



**Timing fresh Azolla supplementation in improved indigenous chicken:
growth cost tradeoffs under Kenyan production scenarios**

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Abstract

Fresh Azolla may reduce purchased-feed requirements, but its economic value depends on the balance between feed savings, production costs and live-weight losses. This scenario analysis compared commercial feeding throughout a 20-week cycle (T1) with partial grower-feed restriction and fresh Azolla supplementation after week 12 (T2) or week 8 (T3). Projected performance summaries were combined with an itemized enterprise budget and deterministic sensitivity analysis. Final body weights were 1,778, 1,746 and 1,689 g, respectively; commercial feed requirements were 7.01, 6.09 and 5.72 kg per bird placed. At an assumed fresh Azolla cost of KES 12/kg and sale price of KES 550/kg live weight, recalculated production costs were KES 455.8, 442.0 and 442.2 per kilogram sold. Budget surpluses were KES 154.1, 173.0 and 168.3 per bird placed. Feed constituted 67.8% of the control budget, while labour accounted for 54.9% of Azolla production expenditure. The modeled cost advantage disappeared above approximately KES 21.8/kg fresh Azolla for T2 and KES 19.2/kg for T3. Later supplementation retained more live weight with a similar unit production cost. These conditional projections identify priorities for field evaluation; they do not establish feeding efficacy, survival effects or an optimal switching age.

Keywords: Azolla pinnata; improved indigenous chicken; supplementary feeding; enterprise budget; sensitivity analysis; Kenya

1. Introduction

Affordable feeding strategies are important to improved indigenous chicken production because purchased feed contributes substantially to enterprise expenditure. Kenyan research on alternative protein ingredients demonstrates that growth performance and economic returns should be evaluated together (Waithaka et al., 2022). Azolla is a floating aquatic fern with potential as a locally produced supplement, although its nutritive value varies with species, cultivation conditions and processing (Swain et al., 2022; Tran, 2015). Its high moisture content makes fresh-weight substitution fundamentally different from replacement on a dry-matter or nutrient basis (Alalade & Iyayi, 2006).

Feeding studies show that responses to Azolla depend on inclusion level and diet formulation. Trials with dried meal and fresh material provide evidence of nutritional potential, but do not establish a universally suitable substitution rate (Basak et al., 2002; Samad et al., 2020; Punyatong et al., 2024). Research on growth-related outcomes and dietary fibre further indicates that physical form, composition and digestive responses require attention (Abdelatty et al., 2020; Mateos et al., 2012). Economic

assessments likewise depend on the cost of producing or obtaining the supplement rather than assuming that home-grown biomass is free (Paudel et al., 2015).

The timing of supplementation introduces an additional trade-off. Earlier use extends the period of purchased-feed savings but may expose developing birds to greater nutrient dilution. Later use can reduce cumulative savings while protecting weight accumulation. This analysis examines that trade-off under defined Kenyan production scenarios, focusing on cost per kilogram sold, budget surplus and break-even Azolla cost. The aim is to identify testable economic conditions rather than prescribe an unverified feeding schedule.

2. Materials and methods

2.1 Analytical design and feeding scenarios

This was a scenario-based economic analysis of projected summary values, not an analysis of completed animal-trial observations. The planning framework comprised 229 producer groups in 14 counties, with three 100-bird batches per group: 687 batches and 68,700 birds in total. Those numbers describe a proposed implementation scale and were not treated as observed replication. The three

feeding scenarios are defined in Table 1. A switch after week 12 implies supplementation during weeks 13–20; a

switch after week 8 implies supplementation during weeks 9–20.

Table 1. Feeding scenarios for a proposed 20-week production cycle.

Scenario	Weeks 1–8	Weeks 9–12	Weeks 13–20
T1: commercial	Commercial starter	Commercial grower	Commercial grower
T2: switch after week 12	Commercial starter	Commercial grower	75% grower allowance + fresh Azolla
T3: switch after week 8	Commercial starter	75% grower allowance + fresh Azolla	75% grower allowance + fresh Azolla

The restricted grower allowance represents 75% of the contemporaneous control intake per bird, with fresh Azolla offered separately. It is not a diet containing 25% Azolla dry matter, nor an isonitrogenous substitution. Fresh Azolla intake was assumed rather than empirically measured. Handling and storage can alter nutrient characteristics (Lejeune et al., 2000), and results from other poultry species cannot be transferred directly to improved indigenous chicken (Shukla et al., 2018). Any field ration must therefore be evaluated against appropriate nutrient requirements (National Academies of Sciences, Engineering, and Medicine, 2026).

