Ahmadu Bello University, Zaria

BEYOND THE RABBIT HOLE: CONCENTRATE AND FORAGE UTILIZATION FOR SUSTAINABLE FOOD AND LIVELIHOOD SYSTEMS

AN INAUGURAL LECTURE

Series No. 09/26



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By

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PREAMBLE

I remember with nostalgia my early days as a student in secondary school, when we were asked to choose careers, we wanted to further in. I choose to be a lawyer or an animal scientist. I told my family my choices but to my shock, I was told that to be a successful lawyer, I would have to consult with native doctors. So as not to do this, I choose my other choice, animal science. I have never regretted this choice. As God would have it, today, my husband and daughter, are lawyers and they have not consulted any native doctor. My passion for animal science was ignited by my mother, and the delicious rabbit stew we enjoyed on Sundays for lunch. My mother raised rabbits and poultry when I was growing up. I was fascinated by the docile and playful behaviour of the rabbits.

As an animal science student in Ahmadu Bello University (ABU), I loved animal nutrition and physiology. I had good lecturers in these specializations who guided my choice and interest. Prof. O. A. Osinowo, my Reproductive Physiology lecturer and mentor, introduced me to the specialization of Physiology, opened my eyes to the intricacies of physiological mechanisms and piqued my interest in reproductive physiology. He patiently taught me to take initiative for things in life and told me to 'talk nicely to people' especially when they were difficult to deal with. I had the honour of working with His Excellency Prof P.C. Njoku, my lecturer and first supervisor, who taught me how to formulate diets and cut my first research tooth as an undergraduate student. My love for animal nutrition was from my work with him. I remember how he would patiently put me through each time I had issues with feed formulation or with my project. In 1987, I had the privilege of working with late Professor T. Ekpenyoung, my master's degree supervisor at the University of Ibadan. While working with him,

I discovered my passion for the interaction between nutrition and physiology.

I got employed by the National Animal Production Research Institute (NAPRI), in 1990 as one of the three pioneer staff in Rabbit Research Unit, then domiciled in Poultry Research Programme, to study rabbit physiology, and I am the only one left out of the three. I moved up the ladder of academic achievement from an Assistant Research fellow in 1990 to Research Professor in 2008. As the only scientist in the Unit, my duties included research in rabbit physiology, nutrition, production and management. I was the pioneer Head of Unit of the Rabbit Research Unit, Programme Leader, Swine and Rabbit Research Programme and currently the pioneer Programme Leader, Animal Products Research Programme. I belong to several professional bodies; Nigerian Society for Animal Production (Fellow, Life member, Member Welfare Committee, Scientific Committee, Communique drafting Committee (Owerri, Sokoto, Abuja); Animal Science Association of Nigeria (First Vice President, Chairman Communique drafting Committee and scientific committee); Nigerian Institute of Animal Science (Fellow Postgraduate College of Animal Scientist, Registered Animal Scientist; Council Member and Chairperson, Micro livestock, Wildlife and Forestry, Member Audit Committee, Resource verification, Curriculum and Internship Committee; Chairman, Resource verification, Curriculum and Internship Committee); and World Rabbit Science Association (Sub Saharan Africa Chapter). I was a member of the Rotary Group exchange Program to Canada, Visiting Scientist to CORAF/WECARD, Senegal and a Chevening Scholar.

INTRODUCTION

Nigerian population is estimated to be around 240 million as of early 2026, which is equivalent to 2.89% of the total world population (Worldometer, 2026). With an estimated growth rate of 2.44%, Nigeria's population is projected to reach about 401.31 million by 2050. This increase in human population correlates with increased demand for food and other agricultural products including those of animal origin (Presidential Livestock Reforms Implementation Committee, 2024). The UNICEF, WHO and The World Bank, Joint Child Malnutrition Estimate (2025) showed that as of 2023-2024, between 713 to 757 million people (8.3% of the world) faced hunger and food insecurity, with over 3 billion unable to afford a healthy diet globally. According to the World Food Programme (2024), malnutrition in Africa, and especially West Africa, is a severe, and worsening crisis driven by conflict, economic hardship, climate change and shocks, and rising food prices, with millions facing acute hunger and rising stunting rates (around 30.9% in West Africa, higher than global average). These arise from challenges of severe food insecurity, displacement, funding gaps, and supply chain disruptions, impacting overall growth and development.

The survey of the Nigeria Demographic and Health Survey (NDHS 2023-2024) showed 40% children under five years are stunted. Matching animal protein consumption and child stunting in the geopolitical zones of Nigeria, Umar *et al*. (2026), reported the North West had 21.2% animal protein consumption with 53.2% child stunting; North East had 17.8% animal protein consumption with 51.8% stunting; North Central has 26.6% animal protein consumption with 36.8% stunting;, South West has 38.1% animal protein consumption with 21.2% stunting; South East has 38.9% animal protein consumption with 20.6% stunting while the South South zone has 47.1% animal protein

consumption with 17.9% child stunting. They also observed that nationally women consume 13.6g/day animal protein while children consume 6.9 g/day animal protein.

A form of malnutrition that results from low protein-high energy misalignments in nutrition results in kwashiorkor, due to protein deficiency mainly in children, and marasmus resulting from overall lack of protein and energy (starvation). These result in swollen and distended abdomens (edema), stunted growth, aneamia, muscle wastage, fat loss and emaciation in adults and children (Arnarson, 2024). To overcome malnutrition, balanced diets that consist of carbohydrates, protein, minerals and vitamins need to be provided in adequate quantities. Unfortunately, animal protein requirement of the balanced diet required is lacking from the combination.

Nigeria's livestock sector is presently valued at ₦33 trillion; however, it contributes between 3-5.81% of the annual GDP (The Presidential Livestock Reforms Implementation Committee, 2024; APMD, 2026). Livestock production is an essential part of the Nigerian society and economy, with about 13 million households who keep farm animals, therefore, contributing to people's livelihoods through numerous channels such as provision of income, savings, food, employment, transport, draft power, manure, urine, insurance and social status (Nayananjalie, 2021). The present economic condition in most tropical countries, characterized by great shortage of animal protein, has turned attention to rabbit production as a ready solution to the provision of animal protein.

Rabbits belong to the order Lagomorpha, split into two large families: the Ochotonidae and Leporidae. Rabbits and hares are members of the Leporidae family, which are indigenous throughout most parts of the world and, are raised in small-holder, large-scale and commercial production systems (Dalle Zotte, 2014). Rabbit production has over the years increased in

popularity and acceptability in Nigeria because of its fast growth rate, large litter size, early maturity, small size, healthy meat, and low price. Rabbit meat is characterized by low fat and cholesterol content, rich in protein with high biological value and high polyunsaturated fatty acid content, essential macro and micronutrients, such as minerals (potassium, phosphorus, and selenium) and vitamins, particularly vitamin B12 (Ana-Maria *et al*., 2025), necessary for healthy living.

Global population of rabbits is estimated at 709 million (Price, 2025). There are no official 2025 census data of the precise rabbit population in Nigeria. However, as of 1992, the estimated population of rabbits in Nigeria was 1.7 million, (Presidential Taskforce on Alternative Formulation of Livestock Feeds, 1992) mostly concentrated in rural areas, kept by women, youths and children. Rabbit production is still relatively underdeveloped in Nigeria with an estimated 3.4-5.2% of the population involved in small-scale production (Ayeni *et al*., 2025). Rabbit production is a corrective measure for animal protein shortage and increased meat source to augment family feed budget and sustain families under any economic situation, being the cheapest and sustainable means of producing high-quality animal protein for expanding populations of developing countries like Nigeria (Onifade *et al*., 1999). Over the decades, exotic rabbit breeds which originally lived under temperate environmental conditions have become adapted to the climatic conditions of the tropics. Breeds of rabbits majorly raised in Nigeria include New Zealand White, California, Dutch, Chinchilla, and Flemish giant. Rabbits are fast growing, early maturing, have high litter size to meet market demands of meat.

Productivity in terms of growth and reproductive performances of rabbits in Nigeria, close to the equator, show lower growth rate and poorer feed conversion ratio than those under temperate conditions, implicating the high ambient temperature of tropical

climates and level of management (Iyeghe *et al*., 1996, Onifade *et al*., 1999, Iyeghe-Erakpotobor *et al*., 2001). The high fecundity of rabbits, coupled with their high meat parts (higher than chickens), in addition to their nutritious white meat, has made them a good alternative to meeting the demand for healthy protein sources for the populace.

Feed is the greatest, and most critical factor in animal production and reproduction. Success in both is determined by several interactive factors like genetic make-up of the animal, temperature, photoperiod, stress and nutrition. Of these factors, nutrition has a great influence on the ability to achieve both production and reproduction goals (Iyeghe-Erakpotobor and Ashworth, 2003). Energy is the largest proportion of nutrients in a compounded animal diet and constitutes the highest cost of production (Soenke *et al.,* 2005). Feed energy concentration is the main factor responsible for the ingestion of dry matter and other nutrients (protein, amino acids, minerals and vitamins) which contributes to animal production and total well-being (Xiccato and Trocino, 2010).

Rabbit nutrition by small scale farmers involves the feeding of forages, kitchen waste, and a wide range of agro-industrial by products which on their own do not adequately meet the nutritional needs of rabbits for fast growth and reproduction. This makes it imperative therefore to produce balanced feed that would improve their growth and reproductive efficiencies under tropical conditions. The problem for small scale and commercial rabbit producers in meeting the nutritional requirements of rabbits, however, is the high cost of concentrate feeds, in addition to optimum feeding regime. This has resulted in the search for cheaper ways of producing rabbits therefore, the need to seek alternative feed sources in forages to reduce the cost of feeding rabbits, especially because of the availability of forages and ability of rabbits to convert forage protein into meat. A

combination of concentrate diet and forage to achieve this goal is especially being sought after, to utilize available resources, reduce cost of feeding, as well as the total cost of production.

For over three decades, I studied several combinations of concentrates and forages, with a bid to find options that farmers can use. For this lecture, studies that cover growth and reproduction phases of rabbit production will be presented. The question asked is *"Can locally available forages partially replace expensive concentrate feeds without compromising rabbit productivity?"*

DEFINITION OF CONCENTRATE AND FORAGE

According to Akinola and Odedire (2019), concentrates are feed containing relatively low crude fibre which is less than 18% and 60% or more total digestible nutrients. It is also a concentrated source of one or more nutrients used to supplement or improve the nutritive balance of a feed mix. Concentrates are, therefore, low-fibre, high energy feeds with low, medium or high protein content. Forages on the other hand, are vegetable foods available to animals which could be browse plants, hay, silage and green feed (Akinola and Odedire, 2019). Forages are high in fibre, maybe low or high in protein and low in energy especially when fresh.

GROWTH PERFORMANCE OF RABBITS

Growth is measured by increase in size as well as development of the animal. This is driven majorly by nutrition. The growth of rabbits fed combinations of different levels of concentrate and forages is shown in Table 1. Daily feed intake, feed:gain ratio and feed cost/kg gain were significantly increased by concentrate level, while feed cost/kg concentrate intake and feed cost/kg gain decreased as concentrate level increased, increasing percentage savings on concentrate feed from 9.30 to

61.58%. Irrespective of forage fed, feed cost/kg gain decreased significantly ($p<0.05$) with decrease in level of concentrate fed. Forages, especially legumes, with their high protein content, have the potential of meeting the need for cheaper feed sources for rabbits. Among the forages, combination of 25% concentrate and mucuna gave the lowest cost compared to lablab and groundnut haulm while at higher levels of concentrate, groundnut haulm performed better than mucuna and lablab (Iyeghe-Erakpotobor *et al*., 2002).

This study shows that reducing concentrate levels lowered feed costs substantially, while mucuna and groundnut haulm maintained acceptable growth performance even at reduced concentrate levels. Partial replacement of concentrate with legumes can drastically reduce production costs while sustaining moderate growth, however, profitability may improve more from reduced feed costs than from maximizing growth rate alone.

Table 1: Effect of feeding different levels of concentrate and forage legumes to weaner rabbits

Treatment	Daily conc. Intake (g)	Daily weight gain (g)	Feed:gain ratio	Feed cost/kg conc. Intake (₦)	Feed cost/kg gain (₦)	Savings on conc. Feed (%)
100C + D	127.5	9.0	14.5^{a}	3.45	383.1^{a}	-
75C +M	99.5	8.6	11.5^{ab}	2.69	313.4^{abc}	18.19
50C + M	61.0	6.7	9.2^{ab}	1.65	248.1^{bc}	35.24
25C + M	36.5	6.8	5.5^{d}	0.99	147.2^{e}	61.58
75C + L	83.0	6.8	12.9^{ab}	2.24	347.5^{ab}	9.30
50C +L	67.5	6.6	10.5^{ab}	1.82	281.8^{bc}	26.44
25C + L	34.0	6.7	5.8^{dc}	0.92	156.3^{de}	59.20
75C + G	98.0	8.6	11.9^{ab}	2.65	319.0^{ab}	16.73
50C + G	65.0	8.1	8.2^{bcd}	1.76	221.1^{bcd}	42.29
25C + G	35.5	5.4	6.7^{cd}	0.96	179.8^{cde}	53.07
SEM		0.86	0.8		46.5	

Means with different superscripts along columns are significantly ($P<0.05$) different.
D=Digitaria, M=Mucuna, L=Lablab, G= Groundnut haulm, C= Concentrate

A combination of standard rabbit diet concentrates, grass and legumes was fed to growing rabbits using the standard rabbit diet fed routinely and a compounded soybean cheese waste diet as concentrates, *Digitaria decumbens* as grass and legumes were groundnut, sweet potato and soybean forages (Iyeghe-Erakpotobor *et al*., 2006a: Iyeghe-Erakpotobor, 2007). The response of rabbits to the concentrate type is shown in Table 2. Rabbits on soybean cheese waste diet consumed 6% more compared to those on the standard rabbit diet. Grass, legume and total feed intake, weight gain and feed conversion were similar for both concentrates. Feed cost and cost/kg gain were respectively, 27 and 37% lower for soybean cheese waste than rabbit diet. Rabbits fed soybean cheese waste diet performed similarly or better than those fed the conventional rabbit diet therefore, soybean cheese waste diet proved to be a viable low-cost alternative concentrate to rabbit diet.

Table 2: Effect of concentrate type on performance of growing rabbits

	Concentrate type		SE
Parameter	Rabbit meal	Soybean cheese waste	
Concentrate intake (g/d)	45.4[b]	48.3[a]	0.64
Grass intake (g/d)	23.2	21.6	0.59
Legume intake (g/d)	33.9	33.2	0.59
Feed intake (g/d)	102.6	104.8	1.50
Weight gain (g/d)	4.5	6.6	2.66
FCE	0.04	0.07	0.024
Feed cost (₦/d)	21.25[a]	15.52[b]	0.25
Feed cost/kg gain (₦)	230.21[a]	145.67[b]	19.46

Means bearing different superscripts along rows are significantly different ($P<0.05$).
FCE= Feed conversion efficiency

The response of growing rabbits to forage type is shown in Table 3. Concentrate intake, total feed intake and feed cost were similar for all forage types. Grass intake was 9% lower, while forage intake was 6-7% higher on groundnut than sweet potato or soybean forages indicating groundnut haulm was more palatable and acceptable to rabbits. Feed cost/kg gain was 18-29% higher for sweet potato than groundnut and soybean forages indicating sweet potato vines were less cost-effective than groundnut and soybean forages. Though weight gains were similar for the forages, rabbits on groundnut haulms were cheaper to produce, hence it was more economically beneficial than the other forages. Feed preference and forage quality directly influence intake and growth of the rabbits.

Table 3: Effect of Forage type on performance of growing rabbits

Parameter	Forage type			SE
	Groundnut haulm	Sweet potato vines	Soybean forage	
Concentrate intake (g/d)	45.9	48.0	46.6	0.82
Grass intake (g/d)	21.5^{b}	23.7^{a}	22.0^{ab}	0.72
Legume intake (g/d)	35.2^{a}	32.9^{b}	32.5^{b}	0.73
Total feed intake (g/d)	105.0	105.0	101.2	1.82
Weight gain (g/d)	7.94	5.60	3.14	3.31
FCE	0.085	0.052	0.025	0.028
Feed cost (₦/d)	18.65	18.41	18.10	0.30
Feed cost/kg gain (₦)	157.69^{b}	223.98^{a}	182.86^{ab}	23.14

Means bearing different superscripts along rows are significantly (P<0.05) different.
FCE=Feed conversion efficiency

Figure 1 shows the interaction between concentrate and forage types on total feed intake and weight gain of growing rabbits. Rabbits on soybean cheese waste diet (SBW) and sweet potato vines (SPV) had the lowest total feed intake while those on rabbit diet (RM) and SPV had the highest total feed intake. Rabbits fed SBW and groundnut haulm (GH) had the highest ADG compared to those fed RM and GH, however, there was no difference in ADG for rabbits on RM or SBW fed SPV or soybean forage (SBF). This indicates that not all forages are

nutritionally equivalent even when crude nutrient levels appear similar. Feed cost per day and feed cost/kg gain (Figure 2) were lower for rabbits on SBW than RM for all the forage types. From the study, soybean cheese waste diet is a potential cheap concentrate for rabbits while feeding groundnut haulms and soybean forage were more cost effective than sweet potato vines. It is evident that agro-industrial by-products can play major roles in livestock feeding, especially in rabbit nutrition.

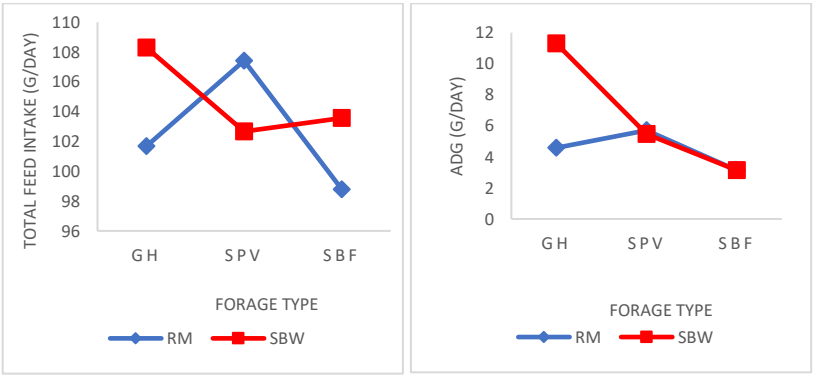


Figure 1: Effect of concentrate and forage types on total feed intake and average daily weight gain of growing rabbits

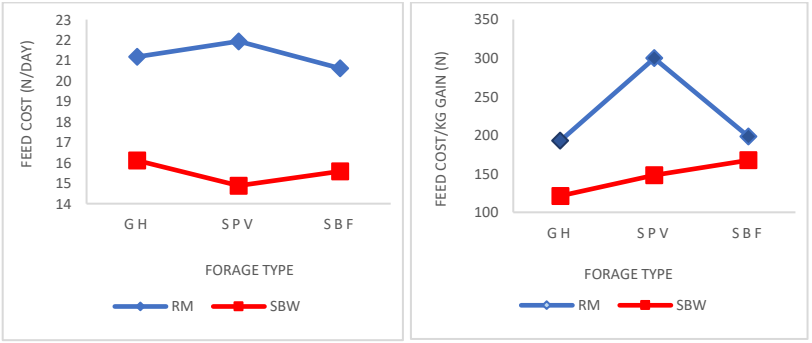


Figure 2: Effect of concentrate and forage types on feed cost and feed cost/kg gain of growing rabbits

The response of growing rabbits to concentrate and Stylosanthes combinations, at 25:100, 50:75, 75:50, 100:25 and 125:10, offered separately to rabbits was evaluated by Iyeghe-Erakpotobor (2006). These combinations ranged from low concentrate/high fibre to high concentrate/low fibre rations. Table 4 shows that total weight gain was lower while feed:gain ratio was higher with the low concentrate/high fibre (25:100) combination than other combinations indicating that extremely low concentrate levels negatively affected growth of rabbits. Daily feed intake significantly ($p<0.05$) decreased as concentrate level increased resulting from high energy density of the concentrate to meet feed energy requirement of the rabbits. Feed intake is positively influenced by energy content of the diet.

