

Sustainable Utilization of Tannery Raw Hide Trimmings Waste for Poultry Feed Production

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ABSTRACT

Rising prices of traditional protein sources like soybeans and maize are challenging the global livestock industry, necessitating cost-effective and sustainable alternatives. This study explores tannery raw hide trimmings waste (TRHTW), a chromium-free byproduct with high protein (33%) and fat (2%) content, as a viable poultry feed ingredient. Unlike chromium-tanned leather waste, TRHTW offers a safer and nutritionally balanced feed. The research formulated poultry feed blends incorporating TRHTW by washing, boiling, sun-drying, and grinding into fine powder alongside traditional ingredients like maize and soymeal, comparing them to conventional diets based on nutrient profile, energy value, and heavy metal content. Structural and chemical properties were analyzed using FTIR, SEM, and AAS. Key findings demonstrate that TRHTW-based feed is chromium and lead free, with 85% digestibility, reducing costs while providing a sustainable protein alternative for poultry feed formulation. Adherence to safety and regulatory standards is essential to ensure poultry and consumer health. Future studies should refine TRHTW processing for optimized nutritional and safety outcomes, advancing sustainable feed solutions within a circular economy framework.

Keywords: Raw Hide, Trimming, Poultry Feed, Protein, Solid Waste.



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1. Introduction

The leather industry generates about 23 billion sq ft of leather every year and 25.5% of rawhide turns into finished leather which leads to a large volume of waste generation [1,2]. Traditionally, much of this waste ends up in landfill sites. They are hazardous due to high organic load and chemicals such as chromium used in tanning [3]. Basic disposal methods; incineration, anaerobic digestion, open dumping and heat combustion pose environmental risks that include pollution of water, soil and emissions of greenhouse gases [4]. Although, some of the waste is turned into useful by products like regenerated leathers and leather blended fabrics, most of the wastes especially raw hide trimmings are unused. These trimmings contain collagen and proteins which has the potential to be used in protein-fortified poultry feed [5,6].

As traditional feed ingredients for poultry like soyabean and maize are getting scarce and expensive, these solid wastes from tannery are showing potential as feed ingredients [7]. Logistics and competition for land has made the price of soybeans to rise thus making it expensive for poultry production [8]. In the developing world, cost of poultry feed accounts for 70% of total production costs; demonstrating need for affordable, sustainable feed sources [9]. Incorporation of tannery raw hide trimmings waste (TRHTW) in poultry feed might help in cutting down cost and at the same time solving to reduce tannery waste [10]. Moreover, Collagen supplementation has also shown to increase poultry growth and improve feed efficiency making it a nutritionally viable option [11, 12].

Previous researches on tannery solid wastes (TSWs) have shown their potential as a protein-rich poultry feed alternative. A comprehensive study found dechromed leather waste to be safe and nutritionally beneficial whereas other studies in Bangladesh disclose that a large portion of TSWs, like TRHTW, continue to be hazardous to the environment and less used [6,10]. Though there are some researches showing various utilization of TRHTW like extraction of collagen, non-edible gelatin production and potential industrial applications [13-15]. Despite these developments in the utilization of tannery solid wastes, regulatory and technical barriers have limited TRHTW utilization, particularly in feed production [6,16]. In economic aspect, TRHTW has the potential of decreasing the costs of poultry feeds; but there are potential risks of heavy metals leaching hence safety analysis before application should be encouraged [17].

Hence, this study aims to investigate the potential of tannery raw hide trimmings (TRHTW), which are minimally contaminated with hazardous materials, as a sustainable, protein-rich poultry feed ingredient. By addressing the dual challenges of tannery waste management and the need for cost-effective, high-quality feed, the research evaluates TRHTW's nutritional value, safety, and environmental impact. Comprehensive analyses include protein composition, heavy metal screening (via FTIR, SEM, and AAS), and nutritional trials to assess effects on poultry health and productivity. The findings aim to promote waste valorization in the tannery industry while enhancing the sustainability and profitability of poultry farming.

