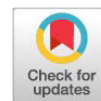


Research Article



Improving Arabian Chicken Egg Lipid Profile via Tuna Waste-Based Concentrate

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Abstract | High feed costs, largely driven by the price of commercial concentrates, are a major constraint to poultry production. This study evaluated the effects of partially replacing commercial concentrate with a natural concentrate formulated from hydrolyzed tuna head waste and fermented pollard on productive performance, blood lipid profile, egg quality, and yolk chemical composition in Arabian chickens. Sixty 20-week-old Arabian laying hens were randomly allocated to four dietary treatments with five replications: R0 (100% commercial concentrate), R1 (12% replacement with natural concentrate), R2 (24% replacement), and R3 (36% replacement). The experiment was conducted using a completely randomized design, and significant differences among treatments were assessed using Duncan's multiple range test. The results showed that replacing 24% of the commercial concentrate with the natural concentrate did not significantly affect ($p > 0.05$) feed, energy, or protein intake, feed conversion ratio, blood triglyceride levels, or egg quality compared with the 100% commercial concentrate diet. However, the 24% replacement significantly reduced ($p < 0.05$) yolk cholesterol and ether extract contents by 7% and 14.44%, respectively. These findings indicate that replacing 24% of commercial concentrate with a concentrate containing hydrolyzed tuna head waste and fermented pollard can maintain productive performance and egg quality while improving selected nutritional characteristics of egg yolk in Arabian chickens.

Keywords | Arabian chicken, Tuna head waste, Fermented pollard, Yolk cholesterol, Functional egg, Natural concentrate

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INTRODUCTION

Feed expenditure represents the largest operational cost in poultry production, frequently comprising between 50% and 70% of total farm expenses. This economic burden is primarily driven by the high price of commercial concentrates, which are often less affordable for small-scale and rural producers. To address this challenge, researchers have explored alternative strategies such as incorporating agricultural by products and enhancing nutrient

digestibility through enzymatic or microbial processing (Alagawany *et al.*, 2018).

Tuna head waste is an underutilized yet nutrient-rich by-product containing a high proportion of crude protein, primarily in the form of collagen (Li *et al.*, 2019). Despite its nutritional potential, tuna waste is commonly discarded due to its poor digestibility in poultry (Siddik *et al.*, 2019). The rigid triple-helix structure of collagen limits enzymatic breakdown in monogastric species (Butnariu, 2024), making

direct application in feed inefficient. However, enzymatic hydrolysis, particularly using bromelain from pineapple, has shown promise in cleaving complex proteins into smaller peptides and free amino acids, thereby enhancing their bioavailability (Sukri *et al.*, 2023). Although enzymatic hydrolysis is well documented in food and aquaculture applications, its specific use in converting fish processing waste for poultry feed remains insufficiently explored.

To formulate a nutritionally balanced feed, protein-rich materials such as hydrolyzed tuna waste must be complemented by suitable energy sources. Wheat pollard, a common milling by-product, offers potential in this role but is limited by low protein and high fiber content. Recent studies have demonstrated that fermentation with *Saccharomyces cerevisiae* can substantially enhance the nutritional profile of wheat pollard raising crude protein levels while reducing indigestible components, thus improving its value in poultry diets (Sugiharto and Ranjitkar, 2019). A feed composition combining these two processed by-products could yield a functional concentrate with significant economic potential, as it utilizes underutilized agro-industrial wastes that are typically available at minimal or no cost compared to conventional feedstuffs.

Beyond nutritional adequacy, the inclusion of fishery and agro-industrial waste in feed aligns with sustainable agriculture practices. Tuna head waste is generated in significant quantities, estimated at over 240,000 tons annually in Indonesia based on 2021 national production data and industrial yield standards, yet it remains largely unexploited. Transforming such waste into poultry feed supports circular economy principles, reduces environmental pollution, and lessens reliance on conventional feed ingredients. Additionally, tuna-derived feeds may enhance product quality by enriching poultry eggs with omega-3 fatty acids and minerals such as calcium and phosphorus, which are essential for eggshell strength and overall egg quality (Syazili *et al.*, 2021; Cheeke and Dierenfeld, 2010).

