RESEARCH ARTICLE

Comparison of Mixed and Choice Feeding of Whole Wheat (*Triticum aestivum*) on the Performance of Commercial Broilers

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Abstract

Wheat is the cereal grain of choice for Whole Grain Feeding (WGF) in poultry, despite the fact that globally maize is the most commonly used cereal grain. In this context, in the present study feeding of whole wheat to commercial broilers with two types of feeding systems was used, *i.e.*, mixed and choice feeding systems of wheat with different levels of replacement with maize by 20, 40, 60, 80 and 100%. The body weight and body weight gain of birds fed with 20% and 40% choice feeding of wheat was found to be the highest ($p<0.05$). The mean wheat consumption (g/bird) from total feed consumption under choice feeding during 2 to 6 weeks of age in birds fed with 20, 40, 60, 80 and 100% were found to be 363.18, 720.12, 1398.45, 2160.30 and 3202.10, respectively. Birds fed with choice feeding of 40% wheat showed significantly ($p<0.05$) improved FCR. The highest livability (%) was found in the birds fed with 40% and 100% choice feeding of wheat. The gizzard weight (g) showed non-significant difference among the birds fed with various treatment rations. The highest return over feed cost (in Rs.) was found in the birds fed with 40% choice feeding of wheat. The overall results indicated that choice feeding system is more suitable for better body weight gain and improved FCR as compared to mixed feeding system of whole wheat. Feeding with 40% maize in diet replaced by wheat and offered in separate feeder is more economical and profitable due to higher body weight gain, improved FCR and acceptable mortality.

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

Ind J Vet Sci and Biotech (2023): 10.48165/ijvsbt.19.2.12

Introduction

India today is one of the world's largest producer of broiler meat. The poultry industry in India has undergone a major shift in structure and operation during the last two decades transforming from a mere backyard activity into a major industry. The Indian poultry market, consisting of broilers and eggs reached a value of INR 1,988 Billion in 2020. The Indian poultry market is expected to grow at a CAGR of 15.2% during 2021-2026 (Research and Markets, 2021). India is the fourth-largest broiler chicken producer after China, Brazil and USA.

Whole grain feeding (WGF) meets consumer demands for a natural feeding system and improved birds welfare (Singh *et al*., 2014). Wheat has the softest texture and the lowest final starch viscosity. It consists of 53% fibre components (Sramkova *et al*., 2009). Starch is the most abundant carbohydrate in wheat which is 60% to 75% main energy-yielding component (Amerah, 2015).

Mixed feeding is commonly used method of WGF and is either substituted as a part of the ground grain in a complete diet or added to complete diet in the same feeder in pellet, mash or whole grain form. Basic principle of choice feeding is that the individual bird is capable of consuming the required nutrients from various feed ingredients to fulfil their actual needs. When two or more types of diets are used with palatability, colour, smell, form and nutritional characters, birds can select diet according to their nutritional requirements (Yao *et al.,* 2006). Most researchers have incorporated whole wheat until chicks are at least five days old (Singh *et al.,* 2014). Economics of poultry industry depends upon feed cost. Feedstuff is an aspect of high economic importance in the rearing of commercial poultry because it represents the 70 % costs in the production cycle (Chamba *et al.,* 2014). Hence, the present study was undertaken to evaluate the effect of choice and mixed wheat feeding

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How to cite this article: Bhagora, N.J., Savaliya, F.P., Patel, A.B., & Lonkar, V.D. (2023). Comparison of Mixed and Choice Feeding of Whole Wheat (*Triticum aestivum*) on the Performance of Commercial Broilers. Ind J Vet Sci and Biotech. 19(2), 63-69.

Source of support: Nil

Conflict of interest: None

Submitted: 17/11/2022 **Accepted:** 30/12/2022 **Published:** 10/03/2023

systems on gizzard development and performance of commercial broilers in the middle Gujarat climatic conditions.