2. Materials and methodology

2.1 Materials Collection

All poultry feed ingredients, including maize, soymeal, rice polish, DRB (wheat husk), Hydance (phytogenic feed additive), DL-Methionine (sulfur-containing amino acid for broilers), lysine (amino acid), DCP (calcium powder), toxin binder (mycotoxins), Sal stop (formaldehyde + propionic acid), L (layer premix with micronutrients such as CaCO₃, phosphorus, sodium), Thiabin B1B2B6 (phytogenic feed additive), enzyme blends (glucanases, xylanases, phytases, proteases, lipases, galactosidases), baking soda (NaHCO₃), and salt (NaCl) were sourced from Mim Poultry and Feed Fish, Zero Point, Khulna, Bangladesh. The raw hide trimmings waste was purchased from a random municipal slaughterhouse located at Gollamari, Khulna, Bangladesh, weighting 100 kg.

2.2 Treatment of raw hide trimmings waste

The raw hide trimmings waste were collected and transported to Moilapota, Khulna, for processing. First, the trimmings were washed to eliminate contamination. They were then chopped into 5 cm x 5 cm pieces for optimal cooking and boiled in distilled water for 30-35 minutes to enhance protein extractability. After boiling, hair was scraped off, and the hides were sun-dried for 36 hours to ensure complete organic material breakdown as previously emphasized. Once dried, the material was ground twice into a fine powder suitable for poultry feed, as finer particle size improves digestibility and nutrient assimilation [18]. The treatment process is shown in Fig. 1.

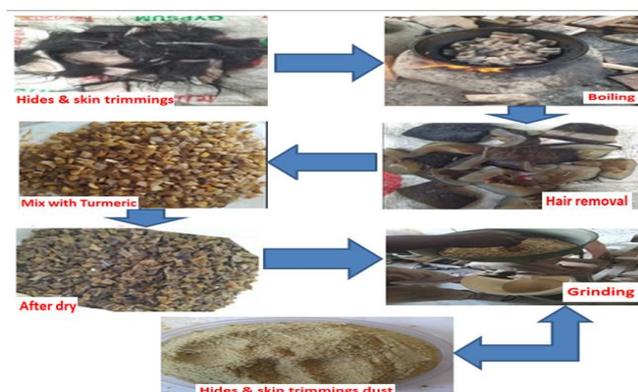


Fig.1 Flow chart of producing leather dust from raw hide trimmings.

2.3. Main ingredients used in poultry feed formulations

Cost of feed can go up to 70% of the poultry production costs, of which 95% is dedicated towards energy and protein requirements 3-4% for mineral, trace mix and vitamins 1-2% for feed supplements. Poultry diets contain a number of components including maize, wheat husk, rice polish, by-products such as meat and bone meal, animal fat, plant and animal proteins, vitamins, minerals, essential amino acids and additives that are chosen on the basis of their nutrient value in relation to their cost. Table 1 displays common ingredients used globally in poultry feed formulations. [19, 20]

2.4 Formulation of poultry feeds

The formulation of poultry feed is to develop feed that are nutritionally adequate, acceptable and inexpensive to the

animal owner in relation to rearing environment objectives. Balanced feeding entails precise determination of the quantities of the feed to be used for proper body growth, egg productivity and realization of good profit. These requirements embrace genetic makeup, sex, weight, life cycle, appetite, and prevailing environmental conditions. Nutrient specifications for major ingredients are expressed as metabolizable energy, crude protein, essential amino acids (lysine and methionine) and minerals (calcium and phosphorus). The chemical composition, nutritional profile, and anti-nutritional effects of each ingredient cannot be overlooked lest the intended diet becomes toxic, unbalanced, or mal nutritional [22,23].

Table 1 Common Ingredients and Nutrient Sources in Poultry Feed [19-21]

Serial no.	Types of Nutrients	Source of ingredients
1.	Energy	Mainly maize,
2.	Protein	Soybean meal
3.	Carbohydrate	Rice Polish
4.	Crude fiber	Wheat Husk
5.	Digestive enzymes	Hydance
6.	Bone development and eggshell strength,	Mineral supplements: Limestone, Dicalcium phosphate (DCP), NaCl, Sodium bicarbonate
7.	Energy metabolism, nervous system function, and red blood cell formation	Vitamin supplements: Vitamin premixes, toxin binder, Thiabin B1B2B6, Sal Stop, Enzyme blends

As shown in table 2, a normal poultry feed can be formulated according to the various growth phases of poultry.

