Nutritional status and growth performance of Fijian local chickens and their crosses with broilers under different production systems

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Abstract

The study compared nutrient content intake and growth performance of local chickens and local x broilers crossbreds under scavenging and indoor conventional systems. A total of 48 male and 48 female chickens for each of the two chicken types were allocated to four outdoor free-range pens and allowed to scavenge whilst being supplemented with sorghum plus kitchen waste and broilers growers from week 5 to week 13 of age. The same design was repeated on indoor pens with the chickens being fed the same diets without scavening. The crops and gizzards contents from local chickens had the same crude protein and crude fat as their crosses with broilers under both systems (P > 0.05). The energy content of crop and gizzard contents from scavenging chickens was lower than that from chickens under indoor conventional system (P < 0.05). Chickens of the same type had high iron content in their crops and gizzards contents under scavenging system than the conventional system (P < 0.05). Local chickens and their crosses with broilers had higher growth rates under the scavenging system than the indoor production system (P < 0.05). Local chickens and their crosses with broilers had the same growth rates when fed the same diet (P > 0.05). Crossbreds between local chickens and broilers matches the scavenging abilities of the local chickens but have lower growth rates under scavenging systems.

Introduction

Local chickens, which are also commonly referred to as indigenous chickens, are regaining their popularity in many regions due to appreciation of their desirable traits such as adaptability to low input scavenging production systems and highly desirable meat and eggs (Dessie et al., 2011). The local chickens, however, are characterized by slow growth rates (Batkowska et al., 2015) which is one of the biggest concerns of most chicken producers. In quest of optimizing productivity under free range conditions, there has been a general drive towards promotion of crossbreeding between the local and fast-growing chickens such as broilers (Dana, 2011). Although there is abundant literature on the characteristics of both local and improved chickens under different production systems (Batkowska et al., 2015; Castellini et al., 2016), their crossbreds are not well characterized.

Local chickens and fast-growing improved breeds have distinguished nutritional status under different production systems due to their differences in scavenging abilities, digestive capabilities, and environmental requirements (Mekonnen et al., 2009). With most poultry improvement programs promoting the use of crosses between local chickens and fast-growing improved breeds, it is important to determine how they perform under different production systems. Besides adaptability and growth performance, the nutritional status of chickens under any production system is of paramount importance. The type of nutrients that a chicken consumes, and their proportions determines growth performance, health status and the quality of its meat (Ferket et al., 2006).

For scavenging systems, nutritional composition of crop and gut contents can be one of the ways to obtain information about nutrient intake (Raphulu and Jansen van Rensburg, 2018; Yadav et al., 2019). The nutrient intake of scavenging chickens depends on their scavenging ability and availability of
supplements (Magothe et al., 2012). Commonly used supplements for scavenging systems include grains such as sorghum and kitchen waste (Etuk et al., 2012; Manuya et al., 2020). Although the scavenging ability of many local chicken breeds, as denoted by nutrient intake, has been extensively studied (Mwalusanya et al., 2002; Pousga et al., 2005; Raphulu, 2019), such studies are limited for crossbreeds between local chickens and fast-growing commercial breeds. Data on the performance of the crossbreds fed on common supplements such as sorghum and kitchen waste are also scanty.

In attempt to reduce pressure on maize, recent poultry improvement programs are targeting the efficient use alternative energy sources such as sorghum for enclosed production systems (Gualtieri et al., 1990; Alders et al., 2009). Local chickens have been reported to efficiently digest whole sorghum when under scavenging systems whilst sorghum-based diets are associated with inferior broiler performance under both scavenging and enclosed systems (Selle et al., 2018). To our knowledge, there is very little, if any, literature on performance of crosses between broilers and local breeds supplemented with and/or fed on sorghum-based diets under any production system.

