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# Selection of Whole Wheat by Broiler Chickens in Semi-commercial Experimental Conditions

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**Abstract**: The intake of whole wheat by choice feeding of broiler chickens was examined in two experiments under semi-commercial experimental conditions with respect to food intake, food efficiency and carcass characteristics. Choice-fed broiler chickens were offered a choice of a concentrate food (CON, 272 g CP $kg^{-1}$) and whole wheat (WW, 115 g CP $kg^{-1}$), while control chickens were fed on a commercial food (230-190 g CP $kg^{-1}$).

Choice fed-broiler chickens consumed higher amount of food than that of single-fed broiler chickens. Food efficiency was not affected by choice feeding while protein efficiency reduced.

With respect to final body weight and carcass parameters, both single-fed broilers and choice-fed broiler chickens were similar except liver weight (experiment 1) and abdominal fat pad (experiment 2) which were heavier in choice fed birds.

Choice fed broiler chickens showed adaptive wheat selection behaviour, choosing a diet having from 8 % (8-13 d) to 55 % (35-42 d) whole wheat. This selection was, in overall, 57 % of concentrate food and 43 % of whole wheat.

In conclusion, the use of whole wheat by choice feeding in the current experiments has a potential for commercial benefit, as shown reduction in food cost by birds' self-replacement of whole wheat in their diet.

**Keywords**: broiler chickens, diet selection, whole wheat

## Yarı-ticari Deneme Şartlarında Etlik Piliçlerde Tüm Dane Buğday Seçimi

**Özet:** Etlik piliçlerde seçmeli yemleme ile tüm dane buğday seçimi, yem tüketimi, yemden yararlanma ve karkas özellikleri bakımından iki deneme ile araştırılmıştır. Seçmeli yemlenen etlik piliçlere, konsantre yemin (CON, 272 g ham protein kg-1) yanında tüm dane buğday (WW, 115 g ham protein kg-1) sunulmuş, kontrol grubundaki etlik piliçler ise ticari yemle (230–190 g ham protein kg -1) beslenmişlerdir.

Seçmeli yemlenen etlik piliçler, tek yemle beslenenlerden daha fazla yem tüketmişlerdir. Yemden yararlanma seçmeli yemlenmeden etkilenmemesine rağmen; proteinden yararlanma, seçmeli yemlenen etlik piliçlerde düşük bulunmuştur.

Besi sonu canlı ağırlığı ve karkas özellikleri bakımından seçmeli yemlenen etlik piliçlerle tek yemlenen etlik piliçler arasındaki fark istatistiki olarak önemsizdir. Fakat, seçmeli yemlenen piliçler tek yemle beslenenlere göre daha ağır karaciğer (deneme 1) ve karın içi yağına (deneme 2) sahip olmuşlardır.

Seçmeli yemlenen etlik piliçler, deneme süresi boyunca artan bir eğilimde buğday seçimi davranışı göstererek, deneme başında (8-13 günlük yaşta) %8 olan (toplam yem tüketiminin) oransal buğday tüketimi, deneme sonunda (35-42 günlük yaşta) %55'e ulaşmıştır. Tüm deneme

süresi dikkate alındığında, seçmeli yemlenen etlik piliçler %57 oranında konsantre yem ve %43 oranında tüm dane buğday tüketerek, kendilerine özgü rasyonu oluşturmuşlardır.

Sonuç olarak, seçmeli yemlenen etlik piliçlerin, tüm dane buğdayı yem seçim davranışı göstererek rasyonlarına katmalarından anlaşıldığı üzere, tüm dane buğdayın seçmeli yemleme ile birlikte uygulanmasının ekonomik yararı olabilir.