Table 2 Conventional Poultry Feed Formulation

Sl no.	Ingredients of Poultry Feed	Starter Feed Week (0-4)		Grower Feed Week (5-18)		Layer Feed Week (18+)	
		100k g/batch	% of composition	100k g/batch	% of composition	100k g/batch	% of composition
1	Maize	54	54	57	57	61	61
2	Soymeal	26	26	23	23	19	19
3	Rice Polish	10.	10	10	10	10	10
4	Wheat Husk (DRB)	5.0	5	4.5	4.5	4	4
5	Hydance	5.0	5	5.5	5.5	6	6
6	Minerals & Miscellaneous	3.0	0.3	3.5	3.5	3.5	3.5

2.5 Feed formulation methods

Depending on experience, empirical methods include suggesting combinations of ingredients and modifying them as a result of production outcomes or fluctuations in the raw material market. It tilts towards simplicity and flexibility to market conditions but may not be accurate. On the other hand,

trial and error method is globally used that meet the nutrient concentration by modifying the values of the ingredients individually or by using software like Excel. While time consuming, it makes it possible. Inclusion of both offers this study a vibrant method that incorporate industry standard and research rigors.

3. Results and discussion

3.1 Fourier Transform Infrared (FTIR) analysis

The red curve analysis indicated that the prepared poultry feed composition included the mix of raw hide trimmings waste in addition to soybean meal, maize, wheat husk, rice polish, and hydance have a typical dip absorption band of proteins at 1000 cm^{-1} (amide I, C=O stretching),

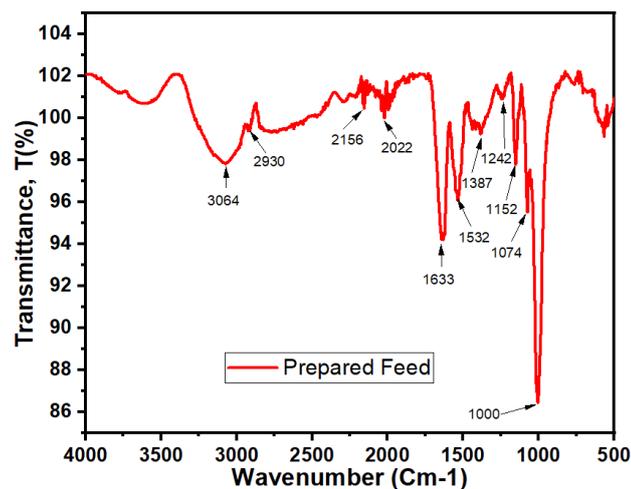


Fig.2 FTIR analysis of prepared poultry feed.

1532 cm^{-1} (amide II, C–N stretching), and 1242 cm^{-1} (amide III, C–N stretching and N–H bending). Wavenumber 1310 cm^{-1} to 1387 cm^{-1} OH in-plane bending CH_2 wagging CH in plane scissoring indicates cellulose presence. In addition, the band at 3385 cm^{-1} was formed with O–H and N–H stretching, the band at 1074 cm^{-1} was assigned to C– NH_2 bending, and the bands at 1633 cm^{-1} and 1468 cm^{-1} were related to carboxylic groups (COOH) of soybean meal that indicated of carbohydrates and protein content. Wavenumber $2870\text{--}3078\text{ cm}^{-1}$ has typically associated with C–H stretching, likely from organic molecules like fats or oils in the poultry feed.

3.2 Scanning Electron Microscopy (SEM) analysis

The SEM images (fig.3) showed microstructural differences between traditional poultry feed (A) and prepared poultry feed (B). The images A (Traditional Poultry Feed), the microstructure had shown a relatively smoother surface with larger, more distinct spherical particles and fewer fines. Larger particles such as maize and soybean meal had appeared prominently, with less porosity. The surface had appeared cohesive, likely due to the combination of maize and soybean meal. On the other hand, the images B (Prepared Poultry Feed) had presented a more fragmented and porous structure.

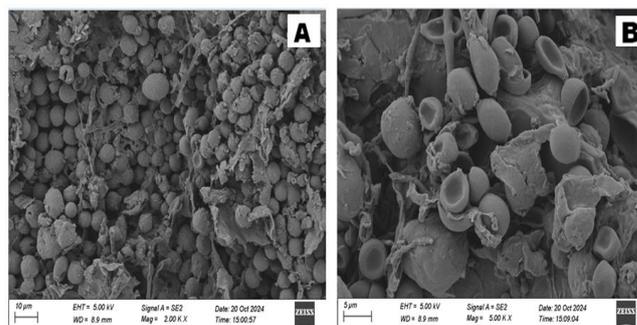


Fig.3 SEM images (A) Traditional and (B) Proposed Feed.

