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# Research Article
# Effects of Self-Selection Diets Differing in Cereal Source and Protein Level on Broiler Performance

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## Abstract

**Objective:** An experiment was conducted to investigate the effects on broiler performance caused by the free choice of three-phase-feeding diets with different cereal sources (maize or wheat) and dietary protein levels. **Materials and Methods:** Four-hundred and eighty 1-day old Ross-308 male broiler chicks were used in a 42-day trial. The experiment consisted of 8 treatments, which are as follows: MN: Birds were fed a single maize-soybean diet with a normal level of dietary protein, WN: Birds were fed a single wheat-soybean diet with a normal level of dietary protein, ML: Birds were fed a single maize-soybean diet with a low level of dietary protein, WL: Birds were fed a single wheat-soybean diet with a low level of dietary protein, MNWN: Birds were fed a mixture of two diets of MN and WN, MLWL: Birds were fed a mixture of two diets of ML and WL, MNWL: Birds were fed on a mixture of the two diets MN and WL and MLWN: Birds were fed on a mixture of the two diets ML and WN. Each dietary treatment consisted of 4 replicates (15 birds/pen). **Results:** Normal protein levels in the free-choice feeding significantly increased the Body Weight Gain (BWG) and feed consumption for birds fed maize or wheat as single or mixed diets. Choice diets of normal and low levels of dietary protein achieved a BWG that was not significantly different from birds fed normal dietary protein. The most detrimental effects were shown in birds that were fed a low dietary protein and a wheat-based diet. Birds that were given free-choice feeding of maize or wheat tended to consume a diet containing wheat, irrespective of protein level. The results of this experiment indicate that feeding a wheat diet is more suitable for the Ross 308 strain than feeding maize. **Conclusion:** The level of dietary protein plays an important role in performance but feeding behavior depends mainly on the different sources of grain.

Key words: Free feeding, growth performance, broiler, wheat, maize

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Broiler chickens are routinely fed diets with various ingredients in their formulas. Formulating diets that differ in cereal type is common due to the manufacturing of feed depending mainly on availability and price. Designing ration formulas that maximize growth and profit is the major issue facing producers and feed mills in developing countries. Diets offered to broilers are different in feed sensory properties, making it necessary to require the birds to select preference feeds that maximize biological performance. Forbes and Shariatmadari[1] and Gous and Swatson[2] stated that broiler chickens tend to eat optimal levels of protein to support optimal growth when choosing between two feeds; one that contained a higher concentration of protein than required and one with a lower concentration. These phenomena make chickens select a balanced diet, as mentioned previously[3-6]. In commercial broiler feeding, single diets were offered to birds in different phases (three phases according to age being the most preferable) to fulfill the birds' nutrient requirements without considering feedstuff. Protein, energy and mineral contents of the feed are key parameters in free-choice feeding[7]. Protein levels in feedstuffs are widely different and vary from 8.5 g $kg^{-1}$ in maize to 60 g $kg^{-1}$ or more in fish meal; therefore, birds predominantly select their feed based on protein content rather than energy content[1]. Broilers make a choice when choosing between diets that differ in protein quality[8]. Gous and Swatson[2] postulated that when free feeding 2 or 3 different feedstuffs that contain only one protein source that covers the birds' dietary requirements, they tend to select a combination that maximizes their biological performance. Cruz *et al.*[9] confirmed that in free-choice feeding, the feeding of maize gluten as a protein source achieved the worst performance out of the feedstuffs tested. This indicates that the eating behavior was not dependent on the protein level but rather on its quality.

