43%, indicating that the treatment method employed was effective in achieving the desired partial defatting. A total of 225 day-old broiler chicks were randomly allocated into five groups, each consisting of three replicates of 15 chicks. The control (C) group was fed a basal diet, while the treatment groups (T1, T2, T3, and T4) received diets in which meat and bone meal (MBM) was replaced with WSWPM-ET at 25%, 50%, 75%, and 100% levels, respectively. At the conclusion of the 42-day growth trial, two birds from each replicate were slaughtered for carcass evaluation. The findings suggest that WSWPM-ET can successfully replace MBM up to 75% in broiler rations without any adverse effects on growth performance, health status, or production traits.

Keywords: Broiler chicken ration, Meat-cum-bone meal, Nutrient metabolizability, Treated waste silkworm pupae meal (WSWPM-ET)

The scarcity of feed is one of the main obstacles impeding the growth of the livestock industry in the nation (Prusty *et al.* 2017., Prusty *et al.* 2016). The need for traditional feed ingredients, such as soybean meal and oil, has increased due to the poultry industry's rapid development, pushing up costs and adding to environmental pressure (Sharma *et al.* 2013., Datt *et al.* 2017., Singh *et al.* 2012). Paving way to ever-increasing interest in protein-rich bug species as innovative additives for poultry feeds due to the hunt for sustainable alternatives. About 90% of the global production of silk arises from cocoons of domestic mulberry silkworm (*Bombyxmori*), a moth belonging to the family Bombycidae. Nevertheless, they are frequently

thrown away, which results in the loss of possible nutrients and a further environmental issue (Wang *et al.* 2010). The spent worm pupae is a waste material and used as soil fertiliser or is discarded in the environment (Wei *et al.* 2009). From a nutritional perspective, the CP content of silkworm pupa meal ranges from 52 to 80% on a DM basis and 35–40% of its total fatty acids (FAs) are omega-3, it is also a noteworthy source of healthful lipids (Makkar *et al.* 2014; Tassoni *et al.* 2022). The present study was done to assess the nutritional content of treated waste silk worm pupae meal, and the impact of treated waste silk worm pupae meal-containing ration on broiler chicken growth and performance.

MATERIALS AND METHODS

The present trial was carried out, using two hundred twenty five day-old broiler chicks. The feeding trial was undertaken for six weeks to evaluate the effects of treated waste silk worm pupae meal containing ration on intake and utilization of nutrients, blood biochemical profile and immune response of broiler chicken.

The research work was carried out in the poultry shed of the Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and

Present address: ¹Division of Animal Nutrition, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), Jammu and Kashmir, India.²Livestock Farm Complex, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), Jammu and Kashmir, India.³Directorate of Extension, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), Jammu and Kashmir, India. ✉Corresponding author email: vjsharmandri@gmail.com

Technology of Jammu, R. S. Pura, Jammu during the months of March, April and May. The chemical analysis of feed and excreta samples and evaluation of blood biochemical parameters were carried out in the Department of Animal Nutrition, and the slides of micrometric parameters of intestines were analysed in the Department of Veterinary Anatomy of the Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, R. S. Pura, Jammu.

Collection and defatting procedure of waste silkworm pupa meal: Waste silk worm pupae meal (WSWPM) was purchased from silk rearing farmers of Jammu region. The purchased WSWPM was ground and dried to moisture content of 10% or less. It was partially defatted by soaking it in an organic solvent (absolute ethanol) in the ratio of one part of WSWPM to 3 parts of ethanol for two hours at room temperature. After treatment, the defatted WSWPM was collected by sieving and collected material was sun dried for further use in *in vivo* feeding trial. The WSWPM-ET (Waste silkworm pupae meal- ethanol treated) was analyzed for its proximate constituents. Based on the chemical composition of the available WSWPM-ET, different rations containing different levels of WSWPM-ET was prepared for broiler chicken.

