RESEARCH ARTICLE

Effect of Whole Wheat (*Triticum aestivum*) Feeding on the Performance of Commercial Broilers

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Abstract

An experiment was conducted for six weeks to study the effect of mixed or choice feeding of whole wheat on the performance of commercial broiler chicken. A total of 352 straight-run day-old commercial broiler chickens were randomly divided into 11 treatments from T1 to T11, with 32 chicks in each treatment and eight chicks in each of four replicates. The corn soya control diet (T1) was fed to the broiler birds without the inclusion of wheat. Results indicated that final body weight, weight gain, and FCR were significantly ($p < 0.05$) improved in broiler birds fed with 40% choice feeding of wheat at marketing age without affecting feed consumption. The wheat consumption was linearly increased in the wheat choice feeding levels from 20 to 100 %. The study concluded that the choice feeding of wheat instead of maize at 40% was cost-effective and beneficial for improving growth performance.

Keywords: Choice feeding, Commercial broilers, Economics, Mixed feeding, Production performance, Whole wheat.

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Introduction

The Indian poultry industry has emerged as the most dynamic and fast expanding segment of the agro-animal-based industry. The poultry industry was the most dynamic sector within global meat production during the last decade concerning increased growth in the demand for meat. The average growth rate of the Indian poultry sector for the year 2016-17 was 6.3 % in egg production and 12 % in broiler production per annum against the growth rate of the agriculture sector, which was around 2.5 % (BAHFS, 2017).

Whole Grain Feeding (WGF) in the broiler industry is completely different from the traditional approach of the finely grounded grain component of the diet, which increases the surface areas of finely ground grains and facilitates enzymatic digestion (Liu *et al.,* 2015). Wheat is the cereal grain of choice for WGF, despite the fact that globally maize is the most commonly used cereal grain. Whole grain is incorporated into poultry diets to stimulate digestive tract development and improve the health status of birds (Mikulski *et al*., 2015). Whole grain feeding influences weight gains and reduces feed intake by 2.97 % and enhances feed conversion ratio (FCR) by 2.55% (Liu *et al*., 2015). In addition, to feed cost, WGF also improves the performance, gut health, and general flock health. Singh *et al.* (2014) reported that the size of whole grains and their hardness are physical limitations to feed whole grains to chicks as they face difficulties in breaking or swallowing whole grains, particularly during their first few days of life, so most researchers have delayed introduction of whole wheat until chicks are at least five days old.

Mixed feeding is a commonly used method of WGF and is either substituted as a part of the ground grain in a complete diet or added to a complete diet in the same feeder in pellet, mash, or whole grain form. Mixed feeding has resulted in a significant increase in body weight gain in broilers with no effect on feed intake (Singh *et al.,* 2014). The theory of choice feeding is not new and is traditionally part of the feeding practice of backyard poultry. The basic principle of choice feeding is that the individual bird can consume the required nutrients from various feed ingredients to fulfill their actual needs. When two or more types of diets are used with palatability, color, smell, form, and nutritional characteristics, birds can select a diet according to their nutritional requirements (Yao *et al.,* 2006). Hence, the present study was undertaken to evaluate the effect of different levels of whole wheat with mixed and choice feeding systems on the performance and economics of commercial broilers in the middle Gujarat climatic conditions.

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Materials and Methods

Experimental Birds and Design

The study was conducted from 16th November to 27th December 2019, following approval of IAEC of the College, at Poultry Research Station, College of Veterinary Science and AH, AAU, Anand, Gujarat (India). The meteorological data of experimental period pertaining to temperature and humidity were obtained from the meteorological department, AAU, Anand. The maximum ambient temperature was 27.50 °C and minimum of 19.00 °C, and the maximum relative humidity was 66.00 % and a minimum of 38.00 %. Three hundred fifty-two-day-old commercial broiler chicks were used. The chicks were equally divided into 11 treatments (each of 32 chicks), each consisting of four replicates with eight birds in each replicate.

