Ethiop. J. Agric. Sci. 34(1) 94-112 (2024)

Performance Evaluation of Sasso Chickens that Fed on Rations formulated from Locally Available Feed Ingredients around Nekemte Area, Western Ethiopia

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Abstract

The present experiment was conducted to evaluate feed intake, growth performance, carcass characteristics and profitability of rearing Sasso chickens that fed rations made from locally available feed ingredients around Nekemte area, western Ethiopia. The experiment was conducted with a total of 120 male Sasso T44 chickens at the age of 42 days. The chicks were randomly assigned to the four dietary treatments of T_1 (diet formulated from maize, non-toasted soybean, lupine, noug seed cake, limestone, salt (MSL));T_2 (diet formulated from wheat, non-toasted ground soybean, non-toasted ground lupine, noug seed cake, limestone, salt and premix (WSL)); T_3 (diet formulated from maize, wheat, non-toasted ground soybean, non-toasted ground lupine, noug seed cake, limestone, salt and premix (MWS)] and T_4 [Commercial ration (CR), positive control]. The dietary treatments for growers and finishers were formulated from same feed sources nearly an isocaloric (3600 and 3500 kcal/kg DM and ME, respectively) and iso-nitrogenous (19 and 18% CP, respectively). The treatments were replicated three times with 30 chickens per treatment. The General Linear Model (GLM) Procedures of the Statistical Analysis System (SAS, 2008) was used to analyze the data. Average daily feed intake and all growth parameters were significantly affected ($p < 0.05$) by the dietary treatments. The highest feed intake was recorded in chickens that fed CR (151.7 g/day) while the least was for those fed on MSL (135.4 g/day). Similarly, chickens fed on CR and MWS attained the highest final body weight (BW) of 4048.3 g and 3928.1 g, respectively. The highest eviscerated carcass yields were recorded for those chickens fed on CR (2874.7 g) and MWS (2827.0 g) while those fed on MSL (2138.3 g) and WSL (2197.3 g) attained the least. The highest dressing percentages were obtained from those fed on CR (72.7%) and MWS (72.0%) whereas those fed on MSL (64.0%), and WSL (64.0%) showed the least. From the results of the current study, it can be concluded that MWS can be used as an alternative feed source in Sasso chicken for meat purpose without any adverse effects on feed intake and growth, and for better profitability of Sasso chickens according to this experiment.

Keywords: Carcass Yield; Feed Intake; Growth Performance; Homemade Ration; Sasso Chickens

Introduction

Poultry production has important economic, social and cultural benefits and plays a significant role in the provision of animal protein and family income in the developing countries (Mebratu *et al.,* 2020). They provide animal protein of high biological value in terms of eggs and meat (Desalew *et al*., 2013). Chicken constitutes a high-quality food source, densely packed with essential macro and micronutrients particularly, important for infants and young children, pregnant and lactating women and elders (De Bruyn *et al*., 2015). The rapid growth of human population in the world has led to a relatively high demand for quality protein, where Ethiopia is not exceptional.

In Ethiopia, chicken production is an important and integral part of most activities of households in rural, urban and peri-urban areas like other developing countries, enabling farmers to harvest the benefits of high-quality protein in the form of eggs and meat (Habte *et al*., 2017). Ethiopia's chicken population is estimated at 57 million (CSA, 2021). According to Sahpiro *et al.* (2015), successful poultry intervention would contribute to considerably to reducing poverty and malnutrition among rural and urban poor, as well as increasing national income. However, most of the chicken populations of the country (78.9%) are indigenous chicken which stay on scavenging where their nutritional status, particularly in rural areas found to be below the requirements of improved growers and finishers for optimum performance. Based on crop content analysis of confined hens, Minh (2005) reported that the crude protein (CP) and metabolizable energy (ME) intake of the hens were about 30%. Feeds consumed by scavenging chicken contain on average low nutrient concentration of protein (100 g/kg DM), energy (11.2 MJ/kg DM) and minerals such as Ca (11.7 g/kg DM) and P (5 g/kg DM) (Goromela *et al*., 2006).

Even though, the chicken population of Ethiopia is large in number , the annual meat and egg outputs are only about 50,000 and 54,395 metric tons, respectively (FAO, 2019). The average annual per capita chicken product consumption is less than 1 kg, which is one of the lowest in the world (FAS, 2017), indicating a huge gap between demand and supply of poultry product in the country. To alleviate the problems regarding the lowest annual per capita chicken products, Ethiopia planned in its National Livestock Road Map (NLRM) to increase the total chicken meat and egg production to 64,000 and 3,889 million tons, respectively (Shapiro *et al*., 2015). In the contrary, indigenous chickens kept under village management systems contributed about 94.31% of the total national poultry products (eggs and meat) while the remaining 2.49% is obtained from exotic breed of chickens kept under intensive management system and 3.21% is obtained from crossbreds in Ethiopia (CSA, 2017).