The genetic origin of birds may play a large role in free-choice feeding since broilers were developed and selected for in more than one region of the world. For example, the Ross strains were developed in the UK where wheat is the major cereal grain ingredient in feed. In some areas, including the US, Brazil and the Middle East, maize was the main cereal grain introduced into broiler formulas and the dominant strain of bird reared across the world is the Ross broiler. For these reasons, it does not make sense to give this strain any diets without taking into consideration the feeds they prefer and have achieved the maximum growth with. Fast growing broilers can discriminate between diets that differ in amino acids[10,11] and protein content[12,13] better than chickens selected for egg production. Siegel *et al.*[14] reported that the genetic variation among and within populations is crucial in free-choice feeding because different stocks will not eat to maximize growth and gross feed utilization in the same time period. As modern broiler chickens are selected for maximum growth efficiency, tailoring diets specifically for these stocks will become more important. Previous studies on choice feeding have claimed that birds chose a diet suitable for optimal growth[9,12.] However, Siegel *et al.*[14] reported that chicks that are provided a dietary choice of protein and energy do not eat to maximize growth or feed efficiency, despite being on diets that are formulated to enhance these two traits.

Choice feeding of different cereal grains for broilers has also been investigated[15] and no differences have been noticed. In all of the studies mentioned, protein source or quality was of importance in free-choice feeding. However, cereal sources in complete and deficient diets, particularly with Ross strains adapted to wheat-based diets, are still uninvestigated throughout broiler production.

An experiment was conducted to evaluate any influence that free-choice feeding of diets with different cereal types (maize or wheat) and protein levels may have on performance of male broilers.

## MATERIALS AND METHODS

**Birds and housing:** This study was conducted in accordance with the guidelines of the Canadian Council on Animal care and use of laboratory animals and was approved by the Office of Agricultural Research Ethics Committee that was recently performed in Iraq (2014/5849). A total of 480 1-day-old male Ross chicks (Ross 308) were randomly distributed into 32 pens with 15 chicks per pen. Chicks were housed in wood shaving deep litter floor pens (1.75×3 m) at the Poultry Research Station/Ministry of Agriculture from 4 Sep 2016 to 16 Oct 2016. The temperature was maintained at 32°C for the first 3 d and then reduced to 31°C on d 7 and gradually decreased by 2°C every week until it reached 22°C. Pens were equipped with a plastic round feeder and waterer from one day to 7 d of age. The pens were also equipped with a plastic round hanging feeder and automatic round hanging waterer from 8 d to the end of the experiment. When given the mixed diets, two feeders were supplied for each pen. Food and water were provided *ad libitum*. Birds were subject to a 23L: 1D h

(light: dark) lighting regimen. Vaccination against infectious bronchitis was done at the hatchery, while vaccination for Newcastle disease was performed at one and three weeks of age. Infectious bursal disease was vaccinated against at two and four weeks of age.

**Treatments:** All birds were fed isocaloric and isonitrogenous diets *ad libitum* that had been formulated for three phases of chick feed (a starter diet for chicks from 1-14 d of age; a grower diet for chicks from 15-28 d of age; a finisher diet for chicks from 29-42 d of age), all of which were formulated to meet the Ross 308 specifications[16], except for the diets that contained low levels of protein (Table 1). Maize and wheat were the only cereal grains used to formulate experimental diets. Soybean meal represented the primary source of protein for all of the feeds. The chicks were distributed into 8 treatments, which are as follows: MN, birds were fed a single maize-soybean diet with normal levels of dietary protein; WN, birds were fed a single wheat-soybean diet with normal levels of dietary protein; ML, birds were fed a single maize-soybean diet with low levels of dietary protein; WL, birds were fed a single wheat-soybean diet with low levels of dietary protein; MNWN, birds were fed a mixture of the two diets MN and WN; MLWL, birds were fed a mixture of the two diets ML and WL; MNWL, birds were fed a mixture of the two diets MN and WL and MLWN, birds were fed a mixture of the two diets ML and WN. Each dietary treatment was fed to 4 replicate groups (15 birds/pen).

The feed was prepared as a mash and the amount of feed put into each feeder in the free-choice feeding was the same across groups. All supplements and additives were mixed by hand with synthetic amino acids, di-calcium phosphate and small amounts of premix until homogenized to ensure mixing and then were added with the major elements into the mixer. The diets were also supplemented with mold killer to prevent any negative effects caused by aflatoxin or mycotoxin in the maize or wheat.