2.2 Economic assumptions and calculation

The analysis retained projected final weights, cumulative feed quantities and revenue assumptions and recalculated the enterprise budget from its component items. Chick cost was KES 120 per bird; health inputs, brooding/litter and depreciation were KES 50, 30 and 40, respectively. Chick mash and grower mash were priced at KES 78 and 70/kg. Fresh Azolla cost was set at KES 12/kg, and live-bird sales at KES 550/kg. These values are scenario inputs rather than independently verified current market quotations. Shared poultry-care labour was excluded; incremental Azolla labour was included through the Azolla unit cost.

Feed expenditure equalled commercial mash expenditure plus fresh Azolla

quantity multiplied by its unit cost. Total modeled cost added chick, health, brooding and depreciation expenditure. Saleable live mass per bird placed was derived consistently as projected revenue divided by KES 550/kg, retaining additional decimal places during calculations. Production cost equalled total modeled cost divided by saleable mass. Budget surplus equalled revenue minus modeled cost, and the benefit–cost ratio equalled revenue divided by modeled cost. The term budget surplus is used because fixed-cost depreciation was included while shared family labour was excluded.

2.3 Sensitivity analysis and inferential scope

A deterministic sensitivity analysis varied fresh Azolla cost from KES 0 to 30/kg while holding saleable mass and other costs constant. Break-even cost was the Azolla price at which a supplemented scenario matched T1 cost per kilogram sold. The equations and assumptions were kept explicit in accordance with transparent simulation-reporting principles (Morris et al., 2019). No new random observations were generated. Inferential p-values, confidence intervals

and claims of treatment significance were not retained because the underlying simulated observations and executable data-generating code were unavailable.

Future field validation should use producer group as a block and independently managed batch as the experimental unit. Individual bird weights would be subsamples, not independent treatment replicates. Animal ethics authorization, producer consent and a prespecified welfare response to growth deterioration would be required before implementation; reporting should follow ARRIVE guidance (Percie du Sert et al., 2020). No animal experiment was conducted for the present scenario calculations.

3. Results

3.1 Projected growth and feed demand

Projected final weights were 1,778 g for T1, 1,746 g for T2 and 1,689 g for T3 (Figure 1). Relative to T1, the modeled weight reductions were 32 g (1.8%) and 89 g (5.0%). These differences arise from assumed growth responses and must not be interpreted as measured treatment effects. T2 retained 57 g more final weight than T3.

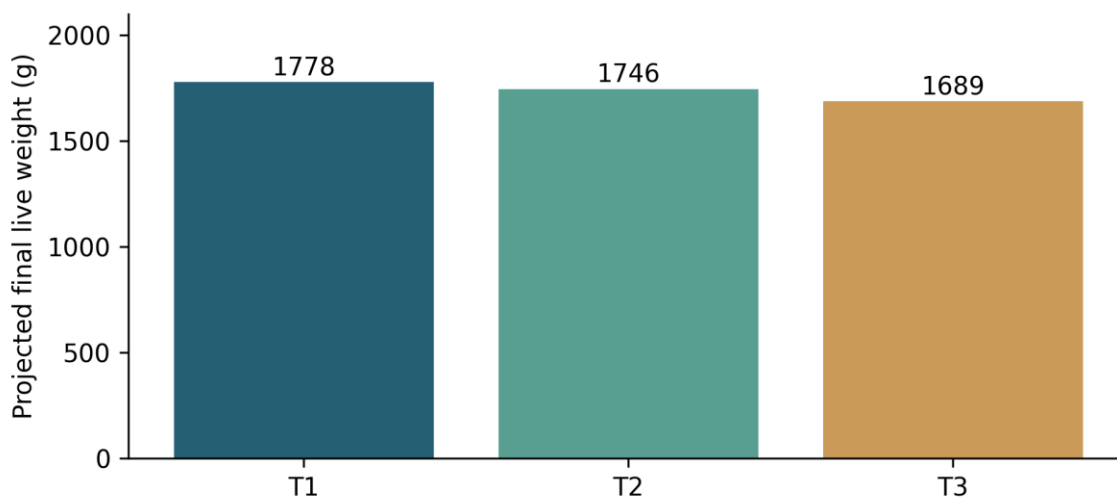


Figure 1. Projected final body weight at 20 weeks.