In the intensive commercial system, the profit from poultry production can be attained by minimizing feed cost which accounts for more than half of the total cost of production. According to Wilson and Beyer (2000), feed cost accounts 60-70% of the total cost of poultry production. Any attempt to improve commercial poultry production and increase its efficiency, therefore, needs to focus on better utilization of available feed resources (DZARC, 1997 as cited by Etalem, *et al*., 2009). In the current study area, availability, quality and cost of feed are the major constraints to poultry production despite of its immense potential for different cereal grain production. Broilers/pullets (commercial layers) have been distributed by extension workers to smallholder farmers of this region for the objective of increased income. Though the impact was not evaluated yet, farmers complained that the distributed broilers/pullets are not profitable due to absence of poultry compound feed in the area. Procurement of poultry ration either from Addis Ababa or Bishoftu is a major challenge for smallholder chicken producers and even beyond their reach. Unless problems related to feed cost are addressed through formulating rations from locally available feed resources, the high feed cost will discourage chicken producers and may even jeopardize the future expansion and development of chicken production in the country. It is, therefore, very important to formulate rations from locally available feed sources with affordable costs, without negatively affecting the nutritional values, to improve egg laying performances of chickens in the area. The current study, therefore, was conducted to determine the effect of rations from locally available ingredients on feed intake, growth performance, meat yield and profitability of Sasso chicken.

Materials and Methods

Description of the study area

The present study was conducted in Wallaga University (Figure 1) poultry farm which is located $9^{0}5'$ North latitude and $36^{0}33'$ East longitude and an elevation of 2,088 meters above sea level. It is at a distance of 328 km from Addis Ababa, the capital city, Ethiopia. The mean annual rainfall of the area is about 1998 mm and the minimum and maximum temperatures are 8 ^{o}C and 30 ^{o}C, respectively, and the mean was 19 ^{0}C (Nekemte Metrology Agency, 2020, unpublished report).

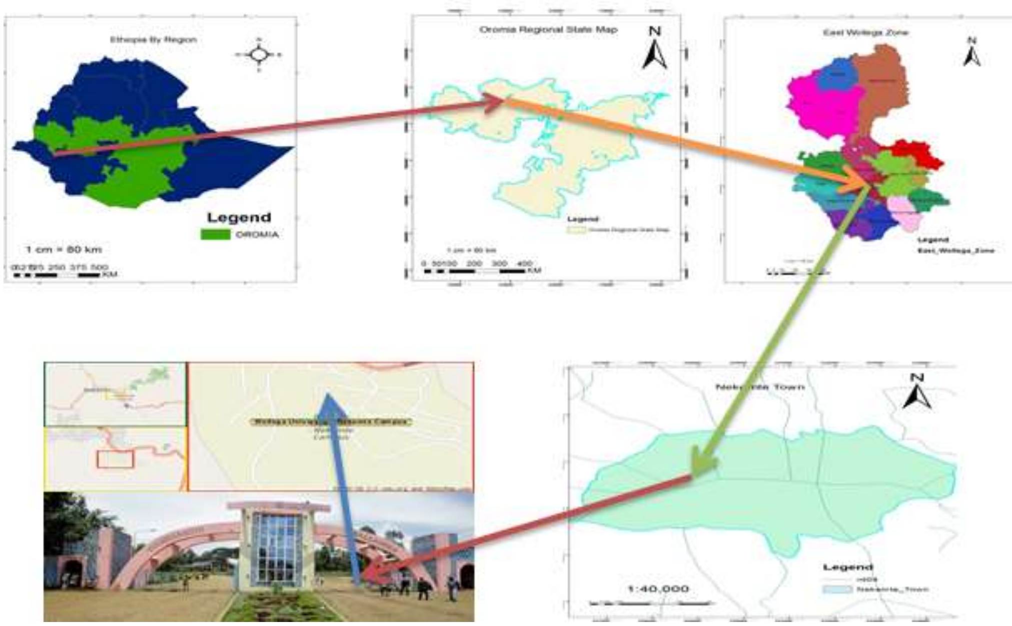

Figure 1. Map of study area

Housing and equipment

Properly constructed house with concrete floor was partitioned into equal pens depending on an individual chicken floor space requirement (0.96 m^2/ chicken) (Galobart and Moran, 2005) and covered with saw dust at a depth of 5 cm. The house was roofed with corrugated iron sheet, concrete wall, half wall covered with a wire mesh and curtain. The house was partitioned in to 12 pens and in each pen, 11 watts bulbs were suspended at 45 cm over the floor to offer heat and light during the night. The rooms were then properly cleaned and disinfected with 37% formalin solution disinfectant based on veterinary professional's guide before chickens were introduced. Different equipment and materials including feeder, waterer, digital weighing balance, record book, and permanent ink marker used to write on their shank for identification of chickens, etc. were bought and used to measure and record data.

Experimental feed preparation and chemical analysis

Preparation of feed ingredients: The rations were prepared from locally available feed ingredients such as maize, wheat, soybean, lupins (*L. albus*), noug seed cake and mineral and vitamin sources such as premix, limestone and common salt similar to the nutrient contents of the commercial ration (CR). The CR was purchased from Ethio-Chicken PLC, Addis Ababa to use as positive control. The local feed ingredients were purchased from open markets in and around Nekemte town.

Chemical analysis of feed ingredients and experimental rations: Samples of feeds were collected from each feed ingredient used in the experiment and taken to the National Veterinary Institute (NVI) at Bishoftu, Ethiopia for chemical analysis before formulating the actual dietary treatments. The chemical composition of feed ingredients used in the current study are shown in Table 1.

Table 1. Chemical composition of feed ingredients used to formulate experimental rations.

