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Scrutinization of Dried Bakery Waste as Maize Substitute in Quail Ration by Evaluating the Growth and Nutrient Utilization

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ABSTRACT

Background: The present study evaluated the bread bakery waste (BaW) containing ration on growth and nutrient utilization of meat quail.

Methods: Three hundred straight run, day old quail chicks of same hatch were randomly divided into five treatment groups, namely T_0 (maize-soya based basal ration, containing no BaW), T_1 (5% maize in quail ration was replaced with BaW), T_2 (containing 10% BaW as maize replacement), T_3 (15% BaW as maize replacement) and T_4 (20% BaW as maize substitute). All the diets formulated were isocaloric and isonitrogenous. Experimental trial lasts for 42 days. Different growth traits *viz*., feed intake (FI), body weight (BW), body weight gain (BWG), feed conversion ratio (FCR) and protein efficiency ratio (PER) was measured weekly. A metabolism trial of 4 days was carried out after 28 days of feeding trial and economics was also calculated.

Result: Results revealed no adverse effect of replacing maize flakes with BaW up to 20% on different growth traits *viz*. weekly FI, BW, BWG, FCR and PER. The metabolizability of nutrients also remained statistically similar irrespective of different dietary treatments. But, Cost benefit ratio was better in T_0 and T_1 followed by T_2 and T_3 and was least in T_4. It may be concluded that maize flakes can be safely replaced by BaW up to 15% in quail ration in an economical manner.

Key words: Bakery waste, Growth, Maize replacement, Quail.

INTRODUCTION

Quail (*Coturnix coturnix japonica*) is the latest domesticated poultry species, which is originating from the wild Japanese quail (Lukanov *et al*., 2021). It is called “Bater” in the local dialect. It is a hardy/robust bird, *i.e*., disease resistant and requires no vaccination/medication in comparison to rest of the poultry species (ICAR, 2013). It is a commercially feasible choice, with a shorter life span/generation interval (3-4 generations/year) and quick/earlier returns. Its marketable age is approximately 5-6 weeks, has low volume/ weight and attains early maturity (Khan *et al*., 2022). Quail requires less feed (20-25 g per day), besides its floor space requirement (0.20 ft^2/adult quail) is also nominal (Sakamoto *et al*., 2018). Its meat is more flavourful and fetches more price than chicken meat. Now a days, its meat is considered as delicacy, contains less fat/cholesterol (Qi *et al*., 2018) and has superior protein of high biological value (Agina *et al*., 2017). Quail use as human food is documented in different religious scriptures and is mentioned in Holy Quran (1500 years ago), the Bible (Exodus 16:13; Deuteronomy 6:12), the Torah (Holy book of Jews) and even in Egyptian murals and Roman writings (Hasan, 2014).

Feeding is the most significant aspect of quail production. Its diet is primarily maize-soya based and almost 60-70% of the bird requirement is for cereals (energy source), particularly maize, which not only enhances competition between humans and poultry species, but also escalates cereal grain rates (NRC, 2011). Thus, there is a dire need to look for alternative energy sources to decrease the feed cost. Numerous research trials have used non-conventional feedstuffs, proving them to be viable substitutes for maize in poultry diets (Shittu *et al*., 2016; Edache *et al*., 2017; Epao *et al*., 2017).

Among different unconventional feeds, BaW is rich in non-fibrous carbohydrates and is considered under energy source (Al-Tulaihan *et al*., 2004; Al-Ruqaie *et al*., 2011). Its protein and amino acid profile is comparable to maize (10.80% CP, 0.27% lysine and 0.10% tryptophan), although the fat % is higher (11.00% for bakery waste *vs*. 4.08% for maize; Tiwari and Dhakal, 2020). As wheat flour is the basic ingredient in all bakery items, bakery meal is usually rich in starch, which is highly digestible. Also, its nutritional value is high as the product is prepared by thermal treatment. BaW comprises of unsold and outdated bakery products,

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stale dough and other items which can be dried/dehydrated. These dried products can, in turn, be used as animal feed/ maize substitutes, thus besides reducing wastage and assuaging environmental concerns, they can also reduce the dependency on cereal grains, particularly maize (Epao *et al*., 2017; Penkov and Chobanova, 2020). The dried bakery products were available at throw-away prices throughout the country as leftover of bakery products were not used for human consumption Ayanrinde *et al*. (2014) and are comparatively more economical than maize (Troung *et al*., 2019).

