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The effect of different levels of crude protein and metabolisable energy on the growth performance of White Leghorn male chicks[#]

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Abstract

The study was carried out at Avian Research Station of Kerala Veterinary and Animal Sciences University to determine the optimal protein and energy levels for White Leghorn male chicks reared for meat production from 1 to 7 weeks of age. A total of 192 one-day-old chicks were randomly assigned to four dietary treatments in a 2x2 factorial design, with two levels of crude protein (CP) at 22 and 20 per cent, and two levels of metabolisable energy (ME) at 3100 kcal/kg and 2800 kcal/kg. The treatments included: T1 (22% CP + 3100 kcal/kg ME), T2 (20% CP + 3100 kcal/kg ME), T3 (22% CP + 2800 kcal/kg ME) and T4 (20% CP + 2800 kcal/kg ME). Chicks fed with 22 per cent CP showed significantly (p<0.01) higher cumulative body weight gain compared to those fed with 20 per cent CP, while the ME levels did not have a significant effect on weight gain. Feed intake was also significantly (p<0.01) higher in chicks which received 22 per cent CP, though feed conversion ratio (FCR) remained unaffected by the dietary treatments. Livability rates were consistently high across all groups, showing no significant differences. Carcass yield was significantly (p<0.05) higher in chicks fed with 22 per cent CP, and abdominal fat was notably higher (p<0.01) in birds fed with 3100 kcal/kg ME. The highest net profit per bird was achieved with the T3 diet (22% CP + 2800 kcal/kg ME). To conclude, a diet consisting of 22 per cent CP and 2800 kcal/kg ME provided the best growth performance and economic return for White Leghorn male chicks raised for meat.

Keywords: *Crude protein, metabolisable energy, growth performance, economics*

In the poultry industry, meat production has traditionally been dominated by broilers, while male chicks from layer breeds are often underutilised (Magala *et al.,* 2012). These male chicks are commonly considered surplus, since commercial farms primarily focus on rearing female chicks (pullets) for egg production. At hatching, the natural 50:50 sex ratio results in a large number of male chicks, yet only a small fraction is retained for breeding purposes. The majority are either culled or sold at minimal value, representing a missed opportunity within poultry meat production. Raising these surplus male chicks as a source of meat could provide poultry farmers with an additional revenue stream and contribute to reducing waste in the industry (Alabi *et al*., 2013). However, a significant gap exists in nutritional guidelines tailored

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to support the growth and meat yield of male chicks from layer breeds. These birds have different growth rates and dietary needs compared to broilers, necessitating targeted research on optimal protein and energy levels to ensure efficient production. This study addresses this gap by investigating the specific dietary requirements for White Leghorn male chicks to optimise their growth and meat quality. By identifying the most effective levels of protein and energy, the research aims to support poultry farmers in creating a more sustainable and profitable system for utilising surplus male chicks in meat production.

Materials and methods

Experimental design

A seven-week feeding trial was conducted using a completely randomized design (CRD) with a 2x2 factorial arrangement to evaluate the effects of protein and energy levels on White Leghorn male chicks. A total of 192 one-day-old chicks were procured from Avian Research Station, Thiruvazhamkunnu, wing banded, debeaked, weighed and randomly assigned to four dietary treatments, each replicated four times with 12 birds per replicate. The birds were reared from day 1 to 49 days of age under deep litter system, with each pen measuring 65 x 75 inches and providing 2551.07 cm^2 of floor space per bird. Four experimental diets were formulated as described in Table. 1 and 2.

Prior to the experiment, pens and equipment were cleaned, disinfected with gluteraldehyde liquid and sun-dried. Brooding was provided using incandescent bulbs until three weeks of age. The birds were fed *ad libitum* and given clean drinking water and vaccination protocols were followed, including Marek's disease, Ranikhet disease and Infectious Bursal Disease vaccines at appropriate ages.

