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EFFECT OF SUPPLEMENTING DIFFERENT NON-CHLORIDE SODIUM SOURCES AND LEVELS ON PERFORMANCE OF GROWING JAPANESE QUAIL THAT FED DIETS VARYING IN THEIR PROTEIN CONTENT

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SUMMARY

The experimental work was conducted in Poultry Research Station, El-Azab, Fayoum, Egypt to study the effect of supplementation of different non-chloride sodium sources and levels with different levels of dietary protein on growing Japanese quail performance. The experiment was designed in a 2 x 2 x 3 factorial arrangement of treatments with crude protein (CP) level, type and level of non-chloride sodium addition as the main effects. Corn-soybean meal basal diets were formulated with two CP levels (24 and 22%), two types of non-chloride sodium addition (sodium sulfate (Na_2SO_4) and sodium bicarbonate ($NaHCO_3$)) and three levels of non-chloride sodium addition (0.00, 0.05 and 0.10%). According to the nutrient requirements of NRC (1994), the minimum dietary Na levels of all treatments groups were 0.15, and the Cl level of all diets were set to be 0.25% which were provided by supplemental level of sodium chloride (NaCl) at 0.35% to satisfy nutrient requirements. Then raising the sodium level above the minimum requirement by adding Na_2SO_4 or $NaHCO_3$. These diets were fed from 10 to 38 days of age. The dietary amino acid levels were adjusted by adding DL-methionine and L-lysine-HCl. Results obtained can be summarized in the subsequent: Quails fed diet containing 24% CP supplemented with 0.10% sodium (Na) from NaHCO3 at dietary electrolyte balance (DEB) 301.4 mEq/kg had significantly higher values of live body weight (LBW) at 38 days and body weight gain during the period from 10-38 days. Quails fed diet containing 22% CP supplemented with 0.05% Na from Na2SO4 at DEB 253.0 mEq/kg had higher value of feed intake during the period from 10-38 days. Quails fed diet containing 22% CP supplemented with 0.10% Na from NaHCO3 at DEB 275.6 mEq/kg had the best values of feed conversion ratio, caloric conversion ratio and crude protein conversion during the total period, also, it had the higher value of performance index during the same period. Supplementation of different non-chloride sodium sources and levels with different levels of dietary protein had insignificantly affected blood parameters. Quails fed diet containing 24% CP supplemented with 0.05% Na from NaHCO3 at DEB 279.0 mEq/kg had higher value of carcass weight after evisceration%, besides, quails fed diet containing 22% CP supplemented with 0.10% Na from Na2SO4 at DEB 275.3 mEq/kg had higher value of dressing%. Birds fed diet containing 22% CP supplemented with 0.10% Na from NaHCO3 at DEB 275.6 mEq/kg had the best economical and relative efficiency values, followed by birds fed diet containing 22% CP supplemented with 0.05% Na from NaHCO3 at DEB 253.3 mEq/kg.

Keywords: *Japanese quail, crude protein, dietary electrolyte balance, non-chloride sodium, sodium sulfate, sodium bicarbonate, performance.*

INTRODUCTION

Sodium (Na^+) is complicated in several physiological processes, for example regulation of osmotic pressure, cell permeability and acid-base balance and it is known to affect tissue protein synthesis and enzyme activities (Olanrewaju *et al.,* 2007). Sodium is also vital for the absorption of amino acids and monosaccharides and a lack of Na^+ in the body can reduce the use of protein and carbohydrates (Smith *et al.,* 2000 and Gal-Garber *et al.,* 2003). Adequate Na^+ consumption has been stated to have helpful effects on growth performance of poultry (Watkins *et al.,* 2005). The Na^+ content of poultry diets has been increased since a sufficient intake of dietary Na^+ has a positive influence on feed intake (FI) and the growth rate (GR) of broiler (Borges *et al.,* 2003; Watkins *et al.*, 2005 and Mushtaq *et al.,* 2007). Sodium chloride (NaCl) and sodium bicarbonate ($NaHCO_3$) are used as additives to sodium sources

Usually in poultry diets, NaCl and $NaHCO_3$ are used as additives Na^+ sources. In commercial production, 0.3% NaCl is usually included in the chicken or hen diet to meet Na^+ and chloride (Cl^-) requirements. However, excess Cl^- in feed may disturb the balance of Cl ion and CO_3^{2-} and harmfully affect $CaCO_3$ synthesis, leading to poor performance (Mushtaq *et al.,* 2007).

Sodium bicarbonate seems to be an advantage element since it offers Na^+, positively affects blood pH, consequently can influence the balance of H^+ ions, and supplies helpful bicarbonate (Mongin, 1968). In another study, Damron *et al.* (1986) stated that the Na^+ in $NaHCO_3$ was similarly bioavailable to that in NaCl for broiler. Further, Merrill (1993) reported that use 0.2% $NaHCO_3$ in broiler diets was the most common level in Western Europe, in combination with 0.1% added NaCl, and the chief purpose was to reduce dietary chloride (Cl^-) and decrease wet litter problems. Excess water consumption and excretion increased humidity in the litter. The Cl^- ion seemed to be responsible for some of the additional litter humidity content since NaCl increased litter humidity to a more extent than both $NaHCO_3$ or sodium sulfate (Na_2SO_4) decahydrate which contain no chloride.

Sodium sulfate, commonly known as Glauber's salt, has been studied as a substitute and cost-effective source of Na^+ free Cl^- for poultry (Ahmad *et al.,* 2005 and Wang *et al.,* 2019). On the other hand, Na_2SO_4 is a chlorine-free source of Na^+, which can be used to reduce NaCl to maintain the diet between Cl and Na^+ in poultry diets. In addition to Na^+, additional sulfur (S) contained in Na_2SO_4 can be combined into some S-containing biological compounds with antioxidant properties for example glutathione, methionine, cysteine and taurine (Battin and Brumaghim, 2009 and Del-Vesco *et al.*, 2014). In broiler chickens, disturbances of Na^+ metabolism and Na^+-Ca interactions may contribute to the pathogenesis of skeletal muscle (Sandercock and Mitchell, 2004). Dietary supplements containing too high levels of Na_2SO_4 may be detrimental to poultry performance and health (Liu *et al.,* 2021).

Because sexual maturity befalls around six to seven weeks, rapid growth, potential for three to four offspring per year, as a result of this, the Japanese quail has become an important research poultry. Advances in genetics, nutrition, health, management and facilities have improved the productivity and development production of poultry, allowing production costs to be reduced and the quality of the final product improved. Developments require continuous monitoring of the nutritional needs of birds during growing or breeding and differences in climatic or other environmental conditions (Abdul Hafeez *et al.,* 2021 and Qureshi *et al.,* 2021).

The high cost of protein sources in poultry diets and environmental pollution associated with high nitrogen (N) excretion have been two important restraining factors in the development of the poultry production. Consequently, producers tend to reduce production costs by decreasing the crude protein (CP) level in feed systems or using the optimal CP level (El-Hindawy *et al.*, 2021 and Alagawany *et al.,* 2022). Both too much or too little protein will have adverse financial and health impacts. High level of CP in the diets can increase concentrations of environmental gases counting amines or ammonia that cause respiratory problems for the poultry (Wang *et al.*, 2017 and Liu *et al.,* 2020) accountable for eutrophication ecosystem disturbance and air pollution. Subsequently, interests in decreasing the CP content of diets have resurfaced. Therefore, low CP diets are widely appreciated as a nutritional intervention to decrease the environmental impact of N, as well as, ammonia emissions, in addition to minimize soybean meal dependence plus decrease feed costs by lowering expensive CP source components in the complete diet (Greenhalgh *et al.,* 2020; Amer *et al.,* 2021 and Cappelaere *et al.,* 2021). Additionally, Swiatkiewicz *et al.* (2017) found that fewer cases of breast blisters and footpad dermatitis as a result of the drier litter related by low CP diets.

Several studies suggested that the best CP level during the growing period for quail’s ranges from 24 (N.R.C., 1994) to 27% (Mosaad and Iben, 2009). Hilliar and Swick (2018) found that using low CP diets in poultry diets has been known to potentially enhance health, and welfare concerns, improves feeding efficiency, decrease feeding costs, reduces footpad dermatitis and improves litter quality (Belloir *et al.,* 2017). But low CP can have a negative impact on the production performance of broilers (Belloir *et al.,* 2017 and Kidd *et al.,* 2021). This is maybe a result of limitations in the levels of essential amino acids (EAA), which are careful necessary in the animal diet (Chrystal *et al.,* 2020).

