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Evaluation of Carcass Traits, Meat Quality, and Sensory Attributes in Slow-Growing Indigenous Chickens Under Intensive and Pasture-Based Rearing Systems

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Abstract

This study assessed the effect of the rearing system on carcass traits, meat quality and sensory attributes of slow-growing indigenous chicken raised on pasture lands. Semi-intensive pasture-raised (PRS) with six replicates and intensive system (IS) with three replicates were tested. Live weight at slaughtering, total carcass yield, yield of meat cuts, and meat quality parameters were collected. Dressing percentage was calculated. Sensory attributes of broiler meat vs PRS meat and IS meat were also evaluated. The data revealed significantly higher (p<0.05) average carcass weight per bird in the IS (954.42±31.20 g) than in the PRS (774.29±22.06 g). The rearing system did not affect the dressing percentage, yield of different meat cuts, WHC, pH and L* values. However, gizzard as a percentage of total carcass yield of PRS (4.12±0.13) was significantly higher (p<0.05) than the IS (3.34±0.18) birds. Furthermore, a* and b* values of PRS meat were significantly higher (p<0.05) than the IS. Sensory evaluation data showed no significant difference in taste, tenderness, odour, appearance or overall acceptability between broiler, PRS or IS meat. However, comparatively higher mortality was observed in PRS due to predator attacks during the daytime.

Furthermore, both cost and income per bird (LKR) were significantly higher

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(p<0.05) in IS (1085.55±11.17 and 1266.00±33.81, respectively) than the PRS (975.18±6.45 and 1087.50±19.52, respectively). However, the profit per bird was not significantly different. Considering meat quality and sensory attributes, it can be concluded that the slow-growing Indigenous meat could be introduced as a substitute for early-aged slaughtered broiler meat.

Keywords: Intensive system, Pasture-raised, Semi-intensive system, Sensory attributes

Introduction

The global poultry industry has expanded rapidly over the past few decades, with chicken meat emerging as the dominant source of animal protein due to its affordability, higher protein content, and lower fat levels than other meat types (Vida and Szakály, 2023). However, increased meat consumption is mainly observed in the broiler sector globally (Roiter *et al*., 2023). Due to the growing demand, birds with faster growth rates were developed so that within a shorter period birds grew to a size fit for human consumption. Thus, specialized poultry feeds were introduced to the market to achieve a rapid broiler growth rate within a shorter period (Ahmad *et al*., 2018).

At present, meat consumers are more concerned about the rearing system, animal welfare, production procedure, safety, and quality. Therefore, there has been a growing demand towards alternative poultry production systems, such as free-range and pasture-raised methods. These systems, which prioritize animal well-being and natural rearing conditions, are seen as more sustainable (Castellini *et al*., 2008; Husak *et al*., 2008). In particular, slow-growing indigenous chicken, often raised under pasture-based systems, are gaining attention due to their potential to produce superior meat quality, enhanced flavour, and improved texture compared to conventional broilers (Sossidou *et al*., 2015; Jin *et al*., 2019). Furthermore, the success of *Label Rouge,* an official regulated symbol of premium quality products in France, has contributed to higher retail prices and a shift towards more sustainable practices in Europe (Fanatico and Born., 2002). Further, birds raised in the *Label Rouge* system produced meat with a firmer texture, darker colour, and more desirable flavour, leading to improved production outcomes (Packard, 2014).

Small-holder indigenous poultry farmers in Sri Lanka currently face many challenges due to competition from well-established commercial meat brands. To overcome this market disadvantage, meat from small-holder farners must be marketed under a eputable meat brand. Achieving this requires consistent production of high-quality products. Understanding how different rearing systems influence carcass traits and overall meat quality in slow-growing indigenous chickens is essential for assessing their potential as a viable alternative to conventionally raised broilers. Therefore, this study aims to evaluate the carcass characteristics, meat quality, and sensory attributes of slow-growing indigenous chicken raised under intensive and pasture-based systems. By comparing these two rearing methods, this research seeks to determine the market viability of indigenous chicken meat, emphasizing its quality attributes and potential as a sustainable alternative to early-slaughtered broiler meat.

