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Evaluation of Carcass Traits, Intestinal Micrometry and Sensory Quality of Broiler Chicken Fed Bakery Biscuit Waste as Maize Substitute

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ABSTRACT

The aim of this study was to envisage the effect of bakery biscuit waste (BBW) feeding on anatomical traits and sensory quality of broiler chicken. Day-old straight run broiler chicks (n=300) were divided into five treatment groups namely T_0 (maize-soybean based basal ration, containing no BBW), T_1 (5% maize flakes, MF were replaced with BBW), T_2 (10% MF replaced with BBW), T_3 (15% MF replaced with BBW) and T_4 (20% MF replaced with BBW). All the diets formulated for all three feeding phases viz. pre-starter, starter and finisher phases were isocaloric and isonitrogenous. Each diet was fed to 4 replicated groups of 15 birds each from 0 to 42 days of age. During trial completion, eight birds per group were slaughtered to study the anatomical and sensory traits. Results revealed that BBW contained 9.00% crude protein comparable to maize. No adverse effect of BBW feeding was observed on the micrometrical observations of different segments of intestine except the duodenal villi length which was found to be significantly higher in T_0 (1289.28 µm) than T_3 (1153.58 µm) and T_4 (1124.25 µm), whereas T_1 (1239.20 µm) had no difference with T_0, T_2 (1221.78 µm) and T_3. Also, the studied carcass traits (as % live weight) and sensory traits were not influenced by BBW feeding as maize replacer at different levels. Length of the intestine intestinal segments (duodenum, jejunum, ileum and caecum; cm) were significantly higher in T_0, T_1 and T_2 in contrast to the T_3 and T_4 groups. It may be inferred that maize substitution with BBW in broiler ration had no adverse effect up to 10% replacement on anatomical traits.

HIGHLIGHTS

- Bakery biscuit waste can replace maize up to 10% in broiler diets without adverse effects on carcass traits, intestinal morphology, and meat sensory quality.
- Utilization of bakery biscuit waste offers a sustainable alternative feed resource by reducing dependence on conventional maize in broiler production.

Keywords: Bakery biscuit waste, Broiler chicken, Carcass traits, Maize replacement, Sensory evaluation

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Poultry production may not be profitable if expensive conventional feeds are not substituted with more affordable unconventional feeds in the diets (Chauhan *et al*., 2023). Also, it has been projected by UN, that the world's population will reach 9.7 billion by 2050 and 10.4 billion in the mid-2080. With this human population explosion, poultry population and demand for animal feed will also rise. This necessitates for searching the newer feed ingredients to expand the feed resource database and to meet up the demand of this vibrant industry.

Non-conventional feedstuffs (NCFR) can serve as a feasible substitute to cereal grains in poultry diets and can lead to reduced cost per kg of live weight (Epao *et al*., 2017). Among the cereal grains, maize represents the main energy component of commercial poultry ration and its inclusion level varies between 60-70%. There is also contest between humans and poultry for maize, which ultimately results in increased cost. Now-a-days, grains are also diverted towards industrial use, which further forces to look for cheaper alternatives (Gupta *et al*., 2023). Newer NCFR, if fulfils the criteria of reasonable price and fine quality, have the capacity to replace conventional feed ingredients (Adegbenro *et al*., 2020). Further, these substitutions also reduces greenhouse gas emissions associated with producing feed, but also lowers the cost of animal feed besides increasing profitability.

Bakery waste is a broader term which includes biscuit waste meal, biscuit dough, bread waste and other left overs of bakery industry (Gupta *et al*., 2022). Among bakery wastes, biscuit waste is a palatable, high-energy feed produced from wheat flour, skimmed milk powder, vegetable fat, sugar, salt and flavor materials. It holds considerable promise to mitigate the maize cost, as its protein and energy value is more or less similar to that of maize besides having no deleterious factors. Earlier researches have also acknowledged the substitution of maize with bakery waste at different levels in poultry ration (Gonzaga *et al*., 2020).