**Anahtar sözcükler**: Etlik piliç, yem seçimi, tüm dane buğday

## Introduction

Feed cost has been a great deal of expenses (70% of all expenses) in poultry production. Many studies have been conducted to minimize the expenses. Today, commercial feed has been used in poultry production including feed formulation cost. Nowadays, conventional poultry production has reached a level that the domestication of chicken without the sense of animal welfare, their metabolic and physiologic comfort. However, animals have the senses to distinguish which foods are the most comfortable for them (Kutlu and Forbes, 1993; Görgülü *et al*., 1996; Şahin, 1999). Moreover, the food would be formulated by animals more accurately than by man if diet selection principles are carefully considered (Forbes, 1995). This gives poultry nutritionist some advantages in practice including less consumption of commercial food, the evaluation of surplus of crop production, minimizing the sudden chances in feeds and less manure production (Forbes, 1995).

The ability of domestic fowl to regulate their protein intake when presented with a choice between high and low protein foods is well established (Boorman, 1979; Hughes, 1979, 1984, Sahin and Forbes, 1997). Growing broiler chicks gained weight at the same rate either they were fed on a commercial food or offered a choice between soya-bean meal (460 g protein $kg^{-1}$) and ground maize (90 g $kg^{-1}$) (Kaufman *et al*., 1978). As they grew from 12 d to 50 d their total food intake increased, but this was almost totally due to an increased intake of maize, resulting in a reduction in the overall protein content of the selected diet from 250 to 140 g $kg^{-1}$ (Kaufman *et al*., 1978).

The price of whole wheat makes it attractive ingredients for broiler feeds but, because of its low protein content and imbalanced amino acid composition, it must be offered in different way such as choice feeding or sequential feeding or dilution of commercial feeds (Forbes and Covasa, 1995). According to Forbes and Covasa (1995), feeding whole wheat to poultry is not new and it was a standard practice 50-60 years ago (Ewing, 1951, cited from their article). Despite this research into choice feeding, using whole wheat is needed be studied for further progress.

Sequential feeding of wheat and commercial food in broiler chickens was investigated by Covasa and Forbes (1994). Female broiler chickens were offered either ground or whole wheat for 6 h period each day followed by a conventional food. Although body weight was reduced in the first 3-weeks, chickens compensated for their loss and attained a similar body weight at 7 weeks of age to those fed conventionally. When birds fed whole wheat consumed ate less amount of protein. Also they fed female

broiler chickens a mash food in which ground or whole wheat was gradually incorporated (starting with 2 % in week 2 and finishing with 34 in week 7) and found that the birds reached final body weights that have similar to those birds fed with conventional food. Recently, Karakozak and Kutlu (1999) conducted an experiment to compare whole grain feeding methods for broilers and to determine whether whole grain feeding would affect performance, carcass parameters and feeding cost of broiler chicks. They found that inclusion of whole wheat to the diet or offering whole wheat as a choice or feeding whole wheat for 8-h a day can provide considerable reduction in feed cost for body gain, while increasing fat deposition due to excess energy intake.

The present literature concerning choice feeding with whole grain under practical conditions shows insufficient information, although there has been an increase demand to assess choice feeding with regard to performance, carcass characteristics besides feeding cost under practical (commercial) conditions. Following experiments were, therefore, designed to asses whether use of whole wheat in choice feeding system in semi-commercial conditions was applicable or not with respect to growth, food efficiency and carcass parameters in broiler chickens so that this kind of studies can give the opportunity to minimize feed cost by shortening the chain between the harvest of raw materials and animal feeding procedure.

## Material and methods

### *Experiment 1*

One d-old commercial broiler chicks were fed on broiler starter crumbs, which contained crude protein (230 g $kg^{-1}$), fat (50 g $kg^{-1}$), fiber (25 g $kg^{-1}$), ash (60 g $kg^{-1}$), Vitamin A (12500 IU $kg^{-1}$), Vitamin D3 (12500 IU $kg^{-1}$), Vitamin E (75 IU $kg^{-1}$) and moisture (135 g $kg^{-1}$). The chicks were raised in mesh-floored rooms with 24 h continuous lighting and 33 to 30 $C^{o}$ of ambient temperature until the experimental procedure.

This experiment was conducted as a randomized block design without replication in which choice feeding with whole wheat was as a main effect (the effect of sex was eliminated because males and females are kept together as in practice).

