Research Article

Effect of Potato Meal as a Maize Substitute Feed on Growth Performance and Carcass Characteristics of Broiler Chickens

Md Tariqul Islam[1,5] *, Aditya Chowdhury Avi[1,5], Md Saiful Bari[2,5], Most Rebeka Sultana Swapna Khandoker[3], Homaira Pervin Heema[4], Goutam Buddha Das[1]

[1]Department of Animal Science and Nutrition, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; [2]Department of Dairy and Poultry Science, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; [3]Department of Microbiology and Veterinary Public Health, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; [4]Department of Pathology And Parasitology, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; [5]Directorate of Farm, Chattogram Veterinary and Animal Sciences University, Chattogram,4225, Bangladesh;

Abstract | In broiler chicken, potato meal (PM) is utilized to replace maize as a source of nutritional carbohydrates. The objective of the study was to observe the impacts of varied ranges of PM on the growth performance and carcass characteristics of broiler chickens. In a 28-day study, Investigation was carried out using 120 Ross-308 unsexed day-old chicks (DOC) of broiler chicken. Birds were selected by random selection to assign them to each of four feed trial groups: T0, T1, T2, and T3, and each of those received 0, 20, 30, and 40% PM supplementation. The result showed that no significant variations were observed in survival rate, feed conversion ratio, or carcass yield within the broiler trial groups even fed potatoes 40% replacing maize according to the findings. In diets that contain potato meals, the percentage of fat was also lower, which could be advantageous for health. It was concluded that the substitution of maize with potato meals in the diets of broilers may be up to 40% without causing any deleterious effects. It's feasible to deliberate that the findings of this study will have a practicable impact in countries that are deficient in maize production but have surplus potato production.

Keywords | Potato meal, Feed conversion ratio, Weight gain, Carcass characteristics, Dressing percentage.

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***Correspondence** | Md Tariqul Islam, Department of Animal Science and Nutrition, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; **Email:** anik.cvasu@yahoo.com
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INTRODUCTION

Commercial broiler farming is a rapidly growing and highly demanding agricultural sector in Bangladesh. Broiler chicken provides tender meat for human consumption within a short period. For the production of broiler meat diets and dietary ingredients are most important. Maize is used as the foremost carbohydrate source in the diet of nearly all livestock, especially non-ruminant animals such as poultry. Maize accounts for around 55% of feed in broiler chicken production (Mourao et al., 2008). Ninety percent of maize is imported to Bangladesh. This has had an important effect on the livestock and poultry industry. Declining maize availability and rising feed prices will directly affect the global broiler market (Ayuk, 2004) and even decrease production (Donohue and

Cunningham, 2009).

An enormous rising the value of grains, as well as the price of chicken eggs and meat production, has come to some people around the world to be unable to consume poultry meat as they cannot buy it (Aho, 2007). A substitute feed source will have to be recognized to accommodate this change (Agwunobi, 1999). And the new feed materials need to be capable of completely or partially replacing maize while having no detrimental influence on broiler efficiency. They should not smash up feed competency, carcass ratio, or create a product of equal or better quality (Ojewolaet al., 2006). Different experiments have assessed the utilization of probable substitute feedstuffs. On the other hand, a more broad feed experiment needs to be conducted to compensate for the necessary fix-up by the National Research Council (NRC).

A feasible substitute is potatoes (*Solanum tuberosum* L.) which are grown in the majority of countries and used primarily as a carbohydrate source (for example starch) in the human diet, although it has plenty of other necessary nutrients (Dominguez et al., 2010). Stored potato crops are a precious carbohydrate source. It also contains vitamins and micronutrients. Potatoes are an annual crop widely grown in Bangladesh. In years of excessive potato production, large quantities of potatoes are steamed due to inadequate storage facilities. Potatoes are now grown exclusively for food and their leaves have always been considered fodder (Dominguez et al., 2010).