Since there is a paucity of information on the nutrient intake and growth performance of local chickens x broilers crossbreds despite their importance, the present study was undertaken to compare their performance to that of local chickens under different production systems. Such data will go a long way to evaluate the potential for genetic improvement of the productive efficiency of the local chickens through crossbreeding them with fast growing improved breeds whilst maintaining their valuable desirable properties such as good scavenging ability and utilization of lowly digestible feed sources. It was hypothesized that local chickens x broilers crossbreds' crop and gizzard nutritional content and growth performance is higher than that of local chickens under both the scavenging and enclosed production systems.

**Materials and methods**

**Study site**

The study was contacted at the Fiji National University (FNU) crop farm in Koronivia. Koronivia is situated in Naitasiri district located at 18°0243.1 S and 178°3150.7 E and 11m above sea level (Zindove et al., 2022). Naitasiri district is located on Fiji’s largest island, Viti Levu. It experiences a tropical climate characterized by rainfall throughout the year, totaling about 3500 mm (Zindove et al., 2022). The average temperature is around 27°C. The plots used for the experiment were previously used for planting cassava, maize, and taro. The plots currently have scattered coconut trees. There are also two contour ridges which are filled with still water throughout the year. The common grass species growing on the plots is Para grass (*Brachiaria mutica*).

**Experimental chickens**

A total of 500 eggs from local scavenging chickens purchased from households in Ra, Nadroga-Navosa and Ba provinces were used in this experiment. The eggs were incubated until hatching at the FNU
livestock farm. A total of 323 eggs hatched. A total of 500 local chicken x broiler F1crossbred day-old chicks were also purchased from a chicken farm in Ba province, Fiji and were reared at the FNU livestock farm. The two batches of chicks were kept inside two separate brooders at 32ºC from day 1 to day 28 (4 weeks). The FNU livestock farm chicken house contains floors covered with about 5 cm thick layer of wood shavings and well-ventilated cages. A conventional starter diet and water were provided ad libitum until the chickens were four weeks old.

**Treatments and experimental design**

Chickens were moved to the experimental site at the FNU crop farm at the start of week 5. They were sexed by looking at body, comb, and wattles sizes. Those with enlarged combs and wattles were confirmed as male (Tao et al., 2000). From the total flock of each of the chicken types (local and local x broiler crossbreds), 96 males and 96 females were selected randomly to be used in the experiment. The chickens were then allocated to 4 outdoor free-range pens and 4 indoor conventional system pens. For the outdoor free-range pens, two pens were allocated 12 cages each: 6 with male local chickens and the other 6 with male local x broiler crossbreds. The other two pens were also allocated 12 cages each: 6 with female local chickens and the other 6 with female local x broiler crossbreds. There were 4 chickens of the same sex and chicken type in each cage. Each cage represented an experimental unit. Two supplementary diets, sorghum + kitchen waste and broiler commercial grower diet, were then randomly allocated to pens with male chickens (one diet per pen). The same diets were also randomly allocated to the two pens with female chickens. The same design was repeated in the 4 pens in the indoor conventional system. Table 1 below illustrates the experimental design used. Each of the chickens was tagged using numbered chicken leg rings. Cages were also labeled with corresponding numbers of the allocated chickens. The free-range pens measured 900m² each and were demarcated by a chain link fence reinforced by wooden poles. There was forage grass, crop residues and coconut waste inside the pens.
Table 1
Layout of the experimental design

<table>
<thead>
<tr>
<th>Scavenging system (Outdoor free-range pens)</th>
<th>Indoor conventional system pens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum + kitchen waste</td>
<td>Males</td>
</tr>
<tr>
<td>Local chicken = 6 cages, 4 chickens in each cage</td>
<td>Males</td>
</tr>
<tr>
<td>Local x broiler Crossbred = 6 cages, 4 chickens in each cage</td>
<td>Males</td>
</tr>
<tr>
<td>Sorghum + kitchen waste</td>
<td>Females</td>
</tr>
<tr>
<td>Broiler grower diet</td>
<td>Males</td>
</tr>
<tr>
<td>Broiler grower diet</td>
<td>Females</td>
</tr>
</tbody>
</table>