Table 4: Performance of growing rabbits fed combinations of concentrate and Stylo

Parameter	Concentrate:Stylo combination (g:g)					SE
	25:100	50:75	75:50	100:25	125:10	
Initial weight (kg)	1.30	1.06	1.12	1.08	1.09	0.09
Final weight (kg)	1.59	1.61	1.70	1.68	1.63	0.08
Average daily gain (g)	6.12^{b}	10.71^{a}	11.74^{a}	12.12^{a}	10.97^{a}	2.19
Concentrate intake (g/d)	23.2	44.20	61.10	66.30	71.20	3.77
Forage intake (g/d)	70.20	44.20	29.30	20.20	9.50	2.13
Total feed intake (g/d)	93.40^{a}	88.40^{ab}	90.40^{ab}	86.50^{bc}	80.70^{c}	2.48
FGR	19.0^{a}	8.9^{b}	11.0^{b}	7.6^{b}	8.0^{b}	2.41

Means with different letters along rows are significantly ($P<0.05$) different.

Table 5 shows increase in feed cost, cost/kg intake and cost/kg gain as the concentrate level increased up to 100 g. Time required to attain market weight of 2.5 kg decreased from 13.6 months to 6.9 months, total feed required to attain market weight decreased from 38.2 kg to 17.8 kg, whereas total cost of feeding increased from ₦293.94 to ₦483.68 with increase in concentrate level. Sanni *et al.* (2005) reported that of these combinations, 50:75 concentrate and Stylo combination gave better return on investment than other combinations, thus reducing the cost of feeding grower rabbits by supplementing

concentrate diet with Stylosanthes. This study shows that moderate concentrate supplementation produced the best balance between performance and cost. There is an optimal concentrate-to-forage ratio of 75:50% beyond which economic efficiency declines. In this study, maximum growth did not necessarily equal maximum profitability.

Table 5: Cost of production and time to market of growing rabbits fed combinations of concentrate and stylo

	Concentrate:Stylo combination (g:g)					
Parameter	25:100	50:75	75:50	100:25	125:10	SE
Feed cost (₦)	0.71[a]	1.33[b]	1.84[c]	1.99[d]	2.14[d]	0.05
Cost/kg intake (₦)	7.70[a]	15.30[b]	20.50[c]	22.90[d]	26.30[e]	0.23
Cost/kg gain (₦)	27.20[a]	69.60[ab]	87.60[bc]	121.90[c]	62.30[ab]	18.40
Time required to attain market weight (months)	13.6	7.8	7.1	6.9	7.6	-
Total feed required to attain market weight (kg/rabbit)	38.2	20.6	19.3	17.8	18.4	-
Cost of feeding to market weight (₦/rabbit)	293.94	315.68	394.77	408.59	483.68	-

Means with different superscripts letters along rows are significantly (P<0.05) different.

Feeding weaner rabbits with graded levels of soybean cheese waste (SBW) diet and Bracharia hay, Iyeghe-Erakpotobor *et al.* (2006b) observed that rabbits on the control diet had significantly higher feed intake compared with the SBW treatments (Table 6). SBW diet decreased grass intake while weight gain and feed conversion efficiency were similar for all treatments except for rabbits on the lowest concentrate (25% SBW) level which lost weight indicating that 25% SBW did not meet the nutrient requirements of the rabbits. Survival rate of rabbits was low ranging between 40 and 60%. This could result from inadequate nutrient supply and the coarse nature of Bracharia hay. Coarse, poorly digestible forages reduce performance and survival of animals. The physical characteristics of forages are as important as their nutrient

composition, hence, feed texture and fibre quality influence feed utilization efficiency.

Table 6: Performance of weaner rabbits fed levels of soybean cheese waste diet and Bracharia hay

Parameter	100:60R	100:60SBW	75:85SBW	50:110SBW	25:135SBW	SE
Initial weight (kg)	0.92	0.99	0.99	1.00	0.92	0.06
Final weight (kg)	1.20^{a}	1.22^{a}	1.03^{ab}	1.07^{ab}	0.84^{b}	0.11
Average daily gain (g)	6.70^{a}	5.47^{a}	0.95^{ab}	1.78^{ab}	-2.08^{b}	2.59
Concentrate intake (g/d)	76.50^{a}	52.8^{b}	41.10^{c}	41.00^{c}	22.40^{d}	2.44
Grass intake (g/d)	33.30^{ab}	31.70^{bc}	31.20^{c}	35.40^{a}	34.90^{ab}	1.22
Total feed intake (g/d)	109.90^{a}	84.60^{b}	72.30^{c}	76.40^{c}	57.30^{d}	3.20
FCE	0.044^{a}	0.040^{a}	0.013^{ab}	0.054^{a}	-0.048^{b}	0.026
Survival rate (%)	80.00	56.00	50.00	60.00	40.00	15.9

Means with different letters along rows are significantly ($P<0.05$) different. FCE= Feed conversion efficiency. 100:60R = 100g rabbit diet and 60g Bracharia hay. 100:60S = 100g SBW and 60g Bracharia hay. 75:85S = 75g SBW and 85g Bracharia hay. 50:110SBW = 50g SBW and 110g Bracharia hay. 25:135S = 25g SBW and 135g Bracharia hay.

The performance of growing rabbits fed levels of soybean cheese waste diet (SBW) and lablab hay was further monitored by Iyeghe-Erakpotobor and Esievo (2008, 2010). Rabbits on high soybean cheese waste diet and lablab (100:60SBW) had significantly higher weight gain than rabbits on the rabbit diet control (R) (Table 7). Weight gain decreased linearly with decrease in SBW. Total daily feed intake was significantly higher on control than the SBW treatments. Among the SBW treatments, total feed intake, feed cost and cost/kg gain significantly ($p<0.05$) decreased with decrease in level of SBW, giving savings of 58-73% on SBW over the control. The rabbits efficiently adjusted forage intake according to concentrate levels. From the study, lablab hay supported excellent growth when combined with SBW diet. This shows the strong potential of lablab hay as a strategic forage for commercial rabbit production.

Rabbits consume legumes well when fed as sole or in combination with other forages or concentrates (Iyeghe-Erakpotobor and Muhammad, 2008). When offered concentrate

and forages, rabbits would consume enough dry matter to meet their requirement for nutrients. The type of forage appears to determine the total feed intake as it affects the intake of both the concentrate and forage. For coarse forage hays such as *Brachiaria decumbens* grass, feed intake of both soybean cheese waste diet and forage was lower (Iyeghe-Erakpotobor *et al*., 2006b) compared with intakes obtained with soybean cheese waste diet and lablab (Iyeghe-Erakpotobor and Esievo, 2010).

Table 7: Performance of grower rabbits fed levels of soybean cheese waste diet and lablab hay

Parameter	100:60R	100:60SBW	75:85SBW	50:110SBW	25:135SBW	SE
Initial weight (kg)	1.29	1.21	1.21	1.19	1.33	0.11
Final weight (kg)	1.69^{a}	1.78^{a}	1.63^{ab}	1.47^{b}	1.56^{b}	0.08
Average daily gain (g)	9.52^{b}	13.69^{a}	10.12^{b}	6.55^{bc}	5.36^{c}	1.42
Concentrate intake (g/d)	82.0	62.58	52.67	30.87	20.11	2.66
Lablab intake (g/d)	36.23	27.48	44.28	56.13	78.91	2.53
Total feed intake (g/d)	118.23^{a}	90.06^{bc}	96.95^{bc}	87.00^{c}	99.02^{b}	3.80
FGR	12.96^{bc}	6.91^{a}	10.09^{ab}	6.34^{a}	20.01^{c}	2.74
Feed cost (₦/day)	3.84^{a}	1.49^{c}	1.68^{b}	1.59^{b}	1.88^{b}	0.11
Cost/kg gain (₦)	419.80^{a}	114.20^{b}	174.67^{b}	115.92^{b}	380.08^{a}	52.12
Savings (₦/kg gain)	-	305.60	245.13	303.88	39.72	-
Percent saving	-	72.80	58.39	72.39	9.46	-

Means with different superscripts letters along rows are significantly (P<0.05) different. 100:60R = 100g rabbit diet and 60g lablab hay. 100:60SB = 100g soybean cheese diet and 60g lablab hay. 75:85S = 75g soybean cheese diet and 85g lablab hay. 50:110SB = 50g soybean cheese diet and 110g lablab hay. 25:135SB = 25g soybean cheese diet and 135g lablab hay.

Savings per kg gain obtained using soybean cheese waste and lablab hay compared with the conventional rabbit diet control, would result in general reduction in cost of production of rabbits; and make it possible for farmers to make profit. Weight gains obtained using lablab forage hay were higher than those obtained with Brachiaria grass. Goetsch *et al.* (2003) observed that an increasing level of concentrate (i.e. 25, 50 and 75%) in diets with moderate to high-quality forage increased average daily gain of young Alpine doelings. Studies have shown that rabbits can utilize 50g of concentrate with forage grass or legume without adverse effect on growth (Bamikole and Ezenwa, 1999; Iyeghe-Erakpotobor *et al*., 2002, Iyeghe-Erakpotobor, 2006b). The reason for higher weight gain and

feed conversion by the 100:60S group over the control could be the higher amino acid composition in soybean compared with that in groundnut cake which was the protein source in the control diet.

Iyeghe-Erakpotobor (2009) studied the response of growing rabbits fed sole groundnut haulms, stylosanthes and mixture of both forages supplemented with 50 g concentrate. Total feed intake of rabbits was similar for the forages (Table 8). Performance of rabbits on sole and mixed forages was similar except for feed conversion ratio which was significantly lower for stylo than groundnut and mixed forages. Though feed cost was similar, cost/kg gain was higher for stylo than mixed forages. This could be because of lower weight gain on stylo compared with the groundnut and mixed forages. Daily weight gain of 5.8-7.7g obtained are similar with gains reported for rabbits on groundnut haulm, sweet potato vines and soybean forage (Iyeghe-Erakpotobor *et al*., 2006a, Iyeghe-Erakpotobor, 2007), mucuna, lablab and groundnut haulm (Iyeghe-Erakpotobor *et al.,* 2002). Cost/kg gain of ₦1114.75 obtained for stylo is much higher than ₦27.20-62.30 reported for rabbits offered various levels of stylo and concentrate by Iyeghe-Erakpotobor (2006). Cost/kg gain of ₦829.78 obtained for groundnut haulm is also higher than ₦157.69, ₦192.67, ₦122.72 obtained by Iyeghe-Erakpotobor *et al*. (2006a) and Iyeghe-Erakpotobor (2007). High cost/kg gain obtained in this study for all the treatments could be because of the wide variations in weight gains of rabbits used which ranged from 0.7-1.5 kg.

The study showed that though concentrate, forage and total feed intake of rabbits was similar for the forages type (Figure 3), total weight gain was higher for mixed forages and lowest on sole stylo, indicating better performance of rabbits on the mixed forages than the sole forages. This shows a possible nutrient

complementarity between the forages, especially protein profiles of groundnut and stylo forages resulting in higher nutrients intake and utilization in the mixed than the sole forages.

Table 8: Performance of rabbits fed groundnut and Verano stylo forage hay supplemented with concentrate

Parameter	Forage type			SE
	Stylo	Groundnut	Mixed (Stylo + groundnut)	
Total feed intake (g/d)	139.69	139.92	139.90	2.47
ADG (g/d)	5.80	7.26	7.69	0.88
FGR	42.12[b]	31.46[ab]	23.93[a]	6.05
Feed cost (₦/d)	3.70	3.70	3.69	0.048
Cost/kg gain (₦)	1114.75[a]	829.78[ab]	634.07[b]	162.66

Means with different letters along rows are significantly ($P<0.05$) different. FGR=Feed to gain ratio

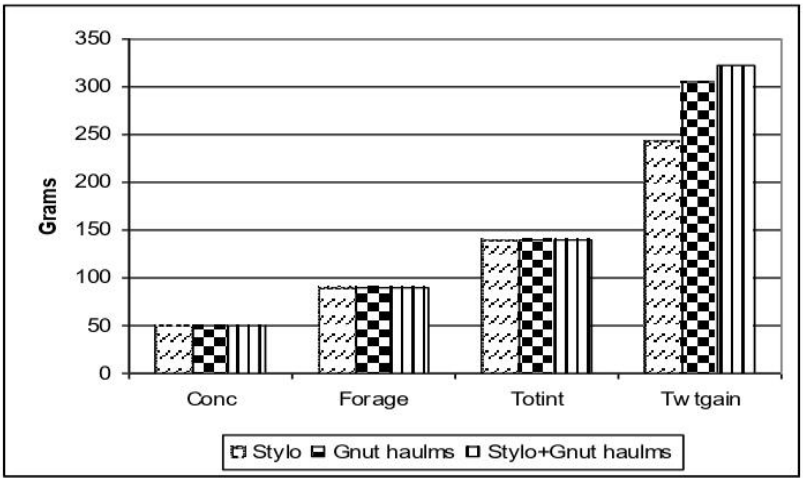


Figure 3: Concentrate, forage, total feed intake (concentrate + forage) and total weight gain of growing rabbits fed forage hay supplemented with concentrate. Conc – concentrate, totint – total feed intake, twtgain – total weight gain.

Performance of growing rabbits fed sole groundnut (GFM), lablab (LFM) forage diets and mixed groundnut and lablab forage (GLFM) diet was further evaluated by Iyeghe-

Erakpotobor (2012). The forages did not affect feed intake, final weight, weight gain, feed cost and feed cost/kg gain of rabbits (Table 9). Feed conversion was slightly lower ($p>0.05$) for mixed forage than sole groundnut and lablab forage meals. Savings/kg gain was higher (₦40.68-₦55.49) for rabbits fed sole lablab and mixed forage than rabbits fed sole groundnut forage diet and lower (₦14.81) between sole lablab forage diet and mixed forage diet. The rabbits performed equally well on groundnut, lablab and mixed forage meal diets, indicating similar nutrient composition for groundnut and lablab forages. From these studies, mixed forage systems generally improved performance compared with sole forage feeding, hence combining forages may create synergistic nutritional effects that could result in improved growth performance in rabbits.

Table 9: Performance of rabbits on sole and mixed forage meal diets

Parameter	Forage meal		
	Groundnut	Lablab	Mixed (Groundnut and Lablab)
Initial weight (kg)	1.27±0.12	1.17±0.10	1.13±0.10
Final weight (kg)	1.57±0.14	1.59±0.11	1.53±0.12
Total feed intake (kg)	4.00±0.22	4.182±0.19	3.94 ±0.19
Feed intake (g/d)	75.26±4.18	78.91±3.50	74.35±3.54
Weight gain (g/d)	6.02±1.18	7.86±0.99	7.53±1.00
FCE (gain/intake)	0.09±0.017	0.10±0.015	0.10±0.015
Feed cost (₦/d)	2.18±0.06	2.29±0.05	2.16±0.05
Feed cost/kg gain (₦)	374.29±56.13	318.80±46.96	333.61±47.63
Saving/kg gain (₦)	-	55.49	40.68

Iyeghe-Erakpotobor *et al*. (2012) studied the response of growing rabbits fed graded levels of groundnut forage and concentrate in separate feeders or mixed as complete diets. Feed intake and weight gain of rabbits fed groundnut forage levels (Figure 4) were higher at 15 and 45% levels than the control (0%) and 30% levels. However, feed cost/kg gain (Figure 5) decreased with increase in groundnut forage level, while saving/kg gain increased from ₦334.4 to ₦442 for the

groundnut forage levels compared with the control, and from ₦7.90 to ₦107.60 for 30 and 45% GFM compared with 15% GFM. This implies better economic returns to farmers with increased groundnut forage levels.

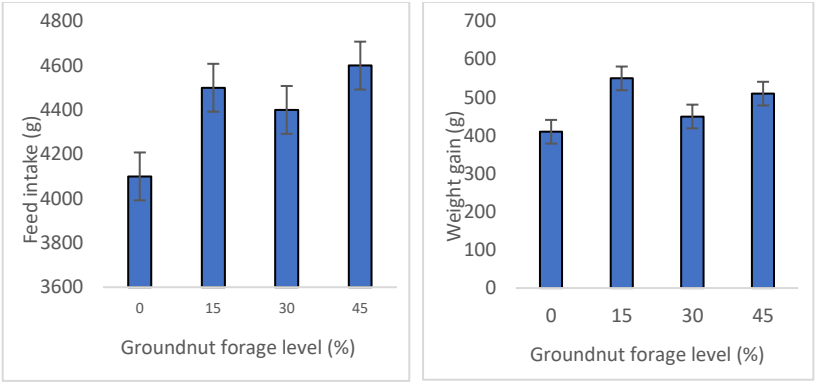


Figure 4: Influence of level of groundnut forage on feed intake and weight gain of growing rabbits

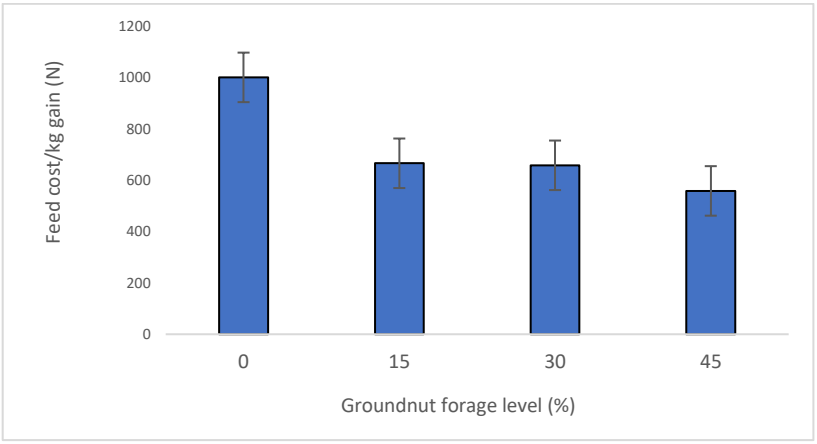


Figure 5: Influence of level of groundnut forage on feed cost/kg gain of growing rabbits

Table 10 shows the effect of feeding system on performance of weaner rabbits fed groundnut forage. Feeding rabbits concentrate and groundnut forage, separately or mixed (complete diet), increased ($p<0.05$) feed intake than when sole concentrate was offered. Average daily gain was higher ($p<0.05$) for separate feeding than mixed and sole feeding. Though feed conversion ratio was similar for all the feeding systems, feed cost and feed cost/kg gain were significantly ($p<0.05$) higher for sole feeding concentrate than separate and mixed feeding systems. Saving/kg gain obtained between sole concentrate feeding and separate and mixed feeding systems was ₦300 to ₦450.