Feeding and management: The chicks were given electrolyte (Electral® by FDC Limited, India, containing NaCl-3.5g, KCl-1.5g, Tri sodium citrate dihydrate - 2.9 g, and Dextrose-20.0 g per 2 liters of water) through drinking water after arriving at the poultry house from the hatchery. The appropriate feed was then sprinkled on papers inside the brooding area for easier consumption and feed recognition by the chicks. To meet the requirements of ICAR (2013), three distinct feed mashes made of maize and soybeans were made and given to the birds viz. pre-starter, starter, and finisher. Chicks were fed a pre-starting diet from day 1 to day 14, a starter diet from day 14 to day 21, and a finisher diet from day 21 to day 42.

Metabolism trial: Two birds per replication participated in a 4-day metabolic trial that was carried out during the final week of the experiment (days 37–40). During this time, the birds were kept in a metabolic cage in pairs, and each bird's excrement was collected every day in pairs. 6 birds were slaughtered per treatment group (two birds per replicate) at the end of the growth trial (42 days old) in order to gather samples for intestinal segment micrometry, antioxidant assays, and carcass yield.

Methods of analysis : Dry matter, crude protein, ether extract, crude fibre, total ash, and nitrogen-free extract were among the proximate principles measured in the offered and residual feed and faeces (AOAC, 2012). Calcium and phosphorus levels were also determined in the feed samples.

Survivability: The percentage of deaths was recorded during the experiment. An extensive post-mortem examination of the deceased birds was carried out in order to ascertain the cause of death. The survival % was calculated using the formula:

$$\text{Survivability (\%)} = \frac{\text{The number of birds that survived} \times 100}{\text{Total number of birds housed at the beginning}}$$

Carcass characteristics: Six birds per treatment group (2 birds per replicate) were slaughtered at the end of feeding trial (42 days age). Before slaughter, all of the experimental birds were weighed.

Blood biochemical profile: Using ERBA Diagnostic Kits, produced by Transasia Bio-Medicals Limited in technical cooperation with ERBA diagnostics Mannheim GmbH, all the biochemical parameters, including total protein, albumin, globulin, globulin ratio, cholesterol, triglycerides, and aspartate amino transferase (AST or SGOT) and alanine amino transferase (ALT or SGPT), were evaluated in the serum.

Statistical analysis: A one-way analysis of variance was used to analyse the generated data as per Snedecor and Cochran (1994). Duncan's multiple range test was used to rank the means that differed significantly (Duncan, 1955).

RESULTS AND DISCUSSION

The current study analysed at how broiler chicken growth performance, overall economics, and nutrient consumption were affected when graded amounts of WSWPM-ET were substituted for MBM.

Chemical composition of feed ingredients: Before commencing the ration formulation of the experimental birds (pre-starter, starter and finisher), WSWPM-ET and meat and bone meal were analyzed for proximate constituents, calcium and phosphorus.

The WSWPM-ET on DM basis in the current study had 51.40 % CP, 9.3 % EE, 5.45 % CF, 4.93% TA, 28.92 % NFE, 0.22% Ca, and 0.92% P. B. Defatted silkworm pupae meal was found to have 2.5% EE, 4% CF, and 68.7% CP, according to Panda (1970). According to Sheikh et al. (2018), the meal's CP composition ranged from 50% to over 80% on a dry matter (DM) basis, while its mineral content was comparatively low (3–10% DM). The results of this study are in contrary to those of Rashmi *et al.*, (2022), who found that the defatted silkworm pupae (DSWP) meal had higher CP (68.7) than the fatted silkworm pupa meal (FSWP), and SBM, but lower ether extract (3.94) than the FSWP. Zotte *et al.* (2021) reported that the CP content of defatted silkworm pupae meal was 66.7%, which was higher than that observed in the current investigation for the untreated sample was 53.37 %.

The chemical composition (g/kg, as feed base) of 4% defatted silkworm pupa meal (SWM-DEF) was calculated by Zsedely *et al.* (2022). The crude protein content in defatted pupae of two distinct hybrids was found to be approximately 55.7% in a research carried out by Bandlamori *et al.* in 2012. The differences in the chemical composition may be due to different agro-climatic conditions or species of silkworm pupae, the chemical composition of mulberry plants on which silkworm is reared and methodology adopted for defatting.