Bakery biscuit consumption is very common in J&K tradition,besides having its significant vendors, resulting in considerable bakery biscuit waste (BBW) generation. No studies have been conducted so far on nutritional profiling of BBW available in Jammu and its use in broiler ration. Keeping this in consideration, present study was carried outto evaluate the anatomical traits of broiler birds on replacing maize flakes with BBW in broiler ration at graded levels.

MATERIALS AND METHODS

Experimental design and diets

The research was carried out in the Poultry Shed, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu. Three hundred day-old broiler chicks (n=300, straight run, Cobb strain) were randomly assigned to five dietary treatment groups as per Completely Randomised Design (CRD), each comprising 60 birds. The groups were housed in a partitioned deep litter system at the experimental site. Each treatment group was further divided into four replicates of 15 chicks each. The control group was fed maize-soya based basal diet, while the treatment groups were fed diets where 5%, 10%, 15%, and 20% of maize were replaced with BBW and designated as T_1, T_2, T_3 and T_4, respectively. All the diets formulated were isocaloric and isonitrogenous, whereas, the nutritional requirements were met as per specifications of ICAR (2013).

Source of bakery biscuit waste (BBW)

Amount of BBW required for the trial was collected from various bakery vendors of Jammu Division. The waste was cleaned to remove any foreign materials, sun-dried to prevent fungal growth, ground into a fine consistency, and packed into bags before being transported to the study site.

Carcass characteristics

After completing the 42 days of feeding trial, 40 birds *i.e*., eight birds per group (2 birds per replicate) were randomly selected for slaughter. Different carcass parameters, including live weight, bled weight (weight after severing the jugular vein), carcass weight, viscera weight (weight of internal organs), giblet weight, were recorded in grams and expressed as a percentage of live weight. The intestinal length was measured in centimeters using a measuring tape. Dressing percentage was calculated by dividing the combined weight of the eviscerated carcass and giblets by the live weight, expressed as a percentage.

Micrometry of different components of small intestine

Tissue samples from different sections of the small intestine (duodenum, jejunum and ileum) were collected from the slaughtered broiler birds. These specimens were fixed in 10% Neutral Buffered Formalin solution (Luna, 1968) and were stained with Hematoxylin and Eosin (H&E) and examined for micrometrical observations in µm (epithelial height, glandular epithelial height, diameter of gland, length of villi) by using ocular micrometry, which was calibrated with a stage micrometer.

Sensory evaluation

Sensory quality of dressed meat was performed by a semi-trained panel of scientists. The chicken meat after thorough washing was boiled in hot water for fifteen to twenty minutes for organoleptic evaluation. The evaluation was done by means of eight-point descriptive scale (Semen *et al*., 1987), where eight signified extremely desirable whereas one represented extremely poor. Panelists were seated in a well illuminated, clean, odorless and noise free room of faculty and were provided self-explanatory individual performa for scoring. The sensory attributes evaluated were appearance, flavor, juiciness, texture and overall acceptability.

Statistical analysis

The data for various parameters were analyzed statistically following the method described by Snedecor and Cochran (2004). The means of different treatments were compared using Duncan's multiple range test (1955). A significance level of $P<0.05$ was considered for the analysis.