Growth performance and economics

Body weight was measured individually for each bird at day-old and at weekly intervals until seven weeks of age using an electronic weighing balance. Feed consumption was recorded weekly and the feed conversion ratio (FCR), was determined for each replicate. At the end of the seven-week feeding trial, eight birds from each replicate (N=128) were randomly selected for humane slaughter, and carcass yield (g) and abdominal fat per centage were estimated according to the Indian Standards Institution (ISI. 1973) guidelines. Mortality rate was recorded for each treatment group throughout the experimental period and livability per cent were calculated. Post-mortem examinations were conducted to determine the cause of death.

Statistical analysis

Statistical analysis was conducted using SPSS software to assess the collected data. Descriptive statistics such as means and standard deviations were computed for all parameters. A completely randomized design (CRD) with a 2x2 factorial arrangement was utilized to compare the means among the different groups or treatments. Post hoc tests were then applied to identify significant

Table 1. Composition of experimental diets, per cent

Ingredients	Per cent composition			
	T1	T2	T3	T4
Maize	53.95	60.32	53.61	56.79
Soyabean meal	38.10	32.49	36.10	29.97
Deoiled rice bran	-	-	6.38	9.53
Rice bran Oil	3.97	3.23	-	-
Calcite	1.30	1.29	1.42	1.49
Di-calcium Phosphate	1.95	2.06	1.79	1.75
Salt	0.34	0.34	0.33	0.32
L- Lysine	0.19	0.19	0.18	0.08
DL- Methionine	0.20	0.08	0.19	0.07
Total	100	100	100	100
Feed supplements (g/100kg)				
Trace minerals	125	125	125	125
Toxin binder	150	150	150	150
Choline chloride	100	100	100	100
Coccidiostat	50	50	50	50
Liver protectant	50	50	50	50
Enzymes	50	50	50	50

Table 2. Chemical composition of experimental diet, per cent

Parameters	T1	T2	T3	T4
Dry matter	88.12	88.32	88.54	88.73
Crude protein	22.00	20.11	22.10	20.00
Crude fibre	3.27	3.17	3.32	3.40
Ether extract	4.67	4.56	2.98	2.67
Total ash	9.11	8.83	8.64	8.42
Acid insoluble ash	1.32	1.34	1.21	1.60
Calcium	1.20	1.10	1.00	1.40
Phosphorous	0.43	0.47	0.45	0.47
ME (kcal/kg) *	3100	3100	2800	2800
Lysine*	1.20	1.08	1.20	1.00
Methionine*	0.54	0.40	0.53	0.40

* Calculated

T1 (Control): Basal diet formulated according to BIS (2007) standards for broiler starter.

T2: Diet formulated by reducing the protein level by 2 per cent from the T1 diet, while keeping the energy level the same.

T3: Diet formulated by reducing the energy level by 300 ME (kcal/kg) from the T1 diet, while keeping the protein level the same.

T4: Diet formulated by reducing the protein level by 2 per cent and the energy level by 300 ME (kcal/kg) from the T1 diet.

differences between specific groups. A significance level of ($p < 0.05$) was established for all statistical tests.

Results and discussion

Body weight gain

Table 3 illustrates the impact of different dietary levels of crude protein (CP) and metabolizable energy (ME) on daily body weight gain from hatch to seven weeks of age. The results indicate that CP levels significantly affected body weight gain throughout the study. Chicks fed a diet containing 22 per cent CP demonstrated significantly ($p < 0.01$) higher weekly body weight gain (except fourth and sixth week) compared to those on a 20 per cent CP diet. The high CP diet resulted in cumulative weight gain also. This suggests that a higher dietary protein level enhanced growth due to increased availability of essential amino acids for muscle development. Similar findings were reported by Deepak *et al.* (2017), Beshara (2022), Divya *et al.* (2023a) and Ekanem *et al.* (2024), who observed greater body weight gains in chicks fed with higher CP diets.

Chicks on the 3100 kcal/kg ME diet exhibited significantly ($p < 0.01$) higher body weight gain for first two weeks only compared to those on a 2800 kcal/kg ME diet. However, this effect was not observed in later weeks, indicating that higher energy intake is vital during early growth, but its importance decreases as the chicks mature due to their ability to adjust the feed intake. This result is in accordance with the findings of Beshara (2022), who reported that a higher energy starter diet led to increased body weight gain in Sinai chicks.