Therefore, it is expected that significant efforts will be directed to maximizing the benefits of low-protein diets. Operating dietary electrolyte balance (DEB) has been planned as a way to recover the performance of poultry fed diets containing low level of CP. Adekunmisi and Robbins (1987) reported that DEB differs depending on the dietary CP, because growth of poultry fed a low-CP diet is reduced when DEB is altered by Na^+ and potassium (K^+) addition. However, the relationship between low CP (supplemented with amino acid) and DEB in broilers diets is not well understood (Fancher and Jensen, 1989 and Martinez-Amezcua *et al.*, 1998). Diets supplemented with high levels of amino acids have harmful effects by interfering with acid-base balance (Summers, 1996). Altering the DEB of these diets results in subclinical acidosis and decreases GR. Low CP in diets results in low K^+, due to the presence of fewer soybean meal (Martinez-Amezcua *et al.*, 1998). Ahmad and Sarwar (2006) also reported that, dietary EB also varied with contents of CP in the diet. Adekunmisi and Robbins (1987) suggest that GR in chicks fed a low CP diet (14.3%) was reduced when DEB was altered by the supplementation of Na^+ and K^+. Nevertheless, adding these salts to a diet high in CP (28.6%) improved the GR. Ahmad *et al.* (2005) noted that we need to determine the appropriate electrolyte source, its quantity and combination of different sources to obtain the appropriate DEB for optimal performance of broilers under different environmental conditions.

Therefore, the objective of this research was to set whether a substantial increase in dietary Na^+ above the recommendations (re-evaluate Na^+ requirements) of N.R.C. (1994), affects positively on growing Japanese quail (*Coturnix coturnix japonica*) performance, and also to determine the best DEB for obtaining maximum productive performance, by addition of sources and levels of non-chloride Na^+ like $NaHCO_3$ and Na_2SO_4 in the diets varying in their protein content.

MATERIALS AND METHODS

The experimental work was conducted in a Poultry Research Station, El-Azab, Fayoum, Egypt, to study the effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in the diets on growing Japanese quail performance.

The experiment was designed in a 2 x 2 x 3 factorial arrangement of treatments with CP level, type and level of non-chloride Na addition as main effects. Corn-soybean meal basal diets (Tables 1and 2) were formulated with two CP levels (24 and 22%CP), two types of non-chloride Na addition (Na_2SO_4 and $NaHCO_3$) and three levels of non-chloride Na addition% (0.00, 0.05 and 0.10%). According to the nutrient requirements of NRC (1994), the minimum dietary Na^+ levels of the all-treatments groups were 0.15, and the Cl^- level of all diets were set to be 0.25% which were provided by supplemental level of NaCl at 0.35% to satisfy nutrient requirements. Then raising the sodium level above the minimum requirement by adding Na_2SO_4 or $NaHCO_3$ (Tables 1and 2).

A total of 720 birds at 10 days old Japanese quail chicks (unsexed) were randomly divided equally into 12 treatments groups (60 birds each), each treatment was equally subdivided into three replicates of 20 birds per replicate.

The basal experimental diets (control) were formulated to satisfy nutrient requirements (iso-caloric) of growing Japanese quail (2900 Kcal ME/Kg diet) according to the NRC (1994). These diets were fed from 10 to 38 days of age (feed and water were provided *ad libitum*). The amino acid levels were adjusted by adding DL-methionine and L-lysine-HCl. The composition and calculated analyses of the experimental diets are shown in Tables 1 and 2. The experimental diets were weighed daily and their residues left in troughs were weighed at the end of each 7 days interval for each replicate and the consumed feed was calculated.

All birds received the same management conditions. The experimental groups were housed in galvanized wire cage batteries provided with the feeders (manual feed distribution) and stainless-steel nipples with plastic cups for each cage. The next parameters were estimated and/or calculated: live body weight (LBW), body weight gain (BWG), daily FI, feed conversion ratio (FCR), crude protein conversion (CPC), caloric conversion ratio (CCR), GR (Brody,1945) and performance index, PI (North, 1981). Every chicken that died was weighed, FI at the same time was noted, and these numbers were used for adjustment of FCR.

Blood hematological and biochemical parameters:

At 38 days of age, individual blood samples were taken randomly from 72 birds (6 birds (3 males and 3 females)/treatment) around the average LBW immediately taken during slaughtering. Two blood samples were collected from brachial vein, one into a heparinized test tube for blood hematological parameters, and the other into a non-heparinized test tube for biochemical parameters, and then plasma was separated by centrifuging at 3500 rpm for 10 minutes. The clear plasma samples were carefully drawn and transferred to dry, clean, small glass bottles and stored at -20ºC in a deep freezer until the time of chemical determinations. Using commercial kits, the biochemical characteristics of blood were colorimetrically determined.

The first sample (fresh blood samples) was taken to determine hemoglobin (Hb), hematocrit (Ht), total count of red blood cells (RBCs), total count of white blood cells (WBCs) and their differentiations (heterophils%(H), lymphocytes%(L), H/L ratio, monocytes%, eosinophils% and basophils%). On individual bases, plasma constituents were determined colorimetrically, using Spectrophotometer and suitable commercial diagnostic kits for, alanine aminotransferase (ALT) and aspartate aminotransferase (AST), phosphorus, creatinine, Na^+, K^+, magnesium, Cl^-, calcium concentration**.**

Table (1): Composition and calculated analysis of the experimental diets (24%) during the growing period.

Items %		Crude protein level % 24					
		Type of non-chloride Na addition					
		Na_2SO_4			$NaHCO_3$		
		Level of non-chloride Na addition %					
		0.00	0.05	0.10	0.00	0.05	0.10
Feed ingredients	Yellow corn, ground	49.74	49.43	49.10	49.74	49.40	49.00
	Soybean meal (44%CP[1])	44.76	44.82	44.89	44.76	44.82	44.90
	Calcium carbonate	1.26	1.26	1.26	1.26	1.26	1.26
	Sodium chloride	0.35	0.35	0.35	0.35	0.35	0.35
	Vit. and Min. premix[2]	0.30	0.30	0.30	0.30	0.30	0.30
	Dicalcium phosphate	0.88	0.88	0.88	0.88	0.88	0.88
	Vegetable oil[3]	2.57	2.66	2.77	2.57	2.67	2.80
	DL–Methionine	0.14	0.14	0.14	0.14	0.14	0.14
	L-Lysine HCl	0.00	0.00	0.00	0.00	0.00	0.00
	Na_2SO_4	0.00	0.16	0.31	0.00	0.00	0.00
	$NaHCO_3$	0.00	0.00	0.00	0.00	0.18	0.37
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis[4]:							
ME, kcal./Kg		2900.9	2899.9	2900.3	2900.9	2899.8	2899.9
Protein and amino acids	Crude protein	24.00	24.00	24.01	24.00	24.00	24.00
	Lysine	1.33	1.33	1.34	1.33	1.33	1.34
	Methionine	0.50	0.50	0.50	0.50	0.50	0.50
	Methionine + Cystine	0.89	0.89	0.89	0.89	0.89	0.89
	Arginine	1.59	1.60	1.60	1.59	1.60	1.60
	Threonine	0.92	0.92	0.92	0.92	0.92	0.92
	Valine	1.12	1.12	1.12	1.12	1.12	1.12
Minerals	Calcium	0.81	0.81	0.81	0.81	0.81	0.81
	Available phosphorus	0.32	0.32	0.32	0.32	0.32	0.32
	Potassium	1.03	1.03	1.03	1.03	1.03	1.03
	Sodium	0.15	0.20	0.25	0.15	0.20	0.25
	Chloride	0.25	0.25	0.25	0.25	0.25	0.25
	EB(electrolyte balance)	257.9	280.2	301.2	257.9	279.0	301.4
Crude fiber		4.23	4.22	4.22	4.23	4.22	4.22
Crude fat		4.82	4.90	4.99	4.82	4.91	5.02
Cost (£.E./ton)[5]		2045.1	2052.8	2061.4	2045.1	2053.6	2063.9

[1]Crude protein ; [2]Each 3.0 Kg of the vitamin and mineral premix manufactured by Egy. Phar. Co. and contains: Vit. A 10000000 IU; Vit. D_3 2500000 IU; Vit. E 10000 mg; Vit. K_3 1000 mg; Vit. B1 1000 mg; Vit. B2 5000 mg; Vit. B6 1500 mg; Vit. B12 10 mg; biotin 50 mg; folic acid 1000 mg; niacin 30000 mg; pantothenic acid 10000 mg; Zn 50000 mg; Cu 4000 mg; Fe 30000 mg; Co 100 mg; Se 100 mg; I 300 mg; Mn 60000 mg, choline chloride 300000 mg and complete to 3.0 Kg by calcium carbonate. [3] Mixture from 25% sunflower oil and 75% soybean oil. [4]According to NRC, 1994.

[5] According to the local market price at the experimental time.

