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Influence of Pearl Millet (*Pennisetum glaucum*) and Finger Millet (*Eleusine coracana*) as Alternative Energy Sources on Nutrient Utilization in Mewari Chicken

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Abstract
The present investigation was designed to evaluate the effect of replacing maize with pearl millet and finger millet as alternative energy sources on nutrient utilization efficiency in Mewari chicken. A total of 200-day-old unsexed Mewari chicks were randomly allotted to five dietary treatments with four replicates of ten birds each and reared up to 20 weeks of age under a completely randomized design. The dietary treatments consisted of a maize-based control diet (T1), diets containing 20% (T2) and 40% (T3) pearl millet and diets containing 20% (T4) and 40% (T5) finger millet as partial replacements for maize. All experimental diets were formulated to be iso-nitrogenous and iso-caloric in accordance with BIS (2007) recommendations. A metabolism trial was conducted at 20 weeks of age to determine the nutrient utilization in Mewari chicken. Dietary inclusion of pearl millet and finger millet significantly ($P<0.05$) influenced nutrient intake and utilization in Mewari chicken. Birds fed the diet containing 20% pearl millet observed the highest dry matter digestibility (63.49%) and crude protein digestibility (70.92%), while crude fibre digestibility was higher in birds receiving 40% pearl millet (72.93%). Ether extract digestibility was significantly higher in birds fed 40% finger millet (81.55%), whereas nitrogen-free extract digestibility was highest in the 20% finger millet group (75.10%). Protein efficiency ratio (1.15) and energy efficiency ratio (7.64) were significantly ($P<0.05$) highest in birds fed 20% pearl millet, indicating superior nutrient utilization efficiency. Based on the results replacement of maize with pearl millet at 20% improved nutrient digestibility and nutrient utilization efficiency without adversely affecting nutrient balance. Therefore, pearl millet may be recommended as a cost-effective alternative energy source at 20 per cent level in diets of Mewari chicken.

Keywords: Mewari chicken, pearl millet, finger millet, nutrient digestibility, nitrogen balance, protein efficiency ratio, energy efficiency ratio

Introduction
Poultry production is one of the fastest-growing sectors of the livestock industry and plays a pivotal role in ensuring food and nutritional security by supplying high-quality animal protein in the form of meat and eggs. Owing to its short generation interval, high feed conversion efficiency and relatively low production cost, poultry farming has emerged as an important enterprise for improving rural livelihoods and enhancing farmers' income. In developing countries such as India, indigenous poultry production contributes significantly to household nutrition and socio-economic development, particularly among resource-poor and smallholder farmers.

Indigenous chicken breeds possess several desirable characteristics, including better adaptability to harsh environmental conditions, greater disease resistance, efficient utilization of locally available feed resources and superior meat quality compared with commercial broiler strains. Feed accounts for nearly 65-70% of the total cost of poultry production, with cereal grains constituting the major source of dietary energy. Maize is widely recognized as the preferred energy source in poultry diets due to its high metabolizable energy content, excellent palatability and superior digestibility. However, increasing competition between livestock, food and industrial sectors, coupled with fluctuations in maize availability and market price, has necessitated the exploration of alternative cereal grains that are economical, locally available and nutritionally efficient. Identifying suitable substitutes for maize is particularly important in arid and semi-arid regions where climate variability often limits maize production (Banergee *et al.*, 2013).

Pearl millet (*Pennisetum glaucum*) is an important cereal crop cultivated extensively in the dryland regions of India because of its exceptional tolerance to drought, high temperature and poor soil fertility (Meena *et al*., 2021) [10]. Compared with maize, pearl millet contains relatively higher crude protein, appreciable levels of essential amino acids, minerals and bioactive compounds, making it a promising alternative energy source for poultry feeding (BIS, 2024). However, the presence of anti-nutritional factors such as tannins and phytic acid may influence nutrient availability and performance, necessitating systematic evaluation under practical feeding conditions (Nour *et al*., 2014) [12]. Previous studies have demonstrated that moderate inclusion of pearl millet in poultry diets can maintain growth performance, improve nutrient digestibility and reduce feed cost without adversely affecting bird health. Nevertheless, excessive inclusion may reduce nutrient utilization because of the presence of antinutritional factors such as tannins and phytates, which interfere with nutrient availability and digestive enzyme activity (Raheem *et al*., 2021) [13].