At the beginning of the experiment, sixty-eight, 11-d old mixed-sexed broiler chicks were randomly divided into two treatment groups. The groups were as follows: thirty-four birds were fed on a commercial food (Control); thirty-four were allowed to choose concentrate food (CON) and whole wheat (WW). CON included 272 g $kg^{-1}$ and WW included 115 g $kg^{-1}$ crude protein (CP). WW was to be inadequate to support optimal growth, while the CON was intended to be higher than the optimal protein requirements (~200 g CP per kg fresh food) for growing chickens. CON food presented to the experimental animals as mash while WW was whole grain. The foods were different in colour, odour and texture naturally.

Table 1. The composition of experimental foods

| Ingredients (g $kg^{-1}$ food) | **Single feeding (control)** Commercial food | **Choice feeding (treatment)** Concentrate food (CON) | Whole wheat (WW) |
|---|---|---|---|
| Starter crumbs | 1000 | 900 | - |
| Whole wheat | - | - | 1000 |
| Fish meal | - | 100 | - |
| Total | - | 1000 | 1000 |
| Content (calculated) | | | |
| Dry matter | 880 | 891 | 880 |
| ME (Kcal /kg) | 3200 | 3160 | 3080 |
| Crude protein | 230-210-190* | 272 | 115 |
| Ash | 80 | 67.6 | 49.5 |
| Cost of one kg food ($) (July-2001) | 0.30 | 0.34 | 0.11 |

*On the basis of stage of growth, these foods were given conventionally.

At the first 4 days of the experiment, 34 broiler chicks 11-d old (240.2 ± 4.17 g) were trained to familiarize to two different foods (CON and WW, Table 1) with respect to physiological effect, taste and position. In this period, they were allowed to eat one food for alternate half days as a training period, which was adopted from Kyriazakis *et al*. (1990) by Forbes and Shariatmadari (1996). At the end of the training period, the birds were given a choice between the two foods.

Water was available throughout the experimental period. The chicks were kept in a group without replication in a poultry room, where 24 hr lighting and 20-24ºC ambient temperatures were provided. Food intake was measured daily. The growth of broiler chicks was recorded by measuring body weight at the age of 11, 22, 31 and 42-d old. Food efficiency (g gain: g food) was calculated for per bird in experimental group during the experimental period.

A random selection of 10 birds (5 males + 5 females) aged 42-d from each treatment was killed for the measurement of body components.

The main effect of feeding system (single or choice feeding) was compared in this experiment. Data concerning growth and carcass characteristics, food intake and diet selection were analysed using the "One-Way" ANOVA procedure of SPSS (SPSS, 1999). Food intake and its relative data obtained in this study are presented as means per group with standard error of difference (SED), whereas carcass data was obtained in this study is presented as means per bird with standard errors of the difference (SED).

### *Experiment 2*

This experiment having a commercial sense was conducted to check the results of experiment 1 with using replications. General procedure was the same as that of experiment 1. This experiment was conducted as a randomized block design with 4 replications, in which choice feeding with whole wheat was as a main effect. In the experiment, one thousand-twenty-four, 8-d old mixed-sexed broiler chicks were

randomly divided into 2 groups with 4 replications. Each replicate group (sub-group) consisted of 128 birds. Single-fed chicks (4 sub-groups) were fed on commercial food (Control), while choice-fed chicks (4 sub-groups) were allowed to choose CON and WW foods.

The composition of experimental foods (CON and WW) was given in Table 1 in experiment 1.

At the beginning of the experiment, the chicks were individually weighed and allocated randomly into experimental groups of equal mean body weight (105.8 ± 0.46 g) according to the experimental design. Water was available throughout the experimental period. The experimental chicks were kept in a poultry room with continuous 24 h lighting and 20-24 $C^0$ ambient temperatures.

During the first 4 days of experiment, the birds were trained to familiarize with two different foods (CON and WW, Table 1) with respect to their physiological effect, taste and position as given in experiment 1.

Food intake was measured weekly. However, this was given in tables on daily basis by dividing into 7 days and number of birds in each group. The growth of chicks was monitored by measuring body weight at the age of 14, 21, 28, 35 and 42-d. Food and protein efficiency

(g gain: g food & g gain : g protein) were calculated for sub-groups during the experimental period.