Table (2): Composition and calculated analysis of the experimental diets (22%) during the growing period.

Items %		Crude protein level % 22					
		Type of non-chloride Na addition					
		Na_2SO_4			**$NaHCO_3$**		
		Level of non-chloride Na addition %					
		0.00	**0.05**	**0.10**	**0.00**	**0.05**	**0.10**
Feed ingredients	Yellow corn, ground	57.16	56.86	56.51	57.16	56.80	56.41
	Soybean meal (44%CP[1])	38.40	38.46	38.53	38.40	38.47	38.54
	Calcium carbonate	1.29	1.29	1.29	1.29	1.29	1.29
	Sodium chloride	0.35	0.35	0.35	0.35	0.35	0.35
	Vit. and Min. premix[2]	0.30	0.30	0.30	0.30	0.30	0.30
	Dicalcium phosphate	0.88	0.88	0.88	0.88	0.88	0.88
	Vegetable oil[3]	1.29	1.38	1.50	1.29	1.40	1.53
	DL–Methionine	0.17	0.17	0.17	0.17	0.17	0.17
	L-Lysine HCl	0.16	0.16	0.16	0.16	0.16	0.16
	Na_2SO_4	0.00	0.15	0.31	0.00	0.00	0.00
	$NaHCO_3$	0.00	0.00	0.00	0.00	0.18	0.37
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis[4]:							
ME, kcal./Kg		2900.9	2900.3	2900.9	2900.9	2900.3	2900.5
Protein and amino acids	Crude protein	22.00	22.00	22.01	22.00	22.00	22.00
	Lysine	1.31	1.31	1.31	1.31	1.31	1.31
	Methionine	0.51	0.51	0.51	0.51	0.51	0.51
	Methionine + Cystine	0.86	0.86	0.86	0.86	0.86	0.86
	Arginine	1.42	1.42	1.42	1.42	1.42	1.42
	Threonine	0.83	0.83	0.83	0.83	0.83	0.83
	Valine	1.01	1.01	1.01	1.01	1.01	1.01
Minerals	Calcium	0.81	0.81	0.81	0.81	0.81	0.81
	Available phosphorus	0.31	0.31	0.31	0.31	0.31	0.31
	Potassium	0.92	0.92	0.92	0.92	0.92	0.92
	Sodium	0.15	0.20	0.25	0.15	0.20	0.25
	Chloride	0.25	0.25	0.25	0.25	0.25	0.25
	EB(electrolyte balance)	232.0	253.0	275.3	232.0	253.3	275.6
Crude fiber		3.95	3.94	3.94	3.94	3.94	3.94
Crude fat		3.77	3.85	3.96	3.87	3.98	3.98
Cost (£.E./ton)[5]		1899.8	1907.3	1916.5	1908.9	1919.0	1919.0

[1]Crude protein [2]Each 3.0 Kg of the vitamin and mineral premix manufactured by Egy. Phar. Co. and contains: Vit. A 10000000 IU; Vit. D_3 2500000 IU; Vit. E 10000 mg; Vit. K_3 1000 mg; Vit. B1 1000 mg; Vit. B2 5000 mg; Vit. B6 1500 mg; Vit. B12 10 mg; biotin 50 mg; folic acid 1000 mg; niacin 30000 mg; pantothenic acid 10000 mg; Zn 50000 mg; Cu 4000 mg; Fe 30000 mg; Co 100 mg; Se 100 mg; I 300 mg; Mn 60000 mg, choline chloride 300000 mg and complete to 3.0 Kg by calcium carbonate. [3]Mixture from 25% sunflower oil and 75% soybean oil. [4]According to NRC, 1994.

[5] According to the local market price at the experimental time.

Slaughter tests:

At the end of the growing period (38 days of age), slaughter tests were performed using six chicks (3 males and 3 females) around the average LBW. Chicks were individually weighed to the nearest gram, and slaughtered by cutting the jugular vein (Islamic method). After two minutes bleeding time, each chick was dipped in a water bath for 45 seconds at 57°C, and feathers were removed (by hand). After the removal of head, carcass was manually eviscerated, and then their weights were obtained. The eviscerated weights included the front part with wings and hind part.

Carcass% = (carcass weight/LBW) x 100. Viscera (gizzard, heart and liver) were individually weighed and measured in relation to LBW and the rest of the body was weighed to determine the dressed weight, the giblets did not include the spleen weight in quails because it is very small (about 0.1 gram). Dressing percentage was calculated as follows: Dressing% = (carcass weight + giblets)/LBW) x 100. The bones of front and rear parts were separated and weighed to calculate meat% as follows: Meat % = ((part weight –

its bone weight)/part weight) x 100. The meat from each part including the skin was weighed. The abdominal fat was removed from the parts around the viscera and gizzard, and was weighed to the nearest gram.

Mortality rate%:

The cumulative mortality rate = the total number of quails dead during the study/ the total number of quails at the beginning of the study period. No treatment-related increased mortality was found throughout the experimental period.

Economic efficiency:

To determine the economic efficiency for the different dietary treatments, the amount of feed consumed during the entire trial period was obtained and multiplied by the price of one Kg of each dietary treatment which was estimated based upon local present prices at the trial time. The price of 38 days old quail was taken as 35.00 LE. Prices of supplementations (Na_2SO_4 or $NaHCO_3$) were 30.0 LE/Kg

Statistical analysis:

Statistical analysis of results was performed using the General Linear Models procedure of the SPSS software (SPSS, 2007), by 2 x 2 x 3 factorial arrangement of treatments according to the follow general model:

$$Y_{ijkl}= \mu+C_i+T_j +L_k+CT_{ij}+TL_{ik}+CL_{jk}+CTL_{ijk}+e_{ijkl}$$

Where: Y_{ijkl}: observed value. μ: overall mean.

C_i: CP level effect (j: 24 and 22%)

T_j: Type of non-chloride Na addition effect (j: Na_2SO_4 and $NaHCO_3$)

L_k: Level of non-chloride Na addition effect % (k: 0.00, 0.05 and 0.10%).

$CT_{ij:}$ Interaction effect of CP level by type of non-chloride Na addition.

$TL_{ik:}$ Interaction effect of type of non-chloride Na addition by level of non-chloride Na addition%.

CL_{jk}: Interaction effect of CP level by level of non-chloride Na addition%.

$CTL_{ijk:}$ Interaction effect of CP level by type of non-chloride Na addition by level of non-chloride Na addition% (treatments). e_{ijkl}: Experimental random error.

Significant differences ($P\leq0.01$ and $P\leq0.05$) among treatment means were tested using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance:

Effect of supplementation of different non-chloride sodium sources and levels with different levels of dietary protein on productive performance are shown in Tables 3 and 4. The main effects of CP level% had insignificantly ($P>0.05$) affected LBW, BWG, FCR, GR and PI, while, significantly ($P\leq0.01$ and $P\leq0.05$) affected on FI, CPC and CCR during the total experimental period (Table 3).

Quails fed diet containing 22% CP had higher value of FI (the best value of CPC and the worst value of CCR) than those fed diet containing 24% CP, this result may be due to the high LBW and BWG values recorded for these groups during these periods. However, quails fed diet containing 24% CP had lower value of FI (the best value of CCR and the worst value of CPC). Numerically, it is noted that quails fed diet containing 22% CP had higher values of LBW, BWG and GR with a non-significant difference than 24% protein.

Type of non-chloride Na addition had significantly ($P\leq0.05$ and $P\leq0.01$) affected all studied production characteristics during the total experimental period, except, GR which was insignificantly ($P>0.05$) affected (Table 3). Quails fed diet containing $NaHCO_3$ had significantly the highest values of LBW, BWG and PI (lower value FI and the best values of FCR, CPC and CCR), while, chicks fed diet containing

Na_2SO_4 had significantly the lowest values of LBW, BWG and PI (higher value of FI and the worst values FCR, CPC and CCR) during the period from 10 to 38 days (Table 3).

Table (3): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on productive performance (main effects).

