

Carcass characteristics of dual-purpose chicken genotypes under natural and irrigated-lucerne foraging systems at Matopos Research Station, Zimbabwe

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Research Article

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Abstract

Background: Feed cost limits productivity of Boschveld dual-purpose chickens in smallholder systems, often exceeding 70% of total production cost. Fresh lucerne *Medicago sativa* forage can supplement scavenging diets, but its effect on carcass yield, meat sensory quality, egg traits and reproduction of Boschveld chickens under Zimbabwean conditions is poorly documented. Objective: To evaluate the effects of fresh lucerne forage under semi-intensive management on production, carcass, sensory and reproductive traits of Boschveld chickens compared to extensive management.

Methods: The trial was conducted at Matopos Research Institute, Livestock Nutrition Section, and approved by the Department of Research Specialist Services, DR&S. One hundred and fifty 12-week-old Boschveld pullets were allocated to 2 treatments in a Completely Randomized Design with 3 replicates: T1 = Extensive: scavenging + 50g sorghum/bird/day, no lucerne; T2 = Semi-intensive: scavenging + 50g sorghum/bird/day + *ad libitum* fresh irrigated lucerne during the day. Water was provided *ad libitum*. No vaccinations were administered. At 60 weeks, 12 hens/treatment were slaughtered for carcass and meat sensory evaluation. Eggs were collected daily to 72 weeks for weight, circumference, hatchability and sensory analysis. Data were analyzed by one-way ANOVA at $P \leq 0.05$.

Results: Semi-intensive + lucerne significantly increased breast weight 261.3g vs 291.7g, $P < 0.001$ and liver weight 44.5g vs 51.6g, $P = 0.031$, but reduced gizzard 61.6g vs 48.1g, back 319.8g vs 302.4g and neck 89.1g vs 85.0g, $P < 0.05$. Live weight and dressing percentage were not affected, $P > 0.05$. For meat sensory, only juiciness improved significantly 1.92 vs 3.33, $P = 0.004$. Lucerne significantly increased egg yolk colour: raw yolk 1.52 vs 2.64, $P = 0.045$; cooked yolk 1.85 vs 4.62, $P < 0.001$, with no effect on egg preference, texture, weight, circumference, hatchability or dead-in-shell, $P > 0.05$.

Conclusion: Access to fresh lucerne forage under semi-intensive management improved breast meat yield, liver size, meat juiciness and egg yolk colour of Boschveld chickens without negative effects on sensory acceptability or reproductive performance. Lucerne is a viable low-cost forage to improve product quality and market value of Boschveld systems, contributing to SDG 2: Zero Hunger.

1. Introduction

Indigenous chicken breeds are a cornerstone of food security and rural livelihoods in sub-Saharan Africa due to their adaptation to low-input, scavenging systems, tolerance to heat stress and endemic diseases, and dual-purpose traits for both meat and eggs (FAO, 2022; Mtileni et al., 2021). In Southern Africa, the Boschveld chicken is a locally developed dual-purpose breed created by crossing Venda, Ovambo and Naked Neck genetics. It is promoted for its hardiness, predator awareness, good mothering ability, and moderate growth rate under scavenging conditions (DR&SS Botswana, 2024; Van Marle-Köster & Nel, 2020). Despite these adaptive advantages, productivity of Boschveld chickens remains constrained by seasonal feed scarcity, low nutrient density of scavenged diets, and high cost of commercial concentrates, which can exceed 70% of total production cost for smallholder farmers (Sebei et al., 2020).

Seasonal variation in feed availability leads to poor body weight gain, delayed age at first egg, low egg production, and reduced carcass quality, limiting the income and nutrition benefits farmers derive from indigenous poultry (Mapiye et al., 2021). Addressing this feed constraint without increasing dependence on purchased concentrates is therefore critical for sustainable intensification of smallholder poultry systems. Forage legumes present a low-cost, climate-smart strategy to improve nutrient intake in scavenging systems. *Medicago sativa* L., commonly called lucerne or alfalfa, is a deep-rooted perennial legume valued for its high crude protein content of 15–22%, balanced profile of essential amino acids including lysine and methionine, and high concentrations of vitamins A, D, E, K and B-complex (Undersander et al., 2023; Mirzaei-Aghsaghali & Maheri-Sis, 2021).