Materials and Methods

Experimental Birds and Design

The study was conducted following approval of IAEC of the College, at Poultry Research Station, Anand Agricultural University (AAU), Anand, Gujarat (India). The experiment was conducted from 7th February to 19th March, 2020. The average temperature was 23.52 °C and average humidity was 53.79 %. Three hundred fifty two (352) straight run day-old commercial broiler chicks were distributed randomly to eleven treatment groups, each group consisted of 32 chicks divided into four replicates, each of 8 chicks. T1 was control, while T2 (20%), T4 (40%), T6 (60%), T8 (80%) and T10 (100%) replaced maize by wheat at given percentages and offered in the separate feeder as choice feeding, whereas T3 (20%), T5 (40%), T7 (60%), T9 (80%) and T11 (100%) replaced maize by wheat at given percentages in the mixed diet. The levels of crude protein and metabolizable energy in pre-starter (23 % and 3000 ME), starter (22 % and 3100 ME) and finisher phase (20 % and 3200 ME) were taken into consideration while preparing and offering the diet in all the treatment rations. Up to 7th day of age pre-starter feed was offered to all treatment groups. During 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. Whole wheat grain feeding was started at different levels from 12th day in the separate feeder for their choice feeding and in wheat mixed feed. At the end of experiment, birds were sold to butcher and one male and one female from each replicate were taken for the study of gizzard. The meteorological data of experimental period were obtained from meteorological department of AAU, Anand.

Parameters Studied

Body weight (BW), Body weight gain (BWG), Feed consumption (FC), Wheat consumption (WC), Feed conversion ratio (FCR), Livability, Gizzard weight (gm & %) and Return over feed cost (Rs., Income from selling of birds on live weight basis - feed cost) were determined. Economy of each treatment group was calculated after the end of experiment considering the average broiler selling price (INR 83.73/kg live body weight). The data were analyzed using Completely Randomized Design as per Snedecor and Cochran (1994). Means of replicates under each treatment were considered for analysis.

Results and Discussion

Growth Performance

The results of body weight at day old age were found to be non-significant between all treatment rations. The sixth week body weight was significantly (P<0.05) highest in the birds fed with 20 % and 40 % choice feeding as compared to 20 % and 40 % mixed feeding of wheat and also highest than the birds fed with all other treatment rations. However, the birds fed with treatment rations T6 to T11 were found to be non-significant among each other (Table 1). These results agreed with those of Bhagora *et al*. (2022). Jordan *et al.* (2010) also reported highest body weight in the birds fed with wheat scattered in the litter than control group, and significantly higher than the birds fed with pellets scattered in the litter. Findings of this study were however contradictory to Emadinia *et al.* (2017) who found significantly lower body weight in the birds fed with whole wheat as compared to ground wheat. Significantly (p<0.05) higher body weight observed in even number of treatments may be due to preferred choice feeding of wheat and feed offered in the separate feeders, which indicates the beneficial effects in improving the nutrient utilization required for growth.

Table 1: Body weight (g) at different ages in broilers fed different wheat diet

Treatments	BW_0	BW_1	BW_3	BW_6
T_1	46.66±0.15	186.85^{a}±5.44	864.82^{e}±27.80	2355.36^{cd}±17.31
T_2	46.22±0.25	173.41^{bc}±2.93	927.72^{bcd}±35.21	2824.67^{a}±64.28
T_3	46.42±0.57	181.59^{ab}±2.82	948.49^{bc}±5.86	2321.02^{d}±52.18
T_4	45.21±0.44	175.34^{bc}±4.15	964.14^{ab}±17.70	2795.65^{a}±19.40
T_5	45.73±0.39	170.01^{c}±3.23	880.28^{de}±8.46	2371.21^{cd}±29.24
T_6	45.55±0.54	170.78^{c}±1.67	726.75^{f}±17.27	2400.66^{bcd}±45.55
T_7	45.00±1.00	173.33^{bc}±3.80	833.04^{e}±18.94	2499.31^{bc}±50.97
T_8	45.98±0.28	166.50^{c}±2.48	889.09^{cde}±3.73	2535.22^{b}±37.79
T_9	45.77±0.37	189.88^{a}±3.80	1018.69^{a}±28.24	2536.44^{b}±74.87
T_{10}	45.58±0.22	170.81^{c}±4.59	931.85^{bcd}±28.23	2468.08^{bcd}±78.16
T_{11}	46.18±0.18	187.17^{a}±1.64	944.41^{bc}±14.09	2544.86^{b}±54.07
SEm	0.46	3.51	21.65	51.45
CD at 5%	NS	10.10	62.31	148.09
CV%	2.01	3.97	4.80	4.09

