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Effect of supplementing different Hydroponic Fodder for dual purpose chicken on Feed Intake, Egg yield and Egg Quality Traits

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Abstract

The rising cost of conventional poultry feed, which accounts for up to 70% of production expenses, poses a critical challenge to the sustainability of poultry enterprises in Ethiopia, especially in urban and peri-urban settings. This study was carried out to evaluate the effects of supplementing dual purpose chickens diets with 5% hydroponic fodders barley (HB), wheat (HW), and maize (HM) on feed intake, egg production, egg quality, and economic performance in dual-purpose Sasso chickens. A total of 180 adult hens were randomly assigned to four dietary treatments: T1 (commercial feed + 5% HB), T2 (commercial feed + 5% HW), T3 (commercial feed + 5% HM), and T4 (control: commercial feed only), with three replications of 15 birds each. Hydroponic fodders were grown in controlled conditions and harvested on eighth day of post-sowing. Results showed significant differences ($p < 0.05$) in egg weight, feed conversion ratio (FCR), and several internal egg quality traits (albumin height, albumin weight, yolk weight, shell thickness, and yolk color) among treatments. Chickens fed T1 exhibited superior egg production (74.25%), egg weight (58.5g), and FCR (2.35), along with the highest internal egg quality scores. Economically, T1 also provided the greatest net income (7680 ETB) and marginal rate of return (1968.6%), making it the most profitable option. The improved nutritional profile of hydroponic barley, particularly its high protein and mineral content, contributed to enhanced performance outcomes. In conclusion, integrating 5% hydroponic barley into poultry diets offers a cost-effective and sustainable feeding strategy that enhances both productivity and profitability. This approach is particularly suitable for small- to medium-scale poultry farms in land-constrained urban and peri-urban areas. Further research is recommended to optimize inclusion levels and assess long-term impacts across diverse production systems

Keywords: Dual purpose chickens; Egg quality; Economic performance; Hydroponic barley

1. Introduction

Ethiopia, especially in densely populated urban and per-urban regions, the chicken business is essential to improving household food security, revenue generation, and nutrition. The demand for goods derived from animals, like as eggs and poultry meat, has increased dramatically with urbanization, which has made it easier for small and medium-sized poultry businesses to grow near consumer marketplaces. Despite its importance poultry sector is constrained by different factors of these factors feed cost takes the largest share which accounts about 60-70 % total cost of production (Ravindran, 2013).

As feed accounts for up to 70% of total production costs in poultry enterprises, there is growing interest in and nutritionally viable feed sources that can support both productivity and profitability (Mekonin & Girma 2020). This challenge underscores the need for alternative feed resources that are affordable, accessible, and nutritionally adequate.

A potential remedy in this regard is hydroponic fodder green forage, which is produced without soil using nutrient-rich water in a controlled environment. Hydroponic fodder production is a modern, soil-free method of growing green forage

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quickly usually within a week from cereal grains like barley, wheat, and maize. It has become increasingly popular as a sustainable feeding option, especially in regions where access to land, water, or traditional feed resources is limited (Naik *et al*., 2015). The resulting fodder is rich in nutrients such as enzymes, vitamins, minerals, and other beneficial compounds, which help improve digestion and metabolic performance in livestock (Sneath & McIntosh, 2003). Although it has been more commonly studied in ruminant feeding systems, there is growing evidence that incorporating small amounts of hydroponic fodder into poultry diets particularly for dual-purpose and laying birds can support better egg production, enhance yolk color, and improve gut health, all without negatively affecting feed intake or efficiency (Zhang *et al*., 2012).

The sprouting process enhances nutrient availability and reduces anti-nutritional factors present in raw grains, making it easier for animals to digest. Moreover, hydroponic fodder systems are space-efficient, require very little water compared to conventional forage crops, and are well-suited for peri-urban and urban environments where space is limited. Despite its benefits, the use of hydroponic fodder in poultry production is still relatively uncommon. This is largely due to low awareness, the initial cost of setup, and the lack of localized research on its long-term economic viability. Nevertheless, as feed costs continue to rise and farmers look for alternative, sustainable feed options, hydroponic fodder presents a valuable and adaptable solution for modern poultry farming.

Commonly utilized in hydroponic fodder systems, cereal grains such as barley, wheat, and maize can sprout into nutrient-rich biomass in 7–10 days (Naik *et al*., 2015). Compared to their ingeminated cousins, these sprouts are known to have higher levels of digestible fiber, vitamins, enzymes, and antioxidants (Sneath & McIntosh, 2003). By adding such fodders to chicken diets, feed expenses can be decreased while digestibility, nutrient absorption, and egg quality are improved. Previous studies have indicated potential improvements in growth and laying performance when hydroponic fodder is used at moderate inclusion levels (Zhang et al., 2012; Naik & Singh, 2013), but outcomes vary depending on the type of grain, inclusion rate, and bird type. Therefore, current study aims to assess the effect of supplementing different hydroponic fodders (barley, wheat, and maize) at a 5% dietary inclusion level on feed intake, egg production, and egg quality traits and economic benefit in dual-purpose chickens.