In light of these benefits, this study evaluates the potential of a natural concentrate made from hydrolyzed tuna head waste and fermented pollard as a partial replacement for commercial concentrate in the diet of native layer chickens. The research examines its effects on feed performance, egg lipid composition, and blood parameters. Emphasis is placed not only on animal productivity but also on economic feasibility and environmental sustainability. By integrating bioconversion techniques with waste valorization, this study proposes a practical approach to improving feed efficiency and developing healthier poultry products in a resource-conscious farming context.

The experimental protocols were approved by the Animal Ethics Committee of the Faculty of Veterinary Medicine, Gadjah Mada University (Reference No. 41/EC-FKH/int./2024), issued on May 31, 2024.

ANIMAL AND DIET PREPARATION

A total of sixty 20-week-old female Arabian chickens (initial body weight was 1.133 ± 56.11 g) were obtained from the Women's Livestock Farmers Group 'Wanita Karya', Banyumas Regency. Birds were individually housed in 60 battery cages made of bamboo measuring 40 × 25 × 40 cm (length × width × height), arranged in a three-story open-house system with a monitor-type roof measuring 6 × 4 m. Cage floors were constructed using a slatted floor system with bamboo walls of 1.5 m height. Each cage was individually equipped with a feed trough and a water trough made from 5-inch PVC pipe divided into two sections. Partitions between adjacent cages were installed to prevent cross-contamination of feed between treatments. Water was connected to a central water supply and provided ad libitum throughout the study. Prior to the experimental period, all birds underwent a 14-day adaptation period during which they received a standard basal diet to allow acclimatization to housing conditions and to establish baseline health and production status

Table 1: Proximate analysis of concentrate used*.

Ingredients	Feed	
	Commercial concentrate	Natural concentrate
Dry matter (%)	89.00	89.00
Metabolizable energy (kcal/kg)	2472.00	2608.03
Crude protein (%)	31.64	29.90
Ether extract (%)	4.94	18.48
Fiber (%)	7.91	7.40
Calcium (%) **	8.90	9.15
Available phosphorus (%) **	1.00	1.51
Lysin (%)	1.70	1.90
Methionine (%)	0.80	0.50

* Analyzed in the Laboratory of Animal Nutrition and Feed Jenderal Soedirman University. ** Analyzed in the Laboratory of Soil Chemistry Jenderal Soedirman University.

Four experimental diets were formulated by incorporating a single type of natural concentrate (comprising tuna head hydrolysate and fermented pollard). The details about nutrient composition of the treatment diets are presented in Tables 1 and 2. The treatment feed incorporated tuna head hydrolyzed with 20% pineapple peel bromelain extract for six hours, followed by heat inactivation and oven-drying at 60–80°C. Additionally, fermented pollard

was included, prepared by inoculating pollard and liquid tofu waste (containing 0.5% urea) with a 10% yeast-based inoculum (*Saccharomyces cerevisiae*), followed by a five-day incubation and oven-drying at 40 °C for 8-12 hours and subsequently ground into a fine powder.

Table 2: Nutrient and composition of treatment diet.