A random selection of 8 birds (4 females + 4 males) aged 42 d from each sub-group were killed for the measurement of carcass characteristics.

The data concerning growth and carcass characteristics was analysed as given in experiment 1.

## Results

### *Experiment 1*

The results below were obtained from experiment 1.

Table 2 shows that choice-fed broiler chickens increased whole-wheat consumption when getting older and this did not affect total food intake significantly during the experimental period ($P>0.05$). Choice–fed birds increased their food consumption quantitively at the last week of the experiment, but this was not statistically significant ($P>0.05$).

Table 2. Daily food intake of broiler chickens (g per bird)

| Age (d) | Choice feeding | | | Single feeding | |
|---|---|---|---|---|---|
| | CON intake | WW intake | Total food intake (CON+WW) | Food intake | Significance |
| 11-17 | 40.5±7.3 | 17.0±2.7 | 57.5 ± 8.4 | 60.7±7.7 | NS |
| 18-24 | 69.1±4.9 | 26.5±3.2 | 95,6 ± 6.4 | 93.4±3.1 | NS |
| 25-31 | 56.5±9.1 | 54.8±4.5 | 111.3 ± 11.9 | 107.4±5.6 | NS |
| 32-38 | 74.8±4.3 | 66.2±4.9 | 140.9 ± 5.1 | 146.5±4.3 | NS |
| 39-42 | 68.0±2.8 | 84.7±8.7 | 152.7 ± 6.8 | 132.8±15.8 | NS |
| Overall | 61.0±3.68 | 45.3±4.58 | 106.3±6.91 | 105.0±6.19 | NS |

As shown in Figure 1, choice feeding did not change the body weights of broiler chickens during the experimental period. Little differences between single feeding and choice feeding were found statistically insignificant (P>0.05). This result tells that choice-fed broilers showed a nearly same body weight changes with those of single fed broilers.

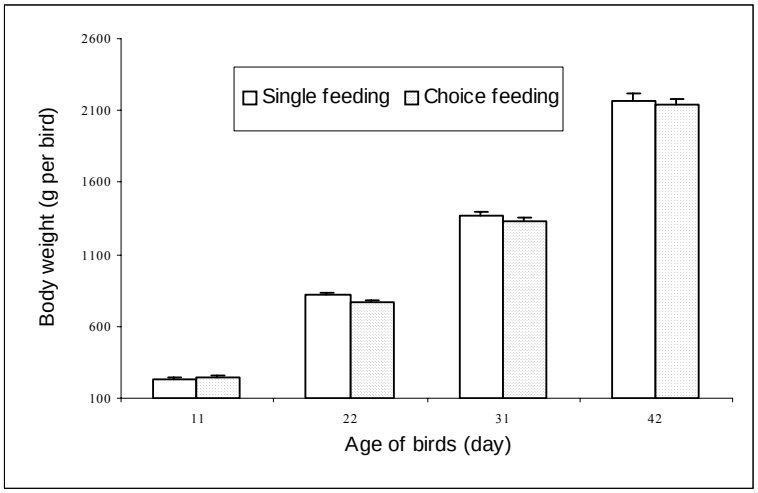


Figure 1. The changes in body weight of chicks in accordance with feeding systems

When whole wheat given a choice, feeding treatment did not affect the final body weight, daily body gain, food intake and efficiency (P>0.05) (Table 3). Also, this feeding did not affect the carcass parameters except liver weight (P<0.05). The birds either in single feeding or choice feeding showed a similar market weight at the age of 42-d. This was supported by the measurements of carcass characteristics.