The addition of raw hide trimmings waste had resulted in more irregularly shaped particles and a less cohesive matrix. This mix had also included more fine particles and microstructures, which had led to increased surface roughness and porosity. These structural differences had indicated that the prepared feed, with the inclusion of organic raw materials like hide trimmings, had altered the microstructure by introducing finer particles and improving texture variability.

3.3 Atomic Absorption Spectroscopy (AAS) analysis

Table 3 had provided the elemental values in poultry feed, with traditional feed showing chromium, Total sulfur, Lead, phosphorus, and calcium levels at 0.0023%, 0.0179%,

Table 3 shown the Toxic elements in Poultry feed.

Element	Traditional Feed Value (%)	Maximum value (%)	Prepared Feed value (%)
Chromium	0.0023	0.0030	0.0018
Total sulfur	0.0179	0.300	0.0199
Lead	0.0000	0.0002	0.0001
Phosphorus	0.050	0.600	0.055
Calcium	0.980	1.200	1.105

0.0000%, 0.050%, and 0.980%, respectively. In the prepared feed, these elements had been found at 0.0018%, 0.0199%, 0.0001%, 0.050%, and 1.105%. Toxic elements present in both traditional and prepared poultry feed remained within safe limits.

3.4 Nutritional value analysis

The nutrient composition of starter feed, grower feed, and layer feed for poultry was compared in Table 4. The results (Table 4) showed that starter and grower feed contained similar energy values, ranging between 2750–2850 kcal/kg and 2800–2900 kcal/kg respectively, while layer feed showed a slightly lower energy range of 2700–2800 kcal/kg. Protein content was examined, revealing that starter feed had the highest minimum protein value of 20%, grower feed ranged from 18% to 20%, and layer feed had the lowest range, varying between 14% to 18%. The excess energy values (Kcal/kg) found in the proposed starter and grower feed were adjusted during the feed formulation period.

Table 4 The nutritional values of poultry feed

Nutrients	Starter Feed (%)			Grower Feed (%)			Layer Feed (%)		
	Values	Min	Max	Values	Min	Max	Values	Min	Max
Energy kcal/kg	2850	2750	2850	2850	2800	2900	2800	2700	2800
Protein	20	20	22	19	18	20	16	14	18
Fat	5	3	5	6.2	3	7	7.5	3	7
Moisture	11.65	10	12	11.6	10	12	11.9	10	12
Cellulose	4.70	3.5	5	6.90	3.5	7	6.80	3.5	7
Starch	55	50	55	55	50	55	50	50	55
Ash	8.67	6	10	8.47	6	10	8.66	6	10

3.5 Comparison of nutrients composition between traditional and prepared poultry feed

The nutrient composition graphs (Fig.4) illustrate differences between traditional and prepared poultry feeds. In the following graph, the protein content in the prepared feed had been higher than in traditional feed.

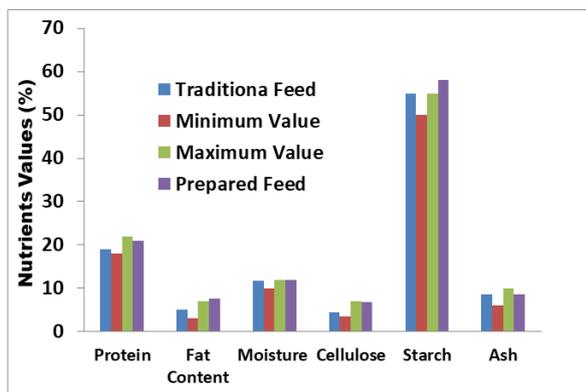


Fig.4 Comparison of nutrients of poultry feed.

Fat content had been comparable between the two, while moisture and ash levels had displayed only minor differences. The starch content had shown a small decrease in the proposed feed, while cellulose percentages had remained consistent across both feeds. Overall, the prepared feeds had exhibited slightly higher protein levels across all stages, with only minor variations in other nutrients.

3.6 Comparison of Energy value (KCal/kg) of different types of Poultry feed.

The graph (Fig.5) had illustrated the comparison of energy (KCal/Kg) between traditional and prepared poultry feed through the three stages: starter feed, grower feed, and layer feed. It had depicted energy values for four categories: Traditional Feed, Minimum Value, Maximum Value, and Prepared Feed. For the starter feed, the prepared feed had shown the highest energy value, surpassing both traditional and maximum values, while the minimum value had been the

lowest. The grower feed had followed a similar pattern, where the prepared feed had the highest energy content, and the minimum value had again been the lowest. The layer feed had also seen the prepared feed exceeding traditional feed values, with the minimum value staying below the maximum and traditional values.