Ingredients	%			
	R ₀	R ₁	R ₂	R ₃
Commercial concentrate*	36	24	12	0
Natural concentrate **	0	12	24	36
Corn	44	44	44	44
Rice bran	20	20	20	20
Total	100	100	100	100
Price (IDR/kg)	6000	5560	5121	4681
Nutritional compositions				
Crude protein (%)	17.65	17.44	17.70	17.72
Metabolizable energy (kcal/kg)**	2946.72	2963.04	2979.36	2995.69
Crude fiber (%)	6.03	5.97	5.91	5.85
Ether extract (%)	5.86	7.48	9.11	10.73
Calcium (%)	3.23	3.25	3.28	3.31
Available phosphorus (%)	0.44	0.49	0.55	0.62
Methionine (%)	0.42	0.37	0.32	0.28
Lysine (%)	0.84	0.80	0.75	0.72
Fatty acid ω-3 (%)	0.04	0.37	0.69	1.02
Fatty acid ω-6 (%)	1.67	1.77	1.86	1.97

*Commercial concentrate label. **Laboratory of Animal Nutrition and Feed.

EXPERIMENTAL DESIGN

Birds were randomly allocated to four dietary treatments with five replications per treatment, each replication consisted of three birds housed in individual cages, which served as the experimental unit (n= 3 birds/replicate, n = 15 birds/treatment, 60 birds total). Treatments were randomly assigned to cages distributed across all three floors of the housing system, conforming to a completely randomized design (CRD). The experimental feeding period lasted 8 weeks, commencing when birds were 20 weeks of age and concluding at approximately 28 weeks of age, corresponding to the onset of peak laying performance in Arabian chickens.

PERFORMANCE AND SAMPLE COLLECTION

The production performance of Arabian chickens was evaluated during a 7-day data collection period at the end of the 20-week trial. Feed intake (FI) was recorded daily by subtracting the weight of the residual feed from the total amount offered, with energy and protein intakes calculated based on laboratory proximate analysis results. Hen-house production (HHP) was determined as the percentage

of total eggs collected relative to the initial number of hens housed multiplied by the recording days. The feed conversion ratio (FCR) was computed as the ratio of total feed consumed (g) to the total egg mass (g) produced during the collection period.

BLOOD SAMPLING

On the final day of the experimental period, before morning feeding, blood samples were collected in the morning from the brachial vein of one bird per replicate (n = 5 per treatment, 20 birds total) without prior fasting, representing postprandial conditions. Blood was collected into vacutainer tubes and centrifuged to obtain serum for biochemical analysis. Serum cholesterol, triglycerides, and high-density lipoprotein (HDL) were measured according to Tugiyanti and Iriyanti (2012), and complete blood count parameters (WBC, RBC, and hematocrit) were determined using standard haematological procedures.

MEASUREMENT

The variables measured in this experiment included productive performance, blood lipid profile, and interior and exterior egg quality. Productive performance parameters included feed intake, energy intake, protein intake, feed conversion ratio, and egg production. Blood lipid profile was assessed based on cholesterol, HDL, and triglyceride concentrations (Tugiyanti and Iriyanti, 2012). Exterior egg quality was evaluated based on shell strength, shell thickness, and egg weight (Okon *et al.*, 2020), while interior egg quality was assessed based on yolk cholesterol, fat, and protein contents (Albuquerque *et al.*, 2016).

DATA ANALYSIS

Data were analyzed by ANOVA using a Completely Randomized Design in R Studio. Normality and homogeneity of variances were confirmed prior to analysis. Significant differences were determined at P<0.05, followed by Duncan's Multiple Range Test as post-hoc test.

RESULT AND DISCUSSION

The effect of replacing conventional concentrate with natural concentrate derived from hydrolyzed tuna waste and fermented pollard on the nutrient intake and performance of Arabian chickens is presented in Table 3.

As shown in Table 3, statistical analysis indicated that natural concentrate inclusion significantly altered feed intake, nutrient consumption, and FCR (p < 0.05). A distinct threshold trend emerged, where these effects were strictly isolated to the highest replacement level; the R3 group (36% replacement) uniquely exhibited a sharp decline in nutrient intake and a corresponding rise in FCR (3.69 ± 0.60). Conversely, the lower substitution levels (R1

and R2) maintained a performance profile comparable to the control (R0), indicating no adverse effects at these doses.