When offered fresh, lucerne can supplement scavenged feed, reduce dependence on purchased grain, and provide bioactive compounds that may influence meat and egg quality. The high lysine and methionine content is particularly relevant for breast muscle development, which is the most valuable cut in indigenous chicken markets (Omojola & Bello, 2021). Lucerne is also rich in xanthophyll pigments, primarily lutein and zeaxanthin, which are efficiently deposited in egg yolk and adipose tissue (Gautier & Lebret, 2021). Deep yellow yolk color is strongly preferred by consumers in Zimbabwe and South Africa as a visual cue for “free-range” or “natural” production and attracts price premiums of 20–30% (Karadas et al., 2021).

Previous work in broilers and commercial laying hens has demonstrated that dietary lucerne increases yolk color due to carotenoid deposition, improves meat oxidative stability through antioxidant activity of vitamin E and polyphenols, and can enhance juiciness without negatively affecting sensory acceptability (Dal Bosco et al., 2022; Ponte et al., 2020; Surai & Fisinin, 2022). Studies in Tanzania and Nigeria using other forage legumes such as *Desmodium* have also reported improved carcass yields in indigenous chickens (Msoffe et al., 2022). However, data specific to dual-purpose indigenous chickens like Boschveld under Zimbabwean semi-arid conditions remain limited. Consumer acceptance of indigenous chicken meat is strongly linked to sensory traits such as color, juiciness, flavor, and texture, and any reduction in these traits would limit market uptake despite production gains (Chikwanha et al., 2023; Fletcher, 2020).

Therefore, evaluating the effect of fresh lucerne forage on growth, carcass yield, meat sensory attributes, egg quality and reproductive performance of Boschveld chickens is critical for informing extension recommendations and market development strategies for semi-intensive systems aligned with Sustainable Development Goal 2: Zero Hunger (FAO, 2022). We hypothesized that access to fresh lucerne forage under semi-intensive management would improve breast meat yield, liver size, meat juiciness, egg yolk color and egg production of Boschveld chickens compared to extensive management with sorghum supplementation only, without compromising sensory acceptability or hatchability.

2. Materials and methods

2.1 Experimental site and ethical approval

The study was conducted at Matopos Research Institute, Livestock Nutrition Section, Bulawayo, Zimbabwe, located at 20°24'S, 28°30'E at an altitude of 1,330 m. The area is classified as agro-ecological region IV, receiving an average annual rainfall of 550 mm, with a distinct wet season from November to March. Mean temperatures range from 12°C in winter to 28°C in summer. The trial protocol was approved by the Department of Livestock Research and Specialist Services, DR&SS, before commencement, reference number DR&SS/ETH/2023/04. The experiment ran from 12 weeks to 72 weeks of age to cover the full production cycle of dual-purpose hens from point-of-lay to end of first laying cycle.

2.2 Birds, housing and experimental design

A total of 150 Boschveld dual-purpose pullets aged 12 weeks were sourced from the institute's breeding flock. Birds were wing-banded, weighed, and randomly allocated to 2 treatments in a Completely Randomized Design, CRD, with 3 replicates per treatment. Each replicate pen measured 4m x 5m with proper ventilation, concrete floor covered with wood shavings, and an attached paddock of 30m x 40m for scavenging/foraging. Each pen stocked 25 hens + 5 cocks, giving a stocking density of ~1.2 birds/m² indoors, within welfare guidelines for free-range systems.

Treatments:

T1 - Extensive

Birds scavenged in paddocks daily + 50g sorghum grain/bird/day as supplement after foraging + water ad libitum. No access to irrigated lucerne.

T2 - Semi-intensive

Birds scavenged in paddocks daily + 50g sorghum grain/bird/day after foraging + ad libitum access to fresh irrigated lucerne *Medicago sativa* during daylight hours + water ad libitum. Lucerne was irrigated and harvested daily at vegetative stage, 10–15 cm height, to maximize protein and minimize fibre. No vaccinations were administered during the trial to mimic typical smallholder conditions where vaccine access is limited. Paddocks were rotated weekly to maintain lucerne availability for T2 and prevent overgrazing. Feed troughs and drinkers were cleaned daily. The 50g sorghum supplement was provided late afternoon to ensure birds returned to shelter.

2.3 Data collection

2.3.1 Reproductive performance

Eggs were collected daily from week 20 to 72. Egg weight was recorded using a 0.01g precision scale and egg circumference measured with a thread + ruler. Hen-day egg production % was calculated as total eggs laid / total hen days x 100. For hatchability, 30 eggs from each replicate were incubated weekly in a forced-draft incubator at 37.5°C and 55% RH for 18 days, then 65% RH for hatching. Hatchability % =

chicks hatched / fertile eggs set x 100. Dead-in-shell % = embryos that died after day 18 / fertile eggs set x 100. Candling was done on day 7 and 18 to confirm fertility.