The interaction between CP and ME levels did not significantly affect mean body weight gain, aligning with findings by Haunshi *et al.* (2012) and Magala *et al.* (2012).

Feed consumption

Table 4 presents the results regarding the impact of different levels of CP and ME on mean feed consumption of White Leghorn male chicks at weekly intervals. Chicks fed a diet containing 22 per cent CP had significantly ($p < 0.01$) higher cumulative feed consumption. The trend was similar in second and third weeks of age. The increased intake is likely due to their higher protein requirements for growth.

Metabolizable energy levels did not have any significant effect on cumulative feed consumption. However, feeding high energy diet has resulted in significantly ($p < 0.01$) higher cumulative feed consumption during first week alone. This finding is consistent with findings of Magala *et al.* (2012), who reported that varying energy levels did not significantly affect feed consumption in Ugandan local chicks.

The interaction between CP and ME levels was not significant for feed intake at any point of study, indicating that the effects of CP and ME on feed consumption were independent of one another. This result aligns with the findings of Magala *et al.* (2012), Haunshi *et al.* (2012) and Beshara (2022).

Table 3. Body weight gain at weekly intervals in White Leghorn male chicks fed with different levels of CP and ME, g

Factor	Age (weeks)							Cumulative body weight gain (1-7 weeks)
	1	2	3	4	5	6	7	
Crude Protein (CP), %								
22	21.49±0.59	43.92±0.84	50.71±1.72	66.93±2.47	81.65±1.78	109.76±4.75	112.28±4.63	486.74±8.18
20	17.70±0.68	40.22±1.03	44.72±0.88	60.58±5.70	75.08±1.21	97.72±2.76	96.29 ±4.12	432.29±5.89
Metabolizable Energy (ME), kcal/kg								
3100	20.99±0.75	43.75±0.90	48.71±1.67	63.99±2.40	76.45±1.64	103.19±4.05	102.75±4.92	459.83±9.16
2800	18.21±0.85	40.39±1.06	46.71±1.79	63.52±5.97	80.28±1.99	104.29±4.90	105.81±5.64	459.2±15.14
CP×ME								
22×3100	22.69±0.64	45.64±0.92	52.26±1.38	66.55±4.25	79.03±2.79	107.66±7.12	106.53±7.88	480.35±8.32
20×3100	19.28±0.53	41.87±0.76	45.17±1.67	61.44±2.13	73.86±0.59	98.71±3.56	98.98±6.43	439.30±6.47
22×2800	20.30±0.50	42.20±0.66	49.16±3.21	67.32±3.19	84.26±1.53	111.86±7.18	118.03±4.01	493.13±14.69
20×2800	16.12±0.49	38.57±1.61	44.27±0.82	59.72±12.11	76.30±2.35	96.72±4.72	93.59±5.74	425.28±9.33
P- value								
CP	0.001	0.004	0.010	0.361	0.007	0.062	0.024	0.001
ME	0.001	0.008	0.332	0.945	0.079	0.853	0.629	0.952
CP×ME	0.490	0.949	0.589	0.856	0.498	0.606	0.197	0.212

Feed Conversion Ratio

The results of the influence of different levels of CP and ME of feed on mean FCR at weekly intervals of White Leghorn male chicks are presented in Table 5. The cumulative FCR from one to seven weeks showed no significant difference between the two CP levels. However, a significantly higher ($p < 0.01$) FCR was observed at first week alone for the birds fed with high protein diet. This suggests that while higher protein content may be advantageous in the early stages, the bird's ability to convert feed into body weight becomes similar as they age, regardless of protein level. The observations in the current study agrees with the findings of Jafarnejad and Sadegh (2011), Haunshi *et al.* (2012) and Magala *et al.* (2012) who found no significant effect of different protein levels on FCR.

The ME levels did not affect the FCR at any stage of the experiment. This finding implies that both energy levels can support similar feed efficiency and hence 2800 kcal/kg ME diet is sufficient to elicit the similar response. The observations in the current study are in harmony with Magala *et al.* (2012) who found that there was no significant effect of different levels of energy on FCR. Contrary to these findings, Jafarnejad and Sadegh (2011), Haunshi *et al.* (2012), Alabi *et al.* (2013) and Divya *et al.* (2023a) reported that birds fed with high energy diet had significantly better FCR.