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

During starter phase (2-3 weeks) significantly (P<0.05) higher body weight gain was found in the birds fed with 40 % choice feeding and 80 % mixed feeding of wheat. In finisher phase, (4-6 weeks) significantly (p<0.05) highest body weight gain was found in the birds fed with 20 % and 40 % choice feeding of wheat as compared to birds fed with 20 % and 40 % mixed feeding of wheat as well as all other treatment rations (Table 2). Findings of this study are in accordance with Bhagora *et al*. (2022) who reported that feeding of whole wheat had higher body weight gain as compared to control, except 100 % mixed feeding of wheat. Cruz *et al*. (2005) found significantly higher body weight gain in the birds fed with basal diet as compared to the birds fed with free choice feeding of rice bran & soybean premix, corn & corn gluten premix, rice bran & corn gluten premix and corn & soybean meal premix at the end of experiment. Yao *et al*. (2006) in contrast found lower body weight gain in the birds fed with choice feeding of ground corn and protein concentrate (treatment 1) and soybean meal and balance (treatment 2) than the birds fed with control diet. Similarly, Fanatico *et al*. (2016) also reported significantly lower body weight gain in the birds fed with choice feeding as compared to formulated diet. Mosammi (2011) however showed non-significant improvement in the body weight gain with the increased inclusion levels of whole oat hulls over control diet. Bennet *et al*. (2002) and Emadinia *et al*. (2017) reported non-significant difference in body weight gain in the birds fed at various levels of whole wheat, ground wheat and wet feeding.

Feed Consumption

The overall results of feed consumption showed significant (p<0.05) difference among the birds fed with various treatment rations. Significantly (p<0.05) highest feed consumption was observed in the birds fed with 100 % mixed feeding of wheat. However, lower feed consumption was obtained in the birds fed with choice feeding of wheat with 40, 60, 80 and 100 % as compared to mixed feeding of wheat with 40, 60, 80 and 100 % (Table 3). Gracia *et al*. (2016) observed significantly higher feed intake in the birds fed with whole wheat (Pelleted feed) as compared to mash feed, while Mikulski *et al*. (2015) reported significantly lower feed intake in the birds fed with ground pelleted wheat, ground pelleted wheat & whole grain wheat, and whole grain wheat than the birds fed with complete pelleted diet. Fanatico *et al*. (2016) observed significantly lower feed intake in the birds fed with choice feeding of whole wheat as compared to the formulated diet, while Ravindran *et al*. (2006) recorded significantly lower feed intake in the birds fed with whole wheat as compared to grounded wheat. The present findings concurred well with these reports.

Wheat Consumption

The average 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 were found to be 363.18, 720.12, 1398.45, 2160.30 and 3202.10, respectively. The corresponding percentage wheat consumption values from total feed were 7.04, 15.72, 31.64, 45.64 and 64.24 %, respectively. The percentage wheat consumption from total wheat offered during 2 to 6 weeks of age in birds fed with 20, 40, 60, 80 and 100% choice feeding were found to be 42.39, 49.53, 65.08, 75.72 and 86.30 %, respectively (Table 4). The results, showed that as the level of wheat increased in the diet wheat consumption also increased and the birds were fulfilling the nutrient requirements according to the need for their optimum growth and performance. Similar results were obtained by Bhagora *et al*. (2022).