The corn soya control diet (T_1) was fed to the broiler birds without the inclusion of wheat. The proportion of maize/corn was replaced by 20, 40, 60, 80, and 100% whole wheat in treatments T_2, T_4, T_6, T_8, and T_{10} with a choice feeding system (Wheat offered in a separate feeder), respectively. In contrast, broiler birds from treatments T_3, T_5, T_7, T_9, and T_{11} were fed with 20, 40, 60, 80, and 100% whole wheat, respectively, by replacing maize in mixed feeding system. Up to 7th day of age, pre-starter feed without wheat was offered to all treatment groups. During the starter phase (8-21 days), from 8th day to 11th day of age, broken wheat was offered in all treatment groups for adaption to wheat feeding and whole wheat feeding was started at different levels from 12th day for their choice and mixed feeding systems. All the diets were made iso-caloric and iso-nitrogenous as per the BIS 2007 standard. The diets prepared contained 23% CP and 3000 ME in the pre-starter phase, 22% CP and 3100 ME in the starter phase, and 20 % CP and 3200 ME in finisher phase. At the end of the experiment, one male and one female from each replicate was slaughtered for recording of gizzard weight.

Parameters Studied

Various traits like body weight (BW), body weight gain (BWG), feed consumption (FC), wheat consumption (WC), feed conversion ratio (FCR), livability, gizzard weight (g), gizzard weight (%) were recorded.

The economics was calculated after the end of the experiment considering the actual wheat and feed consumed and the average broiler selling price (INR 83.73/kg live body weight) of the year 2019 at Anand.

The data were analyzed using Completely Randomized Design as per Snedecor and Cochran (1994). Means of replicate under each treatment were considered for analysis.

Results and Discussion

Growth Performance

Non-significant differences were found in body weights of broiler birds at day-old age for all the treatment rations. At the end of the third week, significantly ($p < 0.05$) higher body weight was found in the birds fed with 20 and 40% mixed feeding of wheat as compared to control. The body weight of birds fed with 40% and 60 % choice feeding of wheat was significantly ($p < 0.05$) higher than the birds fed control, and it was at par with 20 % mixed and 40% choice feeding of wheat at the end of 6th week (Table 1). Emadinia *et al*. (2017) reported significantly ($p < 0.001$) higher body weight in the chicks fed with ground wheat as compared to whole wheat.

During the pre-starter phase, body weight gain was non-significant for all the treatment rations. In the starter phase, significantly ($p < 0.05$) higher body weight gain was observed in the birds fed with 20 % and 40 % mixed feeding, and 60 % choice feeding of wheat, while in finisher phase, body weight gain was significantly ($p < 0.05$) higher in the birds fed with 40 % mixed and 40 % and 60 % choice feeding of wheat. Overall, body weight gain was significantly ($p < 0.05$) higher in the birds fed with 20 % mixed and 40 % and 60 % choice feeding of wheat (Table 2). Cruz *et al*. (2005), however, found significantly higher body weight gain in the birds fed with basal diet than those fed with free choice feeding at the end of the experiment. Fanatico *et al*. (2016) also reported significantly lower body weight gain in the birds fed with choice feeding as compared to a formulated diet. Mingbin *et al*. (2015) stated that the body weight gain was significantly higher in the birds fed with crumble pellet than in the birds fed with mash diet in the wheat-based diet, while Bennet *et al*. (2002) reported a non-significant difference in the body weight gain in the birds fed at various levels of whole wheat.