Commercial feed demand declined from 7.01 kg per bird placed in T1 to 6.09 kg in T2 and 5.72 kg in T3, equivalent to reductions of 13.1% and 18.4% (Figure 2). Fresh Azolla requirements were 2.25

and 2.95 kg per bird placed. T3 therefore required 31.1% more fresh Azolla than T2. Fresh biomass and commercial mash quantities are displayed separately because their dry-matter contents differ.

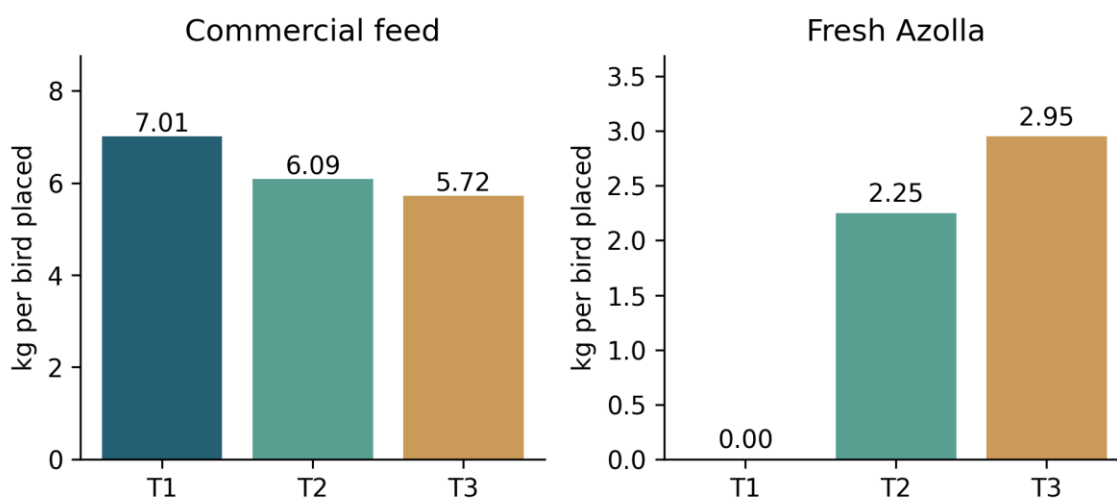


Figure 2. Projected cumulative commercial feed and fresh Azolla requirements per bird placed.

3.2 Enterprise costs and returns

The component-based budget produced feed expenditures of KES 505.5, 468.1 and 450.7 per bird placed for T1, T2 and T3. Thus, modeled feed savings were

7.4% and 10.8%. Adding non-feed expenditure gave total costs of KES 745.5, 708.1 and 690.7. These totals were recalculated directly from the budget components to avoid rounding discrepancies. Table 2 presents the

resulting saleable mass, unit production costs and returns.

Table 2. Recalculated scenario budgets per bird placed; prices and biological responses are assumed.

Indicator	T1	T2	T3
Feed expenditure (KES)	505.5	468.1	450.7
Total modeled cost (KES)	745.5	708.1	690.7
Saleable live mass (kg)	1.636	1.602	1.562
Revenue (KES)	899.6	881.1	859.0
Production cost (KES/kg sold)	455.8	442.0	442.2
Budget surplus (KES)	154.1	173.0	168.3
Benefit–cost ratio	1.207	1.244	1.244

Production costs were KES 455.8/kg for T1, 442.0/kg for T2 and 442.2/kg for T3 (Figure 3), corresponding to reductions of approximately 3.0% under both supplemented scenarios. Budget surplus

increased by 12.3% under T2 and 9.2% under T3. The larger feed saving under T3 therefore did not yield the largest modeled surplus when birds were sold by live weight.