In line with this, Table 3 indicates that although energy and protein consumption decreased, the use of natural concentrate did not have a significant effect on egg production, with no notable differences between the control group and treatments. Chicken can regulate their energy requirements not only from carbohydrates but also from fats (Grobas *et al.*, 1999). The parallel increase in fat intake and natural concentrate inclusion ensured that the Arabian chickens successfully met the NRC-recommended energy requirement of 217 kcal/bird/day. Since diets are nutritionally balanced, poultry tend to regulate their intake based on energy needs Jha and Mishra (2021); thus, higher energy density, particularly from fat, can suppress feed intake that affect to slowed gastric emptying. Interestingly, although protein intake was significantly reduced in the R3 group ($p < 0.01$), HHP remained relatively stable across all treatments. This result is consistent with Wang *et al.* (2017), who emphasized that digestible protein, rather than total crude protein intake, is the key determinant of egg production. The enzymatic hydrolysis applied to the tuna waste likely enhanced protein digestibility, enabling more efficient intestinal absorption of amino acids (Habinschuti *et al.*, 2023). In this context, the high biological value and improved availability of amino acids from the hydrolyzed tuna waste and fermented pollard successfully compensated for the lower feed consumption.

These findings highlight the functional value of this natural concentrate in optimizing nutrient efficiency and maintaining laying performance, while simultaneously serving as a strategic dietary approach to modify egg yolk lipid quality.

The effect of dietary treatments on blood biochemical parameters is presented in Table 4. Mean values for cholesterol, triglycerides, HDL, WBC, RBC, and hematocrit were 107.26 ± 25.29 mg/dL, 508.05 ± 175.07 mg/dL, 30.59 ± 7.17 mg/dL, $247.2 \pm 8.14 \times 10^3/\mu\text{L}$, $2.59 \pm 0.29 \times 10^6/\mu\text{L}$, and $33.19 \pm 4.78\%$, respectively. No significant differences ($p > 0.05$) were observed in cholesterol, HDL, WBC, RBC, or hematocrit levels among the treatment groups. However, triglyceride levels were significantly affected ($p < 0.01$), with the R1 group showing the highest variability.

This pattern may be explained by the relatively uniform cholesterol content across all dietary treatments, as well as the homogeneity of the chickens used. In physiological terms, cholesterol concentration in the body is tightly regulated through feedback inhibition of HMG-CoA reductase, the rate-limiting enzyme in cholesterol synthesis (Duthie and Barlow, 1992; Duan *et al.*, 2022). The lack of significant changes ($p > 0.05$) in systemic blood cholesterol and HDL levels suggests that the baseline circulating lipid pool remained homeostatically controlled. This implies that the dietary omega-3 fatty acids from the natural

Table 3: Nutrient consumption and performance of Arabian chicken.

Variable	Treatments			
	R ₀	R ₁	R ₂	R ₃
Feed consumption(g/bird/d)	73.4 ± 3.12^a	76.3 ± 2.83^a	75.7 ± 2.52^a	68.9 ± 4.32^b
Energy consumption (kcal/bird/d)	215 ± 9.09^a	226 ± 7.92^a	225 ± 7.49^a	206 ± 13.1^b
Protein consumption (g/bird/d)	12.9 ± 0.54^a	13.3 ± 0.47^a	13.0 ± 0.43^a	11.7 ± 0.74^b
Feed conversion	3.34 ± 0.43^a	3.43 ± 0.47^a	3.60 ± 0.24^a	3.69 ± 0.60^b
Hen house production (HHP) (%)	56.9 ± 15.0	55.1 ± 17.6	51.6 ± 11.9	43.9 ± 11.9

Means with different superscript letters within the similar row indicate statistically significant difference ($p < 0.05$). R₀; basal diet, R₁; basal diet + 12% natural concentrate; R₂; basal diet + 24% natural concentrate; R₃; basal diet + 36% natural concentrate.