Earlier researchers recommended that bread bakery waste/bakery waste can be utilized in poultry diets without compromising growth, feed intake, or feed efficiency Catala-Gregori *et al*. (2009); Olafadehan *et al*. (2010); Edache *et al*. (2017) and may replace maize at various levels (Al-Ruqaie *et al*., 2011; Shittu *et al*., 2016; Edache *et al*., 2017). But, there is a paucity of information in evaluating the nutritional composition of BaW of the Jammu region. Moreover, its usage in the quail ration as a maize substitute is also scanty to the best of our knowledge. Thus, the present study was carried out to study the effect of BaW-containing ration on performance, nutrient utilization and cost economics in meat quail.

MATERIALS AND METHODS

The present experiment was carried out on three hundred-day-old quail chicks (purchased from Cheema Farms, commercial hatchery, Jammu, J&K) for 42 days at the Faculty of Veterinary Sciences and Animal Husbandry, SKUAST-Jammu, R.S. Pura. These chicks were divided randomly into five dietary treatment groups and there were four replicates of 15 quail chicks in each treatment group (n=60 quail birds per group). The ingredient composition of the quail starter (0-21 days) and quail finisher (22-42 days) diet was prepared as per the standards of ICAR (2013) and is presented in Table 1. The proximate ingredient composition is depicted in Table 2. Birds of the control group (T_0) were offered a mash diet made up of maize and soybean as principal ingredients, whereas in T_1, T_2, T_3 and T_4 groups, maize was swapped with bakery waste @ 5%, 10%, 15% and 20%, respectively. An adequate quantity of fresh/clean drinking water was provided to the birds during the experimental trial.

Source of BaW

BaW was collected from the Bonn bread factory, positioned at Paloura in the Jammu region of J&K Union Territory. The collected lot was cleaned and dried in the sun, followed by grinding before incorporating it into the quail diet.

Different parameters measured during the trial

Feed intake, weight gain and water intake were recorded at weekly intervals. Also, the feed conversion ratio (FCR) and protein efficiency ratio (PER) were calculated weekly. After four weeks of the experimental trial, a metabolism trial of four successive days was also conducted in cages. Two birds per replicate, *i.e*., eight birds from each treatment unit, were used for this trial. Samples of feed offered, residual feed and faecal dropping of four successive days after oven drying was thoroughly mixed, powdered and estimated for proximate analysis as per AOAC (2012). Apparent digestibilities of nutrients in all experimental groups were noticed by adopting the above-mentioned method. Cost economics was also calculated for the said trial.

Table 1: Ingredient composition (%) of experimental diets (quail starter and quail finisher).

Ingredients	Starter phase (0-21 days)					Finisher phase (22-42 days)				
	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4
Maize (Flaked)	52.80	50.16	47.52	44.88	42.24	64.08	60.88	57.67	54.47	51.26
Bakery waste (Bread waste)	0.00	2.64	5.28	7.92	10.56	0.00	3.20	6.41	9.61	12.82
Meat bone meal	5.00	5.00	5.00	5.00	5.00	4.90	4.90	4.90	4.90	4.90
Soybean meal	39.80	39.80	39.80	39.80	39.80	29.76	29.76	29.76	29.76	29.76
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sodium bicarbonate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Soyabean oil	1.45	1.45	1.45	1.45	1.45	0.28	0.28	0.28	0.28	0.28
DL- Methionine	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16
L- Lysine hydrochloride	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15
Dicalcium phosphate	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Limestone powder	0.18	0.18	0.18	0.18	0.18	0.26	0.26	0.26	0.26	0.26
Vitamin supplement*	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Trace mineral mixture#	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

*Each kg of vitamin premix contains Vitamin A- 50.00 mIU, Vitamin D_3-14.00 mIU, Vitamin E- 20.00 gm, Vitamin K_3- 8.00 gm, Vitamin B_1- 3.20 gm, Vitamin B_2- 32.00 gm, Vitamin B_{12}- 0.024 gm, Calcium D Pantothenate- 16.00 gm, Niacin- 28.00 gm, Vitamin B_6- 3.60 gm, Folic acid- 5.60 gm and Biotin- 0.20 gm.

