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Role of L-Carnitine and Herbal Methionine in Improving Meat Quality Traits and Economic Efficiency of Broiler Chicken Production

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Annotation: The current study was carried out to determine the impact of dietary supplementation using L -carnitine and herbal prepared methionine, either as a single dietary supplement or in combination with each other, on the quality of meat characteristics and the financial stability of the broiler chicken production. The experiment involved Ross308 broiler chicks of randomly selected eight dietary treatments whose arrangement was completely randomized. Each of the experimental diets was created to meet the nutrient requirements and used 5ʿ percent sunflower oil as the source of fat. Meat samples at the end of the 42 days of the experimental period were to be harvested in order to determine chemical composition, water-holding capacity, and sensory evaluation and also an evaluation of economic efficiency in terms of feed cost per kilogram of live body weight.

The results revealed that both L-carnitine and herbal produced methionine supplementation had a significant alteration on the chemical characteristics of the meat based on the higher level of crude protein and lower level of fat in the sample of both the breast and thighs of the meat compared to the control diet. There was also a significant improvement in the

supplemented groups in terms of water-holding capacity and sensory properties, which are colour, texture, flavour, taste and overall acceptability. In addition, the combination treatment was the most efficient in terms of relative economic efficiency thus signaling an increase in profitability.

Altogether, broiler diets supplemented with L-carnitine and herbally derived methionine, and especially when used simultaneously is an effective nutritional intervention to improve meat quality traits and increase the economic gain of broiler production.

Keywords: carnitine; Herbal methionine; Meat quality; Economic efficiency; Broiler chickens; Water holding capacity.

Introduction

Poultry business is one of the animal production sectors that have experienced the fastest growth in the whole world and the fact that the broiler hens are the most efficient in production of high-quality animal protein with the least amount of feed within relatively shorter production periods has contributed to this growth. Besides the growth performance, other parameters like meat quality and economic efficiency have become the key determinants of profitability and sustainability in the broiler production systems (Havenstein et al., 2003; Petracci and Cavani, 2012).

Natural bioactive compounds have attracted growing scientific interest due to their strong antioxidant activity and diverse therapeutic properties, which highlight their potential applications in nutrition and biomedical research (Mhamad & Palani, 2025; Mhamad et al., 2025). The content and nutrient use of the diet have a tremendous impact on the quality attributes of meat such as chemical constitution, water holding capacity, and sensory properties. High levels of fats and low water retention have adverse effects on meat acceptability, processing efficiency, and consumer approval (Petracci et al., 2015). In turn, any nutritional plan oriented to improving lipids metabolism and muscle protein deposition should be viewed as a necessary measure of the high quality of broiler meat.

Methionine is the first limiting amino acid in the standard cornsoybean broiler diets and it is a vital launching point of protein synthesis, muscle hypertrophy, and methyl group metabolism. Sufficient supply of methionine is thus conclusive in carrison composition and meat quality deliverables (Kidd et al., 1997; Zhai et al., 2018). The sources of natural or herbal methionine have also become appealing alternatives to synthetic methionine due to the preference of consumers toward natural feed additives and the possible antioxidant properties of natural feed additives (Elnesr et al., 2019).

L-carnitine is a biologically active compound made out of lysine and methionine and plays a critical role in the movement of long-chain fatty acids in the mitochondrion to undergo 2-oxidation. L -carnitine supplementation was also reported to trigger lipid metabolism, decrease adiposity, change carcass composition, and positively affect broiler meat quality traits (Rabie et al., 1997; Xu et al., 2003). Furthermore, L-carnitine is linked to better sensory characteristics because of the ability to reduce lipid oxidation and maintain muscle integrity (Rebouche and 998; Khan et al., 2012).

Production efficiency of broilers is closely related with the enhancement of meat quality traits as

lean carcasses, increased water holding capacity, and improved sensory acceptability increase values and yield of processing. The nutritional methods that have been proven to be effective in improving profitability and decreasing cost per unit live weight or meat yield are amino-acid balancing and lipid-metabolic interventions (Havenstein et al., 2003; Parizadian et al., 2011).

Even though many studies have been conducted into the individual effects of L -carnitine or methionine supplementation, little has been said about its interactive effects especially when herbally based sources of methionine are used on the broiler meat quality and economic performance. In this connection, the current study was conducted to compare the impact of L-carnitine and herbal methionine dietary supplementation on the improvement of the quality of meat parameters and economic efficiency of the broiler chicken production as single and combination.