2.3.2 Carcass characteristics

At week 60, 4 hens per replicate per treatment = 12 birds/treatment were randomly selected, starved 12h with water access, weighed for live weight, and slaughtered by cervical dislocation according to humane slaughter guidelines. Carcasses were scalded at 60°C for 45s, defeathered, eviscerated, and chilled 4h at 4°C. Dressing percentage = hot carcass weight / live weight x 100. Weights of breast, thigh, drumstick, back, neck, wings, liver, heart, gizzard, feet, and middle joint were recorded using a 0.1g scale. All weights were recorded as absolute grams and as percentage of carcass weight to account for differences in live weight.

2.3.3 Sensory evaluation

Meat: Breast meat from each slaughtered bird was cooked in a water bath to an internal temperature of 74°C, cut into 2x2 cm cubes, and served warm to a 24-member semi-trained panel drawn from Matopos staff. Panelists were screened for ability to detect differences in chicken meat. They evaluated colour of carcass, preferred colour of cooked meat, texture, juiciness, aroma intensity, flavour, and overall acceptability using 6–8 point hedonic scales where higher scores = greater intensity/liking. Water and unsalted crackers were provided between samples to cleanse the palate. Samples were coded with random 3-digit numbers to avoid bias. Eggs: Raw yolk colour and cooked yolk colour were scored using the Roche Yolk Colour Fan 1–15 by 3 trained technicians. Preference and texture of boiled eggs were scored by the same panel on 5-point scales. Boiled eggs were cooked for 10 minutes, cooled, and served as halves.

2.4 Statistical analysis

All data were analyzed as CRD using one-way ANOVA in SPSS v20. Treatment means were separated using Tukey's HSD when ANOVA was significant at $P \leq 0.05$. Results are presented as Mean $\pm$ SD $\pm$ SEM. Significance declared at $P < 0.05$, trends noted at $0.05 < P < 0.10$. Normality was tested using Shapiro-Wilk and homogeneity of variance using Levene's test before ANOVA.

3. Results

3.1 Carcass characteristics

Management system had no significant effect on live weight and dressing percentage, $P > 0.05$, indicating similar overall growth and slaughter yield between systems. However, semi-intensive management with lucerne significantly increased breast weight by 30.4g, 261.3g vs 291.7g, $P < 0.001$ and liver weight by 7.1g, 44.5g vs 51.6g, $P = 0.031$. In contrast, extensive management significantly increased gizzard weight 61.6g vs 48.1g, back weight 319.8g vs 302.4g and neck weight 89.1g vs 85.0g, $P < 0.05$. Weights of heart, drumstick, middle joint, feet and thigh were similar, $P > 0.05$. This suggests

semi-intensive management directs nutrients toward breast muscle and metabolic organs, while extensive management promotes development of digestive organs for fibrous scavenged diets and structural parts due to increased physical activity.

Table 1
Carcass characteristics of Boschveld chickens foraging fresh Lucerne.

Sensory traits	Management		SEM	P. value
	Extensive	Semi-intensive		
	Mean $\pm$ SD	Mean $\pm$ SD		
Live weight	1843.0 $\pm$ 216	1930.5 $\pm$ 214	0.202	0.587
Dressing percentage	68.7 $\pm$ 1.2	66.7 $\pm$ 1.8	1.6	0.997
Liver	44.5 $\pm$ 3.1 ^b	51.6 $\pm$ 4 ^a	5.1	0.031
Heart	8.5 $\pm$ 1.7	9.4 $\pm$ 0.8	1.3	0.367
Gizzard	61.6 $\pm$ 1.2 ^a	48.1 $\pm$ 1.4 ^b	1.7	< .001
Breast	261.3 $\pm$ 2.14 ^b	291.7 $\pm$ 1.9 ^a	16.4	< .001
Drum stick	136.9 $\pm$ 2.9	138.2 $\pm$ 5.4	1.4	0.687
Back	319.8 $\pm$ 1.2 ^a	302.4 $\pm$ 1.8 ^b	9.3	< .001
Middle joint	122.2 $\pm$ 1.5	124.3 $\pm$ 2.8	2.4	0.245
Neck	89.1 $\pm$ 0.8 ^a	85.0 $\pm$ 1.9 ^b	2.3	0.016
Feet	37.8 $\pm$ 1.1	36.5 $\pm$ 1.7	1.5	0.233
Thigh	184.5 $\pm$ 0.8	185.2 $\pm$ 6.2	4.1	0.778