Table 1: Body weight (BW) of broilers at different ages (0, 3, and 6 weeks)

Treatments	BW_0	BW_3	BW_6
T_1	45.54 ± 0.32	823.37^{de} ± 16.50	2422.93^{de} ± 57.39
T_2	45.46 ± 0.18	855.36^{cd} ± 40.19	2679.33^{abc} ± 51.03
T_3	46.75 ± .04	951.39^{a} ± 21.54	2669.91^{abc} ± 41.74
T_4	46.37 ± 0.85	928.81^{ab} ± 26.70	2824.70^{ab} ± 62.78
T_5	46.90 ± 1.06	951.47^{a} ± 14.88	2724.33^{abc} ± 64.82
T_6	45.18 ± 0.87	911.60^{abc} ± 28.02	2837.39^{a} ± 75.45
T_7	45.27 ± 0.57	917.81^{abc} ± 15.25	2637.87^{bc} ± 103.62
T_8	45.51 ± 0.45	870.15^{bcd} ± 21.54	2578.05^{cd} ± 55.63
T_9	45.33 ± 0.76	885.28^{abcd} ± 21.81	2568.45^{cd} ± 47.08
T_{10}	46.00 ± 0.90	877.00^{bcd} ± 13.82	2698.20^{abc} ± 42.29
T_{11}	47.66 ± 0.83	778.68^{e} ± 22.07	2296.66^{e} ± 89.63
SEm	0.77	23.20	65.61
CD at 5%	NS	66.77	188.81
CV%	3.32	5.24	4.99

Means with different superscripts within a column differ significantly ($p < 0.05$).

SEm= Standard error of mean, CD=Critical difference, CV=Coefficient of variance, NS=Non-significant

Table 2: Body weight gain (BWG) of broilers at different stages of life in weeks

Treatments	BWG_{0-1}	BWG_{2-3}	BWG_{4-6}	BWG_{0-6}
T_1	143.96 ± 5.09	633.87^{de} ± 12.48	1599.55^{de} ± 57.08	2377.39^{de} ± 57.08
T_2	149.70 ± 3.65	660.20^{cd} ± 43.49	1823.97^{abc} ± 84.70	2633.87^{abc} ± 50.85
T_3	153.59 ± 4.64	751.04^{a} ± 21.22	1718.52^{bcd} ± 34.52	2623.16^{abc} ±42.05
T_4	155.54 ± 5.61	726.90^{ab} ± 21.51	1895.89^{ab} ± 48.35	2778.33^{ab} ± 62.45
T_5	153.98 ± 4.12	750.60^{a} ± 15.30	1772.86^{abcd} ± 55.91	2677.43^{abc} ± 63.99
T_6	156.63 ± 4.86	709.78^{abc} ± 23.09	1925.79^{a} ± 56.68	2792.21^{a} ± 75.20
T_7	155.89 ± 1.93	716.66^{abc} ± 13.86	1720.06^{bcd} ± 103.80	2592.60^{bc} ± 103.53
T_8	156.37 ± 2.08	668.28^{bcd} ± 20.70	1707.90^{cd} ± 57.14	2532.55^{cd} ± 56.02
T_9	156.43 ± 1.56	683.53^{bcd} ± 20.67	1683.17^{cde} ± 29.45	2523.13^{cd} ± 47.11
T_{10}	151.57 ± 4.60	679.43^{bcd} ± 12.76	1821.21^{abc} ± 45.69	2652.21^{abc} ± 43.03
T_{11}	151.97 ± 7.00	579.05^{e} ±21.91	1517.98^{e} ± 77.77	2248.99^{e} ± 90.41
SEm	4.41	22.20	62.77	65.62
CD at 5%	NS	63.87	180.65	188.84
CV%	5.75	6.46	7.20	5.08

Means with different superscripts within a column differ significantly ($p < 0.05$).