Materials and methods

Experimental site

The experiment received the ethical clearance with the approval of the Research Ethics Committee of the *Uwa Wellassa* University of Sri Lanka (UWU/REC/2022/7).

The experiment was undertaken in two consecutive periods; Experiment 1; from 24th February 2022 to 15th May 2022 and Experiment 2; from 10th August 2022 to 30th October 2022. The brooding and post-brooding periods were undertaken at the Faculty Farm, Faculty of Agriculture (8.37136° N, 80.41639° E), Rajarata University, Sri Lanka. The field trials were conducted at the School of Agriculture, *Puliyankulama*, Anuradhapura (8.37313° N, 80.42086° E), Sri Lanka and it was established under a medium-scale coconut plantation having more than 30-year-old palms. The experimental sites were situated at an altitude of 89 m above sea level. Meat quality characteristics were analyzed at the Animal Science Laboratory, Faculty of Agriculture, Rajarata University of Sri Lanka.

Experimental design

There were two treatments (Treatment and Control) in this experiment. The rearing of the slow-growing chicken under a semi-intensive system called 'pasture-raised system (PRS)' was considered as the treatment and the rearing of slow-growing birds under an intensive system (IS) was considered as the control. The birds in both systems were fed with the same formulated feeds; starter, grower and finisher diets. There were six replicates in the PRS and each replicate consisted with 21 birds and similarly, there were three replicates in the IS where each replicate had 21 birds.

Formulation of diets

Three types of formulated diets (starter, grower and finisher) were fed to birds according to the nutrient recommendations described by Berger *et al*. (2021) based on their age. Commercially available feed ingredients; Rice (*Oryza sativa*) bran, dhal (*Lens culinaris*) dust, soybean (*Glycine max*) meal, wheat (*Triticum aestivum*) bran and maize (*Zea mays*) meal were used for the formulation of the cereal-based feed rations. HCL Lysine, DL-Methionine and a commercially available mineral mixture were also incorporated into three diets. The starter, grower and finisher periods were 28, 35 and 18 days, respectively.

Experimental birds

Two hundred, slow-growing Giriraj cross day-old chicks were purchased from a commercial hatchery (Miloshi Farm and Hatchery, Ragama, Sri Lanka).

Preparation of poultry units

The poultry houses were established at 1.2 m elevation from the ground to protect the birds from predators and ease of collection of poultry manure. Each poultry house had a floor space of 1.5×1.2 m^2 in length and width, respectively with 21 birds housed inside. The poultry house was in the center with a run area of 30×30 m^2 hence, the distance between the two poultry units was 30 m away from each other.

Management practices

Brooding management:

Chicks were given a brooding period of 14 days and another 16 days of post-brooding period as the birds were smaller in body size (0.12±0.002 kg). All chicks were provided with glucose (25g/L) on the day of arrival followed by Vitamin E (Selvit-E®) 1 mL/l L and antibiotic (Enrofloxacin 10%) 1 mL/2 L with drinking water consecutively for 3 days as a treatment for stress. All chicks were fed with the starter diet from day one to day 28. Birds were introduced to the research field at 30 days of age and when the body weight was 0.31±0.008 kg.

Disease management:

All birds were vaccinated with the Gumboro vaccine (Intermediate Type, Living BP) against Infectious Bursal Disease (IBD) at the age of 7 and 14 days and for New Castle Disease (Live, LaSota Strain, BP) at the age of 9 and 16 days. Coccidiostats (BIO-SUPER COC, W.S.P.) was provided with drinking water at the age of 12^{th} and 36^{th} days in trial 01 and 7^{th} and 28^{th} days in trial 02 to protect the birds from coccidiosis.

Other management practices:

The starter ration was provided from day one to 28 days of age, grower diet from 29 to 63 days of age followed by finsher diet from 64 to 81 days. After being introduced to the research field, birds in the PRS were in the run area from 7.00 am to 5.00 pm every day. Birds in the IS were kept inside the house throughout the study period. The birds under PRS were fed only 80% of the daily feed requirement but in the IS, a 100% of daily feed requirement was provided. During the rainy days (there were only 03 days of rain during the trial one), birds in the PRS were also kept inside the houses. But they were fed with cut pasture from the run area together with 80% of the formulated diet. Feed was provided two times per day; morning and evening at 7.00 am and 5.00 pm, respectively for both PRS and IS groups. Drinking water was available throughout the day.