Feed Ingredients	Parameters (gm/kg)						
	DM	CP	CF	EE	Ash (MM)	Ca	ME* (Kcal/Kg)
Maize	884	88	33.9	48.9	14	66.3	3858.90
Wheat	898	135	46.7	44.7	31.2	27.8	3652.50
Soybean	906.3	380	46.3	146.3	40.8	18.6	4169.30
Lupin	924	322	128.8	70.8	41.1	12.6	3025.90
NSC	940	374.6	181.2	92.6	89.7	8.9	2481.30
Limestone	999	-	-	-	969.3	10.5	-

Note: DM=Dry Matter, CP=Crude Protein, CF=Crude Fat, EE=Ether Extract, MM=Mineral Matter, Ca = Calcium, ME*=Metabolizable Energy.

In the same way, samples were taken from each treatment ration at each mixing time and from refusals every day during the experimental period and kept in paper bags until analyzed. All samples were analyzed for dry matter (DM), ether extract (EE), crude fiber (CF) and ash contents (A.O.A.C., 1990). Nitrogen was determined by Kjeldhal procedure and crude protein (CP) was calculated through multiplying N content by 6.25. The Ca content was determined by atomic absorption spectrometer after dry ashing. The ME value was determined according to Wiseman (1987).

$$\text{ME (kcal/kg DM)} = 3951 + 54.4\ \text{EE} - 88.7\ \text{CF} - 40.8\ \text{Ash}$$

Experimental ration formulation:

Locally sourced ingredients (maize, soybean grain and wheat) were milled at a 5 mm mesh to produce their meal ready for formulation. Based on chemical analysis results of sampled feed ingredients, growers (six to eleven weeks of age) and finishers (eleven to twenty weeks of age) rations were formulated at 3000 kcal/kg DM of ME and 19% CP for growers and 3200 kcal/kg DM of ME and 18% CP for finishers. The experimental rations (MSL, WSL and MWS) were formulated using feed win software. Proportion of the experimental feed ingredients and their respective calculated composition (%) used in experimental rations are detailed in Table 2.

Table 2. Proportion of ingredients and calculated composition (%) used in experimental rations

Ingredients (%)	Grower Rations				Finisher Rations			
	MSL	WSL	MWS	CR	MSL	WSL	MWS	CR
Maize	60	-	20	Commercial Ration	60	-	35	Commercial Ration
Wheat	-	70	50		-	70	35	
Toasted Soybean	24	10	23		6	1.5	10	
Lupin	6	10	-		24	24.5	-	
Noug seed cake	8	8	5		7.5	1.5	17.5	
Limestone	1.25	1.25	1.25		1.65	1.65	1.65	
Salt	0.25	0.25	0.25		0.35	0.35	0.35	
Vitamin premix	0.5	0.5	0.5		0.5	0.5	0.5	
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Chemical composition (%)								
Dry Matter	89.34	90.17	89.61	90	89.68	90.25	90.25	90
Crude Protein	19.33	19.47	19.12	19	18.10	18.47	18.16	18
EE (C-Fat)	7.61	6.04	7.04	9	6.20	5.22	5.22	8
Crude Fiber (CF)	5.37	6.47	4.99	5.5	6.76	6.77	6.77	5.5
Ash	4.00	4.93	4.44	6.17	4.34	4.97	5.17	6.168
Calcium	4.60	2.36	3.21	0.25	4.49	2.33	2.33	0.65
ME (kcal/kg DM)	3725	3505	3710	3701	3512	3432	3424	3647

Note: MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; WSL= Wheat, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; MWS= Maize, Wheat, Soybean, Noug seed cake, Limestone, Common salt and premix; CR=Commercial Ration. Vitamin premix=25kg Broiler premix contains, Vitamin A 1000 000IU, Vitamin D3 200 000 IU. Vitamin E 1000 mg, Vitamin K3 225 mg, Vitamin B1 125 mg, Vitamin B2 500 mg, Vitamin B3 1375 mg, Vitamin B6 125 mg, Vitamin B12 2mg, Vitamin PP (niacin) 4, 000 mg, Folic Acid, 100 mg, choline chloride 37,500 mg, Calcium 29.7%, Iron 0.4%, Copper 0.05%, Manganese 0.6%, Zinc 0.7%, Iodine 0.01%, Selenium 0.004 %

Experimental animal management

A total of 120 (Sasso T44) dual purpose chickens with an average initial live weight of 552.0±1.20 gm was bought from '*Ethio-Chicken'*PLC and grown for five months in Wallaga University, Nekemte Campus. The chickens were allowed to adapt to the rations and environment for one week prior to the commencement of the actual data collection. They were 42 days old and they were vaccinated against Mareks, Gumboro, Fowl pox, Fowl typhoid and Newcastle diseases with Marek's, Gumboro, Fowl pox, Fowl thyphoid, HB1 and Lasota vaccines. Other health precautions and disease control measures were taken throughout the study period.

Experimental design and treatments

The experiment was conducted using a Completely Randomized Design (CRD), with four feeding treatments each with three replications. The chickens were weighed individually to determine initial BW before commencement of the trial. One hundred twenty chickens were grouped into four treatments of 30 chickens each and randomly assigned to the four different dietary treatments. Each treatment group was further sub-divided into three replicates of 10 chickens per replicate and kept in 3m x 3m wire mesh partitioned pens. The four experimental treatments were categorized separately as growers and finisher rations (Table 2). In the experimental ration formulation, efforts were done particularly to make the experimental rations iso-nitrogenous with the commercial ration.