*Each cage represents an experimental unit*

The cages were wooden, measuring 2.5 x 2 x 1.5 m. The cages, with slatted floors, were elevated 1m above the ground surface and fitted with wire mesh doors. For the scavenging system, the doors were left open during the day and the chickens were enclosed at night. A standard plastic drinker was placed near each cage to provide clean water. For the conventional production system, cages with the same design were used and placed in a chicken house. The chickens were enclosed throughout the experiment.

Kitchen waste was collected from the university canteens and local restaurants at the end of every day during the experiment. It was mixed and ground using a NAIZEA electric dry-wet grinder. Sorghum grown at FNU crop farm was used as whole grain. For the scavenging system, 250 grams of sorghum plus 250 grams of ground kitchen waste were supplemented per cage every day for those on the sorghum plus kitchen waste diet. A total of 500 grams of broiler grower diet were supplemented per cage for those on broiler grower diet. Chickens in the conventional system were fed ad libitum as per experimental design.

**Growth performance**

At the start of the experiment, all the chickens were weighed to determine the initial average weight. Body weight changes were determined by measuring live weight for chickens in each cage at the end of every week during the experiment. To determine the average weight of chickens in each cage, the chickens were put together in the crate and the weight of the crate with chickens was measured using a digital electronic scale. The weight of the crate was then subtracted from the total weight and divided by four to get the average weight of chickens. Weekly average daily gain (ADG g/bird/day) of the chickens was obtained by subtracting the initial average weight per cage from the final average weight per cage and then dividing by 7 days.

**Slaughtering of chickens and sample collection**
Eight weeks after the experiment commenced, all the chickens were slaughtered by cervical dislocation. The chickens were slaughtered between 1300hs and 1600 hours. All the contents in crops and gizzards were collected and put into plastic bags within 20 mins of slaughtering. The samples of the crops and gizzards contents were weighed and kept at 4ºC inside the refrigerator.

**Chemical analyses**

Freeze-dried samples of the crops and gizzards contents were sent to the Fiji Agricultural Chemistry Laboratory at Koronivia Research Station for chemical analyses. Procedures described by AOAC were used to determine crude protein (CP) (AOAC official method 990.03), crude fat (AOAC official method 920.39), calcium (AOAC official method 935.13), sodium (ISO official method 6869), iron (AOAC official method 968.08), magnesium (AOAC official method 968.08), manganese (AOAC official method 968.08), copper (AOAC official method 968.08), zinc (AOAC official method 968.08), moisture (AOAC official method 930.15) and gross energy were analyzed using a bomb calorimeter (Par Instrument Co., Moline, IL) for crops and gizzards contents. All analyses were performed in duplicate.

**Statistical analyses**

The effect of the production system, sex, feed regimen and chicken type on growth performance and chemical properties of the crops and gizzards contents was determined using the PROC GLM of SAS (2012). The following model was used: $Y_{ijklm} = \mu + P_i + C_j + F_k + S_l + (C\times P)_{ij} + (F\times C)_{jk} + E_{ijklm}$

Where:

$Y$ = average daily weight gain (AGD) and chemical properties of the crops and gizzards contents (moisture, crude protein, calcium, crude fat, phosphorus, magnesium, sodium, iron, manganese, copper and zinc levels in the crops and gizzards contents),

$\mu$ = overall mean,

$P_i$ = effect of $i^{th}$ production system (indoor conventional system; scavenging system),

$C_j$ = effect of $j^{th}$ chicken type (local chickens; local chickens x broiler crossbreds),

$F_k$ = effect of $k^{th}$ feed regimen (sorghum + kitchen waste; broiler grower diet),

$S_l$ = effect of $l^{th}$ sex (male, female),

$C \times P$ = interaction between production system and chicken type,

$F \times C$ = interaction between feed regimen and chicken type,

$E_{ijklm}$ = random error.
All first and second-order interactions were tested. Only significant interactions were included in the final model. Mean separation was performed using the LSMEANS using the PDIFF option (SAS, 2012).