Table 10: Effect of feeding system on performance of weaner rabbits fed groundnut forage

Parameter	Concentrate	Separate	Mixed	SE
Feed intake (g/d)	78.10[a]	81.95[b]	81.13[b]	0.62
Average daily gain (g)	7.97[b]	10.38[a]	8.33[b]	0.62
FGR (intake/gain)	11.46	8.29	10.58	0.87
Feed cost (₦)	6.83[a]	5.42[b]	5.48[b]	0.18
Feed cost/kg gain (₦)	1000[a]	5.50[b]	700[b]	65
Saving/kg gain (₦)	-	450	300	-

Means with different superscript along rows are significantly ($P<0.05$) different. ₦ = Naira

Interaction between groundnut forage level and feeding system on feed intake and weight gain is shown in Figure 6. Feed intake decreased on 15 and 45% GFM mixed diets than separate system but increased on 30% GFM mixed than separate system. For weight gain, however, the response was similar reduction in weight gain on mixed than separate feeding at 15 and 45% GFM, while there was no difference for both systems on 30% GFM. The feed cost/kg gain (Fig. 7) was higher for mixed system for all the groundnut forage levels. Saving/kg gain obtained between sole concentrate feeding, separate and mixed feeding systems was ₦110 for 15S, ₦50 for 30S and ₦310 for 45S groups compared with the mixed groups. This shows better utilization of feed and potential profitability of feeding

groundnut forage up to 45% level. Adeyemo *et al*. (2013) recommended 50% concentrate and 50% forage for optimum performance of rabbits. The rabbits utilized feed better when concentrate and groundnut forage were fed separately than feeding the forage and concentrate mixed as a complete diet. However, it was much easier and faster offering the diets as mixed than separately, especially when feeding space in the cage is limited. It is concluded that rabbits can utilize up to 45% GFM in separate feeding systems. Rabbits also tolerated relatively high inclusion levels of groundnut forage. Separate feeding of concentrate and forage produced better performance than mixed diets. Finally, feeding method can influence nutrient intake and utilization for improved performance of rabbits.

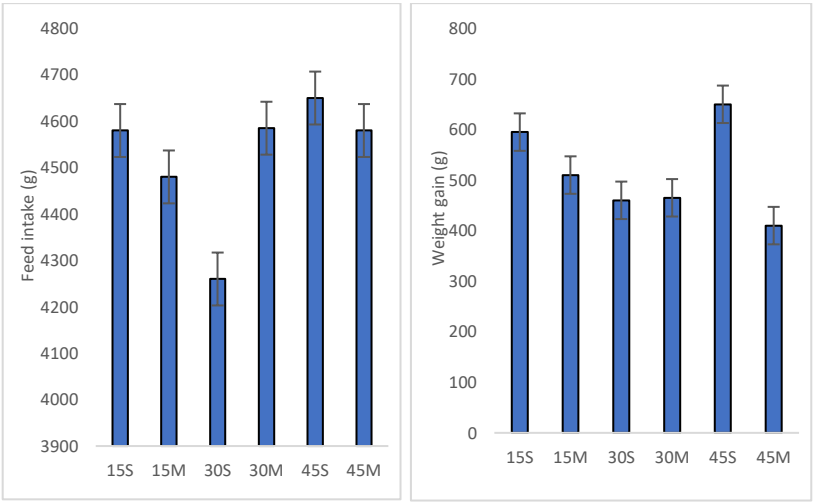


Figure 6: Influence of level of groundnut forage and feeding system on feed intake and weight gain of growing rabbits

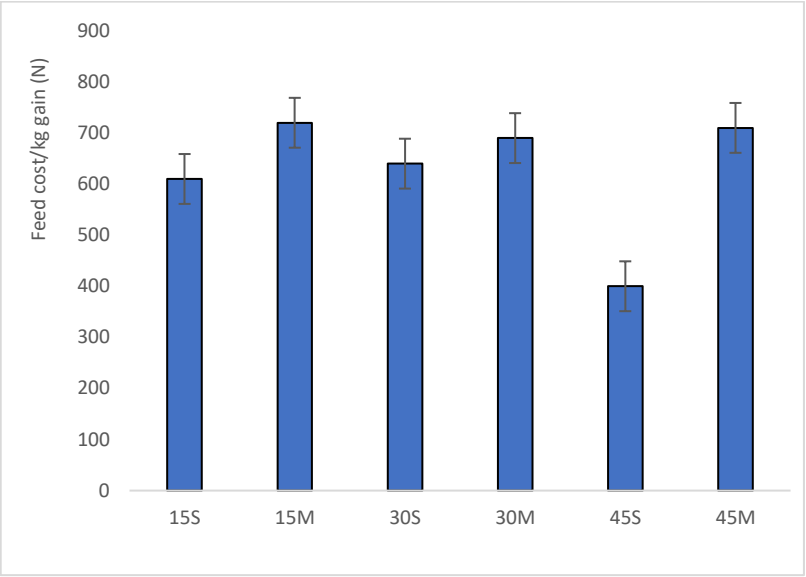


Figure 7: Influence of level of groundnut forage and feeding system on feed cost/kg gain of growing rabbits

The growth performance of growing rabbits to graded levels of lablab forage meal as replacement of the concentrate diet was evaluated by Iyeghe-Erakpotobor and Yakubu (2009), who observed non-significant ($p>0.05$) effect of level of lablab forage meal in the diet, though daily weight gain and feed conversion of rabbits decreased with increase in level of lablab forage meal (Table 11). Feed cost was significantly ($p<0.05$) higher for the 0% LFM than 10 and 20% lablab forage meal groups. Feed cost/kg gain was similar for all the treatments but decreased with increase in level of lablab forage meal diets with a saving per kilogram gain of ₦2.87 for 10% LFM and ₦7.34 for 20% LFM.

Table 11: Effect of inclusion of lablab forage meal on performance of growing rabbits

Parameter	Lablab forage meal level (%)		
	0	10	20
Initial weight (kg)	0.96±0.09	0.91±0.09	1.05±0.09
Final weight (kg)	1.73±0.10	1.56±0.12	1.75±0.11
Daily feed intake (g)	66.86±3.74	72.09±3.59	74.70±3.91
ADG (g)	14.14±0.99	12.70±0.95	12.17±1.04
FGR (intake/weight)	4.83±0.55^{b}	5.87±0.53^{ab}	6.62±0.58^{a}
Feed cost (₦/day)	2.54±0.137^{a}	2.13±0.131^{b}	1.98±0.143^{b}
Feed cost/kg gain (₦)	183.53±16.70	180.66±16.04	176.19±17.44
Savings (₦/kg gain)	-	2.87	7.34

Means with different superscript along rows are significantly (P<0.05) different.

Iyeghe-Erakpotobor and Adeyegun, (2012) also evaluated the response of growing rabbits to graded levels of groundnut forage meal as replacement for concentrate diet and reported similar final weight of rabbits, and significant (p<0.05) increase in feed intake and weight gain as level of groundnut forage meal (GFM) increased in the diet (Table 12). Feed cost, feed conversion and feed cost/kg gain were similar for all levels of groundnut forage meal, however, savings/kg gain decreased (₦71.25 to36.57), with increase in level of groundnut forage meal.

Table 12: Performance of weaner rabbits fed graded levels of groundnut forage meal

Parameter	Groundnut forage meal level (%)			SE
	0	10	20	
Initial weight(kg)	1.32	1.31	1.22	0.04
Final weight (kg)	2.19	2.24	2.21	0.05
Feed intake (g/d)	63.24^{b}	67.04^{ab}	81.04^{a}	2.78
Weight gain (g/d)	9.34	10.37	10.72	0.58
Total feed cost (₦)	219.93	215.40	239.45	12.89
Feed cost (₦/d)	2.42	2.37	2.63	0.14
Feed conversion (intake/gain)	7.80	6.58	8.06	0.79
Feed cost/kg gain (₦)	301.99	230.71	265.42	32.59
Savings kg^{-1} gain (₦)	-	71.28	36.57	-

Means bearing different superscripts are significantly (P<0.05) different, SE – Standard Error.

Iyeghe-Erakpotobor *et al*. (2013) evaluated the potential improvement of palm oil in addition to groundnut forage diets on performance of growing rabbits (Table 13). Final weight, weight gain and feed cost/kg gain were similar for all treatment groups. Feed intake was significantly (p=0.01) lower on 0G (control) than the groundnut forage meal levels and palm oil supplemented groups. Feed cost was significantly (p=0.02) lower on 40% groundnut forage (40G) than 20% groundnut and palm oil (20GPO) and 40% groundnut forage and palm oil (40GPO) which were also lower than control (0G) and 20% groundnut forage (20G). FGR was also lower (p=0.01) on 0G, 20GPO and 20G than 40GPO. Savings/kg gain was 7.5% for 20G, 5.2% for 40G, 3.2% for 20GPO and -5.9% for 40GPO, compared with 0G.

Table 13: Performance of growing rabbits fed groundnut forage meal with or without palm oil supplementation

	Groundnut forage meal level (%)					
Parameter	0G	20G	40G	20GPO	40GPO	Prob.
Initial weight (kg)	0.68 ±0.07	0.69 ±0.07	0.71± 0.07	0.62± 0.07	0.76± 0.07	0.71
Final weight (kg)	1.46± 0.11	1.61± 0.12	1.55± 0.11	1.58± 0.11	1.60 ±0.11	0.88
Feed intake (g/d)	46.71± 3.92^{b}	58.63± 4.23^{a}	63.03±4.23^{a}	62.76± 3.92^{a}	66.21± 3.66^{a}	0.01
Weight gain (g/d)	7.79± 0.93	10.54± 1.00	9.15± 0.87	10.20± 0.93	8.62± 0.87	0.75
FGR	5.56± 0.58^{c}	6.06± 0.62^{bc}	7.52± 0.58^{ab}	6.27± 0.45^{bc}	8.28± 0.59^{a}	0.01
Feed cost (₦/d)	5.736± 0.39^{a}	5.58±0.40^{a}	3.03± 0.39^{c}	4.42± 0.39^{b}	4.26± 0.40^{b}	0.02
Feed cost/kg gain (₦)	545.79±44.13	505.08±47.67	517.53±44.13	528.35±44.13	577.77±45.58	0.70
Savings/kg gain (₦)		40.71	28.26	17.44	-31.98	

Means with different superscripts along rows are significantly (P<0.05) different.

The potential effect of palm oil addition to lablab forage meals to reduce dustiness and improve feed utilization for growth was investigated by Iyeghe-Erakpotobor *et al.* (2015a), who observed that feed intake was higher for lablab forage levels than the concentrate diet (Table 14). Weight gain was significantly higher on 20% lablab forage (20L), 20% lablab forage and palm oil (20LPO) and 40% lablab forage and palm oil (40LPO) than the concentrate and 40% lablab forage (40L) diets. Feed conversion was higher on the concentrate, 20L and 20LPO than 40L and 40LPO. Feed cost was significantly lower on 40L and the concentrate than 20L and 20LPO. Feed cost/kg

gain was similar for all the treatments however, saving/kg gain was 9.6-12.85% for the lablab levels than the concentrate. Lablab and palm oil supplementation reduced dustiness, improved feed utilization and performance. Excessive supplementation, however, did not improve performance. Dietary energy manipulation must be balanced carefully for improved growth.

SEXUAL DIMORPHISM IN RABBITS RESPONSE TO FORAGES

There appear to be a dichotomy in the response of male and female rabbits to forages. Iyeghe-Erakpotobor *et al.* (2011) studied the response of male and female growing rabbits to sole groundnut and lablab forages, and combined groundnut and lablab forages (mixed) supplemented with 50g concentrate diet. Male rabbits had higher feed intake and cumulative weight gain on groundnut forage meal than lablab and mixed forage meals (Figure 8). For female rabbits, the reverse was the case. Feed intake and cumulative weight gain was higher on mixed and lablab forage meals than groundnut forage meal (Figure 9). It appears therefore that the preference of male and female rabbits for forage meals might be divergent. One would have thought that preference should not be exhibited by the various sexes for the forages since they were incorporated in complete diets.

Table 14: Performance of growing rabbits fed lablab forage meal with or without palm oil supplementation

	Lablab leaf meal level (%)				
Parameter	0L	20L	40L	20LPO	40LPO
Initial weight (kg)	0.68 ±0.08	0.70 ±0.09	0.71± 0.08	0.69± 0.08	0.76± 0.09
Final weight (kg)	1.49± 0.11	1.73± 0.12	1.55± 0.10	1.74± 0.10	1.66 ±0.11
Feed intake (g/d)	44.09± 3.35^{b}	59.39± 3.86^{a}	58.25 ±3.35^{a}	58.46± 3.35^{a}	63.43± 3.61^{a}
Weight gain (g/d)	8.48± 0.63^{b}	10.63± 0.60^{a}	8.48± 0.52^{b}	10.71± 0.52^{a}	9.25± 0.55^{ab}
FGR	5.46± 0.45^{c}	5.65± 0.52^{bc}	7.03± 0.45^{a}	5.51± 0.45^{c}	6.84± 0.49^{ab}
Feed cost (₦/d)	4.31± 0.28^{b}	4.95 ±0.32^{a}	4.00± 0.28^{b}	4.93± 0.28^{a}	4.43± 0.30^{ab}
Feed cost/kg gain (₦)	533.90 ±39.09	470.80± 34.16	482.70± 29.58	465.31± 29.58	482.64± 31.63
Savings/kg gain (₦)	-	63.10	51.20	68.59	51.26

Means with different superscripts along rows are significantly different ($p<0.05$)

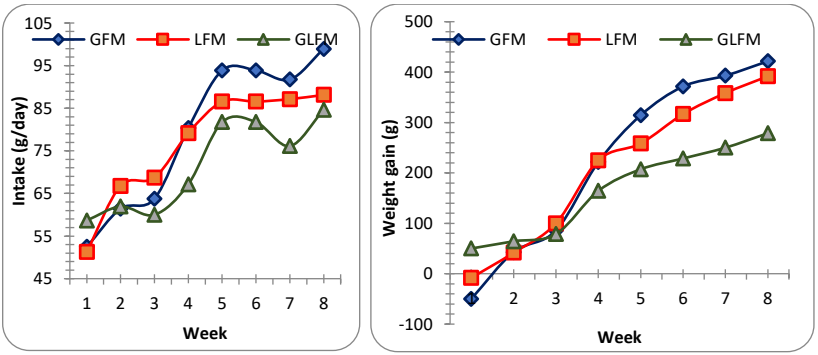


Figure 8: Feed intake and cumulative weight gain of male rabbits fed groundnut and lablab forage meals, sole or mixed.

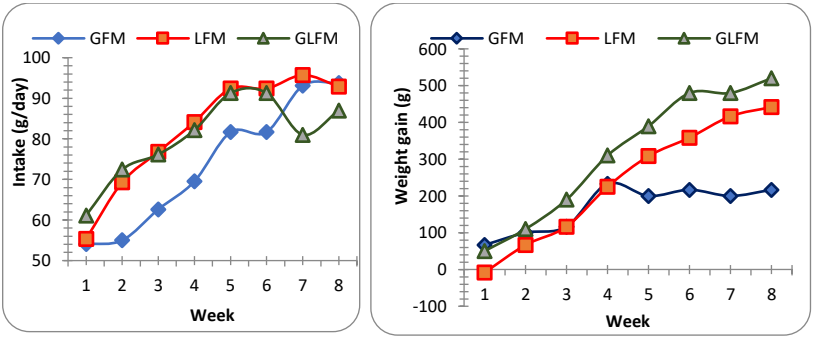


Figure 9: Feed intake and cumulative weight gain of female rabbits fed groundnut and lablab forage meals fed sole or mixed.

Feed cost was higher on groundnut forage meal for male rabbits, but for female rabbits, it was higher on lablab and mixed forage meals (Figure 10). Feed cost/kg gain was higher on the mixed forages for male rabbits and on the groundnut forage meal for female rabbits. Feeding sole groundnut and lablab forage meal diets to male rabbits gave saving/kg gain of ₦96.56 to ₦121.68 over mixed forage diet, and ₦25.12 on sole groundnut forage meal diet over lablab forage meal diet. Saving/kg gain was ₦136.11 to ₦203.05 to for female rabbits fed sole lablab and mixed forage meal diets, and ₦102.94 for mixed forage meal diet than sole lablab forage meal diet. Ekpo *et al.* (2008) did not observe difference between the sexes in growth performance of rabbits fed unpeeled, peeled cassava tuber and cassava peel meals and Laxmi *et al.* (2009) reported non-significant effect of sex on body weights of rabbits. These results show that male rabbits preferred groundnut and lablab forage meal while female rabbits preferred mixed and lablab forage meal to groundnut forage meal diets.

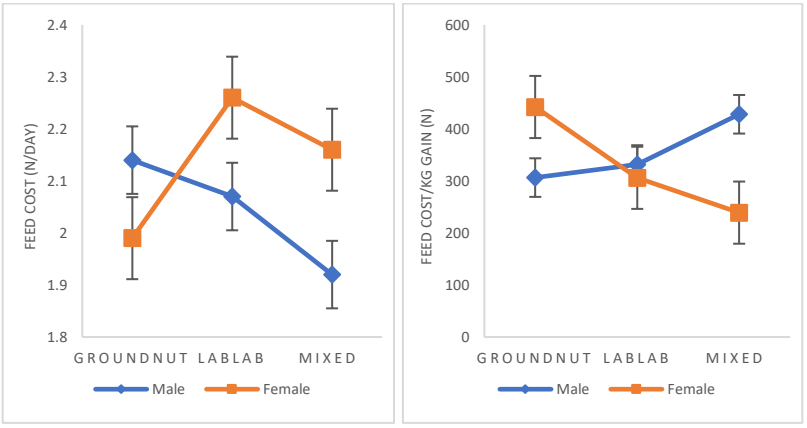


Figure 10: Feed cost and feed cost/kg gain of male and female rabbits fed sole or mixed forage meal diets

Table 15 shows the interaction between sex and level of groundnut forage meal on performance of weaner rabbits. Iyeghe-Erakpotobor and Adeyegun (2012) observed that male rabbits on 0% GFM had the lowest ($p<0.05$) final weight, which was similar with all other groups except for female rabbits on the concentrate (0% GFM). Average daily gain was also lowest ($p<0.05$) in male rabbits on 0% GFM than female rabbits on 0% GFM and 10% groundnut forage meal (10% GFM). Total feed cost was lowest ($p<0.05$) for male rabbits on 0% GFM and highest ($p<0.05$) for females on 0% GFM, and males on 20% groundnut forage meal (20% GFM). Feed intake, feed cost, feed conversion and feed cost/kg gain were similar for all the forage groups. Savings kg^{-1} gain between male and female rabbits was higher for females on 0% GFM (₦111.16) and 20% GFM (₦53.54) than 10% GFM (₦1.83). Figure 11 shows higher total feed intake for female than male rabbits on 0 and 10% GFM while for 20% GFM, feed intake was higher for male than female rabbits. However, total weight gain of rabbits was higher for female than males at all levels of GFM).