RESULTS AND DISCUSSION

Carcass characteristics

The carcass traits of mature broilers were assessed on 42nd day (Table 1). All the studied carcass traits namely live weight, bled weight, defeathered weight (without skin), eviscerated weight (g) were higher ($P<0.05$) for the groups T_0, T_1 and T_2 in comparison to T_3 and T_4 groups and ranged from. 1605.17 to 2196.23g, 1509.44 to 2088.35g, 1205.99 to 1649.01g and 1050.07 to 1433.43g, respectively across all different treatment groups. But, these aforementioned parameters, when expressed as % of live weight, exhibited no statistical difference. In the similar manner, giblet as well as its counter organs exhibited higher weight for T_0, T_1, and T_2, *i.e*., in groups in which maize was substituted with BBW up to 10%. But, its expression on % live weight basis revealed no change. Also, dressing percentage (%) realized for T_0, T_1, T_2, T_3 and T_4 was 70.02, 69.92, 69.58, 69.78 and 69.83, respectively. The carcass traits of mature broilers when expressed as a percent of live weight, no statistical differences were observed. Also, dressing percentage showed no change across all the groups. In line with our results, Shahryar *et al*. (2012) reported that incorporating biscuit and wafer wastes @ 8, 16 and 24% in broiler diets does not affect the carcass yield and relative giblet weight. Likewise, Adeyemo *et al*. (2013) found no change in bled weight, defeathered weight, gizzard, liver and heart weight (as % live weight) on dietary incorporation of 13.75, 27.75, 39.00 and 58.00 % biscuit waste in the diet of broilers. Similarly, Shittu *et al*., (2016a) reported no change in dressing percentage as well as for liver, heart and gizzard weight while replacing 0, 5, 10 and 15% maize with biscuit dough waste. The present results are in agreement with the findings of Omoikhoje *et al*. (2017) who too reported no change in eviscerated weight, dressing percentage and relative weights of heart, liver and gizzard on replacing maize with 25% biscuit waste in the broiler ration. Gonzaga *et al*. (2020) also depicted statistically similar relative weights of carcass and edible organs in meat quails on incorporating 0-20% wafer type biscuit waste in quail ration.

Length of the intestinal segments of duodenum, jejunum, ileum and caecum (cm) was significantly higher in T_0, T_1 and T_2 in contrast to the T_3 and T_4 groups (Table 2). All the studied carcass traits were comparable up to 10% BBW incorporation as maize substitute, indicating BBW can effectively replace maize flakes in the broiler chicken diet. The lengths of the intestinal segments remained consistent up to 10% replacement of maize with BBW. In contrast, Shittu *et al*. (2016a) found no remarkable difference for duodenal length, while large intestine length was found significantly higher by author in 15% biscuit dough fed group. There is positive correlation between body weight and internal organs weight as well as length of intestines. The higher weight of the carcass traits and longer intestines might be attributed to higher body weight of the birds fed diets in which 5 and 10% maize was replaced by BBW.

Table 1: Effect of bakery biscuit waste inclusion on carcass traits of broiler chicken

Attribute	Groups					SEM	P-value
	T_0	T_1	T_2	T_3	T_4		
Live weight (g)	2196.23[b]	2158.64[b]	2108.77[b]	1679.01[a]	1605.17[a]	49.26	0.00
Dressing percentage (%)	70.02	69.92	69.58	69.78	69.83	0.40	1.00
Bled weight (g)	2088.35[b]	2040.73[b]	1997.39[b]	1583.20[a]	1509.44[a]	47.45	0.00
% of live weight	95.10	94.54	94.75	94.32	94.01	0.20	0.51
Defeathered weight* (g)	1649.01[b]	1630.49[b]	1582.98[b]	1264.95[a]	1205.99[a]	37.56	0.00
% of live weight	75.10	75.54	75.02	75.32	75.18	0.27	0.98
Feather weight	379.77[b]	380.62[b]	372.95[b]	296.53[a]	275.47[a]	9.22	0.00
% of live weight	17.30	17.64	17.68	17.67	17.16	0.16	0.77
Weight of viscera (g)	215.58[b]	220.07[b]	209.49[b]	165.30[a]	155.92[a]	7.03	0.00
% of live weight	9.78	10.19	9.95	9.84	9.72	0.23	0.98
Eviscerated weight	1433.43[b]	1410.42[b]	1373.49[b]	1099.65[a]	1050.07[a]	32.50	0.00
% of live weight	65.32	65.35	65.06	65.48	65.46	0.36	1.00
Giblet weight (g)	103.45[b]	98.52[b]	95.50[b]	72.10[a]	70.02[a]	3.30	0.00
% of live weight	4.69	4.56	4.52	4.30	4.37	0.10	0.73
Heart weight (g)	10.77[b]	10.97[b]	10.27[b]	8.33[a]	8.32[a]	0.38	0.03
% of live weight	0.49	0.51	0.48	0.05	0.52	0.02	0.97
Liver weight (g)	49.27[b]	49.69[b]	45.71[b]	36.90[a]	36.58[a]	1.26	0.00
% of live weight	2.24	2.30	2.16	2.20	2.28	0.03	0.73
Gizzard weight (g)	43.41[b]	37.86[b]	39.53[b]	26.87[a]	25.12[a]	2.34	0.03
% of live weight	1.96	1.75	1.87	1.60	1.57	0.10	0.69

[ab]Mean with different superscript within row differ significantly (P<0.05).