2. Materials and Methods

The study was carried out in Poultry research Unit at Arbaminch Agricultural research center compound in April – June 2024.

2.1. Preparation /production of hydroponic fodders

Fodder growing material/ trays/ were prepared by using aluminium sheet and other locally available material. Total of 12 trays were constructed to develop the fodder. Plastic bath was used for washing and soaking grains before sowing into aluminium sheets constant watering was done daily until harvesting. Three cereal grains food Barley, wheat and maize were used to grow hydroponic fodder for this experiment.

The grains were purchased from local market. The seeds were washed with pure water in order to remove dust. Washed grains were soaked in clean water in bath for 24 hour to initiate germination. Regular management like watering was done until harvesting of the hydroponic fodder. Fodder harvesting was done at every ninth day of sowing in the prepared aluminium trays.

2.2. Experimental Animals and Management

Total of 180 adult dual purpose chickens were used to implement this trial; the chickens were purchased from locally enterprise and housed in deep Littre houses and the houses partitioned into 12 pens as 3 pens for each treatment which contains 15 chickens. Regular management like medication, cleaning and other bio-security activity were done in order to keep chickens health. In each pen two nests with each an area of 1.44 meter square was built by using local material and filed with the *Teff* straw in order to prevent eggs from the breakage.

2.3. Chickens and experimental design

A total of 180 adult ***Saso*** breed chickens were assigned to 12 pens which contains 15 chickens. These pens are randomly assigned to these four diet types/treatments/, Treatment1= Commercial feed + Hydroponic barely (5%) , Treatment 2 Commercial feed + Hydroponic wheat (5%), T3 Commercial feed + Hydroponic Maize (5%) and Treatment 4 was control which feed on 100% commercial feeds. Each treatments or diet types have three replications and each replication contains fifteen adult *Saso* chickens. The hydroponic fodder were supplemented in the ninth day of sowing with an amount of 100gm and given in separate feeders for the chickens.

2.4. Data collection and data analysis

2.4.1. Feed intake, feed conversion efficiency and egg quality parameters

Feed provided and feed refusal was recorded daily recorded from each pen to calculate average feed intake. Feed conversion ratio was calculated by using fraction of feed given to the chicken's egg mass produced per each treatment. Nine eggs from each replication taken randomly from each replication and total of 108 eggs were subjected to measure egg quality variables measurement. Albumin weight, yolk weight, shell weight was measured by electric sensitive balance by breaking the sampled eggs. Shell thickness, albumin height, egg height was measure by digital caliper. The yolk fan was used to score the yolk color of the sampled eggs. Collected data was analyzed by using SAS statistical software using GLM. Tukey's HSD was employed to compare treatment means.

3. Result and Discussion

3.1. Chemical composition of Hydroponic fodders

This table shows that average nutritional content of the hydroponic fodders grown for the trial the result of different study indicated that hydroponic barley have high protein content with balanced Metabolizable energy, good calcium content and while hydroponic maize have high amount of Metabolizable energy. This indicates the supplementing hydroponic barley is good for chickens because it have good source of protein and calcium content which plays role in the egg quality. The highest dry matter was recorded in hydroponic wheat compared to hydroponic wheat and hydroponic maize which is similar with findings of Upreti *et al*., 2022.

Table 1 Nutritional Composition of Hydroponic Fodders

Type of fodder	DM (%)	CP (%)	CF (%)	EE (%)	ME Kcal/kg	Ca (%)
Hydroponic barley	13.5	15.95	10.5	2.25	2560	0.27
Hydroponic wheat	15.25	12.45	13.4	2	2700	0.17
Hydroponic maize	12.5	7.5	11.8	2.3	2890	0.15

DM= Dry matter, CP= crude protein, CF= crude Fibre, EE= ether extract, Ca=calcium,

Crude protein content between the fodders was realized that highest crude protein content was recorded for Hydroponic barley with value of 15.95% followed by wheat and barley 12.45%, 7.5% respectively (Table1). This might be due to higher crude protein content of barely grain compared to maize and wheat thus even before sprouting protein content has an advantage than the other grains and this result is slightly similar to the findings of Naiek., *et al* 2015. Feed ingredients of the treatments presented Table 1.