Finger millet (*Eleusine coracana*) is another climate-resilient cereal cultivated widely in tropical and subtropical regions. It is valued for its high calcium content, dietary fibre, antioxidant compounds and remarkable storage stability. The crop can withstand prolonged drought and marginal growing conditions, making it an important component of sustainable agriculture in rainfed ecosystems. Although finger millet has considerable nutritional potential, its utilization in poultry feeding remains limited due to relatively higher fibre content and the presence of phenolic compounds that may influence nutrient digestibility at higher dietary inclusion levels. Consequently, systematic evaluation of appropriate inclusion levels is essential before recommending its large-scale incorporation into poultry diets (Bot *et al*., 2021) [5].

Nutrient utilization is a critical determinant of poultry productivity because efficient digestion and absorption of dietary nutrients directly influence growth performance, feed conversion efficiency, protein deposition and overall economic returns. Assessment of nutrient digestibility, nitrogen retention, protein efficiency ratio and energy efficiency ratio provide a comprehensive understanding of the biological value of alternative feed ingredients. Such information is particularly important for indigenous chickens, whose digestive responses to unconventional cereal grains may differ from those of commercial poultry strains.

Although several studies have investigated the use of pearl millet and finger millet in broiler chickens, scientific information regarding their influence on nutrient utilization in indigenous Mewari chicken is scarce. Considering the increasing need to reduce feed costs through the use of locally available cereal grains while maintaining optimum nutrient utilization, the present study was undertaken to evaluate the effect of dietary replacement of maize with graded levels of pearl millet and finger millet on nutrient intake, digestibility coefficients of nutrients, nitrogen balance, protein efficiency ratio and energy efficiency ratio in Mewari chicken. It was hypothesized that partial replacement of maize with these alternative cereals would improve nutrient utilization efficiency without compromising the nutritional status of the birds.

Material and Methods

A total of two hundred apparently healthy, day-old, unsexed Mewari chicks were randomly selected and divided into five dietary treatments, each comprising four replicates of ten birds (40 birds per treatment) and fed five dietary treatments consisted of a maize-based control diet (T1), diets containing 20% (T2) and 40% (T3) pearl millet and diets containing 20% (T4) and 40% (T5) finger millet as partial replacements for maize. Day old Mewari chicks were procured from Department of Animal Production, Rajasthan College of Agriculture, Udaipur (Raj.). Prior to the arrival of the chick, the brooder house, equipments and utensils were thoroughly cleaned and disinfected with phenol and fumigated using formaldehyde gas to ensure optimum hygienic condition. The chicks were individually weight on the arrival and randomly allotted to the experimental treatment groups. Rice husk was used as litter material, with an initial litter dept of 2 inches, which were subsequently increased by 0.5 inch as required during the experimental period. The birds were reared under unform deep litter management conditions. Feed and fresh drinking water were provided *ad libitum* throughout the experimental period. Standard management practices, including vaccination, sanitation, litter management, deworming and biosecurity measures were followed uniformly for all treatment groups to minimize environmental variation.

A metabolism trial was conducted at the end of the experiment (20 weeks of age) to evaluate to study nutrient utilization. Two birds from each replicate were randomly selected, giving a total of ten birds per treatment (50 birds in total) and transferred individually to metabolic cages equipped for separate collection of feed residues and excreta. Birds were allowed an adaptation period of seven days followed by a three-day quantitative collection period. During three days collection period, quantity of daily feed offered, feed refusal and total excreta voided were recorded and taken for nutrient analysis. Representative samples of feed and excreta were collected, dried and subjected to proximate analysis for determination of nutrient digestibility. Digestibility coefficients of dry matter, crude protein, crude fibre, ether extract and nitrogen-free extract were estimated as per AOAC (2005).

