

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(8): 602-605
www.biochemjournal.com
Received: 23-06-2026
Accepted: 26-07-2026

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Nutrient-sparing nutrition in broilers: Linking dietary efficiency with biochemical and physicochemical meat quality

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8h.9675>

Abstract

The present investigation was undertaken to evaluate the relationship between dietary nutrient efficiency and selected biochemical and physicochemical quality attributes of broiler meat. Commercial broiler chickens were allocated to four dietary treatments consisting of T₁: Standard Protein Standard Energy (SPSE), T₂: Low Protein Standard Energy (LPSE), T₃: Standard Protein Low Energy (SPLE), and T₄: Low Protein Low Energy (LPLE). The experimental diets were evaluated in relation to feed utilization and selected meat-quality characteristics, including water activity, water holding capacity, meat pH, tyrosine value and Thio barbituric acid reactive substances (TBARS). The results indicated numerical variation among dietary treatments in most meat-quality attributes. The modified nutritional treatments, particularly T₃ and T₄, generally showed favourable numerical responses compared with the control treatment. Meat pH, tyrosine value and TBARS, however, did not show statistically significant treatment differences. Water activity and water holding capacity also exhibited treatment-wise variation without consistent statistically significant differences. The findings indicate that efficient nutrient utilization through modified dietary protein-energy regimes can be associated with maintenance of desirable biochemical and physicochemical meat characteristics. The study provides evidence that nutritional efficiency can be considered not only in terms of growth and feed conversion but also in relation to the quality attributes of the final poultry product.

Keywords: Broiler, nutrient efficiency, protein-energy nutrition, meat quality, water activity, water holding capacity, TBARS, tyrosine, pH

1. Introduction

Broiler production is one of the most efficient systems for converting dietary nutrients into high-quality animal protein. The profitability and sustainability of broiler production depend largely on the efficient utilization of feed nutrients because feed represents a major component of production cost.

Dietary protein and metabolizable energy are two major nutritional determinants of broiler performance. Protein supplies amino acids required for muscle development, whereas dietary energy determines the extent to which nutrients can be utilized for maintenance and tissue deposition. An imbalance between protein and energy may reduce feed efficiency, impair growth and increase nutrient wastage.

Modern poultry nutrition therefore increasingly focuses on improving nutrient efficiency, rather than simply increasing dietary nutrient concentration. Optimizing the relationship between dietary protein and energy may allow birds to maintain productive performance while reducing unnecessary nutrient supply and feed expenditure.

The nutritional status of broilers may also influence the characteristics of the meat produced. Meat quality is determined by several biochemical and physicochemical properties, including water activity, water holding capacity, pH, texture and oxidative stability. The thesis from which the present study was derived specifically evaluated water activity, water holding capacity, texture and colour, shear force, pH, tyrosine value and TBARS as meat-quality attributes.

Water-holding capacity is an important quality characteristic because it influences juiciness, processing yield and consumer acceptance.

Meat pH is closely associated with post-mortem biochemical changes, while tyrosine value provides information related to protein breakdown. TBARS is an indicator of lipid oxidation and therefore provides information about oxidative stability.

The present investigation was therefore designed to examine whether modified dietary protein-energy regimes capable of improving nutrient utilization could maintain or improve important biochemical and physicochemical characteristics of broiler meat.

1.1 Objective

The objective of the present study was to evaluate the association between dietary nutrient efficiency and biochemical and physicochemical quality characteristics of broiler meat under different protein energy regimes.

2. Materials and Methods

2.1 Experimental birds and design

A total of 240-day-old commercial broiler chicks were randomly distributed into four dietary treatments. Each treatment consisted of four replications with 15 birds per replicate, following a Completely Randomized Design. The experiment was conducted separately during winter and summer seasons.

2.2 Dietary treatments

The experimental treatments were

Treatment	Dietary Regime
T ₁	Standard Protein Standard Energy (SPSE)
T ₂	Low Protein Standard Energy (LPSE)
T ₃	Standard Protein Low Energy (SPLE)
T ₄	Low Protein Low Energy (LPLE)

2.3 Feeding and management

Birds were provided pre-starter, starter and finisher diets according to the experimental treatment. The feeding programme extended up to 42 days of age. Feed and water were supplied according to the experimental management protocol.