Table 3: Overall feed consumption (FC) of broilers at different stages of life in weeks

Treatments	FC_{0-1}	FC_{2-3}	FC_{4-6}	FC_{0-6}
T_1	142.50^{b} ± 3.57	1063.91^{de} ± 30.84	3411.63 ± 76.45	4618.04 ± 176.19
T_2	127.85^{c} ± 6.28	1187.52^{ab} ± 33.91	3469.17 ± 04.62	4784.54 ± 232.42
T_3	136.94^{bc} ± 1.95	1148.03^{abcd} ± 44.29	3763.72 ± 31.50	5048.68 ± 173.08
T_4	133.41^{bc} ± 3.09	1159.85^{abcd} ± 16.82	3394.89 ± 95.72	4688.14 ± 98.98
T_5	157.97^{a} ± 1.91	1193.60^{a} ± 15.06	3766.26 ± 118.06	5117.83 ± 129.32
T_6	133.81^{bc} ± 10.00	1094.10^{bcde} ± 48.22	3598.21 ± 68.64	4826.12 ± 80.64
T_7	138.32^{bc} ± 3.21	1163.76^{abc} ± 25.86	3638.50 ± 78.29	4940.57 ± 192.45
T_8	132.32^{bc} ± 4.56	1010.85^{ef} ± 36.10	3369.27 ± 128.90	4512.43 ± 164.57
T_9	138.19^{bc} ± 3.76	1075.49^{cde} ± 20.86	3589.34 ± 90.81	4803.02 ± 102.03
T_{10}	143.75^{b} ± 3.22	1002.43^{ef} ± 50.45	3405.21 ± 102.76	4551.39 ± 144.05
T_{11}	138.38^{bc} ± 2.80	922.93^{f} ± 24.24	3298.23 ± 245.55	4359.53 ± 242.82
SEm	4.60	33.63	149.43	165.77
CD at 5%	13.24	96.77	NS	NS
CV%	6.64	6.15	8.49	6.98

Means with different superscripts within a column differ significantly ($p < 0.05$)

Feed and Wheat Consumption

The feed consumption in the pre-starter phase was significantly ($p < 0.05$) different, while in starter phase, feed consumption was significantly ($p < 0.05$) higher in the birds fed with 40% choice feeding as well as in the birds fed with 20 % and 60% mixed feeding of wheat. The feed consumption of birds fed with a finisher diet was found to be non-significant. Overall feed consumption of the birds fed with different treatment rations was also found to be non-significant (Table 3). The overall means of wheat consumption (g/bird) (wheat offered in a separate feeder) from total feed consumption during 2 to 6 weeks of age in birds fed with 20, 40, 60, 80, and 100% choice feeding of wheat were found to be 401.70, 746.89, 1339.15, 1514.74 and 2204.32 g, respectively. The corresponding values in percent were 8.63, 16.40, 28.54, 34.58, and 50.01. Percent wheat consumption from 2 to 6 weeks of age in the birds fed with 20, 40, 60, 80, and 100% choice feeding of wheat from total wheat offered was, however, statistically similar (48.18, 47.36, 55.34, 51.81, and 57.10%, respectively) (Table 4).

Cruz *et al*. (2005) observed significantly higher feed consumption in the basal diet birds than in the free choice feeding. Ravindran *et al*. (2006) also noted significantly lower feed intake in the birds fed with whole wheat as compared to grounded wheat. However, Yao *et al*. (2006) reported a non-significant difference in feed intake of the birds fed with a control diet and free choice feeding system. Emadinia *et al*. (2017) found non-significant differences in the birds fed with whole wheat, ground wheat, dry feed, and wet feed. Contradictory results were found by Fanatico *et al*. (2016),

who observed significantly lower feed intake in the birds fed with choice feeding of whole wheat as compared to the formulated diet.

Feed Conversion Ratio

The FCR was found to be non-significant during pre-starter phase where there was no inclusion of wheat. In the starter phase, significantly ($p < 0.05$) improved FCR was found in the birds fed with 80 and 100 % choice wheat feeding. While in the finisher phase, FCR was non-significant. However, numerically improved FCR was found in the birds fed with 40 % choice wheat feeding. The overall results showed non-significant FCR, but the overall FCR for a 0 to 6 weeks period was found to be better in 40% choice feeding of wheat as compared to the birds fed with control and all other treatment rations (Table 5). Similar results were reported by Emadinia *et al* (2017). Razuki *et al.* (2018) also reported a non-significant difference in FCR of the birds fed with free choice feeding.