Items	Age, days (10 -38)							
	Live body weight, g	Body weight gain,g	Feed intake, g	Feed conversion ratio (FCR)[1]	Crude protein conversion (CPC)[2]	Caloric Conversion Ration (CCR)[3]	Growth rate (GR)[4]	Performance index (PI)[5]
Crude protein level %								
24	211.39	178.23	814.3[b]	4.85	1.164[a]	14.07[b]	0.451	3.110
22	213.21	180.11	842.7[a]	5.00	1.104[b]	14.55[a]	0.454	3.050
SEM[6]	1.58	1.50	3.15	0.06	0.01	0.16	0.01	0.05
P-value	0.414	0.371	<0.001	0.067	0.001	0.038	0.593	0.403
Type of non-chloride Na addition								
Na_2SO_4	209.11[b]	176.01[b]	841.0[a]	5.10[a]	1.175[a]	14.83[a]	0.450	2.940[b]
$NaHCO_3$	214.14[a]	181.01[a]	815.7[b]	4.77[b]	1.102[b]	13.87[b]	0.454	3.190[a]
SEM	1.70	1.61	3.54	0.06	0.01	0.18	0.01	0.05
P-value	0.037	0.029	<0.001	<0.001	<0.001	<0.001	0.357	<0.001
Level of non-chloride Na addition%								
0.00	214.89	181.69[a]	830.16	4.88	1.120	14.12	0.454	3.170[a]
0.05	209.19	175.99[b]	826.74	4.96	1.140	14.37	0.450	2.980[b]
0.10	214.19	181.16[ab]	829.74	4.92	1.140	14.34	0.454	3.150[a]
SEM	1.77	1.68	3.65	0.06	0.02	0.19	0.01	0.05
P-value	0.064	0.042	0.806	0.720	0.683	0.700	0.592	0.028
Sex effect								
Female	221.62[a]	188.36[a]	831.60	4.62[b]	1.062[b]	13.39[b]	0.462[a]	3.330[a]
Male	203.00[b]	169.90[b]	828.97	5.24[a]	1.208[a]	15.27[a]	0.443[b]	2.830[b]
SEM	1.48	1.39	3.48	0.06	0.01	0.16	0.01	0.04
P-value	<0.001	<0.001	0.586	<0.001	<0.001	<0.001	<0.001	<0.001

[a–b] Means in a column with different superscripts differ significantly (P≤0.05) [1]FC= FI/ BWG, [2]CPC= (FI CP%)/ BWG, [3]CCR= (FI* ME. K Cal) / BWG, [4]GR (Brody,1945) and PI (North, 1981) [6] Pooled SEM*

Level of non-chloride Na addition% had significantly (P≤0.05) affected BWG and PI (Table 3). It is clear that, quails fed control diet (0.00% non-chloride Na) had significantly higher value of BWG and PI (the differences between values of BWG and PI for chicks fed diet containing 0.00% non-chloride Na and those fed diet containing 0.10% non-chloride Na were not significant), while quails fed diet supplemented with 0.05% non-chloride Na had significantly lower values. Regarding sex effect (Table 3), females had significantly (P≤0.01) higher values of LBW, BWG, GR and PI and it had the best values of FCR, CPC and CCR than males during the total experimental period (Table 3).

Interaction due to CP level%, type of non-chloride Na addition and level of non-chloride Na addition% (experimental treatments) had significantly (P≤0.05 and P≤0.01) affected all studied production characteristics during the total period, except, GR which was insignificantly (P>0.05) affected (Table 4). Quails fed diet containing 24% CP supplemented with 0.10% Na^+ from $NaHCO_3$ at DEB 301.4 mEq/kg had significantly higher values of LBW and BWG, but quails fed diet containing 24% CP supplemented with 0.05% Na^+ from Na_2SO_4 at DEB 280.2 mEq/kg had lower values of LBW at 38 days and BWG during the total experimental period.

Quails fed diet containing 24% CP supplemented with 0.10% Na^+ from Na_2SO_4 at DEB 301.2 mEq/kg had lower value of FI and quails fed diet containing 22% CP supplemented with 0.05% Na^+ from Na_2SO_4 at DEB 253.0 mEq/kg had higher value of FI. Quails fed diet containing 22% CP supplemented with 0.10% Na^+ from $NaHCO_3$ at DEB 275.6 mEq/kg had the best values of FCR, CCR and CPC (the higher value of PI) during the total period, however, those fed diet containing 22% CP supplemented with 0.10% Na^+ from Na_2SO_4 at DEB 275.3 had the worst values of FCR, CPC and CCR (the lower value of PI).

Our observations agree with those of Ragab (2007) who noted that Japanese quail diets should contain 21% CP during the growing period (10 to 38 days). He also, noted that quails fed 24% CP had the highest value of FI during the same period. The present results partially agree with the findings of Hussein *et al.* (2019) and Alagawany *et al.* (2022) as they noted that chicks receiving low-protein diets incline to consume more feed to reimburse for the decrease in EAA content and requirements to maintain LBW and function.

Table (4): Interaction effect of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on productive performance (treatments).

Items			Age, days (10 -38)							
Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition %	**LBW[1]**	**BWG[2]**	**FI[3]**	**FCR[4]**	**CPC[5]**	**CCR[6]**	**GR[7]**	**PI[8]**
24	Na_2SO_4	0.00	210.93^{abc}	177.72^{bc}	789.76^{ef}	4.78^{c}	1.147^{ab}	13.86^{c}	0.450	3.202^{ab}
		0.05	205.33^{c}	172.15^{c}	819.98^{c}	4.94^{bc}	1.186^{a}	14.33^{bc}	0.445	2.862^{cd}
		0.10	210.50^{abc}	177.27^{bc}	780.63^{f}	4.75^{c}	1.139^{ab}	13.77^{c}	0.451	3.167^{abc}
	$NaHCO_3$	0.00	210.93^{abc}	177.72^{bc}	789.76^{ef}	4.78^{c}	1.147^{ab}	13.86^{c}	0.450	3.202^{ab}
		0.05	209.35^{bc}	176.13^{bc}	805.67^{d}	4.90^{c}	1.177^{ab}	14.22^{c}	0.451	3.090^{abcd}
		0.10	221.12^{a}	188.13^{a}	878.24^{ab}	4.89^{c}	1.175^{ab}	14.19^{c}	0.461	3.226^{a}
22	Na_2SO_4	0.00	218.85^{ab}	185.66^{ab}	870.57^{b}	4.96^{bc}	1.091^{bc}	14.38^{bc}	0.458	3.129^{abc}
		0.05	212.59^{abc}	179.35^{abc}	884.31^{a}	5.28^{ab}	1.162^{ab}	15.32^{ab}	0.454	2.896^{bcd}
		0.10	207.89^{bc}	175.21^{bc}	883.82^{a}	5.47^{a}	1.217^{a}	16.04^{a}	0.450	2.802^{d}
	$NaHCO_3$	0.00	218.85^{ab}	185.66^{ab}	870.57^{b}	4.96^{bc}	1.091^{bc}	14.38^{bc}	0.458	3.129^{abc}
		0.05	209.47^{bc}	176.34^{bc}	796.99^{de}	4.70^{c}	1.033^{c}	13.62^{c}	0.451	3.065^{abcd}
		0.10	217.08^{ab}	183.88^{ab}	786.44^{f}	4.60^{c}	1.021^{c}	13.45^{c}	0.455	3.386^{a}
SEM[9]			3.41	3.22	3.49	0.12	0.03	0.35	0.01	0.10
P-value			0.024	0.011	<0.001	<0.001	<0.001	<0.001	0.867	0.001

$^{a–f}$ Means in a column with different superscripts differ significantly ($P\leq0.05$)
[1]Live body weight, [2]Body weight gain, [3]Feed intake, [4]Feed conversion ratio, [5]Crude protein conversion, [6]caloric conversion ratio, [7]Growth rate, [8]Performance index, [9]Pooled SEM

Furthermore, Ashour *et al.* (2022) found that increasing CP levels may decrease the FI of birds. Jiang *et al.* (2005) indicated that broiler FI was depressed as EAA levels increased because the bird's requirements were met previously. But results obtained herein disagreed with those of Abou Zeied *et al.* (2000) who found that different levels of protein (24 or 20% CP) in the dietary growing Japanese quail had insignificantly affected feed consumption. The present results differ with the research of Ashour *et al.* (2020) who reported that Japanese quail from 0-3 weeks of age required a dietary protein level of 28% and 20% from 4-6 weeks of age for ideal GR and FE in the tropics. Also, contradicted with the finding of Ashour *et al.* (2022) who showed that the best LBW, BWG and FCR values were detected for quail receiving 24% CP with a 3000 Kcal ME/Kg diet. Moreover, Hussein *et al.* (2020) recommended CP levels of 26 to 28% for rapid growth of quail through their early stages.

Moreover, Abd El-Gawad *et al.* (2004) found that optimum level of CP significantly increases LBW and BWG for broiler chicks, however, supplementing these diets with EAA partially enhanced the reduction in BWG. Also, Ragab *et al.* (2012) demonstrated that suboptimal dietary levels of CP (-2%) significantly decreased broiler growth performance, chicks fed diets containing optimal dietary levels of CP had the best FC and CPC. Abd El-Gawad *et al.* (2004) did not find effect on FI of broiler chicks fed diets containing low level of CP. While, Ji *et al.* (2014) reported that growth performance did not affected by low CP levels. Also, Emam (2018) reported that reducing dietary CP had insignificant effect on broiler growth performance.