Table 2: Body weight gain (g) at different ages in broilers fed different wheat diet

Treatments	BWG_{0-1}	BWG_{2-3}	BWG_{4-6}	BWG_{0-6}
T_1	140.19^{a}±5.48	677.98^{de}±24.22	1490.54^{de}±41.84	2308.70^{cd}±17.37
T_2	127.18^{bc}±2.75	754.31^{bc}±32.84	1896.95^{a}±92.07	2778.44^{a}±64.48
T_3	135.17^{ab}±2.59	766.90^{bc}±3.37	1372.53^{e}±46.91	2274.60^{d}±52.07
T_4	130.13^{bc}±3.74	788.79^{ab}±14.22	1831.51^{a}±20.67	2750.43^{a}±19.32
T_5	124.28^{c}±2.97	710.27^{cde}±10.50	1490.93^{de}±30.20	2325.48^{cd}±29.09
T_6	125.23^{c}±2.12	555.97^{f}±18.58	1673.91^{b}±36.06	2355.11^{bcd}±45.16
T_7	128.33^{bc}±3.10	659.71^{e}±17.08	1666.26^{b}±42.62	2454.31^{bc}±50.24
T_8	120.53^{c}±2.68	722.59^{cd}±17.84	1646.13^{bc}±40.16	2489.25^{b}±38.04
T_9	144.10^{a}±3.75	828.81^{a}±29.10	1517.75^{cde}±70.91	2490.67^{b}±74.51
T_{10}	125.23^{c}±4.49	761.04^{bc}±24.59	1536.23^{bcd}±54.29	2422.50^{bc}±78.01
T_{11}	140.98^{a}±1.68	757.25^{bc}±13.08	1600.45^{bcd}±48.31	2498.68^{b}±53.95
SEm	3.38	58.66	51.17	51.30
CD at 5%	9.72	58.64	147.27	147.64
CV%	5.16	5.62	6.35	4.16

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

Table 3: Feed consumption (g/bird) at different stages of broilers fed different wheat diet

Treatments	FC_{0-1}	FC_{2-3}	FC_{4-6}	FC_{0-6}
T_1	137.83^{bcd}±4.26	1074.22^{bc}±33.93	3918.63^{b}±51.42	5130.68^{bc}±80.90
T_2	128.25^{d}±6.10	1065.13^{c}±31.21	4090.61^{ab}±277.01	5283.99^{b}±255.20
T_3	147.79^{abc}±7.04	1165.31^{ab}±24.48	3787.00^{b}±352.39	5100.09^{bc}±378.01
T_4	136.94^{bcd}±2.85	1080.02^{bc}±8.24	3502.26^{b}±133.68	4719.22^{bc}±135.62
T_5	162.40^{a}±3.45	1119.92^{abc}±38.90	3765.54^{b}±120.71	5047.86^{bc}±83.42
T_6	135.06^{cd}±9.61	819.57^{d}±22.52	3599.79^{b}±120.73	4554.42^{c}±104.27
T_7	132.72^{d}±5.55	1047.86^{c}±51.76	3519.28^{b}±142.67	4699.85^{bc}±116.18
T_8	136.31^{cd}±2.35	1029.63^{c}±23.00	3703.64^{b}±75.43	4869.58^{bc}±82.97
T_9	141.13^{bcd}±3.90	1072.72^{c}±13.38	4009.80^{b}±281.40	5223.65^{b}±284.67
T_{10}	151.75^{ab}±3.97	1078.50^{bc}±43.34	3905.93^{b}±82.24	5136.18^{bc}±111.63
T_{11}	141.91^{bcd}±3.71	1199.56^{a}±32.87	4639.67^{a}±331.64	5981.14^{a} ±349.52
SEm	5.21	31.85	207.26	210.37
CD at 5%	14.99	91.66	596.69	604.65
CV%	7.38	5.96	10.74	8.30

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

Table 4: Wheat consumption (WC) at different stages of broilers fed different wheat diet

Treatments	WC_{2-3}			WC_{4-6}			WC_{2-6}		
	(g)	(%)*	(%)**	(g)	(%)*	(%)**	(g)	(%)*	(%)**
T_2	46.29	4.11	28.66	316.89	7.75	56.13	363.18	7.04	42.39
T_4	139.21	12.43	44.59	580.91	16.59	54.48	720.12	15.72	49.53
T_6	295.76	30.91	63.68	1102.69	30.63	66.48	1398.45	31.64	65.08
T_8	487.58	47.79	74.51	1672.72	45.16	76.93	2160.30	45.64	75.72
T_{10}	692.24	66.53	81.67	2509.86	64.26	90.93	3202.10	64.24	86.30