Fanatico *et al.* (2016) found significantly improved FCR in the birds fed with choice feeding as compared to the formulated diet. Gracia *et al.* (2016) reported significantly better FCR in the birds fed with pelleted feeds than the birds fed with mash feeds. Cruz *et al*. (2005) also found improved FCR considerably in the birds fed with basal diet and choice feeding of rice bran, soybean meal and premix than the birds fed with corn, corn gluten meal & premix, rice bran, corn, corn gluten meal & premix. Bennet *et al.* (2002) recorded contradictory results with improved FCR in the birds fed with level 1 control (without wheat) than the birds fed with various inclusion levels of wheat at different days.

Gizzard Weight

The differences in gizzard weight (g) among different treatment rations were non-significant. The gizzard weight percentage was significantly higher in the birds fed with 100 % mixed wheat feeding; however, the trend was indefinite as the gizzard weight was also higher in the birds fed with the control group as compared to some of the treatment groups (Table 6). Preston *et al.* (2000) found significantly higher gizzard weight in the birds fed with whole wheat with balancer pellet than the birds fed with cold pelleted and heat conditioned pelleted feed. Similarly, Bennet *et al.* (2002) observed significantly higher gizzard weight in the birds fed with various inclusion levels of wheat than the birds fed with level 1 control (without wheat). Ravindran *et al.* (2006) found

Table 4: Wheat consumption (WC) at different stages of life in weeks

	WC_{2-3}			WC_{4-6}			W_{2-6}		
Treatments	*(g)*	*(%)**	*(%)***	*(g)*	*(%)**	*(%)***	*(g)*	*(%)**	*(%)***
T_2	68.70	5.79	39.08	333.00	9.60	57.27	401.70	8.63	48.18
T_4	155.19	13.38	43.93	591.70	17.43	49.65	746.89	16.40	47.36
T_6	260.60	23.82	51.15	1078.55	29.97	59.53	1339.15	28.54	55.34
T_8	386.65	38.25	57.38	1128.09	33.48	46.25	1514.74	34.58	51.81
T_{10}	485.22	48.40	58.10	1719.10	50.48	56.09	2204.32	50.01	57.10

*Percent wheat consumption from total feed consumption.
**Percent wheat consumption from total wheat offered.

Table 5: Feed conversion ratio (FCR) of broilers at different stages of life in weeks

Treatments	FCR_{0-1}	FCR_{2-3}	FCR_{4-6}	FCR_{0-6}
T_1	0.753 ± 0.03	1.678^{ab} ± 0.02	2.134 ± 0.09	1.906 ± 0.05
T_2	0.655 ± 0.66	1.820^{a} ± 0.10	1.916 ± 0.15	1.786 ± 0.09
T_3	0.684 ± 0.68	1.529^{bc} ± 0.03	2.193 ± 0.09	1.891 ± 0.05
T_4	0.661 ± 0.66	1.596^{bc} ± 0.03	1.797 ± 0.09	1.660 ± 0.06
T_5	0.786 ± 0.79	1.590^{bc} ± 0.02	2.136 ± 0.13	1.884 ± 0.09
T_6	0.663 ± 0.67	1.541^{bc} ± 0.05	1.875 ± 0.08	1.701 ± 0.04
T_7	0.688 ± 0.69	1.624^{bc} ± 0.05	2.124 ± 0.08	1.873 ± 0.06
T_8	0.655 ± 0.66	1.513^{c} ± 0.05	1.986 ± 0.14	1.750 ± 0.09
T_9	0.685 ± 0.68	1.573^{bc} ± 0.03	2.134 ± 0.06	1.870 ± 0.05
T_{10}	0.728 ± 0.73	1.475^{c} ± 0.09	1.874 ± 0.08	1.687 ± 0.07
T_{11}	0.693 ± 0.70	1.594^{bc} ± 0.06	2.169 ± 0.09	1.898 ± 0.05
SEm	0.03	0.06	0.13	0.04
CD at 5%	NS	0.16	NS	NS
CV%	8.58	6.94	10.02	7.36

Means with different superscripts within a column differ significantly ($p < 0.05$).