The chicks were randomly assigned to the four dietary treatments of T_1 (diet formulated from maize, soybean, lupine, noug seed cake, limestone, salt (MSL)); T_2 (diet formulated from wheat , non-toasted ground soybean, non-toasted ground lupine, noug seed cake, limestone, salt and premix (WSL)); T_3 (diet formulated from maize, wheat, non-toasted ground soybean, non-toasted ground lupine, noug seed cake, limestone, salt and premix (MWS)] and T_4 [Commercial ration (CR) (positive control.

Feed intake:

Measured amount of feed was offered twice a day at 08:00 am and 05:00 pm hours on *ad-libitum* base throughout the experimental period. As age of chickens increased the amount feed offered also increased. Feed left over from each replicate was collected the next morning before the daily offer was given. The feed offered and left over was recorded for each replicate. The amount of feed consumed was determined as the difference between the feed offered and left over. The average daily feed intake (ADFI) was calculated by dividing the total amount of feed consumed by the group for the total number of experimental days (150 days) and for the total number of chickens in each replicate (10 Sasso chickens).

Measurements and observations

All measurements on BW, feed intake and carcass weight were recorded using a digital balance. Data on chemical analysis of rations was recorded based on the assay reports from the National Veterinary Institute.

Body weight measurements: The experimental chickens were weighed on the first day before being randomly assigned to respective replicate of the treatment group by digital balance and the weight per chick was calculated as the mean weights of chickens in the replicate and recorded to form the initial BW. Weekly BW was recorded every week by weighing chickens individually until the end of the experimental period. Final BW was taken at the end of the experiment and recorded. Body weight gain per pen and per chicken was determined as the difference between the final and initial BW. The average daily BW gain (ADG) was calculated by subtracting the initial BW from the final and then dividing by the total experimental days (150).

Feed conversion efficiency

Feed conversion ratio (FCR) was calculated through dividing the average daily feed intake by its corresponding average daily weight gain (gm) (g) per chicken.

Carcass yield

A total of 48 chickens, twelve chickens from each treatment, were randomly selected and slaughtered at the end of the feeding trial. The chickens were starved for twelve hours before slaughter to ensure empty crop. Then, each chicken was weighed, killed and bled for 180 seconds. The slaughtered chickens were immersed in a bucket of hot water (63°C) for approximately 120 seconds, and de-feathered by hand plucking. The carcass was then eviscerated (removing of head, heart, crop, pancreas, kidney, lungs, proventriculus, small intestine, large intestine, caeca, urogenital tracts and lower leg) and suspended over the evisceration line and allowed to drain for 15 minutes prior to weighing. The back, the two thighs, two drumsticks, two wings and breast were used to evaluate the commercial carcass yield. Dressing percentage was calculated as the proportion of carcass weight to slaughter weight multiplied by 100. Gizzard, skin and liver are edible in most places in Ethiopia and included in the edible component. The giblets which included the heart, gizzard and liver were weighed and recorded. The total edible offal (TEO) component which includes skin, gizzard and liver were weighted and recorded as TEO. Under Ethiopian context the total non-edible offal (TNEO) component includes blood, shank and claws, feather, head, crop, esophagus, proventriculus, spleen, pancreas, kidney, heart, lung, small intestine, large intestines and abdominal fat were weighed and recorded as TNEO (Melesse *et al*., 2013).

Partial Budget Analysis

The profitability of feeding the chickens with locally formulated rations was determined by employing partial budget analysis. Partial budgeting is a method of organizing experimental data and information about the cost and benefits from some change in the technologies being used on the farm. The aim is to estimate the change that will occur in farm profit or loss from some change in the farm plan (Yared, 2019).

The profitability of feeding locally formulated rations was determined based on costs of feed ingredients and transporting the ration, the purchasing price of commercial ration, and selling price of Sasso chicken. The costs incurred for purchasing of feed ingredients, transporting, processing locally formulated ration and purchasing price of commercial ration were the total variable costs and the selling price of chickens was the total return. Selling price of chickens was estimated by five experienced persons on marketing of chicken in the study area. The net income (NI) was calculated by subtracting the total variable cost from the total return (Upton, 1979):

NI = Total income – Total variable cost

The change in net income (ΔNI) was calculated as the difference between the change in total income and the change in total variable cost (Upton, 1979):

$$\Delta NI = \text{Change in total income} - \text{Change in total variable cost}$$

The marginal rate of return (MRR) which measures the increase in net return associated with each additional unit of expenditure was computed using the equation developed by (Upton, 1979):

$$\text{MRR} = \frac{Chnage\ in\ net\ income\ (\Delta \text{NI})}{Change\ in\ total\ variable\ cost\ (\Delta \text{TVC})} x100$$

Statistical Analysis

The data on feed intake, BW change and carcass yield were analyzed using the General Linear Model (GLM) procedure of Statistical Analysis System, SAS (2008). Means differences were compared using the Tukey's honestly significant difference (HSD) at $\alpha = 0.05$. The following statistical model was fitted to analyze the data:

$$Yij = \mu + ti + eij$$

Where:

Yij = response variables (i.e. feed intake, body weight gain and carcass yield) taken under treatment i).