**Results**

Table 2 shows the interaction of production system and chicken type on the nutrient and mineral composition of crop and gizzards contents. The moisture content of the crop and gizzard contents was lower under indoor conventional system compared the scavenging system (P < 0.05). Under the scavenging system, local chickens had crops and gizzards contents with more moisture content than that from their crosses with broilers (P < 0.05) whilst there was no difference for those under the indoor conventional system (P > 0.05). The crop and gizzard contents from local chickens had the same crude protein and crude fat as their crosses with broilers under both systems (P > 0.05). Crude fat content in crop and gizzard contents was higher under the scavenging system than under the indoor conventional system (P < 0.05). The energy content of crop and gizzard contents from scavenging chickens was lower than that from chickens under indoor conventional system (P < 0.05). Chickens of the same type had high iron content in their crops and gizzards contents under scavenging system than the conventional system (P < 0.05). Local chickens under the conventional system had lower manganese and zinc in crops and gizzards contents than the rest of the chickens (P < 0.05).
Table 2
Interaction between production system and chicken type on nutrient and mineral composition of crops and gizzards contents

<table>
<thead>
<tr>
<th>Nutrient composition</th>
<th>Scavenging system</th>
<th>Indoor conventional system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local x broiler crossbred</td>
<td>Local chicken</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>11.3 ± 0.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.1 ± 0.77&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>crude protein (%)</td>
<td>30.1 ± 1.78&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30.4 ± 2.81&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>12.5 ± 1.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.4 ± 5.98&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Energy (MJ/kg)</td>
<td>17.1 ± 0.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.2 ± 1.47&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>0.8 ± 0.10</td>
<td>0.8 ± 0.19</td>
</tr>
<tr>
<td>Phosphorus (%)</td>
<td>0.9 ± 0.05</td>
<td>0.9 ± 0.06</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>1.3 ± 0.09</td>
<td>1.3 ± 0.15</td>
</tr>
<tr>
<td>Magnesium (%)</td>
<td>0.2 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.2 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sodium (%)</td>
<td>0.5 ± 0.02</td>
<td>0.5 ± 0.04</td>
</tr>
<tr>
<td>Iron (mg/kg)</td>
<td>1619.38 ± 353.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>655.7 ± 155.25&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Manganese (mg/kg)</td>
<td>178.6 ± 19.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>120.3 ± 28.83&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Copper (mg/kg)</td>
<td>45 ± 7.38</td>
<td>49 ± 12.63</td>
</tr>
<tr>
<td>Zinc (mg/kg)</td>
<td>323.3 ± 59.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>280.2 ± 62.80&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>ab</sup> Means with different superscripts, within a row, are different (P < 0.05)

Table 3 shows the interaction of feed regimen and chicken type on the nutrient composition of crops and gizzards contents. Local chickens fed sorghum plus kitchen waste had the highest energy content in their crops and gizzards contents when compared to local chickens fed on broiler grower diet and crossbreds fed on both feed regimens (P < 0.05). Irrespective of chicken type, chickens fed on sorghum and kitchen...
waste had lower Cu, Zn, Ca and P levels in their crops and gizzards contents than those fed on broiler grower diets (P < 0.05).