Table 15: Effect of sex and level of groundnut forage meal on performance of weaner rabbits

	0% GFM		10% GFM		20% GFM		
Parameter	Male	Female	Male	Female	Male	Female	SE
Initial weight (kg)	1.34	1.31	1.30	1.32	1.25	1.24	0.04
Final weight (kg)	2.02^{b}	2.36^{a}	2.14^{ab}	2.34^{ab}	2.12^{ab}	2.24^{ab}	0.05
Feed intake (g/d)	56.83	69.66	62.62	71.46	84.65	75.03	2.78
ADG (g/d)	7.14^{b}	11.54^{a}	9.61^{ab}	11.13^{a}	9.52^{ab}	10.71^{ab}	0.58
Total Feed cost (₦)	189.60^{b}	250.25^{a}	198.82^{ab}	231.98^{ab}	251.44^{a}	227.46^{ab}	12.89
Feed cost (₦/d)	2.08	2.75	2.18	2.55	2.76	2.50	0.14
Feed conversion (intake/gain)	9.42	6.18	6.69	6.46	8.93	7.19	0.79
Feed cost/kg gain (₦)	357.57	246.41	231.62	229.79	292.19	238.65	32.59
Savings kg^{-1} gain(₦)	-	111.16	-	1.83	-	53.54	-

Means bearing different superscripts are significantly ($P<0.05$) different. SE – Standard Error. GFM – Groundnut forage meal.

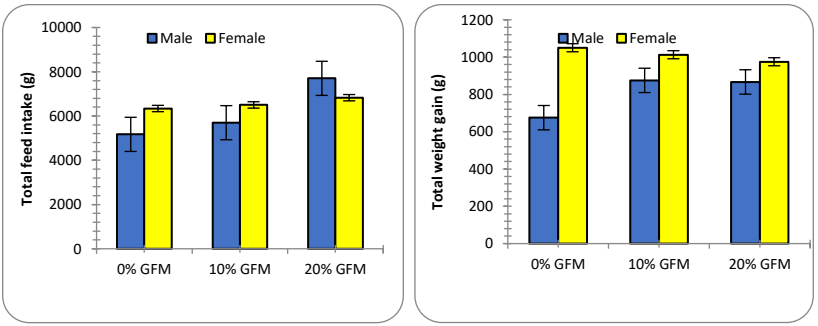


Figure 11: Effect of sex and level of groundnut forage meal on total feed intake and total weight gain of growing rabbits

Response of male and female rabbits to graded levels of lablab forage meal diets with or without palm oil supplementation was studied by Iyeghe-Erakpotobor *et al*. (2013). Feed intake (Figure 12) increased for males and females as groundnut level increased being highest for males on 40% Groundnut forage (40G) and females on 40% Groundnut forage and Palm Oil (40GPO). ADG was higher for males on 20% Groundnut forage (20G) while for females it was higher on 40% Groundnut forage and Palm Oil (40GPO). Feed cost/kg gain (Figure 13) was higher for male rabbits on 40% Groundnut forage and Palm Oil and for females on 0% Groundnut forage (concentrate alone) than the other treatments.

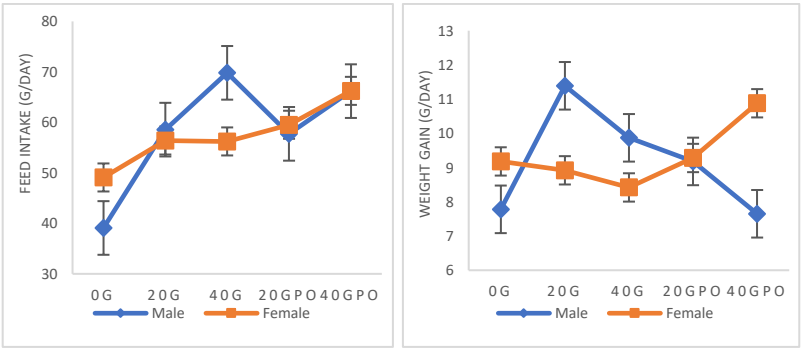


Figure 12: Feed intake and average daily gain of male and female rabbits fed groundnut forage meal with or without palm oil supplementation

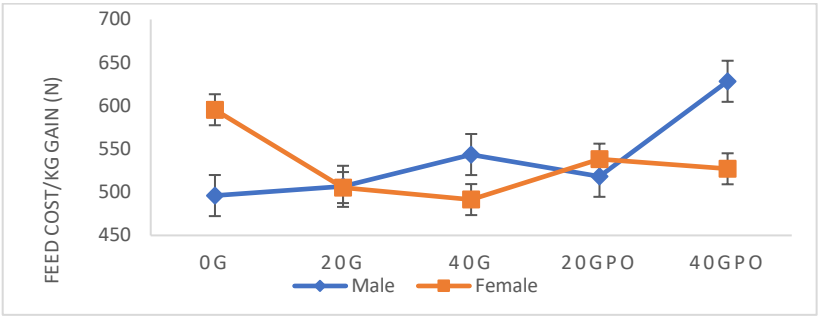


Figure 13: Feed cost per kg gain of male and female rabbits fed groundnut forage meal with or without palm oil supplementation

Response of male and female rabbits to graded levels of lablab forage meal diets with or without palm oil supplementation was studied by Iyeghe-Erakpotobor *et al*. (2015ba). They observed that feed intake and weight gain were higher in male than female rabbits only on 40L (Figure 14). Feed cost was higher than female rabbits on 40LP while feed cost/kg gain was higher in males than females on 40LPO (Figure 15). Saving/kg gain for male rabbits was ₦14.22-96.21 being 2.65-17.95% higher for the lablab forage meal levels compared with the concentrate diet. For female rabbits, it was ₦16.85-88.19 being 3.17-16.66% higher on the lablab levels compared to the concentrate diet (0L).

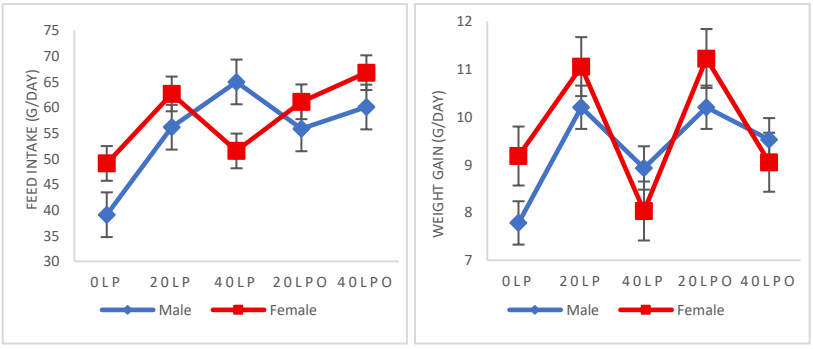


Figure 14: Effect of sex and level of lablab forage meal on total feed intake and total weight gain of growing rabbits

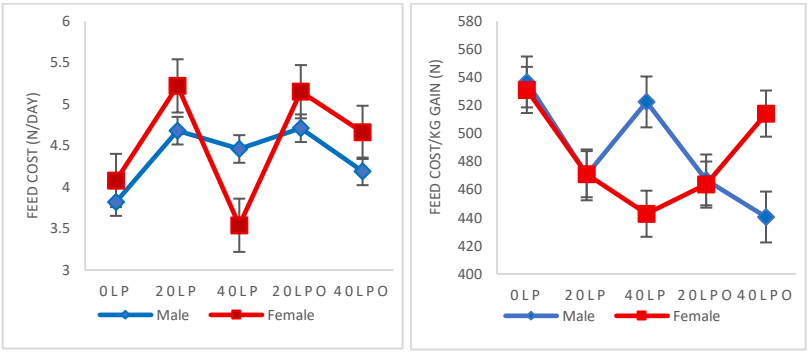


Figure 15: Effect of sex and level of lablab forage meal on total feed intake and total weight gain of growing rabbits

These studies show the existence of sexual dimorphism in the response of rabbits to forages. Nutritional requirements and feeding behaviour may vary by sex. Male and female rabbits responded differently to the same forage diets by preferring certain forage combinations differently. Female rabbits often achieved better weight gain and feed efficiency than male rabbits. This therefore indicates the need for precision feeding strategies that would consider sex-related physiological differences to improve rabbit productivity.

COMPOSITION OF GAIN FOR GROWTH

Growth is made up of in increasing cell proliferation and cell size enlargement (Honig *et al*., 2022). These cell proliferations involve changes in proportions of water, protein, fat and ash (mineral) in the cells of an animal. Iyeghe-Erakpotobor and Esievo, (2008, 2010) evaluated body composition of gain of rabbits fed soybean waste diet and lablab hay. Table 16 shows metabolic weight gain, empty body gain and composition of gain (water, protein, fat and ash contents) were significantly ($p<0.001$) higher for rabbits on 100g soybean cheese and 60g

lablab hay (100:60S) than the control and decreased with decrease in level of soybean cheese waste diet indicating lower weight gains at the lower concentrate to forage levels.

Table 16: Weight gain and body composition of gain of growing rabbits fed graded levels of soybean cheese waste diet and lablab hay.

	Treatments					SEM	
Concentrate (g/d)	100R	100S	75S	50S	25S		P
Lablab hay (g/d)	60	60	85	110	135		Level
Metabolic weight gain ($WG^{0.75}$)	0.50^{b}	0.66^{a}	0.52^{b}	0.46^{b}	0.32^{c}	0.07	0.001
Empty body gain (g/d)	8.29^{b}	11.91^{a}	8.80^{b}	7.46^{bc}	4.66^{c}	0.31	0.001
Water (g/d)	4.88^{b}	7.02^{a}	5.19^{b}	4.39^{bc}	2.74^{c}	0.24	0.001
Protein (g/d)	1.74^{b}	2.50^{a}	1.85^{b}	1.57^{bc}	0.98^{c}	0.14	0.001
Fat (g/d)	1.41^{b}	2.03^{a}	1.50^{b}	1.27^{bc}	0.79^{c}	0.13	0.001
Ash (g/d)	0.23^{b}	0.33^{a}	0.25^{b}	0.21^{bc}	0.13^{c}	0.05	0.001

Means with different superscripts along rows are significantly ($P<0.001$) different.

Weight gain and body composition of rabbits fed stylo, groundnut and mixed (stylo and groundnut forage) was evaluated by Nwagu and Iyeghe-Erakpotobor (2013). Feeding of stylo and groundnut forage hays either sole or mixed did not significantly ($p>0.05$) affect daily gain or body composition of gain of growing rabbits (Table 17).

Table 17: Weight gain and body composition of gain of growing rabbits fed forages hays supplemented with concentrate

Parameter	Mixed	Stylo	Groundnut	SEM	P level
Metabolic weight gain ($WG^{0.75}$)	0.42	0.33	0.39	0.12	0.33
Ave. daily gain (g)	7.69	5.80	7.26	0.61	0.33
Empty body gain (g/d)	6.69	5.05	6.32	0.57	0.33
Water (g/d)	3.93	2.97	3.72	0.44	0.33
Protein (g/d)	1.42	1.07	1.34	0.26	0.33
Fat (g/d)	1.14	0.86	1.08	0.24	0.33
Ash (g/d)	0.19	0.14	0.18	0.10	0.34

Mixed (Stylosanthes + Groundnut) forages

Empty body gain and water content (Figure 16), protein and fat content (Figure 17), and ash content of gain (Figure 18) decreased from weaner to adult rabbits. Empty body gain of rabbits was higher for weaner and pubertal rabbits on groundnut haulm than mixed and stylo fed rabbits while it was higher for growers on

mixed forages and lowest for those on groundnut haulm. For adult rabbits, empty body gain was higher for mixed and stylo fed rabbits and lower for rabbits on groundnut haulm. Water, protein, fat and ash content of gain of rabbits followed the same pattern as empty body gain. Lean tissue growth is characterised by higher increase in protein and water especially in early growth phase. Fat tissue increases significantly at puberty and later stages of growth, while bone mass increases steadily, and particularly during peak pubertal growth (Honig *et al*., 2022).

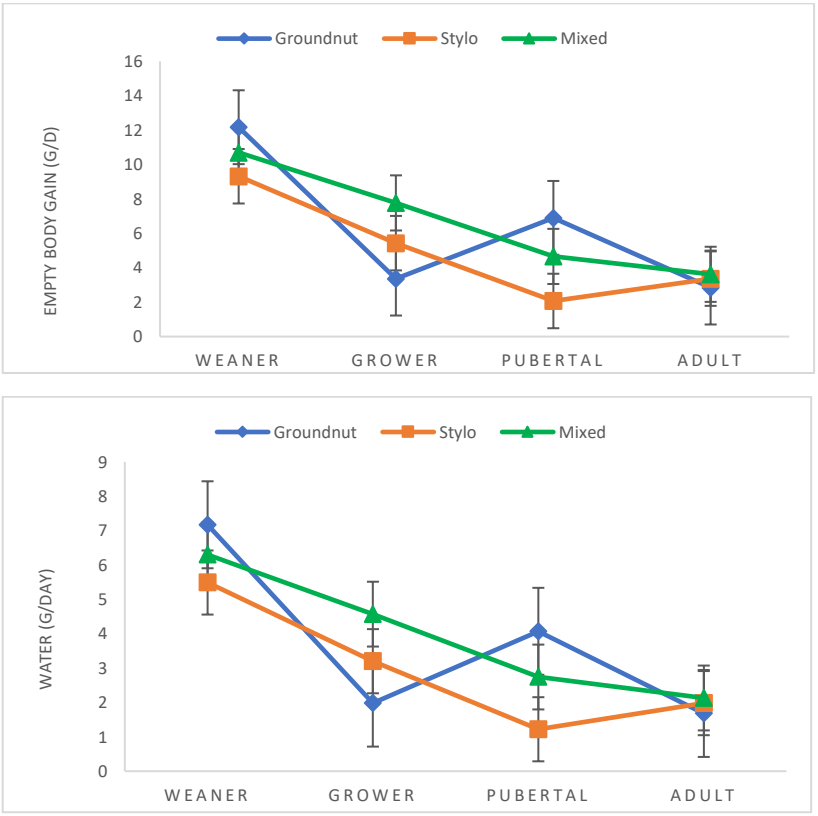


Figure 16: Empty body gain and water content of gain of rabbits fed groundnut, stylosanthes and mixed groundnut and stylosanthes forages with 50g concentrate

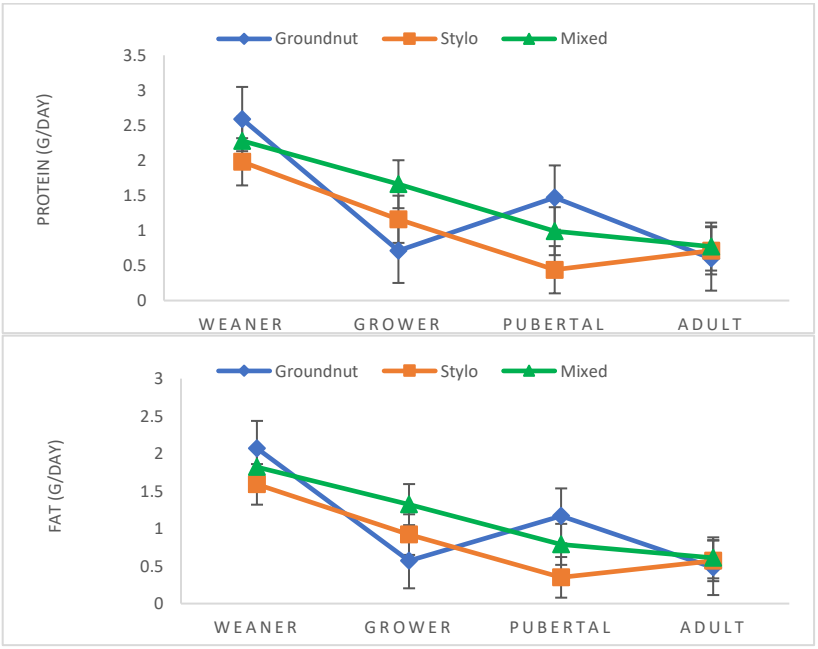


Figure 17: Protein and fat content of gain of rabbits fed groundnut, stylosanthes and mixed groundnut and stylosanthes forages with 50g concentrate

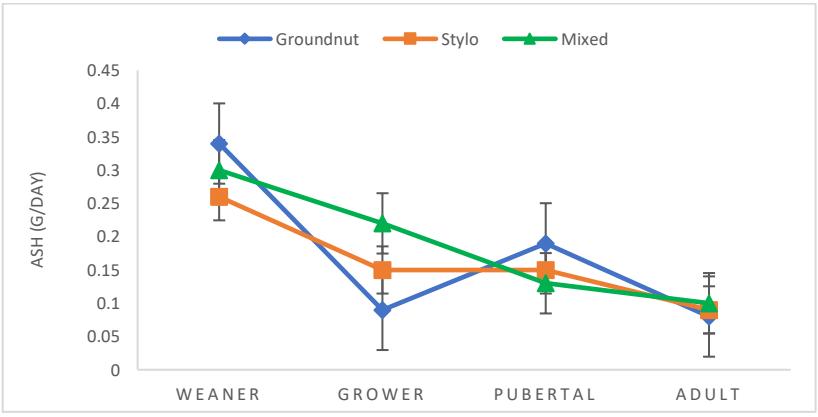


Figure 18: Ash content of gain of rabbits fed groundnut, stylosanthes and mixed groundnut and stylosanthes forages with 50g concentrate

Iyeghe-Erakpotobor and Nwagu (2014) observed that weight gain and empty body gain, gain in water, protein, fat and ash of rabbits were not affected by level of lablab forage meal in the diet (Table 18) of growing rabbits.

Table 18: Weight gain and body composition of gain of growing rabbits fed concentrate substituted with graded levels of lablab forage meal

Parameter	Lablab forage meal (%)			SE	P level
	0	10	20		
Weight gain (kg)	0.79	0.71	0.68	0.15	0.37
Ave. Daily gain (g)	14.14	12.71	12.17	0.62	0.37
Empty body gain (g/d)	12.30	11.05	10.59	0.58	0.37
Water (g/d)	7.25	6.51	6.24	0.44	0.37
Protein (g/d)	2.62	2.35	2.26	0.27	0.37
Fat (g/d)	2.09	1.88	1.80	0.24	0.37
Ash (g/d)	0.34	0.31	0.30	0.10	0.38

Iyeghe-Erakpotobor and Nwagu (2014) also evaluated weight gain and body composition of gain of growing rabbits fed concentrate substituted with graded levels of groundnut forage meal and reported that weight gain, empty body gain and components of body gain (water, protein, fat and ash) increased with GFM level (Table 19) but not significantly ($p>0.05$).