Table 3. The effect of choice feeding on body gain, food intake and body components*

| Parameter (g per bird) | Single feeding | Choice feeding | SED** | Significance |
|---|---|---|---|---|
| Final body weight | 2168.1 | 2143.3 | 28.64 | NS |
| Daily body gain | 62.3 | 61.2 | 0.91 | NS |
| Daily food intake | 105.0 | 106.3 | 4.60 | NS |
| FE (g gain : g food) | 0.59 | 0.58 | - | - |
| Carcass weight | 1609.2 | 1624.1 | 40.72 | NS |
| Breast | 423.8 | 429.2 | 16.53 | NS |
| Legs | 486.4 | 518.0 | 15.14 | NS |
| Wings | 175.4 | 187.0 | 5.12 | NS |
| Liver | 41.2 **a** | 59.0 **b** | 2.76 | P<0.01 |
| Heart | 12.6 | 12.4 | 0.41 | NS |
| Abdominal fat pad | 52.7 | 54.8 | 2.69 | NS |

**a,b** : the difference within the same row is statistically significant (P<0.01).
*: the data were obtained from the mixture of males and females kept together in groups.
**: SED, standard error of difference between means.

The trend in the consumption of whole wheat by the experimental period as proportional intake of whole wheat is given in Figure 2. After 24-d old, choice-fed broiler chickens made a diet consisting of 50% whole wheat.

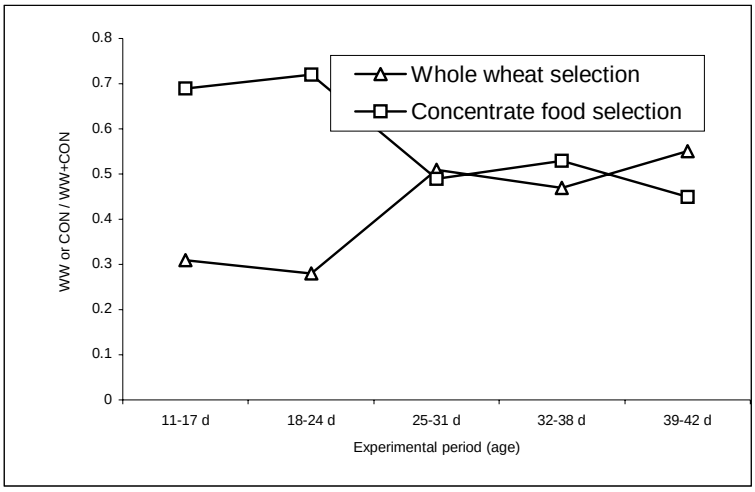


Figure 2. The proportional intake of concentrate food (CON) and whole wheat (WW) by broiler chickens in choice feeding.

### *Experiment 2*

The results below were obtained from experiment 2. These results supported what found in experiment 1.

Table 4. Food intake of broiler chickens in single and choice feeding systems.

| Experimental Period (d) | Feeding systems | WW intake (g/bird) | CON intake (g/bird) | Total food intake (g/bird) |
|---|---|---|---|---|
| 8-13 | Single feeding | - | - | 43.8 ± 3.1 |
| | Choice feeding | 3.5 ± 1.6 | 41.0 ± 1.5 | 44.5 ± 1.3 |
| 14-20 | Single feeding | - | - | 84.7 ± 6.3 |
| | Choice feeding | 14.7± 4.1 | 65.2 ± 3.8 | 80.0 ± 1.1 |
| 21-27 | Single feeding | | | 110.9 ± 2.4 |
| | Choice feeding | 55.6 ± 11.8 | 63.7 ± 9.3 | 119.4 ± 2.8 |
| 28-34 | Single feeding | - | - | 112.3 ± 6.5 |
| | Choice feeding | 74.5 ± 3.9 | 75.2 ± 2.6 | 149.7 ± 2.3 |
| 35-42 | Single feeding | - | - | 167.0 ± 6.9 |
| | Choice feeding | 89.9 ± 3.0 | 73.5 ± 2.3 | 163.3 ±1.8 |
| Overall | Single feeding | - | - | 104.0 ± 9.84 **a** |
| | Choice feeding | 47.7 ± 8.05 | 63.7 ± 3.38 | 111.4 ±10.13 **b** |

**a,b** : Overall food intake of broilers was affected by choice feeding (P<0.01).

Table 4 shows the changes in food intake during experimental period. Birds in choice feeding system reached heavier body weight for 3 weeks (P<0.01) after starting of experiment 2. After that, there was a less consumption of concentrate food in choice-fed birds equalized their body weights with the single-fed broiler chicks for last three weeks of experiment.