Between potato and maize, the most important nutritional significance is the carbohydrate content known as starch. In 100 gm of potato containing 19.7 mg vitamin C, 425 mg potassium, 57 mg phosphorus, 23 mg magnesium, 1.061 mg vitamin B3, 12.1 mg choline where in maize the amount is 6.8 mg vitamin C, 270 mg potassium, 89 mg phosphorus, 37 mg magnesium, 1.77 mg vitamin B3, 23 mg choline. (https://foodstruct.com/compare/potato-vs-maize). Carbohydrates hold up nearly 80-90% of the dry matter of tubers. Potato meal is a crude preparation of grinded sun dried potatoes which is produced by slicing the potatoes and then after sun dried it was turned through milling hammer. It is an important alternative energy ingredient in poultry nutrition because of its high carbohydrate content and comparatively less cost than other energy sources. Thus, incorporation of the inclusion levels of potato meals instead of other energy sources in poultry diets might reduce feed costs. Potato is also esteemed as a carbohydrate source in pig ration (Naskar et al., 2008), but it is unclear to what extent they can manufacture a product of equivalent quality as currently manufactured by the poultry industry. In addition, inadequate knowledge is existing of its effect on carcass quality (Agwunobi, 1999). However, the goal of the present study is to determine the impacts of potato meals on broiler growth performance (feed intake, weight gain, feed conversion ratio (FCR), and carcass characteristics.

MATERIALS AND METHODS

Ethical approval

The Institutional Animal Ethics Committee approved the present study with regards to its experimentation and procedures applied (Approval no: Ec/2016/29-8).

Study design

A completely randomized design (CRD) was applied to assign experimental birds. A total of 120 Ross-308 unsexed day-old chicks (DOC) of broiler chicken were arbitrarily assigned to one of four feed trial groups: T0, T1, T2 , or T3, supplied with 0%, 20%, 30% , or 40% PM respectively. Every treatment group was then separated into three replicates, ten birds in each group.

Rearing of birds

All of the (Ross-308 strain) DOC were inspected for deformities and size uniformity. In the wooden box, the chicks were grouped into different treatments while brooded. The birds were moved to their separate pens after 14 days which were chosen in an unbiased manner to ensure that the chicks were distributed evenly. The experimental shed was made of bricks and was wired with corrugated iron sheet. Each bird has 0.18 square feet of floor space in the brooding pen and 0.75 square feet in the cage. Vaccination was performed among all birds against Newcastle disease (live BCRDV) and infectious bursitis on day 4, followed by a booster dose on day 14 with a multivitamin (RenaWS, Renata; 1g / 5 liters of drinking water) and vitamin C supplements to overcome the effects of vaccination stress and cold shock. Observed parameters were Feed intake, weigh gain, Feed conversion ratio and different carcass characteristics.

Composition of diets in different treatments

Potatoes of good quality and without dust were managed from the North Bengal region of Bangladesh. Then they were sliced, sun-dried , and finally pulverized by passing through a 1mm sieve by using milling. Potato meal was used at the ratios of 0%, 20%, 30% , and 40% to prepare the test mashed diet. The ratio of different feed components and nutritional values of the diets for starter as well as grower birds are shown in Table 1 and Table 2. The feed ingredients were mixed manually and provided the birds ad-libitum on a small round feeder and water dispenser for 0-7 days, from day 8 to day 14 of the medium straight feeder (2.21 ft X 0.25 ft) and circular drinkers were used. Finally, on day 15, a large straight feeder

Table 1: Ingredient and nutrient composition of the broiler starter ration (0-14 days)

Ingredients (%)	Dietary Treatments			
	T0	**T1**	**T2**	**T3**
Maize	60	40	30	20
PM	0	20	30	40
Soybean meal	33.50	34.50	34.50	34.50
Soybean Oil	3.8	2.8	2.8	2.8
DCP	1.4	1.4	1.4	1.4
Limestone	0.50	0.50	0.50	0.50
Vit-min premix	0.20	0.20	0.20	0.20
Common salt	0.20	0.20	0.20	0.20
L-Lysine5	0.08	0.08	0.08	0.08
DL-Methionine	0.22	0.22	0.22	0.22
NaHCO3	0.10	0.10	0.10	0.10
Total	100	100	100	100
Met. energy	3100.5	3098.4	3096.7	3095.6
Crude protein	20.05	19.97	19.87	19.85
Crude fiber	2.87	3.45	3.74	4.03
Calcium	1.18	1.20	1.22	1.25
Phosphorus	0.76	0.76	0.74	0.73
Lysine	1.13	1.12	1.11	1.11
Methionine	0.54	0.54	0.53	0.52
Cysteine	0.37	0.37	0.36	0.35

T_0=Diet without PM; T_1=Diet containing 20% PM; T_2=Diet containing 30% PM; T_3=Diet containing 40% PM;Vitamin-mineral premix (Per kg vitamin mineral premix provided-Vitamin A 5000 IU, D_3 1000 IU, K 1.6 mg, B_1 1 mg, B_2 2 mg, B_3 16 mg, B_6 1.6 mg, B_9 320 µg, B_{12} 4.8 µg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg); DCP (18% P, 23% Ca); DL-Methionine (Purity 99.0%); L-Lysine (Purity 99.0%); Metabolizable energy (kcal/kg).