The interaction between CP and ME levels was not significant for weekly FCR. This indicates that the effects of CP and ME on feed efficiency were independent of each other within the tested range. These findings are in agreement with the reports of Haunshi *et al.* (2012), Magala *et al.* (2012) and Divya *et al.* (2023a).

Livability

The results of effect of dietary CP and ME levels on overall livability at weekly intervals are presented in Table 6. The study reveals that there is no apparent difference among dietary treatments on per cent livability of birds. This result agrees with the findings of Roy *et al.* (2010) and Beshara (2022).

The overall livability was not affected by either different levels of CP and ME or interaction effect of CP and ME of feed, indicating that the average feed intake of various nutrients in all dietary CP and ME levels appears to be adequate for White Leghorn male chicks to sustain optimum health.

Carcass yield and abdominal fat

The results of different levels of CP and ME of feed on carcass yield and abdominal fat of White Leghorn male chicks at seven weeks of age are presented in Table 7.

The results show that the CP level significantly ($P = 0.05$) affected carcass yield, with chicks fed with a diet containing 22 per cent CP having a higher carcass yield compared to those fed with 20 per cent CP. This suggests that higher protein intake supports better growth and muscle development, leading to increased carcass yield.

Table 4. Feed consumption at weekly intervals in White Leghorn male chicks fed with different levels of CP and ME, g

Factor	Age (weeks)							Cumulative feed consumption (1-7 weeks)
	1	2	3	4	5	6	7	
Crude Protein (CP), %								
22	51.53±1.48	89.40±1.34	122.10±1.40	178.82±2.21	252.04±11.44	348.38±14.61	368.80±13.18	1411.06±20.64
20	49.26±1.57	83.24±1.23	113.06±1.55	169.29±8.31	233.22±10.03	341.38±15.12	332.88±12.37	1298.28±21.03
Metabolizable Energy (ME), kcal/kg								
3100	53.44±0.74	87.22±1.77	118.02±2.67	172.73±8.26	237.19±5.88	320.85±15.48	340.25±16.7	1329.70±32.63
2800	47.35±1.35	85.42±1.62	117.14±1.72	175.38±3.43	248.07±14.62	344.88±12.55	361.43±10.38	1379.64±23.10
CP×ME								
22×3100	54.41±0.39	90.17±2.66	123.41±2.67	181.86±3.57	246.15±9.69	348.38±22.31	355.74±23.83	1400.11±30.71
20×3100	52.48±1.33	84.28±1.35	112.63±2.64	163.59±15.80	228.24±3.74	293.32±10.76	324.76±23.96	1259.29±26.86
22×2800	48.66±2.14	88.63±0.95	120.79±0.94	175.78±1.98	257.94±22.22	348.38±22.31	381.86±11.36	1422.02±31.04
20×2800	46.04±1.67	82.21±2.13	113.48±2.03	174.98±7.12	238.20±20.96	341.38±15.12	341.00±9.79	1337.27±18.12
P- value								
CP	0.161	0.007	0.001	0.305	0.266	0.116	0.076	0.001
ME	0.002	0.358	0.693	0.771	0.513	0.214	0.274	0.091
CP×ME	0.822	0.893	0.442	0.346	0.956	0.214	0.794	0.323

Table 5. FCR at weekly intervals in White Leghorn male chicks fed with different levels of CP and ME