#Each kg of the mineral mixture contains Copper- 15 g, Iodine- 2 g, Iron- 90 g, Manganese- 100 g, Selenium- 0.3 g and Zinc- 80 g

T_0, T_1, T_2, T_3 and T_4 groups- maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Statistical analysis

The statistical analysis and interpretation of data was done through SPSS software package Ver 16.0. The data generated during the experiment was analyzed by using one way analysis of variance (ANOVA) as per the method described by Snedecor and Cochran (2004). The mean of different treatments was subjected to Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

The results of the current trial revealed no effect of maize replacement with BaW on weekly FI and showed no substantial difference throughout the experimental trial (Table 3). These results showed similarity with the findings of previous researchers who substituted maize flakes with different inclusion levels of BaW either in quails Edache *et al*., (2017); Lukanov *et al*., (2021) or in other poultry birds (Epao *et al.*, 2017; Al- Sagan *et al*., 2021). But opposite to our results, some authors reported an increase Madiya *et al*. (2005); Shittu *et al*. (2016) while others reported a decrease (Oke, 2013) in weekly FI after inclusion of BaW at different levels. However, while substituting maize flakes with BaW, some researchers reported inconsistent FI patterns (Ayanrinde *et al.*, 2014; Chauhan, 2021). The differences observed in the present trial may be attributed to the different species of poultry as well as different sources, types, compositions and treatments of BaW used. These mentioned reasons might be responsible for the variation found between our study and the above-cited trials.

The weekly BW, as well as BWG, did not show any inclement effect of BaW inclusion at different levels as maize replacers (Table 4 and 5). As reported in our study, non-significant findings have been reported earlier also by many authors (Epao *et al.*, 2017; Al-Sagan *et al*., 2021; Chauhan, 2021). However, significant differences in BW and BWG were observed by some researchers on using BaW as a maize replacer at varying levels (Oke, 2013; Shittu *et al*., 2016).

Likewise, weekly average FCR (realized by dividing FI with BWG) and PER (calculated by dividing PI with BWG) were not affected significantly, irrespective of different levels of BaW used as maize substitute (Tables 6 and 7). But periodically, there is an increase in FCR from week 5

Table 2: Proximate composition of feed ingredients (on % DMB).

Ingredients	CP	TA	OM	EE	CF	NFE
Maize	9.18±0.26	1.47±0.15	98.05±0.31	4.08±0.17	2.14±0.17	82.53±4.37
Meat bone meal	47.62±0.45	20.71±0.33	77.67±1.16	7.52±1.28	8.91±0.64	14.60±0.32
Soybean meal	46.21±1.12	7.53±1.56	90.23±0.24	5.29±0.35	7.22±1.45	33.24±0.28
Bakery waste	11.90±0.66	1.98±0.55	98.03±0.54	12.94±1.92	2.79±0.67	70.40±2.48

CP- Crude protein; TA- Total ash; OM- Organic matter; EE- Ether extract; CF- Crude fibre; NFE- Nitrogen free extract.

Table 3: Effect of inclusion of bakery waste on feed intake (g) of meat quail.

Particulars	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Week 1	25.52±2.05	27.68±1.05	27.95±1.29	28.41±1.24	28.76±1.34	0.63	0.554
Week 2	62.96±3.75	64.05±3.60	63.19±4.80	65.27±2.59	66.14±4.18	1.56	0.971
Week 3	109.43±5.84	112.42±4.21	113.31±5.57	112.60±5.79	110.34±4.56	2.11	0.981
Week 4	132.45±7.28	134.36±6.49	135.47±5.72	137.12±6.58	139.09±6.11	2.62	0.957
Week 5	154.31±9.03	158.18±8.64	155.76±8.14	157.03±8.02	156.76±8.30	3.36	0.998
Week 6	181.00±12.45	185.98±10.76	187.70±10.46	180.10±11.06	183.96±11.07	4.49	0.986

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 4: Effect of inclusion of bakery waste on body weight (g) of meat quail.