μ= the overall mean

ti= the i^{th} treatment effects (1=MSL, 2= WSL, 3= MWS, 4= CR)

eij = is a random error

Result and Discussion

Chemical composition of experimental rations

Chemical compositions of the four dietary treatments of grower and finisher rations are presented in Table 3. The rations were formulated from locally available feed ingredients comparing with the commercial ration (CR) purchased from Ethio-chicken PLC and to contain a minimum of similar amount of the nutrients contained in CR in the grower and finisher rations, respectively. The DM and CP contents of the experimental rations were similar for grower rations as well as for finisher rations. The similarity in CP content between locally formulated and commercial rations implies that the rations were formulated based on the CP requirements of broiler at grower and finisher stage which are 19% and 18%. The highest ash content was observed in CR for grower rations followed by WSL, MSL and MWS, respectively. However, ash content of CR was the least for finisher ration.

In the current study, the highest crude fiber (CF) contents were obtained from MSL and WSL for grower and finisher rations, respectively whereas the least % CF values were observed in CR for grower and finisher rations, respectively. ME was highest in CR and MWS for grower and finisher rations, respectively. This implies that the highest EE in CR and MWS for grower and finisher rations, respectively contributed to the highest values of ME observed in both rations. The highest fiber contents of MSL and WSL could be attributed by inclusion of lupins grain which contains high fiber content unlike that of MWS.

Table 3. Chemical composition of experimental rations (gm/Kg DM basis)

Chemical composition (g/kg)	Experimental Rations							
	Grower Rations				Finisher Rations			
	MSL	WSL	MWS	CR	MSL	WSL	MWS	CR
Dry Matter	925	924	912.7	923	930.3	925.3	919.7	924
Ash	72.4	77.6	62.5	103.7	69.9	76.7	76.5	62.1
Crude Fiber	46.5	22.7	32.9	4.3	37.6	39.9	28.3	20.6
Crude Protein	191.5	199.9	194.1	191.9	181.7	189.8	183.8	183
Crude Fat (Ether Extract)	41.3	9.5	32.2	45.5	103.2	21.2	118.1	37.9
Ca	30.6	25.3	21.9	28.9	26.9	27	21.8	25.3
ME*(kcal/kg)	3468	3485	3580	3737	3894	3398	4031	3722

MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; WSL= Wheat, Soybean, Lupin, Nou g seed cake, Limestone,
Common salt and premix; MWS=Maize, Wheat, Soybean, Noug seed cake, Limestone, Common salt and premix; CR=Co mmercial Ration. DM=

Feed intake, body weight change and feed conversion efficiency of Sasso chickens

The mean daily feed intake, body weight change and feed conversion efficiency of Sasso chickens during the entire experimental period is presented in Table 4. There were significant differences ($p<0.0001$) in average daily feed intake among chickens fed on the different experimental rations. Average daily feed intake of chickens fed on CR was significantly ($P<0.05$) higher than those kept on other experimental rations followed by those fed on MWS. There was no significant difference between chickens fed on MSL and WSL with regard to average daily feed intake during the experimental period.

Table 4. Feed intake, Body weight change and Feed Conversion Efficiency of Sasso Chickens fed experimental rations during the whole experimental period.

Parameters	Experimental rations				SEM	P-value
	MSL	WSL	MWS	CR		
ADFI (gm/day)	135.4^{c}	136.8^{bc}	140.5^{b}	151.7^{a}	0.783	<0.0001
IBW (gm)	553.9	553.7	553.6	553.5	0.246	0.7715
FBW (gm)	3346.6^{b}	3466.3^{b}	3928.1^{a}	4048.3^{a}	32.03	<0.0001
ADG (gm/day)	18.63^{b}	19.43^{b}	22.47^{a}	23.30^{a}	0.217	<0.0001
FCE (gain/intake)	0.14^{c}	0.14^{c}	0.16^{a}	0.15^{b}	0.002	0.0003

Note: abc Means with a different superscript in a row are significantly different (P<0.05): ADF = Average daily feed intake, IBW=Initial body weight, FBW=Final body weight, ADG=Average daily gain, FCE Feed Conversion efficiency; MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; WSL= Wheat, Soybean, Lupin, Noug seed cake, Limestone, Common Salt and premix; MWS= Maize, Wheat, Soybean, Noug seed cake, Limestone, Common salt and premix; CR=Commercial Ration; SEM= standard error of the mean

Average feed intake obtained for chickens fed on CR and MWS in the current study was within the report of Osei-Amponsai *et al.* (2015*)* who reported an average intake of 145 g/chicken/day for Sasso T44.

However, average feed intake values of chickens fed on WSL and MSL were below the average feed intake value reported by the previous same authors. Lower feed intake in MSL and WSL in the present study may be associated with high inclusion level of Lupins in the rations making it unsuitable for chicken feeding. Because, lupins contain relatively high levels of non-starch polysaccharides (NSP). The NSP reduces digestibility of nutrients as well as increased digesta viscosity (Anna and Maria, 2019). The main anti-nutritional factor of lupin grain is related to their specific carbohydrate composition, which is characterized by low levels of starch, high levels of NSP and high levels of raffinose oligosaccharides (Wolko *et al*., 2011). These properties affect the utilization of energy and contribute to the reduction of feed intake and digestibility, mainly in monogastric animals.