Table 19: Weight gain and body composition of gain of growing rabbits fed concentrate substituted with graded levels of groundnut forage meal

	Groundnut forage meal level (%)				
Parameter	0	10	20	SE	P level
Weight gain (kg)	0.87	0.93	0.94	0.17	0.84
Ave. daily gain (g)	9.34	10.37	10.20	0.56	0.74
Empty body gain (g/d)	8.13	9.22	8.88	0.52	0.74
Water (g/d)	4.79	5.32	5.23	0.40	0.74
Protein (g/d)	1.73	1.92	1.89	0.24	0.75
Fat (g/d)	1.38	1.53	1.51	0.22	0.74
Ash (g/d)	0.23	0.25	0.25	0.09	0.72

Collectively, these studies show that growth is not merely increase in body weight; it reflects deposition of water, protein, fat, and minerals. Better-performing diets increased water retention, protein, fat and ash deposition. Soybean cheese waste, lablab and groundnut diets enhanced tissue accretion. Younger rabbits deposited lean tissue more actively than adults. Nutritional quality of the diet affects nature and quality of body growth, not only body size, therefore, efficient rabbit feeding systems should optimize lean tissue growth rather than simply increasing weight.

ENERGY PARTITIONING OF GROWING RABBITS

Growth is determined by how animals' direct energy obtained from feed nutrients in the body. Generally, feed provides energy used for maintaining life and that needed for growth. Nwagu and Iyeghe-Erakpotobor (2012), looked at how rabbits' direct nutrients as energy for growth from levels of soybean cheese waste diet and lablab hay. Table 20 shows the digestible energy (DE) retention, requirement and efficiency of retention of growing rabbits. DE intake of rabbits was significantly ($p<0.001$) higher on 25:135S and lower on 100:60S. More energy was retained as protein, fat and for growth by rabbits on 100:60S than the control and other soybean cheese waste diet levels while 25:135S retained the lowest energy compared with all other treatments. Maintenance energy requirement, requirement for protein, fat, growth and total energy required for growth also decreased, as level of soybean cheese waste diet decreased and lablab hay increased. These parameters were significantly ($p<0.05$) higher for 100:60S and lowest on 25:135S than other treatments. Efficiency of DE utilization was low ranging between 0.21-0.24, indicating inefficient energy utilization resulting from wastes associated with temperature regulation.

Nwagu and Iyeghe-Erakpotobor (2013) further looked at how weaners, growers, pubertal and adult rabbits utilized energy for growth from diets containing 50g concentrate and sole groundnut, stylo or a combination of groundnut and stylo (mixed) forages. DE intake and efficiency of DE utilization were similar for all classes of rabbits for the forages (Table 21) however, maintenance energy requirement was higher for weaner rabbits on all forages except for mixed forage where it was similar to adult rabbits, and with pubertal rabbits on groundnut forage. DE for growth was higher for weaners on groundnut than the other classes however, it was similar for weaners, growers and pubertal rabbits on mixed forage, and only for weaners and growers on stylo. Total DE requirement was higher for weaners than other classes for all the forages. DE efficiency for growth was moderate ranging between 0.37-0.47.

Table 20: Digestible energy retention, requirement and efficiency of retention of growing rabbits fed graded levels of soybean cheese waste diet and lablab hay

	Combination of concentrate and lablab					SEM	P level
Concentrate	100R	100S	75S	50S	25S		
Lablab	60	60	85	110	135		
DE intake (kcalDM/d)	391.94^{b}	298.29^{c}	420.67^{ab}	396.59^{b}	458.11^{a}	21.17	0.001
DE intake (kJDM/d)*	1640	1248	1760	1659	1917	-	-
Retained energy as protein RE_p (kJ/d)	40.37^{b}	58.03^{a}	42.89^{b}	36.33^{b}	22.71^{c}	1.16	0.001
Retained energy as fat RE_f (kJ/d)	50.15^{b}	72.09^{a}	53.28^{b}	45.13^{b}	28.21^{c}	1.29	0.001
Retained energy for growth RE_g (kJ/d)	90.51^{b}	130.11^{a}	96.17^{b}	81.46^{bc}	50.91^{c}	1.79	0.001
Maintenance energy requirement DE_m (kJ/d)	215.14^{b}	282.37^{a}	225.32^{b}	198.13^{b}	139.27^{c}	3.13	0.001
Energy requirement for protein synthesis DE RE_P (kJ/d)	100.92^{b}	145.08^{a}	107.23^{b}	90.83^{bc}	56.77^{c}	1.84	0.001
Energy requirement for fat synthesis DE RE_f (kJ/d)	77.15^{b}	110.90^{a}	81.97^{b}	69.43^{bc}	43.40^{c}	1.59	0.001
Energy requirement for growth DE_g (kJ/d)	178.07^{b}	255.97^{a}	189.19^{b}	160.26^{bc}	100.16^{c}	2.43	0.001
Total digestible energy requirement DE (kJ/d)	393.21^{b}	538.34^{a}	414.51^{b}	358.39^{bc}	239.43^{c}	3.96	0.001
Efficiency of DE utilization for growth	0.23^{ab}	0.24^{a}	0.23^{ab}	0.22^{b}	0.21^{c}	0.04	0.001

Means with different superscripts along rows are significantly ($P<0.001$) different.
*DE-Digestible energy calculated

Investigating complete diets, Iyeghe-Erakpotobor and Nwagu (2014) reported DE intake, DE retained as protein, fat and for growth of rabbits fed 0-20% lablab forage meal as replacement for the concentrate diet was similar (Table 22). Likewise, DE required for maintenance, protein synthesis, fat synthesis, growth and total DE required for growth were similar for all the lablab forage meal levels. Efficiency of DE utilization was

moderate and similar for all treatments, ranging between 0.41-0.42.

Table 21: Effect of forage type and class of rabbit on digestible energy requirement and efficiency of utilization of rabbits fed forages hays supplemented with concentrate

Forage	Class	DE intake (kJ DM/d)	DE reqt for maint. (DE_m kJ/d)	DE reqt. for growth (DE_g kJ/d)	Total DE reqt. (kJ/d)	Eff. of DE utilization for growth (k_g)
Mixed	Weaner	2676	258.56^{a}	231.84^{ab}	490.39^{a}	0.47
	Grower	2322	203.56^{a}	168.31^{b}	371.88^{b}	0.45
	Pubertal	2642	139.64^{b}	100.93^{bc}	240.58^{b}	0.41
	Adult	2384	115.18^{b}	78.50^{c}	193.69^{b}	0.40
Stylo	Weaner	2603	233.98^{a}	201.91^{ab}	435.89^{a}	0.46
	Grower	2469	151.66^{bc}	117.76^{b}	269.41^{b}	0.41
	Pubertal	2649	76.47^{c}	44.86^{c}	121.33^{c}	0.37
	Adult	2611	107.43^{bc}	72.90^{c}	180.33^{bc}	0.39
Gnut	Weaner	2460	285.23^{a}	263.59^{a}	548.82^{a}	0.47
	Grower	2424	108.94^{bc}	72.90^{c}	181.84^{b}	0.39
	Pubertal	2499	187.53^{ab}	149.53^{b}	337.06^{b}	0.44
	Adult	2547	95.34^{bc}	61.68^{c}	157.02^{b}	0.38
	SEM		0.64	0.67	0.92	0.01
	P level**		0.20	0.27	0.23	0.16

Means with the same superscript along columns are significantly ($P<0.05$) different. Gnut= groundnut haulm. Reqt.= requirement. **P level for interaction effect, Maint.= Maintenance, Eff. = Efficiency.

Table 22: Digestible energy retention, requirement and efficiency of retention of growing rabbits fed concentrate substituted with graded levels of lablab forage meal

Parameter	Lablab forage meal level (%)			SE	P level
	0	10	20		
DE intake (kcalDM/d)	365.30	357.88	380.67	3.38	0.90
DE intake (kJDM/d)	1528	1497	1593	-	-
Retained energy as protein RE_p (kJ/d)	60.78	54.63	52.34	1.28	0.37
Retained energy as fat RE_f (kJ/d)	74.43	66.90	64.10	1.42	0.37
Retained energy for growth RE_g (kJ/d)	135.21	121.53	116.44	1.91	0.37
Maintenance energy requirement DE_m (kJ/d)	359.46	330.33	320.45	2.75	0.37
Energy requirement for protein synthesis DE RE_p (kJ/d)	151.94	136.56	130.86	2.03	0.36
Energy requirement for fat synthesis DE RE_f (kJ/d)	114.51	102.92	98.62	1.76	0.36
Energy requirement for growth DE_g (kJ/d)	266.46	239.49	229.49	2.68	0.37
Total digestible energy requirement DE (kJ/d)	625.91	569.81	549.94	3.84	0.37
Efficiency of DE utilization for growth (k_g)	0.42	0.41	0.41	0.04	0.37

Iyeghe-Erakpotobor and Nwagu (2014) also reported similar DE retained as protein, fat and for growth growing rabbits fed 0-20% groundnut forage meal as replacement for concentrate diet (Table 23). Likewise, DE requirement for maintenance, protein synthesis, fat synthesis and growth were similar for all the treatments. Total DE requirement, DE requirement for

maintenance and growth of rabbits increased with increase in level of groundnut forage meal. However, though total DE requirement of rabbits increased as level of GFM increased, DE requirement for maintenance and growth were slightly higher for groundnut forage meal than the control (0% GFM). Efficiency of DE utilization was low (0.16) and constant for all levels of groundnut forage meal

Table 23: Digestible energy retention, requirement and efficiency of retention of growing rabbits fed groundnut forages meal diets

	Groundnut forage meal (%)			SE	P level
Parameter	0	10	20		
Retained energy as protein RE_p (kJ/d)	40.16	44.59	43.87	1.16	0.74
Retained energy as fat RE_f (kJ/d)	49.18	54.61	53.73	1.29	0.74
Retained energy for growth RE_g (kJ/d)	89.34	99.19	97.60	1.73	0.74
Maintenance energy requirement DE_m (kJ/d)	381.47	404.13	409.57	3.13	0.80
Energy requirement for protein synthesis DE RE_p (kJ/d)	100.40	111.47	109.68	1.84	0.74
Energy requirement for fat synthesis DE RE_f (kJ/d)	75.66	84.01	82.66	1.59	0.78
Energy requirement for growth DE_g (kJ/d)	176.06	195.47	192.33	2.43	0.75
Total digestible energy requirement DE (kJ/d)	557.53	559.61	601.90	3.96	0.74
Efficiency of DE utilization for growth	0.16	0.16	0.16	0.04	0.52

These studies showed rabbits utilized digestible energy in the 50g concentrate and sole groundnut, stylo or mixed (combination of groundnut and stylo) forages (0.37-0.47) and lablab meal diets (0.41-0.42) better than soybean cheese waste diet and lablab hay (0.21-0.24), and groundnut forage meal diets (0.16). Higher-quality diets improved retained energy for growth. Rabbits on balanced concentrate-forage combinations utilized energy more efficiently. High forage diets reduced efficiency of energy utilization, indicating a biological limit to how much concentrate can be replaced before energy efficiency and productivity declines.

PROTEIN PARTITIONING OF GROWING RABBITS

Protein retention and requirement of growing rabbits fed graded levels of soybean cheese waste diet and lablab hay was studied by Nwagu and Iyeghe-Erakpotobor (2012). Digestible crude protein (DCP) requirement for maintenance was significantly ($p<0.05$) lower for rabbits on 50:110S than 100:60S and similar for all the other treatments (Table 24). DCP content of gain, and total DCP required for protein synthesis decreased significantly ($p<0.001$) as level of soybean cheese waste decreased and lablab forage increased, being higher for 100:60S than the control and all other treatments. Total DCP utilized for growth was higher for 100:60S than other soybean levels and the concentrate control. The results showed adequate DCP intake for growth and better utilization by rabbits on 100:60S than the other treatments. Efficiency of DCP utilization for growth decreased as soybean cheese waste diet level decreased and ranged between 0.41-0.85.

Table 24: Protein retention and requirement of growing rabbits fed graded levels of soybean cheese waste diet and lablab hay

	Diet combinations					SEM	P level
Concentrate (g/d)	100R	100S	75S	50S	25S		
Lablab hay (g/d)	60	60	85	110	135		
DCP intake (g/d)	16.21^{a}	9.64^{c}	14.18^{b}	13.07^{b}	14.53^{b}	0.25	0.05
DCP requirement for maintenance (g/d)	4.30^{ab}	4.47^{a}	4.18^{ab}	3.85^{b}	4.04^{ab}	0.12	0.05
DCP content of gain (g/d)	1.61^{b}	2.11^{a}	1.68^{b}	1.48^{b}	1.04^{c}	0.12	0.001
DCP requirement for protein synthesis (g/d)	2.87^{b}	3.77^{a}	3.01^{b}	2.65^{b}	1.86^{c}	0.56	0.001
Total DCP utilized for growth (g/d)	7.17^{b}	8.24^{a}	7.19^{b}	6.50^{bc}	5.90^{c}	0.16	0.001
Efficiency of DCP utilization for growth	0.44^{c}	0.85^{a}	0.51^{b}	0.50^{b}	0.41^{c}	0.04	0.001

Means with different superscripts along rows are significantly ($p<0.05$, 0.001) different. DCP- digestible crude protein

For rabbits fed groundnut, stylo and mixed (groundnut and stylo), Nwagu *et al.* (2010) observed similar DCP requirement for maintenance, DCP content of gain, DCP requirement for protein synthesis and total DCP utilized for growth (Table 25) for both sole and mixed forages. When protein requirement and intake were computed from feed intake, results showed higher

(p<0.001) DCP intake and requirement by rabbits on stylo than mixed forages and groundnut haulm. Efficiency of DCP utilization for growth was moderate but higher on mixed forages and groundnut than stylo, ranging between 0.52-0.68. This study revealed that though DCP intake was significantly higher (p<0.001) on stylo than mixed forages and groundnut haulms, efficiency of DCP utilization for gain was higher on groundnut haulm and mixed forage than stylo, indicating that these forages had higher nutrient composition and hence better utilized for growth by rabbits than stylo.

Table 25: Protein retention and requirement of growing rabbits fed forages supplemented with concentrate

Parameter	Mixed	Stylo	Groundnut	SEM	P level
DCP intake (g/d)	11.22^{b}	11.86^{a}	9.84^{b}	0.48	<0.001
DCP requirement for maintenance (g/d)	3.89	3.82	4.01	0.19	0.33
DCP content of gain (g/d)	1.67	1.32	1.57	0.25	0.25
DCP requirement for protein synthesis (g/d)	2.98	2.37	2.81	0.33	0.25
Total DCP utilized for growth (g/d)	6.87	6.19	6.82	0.37	0.29
DCP intake required for growth (g/d)	6.28^{b}	6.64^{a}	5.51^{b}	0.22	<0.001
Efficiency of DCP utilization for growth	0.62^{a}	0.52^{b}	0.68^{a}	0.03	0.002

Means with the same superscript along rows are significantly different (p<0.05). DCP = Digestible crude protein

The response of rabbit classes on groundnut, stylo or mixed (groundnut and stylo) (Table 26), showed decreased DCP requirement for maintenance, protein synthesis, DCP intake, requirement for growth and utilization from weaner to adult rabbits for sole and mixed forages. DCP required for maintenance was higher for adults followed by pubertal, grower and weaner for rabbits fed mixed and stylo forages. DCP required for maintenance of rabbits fed groundnut haulm was higher for pubertal rabbits followed by adults, while grower and weaner rabbits had similar DCP requirement for maintenance.

DCP requirement for protein synthesis and DCP requirement for growth were higher for weaners and pubertal rabbits on groundnut haulm than mixed and stylo forage groups, while for grower and adult rabbits, it was higher for mixed and stylo fed than groundnut haulm fed rabbits. Efficiency of DCP for growth was moderate to high ranging between 0.43-0.85. Weaner rabbits had more efficient utilization of protein for growth than growers, pubertal and adults on the forages except groundnut haulms where pubertal rabbits performed as well as weaner rabbits.

Table 26: Effect of forage type and class of rabbit on protein retention and requirement of growing rabbits fed forages supplemented with concentrate

Forage	*Class*	DCP intake (g/d)	DCP reqt for maint. (g/d)	DCP content of gain (g/d)	DCP reqt protein synthesis (g/d)	Total DCP utilized for growth (g/d)	Efficiency of DCP utilization
Mixed	Weaner	10.50	3.31	2.40	4.29	7.61	0.73
	Grower	11.94	3.85	1.89	3.38	7.23	0.62
	Pubertal	11.49	4.08	1.30	2.32	6.39	0.56
	Adult	10.93	4.32	1.07	1.91	6.23	0.57
Stylo	Weaner	11.11	3.44	2.17	3.89	7.33	0.61
	Grower	11.62	3.73	1.41	2.52	6.25	0.53
	Pubertal	11.94	3.83	0.71	1.27	5.10	0.43
	Adult	12.76	4.29	1.00	1.79	6.07	0.48
Gnut	Weaner	9.21	3.78	2.65	4.73	8.51	0.85
	Grower	9.79	3.70	1.01	1.81	5.51	0.56
	Pubertal	10.29	4.35	1.74	3.12	7.46	0.73
	Adult	10.08	4.19	0.88	1.58	5.78	0.58
	SEM	0.12	0.05	0.05	0.08	0.09	0.06
	P level**	0.34	0.40	0.19	0.20	0.22	0.32

Means with the same superscript along columns are significantly different ($p<0.05$). Gnut = groundnut haulm. Maint. = maintenance. Reqt. = requirement. **P level for interaction effect.

Iyeghe-Erakpotobor and Nwagu (2014) also reported similar metabolic weight, DCP requirement for maintenance, protein retention in gain and DCP requirements for protein synthesis for growth for rabbits fed 0-20% lablab forage meal diets (Table 27). There was no difference in DCP intake and DCP requirement for growth of rabbits on all levels of LFM. Efficiency of DCP utilization for growth was similar and ranged between 0.63-0.69.

Table 27: Protein requirement and retention of growing rabbits fed concentrate substituted with graded levels of lablab forage meal

Parameter	Lablab forage meal (%)			SE	P level
	0	10	20		
Metabolic weight ($LW^{0.75}$)	1.52	1.45	1.51	0.16	0.73
DCP intake (g/d)	15.50[a]	13.48[b]	13.17[b]	0.65	0.04
DCP requirement for maintenance (g/d)	4.40	4.20	4.37	0-27	0.73
DCP content of gain (g/d)	2.69	2.47	2.39	0.24	0.36
DCP requirement for protein synthesis (g/d)	4.80	4.41	4.28	0.32	0.36
Total DCP utilized for growth (g/d)	9.20	8.62	8.65	0.39	0.49
Efficiency of DCP utilization for growth	0.64	0.63	0.69	0.04	0.57

Rabbits on levels of GFM had similar DCP requirement for maintenance, protein retention in gain, DCP requirements for protein synthesis and total daily DCP requirement for growth (Table 28). DCP intake and requirement for growth was similar for all levels of groundnut forage meal (Iyeghe-Erakpotobor and Nwagu, 2014). Total digestible crude protein content of gain and total digestible crude protein requirement for protein synthesis of rabbits increased as level of groundnut forage meal increased. Efficiency of DCP utilization was high and increased as groundnut forage meal level increased ranging between 0.71-0.85.