The CP content (%) of the pre-starter ration on a DM

Table 1. Effect of supplementation of WSWPM-ET on weekly feed intake (g) of broiler chicken

Attributes	Groups				
	C	T1	T2	T3	T4
Week 1	126.57±3.75	124.87±3.19	126.21±3.18	126.11±2.10	129.67±3.17
Week 2	289.25±6.62	288.32±3.26	294.63±5.34	294.48±4.59	292.07±4.35
Week 3	672.45±16.35	667.46±12.59	671.21±11.89	670.13±16.41	674.34±15.24
Week 4	850.33±28.71	838.83±23.06	843.45±36.31	836.39±30.71	831.39±30.93
Week 5	1274.13±32.73	1269.63±34.40	1291.23±39.78	1275.03±34.59	1238.33±35.98
Week 6	1345.83±45.81	1329.23±59.99	1347.03±39.82	1337.83±31.68	1338.53±30.53

Control (C; contains 0 % WSWPM), T1, T2, T3 and T4 has 1.25%, 2.5%, 3.75% and 5% of WSWPM-ET respectively.

basis was 21.97 in the control group and 22.09; meanwhile, the T1, T2, T3, and T4 rations had CP content (%) of 21.99, 22.01, and 22.07, respectively. In the control, T1, T2, T3, and T4 groups, the finisher ration had (%) DMB CP of 19.50, 19.51, 19.48, 19.50, and 19.49, whereas the starting ration had (%) DMB CP of 21.54, 21.50, 21.51, 21.51, and 21.50 in those groups. The given figures confirm that the components of the ration were accurately combined to produce isonitrogenous meals in compliance with ICAR (2013).

Feed Intake: The feed intake data are displayed in tables 1 and 2. During the feeding trial, the experimental groups' average feed intake (g) varied from week 1 to week 6 in the C, T1, T2, T3, and T4 groups, respectively, with no statistically significant change ($P > 0.05$). The results of this investigation are consistent with those of Zsedely *et al.* (2022), who found no statistically significant difference

($P > 0.05$) in the daily feed intake (g/day/bird) between the control and dietary groups on regimens substituting soybean meal for defatted silkworm meal.

Body weight and body weight gain: Table 2 display the average body weight, body weight gain (g) and cumulative body weight gain of the growth trial in C, T1, T2, T3, and T4. As per Zsedely *et al.* (2022) findings, chickens in all experimental groups consistently displayed comparable live weight and weight gains ($P > 0.05$), which was consistent with the current findings of replacing MBM up to 75% inclusion levels of WSWPM-DEF.

The effects of substituting defatted silkworm pupae meal (SPM) for fish meal (FM) in Pacific white shrimp (*Litopenaeus vannamei*) were examined by Rahimnejad *et al.* (2019). Specifically, a basal diet containing 24% FM was created, and then 25, 50, 75, or 100% of FM was substituted with SPM (referred to as FM, SPM25, SPM50,

Table 2. Effect of supplementation of WSWPM-ET on feed intake, body weight gain, feed conversion ratio and protein efficiency ratio during pre-starter, starter and finisher phase of broiler chicken

Phase	Groups				
	C	T1	T2	T3	T4
	Feed intake (g)				
Pre-starter	415.81± 10.06	413.19±1.43	420.83±6.33	420.58±5.24	421.74±2.17
Starter	672.45 ± 16.36	667.46±12.59	671.21±11.90	670.12±16.41	674.33±15.24
Finisher	3470.16±68.30	3437.54±112.50	3481.62±78.13	3449.14±58.69	3408.03±96.21
	Body weight gain (g)				
Pre-starter	336.94 ^b ±6.71	334.15 ^{ab} ±11.95	323.92 ^{ab} ±8.09	324.63 ^a ±7.89	303.11 ^a ±7.97
Starter	414.60±8.30	417.16±11.92	406.59±7.52	408.28±4.45	403.44±5.56
Finisher	1527.22 ^b ±31.87	1496.87 ^b ±30.92	1494.84 ^b ±20.04	1476.60 ^b ±27.33	1358.45 ^a ±29.60
	Feed conversion ratio				
Pre-starter	1.23 ^a ±0.04	1.26 ^{ab} ±0.05	1.29 ^{ab} ±0.05	1.29 ^{ab} ±0.04	1.38 ^b ±0.05
Starter	1.62±0.07	1.60±0.05	1.65±0.06	1.64±0.06	1.67±0.05
Finisher	2.26±0.08	2.30±0.11	2.32±0.04	2.33±0.08	2.50±0.08
	Protein efficiency ratio				
Pre-starter	3.69 ^{ab} ±0.14	3.83 ^b ±0.20	3.51 ^{ab} ±0.14	3.41 ^{ab} ±0.12	3.28 ^a ±0.11
Starter	2.87±0.12	2.90±0.08	2.82±0.10	2.83±0.10	2.78±0.09
Finisher	2.33±0.07	2.33±0.10	2.29±0.05	2.29±0.08	2.12±0.07