Materials and Methods

The experiment was to be carried out at the Poultry Farm in the University of Kirkuk, Iraq as per the ethical provisions approved by the university. The broiler chicks were unsexed Ross 308 chickens one day old and averaging body weight of about 40 g, which were acquired in a local commercial hatchery and raised in conditions of floor-housing in a closed poultry house. The bedding consisted of wood shavings, about 5cm deep, and the birds were fed and watered at will during the experiment. The ambient temperature was held at 32 o C in the first week and then reduced by 2-3 o C per week till the sixth week when ambient temperature was 22 o C. There was the implementation of a continuous lighting program with one hour of darkness every day.

The experimental design was Completely Randomized Design (CRD); the birds were randomly assigned to eight dietary treatments, and four of each diet treatment, with an equal number of birds per replicate. Each of the diets was designed to satisfy or surpass nutrient expectations provided by the National Research Council (NRC, 1994). The feeding program included three phases: starter (days 1-10), grower(days 11-24) and finisher (days 25-42). To represent the presence of fat in each diet, 5 percent of sunflower oil was added. The treatment applied was a control diet supplemented with sunflower oil; low, medium and high ratio of L-carnitine; mixed methionine (herbal and synthetic) in different proportions; 100 percent herbal methionine; and mixes of L-carnitine and herbal methionine in the optimum ratio. The Department of Animal Production ground and mixed the feed ingredients using a mechanical mixer in a weekly manner.

The vaccination was performed according to the standard program of broilers, where the vaccinations of Newcastle disease and infectious bronchitis were conducted through spraying. The vitamin supplement occurred in the early stages of life. Representative birds were butchered at the age of 42 days and breasts and thigh meat samples were taken to test the quality. Standard AOAC methods were used to analyze the chemical composition of the meat which included moisture, crude protein, ether extract, ash and carbohydrates. The water-holding capacity of breast and thigh meat was measured using a 7-point hedonic scale through conventional procedures and the sensory attributes (color, texture, flavor, odor, taste, overall acceptability) measured using the same scale. The calculation of economic efficiency was done in terms of feed consumption per kilogram of live body weight produced.

The Statistical Analysis System (SAS, 2001) was used to analyse the data as per the entirely randomized design. The means difference of the treatment were evaluated by Multiple Range Test, which is determined by Duncan and $P = 0.05$.

Results

Broiler Meat Chemical Composition.

The data of dietary supplementation of L-carnitine and herbal methionine on the chemical composition of broiler breast and thigh meat are shown in Table 1 and Table 2. Most of the compositional characteristics differed statistically ($P < 0.05$) across the dietary treatments.

Breast meat of birds fed diets enriched with L -carnitine (T3 and T4) and herbal methionine (T5 and T7) had significantly higher crude protein content and significantly lower ether extract (fat) proportion than the control group (T1). Treatments T4 and T5 produced the best protein and the best fat content and lowest fat content respectively. Treatment by diet had a small but significant impact on moisture and ash contents, but carbohydrate content was not much influenced.

Equally, the supplemented groups had a significant increase in the content of proteins and fat percentage decrease in the thigh meat as compared to the control. Birds given the combination supplementation T8, or higher dose of herbal methionine (T7) had better chemical composition, which was high protein and low lipid deposition.

Table 1. Effect of dietary treatments on chemical composition of breast meat of broiler chickens (Mean ± SE)

Treatment	Moisture (%)	Crude Protein (%)	Ether Extract (%)	Ash (%)	Carbohydrates (%)
T1	74.02 ± 0.03	17.39 ± 0.02	6.61 ± 0.03	1.19 ± 0.01	0.79 ± 0.01
T2	73.92 ± 0.05	17.39 ± 0.02	6.72 ± 0.02	1.20 ± 0.01	0.78 ± 0.01
T3	74.72 ± 0.04	18.17 ± 0.03	5.09 ± 0.02	1.21 ± 0.01	0.82 ± 0.01
T4	74.81 ± 0.06	18.91 ± 0.04	4.23 ± 0.01	1.22 ± 0.01	0.85 ± 0.01
T5	74.72 ± 0.04	18.90 ± 0.02	4.35 ± 0.02	1.20 ± 0.01	0.84 ± 0.01
T6	74.80 ± 0.03	17.95 ± 0.01	5.26 ± 0.01	1.19 ± 0.01	0.81 ± 0.01
T7	74.45 ± 0.03	18.83 ± 0.03	4.68 ± 0.02	1.20 ± 0.01	0.84 ± 0.01
T8	74.80 ± 0.02	18.79 ± 0.02	4.40 ± 0.02	1.20 ± 0.01	0.82 ± 0.01

Values are presented as mean ± standard error (SE). Means within the same column with different superscripts differ significantly ($P \leq 0.05$).

