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Production performance and egg quality of Japanese quail fed different levels of protein

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Abstract

Small-scale poultry farmers in East Asia face a persistent problem: feed accounts for 65-70% of total production costs, and protein is the most expensive component. Identifying the protein level that maximises egg output without inflating feed costs is therefore a practical priority. This research evaluated the production performance and egg quality of Japanese quail (*Coturnix japonica*) fed diets containing 18%, 20%, 22%, and 24% Crude Protein (CP). Two hundred and forty day-old quail chicks were randomly assigned to four dietary treatments with three replicates of 20 birds each. The feeding trial lasted from week 5 to week 16 of age at the Poultry Research Unit of Chungnam College of Food Science, Daejeon, South Korea, between May and September 2022. Birds receiving 22% CP achieved the highest hen-day egg production (79.8%), the best feed conversion ratio (2.91), and superior egg quality parameters including shell thickness (0.221 mm), Haugh unit (88.4), and yolk colour score (7.1). Increasing protein to 24% CP did not yield further improvements and slightly raised feed costs. The results indicate that 22% crude protein is the most efficient dietary level for Japanese quail during the laying phase under Korean management conditions.

Keywords: Japanese quail, egg quality, protein levels, quail production, small poultry, feed conversion, hen-day production, *Coturnix japonica*, laying performance, crude protein

Introduction

Feed cost remains the single largest barrier to profitability in small-scale quail farming, and protein is the costliest fraction of any poultry ration. In South Korea, soybean meal prices rose by 23% between 2020 and 2022, squeezing margins for farmers who raise Japanese quail for both egg and meat production ^[1]. Setting the dietary protein level too low depresses egg output and shell quality, while setting it too high wastes expensive feed ingredients without proportional gains in performance ^[2].

Japanese quail (*Coturnix japonica*) reach sexual maturity as early as six weeks of age and can produce 250-300 eggs per year under good management ^[3]. Their short generation interval and small body size make them well suited for research on nutritional requirements. The National Research Council ^[4] recommends 20% CP for laying quail, but this recommendation dates from 1994, and modern commercial strains selected for higher output may have different requirements ^[5]. Several authors have tested protein levels ranging from 16% to 26% with mixed results, partly because differences in strain, climate, and management make direct comparison difficult ^[6, 7].

Given the economic pressure on Korean quail farmers and the outdated nature of existing protein recommendations, this research aimed to compare four crude protein levels (18%, 20%, 22%, and 24%) for their effects on laying performance, feed efficiency, and internal and external egg quality traits across a 12-week production cycle.

Material and Methods

Material

Two hundred and forty day-old Japanese quail chicks of the Korean White strain were obtained from a commercial hatchery in Cheonan, South Korea. The birds were reared in a climate-controlled house at the Poultry Research Unit of Chungnam College of Food Science, Daejeon (36°22'N, 127°20'E). Four isocaloric diets (2,900 kcal ME/kg) were formulated with crude protein contents of 18%, 20%, 22%, and 24% using maize, soybean

meal, fish meal, and vitamin-mineral premix as main ingredients. Diets were pelleted and stored in sealed containers at room temperature. The research was approved by the Institutional Animal Care and Use Committee (Protocol CCFS-IACUC-2022-009, approved April 2022).

Field experimental design

The experiment followed a completely randomised design with four treatments and three replicates per treatment. Each replicate consisted of 20 birds (15 females, 5 males) housed in wire cages (120 × 60 × 25 cm) fitted with nipple drinkers and trough feeders. A photoperiod of 16 hours light and 8 hours dark was maintained throughout. The brooding phase (weeks 0-2) used a common starter diet, followed by a grower diet during the adaptation phase (weeks 3-4). Experimental diets were introduced at week 5, and data collection continued through week 16.

Methods

Eggs were collected daily and recorded per replicate. Hen-

day production (%) was calculated as the number of eggs produced divided by the number of hen-days alive, multiplied by 100. Feed consumption was recorded weekly, and Feed Conversion Ratio (FCR) was expressed as kg feed per dozen eggs. Egg quality was assessed on 10 randomly selected eggs per replicate at weeks 8, 12, and 16. Egg weight was measured to 0.01 g, shell thickness at the equator was determined using a micrometer (0.001 mm), yolk colour was scored with the Roche Yolk Colour Fan, and Haugh unit was calculated from albumen height and egg weight [8]. Data were analysed by one-way ANOVA using SAS 9.4, and means were separated by Duncan's multiple range test at $p < 0.05$ [9].