Table 2: Ingredient and nutrient composition of the broiler finisher ration (15-28 days)

Ingredients (%)	Dietary Treatments			
	T0	**T1**	**T2**	**T3**
Maize	65	45	35	25
PM	0	20	30	40
Soybean meal	30.5	31.5	31.5	31.5
Soybean Oil	2.8	1.8	1.8	1.8
DCP	0.50	0.50	0.50	0.50
Limestone	0.50	0.50	0.50	0.50
Vit-min premix	0.20	0.20	0.20	0.20
Common salt	0.20	0.20	0.20	0.20
L-Lysine	0.07	0.07	0.07	0.07
DL-Methionine	0.18	0.18	0.18	0.18
NaHCO3	0.05	0.05	0.05	0.05
Total	100	100	100	100
Met. energy	3108.5	3098.4	3094.7	3091.6
Crude protein	19.15	18.98	18.87	18.79
Crude fiber	2.83	3.41	3.70	3.99
Calcium	1.18	1.19	1.19	1.20

Phosphorus	0.75	0.75	0.73	0.72
Lysine	1.01	1.01	1.00	1.00
Methionine	0.42	0.42	0.41	0.41
Cysteine	0.30	0.30	0.30	0.30

T_0=Diet without PM; T_1=Diet containing 20% PM; T_2=Diet containing 30% PM; T_3=Diet containing 40% PM;Vitamin-mineral premix (Per kg vitamin mineral premix Provided-Vitamin A 5000 IU, D_3 1000 IU, K 1.6 mg, B_1 1 mg, B_2 2 mg, B_3 16 mg, B_6 1.6 mg, B_9 320 µg, B_{12} 4.8 µg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg); DCP (18% P, 23% Ca); DL-Methionine (Purity 99.0%); L-Lysine (Purity 99.0%); Metabolizable energy (kcal/kg)

Table 3: Live weight (g/bird), weight gain (g/bird/d), feed intake (g/bird/d) and FCR of the experimental broiler birds fed diets supplemented with different levels of PM from 1st to 4th weeks of age

Variable	Age	Dietary Treatments				SEM	P value
		T0	T1	T2	T3		
Live weight	1st wk	187.9	176.6	172.3	218.7	1.25	0.27
	2nd wk	402.4	377.4	363.3	386.2	4.73	0.07
	3rd wk	768.5	685.1	669.6	698.2	11.64	0.02
	4th wk	1265.3	1051.5	1032.2	1124.1	24.52	0.004
Weight gain	1st wk	21.1	19.2	18.6	19.6	0.32	0.33
	2nd wk	30.6	28.7	27.2	29.5	0.45	0.33
	3rd wk	52.3	43.9	43.7	44.6	1.11	0.03
	4th wk	70.8	52.2	51.8	60.8	2.22	0.07
Feed intake	1st wk	31.7	32.6	33.9	34.2	0.39	0.42
	2nd wk	58.7	63.6	65.8	69.8	1.40	0.35
	3rd wk	92.5	94.6	95.9	98.6	0.57	0.09
	4th wk	114.3	119.2	120.5	121.1	1.26	0.07

T_0=Diet without PM; T_1=Diet containing 20% PM; T_2=Diet containing 30% PM; T_3=Diet containing 40% PM; SEM=Standard error of mean; NS=non-significant (p<0.05); **=Significant (p<0.01); ***=Significant (p<0.001)

(3.5 feet X 0.38 feet) and a circular drinker (3 liters capacity) were provided to feed and water the birds.

Carcass evaluation

In 4th week of the study period, four birds from each group were selected randomly and had their jugular vein and carotid artery removed. Then scalding, de-feathering, and evisceration were done as per the technique described by Jones (1984). During butchery belly fat, lungs, liver, kidneys, spleen, gizzards, and proventriculus were dissected separately for carcass weight by weighing the dressed bird. The values of different parameters were expressed as percentage (Moses, 2022).

Statistical analysis

Raw data regarding weight gain, feed intake, Feed Conversion Ratio (FCR) and carcass characteristics were checked for normality using a normal probability plot and using Stata (2017) to analyze for ANOVA after being compiled in Excel. For F-tests, at $p < 0.05$ statistical significance was accepted.