Slaughtering

At 81 days of age, three birds were randomly selected from each replicate, regardless of gender. The birds were fasted for 12 hours and the major blood vessels (carotid arteries and jugular veins) were severed. Slaughtered birds were kept in killing cones for bleeding for at least 2 minutes. Slaughtered birds were scaled in hot water (56°C) for 2-5 minutes followed by defeathering (Karunanayaka *et al*., 2020).

Carcass traits

Average carcass weight:

The abdominal cavity was opened and the digestive tract, respiratory tract, heart and liver were removed. The gizzard was cleaned and the inner layer was removed (Karunanayaka *et al*., 2020). The total carcass yields were measured using an electrical balance (WEIGHTECHROLEX 2P-15B, China). Total carcasss weight of individual birds were measured and average carcass weight per bird was calculated.

Yield of different meat cuts:

Carcasses were portioned and the weight of the breast, thigh, wings and neck with bones and organ meats (heart and liver) and cleaned gizzard were measured using an electrical balance. Carcasses were stored at the freezing conditions (-18°C) for further analysis.

Dressing percentage:

The dressing percentage (DP%) was calculated using the equation described by Kareem-Ibrahim *et al*. (2021).

Sample preparation for analysis

Skinless breast muscle samples were stored in polythene bags at -18°C for physical parameter analysis. Meanwhile, additional meat samples were cut into pieces, oven-dried at 60°C for 12 hours, then ground and sieved through a 1 mm sieve and stored in airtight containers for proximate analysis.

Proximate analysis of meat samples

Prepared meat samples of PRS and IS were analyzed for the proximate composition; Ash content, ether extract (EE) were determined by using the muffle furnace (DMF3514, Korea and the solvent extraction unit (Velp Scientifica-SER 148, Italy), respectively. Crude fiber (CF) content was determined by Van Soest Analysis method by using the Fiber Extraction Unit (Microsil, India). Nitrogen content was determined using the Kjeldahl method (Velp Scientifica-DK 20, Italy) and crude protein content was calculated using the equation of N% x 6.25.

Meat quality parameters

pH was measured using the filtrate method determined using a pH meter (E-08328 ALELLA, Barcelona). Water holding capacity (WHC) was calculated using the method described by Karunanayaka *et al*. (2016). The values of lightness (L*), redness (a*) and yellowness (b*) were obtained at three different sites on the same thawed, skinless breast muscle using Colourimeter (Konica Minolta, CR 10, Japan).

Sensory evaluation

Commercially available broiler meat collected from a farm outlet in Anuradhapura, PRS meat and IS meat was cut into 2 cm × 2 cm × 2 cm cubes and steamed using an ordinary kitchen stove. Samples were labelled with random 3-digit numbers. Samples were placed on labelled white plates and served to 30 untrained panelists. Drinking water was provided for mouth rinsing. A 5-point hedonic scale (1=dislike extremely, 5=like extremely) was used to evaluate the appearance, odour, taste, tenderness and overall acceptability.

Cost-benefit analysis

Average cost, income and profit per carcass weight were also calculated.

Statistical analysis

Data related to meat production, dressing percentage, yield of different meat cuts, pH, WHC and colour (L*, a*, b*) values were analyzed using a nested linear model using General Linear Model (proc GLM). Treatment/Control was considered as a fixed effect. Replicate nested within treatment/control was considered as a random effect. The proximate composition of meat sample, cost per bird, income per bird and profit per bird were analyzed using one-way ANOVA procedure in SAS 9.0 (2002). Data related to sensory evaluation was analyzed using Friedman non-parametric method in Minitab 17 software. Means were separated according to Least Significant Procedure (LSD) in proc GLM and statistical significance was given as $p<0.05$.

Results and discussion

The aim of this study was to introduce slow-growing indigenous chicken meat as a substitute for early age slaughtered broiler meat by evaluating the carcass traits and meat quality. Hence, a slow-growing Giriraj crossbred was tested in this study whether they can be reared for meat purposes adapting the *Label Rouge* principles in Sri Lanka. Accordingly, cereal-based starter, grower and finisher diets were formulated. Poultry house and run area were designed considering the space requirement per bird. The birds in the PRS were allowed to have free grazing during the daytime allowing them easy access to edible weeds in the run area.