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

*Without skin.

Table 2: Effect of bakery biscuit waste inclusion on intestine length of broiler chicken

Particulars	Groups					SEM	P-value
	T_0	T_1	T_2	T_3	T_4		
Duodenum (cm)	30.67[b]	30.42[b]	30.67[b]	23.42[a]	22.42[a]	0.83	0.00
Jejunum (cm)	51.50[b]	51.25[b]	51.83[b]	44.83[a]	44.08[a]	1.03	0.01
Ileum (cm)	79.33[b]	77.58[b]	74.67[b]	62.50[a]	60.00[a]	1.65	0.00
Caecum (cm)	14.67[b]	14.92[b]	14.67[b]	10.42[a]	10.25[a]	0.54	0.00

[ab]Mean with different superscript within row differ significantly (P<0.05);

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

Micrometry of intestine

Different micrometrical parameters namely villi length, luminal epithelial height, gland diameter, and glandular epithelial height were measured (µm) in the duodenum, jejunum, and ileum segments of adult broiler chickens at trial completion (Table 3). The epithelial height, glandular epithelial height and diameter of glands (µm) of duodenum varied from 28.92 to 31.87, 20.26 to 21.91 and 77.65 to 79.12, respectively without any significant change. But villi length (µm) was significantly higher in T_0 (1289.28) than T_3 (1153.58) and T_4(1124.25), whereas T_1 (1239.20) has no difference with T_0, T_2 (1221.78) and

Table 3: Effect bakery biscuit waste inclusion on intestinal micrometry of small intestine of broiler chicken

Attribute	Groups					SEM	P-value
	T_0	T_1	T_2	T_3	T_4		
Duodenum							
Epithelial height (µm)	31.87	31.59	30.92	29.33	28.92	0.69	0.59
Length of villi (µm)	1289.28^{c}	1239.20^{bc}	1221.78^{abc}	1153.58^{ab}	1124.25^{a}	17.96	0.02
Glandular epithelial height (µm)	21.91	21.88	21.85	20.51	20.26	0.39	0.50
Diameter of gland (µm)	79.12	79.24	79.28	78.03	77.65	0.76	0.95
Jejunum							
Epithelial height (µm)	24.97	24.71	24.88	23.33	22.82	0.48	0.52
Length of villi (µm)	644.75	657.24	655.76	607.75	600.96	8.04	0.05
Glandular epithelial height (µm)	20.25	20.19	19.72	19.58	19.15	0.48	0.96
Diameter of gland (µm)	62.07	61.65	61.72	59.96	59.39	0.82	0.82
Ileum							
Epithelial height (µm)	21.66	21.73	21.37	20.84	20.59	0.36	0.84
Length of villi (µm)	217.72	216.64	215.65	215.59	213.99	2.16	0.99
Glandular epithelial height (µm)	18.32	17.87	17.88	17.95	17.47	0.33	0.96
Diameter of gland (µm)	51.83	52.90	51.72	51.00	50.22	1.04	0.96

^{abc}Mean with different superscript within row differ significantly ($P<0.05$);

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

T_3. Further, T_2, T_3 and T_4 are statistically similar. These findings suggest that maize can be effectively replaced with BBW up to 10% without adversely affecting the intestinal micrometrical parameters.