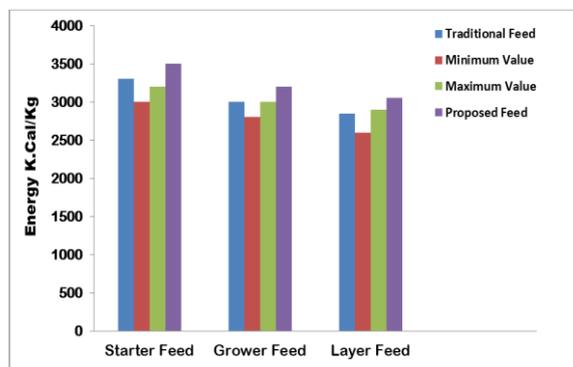


Fig.5 Comparison of Energy kcal/kg between the two feed.

3.7 Feasibility analysis

Fig. 6 (A) had shown the weight progression of chickens fed with either traditional or prepared feed over 18 weeks. Initially, chickens had weighed 36 grams. By the first week, chickens on traditional feed had reached 57 grams, while those on prepared feed had weighed 55 grams.

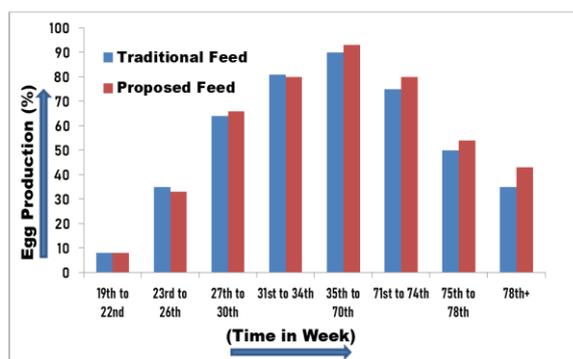
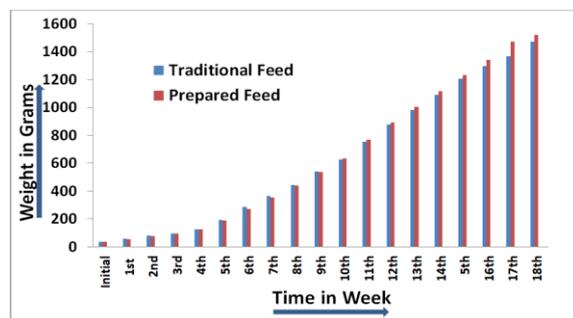


Fig.6 (A) Comprise weight growth from initial to 18th week, **(B)** Comprise of egg production percentage from 18+ weeks.

By the second week, weights had increased to 78 grams and 75 grams for traditional and prepared feed, respectively. In the third week, weights had risen to 96 grams with traditional feed and 93 grams with prepared feed. By the fourth week, traditional feed subjects had reached 125 grams, and prepared feed subjects had attained 124 grams. At the fifth

week, subjects on traditional feed had weighed 192 grams, while those on prepared feed had reached 187 grams. By the tenth week, weights for traditional and prepared feed groups had been recorded at 625 grams and 635 grams, respectively. By the fifteenth week, traditional feed subjects had weighed 1205 grams, and those on prepared feed had reached 1232 grams. Finally, by the eighteenth week, traditional feed subjects had achieved 1470 grams, while prepared feed subjects had attained 1520 grams.

Fig.6 (B) had shown egg production percentages in layer poultry fed traditional or prepared feed from the 19th week onward. By the 22nd week, both groups had reached 8% production. By the 30th week, egg production had been 64% for traditional feed and 66% for prepared feed. By the 34th week, traditional feed subjects had achieved 81% production, while prepared feed subjects had reached 80%. Production had peaked by the 70th week at 90% for traditional feed and 93% for prepared feed, and then declined by the 78th week to 35% and 43%, respectively.