2.4 Assessment of nutrient utilization and production efficiency

Feed utilization was assessed through feed intake and feed conversion ratio (FCR). FCR was calculated as:

$$\text{FCR} = \text{Feed intake} / \text{Body weight gain}$$

Lower FCR values indicated better feed utilization

At 35 days, T₃ and T₄ showed lower FCR than the control in the reported results. In the summer dataset, T₃ and T₄ recorded FCR values of 1.941 and 1.938, respectively, compared with 1.989 in T₁, with a significant treatment effect ($P = 0.028$).

2.5 Meat sample collection

At the end of the experimental feeding period, representative birds were processed and breast muscle samples were collected for meat-quality evaluation.

2.6 Physicochemical and biochemical meat-quality assessment

The following meat-quality parameters were evaluated:

- Water activity
- Water holding capacity
- Meat pH
- Tyrosine value
- TBARS

The thesis also evaluated texture, colour and shear force as additional physicochemical characteristics.

2.7 Statistical analysis

Treatment means were subjected to analysis of variance. Differences were considered statistically significant at $p < 0.05$.

3. Results and Discussion

3.1 Dietary efficiency and feed utilization

The results indicated that modification of the dietary protein-energy regime influenced feed utilization. In general, T₃ and T₄ showed lower FCR values than the control treatment at important stages of production.

At 35 days, winter FCR values were 1.983, 1.975, 1.927 and 1.933 for T₁, T₂, T₃ and T₄, respectively. The corresponding summer values were 1.989, 1.980, 1.941 and 1.938. The summer treatment effect was significant ($P = 0.028$).

This indicates that reducing or modifying nutrient supply did not necessarily compromise feed utilization. Rather, the T₃ and T₄ regimes showed numerically improved feed conversion, supporting the concept of nutrient-efficient feeding.

Table 1: Feed conversion ratio of broiler chickens under different protein energy regimes

Season	T ₁	T ₂	T ₃	T ₄
Winter	0.39 ± 0.04	0.48 ± 0.03	0.50 ± 0.03	0.47 ± 0.05
Summer	0.54 ± 0.05	0.50 ± 0.05	0.48 ± 0.06	0.50 ± 0.04

3.2 Water activity of broiler meat

Water activity is an important physicochemical characteristic of meat because it reflects the availability of water for biochemical and microbial processes.

In winter, water activity ranged from 0.87 in T₂ to 0.93 in T₄. In summer, values ranged from 0.88 in T₁ to 0.93 in T₄. The treatment effects were not statistically significant.

The numerical increase observed in T₄ suggests that the modified protein energy regime did not adversely alter this characteristic under the experimental conditions.

Table 2: Water activity of broiler meat under different dietary regimes

Season	T ₁	T ₂	T ₃	T ₄
Winter	0.89 ± 0.01	0.87 ± 0.01	0.90 ± 0.02	0.93 ± 0.01
Summer	0.88 ± 0.01	0.89 ± 0.01	0.91 ± 0.02	0.93 ± 0.02

Values are expressed as mean ± SE.

3.3 Water holding capacity

Water holding capacity is an important determinant of meat processing quality and eating characteristics. The experimental results showed numerical variation among dietary treatments.

During winter, water holding capacity ranged from 61.84% to 66.13%, with the highest numerical value recorded in T₁. The treatment effect was non-significant.

The observed variation indicates that modification of protein energy supply did not produce a statistically measurable change in water retention capacity.

Table 3: Water holding capacity of broiler meat under different dietary regimes

Treatment	Water Holding Capacity (%)
T ₁	66.13 ± 1.33
T ₂	61.84 ± 2.69
T ₃	64.20 ± 1.11
T ₄	66.93 ± 2.31

Values are expressed as Mean ± SE

3.4 Meat pH

Meat pH is an important indicator of post-mortem biochemical changes. In the present investigation, treatment-wise numerical variation was observed.

During winter, pH values were 5.93, 5.88, 5.89 and 5.79 in T₁, T₂, T₃ and T₄, respectively. During summer, the corresponding values were 5.86, 5.79, 6.03 and 5.91. Treatment effects were non-significant in both datasets.

Table 4: Meat pH under different dietary protein-energy regimes

Season	T ₁	T ₂	T ₃	T ₄
Winter	5.93 ± 0.08	5.88 ± 0.09	5.89 ± 0.10	5.79 ± 0.10
Summer	5.86 ± 0.18	5.79 ± 0.08	6.03 ± 0.02	5.91 ± 0.17

Values are expressed as mean ± SE.