Body Weight Gain (BWG), Feed Consumption (FC) and Feed Conversion Ratios (FCR) during the periods from 1-14, 15-28, 29-42 and 1-42 d of age were determined by pen (replicate). Feed patterns on choice diets were presented as a

Table 1: Composition of experimental diets fed to broilers (g $kg^{-1}$)

| | Starter diets (1-14 d)[1] | | | | Grower diets (15-28 d)[2] | | | | Finisher diets (29-35 d)[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maize-based | | Wheat-based | | Maize-based | | Wheat-based | | Maize-based | | Wheat-based | |
| Ingredients and analysis | Normal | Low | Normal | Low | Normal | Low | Normal | Low | Normal | Low | Normal | Low |
| Maize | 567.0 | 615.3 | --- | --- | 600.0 | 656.3 | --- | --- | 648.0 | 702.5 | --- | --- |
| Wheat | --- | --- | 592.6 | 642.0 | --- | --- | 642.4 | 702.0 | --- | --- | 692.6 | 746.2 |
| SBM (48% CP) | 374.0 | 330.0 | 334.0 | 285.0 | 341.0 | 286.0 | 280.0 | 220.0 | 290.0 | 235.0 | 226.0 | 172.0 |
| Premix | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Sunflower oil | 19.0 | 12.0 | 34.0 | 32.0 | 25.0 | 20.0 | 42.0 | 40.0 | 30.0 | 28.0 | 48.0 | 46.0 |
| Limestone powder | 7.0 | 9.0 | 7.0 | 7.0 | 0.0 | 0.0 | 2.0 | 6.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| Dicalcium phosphate | 5.0 | 5.0 | 4.0 | 4.0 | 8.0 | 8.0 | 6.0 | 3.0 | 7.0 | 7.0 | 6.0 | 6.0 |
| L-Lysine HCL | 1.0 | 2.2 | 1.7 | 2.0 | 0.0 | 2.1 | 1.5 | 2.0 | 0.0 | 0.7 | 0.8 | 2.5 |
| DL-Methionine | 1.0 | 1.5 | 1.7 | 3.0 | 1.0 | 1.6 | 1.1 | 2.0 | 0.0 | 1.8 | 0.6 | 1.3 |
| **Calculated analysis** | | | | | | | | | | | | |
| Protein | 230.3 | 213.6 | 231.3 | 213.4 | 217.2 | 195.7 | 210.9 | 190.0 | 196.7 | 175.0 | 190.7 | 170.9 |
| ME (MJ $kg^{-1}$) | 12.6 | 12.6 | 12.6 | 12.6 | 13.0 | 13.0 | 13.0 | 13.0 | 13.3 | 13.4 | 13.3 | 13.4 |
| Lysine | 14.6 | 14.4 | 14.4 | 14.1 | 13.0 | 13.0 | 12.4 | 12.4 | 11.5 | 11.4 | 10.6 | 10.6 |
| Methionine | 6.6 | 6.9 | 6.9 | 6.9 | 6.4 | 6.4 | 6.9 | 6.3 | 5.2 | 5.6 | 5.4 | 5.6 |
| Methionine+cystine | 10.5 | 10.5 | 10.7 | 10.6 | 10.0 | 10.0 | 9.9 | 9.5 | 8.5 | 8.7 | 8.7 | 8.6 |
| Tryptophan | 3.2 | 2.9 | 3.2 | 2.9 | 2.9 | 2.5 | 2.9 | 2.5 | 2.6 | 2.2 | 2.6 | 2.2 |
| Threonine | 8.2 | 7.6 | 7.8 | 7.1 | 7.7 | 6.9 | 7.0 | 6.2 | 7.0 | 6.2 | 6.2 | 5.5 |
| Calcium | 10.6 | 10.6 | 9.8 | 9.7 | 9.1 | 9.3 | 9.4 | 9.3 | 8.7 | 8.6 | 8.9 | 8.9 |
| Phosphorus (avail.) | 4.7 | 4.7 | 4.8 | 4.7 | 4.6 | 4.5 | 4.5 | 4.4 | 4.3 | 4.3 | 4.4 | 4.3 |