Results

Birds fed the 22% CP diet outperformed the other three groups in nearly every measured parameter. Production and egg quality differences between treatments became statistically significant from week 8 onwards.

Table 1: Production performance of Japanese quail fed four dietary protein levels (weeks 5-16)

Parameter	18% CP	20% CP	22% CP	24% CP	p-value
Hen-day production (%)	68.4c	74.2b	79.8a	77.1ab	0.003
Feed intake (g/bird/day)	28.6a	27.9ab	27.1b	28.3a	0.021
FCR (kg feed/dozen eggs)	3.42a	3.18b	2.91c	3.05bc	0.001
Body weight gain (g)	42.3b	48.7a	51.2a	50.8a	0.014
Mortality (%)	3.3	1.7	1.7	3.3	0.412

Means within a row sharing no common superscript letter differ significantly ($p < 0.05$)

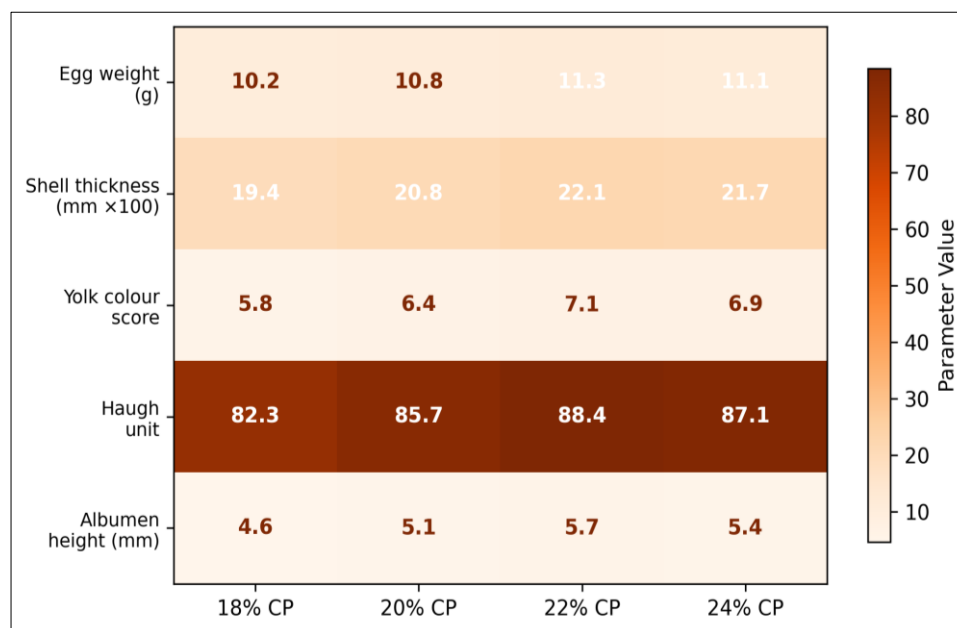


Fig 1: Heatmap of egg quality parameters across four dietary protein levels

Table 2: External and internal egg quality traits at week 16

Trait	18% CP	20% CP	22% CP	24% CP
Egg weight (g)	10.2 ± 0.4c	10.8 ± 0.3b	11.3 ± 0.3a	11.1 ± 0.4ab
Shell thickness (mm)	0.194 ± 0.01b	0.208 ± 0.01a	0.221 ± 0.01a	0.217 ± 0.01a
Yolk colour score	5.8 ± 0.5b	6.4 ± 0.4a	7.1 ± 0.3a	6.9 ± 0.4a
Haugh unit	82.3 ± 2.1b	85.7 ± 1.8a	88.4 ± 1.6a	87.1 ± 1.9a
Albumen height (mm)	4.6 ± 0.3b	5.1 ± 0.2a	5.7 ± 0.2a	5.4 ± 0.3a