^{abc}Mean with different superscript within a row differ significantly ($P < 0.05$); Control (C; contains 0 % WSWPM), T1, T2, T3 and T4 has 1.25%, 2.5%, 3.75% and 5% of WSWPM-ET respectively.

Table 3. Mean nutrient metabolizability (%) during metabolism trial of broiler chicken supplemented with WSWPM-ET

Attributes	Groups				
	C	T1	T2	T3	T4
DM	76.34±1.19	76.07±1.29	75.8±1.50	74.96±0.98	74.2±0.98
OM	75.06±0.98	74.80±0.98	74.93±1.33	73.90±1.33	72.73±1.28
CP	75.17±0.49	74.76±1.13	74.73±1.04	74.83±1.09	74.33±1.76
EE	72.930±83	73.50±0.90	73.04±0.86	70.90±0.77	70.70±1.23
CF	56.39±0.70	56.10±1.12	56.20±1.36	53.23±1.30	52.86±1.61
TA	67.16±1.36	66.73±1.59	66.73±1.80	64.86±1.07	64.97±0.53
NFE	74.28±1.04	74.36±1.12	73.80±1.22	73.36±1.32	73.04±1.35

Control (C; contains 0 % WSWPM), T1, T2, T3 and T4 has 1.25%, 2.5%, 3.75% and 5% of WSWPM-ET respectively.

SPM75, and SPM100 diets, respectively). No significant difference ($P > .05$) was observed in growth performance among FM and SPM groups. In a different investigation, Xu *et al.* (2018) examined the impacts of supplying enzymatic hydrolysates of defatted silkworm pupa (EHDSP) as a dietary supplement to young mirror carp (*Cyprinus carpio* var. *specularis*). Although the growth of the rohu fed with SWP was observed to be poor, Jayaram *et al.*, (1980) observed that the poor growth of the catla given with 30% non-deoiled silkworm pupae diet was caused by the fish's low fat demand. Kumar *et al.*, (2021) conducted a 60-day growth trial in floating cages. Another study found that *Cyprinus carpio* showed much better growth when fed a diet that included 10% pupae and 15% fishmeal. The study also examined the effects of substituting 10, 15, 20, and 25% of de-oiled pupae for fishmeal in a feeding trial (Nandeeshha *et al.*, 1989).

Feed conversion ratio (FCR): The feeding trial's weekly and cumulative FCRs for each treatment and control group are shown in Table 2. No significant changes ($P > 0.05$) were seen in any of the experimental groups during the feeding study from week 1 to week 3 or week 5 respectively. In a study of Zsedely *et al.*, in 2022, chicken diets were supplemented with 4% defatted silkworm (SWM-DEF) meal. When compared to untreated fresh silkworm pupae (SWP) pastes and fishmeal, fermented SWP silage significantly increased body weight gain, feed conversion ratio (FCR), and specific growth rate (SGR) in the diets of carp species (Karthick *et al.*, 2019). Furthermore, studies have demonstrated that incorporating 50% deoiled silkworm pupae into the diet enhanced Mahseer growth outcomes (Shyama *et al.*, 1993). De-oiled SWP added to fish feed showed superior conversion than the conventional feed blend of rice bran and mustard oil cake (1:3) (Nandeeshha *et al.* 1989).