The protein efficiency ratio (PER) was calculated by following equation:

$$\text{Protein efficiency ratio} = \frac{\text{Weight gain (g)}}{\text{Total protein intake (g)}}$$

The energy efficiency ratio (EER) was estimated by using the following formula:

$$\text{Energy efficiency ratio} = \frac{\text{Total Weight gain (g)}}{\text{Total Metabolizable energy intake}} \times 100$$

Statistical analysis

The experimental design was conducted by using a completely randomized design (CRD) and the data pertaining to various parameters obtained during growth and metabolic trial of the present study was analyzed by analysis of variance (ANOVA) described by Snedecor and Cochran (1994) [15].

Results and Discussion

A metabolism trial was conducted at the end of experiment (20 weeks of age). The data pertaining to nutrient intake and digestible nutrient intake in Mewari chicken is described in Table 1. Dietary energy sources significantly ($P<0.05$) influenced nutrient utilization parameters. The digestibility coefficient of nutrients as influenced by feeding of energy sources at different levels are presented in Table-2.

Dry matter intake (DMI) varied significantly among dietary treatments. Birds fed the control diet (T1) recorded the highest DMI (67.32 g/bird/day), whereas the lowest intake was observed in birds receiving 40% finger millet (T4; 63.08 g/bird/day). Despite the lower DMI, the highest dry matter digestibility coefficient was observed in T2 (63.49%), which was significantly ($P<0.05$) superior to T3, T4 and T5, indicating improved digestive efficiency at 20% pearl millet inclusion. The reduced digestibility observed in T4 (60.42%) suggests that higher levels of finger millet may have limited nutrient availability, possibly due to its comparatively higher fibre content and the presence of antinutritional factors. These findings corroborate the observations of Tyagi *et al*. (2004) [6], who reported reduced dry matter metabolizability with increasing levels of finger millet in broiler diets. Likewise, Raju *et al*. (2003) [14] and Elangovan *et al*. (2004) reported better dry matter utilization in pearl millet-based diets.

Crude protein intake was significantly lower in T4 than in the remaining treatments, reflecting the lower feed consumption in this group. The highest crude protein digestibility coefficient (70.92%) was recorded in T2, while T4 exhibited the lowest value (66.99%). Similarly, digestible crude protein intake was highest in T1 and T3 and lowest in T4. The superior protein digestibility observed in T2 may be attributed to improved nutrient synchronization and efficient digestion of pearl millet-based diets, whereas reduced protein utilization at higher finger millet inclusion could be associated with decreased nutrient availability. Similar improvements in protein digestibility with pearl millet feeding have been reported by Raju *et al*. (2003) [14] and Elangovan *et al*. (2004) [6].