Carcass traits

Meat yield depends on the stocking density and the age of slaughter. According to the *Label Rouge* principle, a farmer could rear the slow-growing birds either they grow upto 2 kg or before sexual maturity depending on the growth rate (Berger *et al*. 2021). The genotypes of the slow-growing birds reared in *Label Rouge* system in France is such that they can be slaughtered at the age of 81 days where the body weights would be 2 kg or more. However, the slow-growing birds in Sri Lanka have comparatively slower growth rates thus in the present study at the age of 81 days, they were only 1 kg of body weight. If we were to keep the birds till they gain a higher body weight of (2 kg) that would have increased the production cost as we do not have slow-growing genotypes specifically developed for *Label Rouge* system.

Average carcass weight:

The details of the average carcass weight per bird are summarized in Table 1. Results showed that a significantly higher (p<0.05) average carcass weight was observed in the intensive system than that of the pasture-raised system.

Table 1. Average carcass weight per bird and dressing percentage of pasture-raised and intensively reared slow-growing Indigenous chicken (mean ± standard error)

Parameter	PRS	IS
Average carcass weight (g)	774.29^{b}±22.06	954.42^{a}±31.20
Meat production (kg/Ha)	168.37±7.29	-
Dressing percentage (%)	72.16±2.71	76.71±3.84

a, b means within the same row with different superscripts were significantly different (p<0.05)

note: meat production per 1.8 m^2 in the IS system was 20.06±0.55 kg

Birds under the pasture-raised system spend energy on moving within the run area during the daytime which be one of the reasons for observed lower performances. A similar result was also explained by Dou *et al*. (2009) by testing the growth rate, carcass traits and meat quality of slow-growing chicken grown according to three raising systems. Present results were also agreed with the findings of Mutayoba *et al*. (2012) and Jahan *et al*. (2020). They found that the intensively reared chickens were significantly (p<0.05) heavier than those of semi-scavenging chickens.

Dressing percentage:

Results revealed that there was no significant impact of the rearing system on dressing percentage. The results confirmed the findings of Sanka (2014), that there was no significant difference between dressing percentages in Tanzanian local chicken reared under intensive and semi-intensive production systems. Furthermore, the current findings were higher than the dressing percentage of 50% observed in Giriraja X native chickens, which was reported as 71.7% in Nepal (Sah *et al*., 2011).

Yield of different meat cuts:

Results of the proportional yield of different meat cuts are presented in Table 2.

Table 2. Effect of rearing system on carcass traits of slow-growing Indigenous chicken (mean ± standard error)

Parameter	PRS	IS
Breast%	20.85±0.37	21.47±0.53
Legs%	29.18±0.31	30.00±0.44
Wings%	13.39±0.26	12.49±0.37
Neck%	5.57±0.30	5.55±0.42
Organ	6.56±0.69	5.43±0.97

meat%		
Gizzard%	4.12[a]±0.13	3.34[b]±0.18

[a, b] means within the same row with different superscripts were significantly different (p<0.05)

There was no significant impact of the rearing system (either IS or PRS) on breast, legs, wings, neck and organ meat yields. Present findings were in agreement with the results of Dou *et al*. (2009) and Fanatico *et al*. (2005). In contrast, Castellini *et al.* (2002a) found that the breast and thigh meat yield was increased when birds had outdoor access. Indigenous crossbreeds are often raised in free-range or pasture-based systems, where they are more active and engage in regular movement. This increased physical activity can lead to stronger leg muscles (Berg & Lovland, 2008; Havenstein *et al*., 2003).

In the present study, gizzard weight as a percentage of the total carcass yield of PRS was significantly higher (p<0.05) than IS birds. This could be attributed to the more natural foraging behavior of the pasture-raised birds, which may result in greater development of the gizzard, an organ crucial for grinding food in birds that consume whole grains or forage, stone and any edible objects available in the run area. Similar findings were reported by Durali *et al.* (2014); Iqbal *et al.* (2018) and Dou *et al.* (2009) that birds reared under a free-range management system had a significantly heavier gizzard.