Table 4: Blood profile of Arabian chicken.

Variable	Treatments			
	R ₀	R ₁	R ₂	R ₃
Cholesterol (mg/dl)	96.4 ± 16.3	112 ± 25.1	102 ± 5.86	122 ± 53.4
Triglyceride (mg/dl)	353 ± 117^a	540 ± 216^b	516 ± 185^a	421 ± 131^a
High-density lipoprotein (mg/dl)	27.2 ± 8.35	30.3 ± 2.30	32.9 ± 6.44	32.0 ± 11.6
White-blood cell ($\times 10^3/\mu\text{L}$)	246 ± 8.20	245 ± 4.86	246 ± 14.3	250 ± 5.25
Red-blood cell ($\times 10^6/\mu\text{L}$)	2.60 ± 0.38	2.53 ± 0.15	2.63 ± 0.43	2.62 ± 0.22
Hematocrit (%)	32.9 ± 4.02	31.4 ± 1.95	33.4 ± 5.46	35.1 ± 7.70

Means with different superscript letters within the similar row indicate significant difference ($p < 0.05$). R₀; basal diet, R₁; basal diet + 12% natural concentrate; R₂; basal diet + 24% natural concentrate; R₃; basal diet + 36% natural concentrate.

Table 5: Interior and exterior quality of Arabian chicken egg.

Variable	Treatments			
	R ₀	R ₁	R ₂	R ₃
Shell thickness (mm)	0.37 ± 0.01	0.36 ± 0.01	0.36 ± 0.01	0.34 ± 0.01
Shell weight (g)	5.76 ± 0.36	5.72 ± 0.45	5.45 ± 0.27	5.33 ± 0.26
Shell strength (mPa)	0.39 ± 0.04	0.39 ± 0.05	0.37 ± 0.02	0.34 ± 0.04
Yolk index	0.43 ± 0.01	0.43 ± 0.01	0.42 ± 0.03	0.44 ± 0.01
Albumin index	0.06 ± 0.00	0.05 ± 0.00	0.05 ± 0.01	0.06 ± 0.01
Yolk weight (g)	13.5 ± 0.63	13.6 ± 1.05	13.8 ± 0.48	14.3 ± 0.40
Albumin weight (g)	21.7 ± 0.90	21.1 ± 1.05	21.4 ± 1.58	20.9 ± 1.19
Haugh unit	69.2 ± 2.79	67.2 ± 3.72	68.6 ± 2.80	70.6 ± 4.01
Color	6.80 ± 0.77	6.97 ± 0.45	6.73 ± 0.60	6.87 ± 0.34

R₀; basal diet, R₁; basal diet + 12% natural concentrate; R₂; basal diet + 24% natural concentrate; R₃; basal diet + 36% natural concentrate.

concentrate did not drastically alter systemic lipoprotein profiles or trigger major blood-level fluctuations via lecithin-cholesterol acyltransferase (LCAT) activation (Pizzini *et al.*, 2017). Crucially, as further detailed in the yolk composition section, the metabolic impact of these dietary fatty acids appears to be localized within target tissues (ovarian follicles) rather than modifying the overall systemic blood circulation.

The comparable hematological profiles (WBC, RBC, and hematocrit) further suggest that both natural and standard concentrates supported a similar health and physiological status in the birds. Meanwhile, the elevated serum triglyceride level observed exclusively in the R1 group (540±216 mg/dL, $p < 0.01$) should be interpreted with caution. Because blood samples were collected under postprandial (fed-state) conditions and exhibited high within-group variability (CV=40%), this isolated peak does not reflect a consistent dose-dependent trend, as higher replacement levels (R2 and R3) remained statistically comparable to the control. Eggshell quality and internal egg parameters are shown in Table 5.