Blood parameters:

Effect of supplementation of different non-chloride sodium sources and levels with different levels of dietary protein on hematological parameters are shown in Tables 5.a, 5.b, 5.c and 5.d. The data of Tables 5.a, 5.b, 5.c and 5.d indicated that supplementation of different non-chloride sodium sources and levels with different levels of dietary protein had insignificantly (P>0.05) affected hematological blood parameters.

Effect of supplementation of different non-chloride sodium sources and levels with different levels of dietary protein on biochemical blood parameters are shown in Tables 6 and 7. The data of Tables 6 and 7 indicated that supplementation of different non-chloride sodium sources and levels with different levels of dietary protein had insignificantly (P>0.05) affected biochemical blood parameters except, CP levels with ALT which was significantly (P≤0.05) affected (Table 6). Quails fed diet containing 22% CP had higher value of ALT than those fed diet containing 24% CP. In this connection, Abd El-Gawad *et al.* (2004) demonstrated that optimal dietary levels of CP significantly decreased ALT values of broiler.

Table (5.a): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on hematological parameters (main effects).

Items	Hemoglobin (g/dL)	Red blood cell count ($10^6/mm^3$)	Hematocrit%	Mean corpuscular volume (μ^2)	Mean corpuscular hemoglobin (µµg)	Mean corpuscular hemoglobin concentration%
Crude protein level %						
24	16.41	3.16	42.75	135.62	52.06	38.39
22	16.89	3.21	43.83	137.63	52.12	38.52
SEM[1]	0.40	0.09	1.03	1.06	0.73	0.27
P-value	0.410	0.687	0.474	0.200	0.953	0.746
Type of non-chloride Na addition						
Na_2SO_4	16.85	3.21	43.78	136.67	52.67	38.51
$NaHCO_3$	16.16	3.12	42.34	137.02	51.13	38.15
SEM	0.46	0.10	1.23	1.20	0.83	0.28
P-value	0.302	0.527	0.417	0.839	0.203	0.371
Level of non-chloride Na addition%						
0.00	17.38	3.28	44.50	135.75	53.02	39.07
0.05	16.73	3.18	43.42	136.60	52.67	38.54
0.01	16.28	3.14	42.70	137.09	51.13	38.11
SEM	0.44	0.10	1.67	1.24	0.80	0.30
P-value	0.412	0.736	0.703	0.840	0.293	0.205

[1]*Pooled SEM*

Table (5.b): Interaction effect of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on hematological parameters (treatments).

Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition%	Hemoglobin (g/dL)	Red blood cell count ($10^6/mm^3$)	Hematocrit%	Mean corpuscular volume (μ^2)	Mean corpuscular hemoglobin (µµg)	Mean corpuscular hemoglobin concentration%
24	Na_2SO_4	0.00	17.20	3.35	44.20	132.14	51.38	38.91
		0.05	17.07	3.23	44.67	138.29	52.93	38.26
		0.10	16.60	3.13	42.93	137.06	53.00	38.68
	$NaHCO_3$	0.00	17.20	3.35	44.20	132.14	51.38	38.91
		0.05	15.53	3.00	40.23	134.28	51.82	38.59
		0.10	15.90	3.13	42.20	135.17	50.94	37.69
22	Na_2SO_4	0.00	17.50	3.23	44.70	138.16	54.11	39.17
		0.05	17.40	3.30	44.67	135.97	53.09	39.01
		0.10	16.33	3.17	42.83	135.37	51.64	38.10
	$NaHCO_3$	0.00	17.50	3.23	44.70	138.16	54.11	39.17
		0.05	16.90	3.20	44.10	137.85	52.85	38.32
		0.10	16.30	3.13	42.83	140.78	48.92	37.99
SEM[1]			0.98	0.22	2.59	2.46	1.67	0.64
P-value			0.899	0.993	0.966	0.570	0.651	0.823

[1]Pooled SEM

Similar results were obtained by Ragab (2007) who reported that CP levels in Japanese quails' diets had insignificantly affected biochemical serum parameters. Results obtained are partly congruent with that of Emam (2018) who noted that no significant differences as a result of level of CP and AA addition were observed on hematological parameters, except, RBCs which was significantly affected, where, the broiler chicks fed sub-optimal level -2% CP had higher value of RBCs. However, Ragab *et al.* (2012) noted that broiler chicks fed diet containing recommended level of CP -2% had higher RBCs value.

The results of our study established previous findings of Mushtaq *et al.* (2005), who found no significant effect of dietary Na^+ at levels 0.20, 0.25, and 0.30%, Cl^- at levels 0.30, 0.40, and 0.50% or NaCl on serum Na^+, K^+ contents and blood pH, at stable DEB of 250 mEq/kg. But our results disagree with the findings of Ahmad *et al.* (2005) who indicated that the levels of Na^+, K^+ and Cl^- in the blood were resulted from the direct effect of added minerals, as they observed higher concentrations of Na^+, K^+ and Cl^- in the blood of chicks fed Na^+, K^+, and Cl^- supplements, respectively. Ahmad *et al.* (2005) reported that the enhancement of broiler performance by change in Na^+, K^+ and Cl^- concentrations may be as a result of the normalization of EB in the blood.

In contrast to previous our results, RBCs and hemoglobin concentrations were reduced in hens exposed to 1.5 or 3.0% Na_2SO_4 for 8 weeks (Liu *et al.*, 2021), or 2 to 4% sulfur for chickens (Alam and Anjum, 2003) as compared with the control. In another study, Wei *et al.* (2015) found that RBCs were significantly increased in laying hens receiving 1.8% or more Na_2SO_4 and in broilers exposed to 0.245% NaCl (Fu *et al.*, 2018). Chen *et al.* (2018) noted that plasma ALT and AST activity were raised in hens with addition of 3.0% Na_2SO_4. Also, Liu *et al.* (2021) found negative effects on biochemistry of blood compared with the controls with addition of 3.0% Na_2SO_4. Similar to our results, Liu *et al.* (2021) demonstrated that as compared to the control group, diets containing Na_2SO_4 at level 1.5% or less did not significantly affect biochemical parameters, plasma K^+, Na^+, Cl^-, Ca, P, level and electrolyte balance.

Carcass characteristics: Effect of supplementation of different non-chloride sodium sources and levels with different levels of dietary protein on slaughter parameters%, are shown in Tables 8.a, 8.b, 8.c and 8.d. The main effects of CP levels% had insignificantly (P>0.05) affected some and other slaughter parameters%, (Tables 8.a and 8.c). Numerically, it is noted that quails fed diet containing 22% CP had higher values of liver and abdominal fat% with a non-significant difference than 24% protein at the age of 38 days of age. In the current study, there was no significant effect of reducing the percentage of protein on the percentage of abdominal fat because the percentage of protein restriction was not high, and EAA were also supplemented to the diet.

Table (5.c): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on hematological parameters (main effects).

Items	White blood cells count ($10^3/mm^3$)	Neutrophils	Bands	Segmented	Lymphocytes	Monocytes	Eosinophils
Crude protein level %							
24	141.34	16.57	1.98	14.57	72.86	7.71	3.00
22	142.99	16.87	2.01	14.86	72.73	7.47	2.93
SEM[1]	1.64	0.59	0.04	0.59	0.76	0.20	0.05
P-value	0.490	0.729	0.987	0.729	0.910	0.403	0.343
Type of non-chloride Na addition							
Na_2SO_4	141.48	16.58	1.99	14.58	72.83	7.75	2.99
$NaHCO_3$	141.98	16.42	2.01	14.42	73.25	7.33	3.01
SEM	1.96	0.68	0.03	0.68	0.84	0.21	0.05
P-value	0.859	0.864	0.977	0.864	0.730	0.161	0.987
Level of non-chloride Na addition%							
0.00	144.42	17.80	1.98	15.80	71.60	7.80	2.80
0.05	139.67	15.75	1.99	13.75	73.92	7.50	3.00
0.10	143.78	17.25	2.00	15.25	72.17	7.58	3.00
SEM	1.77	0.62	0.04	0.62	0.81	0.23	0.05
P-value	0.193	0.127	0.985	0.127	0.199	0.783	0.087

[1] *Pooled SEM*

Similar results were reported by Kerr and Kidd (1999) who found that abdominal fat% was unaffected by decreasing dietary CP levels by 2%. On the contrary to our results, Xie *et al.* (2016); Lin *et al.* (2021)

and Heo *et al.* (2023) found that a low CP and AA diet increased the levels of liver fat, abdominal fat, and blood triglycerides, consequential in an increased occurrence of fatty liver. Too much lipid deposition damaged liver function and led to fatty liver hemorrhagic syndrome consequential in reduced performance and death of laying hens (Shini *et al.,* 2019; Gu *et al.,* 2021 and Wang *et al.,* 2023). So, the mediate dietary CP levels have a fundamental influence on hepatic fat deposition (Yuan *et al.,* 2024). In the study of Torki *et al.* (2014) and Khaliq *et al.* (2016), the experimental diets were isocaloric however varied in CP levels resulting in an increased C/P ratio by reducing CP levels in the diets. Although hens consume equal amounts of feed (i.e. equal calorie intake), they reduce CP intake resulting in lower energy per protein intake in laying hens. Therefore, this study confirms that in pullets having low CP diets can activate lipid synthesis for deposition of fat. Ashour *et al.* (2020) establish that increasing the dietary CP level from 24 - 28% in starter and in finisher Japanese quail diets from 18–22% resulted in higher carcass%.