The proximate composition and key nutritional parameters of four treatment diets are presented in table 2. T2 and the control diet had somewhat lower dry matter contents (81.1% and 81.5%, respectively), whereas T1 had the greatest dry matter level (84.2%), closely followed by T3 (83.7%). The denser nutritional profile that hydroponic barley and maize offer may be the cause of the greater DM in T1 and T3. All things considered, adding 5% hydroponic barley or wheat preserves or marginally enhances the diet's nutrient profile without sacrificing important elements like protein or calories.

Table 2 Chemical composition of experimental feeds

Nutrient %	T1(Comercial+5%HB	T2(Comercial+5%HW	T3(Comercial+5%HM	T4 commercial only
DM	84.2	81.1	83.7	81.5
CP	17.2	17.4	17	17
CF	5.8	5.5	5.3	5.0
EE	3.2	3.1	3.4	3.0
Ash	6.0	5.9	5.8	6.0
ME	2700 kcal/kg	2720 kcal/kg	1750 kcal/kg	2750 kcal/kg
Ca	3.5	3.48	3.4	3.5

Ca=calcium CP=crude protein, CF= crude fiber, DM=dry matter, EE=ether Extract, HB=hydroponic Barley, HM= hydroponic maize, HW= hydroponic wheat, Despite adding a little more fat, hydroponic maize (T3) seems to have less metabolizable energy, which could have an impact on performance if it isn't balanced elsewhere in the formulation. Their prospective use in layer diets is supported by the fact that T1 and T2 provide the most nutritionally adequate substitutes for the control.

3.2. Feed Intake, Egg Yield and Feed Conversion Ratio

Mean feed intake, egg yield and feed conversion ratio is presented in table 3 blow. The result indicates that there was no statistical significant difference among the treatments on feed intake gg weight, egg yield and feed conversion efficiency.

Table 3 Mean feed intake, egg yield, and egg weight and feed conversion ration

	Treatments				p-value
Variables	**T1(CF+HB)**	**T2 (CF+HW**	**T3 (CF+ HM)**	**T4(control)**	
FI(g/day) (mean±SEM)	114 ±2.5	113±2.3	111.6±2.4	116.5±2.7	0.0072
EP (%)(mean±SEM)	74.25 ±1.8	72.4 ±2	70.3 ±1.9	72.51 ±1.6	0.009
EW (g) (mean±SEM)	58.5±1.3	53.5 ±1.2	52.5 ±1.5	50.7 ±1.4	0.001
FCR (%)(mean±SEM)	2.35 ±0.07	2.11 ±0.05	2.01 ±0.06	2.21 ±0.08	0.001

Where CF=commercial feed, EW= egg weight, EP= egg production, FI= feed intake, FCR=feed conversion ratio, HB= Hydroponic barley, HM= hydroponic maize, HW= hydroponic wheat SEM standard error of mean.

The findings indicated that the control group, which consisted of chickens without hydroponic fodder supplement, had a higher mean feed intake than the other three treatments; this might be due to hydroponic fodder contain relatively high amount of fiber and moisture this may cause the gut fill which may cause lower voluntary intake of chickens. When we see the voluntary intake among hydroponic fodders the hydroponic barely supplements shows relatively high amount 114 grams per day followed hydroponic wheat and hydroponic maize respectively (table2.). Intake of maize hydroponic supplemented chickens shown low FI this might be due to the fiber content and the size of sprouted seed the barley sprout shown the highest amount of voluntary intake and this findings of Baye *et al*., (2024).

There was no statistical significance difference on egg mass production among the treatments but the result show that there was numerical advantage of hydroponic barley fodder over the other treatments. There was significant among the treatments for egg weight and feed conversion ratio.

3.3. Internal Egg Quality Indicators

Table 4 displays the average values for the interior and exterior egg quality metrics. Current findings revealed that there was significant difference among the treatments in egg quality traits thus supplementing hydroponically produced fodder influenced internal and external quality traits of egg.

Table 4 Mean values of egg internal quality traits

	Treatments						
Variables	**T1(CF+HB)**	**T2 (CF+HW)**	**T3(CF+HM)**	**Control**	**SE**	**p**	**CV**
ALH	7.25[a]	6.5[b]	5.2[c]	5.4[c]	0.67	0.001	13
ALW	37.28[a]	35.17[b]	31.72[c]	31.54[c]	2.63	0.001	7
YW	39.92	38.7	35.6	37.2	1.871	0.042	11
YWt	14.22[a]	11.66[b]	10.86	11.36	0.75	0.001	7.9
ST	0.286[a]	0.182[bc]	0.177[bc]	0.165[c]	0.392	0.001	12
SW	7.02[ab]	6.83[bc]	7.33[ab]	6.37[bc]	0.897	0.035	7.5
YC	9.5	7.8	7.5	6.5	2.29	0.001	11

Where ALH= albumin height, ALW=albumin weight, YW= yolk width, YWt= Yolk weight, ST=shell thickness, SW=shell weight, YC= yolk color. Values letters with the different superscript are statistically different.