Analysis of variance indicated no significant effect ($p > 0.05$) of natural concentrate inclusion on both exterior and interior egg quality traits. This confirms that the substitution of up to 24% of commercial concentrate with the formulated natural concentrate maintains the standard physical quality of the eggs while offering a more sustainable dietary alternative. This is likely due to the chickens' ability to effectively utilize calcium (Ca) and phosphorus (P) from the natural concentrate for eggshell formation in feed ensuring adequate calcium levels across all treatments. According to Stefanello *et al.* (2014), mineral supplementation, particularly Ca, Mn, Zn, and Cu, can influence eggshell thickness. However, as the mineral content in the experimental diets was relatively uniform (3.23–3.31% for calcium).

The lack of significant differences ($p > 0.05$) in both interior and exterior egg quality traits indicates that the natural concentrate effectively maintained standard egg characteristics within the normal range for Arabian chickens (Table 5). This consistency is primarily attributed to the balanced amino acid profile of the natural concentrate, which closely satisfies the specific requirements for egg formation. Adequate dietary protein and optimal amino acid availability ensure the structural integrity of the vitelline membrane which determines the yolk index as well as the synthesis of ovomucin-lysozyme complexes that regulate albumen viscosity and Haugh units (Wang *et al.*, 2019; Damaziak *et al.*, 2020). Furthermore, the uniformity in yolk and albumen weights across treatments confirms that the amino acids derived from the hydrolyzed tuna waste and fermented pollard were efficiently absorbed and utilized for egg protein synthesis, while being supported by the uniform age and body weight of the experimental flock (Tugiyanti and Iriyanti, 2012).

The amino acid profile of the fish head hydrolysate closely resembles that of the egg components, ensuring a balanced nutrient supply necessary for egg formation (Table 6). Although methionine is typically deficient when sourced solely from marine by-products, the inclusion of fermented pollard containing *Saccharomyces cerevisiae* successfully compensated for this limitation. The maintenance of HHP across all treatments serves as a key physiological indicator of essential amino acid adequacy, particularly for lysine and methionine (Reda *et al.*, 2020). This stability in production intensity is further driven by the superior bioavailability of the enzymatically produced short-chain peptides in the tuna hydrolysate, which are more readily absorbed than the complex protein matrices found in commercial feeds (Hou *et al.*, 2017). Additionally, because Arabian chickens possess a smaller body size and daily egg mass compared to commercial strains like Lohmann, their physiological methionine threshold is inherently lower, allowing the

formulated natural concentrate to successfully sustain optimum laying performance.

Table 6: Amino acid composition of hydrolyse tuna head and Arabian chicken egg.

Amino acids	Amino acid of tuna head*		Amino acid of egg**	
	Pineapple skin (%)	Pineapple stem (%)	Albumin (%)	Yolk (%)
Hydroxyproline	4.50	4.4	0.00	0.00
Proline	10.9	10.9	0.00	0.00
Tryptophan	1.40	1.40	0.00	0.00
Alanine	6.20	6.20	0.00	0.00
Histidine	0.00	0.00	0.05	0.05
Glycine	24.9	24.9	0.08	0.05
Threonine	1.10	2.10	0.10	0.09
Arginine	0.00	0.00	0.13	0.12
Tyrosine	0.00	0.00	0.09	0.08
Methionine	0.50	0.60	0.08	0.04
Valine	2.00	2.40	0.14	0.10
Phenylalanine	1.20	1.40	0.12	0.07
Ileucine	1.70	1.70	0.11	0.09
Leucine	1.90	1.80	0.18	0.15
Lysine	1.90	1.60	0.14	0.13

* Analyzed at the Laboratory of Feed, Gadjah Mada University;
**Sauveur (1988) in Yuwanta.

Table 7: Chemical composition of Arabian chicken egg yolk.