Table 3
Interaction between feed regimen and chicken type on nutrient and mineral composition of the crops and gizzards contents

Means with different superscripts, within a row, are different (P < 0.05)

<table>
<thead>
<tr>
<th>Nutrient composition</th>
<th>Sorghum plus kitchen waste</th>
<th>Broiler grower diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local x broiler crossbred</td>
<td>Local chicken</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>10.0 ± 0.99a</td>
<td>10.4 ± 0.87ab</td>
</tr>
<tr>
<td></td>
<td>10.8 ± 0.86ab</td>
<td>11.9 ± 0.77b</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>28.8 ± 2.53a</td>
<td>27.5 ± 2.40a</td>
</tr>
<tr>
<td></td>
<td>29.9 ± 2.05a</td>
<td>29.4 ± 2.88a</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>11.5 ± 1.55a</td>
<td>14.5 ± 4.69a</td>
</tr>
<tr>
<td></td>
<td>17.5 ± 6.75a</td>
<td>11.6 ± 0.64a</td>
</tr>
<tr>
<td>Energy (MJ/kg)</td>
<td>18.9 ± 0.92a</td>
<td>27.3 ± 4.32b</td>
</tr>
<tr>
<td></td>
<td>18.5 ± 0.89a</td>
<td>19.1 ± 1.81a</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>0.7 ± 0.22a</td>
<td>0.4 ± 0.13a</td>
</tr>
<tr>
<td></td>
<td>1.4 ± 0.28b</td>
<td>1.4 ± 0.26b</td>
</tr>
<tr>
<td>Phosphorus (%)</td>
<td>0.8 ± 0.05a</td>
<td>0.9 ± 0.08a</td>
</tr>
<tr>
<td></td>
<td>1.3 ± 0.15b</td>
<td>1.1 ± 0.15b</td>
</tr>
<tr>
<td>Potassium (%)</td>
<td>1.1 ± 0.10a</td>
<td>1.5 ± 0.14b</td>
</tr>
<tr>
<td></td>
<td>1.3 ± 0.11b</td>
<td>1.2 ± 0.09ab</td>
</tr>
<tr>
<td>Magnesium (%)</td>
<td>0.3 ± 0.02a</td>
<td>0.2 ± 0.03a</td>
</tr>
<tr>
<td></td>
<td>0.2 ± 0.025a</td>
<td>0.2 ± 0.03a</td>
</tr>
<tr>
<td>Sodium (%)</td>
<td>0.7 ± 0.16a</td>
<td>0.6 ± 0.06a</td>
</tr>
<tr>
<td></td>
<td>1.2 ± 0.66a</td>
<td>0.6 ± 0.02a</td>
</tr>
<tr>
<td>Iron (mg/kg)</td>
<td>1297.6 ± 406.22a</td>
<td>558.3 ± 182.13bc</td>
</tr>
<tr>
<td></td>
<td>943.1 ± 219.13ab</td>
<td>420.3 ± 156.42c</td>
</tr>
<tr>
<td>Manganese (mg/kg)</td>
<td>143.4 ± 42.16a</td>
<td>52.8 ± 16.15c</td>
</tr>
<tr>
<td></td>
<td>213.3 ± 12.38b</td>
<td>194.5 ± 26.69ab</td>
</tr>
<tr>
<td>Copper (mg/kg)</td>
<td>74.8 ± 43.12a</td>
<td>24.4 ± 4.92b</td>
</tr>
<tr>
<td></td>
<td>57.3 ± 9.25a</td>
<td>121.5 ± 65.59a</td>
</tr>
<tr>
<td>Zinc (mg/kg)</td>
<td>168.8 ± 18.76a</td>
<td>155.1 ± 34.02a</td>
</tr>
<tr>
<td></td>
<td>429.8 ± 39.26c</td>
<td>334.6 ± 36.97b</td>
</tr>
</tbody>
</table>