According to Table 5 below, choice-fed broiler chickens ate higher amount of food than the single-fed broilers, while daily gain of broiler chickens was not affected by choice feeding.

Table 5. Total body mass of broiler chickens with overall food intake and food efficiency

| Parameter | Single feeding | Choice feeding | SED* | Significance |
|---|---|---|---|---|
| Final body weight, g per bird | 2168.1 | 2143.3 | 28.64 | NS |
| Daily food intake, g per bird | 104.1 **a** | 111.4 **b** | 1.40 | P<0.01 |
| Daily protein intake, g per bird | 20.8 **a** | 22.8 **b** | 1.18 | P<0.01 |
| Daily gain, g per bird | 56.8 | 56.3 | 0.55 | NS |
| Feed efficiency, g gain: g food | 0.55 | 0.51 | 0.01 | NS |
| Protein efficiency, g gain: g protein | 2.72 **a** | 2.46 **b** | 0.05 | P<0.01 |

**a,b** : the difference within the same row is statistically significant (P<0.01).
*: SED, standard error of difference between means.

Figure 3 shows the changes in the body weight of broiler chickens. Choice-fed broiler chickens preferred CON food predominantly within the first 3-week of experiment 2.

This resulted a significant increase in body weight of chicks during this period. However, they increased whole wheat consumption and balanced their body weight with that of single-fed broiler chickens. There were no significant differences between feeding systems with respect to daily gain and feed efficiency, while food intake and protein intake increased by choice feeding with less protein efficiency.

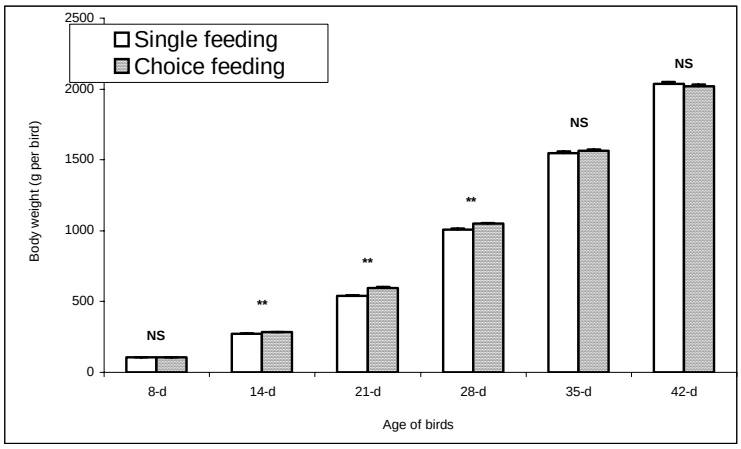


Figure 3. The changes in body weight of broiler chickens

The carcass characteristic of broiler chickens is given in Table 6 with respect to feeding systems. Choice-fed broiler chickens showed a similar carcass data to those of single-fed broiler chickens.

Table 6. Carcass characteristics of broiler chickens in single feeding and choice feeding systems

| Parameter (g per bird) | Single feeding | Choice feeding | SED* | Significance |
|---|---|---|---|---|
| Final body weight | 2069.5 | 2097.6 | 23.84 | NS |
| Carcass | 1553.9 | 1570.1 | 19.06 | NS |
| Breast | 477.6 | 495.2 | 7.74 | NS |
| Legs | 454.9 | 453.9 | 7.01 | NS |
| Wings | 172.7 | 167.7 | 2.24 | NS |
| Abdominal fat pad | 21.9 a | 28.3 b | 1.37 | P<0.05 |
| Liver | 57.5 | 55.7 | 0.90 | NS |
| Heart | 11.3 | 11.1 | 0.31 | NS |

a,b : the difference within the same row is statistically significant (P<0.05).
*: SED, standard error of difference between means.