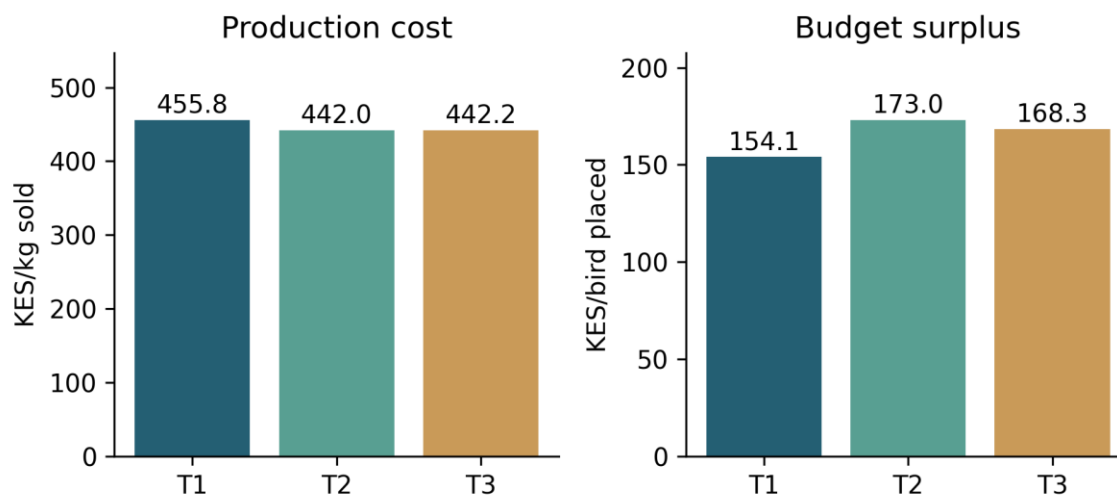


Figure 3. Recalculated production cost and budget surplus under the base-case assumptions.

3.3 Cost composition

Feed accounted for 67.8% of modeled T1 expenditure, followed by chicks (16.1%), health inputs (6.7%), depreciation (5.4%)

and brooding/litter (4.0%; Figure 4). The Azolla production budget totaled KES 6,373 per cycle: labour KES 3,500, liner

depreciation KES 1,350, shade/frame depreciation KES 975, inoculum allocation KES 188 and fertilizer KES

360. Labour represented 54.9% of this total.

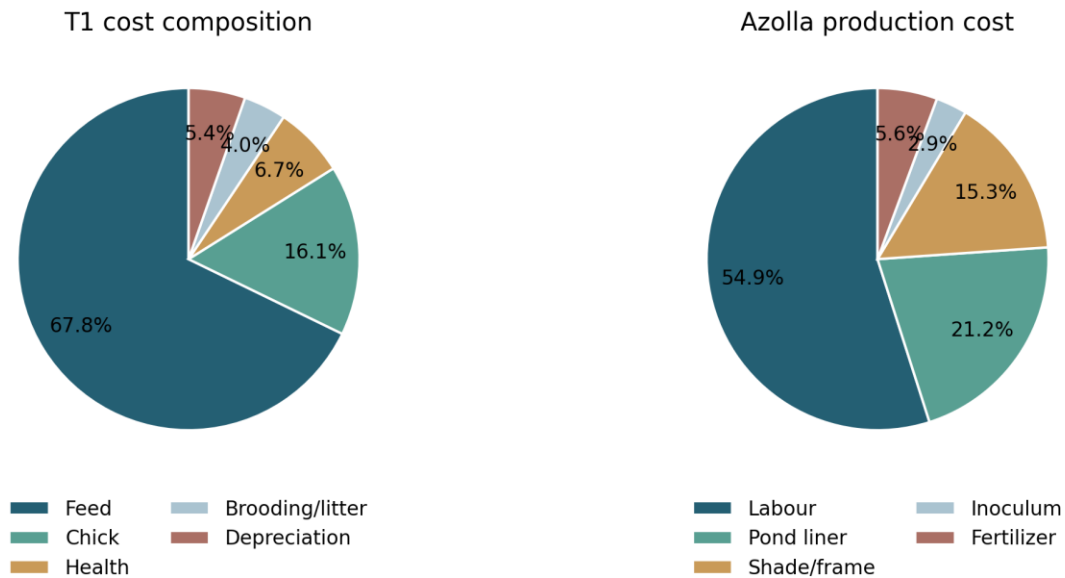


Figure 4. Scenario cost composition: control poultry budget and Azolla production budget.

At a combined projected Azolla requirement of 520 kg for the two supplemented 100-bird batches, the pond budget implied KES 12.26/kg. The base-case KES 12/kg therefore approximated the itemized estimate. Excluding the KES 3,500 labour allowance reduced the implied cost to KES 5.53/kg; this is an accounting comparison, not evidence that labour has no economic value.

3.4 Break-even Azolla cost

Unit production costs increased linearly with fresh Azolla price when output was held constant (Figure 5). T2 matched the control at approximately KES 21.8/kg fresh Azolla, whereas T3 matched it at KES 19.2/kg. T3 had the lower threshold because its greater Azolla requirement and lower saleable mass made it more sensitive to biomass cost. These thresholds apply only to the specified budget and output assumptions.