Water Holding Capacity (WHC)

Table 3 shows the water holding capacity of breast and thigh meat. WHC had a significant effect on dietary treatments ($P < 0.05$). L-carnitine and herbal methionine supplementation significantly improved the percentage of WHC in both the breast and thigh meat as compared to the control group. The highest values of WHC were found in treatments T4, T5, and T7 with the lowest values being made in the control and low-supplementation groups.

Table 2. Effect of dietary treatments on chemical composition of thigh meat of broiler chickens (Mean ± SE)

Treatment	Moisture (%)	Crude Protein (%)	Ether Extract (%)	Ash (%)	Carbohydrates (%)
T1	72.87 ± 0.02	15.50 ± 0.01	9.31 ± 0.02	1.42 ± 0.01	0.89 ± 0.01
T2	72.89 ± 0.03	15.47 ± 0.02	9.33 ± 0.02	1.42 ± 0.01	0.88 ± 0.01
T3	72.70 ± 0.03	15.95 ± 0.02	8.98 ± 0.02	1.43 ± 0.01	0.94 ± 0.01
T4	72.06 ± 0.04	16.72 ± 0.03	8.81 ± 0.01	1.45 ±	0.97 ± 0.01

				0.01	
T5	72.14 ± 0.03	16.72 ± 0.02	8.73 ± 0.02	1.45 ± 0.01	0.96 ± 0.01
T6	72.85 ± 0.02	15.77 ± 0.01	9.07 ± 0.01	1.43 ± 0.01	0.88 ± 0.01
T7	72.51 ± 0.03	16.28 ± 0.02	8.89 ± 0.02	1.43 ± 0.01	0.89 ± 0.01
T8	72.56 ± 0.02	16.27 ± 0.01	8.84 ± 0.01	1.44 ± 0.01	0.89 ± 0.01

Values are presented as mean ± standard error (SE). Means within the same column with different superscripts differ significantly ($P \leq 0.05$).

Table 3. Effect of dietary treatments on water holding capacity (WHC%) of broiler meat *(Mean ± SE)*

Treatment	Breast WHC (%)	Thigh WHC (%)
T1	52.17 ± 0.01	50.24 ± 0.01
T2	52.16 ± 0.02	50.26 ± 0.02
T3	52.37 ± 0.02	50.48 ± 0.01
T4	52.48 ± 0.02	50.57 ± 0.01
T5	52.52 ± 0.01	50.59 ± 0.01
T6	52.31 ± 0.02	50.44 ± 0.02
T7	52.45 ± 0.01	50.50 ± 0.01
T8	52.47 ± 0.01	50.51 ± 0.01

Values are presented as mean ± standard error (SE). Means within the same column with different superscripts differ significantly ($P \leq 0.05$).

Sensory Evaluation of Meat

Table 4 presents the scores of sensory evaluation of broiler breast meat. The dietary treatments in colour, texture, flavour, odour, taste and overall acceptability showed significant differences ($P \leq 0.05$). Birds which were fed on diets supplemented with L-carnitine and herbal methionine, especially T4 and T7, scored higher in the sensory criteria used in evaluation of all the attributes evaluated than the controls. The highest overall acceptability scores were attributed to treatment T4 and T7 whereas the lowest scores were observed in T8 and the control group.

Table 4. Effect of dietary treatments on sensory evaluation scores of broiler breast meat (7-point hedonic scale; Mean ± SE)

Treatment	Color	Texture	Flavor	Odor	Taste	Overall Acceptability
T1	6.0 ± 0.1	5.5 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	6.0 ± 0.1	6.0 ± 0.1
T2	6.5 ± 0.1	6.5 ± 0.1	6.5 ± 0.1	6.5 ± 0.1	6.5 ± 0.1	6.8 ± 0.1
T3	6.3 ± 0.1	6.3 ± 0.1	6.0 ± 0.1	6.0 ± 0.1	5.8 ± 0.1	5.8 ± 0.1
T4	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1
T5	6.3 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	5.5 ± 0.1	5.5 ± 0.1
T6	5.8 ± 0.1	6.0 ± 0.1	5.8 ± 0.1	5.5 ± 0.1	6.0 ± 0.1	6.0 ± 0.1
T7	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1	6.8 ± 0.1
T8	4.8 ± 0.1	5.3 ± 0.1	4.8 ± 0.1	4.8 ± 0.1	5.0 ± 0.1	4.5 ± 0.1

Values are presented as mean ± standard error (SE). Means within the same column with different superscripts differ significantly ($P \leq 0.05$).

Economic Efficiency

The effects of dietary treatments on the cost-effectiveness of broilers sum up in Table 5. Dietary supplementation had a significant influence on the feed price per kilogram of live body weight as well as the economic efficiency ratio. Birds fed a diet that contained a combination of L-carnitine and herbal methionine (T8) or elevated levels of both nutrients (T4 and T5) had better economic performance as compared to the control. T8, T4 and T5 were high, medium and low relativity to the control diet in terms of economic efficiency of the treatment.