Figure 4 shows selected CP values with the experimental periods in which broiler chickens selected CON food predominantly for 2 weeks after the initiation of experiment. Then, the selected CP values were similar to those of single-fed broiler

chickens. Choice-fed broiler chickens made a diet approximately 260 g CP per kg food at the first week of experiment. This was 186 g at the last week of experiment.

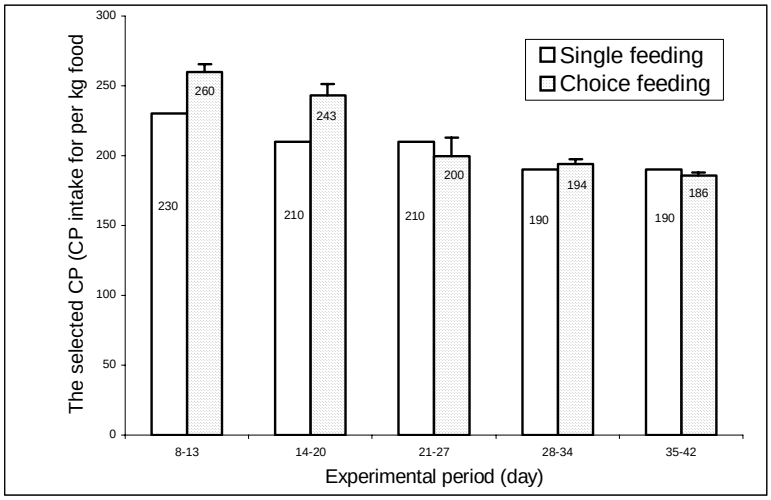


Figure 4. The selected CP (CP intake per kg food intake) by broiler chickens.

According to Figure 5 below, it is clear that wheat selection by choice-fed broiler chickens showed adaptive wheat selection behaviour by selecting 8 % to 55 % of whole wheat when getting older. Overall, choice-fed broiler chickens made a diet consisting of 57 % CON & 43 % WW.

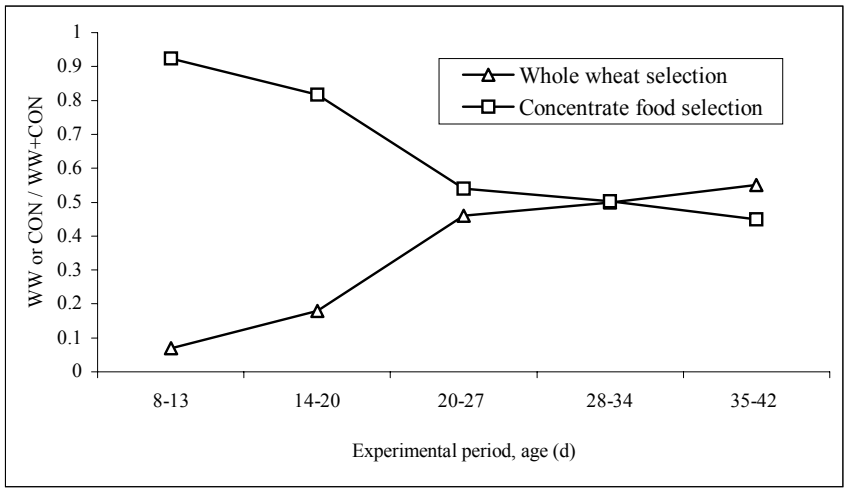


Figure 5. The proportional intake of whole wheat (WW) or concentrate food (CON) in choice–fed broiler chickens.

## Discussion

Firstly, it must be emphasized that the experimental animals were mixed-sex and they were not fed individually. Conventionally, both male and female broiler chicks one-d-old have been obtained together and have not been separated during the experimental period. For this reason, the present experiments were designed to approach choice feeding commercially. Thus, the effect of sex on choice feeding was eliminated. However, if male and female broiler chickens were separated and fed individually, it could have been seen the difference in food intake, diet selection and body composition between them, as it was previously observed by Sahin (1999).