In terms of the protein efficiency ratio and feed conversion rate of the experimental fish in the EHDSP25 and EHDSP50 groups, the effects of dietary supplementation of enzymatic hydrolysates of defatted silkworm pupa (EHDSP) were not significantly different from EHDSP0, according to Xu *et al.* 2018 study. It was observed in a polyculture system containing Indian carp (*Catla catla*), mrigal carp

(*Cirrhinus mrigala*), rohus (*Labeo rohita*), and silver carp (*Hypophthalmichthys molitrix*), addition of fresh silkworm pupae paste (untreated) or fermented silkworm pupae silage to carp feed formulations instead of fish meal, fermented silkworm pupae silage had a higher feed conversion ratio and specific growth rate (Rangacharyulu *et al.*, 2003).

Nutrient utilization and retention: Tables 3 presents the effects of adding waste silkworm pupae meal- ET to broiler chicken diets on nutrient intake and apparent metabolizability of different nutrients, respectively. The experimental groups (C, T1, T2, T3, and T4)'s chicks had beginning and ultimate BWs (g) of 1282.43 and 1804.73, 1279.43 and 1802.63, 1261.53 and 1783.13, 1258.33 and 1773.13, 1182.83 and 1667.63, respectively, during the metabolism trial.

According to the results evaluated by Zotte *et al.*, (2021) the dietary inclusion of SWM- FULL and SWM-DEF in quails provided absolute worst digestibility outcomes for DM ($P < 0.001$), organic matter ($P < 0.001$) and starch ($P < 0.001$) compared to control diet, whereas SWM-DEF exhibited significantly lower digestibility of CP ($P = 0.0117$) and ether extract ($P < 0.001$) compared to SWM-FULL and control diets. The latter two diets led to comparable results for CP and ether extract. Consequently, the dietary treatment affected the nutritive value of diets: Control quails showed the highest metabolisable energy (ME), followed by the SWM-FULL group and SWM-DEF one, the latter exhibiting the lowest value, however, their study can not be used for direct comparison with the present study.

Haemato-biochemical profile: Table 4 presents the impact of WSWPM-ET on the haemato-biochemical profile of broiler chickens, respectively. Total protein, albumin, and globulin levels (g/dl) in the experimental groups varied non significantly from 4.25 to 4.41, 2.24 to 2.36, and 1.94 to 2.10, respectively, indicating that replacement of WSWPM-ET instead of MBM in rations did not have a negative impact on the broiler chicken's vital organs. There were no significant differences ($P > 0.05$) between the measured values of cholesterol (mg/dl) and triglycerides (mg/dl) which were likewise within the normal physiological range (104.74 to 105.75 and 116.64

Table 4. Effect of supplementation of WSWPM-ET on the haemato-biochemical profile (in %) of broiler chicken

Attributes	Groups				
	C	T1	T2	T3	T4
ALT	8.46±0.41	8.13±0.41	8.36±0.48	8.18±0.32	8.07±0.48
AST	206.15±7.83	200.54±8.41	214.53±9.37	204.94±9.87	201.75±8.12
Glucose	223.52±4.14	226.06±5.98	229.35±6.59	228.95±4.56	227.54±5.57
TP	4.26±0.14	4.41±0.11	4.1±0.14	4.09±0.1	4±0.2
Albumin	2.36±0.05	2.31±0.07	2.25±0.07	2.3±0.04	2.23±0.07
Globulin	1.99±0.15	2.16±0.06	1.84±0.11	1.79±0.09	1.76±0.14
Triglyceride	108.84±2.04	109.79±3.20	111.35±2.92	111.59±2.88	110.73±3.01
Cholestrol	118.52±4.85	117.98±5.05	114.3±4.88	117.79±4.46	119.65±4.59

Control (C; contains 0 % WSWPM), T1, T2, T3 and T4 has 1.25%, 2.5%, 3.75% and 5% of WSWPM-ET respectively.

to 117.24) for the species in reference, with no significant differences ($P>0.05$) among the groups.

Not much literature is available in this regards. According to Xu *et al.*, (2018), experimental fish given the EHDSP had significantly lower serum levels of total cholesterol and alanine aminotransferase ($p < .05$) than the control group. According to research by Zhou *et al.* (2017), increasing the levels of fermented meal mixture (FMM)—which contains fermented silkworm pupa meal—reduced serum TG, total cholesterol, LDL-c, MDA, and SOD while raising GOT and GPT. The T2 and T3 groups exhibited substantial differences in the spleen index, while the T3 and T4 groups showed an increase in the relative expression of TNF- α 1 and IL-6 genes in their hepatopancreas.