Figure 1 shows the growth performance of local chickens and their crosses with broilers under different production systems. Local chickens and their crosses with broilers had higher average daily weight gain under the scavenging system than the indoor production system (P < 0.05). Local chickens x broiler crossbreds had higher average daily gain than local chickens under the indoor conventional system and vice versa under the scavenging system (P < 0.05). Figure 2 shows the growth performance of local chickens and their crosses with broilers fed different feed regimens. For both chicken types, the average
daily weight gain of chickens fed on broiler grower feed was higher than those on sorghum plus kitchen waste (P < 0.05). When on the same feed regimen, local chickens and their crosses with broilers had the same growth rates (P > 0.05). Local x broiler crossbred chickens had higher liveweights from week 1 to 8 when fed on broiler growers than when fed on sorghum + kitchen waste diet (P < 0.05; Fig. 3a). Local x broiler crossbred chickens under the scavenging system had higher liveweights than those in indoor conventional system from week 1 to week8 (P < 0.05; Fig. 3b).

Discussion

There is increasing interest in combining the hardiness of local chickens with the feed efficiency of fast-growing improved breeds through crossbreeding. As such, it is important to understand the performance of the crossbreds between local and fast-growing improved chickens under different production systems. The observed differences in moisture content in gizzard and crop contents of scavenging and non-scavenging chickens can be due to differences in diet, exercise, and environmental conditions. In tropical climates, scavenging chickens consume more water than those indoors because they are exposed to high temperatures and exercise more as they scavenge (Abioja and Abiona, 2021). Scavenging chickens also consume feed resources such as a fresh plant leaves and grass which have high water content (Ncobela and Chimonyo, 2015). The high moisture content can therefore be ascribed to high water intake of scavenging chickens coupled with low water loss due to humid conditions. High moisture content in the gizzard and crop contents may promote digestive activities in the gastrointestinal tract of the chickens (Rodrigues and Choct, 2018). The finding that local chickens had gizzard and crop contents with more moisture content than their crosses with broilers might be an indication of genotype-based physiological differences among scavenging chickens as an adaption to the production systems. Further studies on the physiological and behavioural factors behind the observed differences in moisture content of the gizzard and crop contents are necessary.

High fat content in gizzard and crop contents of scavenging chickens resonated with Pousga et al. (2005) and Mwalusanya et al. (2010) who argued that fat intake by scavenging chickens can be high in tropical areas due to abundance of fat sources such as insects and worms among others for the scavenging chickens. The same reason can be tributed to the high iron content in gizzard and crop contents for scavenging chickens than those kept indoors. Low energy content in gizzard and crop contents of scavenging chickens as compared to those under indoor systems might be an indication that the scavenging feed resource base had low energy sources. Energy has been reported as a major limiting nutrient for scavenging chickens (Rashid et al., 2004; Ncobela and Chimonyo, 2016). Scavenging chickens, therefore, requires energy supplementation. The energy, fat and iron intake, however, also depends on the scavenging ability of the chickens (Ncobela and Chimonyo, 2016). The fact that crosses between local chickens and broilers herein had gizzard and crop contents with the same iron, energy, and fat content as that from local chickens shows that they have the similar scavenging abilities for iron, energy, and fat sources. In agreement to findings herein, Raphulu et al. (2015) reported low concentrations of trace elements in crop contents of scavenging local chickens. The finding that crosses between local chickens and broilers had more Mn and Zinc than local chickens could be an indication
that they ingest more soil which is the main source for trace elements for scavenging chickens (Raphulu et al., 2015).

The finding that energy content in gizzard and crop contents of local chickens fed sorghum plus kitchen waste was higher than broilers x local chickens crossbreds on the same diet could because of the variability in composition of kitchen waste and, thus nutrient content. One of the challenges for scavenging chicken systems is the large daily and seasonal variability in nutritional content of feed sources such as kitchen waste (Alshelmani et al., 2021). The feed sources for scavenging systems can, sometimes, have higher energy content than conventional feed sources (Raphulu, 2019) as observed in this study were gizzard and crop contents from local chickens fed on kitchen waste plus sorghum diet had more energy content than those fed on broiler diets. This is, however, not consistent, and the ability to adapt the variability in nutrient content of the feed sources is a desirable characteristic for scavenging chickens.