Table 6: Gizzard weight of broilers in different treatments

Treatments	*Gizzard weight (g)*	*Gizzard weight (%)*
T_1	38.75 ± 0.83	1.53^{bc} ± 0.05
T_2	36.25 ± 1.13	1.33^{d} ± 0.04
T_3	36.50 ± 1.90	1.49^{bcd} ± 0.05
T_4	39.00 ± 1.88	1.51^{bc} ± 0.07
T_5	40.38 ± 0.94	1.53^{bc} ± 0.02
T_6	39.38 ± 1.53	1.39^{cd} ± 0.08
T_7	38.88 ± 1.46	1.53^{bc} ± 0.03
T_8	42.13 ± 1.81	1.58^{b} ± 0.07
T_9	39.25 ± 1.96	1.45^{bcd} ± 0.06
T_{10}	40.13 ± 1.13	1.48^{bcd} ± 0.05
T_{11}	42.25 ± 2.65	1.80^{a} ± 0.06
SEm	1.65	0.06
CD at 5%	NS	0.16
CV%	8.37	7.46

Means with different superscripts within a column differ significantly ($p < 0.05$).
SEm= Standard error of mean, CD=Critical difference, CV=Coefficient of variance, NS=Non-significant

Table 7: Livability (%) of broilers and Return over Feed Cost (*ROFC*) of different treatments

Treatments	*Livability (%)*	*Income from the sale of birds (Rs./bird)*	*Feed cost (Rs./bird)*	ROFC (Rs./bird)
T_1	84.38	202.87	182.72	20.15
T_2	87.50	224.34	190.46	33.88
T_3	93.75	223.55	199.36	24.19
T_4	93.75	236.51	192.98	43.53
T_5	90.63	228.11	200.18	27.93
T_6	93.75	237.57	198.22	39.35
T_7	96.88	220.87	191.46	29.41
T_8	90.63	215.86	197.9	17.96
T_9	87.50	215.06	185.52	29.54
T_{10}	87.50	225.92	196.81	29.11
T_{11}	68.75	192.30	167.51	24.79

higher gizzard weight in the birds fed with 100 and 200 g/kg of wheat in the diet

Mortality and Return over Feed Cost (ROFC)

The lowest mortality (highest livability) was observed in the birds fed with 60% mixed feeding, followed by 20% mixed feeding, and 40 and 60% choice feeding systems (Table 7). Mingbin *et al*. (2015) and Kheravi *et al*. (2017) found a non-significant difference in the mortality in birds fed with different particle sizes and feed forms.

In general, the return over feed cost was higher in all treatment groups over control, and also in even numbers of treatments (choice feeding of wheat) than in odd numbers of treatments (mixed feeding of wheat), except treatments 8 and 9. Overall the highest return over feed cost was INR 43.53 per bird in the birds fed with 40 % choice feeding of wheat (T4) as compared to all other treatment rations (Table 7). This was mainly due to greater body weight and better feed efficiency in birds of choice feeding groups. However, no relevant reference was found on the economics of wheat feeding to discuss the present findings further.

Conclusions

From the study, it can be concluded that the birds preferred 40% and 60% maize replacement in diet by wheat offered in a separate feeder to fulfill their requirements for higher body weight and body weight gain. Wheat consumption was increased linearly in the choice feeding treatment rations. FCR of the birds fed a diet with 40% maize replaced by wheat and offered in a separate feeder (T_4) was better compared to all other treatment rations. The highest profit in terms of return over feed cost was observed in the birds fed diet with 40% maize replaced by wheat and offered in a separate feeder.

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