Compared to other treatments and control chicken feed in hydroponic barley supplement shown highest mean value in albumin weight and albumin height (Table 4) this suggests that hydroponic barley improves egg protein structure ,good indicator of egg freshness and internal quality. Shell thickness was also influenced by the diet type ; the chicken groups feed on hydroponic barley supplement were shown the high shell thickness i.e 0.286mm this might be due to better mineral content and bioavailability from hydroponic barley. This finding is slightly the same with Abouelez *et al.,* 2019 which was supplementing hydroponic barley was improved egg shell thickness in Japanese quail. Hydroponic fodder supplement also influenced Yolk pigmentation; numerically high amount of yolk colour recorded at diet one /hydroponic barley supplement/ this might be due to higher content of carotenoid or xanthophyll.

3.4. Cost Benefit Analysis

Cost benefit analysis was employed to assess an economic benefit of supplementing chickens with different hydroponic fodders by using CYMMT guide line. Table 5 presents the cost benefit analysis, comparisons of marginal rate of return among treatments and final recommendation.

Table 5 Average cost and benefit of adding different hydroponic feeds to chickens

Treatments	Variable cost	Egg yield	Gross income	Net income
T1 (commercial +HB)	14759.82	2040	22440	7680.18
T2 (commercial +HW)	15038.75	1860	20460	5412
T3 (commercial +HM)	14466.6	1800	18000	3533.4
T4 (commercial +HB)	14580	1920	21120	4140
Marginal Rate of Return				
Comparison	Δ VC	Δ NI	MRR (%)	Recommendation
T4 vs T3	113..4	606.6	534.9	Acceptable
T1 vs T4	179.82	3540.18	1968.6	Highly profitable
T2 vs T1	276.93	-2268.18	-818.9	Not recommended

Where HB= hydroponic barley, HM= hydroponic maize, HW= hydroponic wheat, VC=variable cost, NI=net income, MRR= marginal rate of return

Treatment one resulted in highest net income of 7680 ETB compared to the control and other treatments. While hydroponic maize supplementation shown the lowest net income despite the low variable cost. When comparing marginal rate of return between T4 (control) versus T3(commercial + hydroponic maize) yield marginal rate of return is 534.9% (table 5) which is above minimum of CIMMYT recommended minimum of 100% which indicates that moving from hydroponic maize to control diet is economically worthwhile. When we see comparison between T1 (hydroponic barley supplement) T4 (control) the marginal rate of return is 1968.6 %(table 5) showing that supplementing hydroponic barley resulted in additional return for relatively minor cost increase which is highly profitable and economically justified.

4. Conclusions

Findings of current study revealed that supplementing commercial poultry diets with 5% hydroponic fodder significantly influenced feed intake, egg production, egg quality traits, and economic performance in dual-purpose chickens. Among the treatments, T1 (commercial feed + 5% hydroponic barley) consistently outperformed the other groups in terms of egg yield, egg weight, and feed efficiency, while maintaining favorable feed intake levels. This treatment also resulted in the highest net income and marginal rate of return, indicating its superior cost-effectiveness compared to both the control (T4) and other hydroponic-supplemented diets**.** Overall, the findings suggest that hydroponic barley is the most promising among the tested fodders for improving poultry productivity and profitability. Incorporating a small proportion (5%) of hydroponic barley into the feed of dual-purpose chickens can enhance egg production performance and economic returns without increasing feed intake. therefore, this strategy can be recommended as a viable, sustainable, and low-cost feeding intervention, particularly for small- to medium-scale poultry producers of Urban and peri-urban areas where there is the insufficient amount of land resource.

Recommendation

Based on the results of this study, it is recommended to supplement commercial poultry feed with hydroponic barley for dual-purpose chickens. This treatment improved egg production, egg quality, feed conversion efficiency, and provided the better economic return among all tested diets. Although hydroponic wheat (T2) and maize (T3) showed some benefits in specific parameters, their overall performance and cost-effectiveness were lower than hydroponic barley. The control group (T4), which relied solely on commercial feed, was outperformed by T1 both in production and profitability metrics. Therefore poultry producers particularly in urban and peri-urban areas of the country encouraged to adopt 5% of hydroponic barley fodder in the chicken diet as practical in feeding strategies. Future research may further explore optimizing inclusion levels and evaluating long-term impacts across different poultry breeds and production systems.

Compliance with ethical standards

Disclosure of conflict of interest

There Authors declare that there is no conflict of interest

Statement of ethical approval

Animal welfare guideline was applied during the study period and approval was obtained from Arba Minch research center technical committee. All efforts were done during study period in order to minimize experimental hens stress and discomfort.

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