[1]Starter premix supplied per kg of diet: vitamin A: 12000 IU, vitamin D3: 3500 IU, vitamin E: 50 mg, vitamin K: 3 mg, vitamin B1: 4 mg, vitamin B2: 7.5 mg, vitamin B6: 5 mg, vitamin B12: 0.025 mg, pantothenic acid: 15 mg, niacin: 50 mg, folic acid: 1 mg, biotin: 0.05 mg, betaine: 150 mg, Fe: 70 mg, I: 2 mg, Cu: 15 mg, Mn: 70 mg, Zn: 60 mg, Se: 0.25 mg and its provide: 11.2%, CP: 6.4 MJ, lysine: 5.4%, methionine: 8.5%, cystine: 0.5%, threonine: 0.5%, tryptophan: 0.2%, calcium: 19.8%, phosphorus: 10.4%, [2]Grower/finisher premix supplied per kg of diet: vitamin A: 10000 IU, vitamin D3: 2500 IU, vitamin E: 40 mg, vitamin K: 2 mg, vitamin B1: 2 mg, vitamin B2: 7.5 mg, vitamin B6: 3 mg, vitamin B12: 0.025 mg, pantothenic acid: 10 mg, niacin: 35 mg, folic acid: 1 mg, biotin: 0.05 mg, betaine: 100 mg, Fe: 70 mg, I: 2 mg, Cu: 15 mg, Mn: 70 mg, Zn: 60 mg, Se: 0.25 mg and its provide: 10.3%, CP: 6.1 MJ, lysine: 5.2%, methionine: 8.2%, cystine: 0.5%, threonine: 0.5%, tryptophan: 0.2%, calcium: 24.8%, phosphorus: 7.7%

percentage without statistical analysis on a weekly basis. The FCR was adjusted for mortality by adding the weight of the dead birds to the total pen weight.

The experiment was conducted with a completely randomized design of a one-way analysis of variance. The General Linear Model (GLM) procedure from SAS[17] was used to analyze variables and the differences among means were compared using Duncan's multiple ranges. P-values were considered significant at 5% level of significance.

## RESULTS

The performance results of the chicks are presented in Table 2. Dietary treatments showed significant differences in Body Weight Gain (BWG) during the periods from 1-14 d ($p<0.0642$), 15-28 d ($p<0.0001$), 29-42 d ($p<0.0208$) and 1-42 d ($p<0.0019$). From d 1-42, free-choice feeding of diets containing normal levels of dietary protein was similar to the single maize or wheat-based diets. Additionally, free-choice feeding of diets containing low levels of dietary protein was similar to the single maize or wheat-based diets. Meanwhile, chicks fed the mixed diets containing normal levels of dietary protein with either maize or wheat and those fed low levels of dietary protein with either maize or wheat (MNWL and MLWN,) showed the same BWG. A reduction in BWG was noticed in birds that were fed wheat-based diets containing low levels of dietary protein when compared to chicks fed maize-based diets. Feed Consumption (FC) was significant during the periods from 1-14 d ($p<0.0018$) and 29-42 d ($p<0.0020$). Chicks fed mixed diets of normal dietary protein as free-choice were not significantly different from chicks that were fed single diets of maize with normal levels of protein but were significantly different from the wheat-based diet. There was no significance in FC between chicks fed mixed diets of low dietary protein and chicks fed single diets of maize or wheat with low levels of protein. Free-choice feeding on MNWL and MLWN were also not different from MN and WN. During the period from 29-42 d of age, the trend of feeding behavior was the same, except for the chicks fed on the single wheat-based diet with low levels of dietary protein that had significantly reduced FC. Although, chicks that were fed the single wheat-based diet with low levels of dietary protein exhibited low FC, they did consume more feed of wheat origin than of maize origin (Fig. 1-4). In the free-choice feeding, chicks tended to eat diets that were wheat-based, regardless of protein level. This pattern of feeding revealed that chicks prefer to eat wheat feeds until 28 d of age and then to eat maize feeds from then on.