Particulars	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Day 0	6.95±0.17	6.80±0.15	7.03±0.11	6.98±0.14	7.00±0.13	0.06	0.809
Week 1	25.03±0.82	24.45±0.91	24.33±1.01	23.71±0.94	23.93±0.63	0.36	0.844
Week 2	51.57±1.86	49.81±1.59	50.18±1.18	48.99±1.32	48.88±1.09	0.61	0.686
Week 3	95.63±3.66	94.11±3.91	94.79±3.87	93.81±3.35	91.99±3.53	1.48	0.966
Week 4	135.88±5.59	137.43±5.96	133.72±4.02	131.39±6.71	126.64±5.82	2.42	0.701
Week 5	166.22±7.60	170.93±7.08	163.60±6.62	160.41±7.11	154.58±7.26	3.11	0.579
Week 6	189.42±7.92	190.74±7.23	184.71±6.53	180.21±8.38	172.41±8.05	3.40	0.462

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

onwards; suggesting that raising meat quail birds after five weeks of age is uneconomical. Our results corroborates with the findings of different prior researchers who too reported similar findings in their respective studies (Edache *et al*., 2017; Epao *et al*., 2017; Al-Sagan *et al*., 2021; Lukanov *et al*., 2021). However, some authors reported results contradictory to that of the present study (Oke, 2013; Ayanrinde *et al.,* 2014; Chauhan, 2021). The disparity of results in this study may be credited to the different BaW (source/type/ composition) used.

The effect of the replacement of maize with BaW (up to 20% level) on nutrient intake and metabolizability is shown in Table 8 and Table 9, respectively. The FI, dry matter intake (DMI) as well as intake of different nutrients remained unaffected during the metabolism trial. Also, metabolizability of different nutrients *viz*. DM, OM, CP, EE, CF and NFE (%) estimated during this trial was not influenced. It may be inferred that BaW inclusion had no impact on digestive enzymes as well as intestinal integrity, which might be responsible for similar metabolizabilities of different nutrients. The results of the present study match with the findings of Shittu *et al.* (2016) who reported that biscuit dough (BD) inclusion in the broiler diet up to 15% level had no significant effect on the digestibilities of CP, CF, EE and TA except DM and NFE digestibilities. Likewise, Al- Ruqaie *et al*. (2011) reported similar apparent nitrogen retention (%) and nitrogen-corrected metabolizable energy (kcal/kg) on replacing maize with BaW up to 100% levels in broiler ration. The feeding of isocaloric and isonitrogenous diets resulted in similar BWG and FI. Also, the intake of quail birds was far less than that of other poultry birds, which might have resulted in a comparable intake of nutrients and their digestibility.

The cost economics evaluated on substituting maize flakes with varied levels of BaW meal in quail ration is summarized in Table 10. There is a decrease in per kg cost of both starter and finisher feed with the linear increase in BaW meal inclusion in quail ration. But as the FI was higher

Table 5: Effect of inclusion of bakery waste on body weight gain (g) of meat quail.

Particulars	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Week 1	18.08±0.66	17.65±0.83	17.30±0.90	18.56±2.31	16.93±0.51	0.50	0.892
Week 2	26.54±1.05	25.36±1.18	25.85±0.31	25.28±0.43	24.95±0.49	0.33	0.651
Week 3	44.06±1.81	44.30±2.35	44.61±2.71	44.82±2.12	43.11±2.46	0.93	0.986
Week 4	40.25±2.20	43.32±3.22	38.93±1.85	37.58±3.49	34.65±2.33	1.26	0.275
Week 5	30.35±2.21	33.51±1.58	29.88±2.70	29.02±1.86	27.94±1.83	0.93	0.428
Week 6	23.20±2.23	19.81±2.45	21.11±0.39	19.80±1.37	17.83±2.72	0.90	0.458

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 6: Effect of inclusion of bakery waste on weekly feed conversion ratio (FCR) of meat quail.