Type of non-chloride Na addition had significantly ($P\leq0.05$) affected rear meat. Quails fed diet containing Na_2SO_4 had significantly higher value of rear meat, while, chicks fed diet containing $NaHCO_3$ had significantly the lower value (Table 8.c). Level of non-chloride Na addition% had significantly ($P\leq0.01$ and $P\leq0.05$) affected leg, half rear and carcass weight after evisceration% (Tables 8.a and 8.c). Quails fed diet containing 0.05% non-chloride Na had significantly higher values of half rear and carcass weight after evisceration%, and those fed diet containing 0.10% non-chloride Na had significantly lower values.

Interaction due to CP levels%, type of non-chloride Na addition and level of non-chloride Na addition% (experimental treatments) had significantly ($P\leq0.05$) affected LBW, carcass weight after evisceration% and dressing% (Tables 8.b and 8.d). Quails fed diet containing 24% CP supplemented with 0.10% Na from $NaHCO_3$ at DEB 301.4 mEq/kg had higher value of LBW, quails fed diet containing 24% CP supplemented with 0.05% Na from $NaHCO_3$ at DEB 279.0 mEq/kg had lower value (Table 8.b), and quails fed diet containing 24% CP supplemented with 0.05% Na from $NaHCO_3$ at DEB 279.0 mEq/kg had higher value of carcass weight after evisceration%, quails fed diet containing 22% CP supplemented with 0.10% Na from Na_2SO_4 at DEB 275.3 mEq/kg had higher value of dressing%. However, those fed diet containing 22% CP supplemented with 0.10% Na from $NaHCO_3$ at DEB 275.6 mEq/kg had the lower values of carcass weight after evisceration and dressing% (Table 8.d).

Results obtained were in line with those of Abou Zeied *et al.* (2000), Abd El-Gawad *et al.* (2004); Nawaz *et al.* (2006); Ragab (2007) and Emam (2018), who showed that dietary protein level of broilers or Japanese quails had insignificant effect on slaughter parameters%. It may be indicated that the carcass and breast meat weights were not affected because of adequate levels of EAA principally methionine and lysine in low CP diets, since these two EAA are exclusively used for protein accretion in the body (Baker *et al.,* 2002). Sterling *et al.* (2005) and Waldroup *et al.* (2005) found that changes in carcass composition was less in broilers fed diets depressed in CP levels by more than 3%, even when all known nutrient requirements were met. Results obtained herein agree with the findings of Liu *et al.* (2021) who found that had no harmful effects were observed on organ growth with addition of Na_2SO_4 up to 3.0%. He also found that hens getting 0.3 to 1.5% Na_2SO_4 had similar liver as compared with those fed control diet. In this respect, Borges *et al.* (2003) noted that in 42-day-old broilers, there was no significant effect of DEB on carcass yield, abdominal fat, breast, back, thigh plus leg, wing and feet plus head. Allaboutfeed (2001) reported that breast meat production was significantly increased with either NaCl or $NaHCO_3$ compared to control or the NaSO4 decahydrate treatment. At 21-day, using corn - soybean meal or meat meal diets, LBW, and feed efficiency, were significantly enhanced by $NaHCO_3$ or NaCl as compared with the control diet, but no significant effect of $NaSO_4$ dehydrated as compared with the control value.

Economical efficiency (EEf): Values of economical and relative economical efficiency during the growing period (from 10 to 38 days) were improved in quails fed the experimental diets containing 22% CP or 22% CP plus any levels of $NaHCO_3$ supplementation, as compared with those fed the control diet and other experimental diets (Table 9). Quails fed diet containing 22% CP supplemented with 0.10% Na from $NaHCO_3$ at DEB 275.6 mEq/kg had the best economical and relative economical efficiency values being 0.6362 and 123.09%, respectively, followed by birds fed diet containing 22% CP supplemented with 0.05% Na from $NaHCO_3$ (DEB at 253.3 mEq/kg) being, 0.5702 and 110.32%, respectively. These results were in line with conclusions of Ragab (2007) who noted that reducing level of CP increased economic efficiency in quails diets. Also, Emam (2018) concluded that CP can be decreased by 2% from the optimum level and supplementing these diets with both methionine and lysine without harmful effect on broiler performance, in addition, consuming these diets improved economic efficiency and N pollution. However, our results disagreed with conclusions of Abd El-Gawad *et al.* (2004) who found that optimum level of dietary CP increased economic efficiency values for broiler chicks.

From all previous research, we can observe that there are many differences in the results of research using low-protein diets with or without the addition of essential amino acids. This may be due to the level of protein restriction used, the age of the bird, the conditions of rearing or care, and it may also be due to the accuracy of data collection, and the degree and efficiency of the raw materials used in formulating the experimental diet, especially protein sources.

Table (5.d): Interaction effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on hematological parameters (treatments).

Items Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition%	White blood cells count ($10^3/mm^3$)	Neutrophils	Bands	Segmented	Lymphocytes	Monocytes	Eosinophils
24	Na_2SO_4	0.00	146.35	19.00	1.99	17.00	70.00	8.00	3.00
		0.05	140.80	15.67	2.02	13.67	73.33	8.00	3.00
		0.10	142.17	17.00	1.97	15.00	72.67	7.67	3.00
	$NaHCO_3$	0.00	146.35	19.00	1.99	17.00	70.00	8.00	3.00
		0.05	136.07	14.33	1.99	12.33	76.00	7.00	3.00
		0.10	142.97	17.67	1.98	15.67	71.33	8.00	3.00
22	Na_2SO_4	0.00	143.13	17.00	1.99	15.00	72.67	7.67	2.67
		0.05	141.87	17.33	2.01	15.33	72.00	8.00	3.00
		0.10	141.07	16.33	1.99	14.33	73.33	7.33	3.00
	$NaHCO_3$	0.00	143.13	17.00	1.99	15.00	72.67	7.67	2.67
		0.05	139.93	15.67	2.02	13.67	74.33	7.00	3.00
		0.10	148.93	18.00	2.03	16.00	71.33	7.33	3.00
SEM[1]			3.74	1.30	0.06	1.30	1.68	0.47	0.11
P-value			0.597	0.498	0.988	0.498	0.529	0.679	0.510

[1] Pooled SEM

Table (6): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on biochemical blood parameters (main effects).

Items	Sodium mmol/L	Potassium mmol/L	Calcium, mg/dl	Magnesium mg/dl	Chloride mmol/L	Creatinine mg/dl	Phosphorous mg/dl	ALT U/L[1]	AST U/L[2]
Crude protein level %									
24	155.34	5.888	14.460	2.975	113.31	0.410	5.741	21.60[b]	107.60
22	152.99	4.876	18.700	3.020	112.12	0.515	6.508	30.40[a]	128.40
SEM[3]	2.638	0.828	2.303	0.045	1.908	0.088	0.378	2.808	8.087
P-value	0.537	0.399	0.209	0.489	0.664	0.412	0.169	0.040	0.086
Type of non-chloride Na addition									
Na_2SO_4	155.90	5.544	14.09	2.979	113.11	0.353	6.670	21.63	129.00
$NaHCO_3$	153.19	5.515	20.75	3.038	112.99	0.570	5.733	30.00	113.50
SEM	3.277	1.025	2.343	0.053	2.376	0.083	0.459	3.407	9.617
P-value	0.568	0.984	0.064	0.444	0.971	0.085	0.171	0.104	0.274
Level of non-chloride Na addition%									
0.00	152.65	4.792	13.225	2.955	111.38	0.468	5.817	26.75	105.00
0.05	157.23	6.153	14.912	3.031	114.55	0.349	6.472	24.50	128.00
0.10	151.86	4.906	19.925	2.985	111.55	0.574	5.930	27.13	114.50
SEM	2.913	0.941	2.555	0.051	2.131	0.096	0.446	3.613	9.534
P-value	0.413	0.581	0.251	0.665	0.550	0.281	0.605	0.866	0.361

[a–b] *Means in a column with different superscripts differ significantly ($P \leq 0.05$)* [3] *Pooled SEM*
[1]*Alanine aminotransferase (ALT),* [2]*Aspartate aminotransferase (AST)*

Table (7): Interaction effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on biochemical blood parameters (treatments).

Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition%	Sodium, mmol/L	Potassium, mmol/L	Calcium, mg/dl	Magnesium, mg/dl	Chloride, mmol/L	Creatinine, mg/dl	Phosphorous, mg/dl	ALT[1], U/L	AST[2], U/L
24	Na_2SO_4	0.00	153.90	4.240	9.500	3.010	111.95	0.225	5.750	19.50	104.00
		0.05	155.05	6.865	11.200	2.995	113.10	0.325	5.575	22.00	120.00
		0.10	161.80	5.090	10.650	2.775	116.30	0.365	6.460	14.00	94.00
	$NaHCO_3$	0.00	153.90	4.240	9.500	3.010	111.95	0.225	5.750	19.50	104.00
		0.05	157.95	6.550	11.450	3.145	114.75	0.350	5.455	15.50	106.00
		0.10	148.00	6.695	29.500	2.950	110.45	0.785	5.465	37.00	114.00
22	Na_2SO_4	0.00	151.40	5.345	16.950	2.900	110.80	0.710	5.885	34.00	106.00
		0.05	157.45	5.500	16.150	2.995	113.95	0.275	7.905	29.00	158.00
		0.10	149.30	4.720	18.350	3.150	109.10	0.445	6.740	21.50	144.00
	$NaHCO_3$	0.00	151.40	5.345	16.950	2.900	110.80	0.710	5.885	34.00	106.00
		0.05	158.45	5.695	20.850	2.990	116.40	0.445	6.955	31.50	128.00
		0.10	148.35	3.120	21.200	3.065	110.35	0.700	5.055	36.00	106.00
SEM[3]			6.589	2.278	4.147	0.087	5.205	0.194	0.864	4.960	18.350
P-value			0.826	0.971	0.109	0.233	0.977	0.465	0.481	0.053	0.394

[1]Alanine aminotransferase (ALT), [2]Aspartate aminotransferase (AST) [3] Pooled SEM

Table (8.a): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on slaughter parameters%, (main effects).

Items	Live body weight (g)	Blood and feather	Leg	Head	Neck	Heart	Liver	Gizzard
Crude protein level%								
24	204.80	9.922	2.173	4.480	5.072	0.873	1.912	1.829
22	202.40	9.526	2.167	4.668	5.223	0.940	2.121	1.739
SEM[1]	1.700	0.376	0.036	0.074	0.177	0.028	0.139	0.047
P-value	0.327	0.463	0.898	0.085	0.551	0.108	0.298	0.191
Type of non-chloride Na addition								
Na_2SO_4	203.83	9.714	2.116	4.554	5.074	0.919	2.048	1.841
$NaHCO_3$	202.33	9.711	2.197	4.518	5.146	0.913	1.975	1.729
SEM	1.920	0.290	0.040	0.078	0.204	0.035	0.170	0.048
P-value	0.586	0.994	0.168	0.751	0.807	0.898	0.763	0.116
Level of non-chloride Na addition%								
0.00	205.67	9.770	2.224[a]	4.726	5.296	0.868	2.038	1.781
0.05	200.67	9.605	2.089[b]	4.518	5.043	0.875	1.777	1.811
0.10	205.50	9.820	2.224[a]	4.554	5.177	0.958	2.245	1.758
SEM	1.830	0.431	0.036	0.086	0.201	0.031	0.148	0.055
P-value	0.137	0.936	0.027	0.375	0.756	0.127	0.101	0.794

[a–b] *Means in a column with different superscripts differ significantly (P≤0.05)* [1] *Pooled SEM*

Table (8.b): Interaction effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on slaughter parameters% (treatments).

Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition %	Live body weight (g)	Blood and feather	Leg	Head	Neck	Heart	Liver	Gizzard
24	Na_2SO_4	0.00	210.67^{a}	9.819	2.273	4.694	5.259	0.837	2.249	1.883
		0.05	202.00^{ab}	10.429	2.097	4.255	5.127	0.829	1.851	1.908
		0.10	203.00^{ab}	9.995	2.215	4.664	5.529	0.926	1.828	1.748
	$NaHCO_3$	0.00	210.67^{a}	9.819	2.273	4.694	5.259	0.837	2.249	1.883
		0.05	197.33^{b}	9.591	2.078	4.339	4.760	0.850	1.530	1.774
		0.10	211.00^{a}	9.775	2.205	4.448	4.683	0.924	2.104	1.831
22	Na_2SO_4	0.00	200.67^{ab}	9.720	2.176	4.759	5.332	0.899	1.827	1.680
		0.05	200.67^{ab}	9.544	2.052	4.837	4.956	0.923	1.635	1.872
		0.10	209.67^{a}	8.888	2.100	4.459	4.686	0.999	2.878	1.834
	$NaHCO_3$	0.00	200.67^{ab}	9.720	2.176	4.759	5.332	0.899	1.827	1.680
		0.05	202.67^{ab}	8.855	2.131	4.642	5.330	0.896	2.094	1.691
		0.10	198.33^{b}	10.624	2.375	4.644	5.809	0.981	2.171	1.619
SEM[1]			3.084	0.927	0.069	0.165	0.398	0.068	0.274	0.111
P-value			0.032	0.935	0.082	0.288	0.543	0.708	0.103	0.646

$^{a–b}$ Means in a column with different superscripts differ significantly (P≤0.05). [1] *Pooled SEM*

Table (8.c): Effect of use different sources of sodium in Japanese quail diets on slaughter parameters%, (main effects).

Items	Total giblets	Abdominal fat	Half breast	Half rear	Breast meat	Rear meat	Carcass weight after evisceration	Dressing
Crude protein level %								
24	4.614	0.148	41.38	24.95	86.17	86.42	66.33	70.95
22	4.800	0.205	40.90	25.12	86.70	86.54	66.05	70.85
SEM[1]	0.153	0.064	0.334	0.274	0.495	0.395	0.345	0.358
P-value	0.399	0.531	0.318	0.658	0.459	0.841	0.562	0.844
Type of non-chloride Na addition								
Na_2SO_4	4.808	0.140	41.23	24.99	87.32	87.20[a]	66.22	71.03
$NaHCO_3$	4.616	0.246	40.92	25.12	86.10	86.05[b]	66.05	70.67
SEM	0.183	0.075	0.417	0.340	0.523	0.389	0.417	0.418
P-value	0.468	0.328	0.602	0.787	0.113	0.049	0.774	0.454
Level of non-chloride Na addition %								
0.00	4.688	0.112	41.42	24.96[ab]	85.33	85.89	66.39[a]	71.08
0.05	4.463	0.268	41.39	25.61[a]	86.88	87.09	67.01[a]	71.47
0.10	4.961	0.118	40.76	24.50[b]	86.55	86.17	65.27[b]	70.23
SEM	0.163	0.069	0.375	0.274	0.542	0.423	0.314	0.370
P-value	0.115	0.256	0.422	0.027	0.650	0.184	0.002	0.072

[a–b] Means in a column with different superscripts differ significantly (P≤0.05). *[1] Pooled SEM*

Table (8.d): Interaction effect of using different sources of sodium in Japanese quail diets on slaughter parameters%, (treatments)

Items: Crude protein level %	Type of non-chloride Na addition	Level of non-chloride Na addition %	Total giblets	Abdominal fat	Half breast	Half rear	Breast meat	Rear meat	Carcass weight after evisceration	Dressing
24	Na_2SO_4	0.00	4.969	0.000	41.89	25.19	84.84	86.35	67.09^{ab}	72.06^{ab}
24	Na_2SO_4	0.05	4.588	0.157	41.70	24.91	88.11	87.74	66.61^{abc}	71.20^{abcd}
24	Na_2SO_4	0.10	4.503	0.089	40.47	24.52	86.38	85.72	64.99^{cd}	69.49^{cd}
24	$NaHCO_3$	0.00	4.969	0.000	41.89	25.19	84.84	86.35	67.09^{ab}	72.06^{ab}
24	$NaHCO_3$	0.05	4.154	0.170	41.68	26.19	85.63	86.33	67.85^{a}	72.00^{ab}
24	$NaHCO_3$	0.10	4.859	0.326	41.17	23.95	85.91	85.97	65.11^{cd}	69.97^{cd}
22	Na_2SO_4	0.00	4.406	0.224	40.95	24.74	85.83	85.43	65.69^{bcd}	70.10^{bcd}
22	Na_2SO_4	0.05	4.430	0.315	41.20	25.63	86.27	88.17	66.85^{abc}	71.28^{abcd}
22	Na_2SO_4	0.10	5.710	0.000	41.55	24.91	88.53	87.16	66.44^{abc}	72.15^{a}
22	$NaHCO_3$	0.00	4.406	0.224	40.95	24.74	85.83	85.43	65.69^{bcd}	70.10^{bcd}
22	$NaHCO_3$	0.05	4.680	0.428	40.99	25.72	87.51	86.11	66.73^{abc}	71.41^{abc}
22	$NaHCO_3$	0.10	4.771	0.058	39.83	24.64	85.36	85.81	64.52^{d}	69.29^{d}
SEM[1]			0.294	0.138	0.795	0.577	1.041	0.849	0.579	0.605
P-value			0.080	0.394	0.760	0.296	0.264	0.373	0.011	0.014

$^{a–d}$ Means in a column with different superscripts differ significantly (P≤0.05). *[1] Pooled SEM*

Table (9): Effect of supplementation of different non-chloride sodium sources and levels with different levels of protein in Japanese quail diets on economical efficiency (EEf).