Table 28: Protein retention and requirement of growing rabbits fed groundnut forages meal diets

Parameter	Groundnut forage meal level (%)			SE	P level
	0	10	20		
DCP intake (g/d)	11.72	10.68	10.13	0.53	0.45
DCP requirement for maintenance (g/d)	5.22	5.30	5.21	0.21	0.89
DCP content of gain (g/d)	1.76	1.86	1.88	0.21	0.80
DCP requirement for protein synthesis (g/d)	3.13	3.32	3.36	0.28	0.80
Total DCP utilized for growth (g/d)	8.35	8.62	8.58	0.34	0.80
Efficiency of DCP utilization for growth	0.71	0.81	0.85	0.13	0.85

These studies showed moderate to high efficiency of DCP utilization indicating better utilization of DCP for growth. Higher-quality diets improved efficiency of utilization of DCP for growth. Rabbits on balanced concentrate-forage combinations utilized protein more efficiently than higher forage to concentrate ratios. There is need to improve performance of rabbits during the period of slow growth

which occurs from the growing to adult phases, to reduce cost of production. There is a biological limit to how much concentrate can be replaced before protein efficiency declines.

CARCASS QUALITY

Over the decades, there has been a great clamour for healthy foods and meat that would adequately nourish the populace, this has necessitated the production of healthy animals with little fat as necessary to meet the fat requirement but not increase the rate of obesity and diseases arising from excess fat intake. Feeding rabbits with groundnut forage meal diets with or without palm oil supplementation, Iyeghe-Erakpotobor *et al.* (2013) observed similar dressing percent for all the levels from 0-40% groundnut meal diets (Table 29). Abdominal fat level was, however, reduced on the groundnut levels than the concentrate, indicating that high groundnut forage and palm oil supplementation produced healthier leaner carcass than the concentrate diet. The skin was significantly (p=0.01) heavier on 40G and 20GPO than the other treatments indicating higher leather yield. The kidney, head, lungs, and GIT were not affected by groundnut forage meal levels nor palm oil supplementation.

Table 29: Carcass characteristics of growing rabbits fed groundnut forage meal with or without palm oil supplementation

Parameter	Groundnut forage meal level (%)					Prob.
	0G	20G	40G	20GPO	40GPO	
Live weight (kg)	1.87±0.09	1.73±0.09	1.82±0.09	1.77±0.09	1.75±0.09	0.84
Dressing percent	52.70±1.02	53.23±1.02	53.35±1.02	52.84±1.02	52.36±1.02	0.96
Abdominal fat	1.00±0.15^{b}	1.67±0.15^{a}	2.00±0.15^{a}	2.00±0.15^{a}	2.00±0.15^{a}	0.03
Organs (% LWT):						
Skin	8.89±0.47^{b}	9.31±0.47^{b}	11.10±0.47^{a}	11.35±0.47^{a}	9.48±0.47^{b}	0.01
Head	9.28±0.69	11.69±0.69	10.78±0.69	10.37±0.69	10.49±0.69	0.23
Heart	0.55±0.13	0.47±0.13	0.56±0.13	0.56±0.13	0.48±0.13	0.97
Kidney	1.13±0.25	1.08±0.25	1.30±0.25	0.57±0.25	0.85±0.25	0.34
Liver	2.93±0.36	2.73±0.36	2.35±0.36	2.44±0.36	2.60±0.36	0.79
Lungs	1.18±0.15	1.05±0.15	1.01±0.15	0.84±0.15	0.85±0.15	0.50
GIT	16.20±1.57	15.66±1.57	15.70±1.57	14.19±1.57	15.46±1.57	0.91

Means with different superscripts along rows are significantly different. 1= fatty 1.67-2=lean carcass

Sabo *et al*. (2016) fed rabbits with lablab forage meal diets with or without palm oil supplementation and reported similar dressing percent for all the levels from 0-40% (Table 30). Abdominal fat level was higher for 0L and 40L than other treatments, indicating that the high lablab and concentrate diets produced fattier carcasses than the low lablab level and palm oil supplemented groups. The kidneys were smaller in 40LPO and larger in 20LPO. Head was smallest on 0L than the lablab levels. Lungs were smaller on 40LPO and larger on 0L and 40L while GIT was smallest on 20LPO and biggest on 40L.

ECONOMICS OF PRODUCTION

Economic evaluation of an enterprise indicates its potential and profitability. Sanni *et al*. (2009) estimated cost of feeding, value of gain and value/cost ratio of growing rabbits fed groundnut haulm, stylo and mixed (groundnut and stylo) forage hays supplemented with 50g concentrate (Table 31) and showed non-statistical ($p>0.05$) difference between the groups however, mixed forage had a slight advantage above groundnut haulm and stylo forage.

For rabbits fed combinations of soyabean cheese waste diet and lablab hay, using the standard rabbit diet as a control shown on Table 32, there were significant ($p<0.05$) differences in the estimated cost of feeding, value of gain and value/cost ratio of growing rabbits. Cost of concentrate, forage and total cost of feed decreased as concentrate level decreased up to 50% concentrate level, while value of gain increased with decrease in concentrate level up to 50% concentrate level. Value/cost ratio was higher on the soybean cheese waste meal diets than the standard rabbit diet, being highest on 100:60 combination. This indicates that the soybean cheese waste and lablab

combinations were more profitable than the standard concentrate and lablab combination for growth.

Table 30: Carcass characteristics of growing rabbits fed lablab forage meal with or without palm oil supplementation

Parameter	Lablab forage meal level (%)				
	0L	20L	40L	20LPO	40LPO
Live weight (kg)	1.87± 0.12	1.87± 0.12	1.77± 0.12	1.85± 0.12	1.65 ±0.12
Dressing percent	52.70±2.13	52.33±2.13	53.84±2.13	54.13±2.13	53.51±2.13
Abdominal fat	1.00 ±0.30	1.67±0.30	1.33±0.30	1.67±0.30	1.67±0.30
Organs (% LWT):					
Skin	8.89± 0.77	10.34± 0.77	10.38± 0.77	10.82± 0.77	10.07± 0.77
Head	8.01± 0.87^{b}	11.35± 0.87^{a}	11.23 ±0.87^{a}	10.82± 0.87^{a}	9.11± 0.87^{ab}
Heart	0.55± 0.10	0.39± 0.10	0.47± 0.10	0.45± 0.10	0.40± 0.10
Kidney	1.11± 0.19^{ab}	0.89± 0.19^{ab}	0.94± 0.19^{ab}	1.26± 0.19^{a}	0.60± 0.19^{b}
Liver	1.76±0.51	2.34±0.51	2.64±0.51	3.07±0.51	2.49±0.51
Lungs	1.18 ±0.13^{a}	1.07± 0.13^{ab}	1.24 ±0.13^{a}	1.08 ±0.13^{ab}	0.71± 0.13^{b}
GIT	16.20 ±1.28^{ab}	16.39± 1.28^{ab}	19.84± 1.28^{a}	13.47± 1.28^{b}	17.21 ±1.28^{ab}

Means with different superscripts along rows are significantly different (P<0.05)

Table 31: Estimated cost of feeding, value of gain and value/cost ratio of rabbits fed groundnut, verano stylo and mixed stylo and groundnut forage hays supplemented with concentrate

Parameter	Forage			SE
	Stylo	Groundnut haulm	Mixed (Stylo + Groundnut)	
Cost of concentrate (₦/rabbit)	651.09	507.70	404.89	101.03
Cost of forage (₦/rabbit)	604.08	476.54	375.66	89.56
Total cost of feed (₦/rabbit)	1255.17	984.24	780.55	190.11
Value of gain	420.57	407.47	412.13	25,11
Value/cost ratio	0.335	0.414	0.528	

Table 32: Estimated cost of feeding and value/cost ratio of growing rabbits fed varying levels of soybean cheese waste diet and lablab hay

Concentrate type	Rabbit diet	Soybean cheese waste meal diet (g)				
Concentrate level (g)	100	100	75	50	25	SE
Forage level (g)	60	60	85	110	135	
Cost of concentrate (₦/rabbit)	403.54[a]	90.69[b]	103.24[b]	82.94[b]	69.39[b]	19.48
Cost of forage (₦/rabbit)	94.13[a]	51.49[a]	116.04[a]	204.90[b]	369.73[c]	22.30
Total cost of feed (₦/rabbit)	497.67[a]	142.18[b]	219.28[bc]	287.84[b]	437.12[a]	34.42
Value of gain	386.67[bc]	413.33[b]	413.33[b]	448.00[a]	373.33[c]	31.88
Value/cost ratio	0.777	2.907	1.885	1.556	0.854	

Means with different superscripts within the same row are significantly different ($p<0.05$).

HORMONAL RESPONSES OF GROWING RABBITS

Hormonal influences have strong effect on growth of rabbits while nutrition influenced the hormonal profile of rabbits and consequently their reproductive and productive performance (Meshreky and Shaheed, 2003; Meshreky *et al*., 2007). Iyeghe-Erakpotobor *et al*. (2015b); investigated the effect of groundnut and lablab forages on hormone profiles of rabbits (Table 33). There was non-significant ($p>0.05$) difference in serum concentration of testosterone in rabbits fed groundnut and lablab forage meals. However, there was significant ($p<0.05$) increase in serum progesterone concentration in female ($p<0.05$) and male ($p<0.001$) rabbits fed groundnut forage meal than those fed lablab forage meal. It has been established that groundnut forage has oestrogenic properties; however, its effect on progesterone or testosterone concentrations is being established. Forage level did not significantly ($p>0.05$) affect testosterone concentration in male rabbits and progesterone concentration in female rabbits fed diets with 20% or 40% forage meal. Surprisingly, significantly ($p<0.001$) higher progesterone level was observed in male rabbits fed diets with 40% forage level than those fed 20%. The reason for this result might have to do with increased clearance rate of progesterone on high concentrate diet.

Table 33: Effect of forage type and level on testosterone and progesterone profile of rabbits

Hormone (ng/ml)	Forage type		P value	Forage level (%)		P value
	Groundnut	Lablab		20	40	
Testosterone	3.02±0.46	3.13±0.46	0.87	3.15±0.46	3.02±0.46	0.80
Progesterone (Females)	3.90±0.43[a]	2.53±0.43[b]	0.03	2.88±0.44[b]	3.55±0.11[a]	0.03
Progesterone (Males)	0.92±0.11[a]	0.39±0.11[b]	0.001	0.44±0.11[b]	0.87±0.11[a]	0.01

Means with different superscripts along rows are significantly different. SE= Standard error.

The general trend of response observed in Figure 19 indicates that as the rabbit aged, serum testosterone increased at a faster rate in rabbits fed lablab forage meal than groundnut forage, indicating that male rabbits fed lablab attained puberty earlier at 14 weeks than those on groundnut forage that attained puberty at 16 weeks of age. At 18 weeks, rabbits fed lablab forage had significantly ($p<0.05$) higher testosterone than those fed groundnut forage meal. Adeyemi *et al*. (2014) did not observe significant difference in the testosterone profile of rabbits fed *Moringa oleifera* leaf meal. The range in testosterone (0.78-6.45 ng/ml) obtained in this study is similar to that of 0.5-10 ng/mL reported by Moor and Younglai (1975) and 7.17±0.72 ng/mL reported by Sanni *et al.* (2012). Serum progesterone of female rabbits fed groundnut and lablab forages (Figure 20) increased as the rabbits aged but the rate of increase was faster in male and female rabbits fed groundnut forage meal than on lablab forage meal diet.

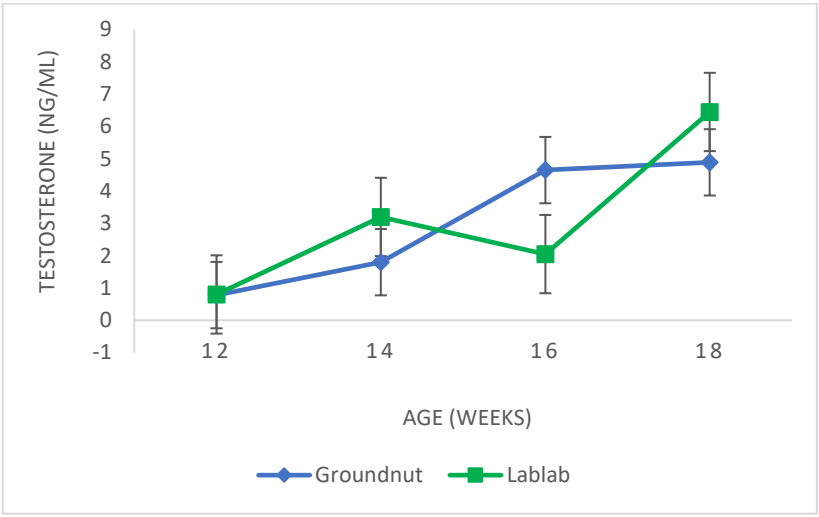
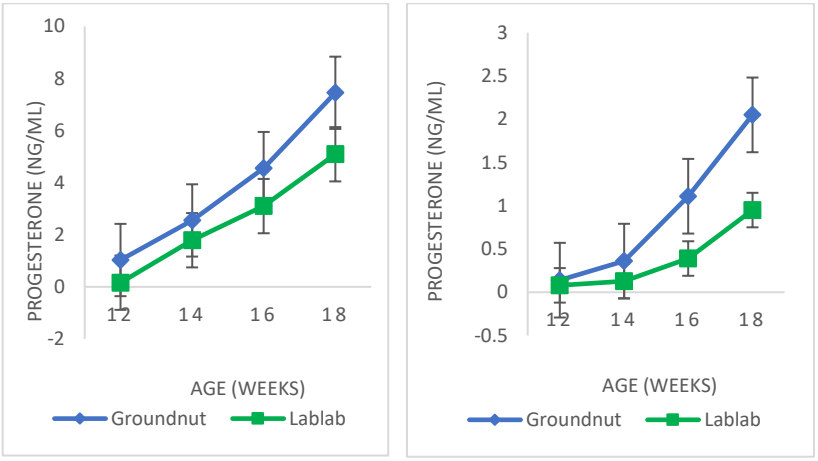


Figure 19: Testosterone concentration with age of growing rabbits fed lablab and groundnut forage meal



a) Female b) Male

Figure 20: Progesterone concentration with age of growing female and male rabbits fed lablab and groundnut forage meal

Progesterone concentration of 2.55 ng/mL in groundnut fed rabbits at 14 weeks as compared to 1.79 ng/mL in lablab fed rabbits at 14 weeks of age indicate attainment of puberty in the groundnut fed but not the lablab fed rabbits. Based on the progesterone concentration observed, female rabbits fed groundnut forage attained puberty at 14 weeks of age while those on lablab forage attained puberty at 16 weeks of age. During the pre-pubertal phase, progesterone concentration remained at the basal levels of 0.1-0.6 ng/ml, with fluctuations a few days before the onset of puberty (Shahnaz *et al*., 2000). Lower planes of nutrition delayed the onset of puberty by inhibiting maturation of the endocrine system (Patterson *et al*., 1992).

Nwagu *et al*. (2024) further evaluated the hormonal profiles of growing rabbits fed groundnut, moringa and lablab forage meal-based diets. Figure 21 shows progesterone and oestradiol profiles of growing rabbits fed these forage meal-based diets. Progesterone concentration of rabbits on lablab forage meal diet was slightly higher than groundnut and moringa forage meal and the concentrate diets. Oestradiol concentration on the other hand was lower on lablab forage meal diet than groundnut, moringa forage diets and the concentrate. Testosterone concentration was lower on lablab forage meal diet than groundnut, moringa forage diets and the concentrate (Figure 22). Contrary to this, Iyeghe–Erakpotobor *et al*. (2015b) reported that groundnut forage meal influenced higher progesterone concentration in male and female rabbits than lablab forage meal diet and did not show significant ($p>0.05$) difference in serum concentration of testosterone in growing rabbits fed groundnut and lablab forage meals. Groundnuts increased oestradiol and testosterone levels in boars (Chen *et al*., 2018), testosterone levels in rats (Iddi *et al.,* 2013) and broiler breeder roosters (Abbaspour et al., 2019). Moringa leaf meal significantly increased testosterone

concentration in rabbit bucks (El-kashef, 2022) and in male and female rats (Ogunsola *et al.,* 2017).

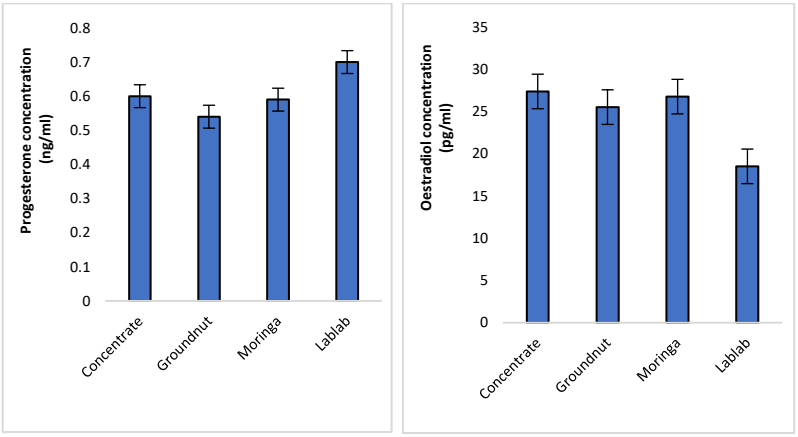


Figure 21: Progesterone and Oestradiol concentrations of growing rabbits fed forage meal-based diets

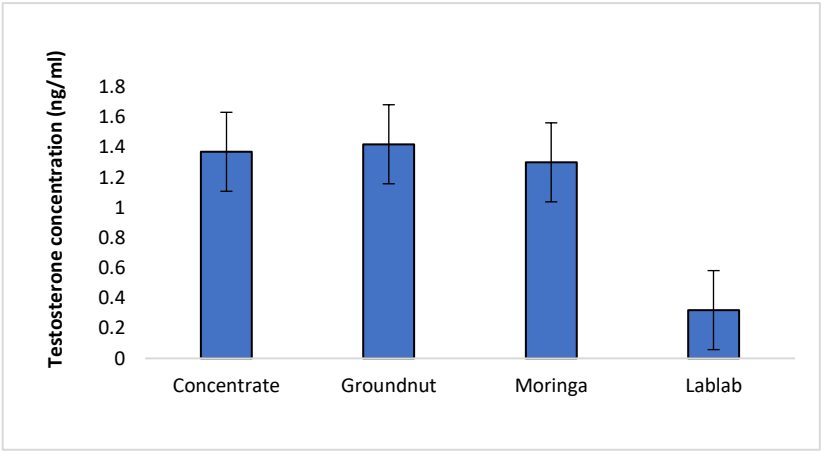


Figure 22: Testosterone concentration of growing rabbits fed forage meal-based diets

Nutritional factors influence hypothalamic-pituitary function and therefore gonadotrophin profiles, directly through effects of nutrients or metabolic hormones, acting on target organs or through changes in sensitivity of these organs to oestradiol, progesterone, testosterone and other hormonal feedback mechanism (Muzvondiwa *et al*., 2011). In addition, flavonoids, alkaloids and other phytochemical content in moringa increased testosterone hormone concentration (Alabi *et al*., 2017). Flavonoids, alkaloids and other phytochemical content in moringa, groundnut, lablab and other legume forages could be implicated in their effect on hormone concentration in animals, especially the phytoestrogens (isoflavones, stilbene, coumestan, and lignan) which are found in many legume species. It is concluded that groundnut and moringa forages could be used in diets of growing rabbits to evoke oestradiol and testosterone production while for progesterone production, lablab, groundnut and moringa forage meal diets performed equally well, to enhance growth and reproduction efficiency.