Variable	Treatments			
	R ₀	R ₁	R ₂	R ₃
Cholesterol (mg/100g)	231 ± 11.4 ^a	239 ± 6.94 ^a	215 ± 3.29 ^b	216 ± 10.1 ^b
Crude protein (%)	15.7 ± 1.19	16.1 ± 1.47	15.6 ± 1.70	16.2 ± 1.64
Ether extract (%)	37.4 ± 1.23 ^a	39.2 ± 3.51 ^a	32.0 ± 6.33 ^b	31.8 ± 5.53 ^b

Means with different superscript letters within the similar row indicate significant difference (p<0.05). R₀; basal diet, R₁; basal diet + 12% natural concentrate; R₂; basal diet + 24% natural concentrate; R₃; basal diet + 36% natural concentrate.

The chemical composition of the egg yolk revealed that the substitution of conventional concentrate with natural concentrate significantly reduced (p<0.05) both cholesterol and ether extract contents, particularly in the R2 and R3 groups, while crude protein levels remained unaffected (Table 7). Specifically, the R2 treatment successfully lowered yolk cholesterol by 7% and ether extract by 14.44% compared to the control. The recorded yolk cholesterol (averaging 225.45±7.92 mg/100g) was higher than the findings of Hosseini-Vashan *et al.* (2011)

but lower than Muharliien and Nurgiartiningsih (2015) for Arabian chickens. This demonstrates that incorporating the formulated natural concentrate up to a 24% inclusion level optimizes the yolk lipid profile without compromising structural protein content.

This synchronized decline in yolk lipids is driven by the biological activity of omega-3 fatty acids present in the tuna waste hydrolysate, which modulate both hepatic lipogenesis and cholesterol biosynthesis. Mechanistically, omega-3 fatty acids downregulate the activity of hepatic HMG-CoA reductase, the rate-limiting enzyme in cholesterol synthesis, and suppress the secretion of very low-density lipoproteins (VLDL), the primary transport vehicles for lipid deposition into developing ovarian follicles (Duthie and Barlow, 1992; Zhao *et al.*, 2022). Furthermore, marine-derived fatty acids can lower oestradiol levels, thereby reducing fatty acid synthesis and accelerating lipolysis (Wang *et al.*, 2023). While these dietary fatty acids did not trigger statistically significant changes in systemic blood profiles (Table 4), they targeted nutrient partitioning directly during follicular maturation, effectively inhibiting excessive lipid and cholesterol deposition into the yolk (Usturoi *et al.*, 2025).

Conversely, the stability of yolk crude protein levels (averaging 15.78±1.50%) confirms that the amino acid profile and bioavailability supplied by the natural concentrate, specifically the balanced concentrations of lysine (1.9%), leucine (1.9%), tryptophan (1.4%), and methionine (0.5%), adequately supported target protein biosynthesis. Consequently, the R2 formulation successfully transitions standard Arabian chicken eggs into functional poultry products. These health-optimized eggs offer distinct advantages for the functional food market, capturing the growing consumer demand for low-cholesterol, omega-3-enriched products that promote cardiovascular health.

CONCLUSION

Replacing conventional concentrate with 24% of conventional concentrate with a natural concentrate from hydrolysed tuna waste and fermented pollard is optimal for Arabian chickens. This level maintains egg production and feed efficiency comparable to commercial diets without adversely affecting blood profiles or physical egg quality. Furthermore, it improves the yolk's nutritional profile by reducing cholesterol and ether extract.

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NOVELTY STATEMENT

A novel finding of this study is that tuna head waste and wheat pollard enriched with yeast *Saccharomyces cerevisiae* can be used to reduce egg yolk cholesterol without compromising livestock productivity or health in 24% of replacing commercial concentrate

AUTHOR'S CONTRIBUTION

PRS and TRP: Data analysis and manuscript writing.

IH and NH: Data analysis.

HRW and BH: Manuscript writing.

ET and WC: Sample collection and analysis.

WYN : Manuscript Language Editing

GENERATIVE AI AND AI ASSISTED TECHNOLOGY STATEMENT

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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