Crude fibre utilization was also significantly influenced by dietary treatments. Although crude fibre intake remained comparable among most treatments, the highest crude fibre digestibility coefficient was recorded in T3 (72.93%), followed by T2 (70.20%). This indicates enhanced utilization of fibre fractions in pearl millet-based diets, particularly at 40% inclusion. In contrast, birds fed finger millet diets exhibited comparatively lower fibre digestibility. The improved fibre utilization may be associated with the structural characteristics of pearl millet fibre, which is relatively more fermentable than that of finger millet. Ether extract intake and digestible ether extract intake differed significantly ($P<0.05$) among treatments. Birds receiving 40% finger millet (T5) recorded the highest ether extract digestibility (81.55%), which was statistically comparable with T2 but significantly higher than T3. Improved lipid digestibility in finger millet-containing diets may be associated with enhanced fat utilization efficiency; however, this improvement was insufficient to compensate for the lower digestibility of dry matter and crude protein observed at higher finger millet inclusion. Nitrogen-free extract (NFE) digestibility was significantly influenced by dietary energy sources, with the highest digestibility coefficient observed in T4 (75.10%), followed by T5, T2 and T1, while the lowest value was recorded in T3 (72.09%). Nevertheless, the overall differences among treatments were relatively small, indicating that dietary carbohydrate utilization remained largely unaffected by millet inclusion. Nitrogen intake and nitrogen balance were significantly higher in T1 than in T4 group, while intermediate values were recorded in the remaining treatments. Importantly, nitrogen balance remained positive in all dietary groups, indicating satisfactory nitrogen retention and efficient utilization of dietary protein irrespective of the energy source. Dietary treatments also significantly affected nutrient utilization efficiency. Total protein intake was highest in T3 (1172.33 g), although statistically comparable with T2 and T5 groups. More importantly, the highest protein efficiency ratio (PER) was obtained in T2 (1.15), indicating more efficient conversion of dietary protein into body weight gain. Similarly, energy efficiency ratio (EER) was significantly highest in T2 (7.64), demonstrating superior utilization of metabolizable energy when pearl millet replaced maize at 20% of the diet. The finding Mohanta *et al*. (2022) [11] who reported the performance of indigenous Nusuri chicken germplasm of Odisha. The mean cumulative EER and PER was 9.07 and 1.23 at the age of 8th week and 7.39 and 1.15 at 20th week, respectively. These results of nitrogen intake and balance are in close agreement with the findings of Baurhoo *et al*. (2011) [3], Ibe *et al*. (2014) [7] and Malik *et al*. (2021) [9], who reported that moderate inclusion of millet did not impair nutrient utilization in poultry. However, the present findings differ from those of Tyagi *et al*. (2003) [16] and Jha and Kumar (2008) [8], who observed non-significant changes in nutrient metabolizability at higher pearl millet inclusion levels. The positive nitrogen balance observed in all treatment groups of the present study further confirms adequate nutrient retention irrespective of dietary treatment.

Overall, the present investigation demonstrated that replacement of maize with pearl millet at 20% (T2) optimized nutrient utilization by improving dry matter and crude protein digestibility together with the highest protein and energy efficiency ratios. Although 40% pearl millet enhanced crude fibre digestibility and finger millet improved ether extract and NFE digestibility, these advantages were insufficient to improve overall nutrient utilization efficiency. Therefore, 20% pearl millet can be considered the optimum inclusion level for maximizing nutrient digestibility and utilization in growing Mewari chicken.

Table 1: Effect of feeding of energy sources on nutrient intake in Mewari chicken

Particulars	T_1	T_2	T_3	T_4	T_5	SEm±	CD
DM Intake (g/bird/d)	67.32±0.14^{a}	65.80±0.31^{a}	65.45±0.38^{a}	63.08±1.49^{b}	66.23±0.48^{a}	0.73	2.21
Digestible DMI (g/bird/d)	41.79 ±0.38^{a}	41.78 ±0.41^{a}	39.88 ±1.15^{ab}	38.13±0.93^{b}	40.45±0.74^{ab}	0.78	2.35
CP intake (g/bird/d)	10.99 ±0.02^{a}	10.77 ±0.05^{a}	10.95 ±0.07^{a}	10.19±0.24^{b}	10.82±0.08^{a}	0.12	0.36
Digestible CP intake (g/bird/d)	7.74 ±0.05^{a}	7.63 ±0.10^{ab}	7.72 ±0.16^{a}	6.73±0.21^{c}	7.26±0.11^{b}	0.14	0.41
CF intake (g/bird/d)	4.50 ±0.01^{ab}	4.39 ±0.07^{bc}	4.56 ±0.03^{a}	4.35±0.04^{c}	4.47±0.04^{abc}	0.04	0.12
Digestible CF intake (g/bird/d)	2.97 ±0.02^{b}	3.09 ±0.14^{ab}	3.32 ±0.06^{a}	2.90±0.09^{b}	3.07±0.07^{ab}	0.09	0.26
EE intake (g/bird/d)	1.824 ±0.003^{a}	1.816 ±0.009^{a}	1.819 ±0.011^{a}	1.634±0.039^{c}	1.742±0.013^{b}	0.02	0.06
Digestible EE intake (g/bird/d)	1.47±0.004^{a}	1.48 ±0.013^{a}	1.45±0.021^{a}	1.33±0.035^{c}	1.42±0.015^{b}	0.02	0.06
NFE Intake (g/bird/d)	41.41±0.09^{a}	40.20±0.19^{ab}	39.86±0.23^{bc}	38.52±0.91^{c}	40.56±0.29^{ab}	0.45	1.35
Digestible NFE intake (g/bird/d)	30.60±0.15^{a}	29.7±0.34^{ab}	28.74±0.55^{b}	28.93±0.43^{b}	30.31±0.38^{a}	0.39	1.18
Nitrogen intake (g/bird/d)	1.76±0.005^{a}	1.72±0.008^{a}	1.75±0.011^{a}	1.63±0.039^{b}	1.73±0.011^{a}	0.02	0.06
Nitrogen balance(g/bird/d)	1.24±0.007^{a}	1.22±0.016^{ab}	1.23±0.025^{ab}	1.08±0.034^{c}	1.16±0.018^{b}	0.02	0.07