Particulars	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Week 1	1.42±0.13	1.58±0.11	1.62±0.04	1.59±0.16	1.71±0.11	0.05	0.548
Week 2	2.39±0.19	2.55±0.21	2.44±0.18	2.59±0.15	2.65±0.16	0.07	0.835
Week 3	2.48±0.07	2.55±0.09	2.57±0.19	2.54±0.20	2.59±0.23	0.07	0.993
Week 4	3.35±0.37	3.15±0.26	3.48±0.06	3.75±0.39	4.06±0.28	0.14	0.268
Week 5	5.23±0.68	4.76±0.37	5.28±0.24	5.53±0.63	5.72±0.59	0.22	0.760
Week 6	8.20±1.39	9.78±1.10	8.89±0.46	9.12±0.31	10.84±1.13	0.44	0.414

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 7: Effect of inclusion of bakery waste on weekly protein efficiency ratio (PER) of meat quail.

Particulars	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Week 1	2.89±0.25	2.56±0.17	2.47±0.06	2.60±0.28	2.37±0.17	0.09	0.471
Week 2	1.70±0.14	1.60±0.12	1.66±0.12	1.56±0.09	1.52±0.10	0.05	0.803
Week 3	1.61±0.04	1.57±0.06	1.58±0.12	1.61±0.11	1.57±0.13	0.04	0.997
Week 4	1.44±0.14	1.51±0.12	1.34±0.03	1.28±0.13	1.16±0.08	0.05	0.249
Week 5	0.93±0.11	1.00±0.08	0.89±0.04	0.87±0.09	0.84±0.09	0.04	0.753
Week 6	0.62±0.10	0.49±0.05	0.53±0.03	0.51±0.02	0.44±0.04	0.03	0.303

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 8: Effect of inclusion of bakery waste on body weight (g) and nutrient intake (g) during metabolism trial of meat quail.

Attributes	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
Initial body weight	141.18±3.51	142.55±3.51	140.58±3.78	139.74±4.81	130.65±3.53	1.77	0.220
Final body weight	163.72±4.85	167.64±3.51	161.39±3.58	160.30±3.54	152.75±3.59	1.81	0.112
Average body weight	152.45±4.11	155.10±3.43	150.98±3.67	150.02±4.16	141.70±3.47	1.76	0.154
Nutrient intake							
Feed	145.25±4.23	150.75±4.61	146.00±4.49	148.75±2.78	147.00±5.69	1.83	0.907
DM	135.08±3.93	140.20±4.28	135.78±4.18	138.34±2.59	136.71±5.29	1.70	0.907
CP	29.06±0.85	30.23±0.92	29.32±0.90	29.91±0.56	29.64±1.15	0.37	0.894
EE	7.63±0.22	7.81±0.24	7.50±0.23	7.58±0.14	7.34±0.28	0.10	0.685
CF	6.40±0.19	6.56±0.20	6.25±0.19	6.31±0.12	6.06±0.23	0.08	0.454
TA	6.73±0.19	6.94±0.21	6.57±0.20	6.59±0.12	6.45±0.25	0.09	0.511
OM	128.36±3.74	133.26±4.07	129.21±3.98	131.75±2.46	130.26±5.04	1.62	0.906
NFE	85.27±2.48	88.66±2.71	86.15±2.65	87.96±1.64	87.22±3.37	1.08	0.894

DM- Dry matter, CP- Crude protein, EE- Ether extract, CF- Crude fibre, TA- Total ash, OM- Organic matter, NFE- Nitrogen free extract, T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 9: Effect of inclusion of bakery waste on digestibility (%) of nutrients in meat quail.