The gastro-intestinal development and health are critical to productivity in all farm animals and poultry. The digestive functions could be viewed as the most limiting aspects in performance. Overall gut surface area affects net utilization of dietary nutrients in chicken and can be determined by gross morphological features such as length and cross-sectional area of the duodenal, jejunal, and ileal segments, as well as finer morphological features such as villus height and surface area of the epithelium in each of these segments (Jin *et al*., 1998; Iji, 1999). Several researchers have investigated intestinal morphology in poultry over the last decade, mostly from the perspective of normal development. There are no thorough published studies on the impact of bakery biscuit waste as maize substitute on the intestinal morphology of broiler chickens. The micrometrical parameters (villi length, luminal epithelial height, gland diameter, and glandular epithelial height) measured (µm) in the duodenum, jejunum, and ileum segments showed no change ($P>0.05$), except the villi length (µm) of duodenum, which was found significantly higher in T_0 than T_3 and T_4 whereas T_1 has no difference with T_0, T_2 and T_3. Further, T_2, T_3 and T_4 are statistically similar. Shittu *et al*. (2016b) also reported significant increase ($P<0.05$) in villus height on incorporating biscuit dough @5, 10 and 15% in broiler feed. But the author got higher villus height in ileum. The non-significant differences in the observed micrometrical parameters further warrant that BBW feeding had no adverse effect on intestinal integrity whereas reduced villi length of duodenum might be because of less CF content with the increased inclusion levels of BBW in broiler diets. Gupta *et al*. (2023) also observed no change in micrometrical parameters while replacing maize with dry bakery waste (bread waste) in quail ration. A shortening of the villi decreases the surface area for nutrient absorption. The crypt can be regarded as the villus factory, and a large crypt indicates fast tissue turnover and a high demand for new tissue (Yason *et al*., 1987). In chickens, villus height gradually declines from orad to aborad along the small interstine (Yamauchi, 2002). This is because the duodenum has a higher absorptive capacity than the jejunum followed by the ileal villi. The intestinal histological alterations are largely related to the

Table 4: Effect of bakery biscuit waste inclusion on sensory attributes

Attributes	Groups					SEM	P-value
	T_0	T_1	T_2	T_3	T_4		
Color	7.17	7.00	7.00	6.83	6.67	0.15	0.89
Flavour	6.67	6.83	7.00	6.67	6.50	0.10	0.55
Texture	6.83	6.83	6.50	6.50	6.33	0.11	0.57
Juiciness	6.33	6.50	6.17	6.33	6.17	0.12	0.91
Overall acceptability	6.83	6.83	6.67	6.50	6.50	0.11	0.80

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

availability and nature of the nutrients within the intestine (Isshiki, 1989). Numerous investigations have shown that dietary components have an effect on the intestinal villi in ducks (Ruttanavut *et al*., 2009) and chickens (Incharoen *et al*., 2009). Decreasing villus characteristics were associated with decreases in villus surface area, enzyme activities such as mucosal lactase and sucrease (Park *et al*., 1998), lactase and alkaline phosphatase (Zijlstra *et al*., 1997), total lactase phlorizin hydrolase and mucosal protein concentration (Dudley *et al*., 1998), and alkaline phosphatase and disaccharidase (López-Pedrosa *et al*., 1998).

Sensory evaluation

Sensory attributes consisting of color, flavour, texture, juiciness and overall acceptability were assessed and the findings realized are summarized in Table 4. The sensory scores ranged from 6.67 to 7.17 for color, 6.50 to 7.00 for flavour, 6.33 to 6.83 for texture, 6.17 to 6.50 for juiciness, and 6.50 to 6.83 for overall acceptability, without any significant change, indicating no adverse impact on sensory characteristics and appeal of the meat. The sensory evaluation is a method that measures consumer's perception regarding the different attributes of meat. The sensory traits scores for color, flavor, texture, juiciness, and overall acceptability showed no difference. Thus, it may be inferred that substituting of maize with BBW (up to 20%) does not impact the broiler meat's appeal. The present results corroborate with the findings of Gupta *et al*. (2023) who also observed no change in sensory parameters of quail meat while replacing maize with dry bakery waste (bread waste) at different levels. There is no relevant literature available for comparison, so these findings are not discussed in detail.

CONCLUSION

From the present study, it can be postulated that maize flakes can be replaced with bakery biscuit waste (BBW) upto 10% in broiler ration without any adverse effect on carcass traits and sensory attributes of meat.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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