GENE EXPRESSION OF OESTRADIOL AND ANDROGEN RECEPTORS

A gene is a region of DNA that encodes heritable and genomic sequence, which affects the traits of an organism by being expressed as a functional product or by regulation of gene expression (Hubé and Francastel, 2015; Francis and Wörheide, 2017). Cells regulate their gene expression depending on their external environment, internal environment and specific role in a multicellular organism. I-Argenine in groundnut increased the expression of testosterone related genes (Jia *et al.,* 2020). Iyeghe-Erakpotobor *et al*. (2023) and Nwagu (2025) investigated how forages influence expression of oestradiol (ESR1, ESR2) and androgen (AR) receptors in rabbits. These protein receptors influence production of hormones, oestrogen

and testosterone. Oestradiol (ESR1) gene expression in rabbits fed concentrate diet was 2.39-fold up-regulated than moringa (2.25-fold) and groundnut (2.02-fold) forage meal diets (Figure 23). The oestradiol (ESR2) and androgen (AR) gene expressions as affected by groundnut and moringa forage meal diets are shown in Figure 24. Groundnut and moringa forages induced 2-3-fold up-regulation of the expression of oestradiol receptor 2 gene than the concentrate fed rabbits which showed a 0.63-fold up-regulation of the gene expression. The forages showed a 3-4 folds up-regulation of the expression of androgen receptor gene in rabbits than the concentrate fed rabbits which showed a 1-fold up-regulation of the gene expression. This study indicates that tropical forages may exhibit phytoestrogenic, androgenic, or reproductive-modulating properties, and shows their potential use in growth and reproduction enhancement of rabbits. This opens opportunities for fertility enhancement, puberty manipulation, and reproductive management through nutrition.

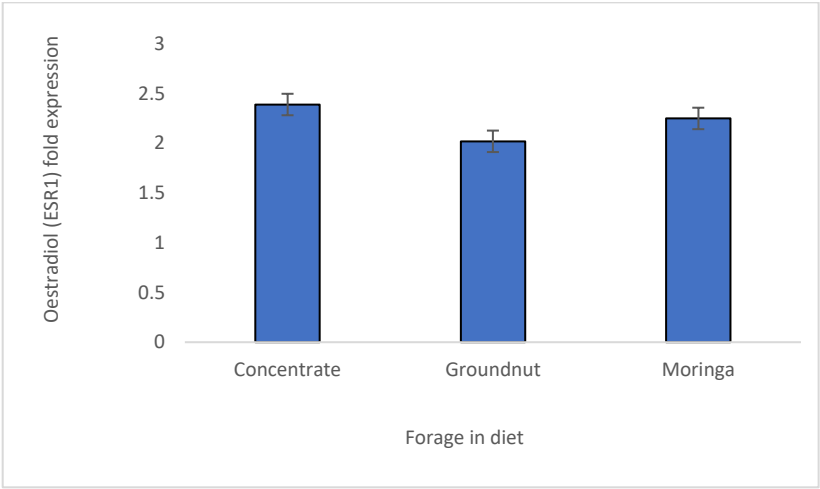


Figure 23: Forage effect on oestradiol (ESR1) gene expressions in rabbits

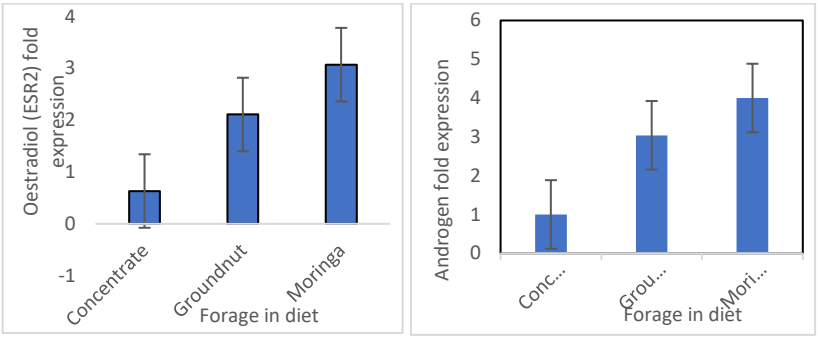


Figure 24: Forage in diet effect on oestradiol (ESR2) and androgen gene expressions of rabbits

RESPONSES OF BREEDING RABBITS

Iyeghe-Erakpotobor *et al*. (2025) evaluated the feed intake of adult rabbits fed concentrate, groundnut and moringa forage meal diets constituted by replacing 10 or 20% of the concentrate diet with the forages. Feed intake was significantly ($p<0.05$) higher for adult rabbits, fed groundnut and moringa forage meal diets than concentrate diet (Figure 25). This is associated with higher fibre levels or phytochemicals in the forage diets, than the concentrate diet. Phytochemicals in diets of poultry and pigs showed positive effects on feed intake (Velenzuela-Grijalva *et al*., 2017), or no significant effect of phytochemical on feed intake (Zhou *et al*., 2011; Rossi *et al*., 2013). Flavonoids, vitamin C and carotenoids in legumes possess immune-stimulatory properties by improving the activities of lymphocytes, immunoglobulin response, monocytes, macrophages and NK cells (Hong *et al.*, 2012), and improve duodenal function and increase availability of nutrients which transform into energy sources and tissues for growth (Velenzuela-Grijalva *et al.,* 2017) and reproduction in animals.

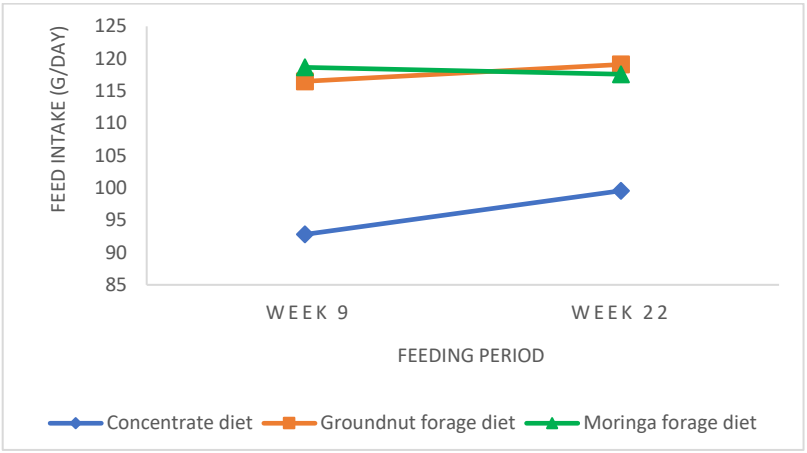


Figure 25. Feed intake of adult rabbits fed concentrate, groundnut and moringa forage meal diets

The response of breeding rabbit does to various combinations of concentrate diet and lablab hay offered separately (concentrate:lablab ratio of CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50) was evaluated by Iyeghe-Erakpotobor and Muhammad (2007) and Iyeghe-Erakpotobor *et a*l. (2009). Concentrate intake (Figure 26) was significantly ($p<0.05$) lower on low concentrate and high fibre treatments (CL1 and CL2) compared with high concentrate and low fibre treatments (CL3 and CL4) which had similar concentrate intake during pregnancy and first week of lactation, though the quantity supplied was different. This shows that does' intake of concentrate during pregnancy is between 60 to 73 g/day even when 100g/day of concentrate was offered. Lablab intake increased during pregnancy for all the treatments and decreased during lactation being higher on low concentrate and high fibre treatments (CL1 and CL2) than high concentrate and low fibre treatments (CL3 and CL4). The reduction in lablab intake during lactation could be because of increase in concentrate supplied to rabbit does, in the second and third weeks of lactation.

Figure 27 shows the total feed intake and weight gain of rabbit does during pregnancy and lactation. Does on CL2, CL3 and CL4 had similar feed intake, which was significantly ($p<0.05$) higher than on CL1 during the premating phase. Rabbits adjust their feed intake according to the energy concentration of the feed, the balance of proteins and other dietary components such as minerals and crude fibre (Lebas *et al*., 1986). Rabbits require high-energy intake of 300 kcal DE/kg $W^{0.75}$ which increases to 360 kcal DE/kg $W^{0.75}$ during maximum milk production (Lebas *et al*. 1986) between the 18th and 23rd day of lactation (Paufler, 1985; Sandford, 1986). This high nutrient requirement was not met at the levels of concentrate and lablab offered during lactation. Rabbit does gained weight (Figure 27) in the pre-mating phase, first, second and third weeks of pregnancy for all the treatments. In the fourth week of pregnancy however, CL2, CL3 and CL4 lost weight. This indicates the ability of the does to meet their requirements within the range of 20 to 100g concentrate intake for weight gain during pregnancy. During lactation, the rabbit does lost weight in the first and third weeks. In the second week of lactation, does on CL1 and CL4 gained weight while those on CL2 and CL3 lost weight. This indicates that the rabbit does, did not consume enough nutrients to meet their nutrient requirement for lactation on the combinations.

Gestation length (Table 34) decreased with increase in concentrate level from CL1 to CL3. Litter size at birth and alive at birth was similar for all the treatments. Litter size and weight at 21 days postpartum, total litter weight gain, and percent kit mortality were lower ($p<0.05$) on CL4 than the other treatments. This is contrary to the expectation of higher breeding response with high concentrate level.

Iyeghe-Erakpotobor *et al*. (2008), examined the response of breeding rabbit does to various combinations of concentrate: *Stylosanthes hamata* hay offered separately at ratios of 20:80, 40:60, 60:40 and 80:20. Concentrate and stylo intakes (Table 35) during pregnancy and lactation increased with increase in

quantity offered. Total feed intake during pregnancy increased but decreased during lactation with increase in concentrate level in the combination. Crude protein intake increased with increase in concentrate to stylo levels during pregnancy and decreased during lactation. Relative intake of rabbit does (Figure 28) during pregnancy increased as the proportion of concentrate to stylo increased while during lactation it was constant. The expectation was that relative feed intake during lactation should be higher than during pregnancy.

The kindling rate of does (Table 36) increased with increase in concentrate level up to 60:40. The highest kindling rate of 90% was obtained at 60:40 and the lowest rate (45%) on 20:80 and 80:20 treatments. Gestation length was similar for 20:80, 40:60 and 60:40 but shorter for does on 80:20 combinations. Litter size and weights were similar for all the treatments. Kit mortality was higher ($p<0,05$) on 80:20 concentrate to stylo combination than other combination groups. Iyeghe-Erakpotobor and Muhammad (2004) also did not observe significant differences in litter size at birth and litter size alive at birth for rabbit does offered varying levels of concentrate and lablab combinations. It is concluded from this study that does on 60:40 concentrate to stylo combination have better performance in terms of feed intake, kindling rate and litter size.

Reproductive performance of rabbit does fed soybean cheese waste (SBW) diets at 10, 20, 30, 40 and 100%SBW was evaluated (Ahmad, 2010) using diets containing 0% soybean cheese waste as control. Brachiaria grass hay was fed to all the groups at 60 g/rabbit/day. Gestation length was similar for rabbit does on 0, 10, and 20% SCW and significantly ($p<0.05$) longer than on 30, 40, and 100% SBW. Litter size at parity and alive at birth were similar for does on 0, 20, 30, 40 and 100% SBW but significantly ($p<0.05$) larger on 20%SBW than 10%SBW (Table 37). Kit mortality was higher on 10, 30, 40 and 100% SBW than on 0 and 20%SBW. Rabbit does on 40%SBW, lost all their kits by the second week of

lactation resulting from contamination arising from improper drying of the batch of soybean cheese waste used in the diet. Litter weight at birth was significantly ($p<0.05$) higher for does on 20%SBW than 10%SBW which was similar with all the other treatments. Litter weight at weaning was significantly higher for 0 and 20% SBW than other treatments.

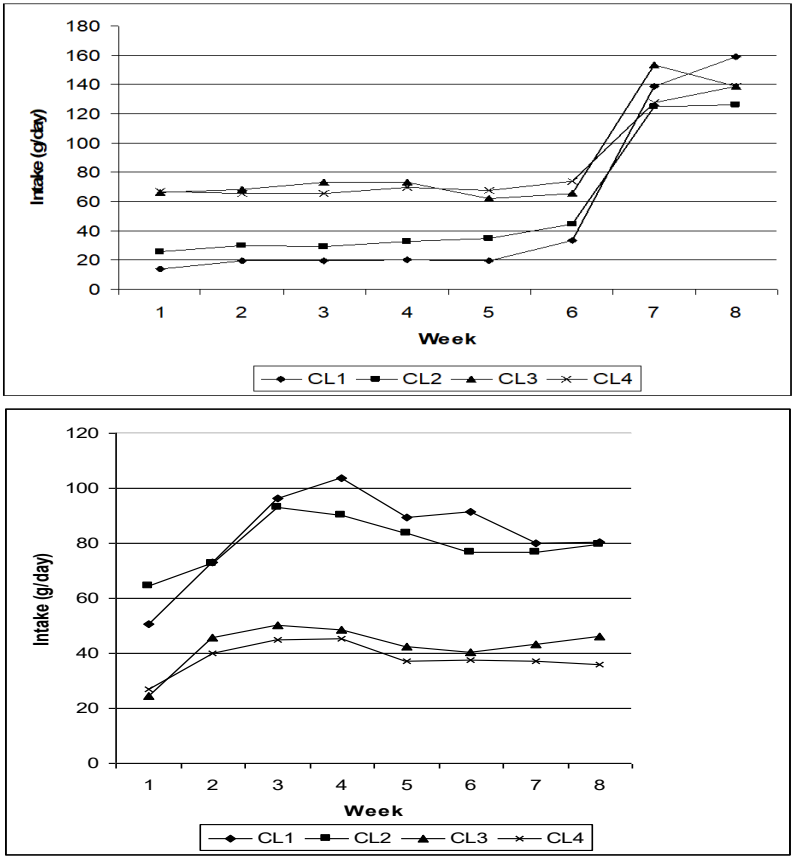
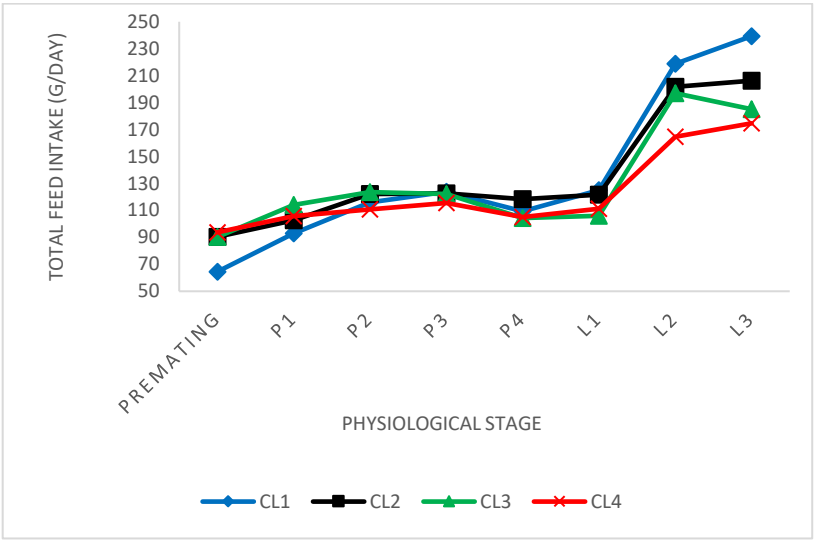


Figure 26: Concentrate and lablab intake pattern of nulliparous does fed concentrate and lablab combinations during pregnancy and lactation. CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50. Week 1= premating phase, Week 2-5= pregnancy phase and Week 6-8= lactation phase.



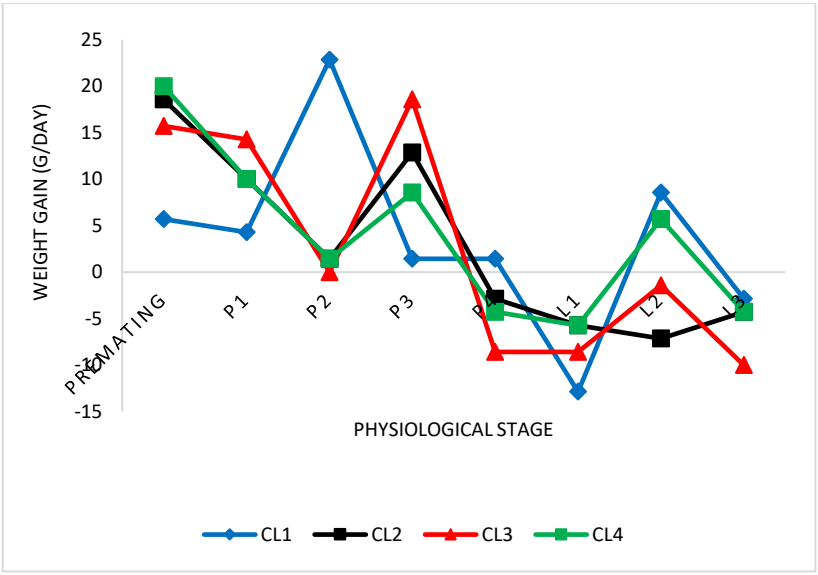


Figure 27: Total feed intake and weight gain of nulliparous does fed concentrate and lablab combinations. CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50. P1-P4= pregnancy phase and L1-L3= lactation phase.

Table 34: Gestation length, litter size and kit mortality of nulliparous does fed concentrate and lablab combinations

	Concentrate: lablab treatment (g:g)				
Parameter	CL1	CL2	CL3	CL4	SE
Gestation length (days)	33.0^{ab}	32.0^{bc}	31.8^{c}	34.0^{a}	0.69
Litter size:					
At birth	5.3	5.0	6.0	4.8	0.72
Born alive	5.3	4.7	5.8	4.8	0.63
21-d postpartum	5.3^{a}	4.7^{ab}	5.3^{a}	3.0^{b}	0.80
Weight (g):					
Litter birth weight	240.0	223.3	265.0	237.5	18.42
Kit birth weight	46.2	48.3	48.1	52.6	3.30
Litter weight at 21-d PP	1166.7^{a}	1050.0^{a}	1075.0^{a}	600.0^{b}	128.78
Weight gain:					
Total litter weight gain	926.7^{a}	826.7^{a}	810.0^{a}	537.5^{b}	87.37
Total kit weight gain	180.7	183.6	154.2	135.4	14.61
Kit mortality (%)	0.00^{b}	0.00^{b}	6.25^{b}	43.75^{a}	0.82

Means with different superscripts along rows are significantly different (P<0.05). PP= postpartum. CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50.