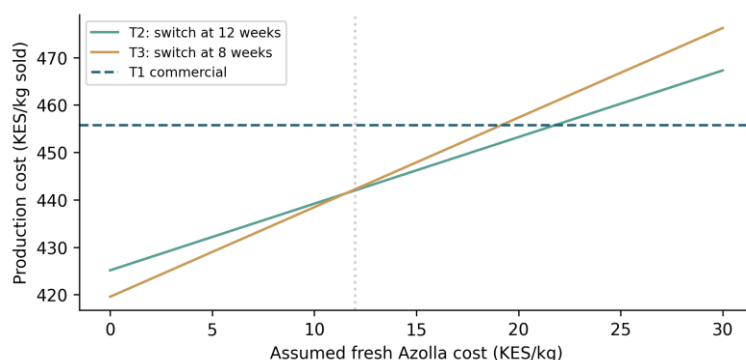


Figure 5. Deterministic sensitivity of unit production cost to fresh Azolla price. The dashed horizontal line shows T1; the vertical dotted line marks the KES 12/kg base case.

4. Discussion

The modeled economic advantage was smaller than the reduction in purchased feed because supplemented birds were assumed to produce less saleable live mass. The approximately 3% unit-cost reduction therefore expresses a balance between feed expenditure and output, rather than an automatic consequence of commercial-feed restriction. This distinction is consistent with the need to evaluate growth and cost together in alternative-feed research (Waithaka et al., 2022; Paudel et al., 2015).

The results suggest that switching after week 12 deserves comparison with earlier supplementation in a field trial. Under the specified assumptions, T2 retained more live weight, used less fresh Azolla and achieved a slightly lower unit cost and larger surplus than T3. This ranking is conditional on the imposed growth response. Fresh-Azolla trials in native crossbred chickens provide relevant

evidence, but differences in genotype, age, management and nutrient formulation limit direct transfer to Kenyan systems (Punyatong et al., 2024). Studies of meal inclusion and digestibility further show why performance must be measured rather than assumed (Basak et al., 2002; Samad et al., 2020; Abdelatty et al., 2020).

Fresh Azolla should be evaluated as a supplementary feed resource with explicit dry-matter and nutrient accounting. A reduction in mash allowance does not establish equivalent energy or amino-acid supply. Chemical-composition research, reviews of Azolla feeding and evidence on poultry fibre responses support careful ration formulation (Swain et al., 2022; Alalade & Iyayi, 2006; Mateos et al., 2012). Research on carotene preservation and turkey feeding also illustrates the importance of processing and species-specific responses (Lejeune et al., 2000;

Shukla et al., 2018). Growth monitoring should be accompanied by measurements of feed refusals, Azolla dry matter, nutrient adequacy and saleable output (National Academies of Sciences, Engineering, and Medicine, 2026).

Labour was the dominant Azolla expenditure, making pond location, harvest efficiency and biomass yield important economic determinants. A producer may perceive a home-grown supplement as inexpensive while omitting the opportunity cost of daily harvesting. The contrasting labour-inclusive and labour-excluded calculations show how that omission can change the apparent affordability of supplementation. Cultivation constraints identified in technical feed-resource literature reinforce the need to measure local water supply, harvestable biomass and maintenance requirements (Tran, 2015). No greenhouse-gas or climate-resilience benefit can be inferred from the present budget alone.

Field validation should prioritize differences in cost per kilogram sold and budget surplus, with growth and welfare measured alongside them. A replicated blocked design can separate feeding responses from group-level management differences, but statistical power must be

based on justified field variance rather than an unverified synthetic dataset. Transparent specification of data-generating assumptions and animal-study reporting requirements would strengthen the resulting evidence (Morris et al., 2019; Percie du Sert et al., 2020).

5. Conclusion

Under the defined scenarios, fresh Azolla supplementation reduced purchased-feed demand and modeled production cost, with the unit-cost benefit limited to approximately 3% by assumed live-weight losses. Switching after week 12 retained more weight and produced the largest budget surplus when sales were based on live weight. Economic viability depended particularly on labour-inclusive Azolla cost, with break-even values of approximately KES 21.8/kg and KES 19.2/kg for the later and earlier switches. These results provide conditional benchmarks for a feeding trial rather than evidence for a confirmed substitution schedule.

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