The present study showed that choice-fed broiler chickens increased the intake of whole wheat when getting older with increase in total food intake in experiment 2. This increase in food intake was due to the increased intake of whole wheat so that birds can adjust their body composition (i.e., innate fat deposition in the abdominal area). These results are in agreement with those of Karakozak and Kutlu (1999). On the other hand, the higher amount of concentrate food intake at the first 2 weeks of experiment 2 would come from the genetic potential of broiler chickens to deposit protein in their body (Sahin, 1999). However, the early introduction of whole wheat in the present experiments may cause higher consumption of concentrate food that includes 272 g CP per kg food because of underdevelopment of digestive system of birds). Karakozak and Kutlu (1999) found that choice feeding increased food intake with lesser food efficiency. However, food efficiency was not affected by choice feeding, while protein efficiency was reduced in choice-fed broiler chickens in this study.

There was a slight difference between experimental foods with respect to their ME values (~75 Kcal/kg diet). This induced an increase in food intake by choice-fed broiler chickens (1 % in Experiment 1 and 6 % in Experiment 2). This was related to birds' attempt to compensate for an E:P (energy:protein) imbalance by increasing energy from selected foods, i.e., CON and WW in order to catch their innate body composition (Covasa and Forbes, 1995).

With respect to final body weight, results showed that choice feeding did not differentiate the growth performance. However, birds fed commercial foods had significantly less abdominal fat pad than that of choice-fed birds. This effect is most likely to come from the higher energy intake by consuming whole wheat. It has been reported that both fat synthesis and fat distribution to abdominal area require a considerable amount of energy and protein (Bocharov *et al*., 1995). However, Siegel *et al*. (1997) found that choice-fed broiler chickens weighed lighter than single–fed birds. In terms of abdominal fat pad weight, current findings are in line with those of Siegel *et al*. (1997).

The carcass measurements (carcass, breast, legs and wings) were not affected by choice feeding as found by of Karakozak and Kutlu (1999) with respect to carcass weight. According to Siegel *et al*. (1997), choice feeding decreased breast weight as reported by

Leeson and Caston (1993), while the current experiments showed that choice feeding did not change any edible carcass parameters.

The training method of Forbes and Shaiatmadari (1996) was applied and observed a successful diet selection paradigm for whole wheat against concentrate food in the present experiments. Choice-fed broiler chickens showed time dependent food selection behaviour, choosing a diet having 8 % (8-13 d) to 55 % (35-42 d) of whole wheat. Overall, choice-fed broiler chickens made a diet consisting 57 % of CON food and 43 % of WW. This result is in line with that of Rose *et al*. (1986). They found that if a mash balancer was provided, the broilers selected a 42.2 % of whole wheat. On the other hand, Siegel *et al.* (1997) found that chicks showed a dietary choice by not selecting foods to maximize growth and feed efficiency (their diet were 82 g CP for low protein food and 330 g CP $kg^{-1}$ for high protein food). They did not educate birds with respect to organoleptic properties of foods. However, in the present experiments chicks were trained to familiarize themselves to organoleptic properties of experimental foods. In their study, broiler chickens had to make a diet from two foods having a wide nutritional distance (330 g CP and 82 g CP $kg^{-1}$), while present experiments were designed to allow birds to make a diet from a narrower range of concentrate food (CON, 272 CP $kg^{-1}$) and WW (115 g CP $kg^{-1}$).

Choice-fed broiler chickens made a diet approximately 260 g CP $kg^{-1}$ food at the first week of experiment 2. This is higher than what recommended (230 g $kg^{-1}$ food) in Nutrient Requirements for Poultry (1984) for broiler chicks. Also, there could be another reason that broiler chicks may not have efficiently digested whole wheat because of their undeveloped digestive system at the early ages. This may cause higher amount of protein intake with less protein efficiency in choice-fed broiler chickens.

In conclusion, the present results suggest that diet formulation with dietary preferences of chicken would be having an economically important (considering the price of WW). Broiler chickens in this study chose a diet with optimal body gain and modify their food choice according to the changes in the body composition to catch economic benefits to market age. Implementing the usage of whole wheat with choice feeding in current experiments have a potential for commercial benefit, as shown reduction in food cost by birds' self-replacement of whole wheat in their diet.

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