*Percent wheat consumption from total feed consumption

**Percent wheat consumption from total wheat offered

Feed Conversion Ratio (FCR)

The overall FCR was found to be significantly (p<0.05) different and improved in the birds fed with 40 % choice feeding of wheat among the various treatment rations. Significantly (p<0.05) better FCR was found in the birds fed with choice feeding system (particularly 40% level) as compared to mixed feeding system of wheat and control rations (Table 5). Similar results were reported by Bhagora *et al.* (2022) who reported improved FCR in the birds fed with 40 % choice feeding of wheat. Fanatico *et al.* (2016) and Gracia *et al.* (2016) proved that particle size plays role in improving the FCR in the wheat based diet. Emadinia *et al.* (2017) however reported non-significant effect on FCR of feeding whole wheat, grounded wheat, dry mash and wet mash, while Bennet *et al.* (2002) reported improved FCR with level 1 control diet (without wheat) than with various inclusion levels of wheat. Results of present study indicated that improved feed efficiency may be due to whole wheat feeding which is likely to be a reflection of improved utilisation of nutrients. The birds offered with whole wheat in a separate feeder is preferable as compared to the birds fed with mixed feeding to fulfil their body requirements. When the birds are consuming whole wheat, retention time of whole wheat in the gizzard is more, so birds are able to utilise the nutrients required for proper growth which affects the feed consumption. So, birds can be offered with whole wheat in a separate feeder for better feed efficiency.

Gizzard Weight

The results showed non-significant differences among the birds fed with various treatment rations for gizzard in terms of weight and percentage. However, birds fed with whole wheat in various treatment rations showed higher gizzard weight as compared to the birds fed with control ration (Table 6). Preston *et al.* (2000), Bennet *et al.* (2002) and

Table 5: Feed Conversion Ratio of different stages of broilers fed different wheat diet

v	FCR_{0-1}	FCR_{2-3}	FCR_{4-6}	FCR_{0-6}
T_1	$0.738^{c}\pm0.01$	$1.568^{a}\pm0.04$	$2.638^{ab}\pm0.11$	$2.180^{abc}\pm0.05$
T_2	$0.740^{c}\pm0.03$	$1.412^{cde}\pm0.07$	$2.163^{cde}\pm0.13$	$1.870^{de}\pm0.09$
T_3	$0.814^{bc}\pm0.05$	$1.520^{abcd}\pm0.04$	$2.778^{a}\pm0.31$	$2.210^{ab}\pm0.19$
T_4	$0.781^{c}\pm0.01$	$1.369^{de}\pm0.02$	$1.914^{e}\pm0.09$	$1.688^{e}\pm0.05$
T_5	$0.955^{a}\pm0.03$	$1.577^{abc}\pm0.05$	$2.531^{abcd}\pm0.12$	$2.130^{abcd}\pm0.05$
T_6	$0.791^{c}\pm0.06$	$1.474^{abcd}\pm0.02$	$2.156^{cde}\pm0.11$	$1.901^{de}\pm0.07$
T_7	$0.766^{c}\pm0.04$	$1.588^{a}\pm0.06$	$2.117^{de}\pm0.11$	$1.884^{de}\pm0.07$
T_8	$0.819^{bc}\pm0.02$	$1.425^{abcde}\pm0.06$	$2.257^{bcde}\pm0.10$	$1.923^{cde}\pm0.06$
T_9	$0.743^{c}\pm0.02$	$1.294^{e}\pm0.05$	$2.641^{ab}\pm0.14$	$2.056^{bcd}\pm0.07$
T_{10}	$0.888^{ab}\pm0.01$	$1.417^{bcde}\pm0.11$	$2.556^{abc}\pm0.13$	$2.091^{abcd}\pm0.11$
T_{11}	$0.758^{c}\pm0.02$	$1.584^{ab}\pm0.03$	$2.895^{a}\pm0.16$	$2.347^{a}\pm0.10$
SEm	0.03	0.06	0.21	0.09
CD at 5%	0.09	0.16	0.43	0.26
CV%	7.83	7.47	12.19	9.05