Means with different superscripts a,b within row differ significantly $P < 0.05$

3.2 Egg quality and reproductive performance

Fresh lucerne forage under semi-intensive management significantly increased hen-day egg production 44.4% vs 56.5%, $P < 0.001$. Egg weight 52.3g vs 56.4g, egg circumference 13.23 cm vs 13.42 cm, hatchability 78% vs 76% and dead-in-shell 6.4% vs 7.2% were similar between treatments, $P > 0.05$. This indicates that lucerne can be safely included in breeding flocks without compromising egg production efficiency or chick output. The numerically higher egg weight in lucerne-fed birds suggests potential nutritional benefit, but longer trials are needed to confirm. For egg sensory traits, semi-intensive birds foraging fresh lucerne laid eggs with much deeper/yellower yolks. Raw yolk colour went from 1.52 $\rightarrow$ 2.64, $P = 0.045$. Cooked yolk jumped from 1.85 $\rightarrow$ 4.62, $P < 0.001$. SEM was small, confirming the difference is real. Preference 1.18 vs 1.45 and texture 1.09 vs 1.00 were not different, $P > 0.05$, meaning

consumers did not prefer one over the other based on taste/texture. Texture scores ~1.0-1.1 suggest no toughening from lucerne.

Table 2
Effects of Foraging Fresh Lucerne on Egg Sensory Attributes and Reproductive Performance of Boschveld chicken eggs

Sensory traits	Management system		SEM	P. Value
	Extensive	Semi-intensive		
	Mean $\pm$ SD	Mean $\pm$ SD		
Egg weight	52.3 $\pm$ 1.6	56.4 $\pm$ 0.8	1.1	0.657
Hen egg production (%)	44.4 $\pm$ 0.6 ^b	56.5 $\pm$ 1.2 ^a	1.3	< 0.001
Egg circumference (cm)	13.23 $\pm$ 1.2	13.42 $\pm$ 2.3	1.0	0.532
Hatchability (%)	78 $\pm$ 1.9	76 $\pm$ 1.4	0.5	0.852
Death in the shell (%)	6.4 $\pm$ 0.5	7.2 $\pm$ 0.2	0.6	0.260
Raw yolk colour Roche Fan	1.52 $\pm$ 0.3 ^b	2.64 $\pm$ 0.24 ^a	0.21	0.045
Cooked yolk colour Roche Fan	1.85 $\pm$ 0.21 ^b	4.62 $\pm$ 0.15 ^a	0.36	< 0.001
Preference 1–5 scale	1.18 $\pm$ 0.23	1.45 $\pm$ 0.25	0.17	0.426
Texture 1–5 scale	109 $\pm$ 0.16	100 $\pm$ 0.14	0.10	0.672

Means with different superscripts a,b within row differ significantly P < 0.05

3.3 Meat sensory attributes

Only juiciness was significantly improved by lucerne access, 1.92 vs 3.33, P = 0.004. Colour of carcass 3.25 vs 3.25, preferred colour of cooked meat 4.33 vs 3.25, texture 3.67 vs 3.75, aroma intensity 1.75 vs 2.33, flavour 2.08 vs 3.25, and acceptance 1.75 vs 2.75 were not significantly different, P > 0.05. Numerically higher scores for aroma, flavour and acceptability in T2 suggest a positive trend that could become significant with longer feeding or larger panel size.

Table 3
Effect of fresh lucerne forage on meat sensory attributes of Bosch veld chickens.

Sensory attribute	Management system		SEM	P. value
	Extensive	Semi-extensive		
	Mean $\pm$ SD	Means $\pm$ SD		
Colour of raw meat 1–8 scale	3.25 $\pm$ 1.36	3.25 $\pm$ 1.96	0.23	0.726
Preferred colour of cooked meat 1–8 scale	4.33 $\pm$ 1.73	3.25 $\pm$ 1.96	0.38	0.165
Texture 1–8 scale	3.67 $\pm$ 1.1	3.75 $\pm$ 1.55	0.26	0.870
Juiciness 1–8 scale	1.92 $\pm$ 0.79 ^a	3.33 $\pm$ 1.3 ^b	0.26	0.004
Aroma intensity 1–8 scale	1.75 $\pm$ 0.97	2.33 $\pm$ 1.44	0.25	0.255
Flavour 1–8 scale	2.08 $\pm$ 1.73	3.25 $\pm$ 1.82	0.37	0.121
Acceptance 1–8 scale	1.75 $\pm$ 1.55	2.75 $\pm$ 1.87	0.35	0.167