Table 2: effect of feeding of energy sources on nutrient digestibility cofficient in Mewari chicken

Particulars	T_1	T_2	T_3	T_4	T_5	SEm±	CD
DM	62.08±0.62^{ab}	63.49±1.02^{a}	60.92±0.57^{b}	60.42±0.47^{b}	61.06±0.58^{b}	0.68	2.05
CP	70.79±0.54^{a}	70.92±0.80^{a}	70.24±1.09^{a}	66.99±0.80^{b}	68.58±0.23^{ab}	0.75	2.26
CF	66.26±0.58^{c}	70.20±1.42^{ab}	72.93±1.08^{a}	66.02±1.06^{c}	68.58±1.20^{bc}	1.10	3.33
EE	81.11±0.49^{ab}	81.43±0.54^{a}	79.41±0.78^{b}	80.92±0.57^{ab}	81.55±0.37^{a}	0.56	1.70
NFE	73.88±0.43^{a}	73.94±0.73^{a}	72.09±0.61^{b}	75.10±0.64^{a}	74.72±0.55^{a}	0.60	1.81
Total Protein intake (g)	1124.07±5.35^{b}	1171.59±1.75^{a}	1172.33±2.44^{a}	1137.03±2.94^{b}	1161.33±4.28^{a}	3.59	10.83
Protein Efficiency Ratio	1.12±0.006^{ab}	1.15±0.006^{a}	1.06±0.002^{c}	1.14±0.003^{a}	1.09±0.004^{b}	0.005	0.014
Total ME intake (Kcal)	17209.09±81.36^{c}	17680.60±27.80^{a}	17252.73±36.07^{c}	17363.89±44.12^{bc}	17481.48±64.52^{ab}	54.37	163.89
Energy Efficiency Ratio	7.33±0.04^{b}	7.64±0.04^{a}	7.22±0.01^{c}	7.46±0.02^{b}	7.26±0.01^{c}	0.03	0.09

Conclusion

The present investigation demonstrated that dietary replacement of maize with pearl millet and finger millet significantly influenced nutrient utilization in Mewari chicken. Birds fed the diet containing 20% pearl millet (T2) exhibited superior dry matter and crude protein digestibility, together with the highest protein efficiency ratio and energy efficiency ratio, indicating improved utilization of dietary nutrients. Although higher inclusion levels of pearl millet and finger millet. Based on the overall biological response, replacement of maize with pearl millet at 20% of the diet can be recommended as a nutritionally efficient and economically feasible alternative energy source for Mewari chicken reared under semi-arid conditions of Rajasthan. Adoption of locally available pearl millet may reduce dependence on maize, lower feed costs and contribute to sustainable indigenous poultry production.

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