Attributes	Groups					SEM	P value
	T_0	T_1	T_2	T_3	T_4		
DM	71.80±1.35	72.27±1.18	69.38±1.79	69.75±1.16	70.65±1.12	0.59	0.502
CP	71.11±1.58	73.01±2.04	68.76±3.11	70.00±0.61	71.10±1.10	0.82	0.612
EE	74.63±2.07	75.60±1.74	75.37±1.72	75.30±1.56	75.86±1.80	0.72	0.991
CF	48.84±1.30	49.49±2.88	50.75±1.53	50.91±2.80	51.11±2.98	0.98	0.950
TA	40.10±2.63	40.35±3.12	40.05±0.66	41.86±1.59	40.16±2.72	0.94	0.978
OM	72.05±1.30	72.45±1.23	70.59±1.88	70.80±1.12	71.86±1.09	0.56	0.834
NFE	72.62±1.10	72.61±1.50	71.95±1.55	71.69±1.28	72.10±1.71	0.58	0.987

DM- Dry matter, CP- Crude protein, EE- Ether extract, CF- Crude fibre, TA- Total ash, OM- Organic matter, NFE- Nitrogen free extract, T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

Table 10: Effect of bakery waste feeding on cost economics in meat quail.

Attributes	Groups				
	T_0	T_1	T_2	T_3	T_4
No. of quail chicks	60	60	60	60	60
Cost of quail chicks @Rs. 18/chick	1080	1080	1080	1080	1080
Cost of litter (Rs.)	150	150	150	150	150
Cost of starter feed/kg (Rs.)	48.47	48.21	47.95	47.68	47.42
Total cost of starter feed (Rs.)	576	591	588	590	584
Cost of finisher feed/kg (Rs.)	41.72	41.40	41.08	40.76	40.44
Total cost of finisher feed (Rs.)	1171	1189	1181	1160	1164
The total cost of feed (Rs.)	1747	1780	1769	1750	1748
Mortality (in no.)	2	2	2	1	3
Mortality (%)	3.33	3.33	3.33	1.67	5.00
Total live quail birds (in no.)	58	58	58	59	57
Total input cost (Rs.)	2977	3010	2999	2980	2978
Final body weight of treatment groups (kg)	10.99	11.06	10.71	10.63	9.83
Income from quail birds (@Rs. 600/kg live bird)	6591.84	6637.74	6427.92	6379.44	5896.44
The total difference over control (Rs.)	0.00	45.90	-163.92	-212.40	-695.40
The difference over control/bird (Rs.)	0.00	0.79	-2.83	-3.60	-12.20
Cost-benefit ratio	1.21	1.21	1.14	1.14	0.98

T_0, T_1, T_2, T_3 and T_4 groups- Maize was replaced with bakery waste @ 0, 5, 10, 15 and 20% BaW, respectively.

in BaW meal-fed treatment groups, it resulted in the comparable cost of starter feed, finisher feed as well as the total cost of feed. Noticeable reduction in the cost of total feed in broiler birds on increasing the levels of BaW inclusion as maize replacer was reported earlier by some researchers (Al-Ruqaie *et al*., 2011; Al-Sagan *et al*., 2021). Similar to our study, some authors reported a non-significant difference in the feed cost reduction per bird while using BaW as a maize replacer (Oke, 2013; Epao *et al*., 2017; Chauhan, 2021). The total input cost after including chick, litter and feed costs was Rs. 3010 and 2999 in T_1 and T_2, whereas in T_0, T_3 and T_4, it was Rs. 2977, 2980 and 2978, respectively. The cost-benefit ratio was found to be similar and/or highest in T_0 and T_1 followed by equivalent values of T_2 and T_3, but it was found lowest in T_4. Chauhan, (2021) also reported a similar cost-benefit ratio in broiler birds on adding BrW meal as a maize substitute. The comparable values of the B:C ratio of different treatment groups depict that it is safe to replace maize flakes by up to 15% BaW in quail ration without any negative impact on economics.

CONCLUSION

The replacement of maize flakes with BaW in quail ration may be made maximum up to 15% level in an economical manner without affecting feed intake, body weight, FCR, PER and nutrient digestibility. At 20% inclusion of BaW as maize replacer in quail ration, cost benefit ratio is adversely affected and leads to economic loss. Thus, BaW inclusion (up to 15% of maize flakes) may act as suitable unconventional substitute and reduce the dependency on maize grains.

Conflict of interest: None.

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