The FCR was different ($p<0.0190$) between chicks on free-choice MNWL and single diets of maize during the period from 1-14 d of age, whereas the different treatments did not differ significantly during the other periods. In the total experimental period (1-42 d) chicks fed choice diets that contained normal levels of protein, either in a single diet or in a mixed diet, achieved the same FCR as chicks fed single or choice diets with low dietary protein.

Table 2: The effect of experimental treatments on body weight gain, feed consumption and the feed conversion ratio of male chicks

| | Treatments[1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Traits | MN | WN | ML | WL | MNWN | MLWL | MNWL | MLWN | Pooled SEM | p-value |
| **Body weight gain, g (days)** | | | | | | | | | | |
| 1-14 | $300^{abc}$ | $326^{a}$ | $285^{bc}$ | $283^{c}$ | $321^{ab}$ | $284^{c}$ | $309^{abc}$ | $293^{abc}$ | 4.5 | 0.0642 |
| 15-28 | $1134^{a}$ | $1168^{a}$ | $1072^{b}$ | $1042^{b}$ | $1156^{a}$ | $1048^{b}$ | $1147^{a}$ | $1133^{a}$ | 10.1 | 0.0001 |
| 29-42 | $1364^{a}$ | $1316^{a}$ | $1296^{a}$ | $1096^{c}$ | $1324^{a}$ | $1245^{b}$ | $1253^{b}$ | $1351^{a}$ | 21.1 | 0.0208 |
| 1-42 | $2797^{a}$ | $2810^{a}$ | $2653^{ab}$ | $2421^{c}$ | $2802^{a}$ | $2577^{bc}$ | $2709^{ab}$ | $2777^{ab}$ | 30.4 | 0.0019 |
| **Feed consumption, g/bird (days)** | | | | | | | | | | |
| 1-14 | $339^{c}$ | $377^{ab}$ | $335^{c}$ | $341^{c}$ | $395^{a}$ | $353^{bc}$ | $396^{a}$ | $364^{abc}$ | 5.4 | 0.0018 |
| 15-28 | $1482^{ab}$ | 1516a | $1487^{ab}$ | $1393^{b}$ | $1532^{a}$ | $1455^{ab}$ | $1463^{ab}$ | $1438^{ab}$ | 60.0 | 0.0938 |
| 29-42 | $2503^{a}$ | $2359^{ab}$ | $2411^{ab}$ | $2150^{c}$ | $2431^{ab}$ | $2382^{ab}$ | $2358^{ab}$ | $2309^{b}$ | 22.9 | 0.0020 |
| 1-42 | $4324^{ab}$ | $4251^{ab}$ | $4233^{ab}$ | $3883^{c}$ | $4359^{a}$ | $4190^{ab}$ | $4216^{ab}$ | $4111^{b}$ | 75.7 | 0.0029 |
| **Feed conversion ratio, g feed: g gain (days)** | | | | | | | | | | |
| 1-14 | $1.13^{c}$ | $1.16^{bc}$ | $1.18^{bc}$ | $1.21^{abc}$ | $1.23^{ab}$ | $1.24^{ab}$ | $1.28^{a}$ | $1.24^{ab}$ | 0.01 | 0.0190 |
| 15-28 | 1.33 | 1.30 | 1.41 | 1.38 | 1.32 | 1.40 | 1.31 | 1.32 | 0.01 | 0.1755 |
| 29-42 | 1.90 | 1.83 | 1.87 | 2.00 | 1.92 | 1.94 | 1.90 | 1.96 | 0.02 | 0.8873 |
| 1-42 | 1.58 | 1.53 | 1.61 | 1.64 | 1.58 | 1.64 | 1.56 | 1.58 | 0.01 | 0.6585 |