Means with different superscripts a,b within row differ significantly $P < 0.05$

4. Discussion

4.1 Carcass traits and meat yield

Semi-intensive management with fresh lucerne forage significantly increased breast weight by 30.4 g and liver weight by 7.1 g compared to extensive management, $p < .05$. This agrees with studies in slow-growing and indigenous chickens where legume forages high in digestible protein 15–22% CP improve breast muscle deposition (Dal Bosco et al., 2022; Msoffe et al., 2022). Lucerne is rich in lysine and methionine, the first limiting amino acids for breast development, which likely explains the higher breast yield in T2 (Mirzaei-Aghsaghali & Maheri-Sis, 2021). The heavier livers in lucerne-fed birds reflect increased metabolic activity for nutrient assimilation and carotenoid processing, as the liver is the primary site for vitamin and pigment metabolism (Surai & Fisinin, 2022). Conversely, extensive birds had significantly heavier gizzards, backs and necks, $p < .05$. A heavier gizzard is a known adaptation to high-fiber, low-energy scavenged diets because birds need stronger grinding to break down fibrous feedstuffs and ingested grit (Abdelqader & Al-Fataftah, 2020). The increased back and neck weight in T1 may be due to more physical activity during scavenging and less energy directed to breast muscle. Live weight and dressing percentage were similar between systems, $p > .05$, indicating that lucerne improved carcass cut distribution rather than total body weight. This is economically important because breast meat commands higher market price than back/neck, often 40–60% more per kg in local markets (Omojola & Bello, 2021).

Fresh lucerne forage caused a highly significant increase in both raw and cooked yolk color, $p = .045$ and $p < .001$. The jump from 1.85 to 4.62 for cooked yolk confirms deposition of lutein and zeaxanthin from lucerne into yolk (Gautier & Lebret, 2021). Yellow yolk is preferred in Zimbabwe and South Africa as a visual cue for “free-range” or “natural” eggs and attracts 20–30% price premiums (Karadas et al., 2021). The significant increase in hen-day egg production from 44.4% to 56.5%, $p < .001$, suggests lucerne improved nutrient balance and reduced seasonal feed gaps, supporting better ovarian follicle development and reducing nutrient stress during lay. The absence of effect on egg weight, circumference, hatchability or dead-in-shell, $p > .05$, shows that lucerne supplementation did not disrupt reproduction when birds received 50 g sorghum as energy base. This matches findings in laying hens where 2–4% alfalfa meal improves yolk color without affecting laying rate or fertility (Karadas et al., 2021). Preference and texture scores for eggs were also not different, $p > .05$, meaning the deeper yolk color did not introduce off-flavors. This is critical for adoption, as consumers reject eggs with bitter or “grassy” taste (Chikwanha et al., 2023). The results support use of lucerne as a low-cost supplement for dual-purpose systems where both meat and chicks are income sources. Only juiciness was significantly improved by lucerne access, 1.92 vs. 3.33, $p = .004$. The higher juiciness may be due to antioxidants and vitamin E in lucerne reducing protein oxidation post-mortem, which improves water-holding capacity of meat (Ponte et al., 2020; Surai & Fisinin, 2022). Vitamin E and polyphenols in alfalfa have been shown to reduce lipid oxidation in poultry meat, preserving membrane integrity and moisture retention. Numerically higher scores for aroma, flavor and acceptability in T2, though not significant, suggest a positive trend that could become significant with longer feeding or larger panel size. Texture scores were similar, confirming that forage access did not toughen meat, unlike older scavenging birds > 72 weeks (Fletcher, 2020). Color of carcass and preferred color of cooked meat were not affected, $p > .05$. Boschveld chickens already have pigmented skin and darker meat than broilers, so 4 weeks of lucerne may be insufficient to alter breast color visibly. Longer trials or higher lucerne intake may be needed for color effects.

5. Conclusion

Access to fresh lucerne forage under semi-intensive management improved breast meat yield, liver size, meat juiciness, egg yolk color and hen-day egg production of Boschveld chickens without negative effects on sensory acceptability or reproductive performance. Lucerne is a viable low-cost forage to improve product quality and market value of Boschveld systems. Adoption of lucerne-based semi-intensive management can enhance household nutrition and income, contributing directly to SDG 2: Zero Hunger. Future studies should evaluate optimal lucerne inclusion levels, effects on meat oxidative stability during storage, economic analysis under farmer conditions, and farmer adoption pathways.

Declarations

Author Contributions: M.M. and P.N. conceptualized the study, conducted the trial and data collection at Matopos Research Institute. S.M. contributed to experimental design and manuscript editing. All authors reviewed and approved the final manuscript.

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