Significant differences (p<0.0001) were observed in final body weight among chickens fed on the different experimental rations. Chickens fed on CR recorded the heaviest final BW followed by those fed on MWS. However, no significant (p> 0.05) difference was observed between chickens fed on CR and MWS regarding the final BW recorded and average daily gains in 150 days. Significant difference was also not observed between chickens fed on WSL and MSL about final weight. The average final BW obtained in the current study was higher than 2.98 kg reported by Aman Getiso *et al*. (2017) for male Sasso T44 at age of sexual maturity. This might be due to management, location and nutritional differences. Additionally, the final BW obtained for chickens at 20 weeks in the present study was higher than the final BW reported by Mezgebu *et al.* (2020) who reported final BW in the range of 2755.98 g-3907.42 g for male Sasso T44 at 20 weeks of age in Nekemte. This might be due to nutritional differences among experimental rations.

The highest final BW attained by chickens fed on CR and MWS respectively. This might be due to absence of lupins in MWS, lower fiber content and higher energy content of both rations. In contrast to this, the lower final BW was obtained with MSL and WSL; although they contained similar CP values with the previous rations. This was probably due to higher fiber content as well as inclusion of lupin in both rations which may affect feed intake and proper utilization of nutrients in the rations.

Therefore, significantly lower BW recorded for chickens fed on MSL and WSL might be due to significantly lower feed intake of those chickens. Ferket and

Gernat (2006) confirmed in their report that feed intake was the major factor that influences the BW gain of broiler chicken.

In similar fashion to final BW, chickens fed on CR and MWS gained significantly ($p < 0.05$) more weight than those fed on WSL and MSL. Chickens fed both on MSL and WSL gained the least BW. The lower average daily gain attained by chickens fed on MSL and WSL might be due to the higher fiber content and the anti-nutritional content of lupin in MSL and WSL which might have depressed both feed intake and nutrient utilization by chickens. No significant difference ($p > 0.05$) was observed between chickens fed on WSL and MSL about average daily gain (ADG). Faster growth is usually associated with better feed utilization. Similar trends were observed between the final BW and ADG, which indicate that ADG is the direct translation of BW. It has also been reported that growth rate and feed efficiency are highly correlated (Scanes *et al*. 2004).

The ADGs observed in this study were higher than the ADG values of 16.6 g, 15.7 g, and 16.8 g according to the survey result reported by Etalem *et al*. (2013) for Sasso T44 chickens fed on maize diets substituted by 25%, 50% and 75% cassava root chips, respectively. Similarly, the result of ADGs in the present study were higher than the report of Mezgebu *et al*. (2020) who reported that ADGs range from 14.2 g/day to 21.9 g/day for male Sasso T44 at 20 weeks of age. These differences could be due to nutritional differences. Franco *et al*. (2012) reported lower ADG value of 5220 g/10 months (i.e. 17 g/day) for Mos rooster and Sasso T-44 which is lower than the ADGs reported in the current study. This might be due to nutritional differences as well as extended growth period in the former study.

There was significant difference ($P < 0.0003$) in feed conversion efficiency between group of chickens fed on the experimental rations and commercial ration. Chickens were most efficient in converting feed to BW from CR and MWS which is due to the higher growth rates obtained from chickens fed those diets. There was no significant ($P > 0.05$) difference in feed conversion efficiency between chickens fed on MSL and WSL. The better feed conversion efficiency in MWS and CR could be due to differences in feed intake and weight gain among the treatment groups. The FCE values obtained in the current study were higher than the 0.10-0.12 FCE values reported by Mezgebu *et al*. (2020) for Sasso T44 chickens at 20 weeks of age. From this, one could easily observe that among the locally formulated rations; feeding of MWS had better feed utilization efficiency than CR. In general, chickens required more feed per unit of weight gain in WSL and MSL compared with MWS and CR.

Generally, the Saso chickens fed lupine-based diets showed markedly decreased feed intake and growth rate in the present study which is in line with the findings of Hong *et al.* (2022) who indicated that the lower performance of chickens could relate to the presence of anti-nutritional factors as lupine contains relatively high levels of non-starch polysaccharides (NSP). The NSP reduces digestibility of nutrients as well as increased digesta viscosity (Anna and Maria, 2019). This increase in gut viscosity reduced the mixing of digestive enzymes and substrates in the intestinal lumen. Also, the alkaloid content of bitter cultivars ranges from 5 to 40 g/kg (Erbas *et al.*, 2005). All of the above could eventually lead to a reduction in nutrient digestion and utilization.

Carcass characteristics of Sasso chickens fed the experimental rations

The carcass characteristics of Sasso chickens fed different experimental rations are presented in Table 5. The slaughter weight of chickens fed on the different dietary treatments ranged from 3360.3 g -3955.7 g. No significant (p>0.05) difference was observed between chickens fed on CR and MWS in all the parameters measured in the current study. In similar fashion, no significant (p> 0.05) difference was observed between chickens fed on MSL and WSL for all the carcass parameters investigated. Differences were observed among chickens fed on CR and MWS and those fed on WSL and MSL for all carcass characteristics considered during the current study, except for back and neck weights. There was no significant difference (p> 0.05) among chickens of the different treatment groups about back and neck weights.