[a-c]Means in a row having different superscripts are significantly different ($p<0.05$), [1]MN: Birds fed a single maize-soybean diet with normal levels of dietary protein, WN: Birds fed a single wheat-soybean diet with normal levels of dietary protein, ML: Birds fed a single maize-soybean diet with low levels of dietary protein, WL: Birds fed a single wheat-soybean diet with low levels of dietary protein, MNWN: Birds fed a mixture of the two diets MN and WN, MLWL: Birds fed a mixture of the two diets ML and WL, MNWL: Birds fed a mixture of the two diets MN and WL and MLWN: Birds fed a mixture of the two diets ML and WN

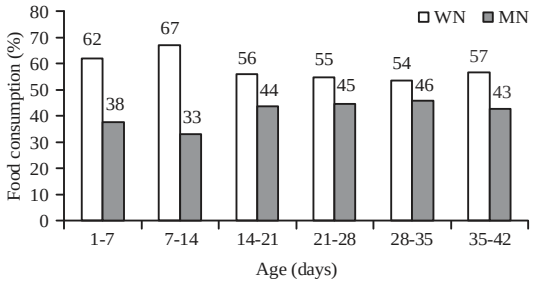


Fig. 1: Percentage of feed consumption from chick's choice-fed maize (MN) or wheat (WN) based-diets with a recommended dietary protein level

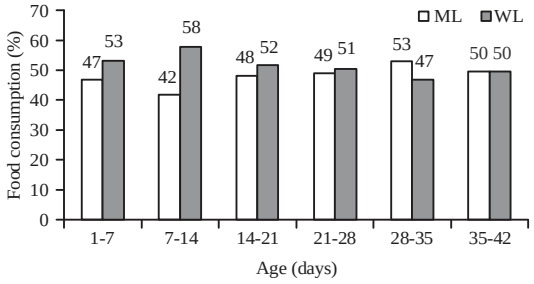


Fig. 2: Percentage of feed consumption for chick's choice-fed a maize (ML) or wheat (WL) based-diet with low dietary protein levels

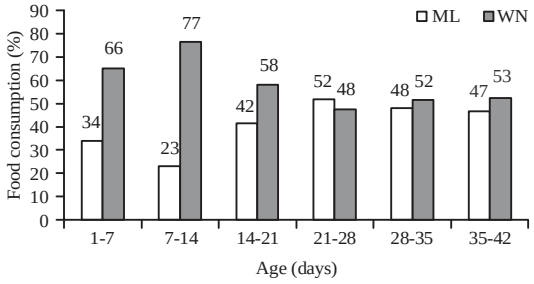


Fig. 3: Percentage of feed consumption for chick's choice-fed maize with low dietary protein (ML) and wheat (WN) with a recommended dietary protein level

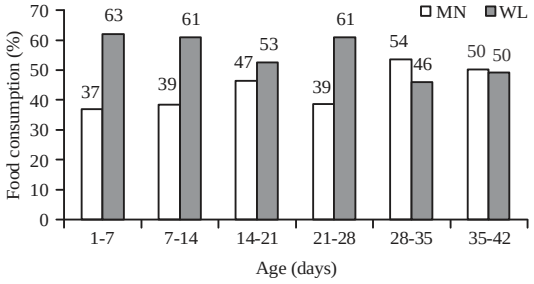


Fig. 4: Percentage of feed consumption for chick's choice-fed maize (MN) with a recommended dietary protein level and wheat (WL) with a low dietary protein level