Proximate composition of pasture-raised and intensively reared indigenous meat

Results of the proximate composition of PRS and IS meat were summarized in Table 3.

Table 3. Proximate composition of pasture-raised and intensively reared slow-growing Indigenous chicken (mean ± standard error)

Parameter	PRS	IS
CP%	21.94±0.11	20.68±0.17
EE%	1.77±0.35	2.56±0.43
CF%	0.68±0.12	0.64±0.12
Ash%	5.036±0.36	4.39±0.69

CP%- crude protein, EE%-ether extract, CF%-crude fiber

The proximate composition of meat depends on breed, age, diet, management and environmental conditions while the physical and chemical composition of meat depends on sexual maturity, growth potential, muscle development, age of slaughter and sex of birds (Gnanaraj *et al*., 2020). Results revealed that there was no significant difference in crude protein, ether extract, crude fibre and ash contents between PRS and IS meat.

Meat quality parameters

The pH, colour (L*, a*, b* values), and water-holding capacity (WHC) of the breast muscles collected from PRS and IS meat are shown in Table 4. The WHC, pH and L* values were not significantly different among PRS and IS but a* and b* values of meat of the PRS were significantly higher (p<0.05) than the IS.

Table 4. Meat quality parameters of pasture-raised and intensively reared slow-growing Indigenous chicken (mean ± standard error)

Parameters	PRS	IS
pH	6.75±0.03	6.76±0.04
Water Holding Capacity (%)	72.93 ±1.15	75.44±1.63
Colour values		
L* value	66.59 ±0.79	66.52±1.12
a* value	5.48^{a}±0.28	4.24^{b}±0.39
b* value	13.17^{a} ±0.41	11.22^{b}±0.58

$^{a, b}$ means within the same row with different superscripts were significantly different (p<0.05)

Meat colour is the most significant quality attribute which affects customer preference and demand for meat and meat products. The genetic capability of poultry breeds, dietary source of pigments, health status of the birds and method of processing are the factors that affect the ultimate meat colour. The results of the present study also showed that the management system has a positive impact on meat colour as observed by Cygan-Szczegielniak and Bogucka (2021).

In this study, there was no significant difference in the Lightness (L* value) of meat between PRS and IS systems. But the redness (a* value) and yellowness (b* value) of PRS meat was significantly higher (p<0.05) than that of the IS meat agreeing with the findings of Owens *et al*. (2006) and Küçükyılmaz *et al*. (2012). This increased redness could be associated with the increased myoglobin content due to physical activities associated with access to the outdoors (Cygan-Szczegielniak and Bogucka, 2021). Furthermore, the age of the birds could also affect the redness value of the meat. The increased yellowness of the meat of PRS may be associated with the outdoor access and consumption of green forages available in the run area. Moreover, it indicates that the forage and formulated diet both caused increased yellowness of meat due to higher carotenoid pigment content as shown by Küçükyılmaz *et al*. (2012).

Sensory evaluation

The results of the sensory evaluation are summarized in Figure 1. Results showed that there was no significant difference in taste, tenderness, odour, appearance or overall acceptability between conventional broiler, intensively reared (IS) or pasture-raised slow-growing indigenous chicken (PRS) meats. Farzana *et al*. (2017) also reported that the colour, flavour and overall acceptability were not significantly different between commercial broiler chicken and indigenous chicken. But in contrast, the above authors observed that the tenderness and juiciness were significantly higher (p<0.05) in commercial broiler meat which was not observed in the present study.