3.5 Tyrosine value

Tyrosine value showed numerical variation among dietary treatments. During winter, T₂ and T₃ recorded the highest numerical values (0.27 mg/100 g), whereas T₁ recorded 0.22 mg/100 g. The treatment effect was non-significant (F = 1.23; P = 0.3414).

During summer, values varied narrowly from 0.23 to 0.25 mg/100 g, with no significant treatment effect (F = 0.08; P = 0.9669).

Table 5: Tyrosine value of broiler meat under different dietary regimes

Season	T ₁	T ₂	T ₃	T ₄
Winter	0.22 ± 0.01	0.27 ± 0.03	0.27 ± 0.03	0.25 ± 0.02
Summer	0.24 ± 0.02	0.23 ± 0.02	0.24 ± 0.03	0.25 ± 0.03

Values are expressed as mean ± SE. Unit: mg/100g.

3.6 Oxidative stability of meat

TBARS values were used to assess lipid oxidation. During winter, TBARS values ranged from 0.39 mg MDA/kg in T₁ to 0.50 mg MDA/kg in T₃. During summer, values ranged from 0.48 mg MDA/kg in T₃ to 0.54 mg MDA/kg in T₁. Treatment effects were non-significant in both seasons.

The relatively lower numerical TBARS value observed in T₃ during summer suggests a favourable oxidative stability response, although this difference should not be interpreted as a statistically confirmed treatment effect.

Table 6: TBARS value of broiler meat under different dietary regimes

Season	T ₁	T ₂	T ₃	T ₄
Winter	0.39 ± 0.04	0.48 ± 0.03	0.50 ± 0.03	0.47 ± 0.05
Summer	0.54 ± 0.05	0.50 ± 0.05	0.48 ± 0.06	0.50 ± 0.04

Values are expressed as mean ± SE. Unit: mg MDA/kg.

3.7 Integrated interpretation of nutrient efficiency and meat quality

The results demonstrate that dietary nutrient efficiency and final meat quality should be considered together rather than independently.

T₃ and T₄ generally demonstrated favourable feed conversion responses compared with T₁, particularly during the later production stage. At the same time, the modified diets did not result in statistically significant deterioration of the evaluated meat-quality parameters.

The overall thesis findings similarly report that modified nutritional treatments, particularly T₃ and T₄, were associated with improved meat-quality characteristics including water holding capacity, oxidative stability and texture.

Thus, the results support the concept that nutrient-efficient feeding can maintain desirable product quality while improving utilization of dietary nutrients.

However, because several individual meat-quality parameters were statistically non-significant, the findings should be interpreted as maintenance of meat quality alongside improved feed efficiency, rather than claiming a statistically significant improvement in every quality parameter.

4. Discussion

Dietary protein and energy are central determinants of nutrient utilization in broilers. The literature reviewed in the thesis indicates that optimizing crude protein, metabolizable energy and essential amino acids is important for maintaining growth and feed conversion efficiency.

The present findings are consistent with this nutritional concept. The lower FCR observed in T₃ and T₄ suggests that the modified nutrient regimes enabled efficient utilization of dietary nutrients during the grower-finisher period.

An important aspect of the present findings is that improved feed utilization was not accompanied by a statistically significant deterioration in the major meat-quality characteristics assessed. Water activity, pH, tyrosine value and TBARS showed numerical treatment differences but no significant treatment effects.

The results therefore suggest that dietary nutrient efficiency can potentially be improved without compromising the biochemical and physicochemical characteristics of the final product.

The concept is particularly relevant to commercial poultry production because excessive dietary nutrient supply may increase feed cost and nutrient wastage. The thesis introduction also highlights the importance of efficient nutrient utilization for economic sustainability and notes that excessive nutrient supply can increase nitrogen and phosphorus excretion.

5. Conclusion

The present study demonstrated that modified dietary protein-energy regimes influenced feed utilization while generally maintaining the measured biochemical and physicochemical quality characteristics of broiler meat.

T₃ and T₄ showed favourable feed conversion responses compared with the control, particularly during the later growth stage. Meat-quality parameters including water activity, water holding capacity, pH, tyrosine value and TBARS showed numerical variation among treatments, but most treatment effects were statistically non-significant.

The findings indicate that nutrient-efficient dietary strategies can potentially improve utilization of dietary resources without adversely affecting important meat-quality characteristics. Therefore, nutrient efficiency should be considered alongside final product quality when designing practical broiler feeding programmes.

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