3.8 Cost analysis

3.8.1 Calculation the costing of prepared leather trimmings waste

Here provided a cost breakdown for processing 100 kg of raw hide trimmings. Initially, 1 kg of raw hide trimmings had cost 5 takas, so 100 kg had amounted to 500 taka. The cleaning, chopping, boiling, and hair removal for 100 kg had required 600 takas, while grinding costs had totaled 1000 taka for 100 kg. Transport costs had been 1.5 taka per kg, bringing the total transport cost to 150 takas for 100 kg. Therefore, the total processing cost for 100 kg of raw hides and trimmings had reached 2250 taka. After processing, 100 kg of raw trimmings had yielded 33 kg of leather dust, making the cost of 1 kg of raw hide trimmings dust 68 taka ($2250 \div 33$).

3.8.2 Costing calculation of traditional and prepared poultry feed

The Table 5 had compared the costs associated with 100 kg batches of traditional and prepared feed formulations.

Table 5 Comparison Feed Formulation cost.

Ingred- ients	Traditional Feed Cost			Prepared Feed Cost		
	Quantit y (kg)	Cost/k g (Taka)	Total Cost (Taka)	Quanti ty (kg)	Cost/k g (Taka)	Total Cost (Taka)
Leathe r dust	-	-	-	6.0	68.00	408.00
Maize	61.0	36.00	2196.0 0	73.0	36.00	2304.0 0
Soybea n meal	19.0	78.00	1482.0 0	1.0	78.00	78.00
Rice Polish	10.0	38.00	380.00	10.0	38.00	380.00
wheat Husk	4.0	42.00	168.00	5.0	42.00	210.00
Hydan ce	6.0	94.00	564.00	5.0	94.00	470.00
Minerals & Miscellaneous cost			522.00	-	-	522.00
Traditional Feed Cost (100 kg)			5312.0 0	Prepared Feed Cost		4372.0 0

The prepared feed had included 6.0 kg of leather dust at 68.00 Taka/kg, totaling 408.00 Taka. Traditional feed had contained 61.0 kg of maize costing 2196.00 Taka, whereas prepared feed had used 73.0 kg of maize at 2304.00 Taka. Soymeal usage had been 19.0 kg in the traditional feed (1482.00 Taka) and only 1.0 kg in the prepared feed (78.00 Taka). Both feeds had contained 10.0 kg of rice polish, costing 380.00 Taka. Wheat husk quantities had been 4.0 kg (168.00 Taka) for the traditional feed and 5.0 kg (210.00 Taka) for the prepared feed.

Hydance had been included at 6.0 kg in traditional feed (564.00 Taka) and 5.0 kg in prepared feed (470.00 Taka). Identical mineral and miscellaneous costs of 522.00 Taka had applied to both feeds. Consequently, the total cost had amounted to 5312.00 Taka for the traditional feed and 4372.00 Taka for the prepared feed, indicating cost efficiency in the prepared feed formulation.

Based on data provided by Aklima Poultry Farm in Fakirhat, Bagerhat, the average weekly feed consumption for 100 poultry

chickens over 82 weeks had been 45.00 kg. Since feed had been supplied for 82 weeks, the total cost for prepared feed over this period had amounted to 197,177 Taka (calculated as $55.00 \times 43.72 \times 82$). In contrast, the total cost for traditional feed over 82 weeks would have been 239,571 Taka (calculated as $55 \times 53.12 \times 82$).

Consequently, the total cost for 100 poultry feed saved from using prepared feed had been clearly evident as 42,394 taka ($239,571 - 197,177$). After analyzing the costs of traditional and prepared poultry feed, it had been proven that for 1,000 poultry chicken, approximately 4,23,940 taka had been saved over the course of their life cycle.

4. Conclusion

This study demonstrates the feasibility of utilizing raw hide trimmings as a protein-rich, cost-effective ingredient in poultry feed. FTIR analysis confirmed the presence of essential nutrients such as proteins, carbohydrates, and fats in the prepared feed, while SEM revealed its porous microstructure, enhancing nutrient absorption. AAS analysis indicated that heavy metals, including chromium, sulfur, and lead, remained within safe limits. Nutritional and energy value assessments showed comparable or superior results in prepared feed compared to traditional options, particularly in protein content. Growth and productivity trials validated the efficiency of the prepared feed, achieving similar or better poultry weight gain and egg production metrics. Furthermore, cost analysis highlighted significant economic benefits, saving approximately 4,23,940 Taka per 1,000 chickens over their lifecycle. This innovative approach not only addresses the challenges of tannery waste management but also promotes sustainable practices in poultry farming, contributing to a circular economy.

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