Items	Crude protein level %											
	24						22					
	Type of non-chloride Na addition											
	Na_2SO_4			$NaHCO_3$			Na_2SO_4			$NaHCO_3$		
	Level of non-chloride Na addition %											
	0.00	**0.05**	**0.10**	**0.00**	**0.05**	**0.10**	**0.00**	**0.05**	**0.10**	**0.00**	**0.05**	**0.10**
a	0.78976	0.81998	0.78063	0.78976	0.80567	0.87824	0.87057	0.88431	0.88382	0.87057	0.79699	0.78644
b	2045.1	2052.8	2061.4	2045.1	2053.6	2063.9	1899.8	1907.3	1916.5	1899.8	1908.9	1919.0
a x b=c	1615.15	1683.28	1609.18	1615.15	1654.54	1812.61	1653.92	1686.68	1693.84	1653.92	1521.37	1509.20
d	692.21	692.21	692.21	692.21	692.21	692.21	692.21	692.21	692.21	692.21	692.21	692.21
e = c + d	2307.36	2375.49	2301.38	2307.36	2346.75	2504.82	2346.12	2378.89	2386.05	2346.12	2213.58	2201.41
f	0.21093	0.20533	0.2105	0.21093	0.20935	0.22112	0.21885	0.21259	0.20789	0.21885	0.20947	0.21708
g	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2	16593.2
f x g=h	3500.00	3407.08	3492.86	3500.00	3473.78	3669.08	3631.42	3527.54	3449.56	3631.42	3475.77	3602.05
h - e =i	1192.64	1031.59	1191.48	1192.64	1127.04	1164.27	1285.29	1148.66	1063.51	1285.29	1262.19	1400.64
EEf = i / e	0.5169	0.4343	0.5177	0.5169	0.4803	0.4648	0.5478	0.4829	0.4457	0.5478	0.5702	0.6362
r	100.00	84.02	100.16	100.00	92.91	89.93	105.99	93.42	86.23	105.99	110.32	123.09

Average feed intake (Kg/quail) a
Price / Kg feed (P.T.) b (based on average local market price of diets).
Total feed cost (P.T.) = a x b = c
Other costs d (including quail prices and other management costs (based on feed cost = 70% of total cost))
Total cost = c + d = e
Average LBW (Kg/ quail) f
Price / Kg live weight (P.T.) g (according to the local market price).
Total revenue (P.T.) = f x g = h
Net revenue (P.T.) = h - e = i
Economical efficiency = (i /e) (net revenue per unit of total cost).
Relative efficiency r (assuming that economical efficiency of the control group (1) equals 100).

CONCLUSION

It can be recommended that, 22% CP supplemented with 0.10% Na^+ from $NaHCO_3$ at DEB 275.6 mEq/kg can be used in the diets for growing Japanese quail, without negative effect on the productive performance of quails and/or the economic efficiency. More further studies are required to apply diets containing more quantities of $NaHCO_3$ (more than those added in the present work) for feeding growing Japanese quail and the possibility to consume beneficial feed additives to reduce cost of quail production and environmental pollution. The benefits of DEB necessity should be considered carefully, and further studies are needed to estimate DEB benefits especially in low CP diets with added synthetic EAA.

In general, the most important benefit from present study is that low levels of protein can be used without harmfully affecting the performance of growingJapanese quail in the presence of suitable DEB. Moreover, it is considered beneficial as manifested by increased performance and economic efficiency in growingJapanese quail.

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تأثير إضافة مصادر ومستويات مختلفة من الصوديوم غير الكلوريدي على أداء السمان الياباني النامي التي تتغذى على علائق مختلفة في محتواها من البروتين

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أجريت التجربة في محطة أبحاث الدواجن، العزب، الفيوم، مصر، لدراسة تأثير اضافة مصادر ومستويات مختلفة للصوديوم غير الكلوريدي مع مستويات مختلفة من البروتين في العلائق على أداء السمان الياباني النامي. تم تصميم التجربة في ترتيب عاملي 2×2 ×3 لتمثل كل من مستوى البروتين الخام ونوع ومستوى إضافة الصوديوم غير الكلوريدي كتأثيرات رئيسية. إستخدمت علائق تتكون أساسا من الذرة وكسب فول الصويا بمستويين من البروتين الخام (24 و22٪)، ونوعين من إضافة الصوديوم غير الكلوريدي (كبريتات الصوديوم وبيكربونات الصوديوم) وثلاث مستويات من إضافة الصوديوم غير الكلوريدي% (0,00 و0,05 و0,10٪). ووفقًا للاحتياجات الغذائية لـ N.R.C. (1994)، كانت المستويات الغذائية الدنيا للصوديوم لجميع المعاملات هي 0,15%، وتم ضبط مستوى الكلوريد لجميع العلائق ليكون 0,25٪ والتي تم توفيرها من خلال إضافة 0,35٪ كلوريد الصوديوم لتغطية الاحتياجات الغذائية. ثم رفع مستوى الصوديوم فوق الحد الأدنى من المتطلبات عن طريق إضافة كبريتات الصوديوم أو كربونات الصوديوم. تم تغذية هذه العلائق من عمر 10 إلى 38 يومًا. وتم تعديل مستويات الأحماض الأمينية عن طريق إضافة المثيونين والليسين.

يمكن تلخيص النتائج التي تم الحصول عليها فيما يلي:

سجل السمان الذي تغذى على عليقة تحتوي على 24٪بروتين مع 0,10٪ صوديوم من بيكربونات الصوديوم (إتزان معدني 301,4 مللي مكافئ/كجم عليقة) أعلى القيم لكل من وزن الجسم عند عمر 38 يومًا والوزن الجسم المكتسب أثناء الفترة من 10 إلى 38 يومًا. أظهر السمان الذي تغذى على عليقة تحتوي على %22 بروتين مع 0,05 %صوديوم من كبريتات الصوديوم (إتزان معدني 253,0 مللي مكافئ/كجم عليقة) أعلى قيم لاستهلاك العلف خلال الفترة من 10-38 يومًا. بينما سجل السمان الذي تغذى على علائق تحتوي على %22 بروتين مع %0,10 صوديوم من بيكربونات الصوديوم (إتزان معدني 275.6 مللي مكافئ/كجم عليقة) أفضل القيم لكفاءة تحويل الغذاء، الطاقة والبروتين خلال الفترة الإجمالية وايضا الاعلى في دليل الأداء الإنتاجى خلال نفس الفترة. لم يكن هناك أي تأثير معنوي على صفات الدم بإضافة مصادر ومستويات مختلفة من الصوديوم غير الكلوريدي مع مستويات مختلفة من البروتين في العلائق. كان للسمان الذي تغذى على علائق تحتوي على 24% بروتين مع 0,05 % صوديوم من بيكربونات الصوديوم (إتزان معدني 279,0 مللي مكافئ/كجم عليقة) أعلى قيمة للذبيحة بعد نزع الأحشاء، والسمان الذي تغذى على علائق تحتوي على 22% بروتين مع 0,10% صوديوم من كبريتات الصوديوم (إتزان معدني 275.3 مللي مكافئ/كجم عليقة) أعلى قيمة لنسبة التشافي. كان للطيور التي تغذت على عليقة تحتوي على %22 بروتين مع 0,10% صوديوم من بيكربونات الصوديوم (إتزان معدني 275,6 مللي مكافئ/كجم عليقة) أ فضل قيم للكفاءة الاقتصادية والنسبية، تليها الطيور التي تغذت على عليقة تحتوي على %22 بروتين مع 0,05% صوديوم من بيكربونات الصوديوم (إتزان معدني 253,3 مللي مكافئ/كجم عليقة).