RESULTS

To inspect the impacts of various levels of potato meal (PM) on the growth performance and quality of meat of Ross-308 chicken (broiler), the experiment was performed. The results obtained from the present study have been presented in this chapter. Table 3 shows live weight, weight gain, feed intake and FCR of the experimental broiler birds fed diets supplemented with different levels of PM from 1st to 4th weeks of age.

There presents a notable significant difference ($p< 0.05$) in achieving weekly average live weight among the trial groups, especially at the 3rd and 4th week of age. In the control group, A higher bird's body weight was noted and after an increment of PM in the feed ration, the bird's live weight was reduced clearly. The highest (1265.3 g/bird) and lowest (1032.2 g/bird) average live weights were recorded in T_0 and T_3 groups, respectively in the 4th week. Maximum (70.9 g/d) and minimum (51.8 g/d) average weight gains were recorded in T_0 and T_2 groups, respectively in the 4th week. The mean weekly consumption was insignificantly different ($p>0.05$) among the different feed trial groups (Table 3), The highest (121.1 g/bird/d) and the

Table 4: Feed Conversion Ratio

Variable	Age	Dietary Treatments					
		Mean ± S					
		T0	T1	T2	T3	SEM	P value
FCR	1st wk	1.50	1.69	1.82	1.74	0.03	0.25
	2nd wk	1.91	2.21	2.41	2.36	0.05	0.26
	3rd wk	1.76	2.16	2.16	2.21	0.06	0.12
	4th wk	1.60	2.28	2.32	1.98	0.08	0.20

FCR did not differ (p>0.05) within experimental birds at weekly observation with irrespective of the levels of PM supplementations (**Table 4**). The best (1.64) and worst (2.14) FCR was recorded in the T_0 and T_2 groups, respectively at 4th week.

Table 5: Live weight (g/bird), weight gain (g/bird), feed intake (g/bird), FCR, survivability and carcass characteristics of the experimental broiler birds fed diets supplemented with different levels of PM at the end of 4th weeks of age

Parameter	Potato content (%)				Level of Significance
	0	20	30	40	
Live weight (g/broiler)	1265.3^a	1051.5^c	1032.2^d	1124.1^b	**
Weight gain (g/broiler)	1224.8^a	1009.8^c	990.3^d	1081.9^b	**
Feed intake (g/broiler)	2080.40^d	2170.00^c	2212.70^b	2265.91^a	**
FCR	1.69^d	2.14^b	2.23^a	2.09^c	**
Survivability (%)	100	100	100	100	NS
Body weight (g/broiler) of slaughtered bird	1285.5±64.1	1047.6±18.34	1033.3±34.25	1149.5±67.36	0.22
Thigh weight	10.25± .13	8.95 ± .19	9.76 ± .15	9.32 ± .07	0.17
Drumstick weight	8.48 ± .34	8.09 ±.35	8.37 ± .78	8.73 ± .69	0.63
Wing weight	7.95 ± .79	7.71 ± 1.05	7.82 ± .51	8.06 ± .66	0.91
Breast weight	9.42 ± .56	9.01 ± .18	9.61 ± .40	8.98 ± .16	0.32
Abdominal fat	.86 ± .06	.19 ± .02	.22 ± .03	.19 ± .05	0.08
Dressing %	60.2 ± 3.55	55.08 ± 2.88	63.67 ± 6.57	58.14± 3.15	0.39

[a, b,c,d]Means within a row with different superscripts are significantly different (*P* < 0.01)
NS non-significant, *g* gram
** P < 0.01, significant at 1% level

lowest (114.3 g/bird/d) average feed intakes were recorded in T_3 and T_0 groups, respectively in the 4th week. The mean weekly FCR was insignificantly different (p>0.05).