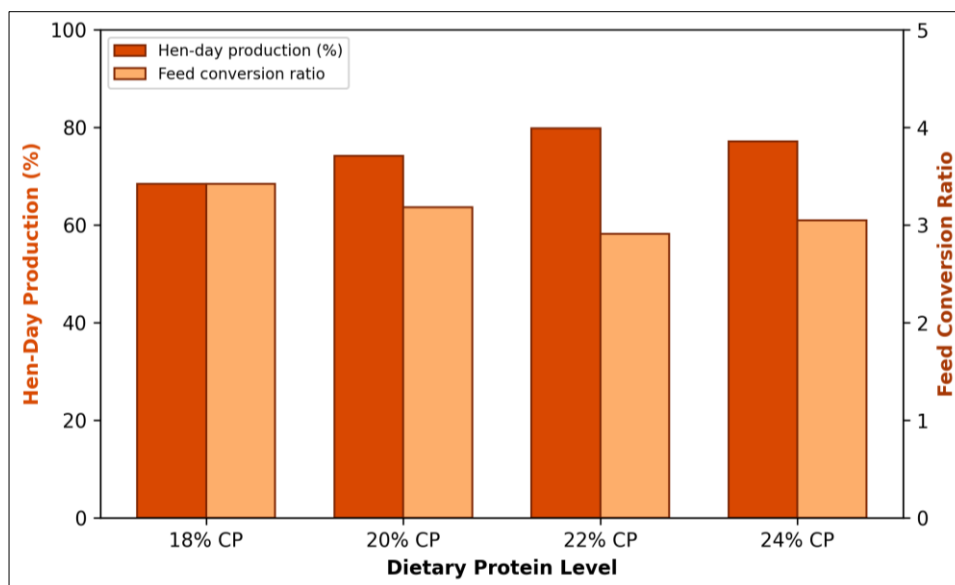


Fig 2: Hen-day production and feed conversion ratio at four protein levels



Fig 3: Experimental feeding protocol used in the Japanese quail trial

Nutrient budget

At 22% CP, daily protein intake per bird was approximately 5.96 g, of which an estimated 2.14 g was deposited into egg protein (based on an average egg weight of 11.3 g with 12.7% protein content). This gives an apparent protein retention efficiency of 35.9%, compared to 31.2% at 18% CP and 28.7% at 24% CP. The decline in retention efficiency at the highest protein level suggests that excess dietary amino acids were deaminated and excreted as uric acid rather than converted to egg mass.

Comprehensive interpretation

The 22% CP diet achieved the best balance between production output and feed efficiency. Moving from 20% to 22% CP boosted hen-day production by 5.6 percentage points and improved FCR by 0.27 units, while moving from 22% to 24% CP produced no statistically significant gain in any performance or quality parameter and slightly raised daily feed intake.

Discussion

The 22% CP diet produced the highest egg output (79.8% hen-day) among the four treatments. This value is close to the 81.2% reported by Shim and Vohra^[6] for Japanese quail fed 23% CP diets under Californian conditions, and it exceeds the 72-76% range observed by Reda *et al.*^[10] in Egyptian quail farms using 20% CP. The likely explanation is that 22% CP provides enough essential amino acids particularly methionine and lysine to support maximal albumen synthesis without crossing the threshold where excess nitrogen becomes metabolically costly^[11].

Shell thickness improved from 0.194 mm at 18% CP to 0.221 mm at 22% CP, a 14% increase. Nahashon *et al.*^[7]

noted a similar trend and attributed it to improved calcium utilisation when protein supply matches calcium-binding protein synthesis in the shell gland. And from a market perspective, stronger shells mean fewer cracked eggs during handling and transport, which directly affects farmer revenue^[12].

The absence of further improvement at 24% CP agrees with the plateau effect described by Lesson and Summers^[13], who argued that once amino acid requirements are met, additional protein yields diminishing returns and may even depress performance through increased heat increment during protein catabolism. This is particularly relevant in warm climates where metabolic heat load affects feed intake^[14].

Conclusion

The main contribution of this research is a clear, data-backed recommendation that 22% crude protein is the most effective dietary level for laying Japanese quail under Korean management conditions. Supporting evidence includes the highest hen-day production (79.8%), the lowest feed conversion ratio (2.91), and the best egg quality scores across all measured traits. The 24% CP diet offered no measurable advantage over 22% CP, making the higher protein level economically unjustifiable. These findings carry significance for small-scale quail farmers seeking to optimise feed costs without sacrificing output quality. Open questions include whether the 22% CP recommendation holds for other commercial quail strains, whether performance responses differ in open-sided housing during winter months, and whether amino acid supplementation could allow protein levels to drop below 22% while maintaining the same output.

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