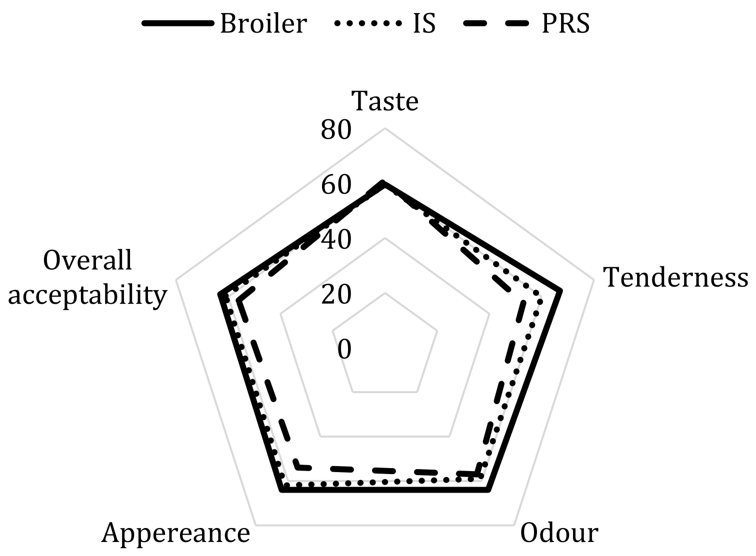

Figure 1. Sensory evaluation of broiler vs intensively reared Indigenous meat (IS) vs pasture raised indigenous meat (PRS)

Sensory perception is mainly affected by assessor training. Owens *et al*. (2006), reported that a trained panel is able to detect some differences in texture and flavour between organic and conventional broiler meat whereas an untrained panel is unable to indicate any difference. Furthermore, consumer preference is related to what consumers are familiar with and as a result of long-term exposure to conventional broiler meat flavours may cause resistance in accepting any other flavours (Castellini *et al*., 2008).

Overall, Fanatico *et al*. (2007a), stated that the genotype had more impact on sensory attributes than does production system. But in contrast, Castellini *et al*. (2002b) found that organic production resulted in better sensory attributes than that of conventional production in terms of overall acceptability and juiciness.

Cost-benefit analysis

The summary of cost per bird, income per bird and profit per bird were presented in Table 5.

Table 5. Cost, income and profit per bird of pasture-raised and intensively reared slow-growing Indigenous chicken (mean ± standard error)

Components	PRS	IS
Cost per bird (LKR)	975.18^{b} ±6.45	1085.55^{a}±11.17
Income per bird (LKR)	1087.50^{b}±19.57	1266.00^{a}±33.81
Profit per bird (LKR)	112.32±16.06	180.45±27.81

[a, b] means within the same row with different superscripts were significantly different (p<0.05)

The results clearly showed that the IS system had a significantly higher (p<0.05) cost per bird compared to the PRS system, indicating that the IS system may require higher expenditures, particularly for feed. Despite these increased costs, the IS system generates substantially higher income per bird. This is largely due to the significantly higher average carcass weight in the IS system, observed compared to the PRS system. Therefore, while the IS system incurs higher costs, its ability to produce larger, more profitable birds makes it financially advantageous in terms of overall income.

Conclusion

The study demonstrated that the rearing system did not significantly affect key carcass traits such as dressing percentage or the yield of various meat cuts. However, a significant difference was observed in the gizzard weight in the PRS group compared to the IS group. Furthermore, the analyses indicated no impact of the rearing system on pH, WHC and lightness (L*) of meat. These results suggest that the two rearing systems, despite their differences in environment and management, produce meat with similar attributes in terms of basic physical and chemical properties. However, significant differences were found in the redness (a*) and yellowness (b*) of the meat, with pasture-raised meat exhibiting higher values in these color parameters.

However, despite the fact that the intensive rearing system produced higher quantities of meat, no differences were found in sensory attributes such as odour, appearance, taste, tenderness, or overall acceptability and neither in the quality of meat.

Thus, the present study shows that slow-growing chicken has the potential for meat purposes and depending on the farmer's preference, the birds can be reared either with the outdoor access free range system or as the intensive management system. The findings also highlight the potential for establishing a niche market for pasture-raised poultry, particularly due to its animal-friendly production system. However, the farmers in Sri Lanka may need further assistance to establish a separate market channel with a premium brand name for this slow-growing pasture-raised chicken meat.

The sensory and quality attributes of the meat were not negatively affected by the pasture-based system, which strengthens the argument for its market potential, especially as consumers become more conscious of animal welfare and looking for products that align with these values. Furthermore, the IS system acquires higher costs, and its ability to produce larger, more profitable birds makes it financially advantageous in terms of overall income.

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Conflict of interest

The authors declare that there is no conflict of interest.

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