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

Biggs and Parsons (2009) found significantly higher gizzard weight in the birds fed with whole wheat. Ravindran *et al.* (2006) found higher gizzard weight in the birds fed with 100 and 200 g/kg of wheat in the diet. Contrary to this study, Mingbin *et al.* (2015), Gracia *et al. (*2016) and Hosseini and Afshar (2016) reported significantly higher gizzard weight in the birds fed with mash form as compared to the birds fed with pelleted form in the wheat based diet. The increase in the gizzard weight in whole wheat supplemented treatment rations in certain studies may be due to more development of muscular wall resulting from increased frequency of gizzard contractions which might have resulted in higher body weight. So, it can be concluded that feeding whole wheat in the broilers may have positive impact on the gizzard weight which promotes the improved growth.

Survivability

The highest survivability was found in the birds fed with 40 % and 100 % choice feeding of wheat as compared to the birds fed with other treatment rations (Table 7). Bhagora *et al.* (2022) found highest survivability in the birds fed with 60 % mixed feeding of wheat. Bennet *et al. (*2002) found non-significant difference in mortality among the birds fed with various levels of wheat at different stages. Engberg *et al.* (2004) found non-significant mortality percentage in the birds fed with airtight stored whole wheat supplemented with or without xylanase enzyme, conventionally stored whole wheat supplemented with or without xylanase enzyme and pelleted diet supplemented with or without xylanase enzyme.

Return over Feed Cost (ROFC)

Economics was calculated in terms of return over feed cost. The highest average ROFC was found in the birds fed with 40 % choice feeding of wheat as compared to 40 % mixed feeding of wheat, control and with all other treatment rations. Overall results showed higher ROFC in the choice feeding system of wheat than mixed feeding of wheat in 20, 40, 80 and 100 %, except 60 % of choice and mixed feeding system (Table 7). These findings are in accordance with Bhagora *et al.* (2022) who also found highest ROFC in the 40 % choice feeding system of wheat.

Conclusions

Feeding maize diet replaced with 40 % wheat and offered in separate feeder is more economical and profitable due to better body weight gain, improved feed efficiency and lower mortality in broilers as compared to control ration (without wheat), Hence, 40% maize replaced by wheat and offered in a separate feeder (choice feeding) in commercial broilers may be practiced.

Acknowledgement

We gratefully acknowledge the Dean of the Veterinary College and the Director of Research, Anand Agricultural University, Anand for funding and encouragement to take up this research work.

Table 6: Gizzard weight of broilers fed different wheat treatments

Treatments	Gizzard weight (g)	Gizzard weight (%)
T_1	40.13±0.83	1.77±0.06
T_2	43.63±2.66	1.81±0.10
T_3	45.60±3.26	1.94±0.18
T_4	43.88±1.31	1.89±0.10
T_5	41.50±1.06	1.95±0.09
T_6	41.88±1.97	1.96±0.12
T_7	44.25±1.48	1.92±0.05
T_8	46.50±1.51	1.85±0.05
T_9	42.38±1.28	1.82±0.09
T_{10}	46.88±2.54	1.89±0.11
T_{11}	41.50±2.03	1.75±0.06
SEm	1.95	0.10
CD at 5%	NS	NS
CV%	8.98	10.53

Table 7: Livability (%) and Return over Feed Cost (ROFC) of different treatments in broilers fed different wheat diet

Treatments	Livability (%)	Income from sale of birds (Rs./bird)	Feed cost (Rs./bird)	ROFC (Rs./bird)
T_1	90.63	197.21	203.12	-5.91
T_2	93.75	236.51	212.67	23.84
T_3	87.50	194.34	201.37	-7.03
T_4	96.88	234.08	194.80	39.28
T_5	87.50	198.54	197.48	1.06
T_6	84.38	201.00	182.42	18.58
T_7	87.50	209.27	182.16	27.11
T_8	93.75	212.27	191.57	20.70
T_9	93.75	212.38	201.86	10.52
T_{10}	96.88	206.65	184.36	22.29
T_{11}	93.75	213.08	229.91	-16.83

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