The finding that trace elements such as Cu, Zn, Ca and P were low in gizzard and crop contents of chickens fed on kitchen waste and sorghum than those fed on broiler growers’ diet was expected. Although sorghum grain is a rich source of minerals including magnesium zinc and calcium (Mabelebele et al, 2015), a sorghum plus kitchen waste only diet cannot meet the chickens’ Cu, Zn, Ca and P requirements as it cannot match the levels in broiler growers’ diet. This might also be part of the explanation of why chickens fed on growers had higher growth rates and liveweights than those on sorghum plus kitchen waste.

The finding that both local chickens and their crossbreds with broilers had higher growth rates and liveweights under the scavenging systems contradicts literature. Li et al. (2017) found that the growth performance of medium-growing chickens was higher under cage and indoor-floor systems than the free-range system. Li et al. (2011) also found that the performance of Chinese local chickens under scavenging systems was lower than under indoor systems. Limited feed resource base, exposure heat and increased exercise whilst scavenging have been attributed as the major causes of poor growth performance of scavenging chickens (Ncobela and Chimonyo, 2016). The observed differences might be due to differences in shed provision in form of coconut trees in the pens, supplementation and a rich feed resources base found under tropical conditions.

The observed growth performance differences between local chickens and their crossbreds with broilers under the two production systems are more likely to be genetic. Youssao et al. (2012) suggested that differences in growth performance of chickens under the same production system can be attributed to differences in their genetic make-up. At can, therefore, be insinuated that local chickens in this study grow better than their crosses with broilers under the scavenging system because they are more suited to the system whilst the crosses do better than local chickens under indoor systems. The finding that local chickens and their crosses with broilers had the same growth rates when fed on the same feed regimen was unexpected. Khawaja et al. (2012), Castellini et al. (2016) and Mancinelli et al. (2023) reported that
crossbreds between fast-growing and hardy slow-growing chickens have better growth performance than their purebred counterparts. The unexpected findings warrant further exploration.

**Conclusion**

Crosses between local chickens and broilers have the similar scavenging abilities as denoted the same energy and fat content in their crop and gizzard contents. The crosses between local chickens and broilers had high levels for trace elements in their crop and gizzard contents further indicating their scavenging abilities. Indoor chickens fed on kitchen waste plus sorghum diet have low levels of trace elements such as Cu, Zn, Ca, and P. Although crosses between local chickens and broilers grew better local chickens under indoor systems but not scavenging systems, their growth performance was better under scavenging systems than indoor systems. It can be concluded that crossbreds between local chickens and broilers matches the scavenging abilities of the local chickens but not their growth performance under scavenging systems. Further studies on feed intake and nutrient digestion of the crossbreds between local chickens and broilers are necessary.

**Declarations**

**Author contribution** Lorenzo Tiko Berukilukilu: study conception and design, data collection, analysis, and drafting the first version of the manuscript. Archibold Garikayi Bakare: study conception and design, data analysis, manuscript editing. Paul Ade Iji: study conception and design, manuscript editing. Titus Jairus Zindove: study conception and design, data analysis, manuscript editing.

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**Data availability** Data will be made available on request.

**Ethics approval** The handling and usage of animals during the experiment were approved by the Fiji National University Animal Ethics Committee (FNU-AREC-22-002)

**Consent for publication** All authors revised and approved the final manuscript.

**Conflict of interest** The authors declare no competing interests.

**References**


Figures

Figure 1

Average daily gain of local chicken and their cross with broilers under scavenging and indoor conventional systems
Figure 2

Average daily gain of local chickens and their cross with broilers fed on sorghum plus kitchen waste and broiler grower diet.

Figure 3

Liveweight a) local x broiler crossbred chickens fed on sorghum + kitchen waste and broiler grower diet over a period of 8 weeks b) local x broiler crossbred chickens under indoor conventional and scavenging systems