Sheikh *et al.* (2006) found that none of the experimental groups' blood protein, cholesterol, or SGOT levels were significantly affected by the addition of SWPM to the broiler meal. However, when silkworm meal was added to the diet at a 5% level, there were substantial differences in the serum levels of glutamic pyruvic transaminase and phosphorous. According to reports by Banday *et al.* (2009), broiler chickens fed diets supplemented with 0, 25 and 50% SWPM in the diet instead of fish meal did not exhibit any significant effects on various blood biochemical parameters. With the exception of serum albumin, the blood picture analysis revealed no discernible changes as a result of feeding silkworm pupae-based diets (Rafiullah, 2016). According to Nandeeshha *et al.*, (1989), the percentage of protein in SWPM may be the cause of the notable

differential in serum albumin that was detected. However, the findings of above studies cannot be utilized for direct comparisons with present study. According to the reported data, broiler chickens fed a diet containing WSWPM-ET at 100% replacement of MBM did not have any negative effects on their health, liver, or kidneys.

Cell mediated immunity (CMI) response: Table 5 presents the observed data pertaining to the CMI response. The percentage of the cell-mediated immune response on the thickness of the foot pad in relation to the intradermal injection of phytohaemagglutinin-p (PHA-P) as an antigen in the foot pad of broiler chickens was determined (0 hr data were considered as 100% and other values were calculated accordingly). This showed that feeding WSWPM-ET-based diets to experimental birds had no negative effects on their immunity.

Cost economics: Table 3 displays the cost-benefit ratios for the control and experimental groups. The results of this study were consistent with those of Reddy *et al.*, (1991), who noted that broiler farm economics index (BFEI) declined and production costs increased when 5% of silkworm pupae meal which replaced half of the fish meal was added to broiler diets. The present study's results were consistent with those of Khatun *et al.*, (2005), who examined the effects of an SWP-based ration on the growth and egg production performance of Rhode Island Red (RIR) eggs, and who discovered that feed cost/kg reduced as the dietary quantities of silkworm pupae (SWP) increased. According to Zsedely *et al.* (2022) and

Table 5. Effect of supplementation of WSWPM-ET on cell mediated immune response (CMI) of broiler chicken

Groups	Cell Mediated Immunity (%)				
	0	24	48	72	Mean
C	100.00	110.13±2.32	121.67±1.76	110.7±1.23	110.82±1.38
T1	100.00	111.77±2.64	122.53±2.38	112.33±2.08	111.76±1.68
T2	100.00	111.97±2.96	122±1.98	113.75±2.72	111.75±1.75
T3	100.00	110.82±2.62	122.4±2.03	110.65±2.68	110.62±2.14
T4	100.00	113.19±2.29	120.23±1.79	111.3±1.41	111.13±1.37

Control (C; contains 0 % WSWPM), T1, T2, T3 and T4 has 1.25%, 2.5%, 3.75% and 5% of WSWPM-ET respectively.

the research done so far suggests that 4% SWM-DEF can be given to hens at various stages of their growth, and the choice of the inclusion period is mostly based on an industrial cost-benefit analysis. Because of its low cost and high protein content, non-deoiled dry SWP is one of the best substitutes for fishmeal in the diets of different species of carp (Rana *et al.*, 2009).

When the silkworm pupa proportion was increased in the meal, the profit also increased significantly (Khatun *et al.* 2003). Reddy *et al.* (1991), Rahman *et al.* (1996), Narang and Lal (1985), Nandeeshha *et al.* (1989) and Habib *et al.* (1994) have reported findings that are consistent with the present findings and acknowledge silkworm pupae as a useful, reasonably priced source of feed that is high in protein and could reduce production costs.

From this study, it may be recommended that meat cum bone meal can be replaced upto 75% level with treated waste silkworm pupae meal (WSWPM-ET) in the ration of broiler chicken with no adverse effects on body weight, feed intake, utilization of nutrients, blood biochemical parameters, immune response, carcass characteristics, intestinal micrometric and overall economics.

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