In the current study, though there was no significant difference recorded between chickens fed on both MWS and CR in most of parameters evaluated (eg. Slaughter Weight, Breast, Back, Carcass Weight and Dressing Percentage), chickens fed on CR outperformed those fed on the other experimental rations in all carcass parameters investigated followed by those fed on MWS. On the other hand, those chickens fed on MSL (T_1) were inferior to the other two groups of chickens fed on WSL (T_2) and MWS (T_3). This could be due to the lower feed intake attributed by high fiber content and anti-nutritional factors of lupin included in MSL and WSL rations. Consumers prefer chickens with high yield of fine parts, such as breast, drumsticks, and thighs (Faria *et al*., 2010). Hence, the highest yields of commercial carcass components (breast, thigh, drumstick and wings) were attained by chickens fed on CR and MWS while the lowest yields of commercial carcass components were scored by those fed on MSL and WSL. This implies that carcass yield obtained from chickens fed on CR and MWS could produce more commercial carcass components as compared to others.

Table 5. Carcass characteristics of Sasso chickens fed on experimental rations

Parameters (g)	Experimental rations				SEM	P-value
	MSL	WSL	MWS	CR		
Slaughter Weight	3360.3[c]	3441.0[bc]	3934.0[ab]	3955.7[a]	10.4	0.0117
Breast (BT)	556.67[b]	571.00[b]	727.33[a]	756.67[a]	16.8	0.0003
Thigh (TH)	501.67[b]	510.33[b]	650.67[a]	680.33[a]	16.1	0.0004
Drumstick (DK)	363.33[b]	389.67[b]	522.33[a]	555.00[a]	10.6	<0.0001
Back (BK)	392.67	406.67	506.00	423.67	40.8	0.2963
Wings (WS)	205.33[b]	201.67[b]	289.33[a]	320.67[a]	11.7	0.0008
Neck (NK)	118.67	117.67	131.67	138.67	8.06	0.2831
Carcass weight	2138.3[b]	2197.3[b]	2827.0[a]	2874.7[a]	67.7	0.0004
Dressing (%)	64.0[b]	64.0[b]	72.0[a]	72.67[a]	0.29	<0.0001

Note: abcd Means with a different superscript in a row are significantly different (P<0.05); MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; WSL=Wheat, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; MWS= Maize, Wheat, Soybean, Noug seed cake, Limestone, Common salt and premix; CR=Commercial Ration; SEM=standard error of the mean

The dressing percentage (DP), as commonly observed in other parameters in Table 5, was highest for chickens raised on MWS and CR while those kept on MSL and WSL attained the least. The DP attained from CR and MWS agreed with the 71.20% reported by El said *et al.* (2016) for Sasso chickens. However, the DP obtained from MSL and WSL was lower than the reports of the same authors. Generally, the dressing percentage obtained during the current study was higher than the dressing percentage ranging from 53.7 – 56.7% reported by Melkamu (2017) for Sasso chickens slaughtered at 56 days of age. These differences could be due to age and nutritional differences.

It appeared that chickens fed on the MSL and WSL rations poorly utilized their feed as evidenced by lower slaughter weight, breast muscle, thigh, drumstick, carcass weights and dressed carcass. Low nutrient utilization which resulted in poor tissue growth and muscle deposition were suggested to be the cause for low carcass yield in broilers (Berhan and Wude, 2010). Additionally, Tegene and Asrat (2010) argued that high carcass yield suggests more nutrient bioavailability for anabolic process than other diets since the true muscle development is an accumulation of protein. Therefore, lower weights of carcasses from chickens fed on MSL and WSL may be due to less deposition of protein as well as lower nutrient utilization as result of anti-nutritional factors of lupin grain in both rations.

Giblet, total edible offal (TEO) and total non-edible offal (TNEO) yields of Sasso chickens

The giblets, total edible offal and total non-edible offal yields of Sasso chickens fed experimental rations are presented in Table 6. There was no significant difference (P>0.05) in giblet yield among chickens fed on the different experimental rations, except heart weight. Chickens fed on MWS recorded the highest heart weight followed by those fed on CR. During the current study, there were no significant differences among chickens fed on the different experimental rations both in yields of total-edible offal (skin, Liver and Gizzard) and the non-edible offal. The non-significant differences observed among the individual components of the giblet such as liver and gizzard in the present study were confirmed by the report of Melkamu (2016) who noted that the giblet weight and its components were not significantly (P>0.05) influenced by a diet containing dried blood-rumen content mixture.

Table 6.Giblet, Total edible offal (TEO) and Total nonedible offal (TNEO)

Parameters (gm)	Experimental rations				SEM	P-value
	MSL	WSL	MWS	CR		
Skin	218.67	209.67	228.00	232.67	10.3	0.46
Liver	51.00	50.00	52.00	49.33	1.72	0.72
Gizzard	54.00	54.00	57.00	58.00	1.40	0.19
Heart	19.33[b]	20.00[ab]	24.33[a]	21.67[ab]	0.96	0.04
Head	141.33	140.33	143.33	145.33	3.87	0.78
Shank	135.00	134.67	134.67	134.33	4.16	0.99
Feather	197.33	198.00	198.33	198.67	6.15	0.99
Giblet	124.67	124.00	128.67	131.00	3.95	0.58
Total edible offal	323.33	313.67	341.67	335.33	11.8	0.41
Total non-edible offal	448.33	493.33	501.00	500.33	24.6	0.44

Note: [ab] Maens with a different superscript in a row are significantly different (p<0.05); MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix: WSL= wheat, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; MWS=Maize, Wheat, Soyabean, Noug seed cake, Limestone, Common salt and Premix; CR=Commercial Ration; SEM=standard error of the mean

Total edible offal (TEO) under Ethiopian context includes gizzard, skin and liver (Asrat *et al*., 2008). The non-responsive of total edible offal (TEO) to the different experimental rations of the present study was in agreement with report by Melkamu (2016), where the TEO of chickens was not significantly influenced (P>0.05) by the dietary treatments.