There is no noticeable impact of the feed experiment on the carcass percentage and carcass cuts, such as , thighs, drumsticks, wings,breast etc. (p>0.05), which is demonstrated in Table 5. In the case of body weight the highest (1285.5±64.1) and lowest (1033.3±34.25) were recorded in T_0 and T_2 groups, respectively whereas for thigh weight the highest (10.25±.13) and lowest (8.95 ± .19) was recorded in T_0 and T_1 groups, respectively after the slaughter at 4th week. Again, for drumstick the highest (8.73±0.69) and lowest (8.09 ±0.35), and wing weight highest (8.06 ± .66) and lowest (7.71 ± 1.05) were recorded in T_3 and T_1 groups, respectively after slaughter in the 4th week. For breast weight the highest (9.61±0.40) and lowest (8.98 ±0.16) were recorded in T_2 and T_3 groups, respectively whereas for dressing -percentage, the highest (63.67 ± 6.57) and lowest (55.08 ± 2.88) were recorded in T_2 and T_1 groups, respectively after the slaughter at 4th week (Table 5). Treatments diet was observed insignificantly affected (p>0.05) abdominal fat. The highest (0.86±0.06) and the lowest (0.19) were recorded in T_0 and both T_1 and T_3 groups, respectively after the slaughter in the 4th week.

DISCUSSION

Several results recommended that the PM inclusion in broiler chicken diets leads to poorer nutrient utilization compared with corn-based diets (Maphosa et al., 2003), which leads to the lessened gaining of live weight in broilers. This may be accountable for the increase in live weight inversely proportional to sweet potato meal intake (Agwunobiet al., 1999).To find out the decreasing causes in live weight due to the use of PM needs further study.

In the present study, feed consumption was grossly increased with the potato meal percentage, although statistically there were no significant differences between the feed intake of different treatment groups. The lessening in live weight and increased PM-based feed ingestion is parallel to the consequence of Maphosa et al. (2003). The results of the feed intake of birds in this study also have similarities with Sultana et al. (2016).

The supplemented potato mead had no effect on the feed conversion ratio of broiler chickens. Since animals generally are noticed to eat first to meet their carbohydrate demands (NRC, 1998), birds expand feed ingestion as the carbohydrate ratio of their diet decreases. The fowls in the current experiment were unable to boost their feed consumption to meet energy requirements. According to Banser et al. (2000), depressed feed consumption can be a result of palatability issues related to the characteristics of the particles which tend to be sandy and poorly edible. In contrast, some other studies, with 25% potatoes for starter chickens (Mozafari et al., 2013), 50% sweet potatoes for starters (Ayuk et al., 2009), 36 and 45% sweet potatoes for starters and broiler chickens, respectively (Agwunobi et al., 1999), reported that dietary potatoes or sweet potatoes are affectless on live weight gain, feed intake and feed conversion index. This study also showed that dietary experiment had no noticeable impact on the percentage of dressing and weight of other carcass cuts, such as thighs, drums, wings, and abdominal fat of the carcass. These reports agreed with the results of the literature reported (Mozafariv et al., 2013) on diets based on up to 35% dried cooked potato flour. An important point is that the percentage of abdominal fat decreased with increasing the amount of potato flour. Since the fat content of the other limbs of poultry is associated with the belly fat component, it might be said that the other extremity fat content of the meat is also lower than that of the group control. It is already stated that the high fiber portion plays an important lead in this. Two-fold significance of the present outcome is observed. First, the diminished weight of the birds may be due to the lower fat content. Second, the decreased meat fat content is certainly more valuable in raising the market price, as the high animal fat content causes high cholesterol in the blood and induces atherosclerosis as well as heart failure.

CONCLUSION

The study investigated the effects of potato meal supplementation on broiler performance parameters, and carcass characteristics under intensive rearing system.According to the findings, there were no significant changes in meat production or quality between the treatment groups of broilers who had up to 40% of their maize replaced with potato. These findings suggested that potato meal could be safely substituted for maize meal in broiler diets up to 40% without affecting output performance. Importantly, broilers fed potato food had a low-fat level. As a result, this might have a significant impact on the future development of low-fat poultry meat.

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CONFLICT OF INTEREST

There was not present any conflict of interest among the author during the study period.

NOVELTY STATEMENT

Formulation of least cost broiler ration is a challenge in recent times. Maize is the major ingredients in broiler ration. Replacing maize with surplus potato as potato meal might contribute to reduce feed cost with good production performance of broilers. To the best of the authors knowledge a few research has been done on replacing 40 % maize with potato meal, although some study conducted replacing 30 % maize with potato meal. Thus, replacing 40% maize with potato meal is a novel study.

AUTHORS CONTRIBUTION

All authors contributed significantly to the manuscript. Md Tariqul Islam and Aditya Chowdhury Avi designed the experiment, collected data. Md Saiful Bari analysed the Data. Most Rebeka Sultana Swapna Khandoker and Homayra Pervin Heema helps in data processing and revising the manuscript.

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