Factor	Age (weeks)							(1-7 weeks)
	1	2	3	4	5	6	7	
Crude Protein (CP), %								
22	2.40±0.07	2.04±0.04	2.43±0.09	2.69±0.09	3.10±0.16	3.16±0.11	3.31±0.13	2.91±0.07
20	2.80±0.09	2.08±0.05	2.53±0.03	3.03±0.42	3.11±0.14	3.30±0.17	3.50±0.18	3.01±0.07
Metabolizable Energy (ME), kcal/kg								
3100	2.56±0.07	2.00±0.03	2.43±0.05	2.71±0.13	3.11±0.11	3.09±0.11	3.34±0.17	2.9±0.06
2800	2.64±0.13	2.12±0.04	2.53±0.08	3.01±0.42	3.10±0.18	3.37±0.16	3.46±0.15	3.02±0.08
CP×ME								
22×3100	2.40±0.05	1.98±0.07	2.37±0.09	2.76±0.14	3.14±0.23	3.21±0.22	3.38±0.27	2.92±0.11
20×3100	2.73±0.05	2.02±0.01	2.50±0.04	2.66±0.24	3.09±0.03	2.98±0.04	3.30±0.24	2.87±0.05
22×2800	2.41±0.14	2.10±0.03	2.49±0.17	2.63±0.14	3.06±0.26	3.12±0.09	3.24±0.03	2.89±0.09
20×2800	2.87±0.17	2.14±0.09	2.57±0.04	3.39±0.83	3.13±0.30	3.62±0.26	3.69±0.26	3.15±0.10
P- value								
CP	0.005	0.546	0.326	0.469	0.962	0.458	0.415	0.275
ME	0.542	0.055	0.361	0.516	0.945	0.143	0.591	0.190
CP×ME	0.556	0.983	0.819	0.352	0.802	0.066	0.260	0.106

Table 6. Livability at weekly intervals in White Leghorn male chicks fed with different levels of CP and ME, %

Factor	Age (weeks)							(1-7 weeks)
	1	2	3	4	5	6	7	
Crude Protein (CP), %								
22	98.96±1.04	98.96±1.04	100.00±0.00	98.96±1.04	98.96±1.04	100.00±0.00	100.00±0.00	95.83±1.57
20	98.96±1.04	98.96±1.04	100.00±0.00	98.96±1.04	98.96±1.04	98.96±1.04	100.00±0.00	94.79±2.19
Metabolizable Energy (ME), kcal/kg								
3100	97.92±1.36	98.96±1.04	100.00±0.00	100.00±0.00	98.96±1.04	98.96±1.04	100.00±0.00	94.79±2.19
2800	100.00±0.00	98.96±1.04	100.00±0.00	97.92±1.36	98.96±1.04	100.00±0.00	100.00±0.00	95.83±1.57
CP×ME								
22×3100	97.92±2.09	97.92±2.09	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	95.83±2.41
20×3100	97.92±2.09	100.00±0.00	100.00±0.00	100.00±0.00	97.92±2.09	97.92±2.09	100.00±0.00	93.75±3.99
22×2800	100.00±0.00	100.00±0.00	100.00±0.00	97.92±2.09	97.92±2.09	100.00±0.00	100.00±0.00	95.83±2.41
20×2800	100.00±0.00	97.92±2.09	100.00±0.00	97.92±2.09	100.00±0.00	100.00±0.00	100.00±0.00	95.83±2.41
P- value								
CP	1.00	1.00	-	1.00	1.00	0.337	-	0.724
ME	0.183	1.00	-	0.183	1.00	0.337	-	0.724
CP×ME	1.00	0.183		1.00	0.183	0.337	-	0.724

However, the abdominal fat per cent was not affected by different levels of CP in diet, indicating that protein content did not influence fat deposition in the abdominal region. The results obtained from this study are in accordance with the observations of Nguyen and Bunchasak (2005), Niu *et al.* (2009), Melesse *et al.* (2013), Sompie *et al.* (2015), Khatun *et al.* (2021) and Divya *et al.* (2023b).