In Ethiopia, the total non-edible offal components include blood, shank and claws, feather, head, crop, esophagus, proventriculus, spleen, pancreas, kidney, heart, lung, small intestine, large intestines and abdominal fat. In the current study, the TNEO weights obtained from chickens fed on the different dietary treatments were in close agreement with the TNEO weights ranging from 431.1g -525.8g reported by Melkamu (2016) which were also not significantly differed (P>0.05) among chickens fed on different dietary treatments.

Partial budget analysis

Output of the partial budget analysis of Sasso chickens fed on different experimental rations is presented in Table 7. The net income was determined based on ingredients' average costs of feed consumption in the treatment, transport, labor, and feed preparation costs and sales of chickens in the respective treatments. Price (ETB/kg) for MSL, WSL, MWS and CR were 9.27, 13.94, 11.48

and 15.38, respectively. Accordingly, the total costs (ETB) incurred to chickens fed on MSL, WSL, MWS and CR were 5273.86, 8006.99, 6773.83 and 9796.60, respectively. On the other hand, net incomes obtained in Ethiopian birr (ETB) were 4602.45, 2441.81, 5441.61 and 1251.27 from group of birds, fed on MSL, WSL, MWS and CR, respectively. This indicated that CR was the most expensive as compared to the other experimental rations.

Table 7. Partial budget analysis of Sasso chickens fed experimental rations.

Parameters	MSL	WSL	MWS	CR
Number of chickens	30	30	30	30
Total amount of feed consumed (kg)	568.68	574.56	590.11	637.14
Feed cost (ETB)	5273.86	8006.99	6773.83	9796.60
Transport cost (ETB)	203.00	214.31	120.84	1274.28
Labor and processing costs (ETB)	668.98	675.80	694.05	1401.71
Total variable costs (ETB)	6145.84	8897.11	7588.72	12472.58
Total income (ETB)	10748.29	11338.92	13033.33	13723.85
Net income (ETB)	4602.45	2441.81	5444.61	1251.27
∆TVC	-6326.74	- 3575.47	- 4883.86	-
∆TI	-2975.56	-2384.93	-690.52	-
∆NI	3351.18	1190.54	4193.34	-
MRR	52.97	33.30	85.86	-

Note: MSL=Maize, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix: WSL=wheat, Soybean, Lupin, Noug seed cake, Limestone, Common salt and premix; MWS=Maize, Wheat, Soyabean, Noug seed cake, Limestone, Common salt and Premix; CR=Commercial Ration; ETB= Ethiopian Birr ∆TVC=change in total variable cost, ∆TI=change in total income, ∆NI=change in net income, MRR= Marginal Rate of Return

Accordingly, the highest net income was generated from chickens fed on MWS followed by MSL, WSL and CR, respectively. Change in net income (∆NI) was highest for chickens fed on MWS, followed by those fed on MSL and then WSL. The differences in change of net income were due to the differences in feed cost, feed consumption efficiency and selling price of individual chickens in each treatment. The marginal rate of return (MRR) in the present study showed that a unit of ETB cost increment of ingredients per chicken, resulted in additional income (%) of 52.97, 33.30 and of 85.86 for MSL, WSL and MWS, respectively. Among experimental rations, MWS was the most profitable ration based on the consideration of net income (NI) and marginal rate of return (MRR).

Conclusion

Higher BW gain, better feed conversion efficiency, heavier carcass yield as well as the highest net income were obtained from feeding of Sasso chickens with MWS. Even if the CR had higher weight gains and heavier carcass yields, it is associated with highest cost (the most expensive one). Inversely, feeding of Sasso chickens on MSL and WSL had lower weight gains and carcass yields with lower total variable cost as compared to the CR. Thus, by considering weight gains and carcass yield parameters and feed costs, MWS was the most profitable ration with the desirable quantity of carcass from Sasso chickens. Therefore, MWS can be used as an alternative feed source in Saso chicken's ration, without any adverse effects on feed intake, for best growth performance, carcass yield and profitability of Sasso chickens, according to this experiment, instead of commercial ration which is expensive and not accessible.

Acknowledgements

The authors thank National Veterinary Institute of Ethiopia for their support in chemical analysis of feed and meat samples. Besides, we would also like to thank Mr. Waseyehun Hassen and Mr. Temesgen Minamo of Jimma University for sharing us their good experience on feed wins software application. Finally, we would like to say thanks to Wallaga University for feeding experiment facilities.

Contribution of Authors

- This article is extracted from the MSc thesis of the major author, Geremew Asfaw.
- Hasan Yusuf has contributed in the analysis and interpretation of data in the preparation of the article.
- Gemeda Duguma and Diriba Diba are advisors of the MSc thesis work and involved in the conception, design, analysis and interpretation of data

Conflicts of interest

- We declare that there is no conflict of interest.

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