## DISCUSSION

In this study, birds fed wheat-based diets with a recommended level of dietary protein as a sole source of cereal grain achieved performance close to or slightly in excess of those fed maize-based diets, with the opposite being true when fed low levels of dietary protein. However, when choice-fed a mixture of the low protein maize and wheat diets, there was a reduction in BWG of approximately 8%, compared to 14% for the single low protein wheat diet. The poor performance displayed by the chicks fed low levels of protein in their feed may be due to an imbalance of essential amino acids or a low biological value of protein due to the reduction in soybean meal in the formula. Consequently, the major portion of protein came from wheat or an imbalance between the caloric protein ratios. Moran *et al.*[18] and Razuki and Al-Rawi[19] noticed a reduction in body weight gain and FCR in fast-growing chicks due to a reduction in dietary protein. These results indicate that as protein levels of a feed decrease, either during the starter or grower periods, the total feed intake decreases. This finding was not supported by other researchers[20-22] who reported that the total feed intake was decreased when protein levels were increased. In this experiment, reducing the crude protein level from 21% in starter diets to 17% in finisher diets may have caused the reduced FC and FCR that was observed. Because the responses of the birds to essential amino acids can vary, a significant lack of any one of them (the first limiting or second limiting) may cause an imbalance or a toxicity, which can lead to a deficiency in FC[23]. Meanwhile, chicks fed low protein feeds were eating energy below the recommended levels of protein, even when provided iso-caloric feeds.

In the same context, chicks fed complete wheat-based diets exhibited better performance in either single or choice feed. This may be because the Ross broiler strains were selected and developed in the UK where the dominant cereal feedstuff is wheat, meaning that this strain was adapted to digest wheat more efficiently than first believed. This hypothesis may be supported by the free-choice feeding pattern (Fig. 1-4) where chicks ate greater amounts of wheat feeds than maize feeds. Kiarie *et al.*[24] and Razuki *et al.*[25] also reported good levels of performance in chicks fed wheat-based diets.

Ingredient feedstuffs have wide ranges of protein levels; therefore, the selection between two feeds is most likely based on protein content[1]. Shariatmadari and Forbes[12] used a wide range of protein levels (a low protein feed with 65 g protein $kg^{-1}$ dry matter and a high protein feed with 280 g $kg^{-1}$) and reported that 189 g $kg^{-1}$ of protein satisfied

the growth needs of the animals and gave a carcass composition very close to those of birds given a single diet containing 225 g $kg^{-1}$ of protein. They concluded that the broilers were selecting a diet close to that for optimal growth. The results of the current experiment could not confirm this hypothesis due to the chicks' preference in choice feeding being closer to wheat, irrespective of protein level. This may be because the range of reduced protein was approximately 2% and the first limiting amino acid was fortified according to the birds' requirements[16]. Another reason may be the adaptation of the Ross strain to feed on wheat-based diets, which may act on and influence feed intake and preference of long-term selection for this strain. In all four figures, it can be seen that chicks ate more feed that contained wheat even when they contained low levels of dietary protein. Cumming[26] demonstrated marked genetic differences between egg-type chickens and meat-type chickens regarding their abilities to adapt to free-choice. The same author reported that commercial layers and broilers can regulate their intake of energy and protein to maximize production and optimize economic returns. However, sensory tools can also affect feed intake[27] as diets differing in sensory properties have a significant effect on maximum biological performance. The taste of feeds[9,28] and feed forms[28] are another factor that hinders intake and consequently impairs performance.

## CONCLUSION

In summary, the results of this experiment indicate that feeding wheat-based diets is more suitable for the Ross 308 strain than maize because the feeding behavior mainly trends towards diets containing wheat, irrespective of the protein levels of the feeds.

## SIGNIFICANCE STATEMENT

This study suggests that it is possible to use wheat as a sole source of cereal grain in high levels without causing negative effects on performance. The feed pattern trended toward wheat regardless of protein level. This study can help researchers and poultry producers incorporate wheat into their feed formulations, especially for the Ross 308 broilers strain. Conducting further studies to confirm these results is recommended.

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