The dietary ME levels had no effect on carcass yield at seven weeks of age, suggesting that energy level, within the tested range, does not substantially influence muscle mass of the birds. The observations in the current study are in harmony with Nguyen and Bunchasak (2005), Magala *et al.* (2012), Niu *et al.* (2009), Sompie *et al.* (2015) and Khatun *et al.* (2021). The results revealed that birds fed with diet containing 3100 kcal/kg of ME had a significantly ($p<0.01$) higher abdominal fat per cent (0.73 per cent) compared to those fed with a diet of 2800 kcal/kg of ME (0.34 per cent). The result agrees with the findings of Nguyen and Bunchasak (2005), Niu *et al.* (2009), Sompie *et al.* (2015) and Divya *et al.* (2023b) in which the abdominal fat tends to increase with increase in ME levels

Table 7. Carcass yield (g) and Abdominal fat (%) of White Leghorn male chicks fed with different levels of CP and ME

Factor	Carcass yield (g)	Abdominal fat (%)
Crude Protein (CP), %		
22	380.68±5.74	0.54±0.07
20	361.76±6.58	0.53±0.08
Metabolizable Energy (ME), kcal/kg		
3100	373.48±6.49	0.73±0.06
2800	368.97±7.03	0.34±0.02
CP×ME		
22×3100	383.15±6.19	0.73±0.06
20×3100	363.8±10.47	0.73±0.10
22×2800	378.22±10.21	0.35±0.03
20×2800	359.72±8.88	0.33±0.04
P -value		
CP	0.05	0.839
ME	0.626	0.001
CP×ME	0.857	0.963

in the diet. The interaction effect of CP and ME of feed had no effect on mean carcass yield and abdominal fat per cent of White Leghorn male chicks at seven weeks of age.

Techno-economics

The techno-economics of diets of White Leghorn male chicks in four different treatment groups were calculated and are presented in Table 8. The total cost of production and total returns per bird were calculated to assess the techno-economics. The cost of production included the cost of day-old chick, feed and other miscellaneous costs. The cost of a day-old chick was Rs 2 per bird. The feed cost per kg for T1, T2, T3 and T4 was Rs. 43.52, 41.25, 39.14 and 36.83, respectively. The miscellaneous cost for each bird was Rs 5 per bird.

The total production cost per bird was Rs 67.93, 57.93, 62.66 and 56.25, respectively, for the treatment groups. The net profit per bird was found to be highest in the T3 group (Rs 42.55) followed by T2 (Rs 36.48), T4 (Rs 35.38) and T1 (Rs 34.76) groups. The net profit per kg body weight for the treatment groups T1, T2, T3 and T4 was Rs 67.69, 77.28, 80.89 and 77.23, respectively.

Conclusion

The study demonstrated that varying dietary levels of CP and ME influenced the growth performance, feed consumption, FCR, livability, carcass yield and abdominal fat of White Leghorn male chicks. Chicks fed with a diet having 22 per cent CP exhibited higher cumulative body weight gain and carcass yield compared to those on a 20 per cent CP diet, highlighting the importance of protein for muscle development. Feed consumption was higher in chicks fed with 22 per cent CP, yet the interaction between CP and ME levels did not significantly affect overall feed intake or FCR. Livability remained consistent across dietary treatments, indicating that both CP and ME levels adequately support the health of the chicks. A higher CP level increased carcass yield and higher ME level led to increase in abdominal fat per cent. Overall, the findings indicated that 22 per cent CP and 2800 kcal/kg ME is the ideal ration for optimizing growth performance of White Leghorn male chicks.

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Table 8. Techno-economics for the different treatment groups

Particulars	Treatments			
	T1 (22% CP+3100 kcal/kg ME)	T2 (20% CP+3100 kcal/kg ME)	T3 (22% CP+2800 kcal/kg ME)	T4 (20% CP+2800 kcal/kg ME)
Cost of birds, Rs	**2**	**2**	**2**	**2**
Cost of feed, Rs/kg feed	43.52	41.25	39.14	36.83
Total feed intake, g/bird	1400.11	1234.72	1422.02	1337.27
Miscellaneous cost, Rs/bird	5	5	5	5
Total cost of production, Rs/bird	67.93	57.93	62.66	56.25
Selling price (Rs/kg live weight)	200	200	200	200
Body weight at 7 weeks, g	513.44	472.08	526.03	458.17
Return from sale of birds, Rs	102.69	94.42	105.21	91.63
Net profit per bird, Rs	34.76	36.48	42.55	35.38
Net profit per kg body weight, Rs	67.69	77.28	80.89	77.23

Conflict of interest

The authors declare that they have no conflict of interest

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