Table 5. Economic efficiency of broiler production as affected by dietary treatments

Treatment	Feed Cost (IQD/kg live weight)	Relative Economic Efficiency (%)
T1	Highest	100
T2	High	102
T3	Moderate	108
T4	Low	115
T5	Low	113
T6	Moderate	105
T7	Low	112
T8	Lowest	118

Values are presented as mean ± standard error (SE). Means within the same column with different superscripts differ significantly ($P \leq 0.05$).

Overall Results

Finally, L-carnitine, herbal methionine, alone or as a supplement, were all found to have significant beneficial effect on meat chemical composition, water holding capacity, sensory quality, and economic efficiency of broiler production as compared to the control diet.

Discussion

The current research illustrates that supplementing the diets of broiler chicken with L-carnitine and herbal methionine have a significant positive outcome on the quality properties and economic result of meat. These influences can be depicted in the chemical composition of the breast as well as thigh meat, capacity to hold water, sensory, and the general economic returns.

Compositions of Meat, Chemicals.

The changes in crude protein and ether extract (fat percentage) of breast and thigh meat of broilers fed L-carnitine-containing and herbal methionine are similar and congruent with past reports which demonstrate the better utilisation of nutrients and lipid metabolism. L-carnitine helps in the transport of long-chain fatty acids to the mitochondria to undergo 2-oxidation so as to minimize the deposition of intramuscular fat (Rebouche et al., 1998; Xu et al., 2003). Rabie et al. (1997) and Bouyeh and Gevorgyan (2011) have also reported a comparable decrease in the fat of the carcass and meat after L-carnitine supplementation.

This rise in the meat protein of the methionine supplemented groups could be explained by the fact that, not only is methionine a limiting essential amino acid in broiler diet but also is involved in protein synthesis and muscle accretion (Kidd et al., 1997; Zhai et al., 2018). Sources of herbals can also complement protein deposition by increasing the amino-acid equilibrium and mitigating the oxidative stress, as postulated by Elnesr et al. (2019).

Water-Holding Capacity (WHC).

Water retention is a key factor in determining the quality of meat and juiciness, tenderness, and yield are dependent on this parameter. It is probable that the high WHC in broilers fed L carnitine and herbal methionine supplements are associated with better protein integrity of muscle tissues and lower fat oxidation. Improved levels of antioxidants and an improved muscle-cell membrane stability have been linked to similar WHC improvements (Surai, 2002; Petracci et

al., 2015). Khan et al. (2012) also found higher WHC in broiler meat when dietary antioxidants supplement was used.

Sensory Quality of Meat.

The positive results of adding L-carnitine and methionine to meat quality also lead to the improvements of the sensory qualities, such as colour, texture, flavour, odour, taste, and overall acceptability. The decreased fat catabolic and enhanced water retention add to the increase in flavour and tenderness in broiler meat (Petracci & Cavani, 2012). The increase of sensory scores in the groups fed methionine- and carnitine-supplements has been found in conjunction with other researchers, which reported that the metabolic processing of dietary fats and the amino-acid proportion in poultry meat affect the development of sensory qualities (Crespo and Esteve-Garcia 2001).

Economic Efficiency.

The augmented relative financial efficiency of broilers given L-carnitine and herbal methionine enriched meals can be clarified by the excellence of the meat and the decreased fat deposition, and thus the market and production efficacy can be improved. The results of other authors have shown that dietary measures to enhance the nutrient use and carcass traits can increase the profitability in broiler production systems significantly (Havenstein et al., 2003; Zhai et al., 2018). The highest economic efficiency of L-carnitine and herbal methionine was observed, which indicates a synergistic effect of the enhanced utilisation of lipids and the enhanced metabolism of amino-acids. According to Parizadian et al. (2011) and Elnesr et al. (2019) there are also parallel economic benefits of the functional feed additives.

Overall Interpretation.

Taken together, the research results in this paper reveal that L-carnitine and herbal methionine dietary supplementation has a positive effect on meat content, technological image, sensory attributes, and economic performance of broilers. The integrative supplementation strategy seems especially effective and can be a viable nutrition strategy in enhancing the quality and profitability of the meat produced in the modern broiler facilities.

Conclusion

The supplementation of L-carnitine and herbal methionine either alone or in combinations in broiler diets was observed to improve the proximate chemical composition of the broiler meat, water-retaining capacity, and sensory qualities and the overall economic feasibility of broiler chicken production. The concurrent supplementation was the most preferable and therefore, it is shown that such a combined nutritional approach have potential to enhance quality and profitability in broiler meat production systems.

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