Table 35: Feed intake of rabbit does offered concentrate and Stylosanthes combinations during pregnancy and lactation

	Concentrate: Stylosanthes combinations (%)					
Parameter	20:80	40:60	60:40	80:20	Prob.	SE
Pregnancy:						
Concentrate intake (g/d)	27.9^{d}	53.5^{c}	83.2^{b}	96.4^{a}	<0.01	1.87
Stylo intake (g/d)	69.6^{a}	56.8^{b}	36.2^{bc}	26.5^{c}	<0.01	2.36
Total feed intake (g/d)	97.6^{c}	110^{b}	119^{a}	123^{a}	<0.01	3.20
Crude protein intake (g/d)	16.6^{c}	20.3^{b}	23.7^{a}	25.1^{a}	0.001	0.58
Lactation:						
Concentrate intake (g/d)	141^{c}	170^{b}	187^{a}	202^{a}	0.001	8.55
Stylo intake (g/d)	203^{a}	156^{b}	109^{b}	64.7^{c}	0.001	3.29
Total feed intake (g/d)	344^{a}	326^{a}	297^{b}	266^{c}	0.001	9.59
Crude protein intake (g/d)	61.5^{a}	60.8^{a}	57.5^{ab}	53.9^{b}	0.05	2.01

Means with different superscripts along rows are significantly different.

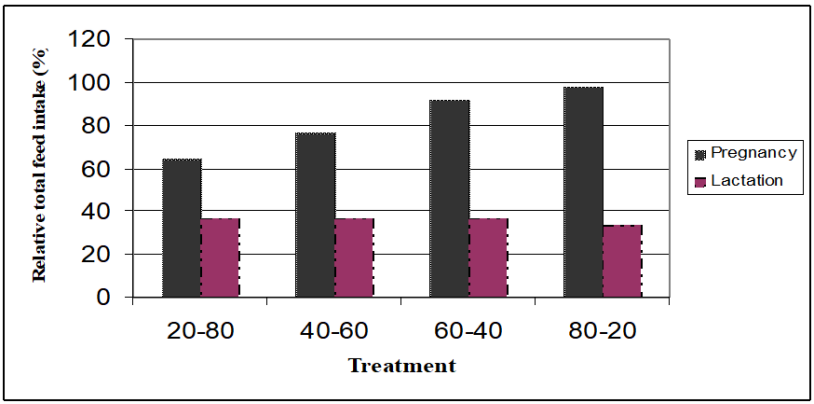


Figure 28. Relative intake of feed of rabbit does fed concentrate-stylosanthes combinations during pregnancy and lactation.

Table 36: Reproductive performance of rabbit does offered concentrate-Stylosanthes combinations

	Concentrate: Stylosanthes (%)					
Parameter	20:80	40:60	60:40	80:20	Prob.	SE
Kindling rate	45^{c}	60^{b}	90^{a}	45^{c}	0.05	0.20
Gestation length (days)	29.9^{a}	30.2^{a}	30.8^{a}	27.0^{b}	0.05	1.01
Litter size at birth	4.20	5.00	4.67	4.80	0.49	0.56
Litter size alive at birth	4.00	4.67	4.50	4.60	0.80	0.68
Litter size at weaning	3.67	4.11	4.25	4.00	0.94	0.62
Litter birth weight (g)	225	244	244	250	0.34	29.9
Litter weight at weaning (g)	1517	1633	1487	1660	0.94	181
Total litter weight gain (g)	1292	1389	1244	1410	0.92	159
Kit weight gain (g)	368	363	344	357	0.75	30.1
Kit mortality (%)	0.00^{b}	0.00^{b}	6.25^{b}	43.75^{a}	10.01	0.010

Means with different superscripts along rows are significantly different.

These studies show that increasing the ratio of concentrate: lablab increased litter size, total litter gain and decreased kit mortality. Levels of concentrate and lablab did not negatively affect reproductive performance in the short term, despite weight loss during lactation. Rabbit does fed dietary combinations of 60:40 and 80:20 concentrate and stylo hay had higher kindling rate and lower kit mortality than 20:80 and

40:60 combinations. Reproductive performance of rabbit does fed soybean cheese waste diet at 20%, had high litter size, weaning weight and kit mortality, however, 100%SBW compared favorably with the other treatment groups, farmers could use this level of inclusion of soybean cheese waste in diets of breeding does. It is very important that properly dried soybean cheese waste meal should be included in rabbit diets. Soybean cheese waste, Stylosanthes and lablab forage can partially or wholly replace expensive conventional concentrates.

Table 37: Reproductive performance of rabbit does fed on soybean cheese waste diets and Brachiaria hay

	Soybean cheese waste level (%)					
Parameter	0	10	20	30	40	100
Gestation length (days)	34.00±0.00^{a}	34.00±0.00^{a}	34.00±0.00^{a}	32.00±0.00^{b}	32.00±0.00^{b}	32.00±0.00^{b}
Litter size at birth	6.00±1.12^{ab}	4.00±0.79^{b}	7.00±1.12^{a}	5.00±1.91^{ab}	5.33±1.91^{ab}	5.33±1.91^{ab}
Litter size alive at birth	5.50±1.19^{ab}	3.75±0.84^{b}	7.00± 1.19^{a}	4.67±0.97^{ab}	5.33±0.97^{ab}	5.33±0.97^{ab}
Litter size at weaning	5.50±1.24^{a}	1.25±0.88^{bc}	6.00±1.24^{a}	2.33±1.01^{b}	0.00±1.01^{c}	3.00±1.01^{ab}
Litter birth weight (g)	150.0±58.1^{ab}	156.1±41.1^{b}	325.0±58.1^{a}	233.3±47.4^{ab}	266.7±47.4^{ab}	216.7±47.4^{ab}
Litter weaning weight (g)	1500.0±383.7^{a}	300.0±271.3^{b}	1550.0±383.7^{a}	883.3±313.3^{ab}	0.0±313.3^{b}	933.3±313.3^{ab}
Kit mortality (%)	8.33	68.75	14.29	53.33	100.00	43.75

Means with different superscripts along rows are significantly different ($P<0.05$)

Breeding rabbits can successfully utilize varying combinations of concentrate and forage without severe reduction in reproductive efficiency, especially when the forage quality is good. High forage inclusion did not necessarily reduce reproduction if nutrient balance was maintained. Moderate concentrate and forage combinations improved kindling rate, litter performance, kit survival, and reproductive efficiency. Smallholder farmers can reduce feed costs while maintaining acceptable reproductive output.

ENERGY UTILIZATION FOR REPRODUCTION

Energy utilization in pregnancy and lactation is an important determinant of reproductive success and subsequent productivity in animals. It shows how energy is partitioned for maintenance, foetal growth, milk synthesis and maternal accretion by the dam. Olutunmogun *et al*. (2017) observed similar ($p>0.05$) energy utilization by pregnant rabbit does fed combinations of concentrate and lablab (Table 38). The positive balance DE observed indicates that all the combinations were adequate to meet the requirements for pregnancy in rabbits and, points to the fact that there was high availability of nutrients from the lablab forage in conjunction with the concentrate ensuring the adequacy of energy release to support foetal growth and development. Ojewole *et al.* (1999) reported that rabbits perform better when fed mixture of forage and concentrate in equal quantity. Xiccato *et al.* (1999) observed that voluntary dry matter intake of reproductive rabbit does is unaffected by dietary energy concentration in the feed consumed when above the critical level of 210 to 310 kcal/d/kg $BW^{0.75}$ which is below the values of 641.11-686.46 KJ/$LW^{0.75}$/day in this study. During the lactation phase (Table 39), there was no significant ($p>0.05$) difference in DE utilization, though negative DEbal (-304.67, -220.91 and -116.27 KJ/day) were obtained on CL1, CL2 and CL4 while the CL3 combination had positive energy balance of 78.55 KJ/day.

Table 38: Energy Utilization by Pregnant Rabbit Does offered combinations of concentrate and lablab hay

Parameter	Concentrate: lablab hay combination				SEM	P value
	CL1	CL2	CL3	CL4		
DE intake (KJ/day)	2076.62	1972.96	2205.77	1921.18	69.53	0.162
DE requirement (KJ/day)	1358.86	1316.42	1411.42	1318.78	16.47	0.178
DE for maintenance (KJ/day)	715.11	704.81	727.66	723.22	8.27	0.783
DE reqd. for foetal growth (KJ/day)	643.75	611.62	683.79	595.57	14.04	0.162
DE for maternal accretion (KJ/day)	1017.54	966.75	1080.83	941.38	22.20	0.162
DE balance (KJ/day)	717.76	656.54	794.32	602.39	32.14	0.215
DE reqd. (KJ/$LW^{0.75}$/day)	670.61	657.23	686.46	641.11	8.01	0.264

CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50

Table 39: Energy utilization by lactating does fed different combinations of concentrate and Lablab

Parameter	Concentrate: Lablab hay combination (g:g)				SE	P-value
	CL1	CL2	CL3	CL4		
DE intake (KJ/day)	2671.76	2641.18	3024.48	2074.25	157.17	0.779
LWT3 (g)	1166.67	1050.00	1075.00	717.26	189.01	0.425
TMP (Kg/day)	3.39	3.23	3.27	3.27	1.03	0.380
Daily MP (g/day)	161.51	153.79	155.44	104.56	21.72	0.380
TDE req (KJ/day)	2976.46	2862.09	2945.93	2272.26	152.47	0.418
DE_m (KJ/day)	823.02	811.61	873.39	948.77	26.77	0.374
DE_{milk} (KJ/day)	2153.44	2050.47	2072.54	2066.85	40.16	0.835
E_{milk} (KJ/day)	1356.67	1291.80	1305.70	1180.72	37.20	0.496
DEbal (KJ/day)	-304.67	-220.91	78.55	-116.27	53.66	0.135
Doe metabolic weight ($LW^{0.75}$)	1.92	1.89	2.03	2.03	0.08	0.379
DEreq (KJ/ $LW^{0.75}$/day)	1567.11	1516.65	1456.03	1233.57	57.18	0.299
E_{milk} FE (KJ/day)	1046.64	953.01	864.21	711.78	47.21	0.159
E_{milk} BE (KJ/day)	310.03	338.79	441.49	329.83	19.31	0.136
BE_{retain} (KJ/day)	397.47	434.35	566.02	422.85	24.80	0.136
Fat loss (KJ/day)	10.89	11.90	15.51	11.59	0.68	0.136
TB loss (KJ/day)	228.68	249.90	325.65	243.29	14.25	0.136

CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50. DM intact = Dry matter intake, TMP =Total milk produced, MP =Milk produced, TDEreq = Total digestible energy for requirement, DE_m= Digestible energy for maintenance, E_{milk} = Energy in milk, DEbal = Digestible energy balance, DEreq$LW^{0.75}$/day = Digestible energy requirement per metabolic weight, LWT3 = Litter weight at 3 weeks, E_{milk} FE = Energy in milk from feed, E_{milk} BE = Energy in milk from body energy, BE_{retain} = Body energy retained, TB loss = Total body loss.

Tsavkar *et al*. (2019) reported increase in dry matter intake, DE intake, DE requirement, DE requirement for maintenance, DE requirement for foetal growth, DE requirement for maternal accretion, balance of DE and DE requirement per metabolic weight as the amount of concentrate increased and stylo decreased during pregnancy (Table 40). The pregnant rabbits were in positive DE utilization for all the parameters considered. The positive balance DE observed indicates that all the combinations were adequate to meet the requirements for pregnancy in rabbits and, points to the fact that there was high availability of nutrients from the stylo and concentrate ensuring adequate energy release to support foetal growth and development. During lactation, all parameters showed no significant ($p>0.05$) difference (Table 41). The rabbit does were

in positive balance of DE utilization for all the combinations of concentrate and stylo hay. This shows the combinations did not only meet the requirements of the does for pregnancy but also of lactation, indicating the potential of stylo as a good candidate in concentrate forage combinations in rabbit feeding.

Table 40: Energy utilization of pregnant rabbit does offered levels of concentrate and S*tylosanthes hamata* hay combinations

	Concentrates and *Stylo* hay combinations (g)					
Parameters	20:80	40:60	60:40	80:20	SEM	P-value
DM intake (g/d)	88.62^{b}	110.09^{b}	152.54^{a}	159.20^{a}	3.28	0.0001
DE intake (kJ/d)	1739.24^{b}	2180.70^{b}	3006.63^{a}	3173.38^{a}	14.45	0.0001
DE_{req} (kJ/d)	1238.73^{c}	1392.20^{b}	1631.98^{a}	1750.28^{a}	19.03	0.0001
DE_{m} (kJ/d)	699.56^{b}	716.19^{a}	699.92^{b}	766.53^{a}	7.80	0.032
DE_{fg} (kJ/d)	539.16^{b}	676.02^{b}	932.05^{a}	983.75^{a}	18.75	0.0001
DE_{macc} (kJ/d)	852.23^{b}	1068.54^{b}	1473.25^{a}	1554.96^{a}	29.64	0.0001
Balance DE (kJ/d)	500.51^{b}	788.49^{b}	1374.65^{a}	1423.10^{a}	43.76	0.0001
$DE_{req}/LW^{0.75}$ (d)	622.99^{b}	689.91^{b}	823.33^{a}	804.80^{a}	10.88	0.0001

Means within rows with different superscripts are significant ($p<0.05$) different. DM intake = dry matter intake, DE_{req} = Digestible energy required, DE_{m} = Digestible energy for maintenance, DE_{fg} = Digestible energy for foetal growth, DE_{macc} = Digestible energy for maternal accretion, Balance DE= Balance of digestible energy, DE_{req}/LW0.75/day = digestible energy requirement per metabolic weight per day.

Table 41: Energy utilization by lactating does fed different concentrate and *Stylosanthes hamata* hay combinations

	Concentrate and *Stylosanthes hamata* hay combinations (g)					
Parameter	20:80	40:60	60:40	80:20	SEM	P-value
$LW^{0.75}$ (d)	2.04	2.31	2.05	2.04	0.12	0.778
DE intake (kJ/d)	4822.82	4523.79	4555.64	3676.10	165.00	0.189
TMP (kg)	3.21	3.36	3.34	3.41	0.09	0.893
TDE_{req} (kJ/d)	2920.96	3127.63	3004.94	3043.68	87.36	0.859
DE_{m} (kJ/d)	880.78	993.81	883.87	878.47	49.85	0.779
DE_{milk} (kJ/d)	2040.18	2133.83	2121.08	2165.21	54.34	0.895
E_{milk}	1285.31	1344.31	1336.28	1364.08	34.23	0.895
Balance DE (kJ/d)	1901.86	1396.16	1550.73	632.42	213.27	0.329
$DE_{req}/LW^{0.75}$ (d)	1426.92	1426.36	1463.83	1505.22	36.06	0.877
LWT3 (kg)	2.60	3.16	2.62	2.60	0.61	0.750
E_{milk} FE (kJ/d)	809.74	846.91	841.86	859.37	57.05	0.895
E_{milk} BE (kJ/d)	475.57	497.40	494.42	504.71	33.51	0.895
BE_{retain} (kJ/d)	609.70	637.69	633.88	647.06	42.96	0.895

DM intake = Dry matter intake, TMP =Total milk produced, TDE_{req} = Total digestible energy for requirement, DE_{m}= Digestible energy for maintenance, E_{milk} = Energy in milk, balance DE = Digestible energy balance, DE_{req} $LW^{0.75}$/day = Digestible energy requirement per metabolic weight, LWT3 = Litter weight at 3 weeks, E_{milk} FE = Energy in milk from feed, E_{milk} BE = Energy in milk from body energy, BE_{retain} = Body energy retained.

Energy supplied from forage–concentrate combinations was generally adequate for pregnancy but became limiting during lactation except for the concentrate and stylo hay combinations which sufficiently provided the necessary digestible energy to meet the physiological needs of rabbit does during pregnancy and lactation phases. Pregnant does maintained relatively balanced energy utilization in all the studies. Lactating does often enter negative energy balance because pregnancy requires moderate nutrient partitioning while lactation imposes much greater metabolic demand resulting in the need for rabbit does to mobilize body reserves during milk production. Forage-based systems require strategic supplementation during lactation to meet this high nutrient requirement. Rabbit farmers must increase nutrient density during lactation to avoid reproductive decline and excessive body tissue mobilization.

PROTEIN UTILIZATION FOR REPRODUCTION

Protein utilization during pregnancy and lactation for maintenance, foetal growth and milk synthesis determines reproductive success. Latu *et al*. (2017) evaluated protein utilization of rabbit does offered levels of concentrate and lablab hay combinations and showed that DCP intake, DCP requirement, DCP required for foetal growth and balance of DCP significantly ($p<0.05$) increased as concentrate level increased in the combination (Table 42). Non-significant ($p>0.05$) differences were, however, observed for dry matter intake, DCP required for maintenance and DCP requirement per metabolic weight. Ojewole *et al.* (1999) reported better performance of growing rabbits fed mixture of concentrates and forages compared to the sole feeding of concentrates or forages. Lablab, a well digested forage, and in combination with concentrate has shown potential in provision of nutrients for

growth (Nwagu and Iyeghe-Erakpotobor, 2012). During lactation (Table 43), though dry matter intake increased (p=0.05), the rabbit does were in negative DCP balance in all the combinations, indicating that these combinations were not adequate in meeting the lactation requirements of the rabbits.

Table 42: Protein utilization by pregnant rabbit does offered levels of concentrate and lablab hay combinations

Parameter	CL1	CL2	CL3	CL4	SE	P-value
DM intake (g/d)	135.02	131.19	130.64	121.53	4.09	0.362
DCP intake (g/d)	20.83^{b}	21.98^{b}	26.32^{a}	25.44^{a}	0.57	0.006
DCPrequirement (g/d)	16.27^{b}	16.64^{b}	18.71^{a}	18.29^{a}	0.41	0.008
DCP_{m} (g/d)	7.52	7.41	7.65	7.60	0.13	0.787
DCP_{fg} (g/d)	8.75^{b}	9.23^{b}	11.06^{a}	10.69^{a}	0.37	0.006
Balance of DCP (g/d)	4.57^{b}	5.34^{b}	7.62^{a}	7.15^{a}	0.51	0.010
DCPrequirement (g/$LW^{0.75}$/d)	2.03	2.01	2.07	2.06	0.02	0.793

Means within rows with different superscripts are significant (p<0.05) different. DM= Dry matter, DCPreq = Digestible crude protein requirement, (DCPm) = Digestible crude protein for maintenance, DCPfg = Digestible crude protein for fetal growth, Balance DCP = Balance of digestible crude protein, DCPreq/LW0.75/d = digestible crude protein requirement per metabolic weight per day. CL1=20:130, CL2=40:110, CL3=80:70 and CL4=100:50.

Table 43: Protein utilization by lactating does offered different combinations of concentrate and lablab hay

	Concentrate and lablab hay (g:g)					
Parameter	CL1	CL2	CL3	CL4	SE	P-value
Litter weight at 21 days (g)	1166.67	1050.00	1075.00	717.26	90.38	0.426
TMP (kg)	3.39	3.23	3.27	3.27	5.90	0.380
Daily MP (g)	161.51	153.79	155.44	104.56	11.51	0.381
DM intake (g/d)	202.04^{a}	185.93^{a}	154.98^{b}	147.96^{b}	9.69	0.001
DCP intake (g/d)	21.07	20.45	19.04	17.76	1.16	0.380
Total DCP required (g/d)	23.32	22.64	22.12	21.04	1.88	0.374
DCP_{m} (g/d)	7.31	7.10	7.65	7.54	0.28	0.497
DCP_{milk} (g/d)	16.01	15.54	14.47	13.49	1.88	0.374
Balance DCP (g/d)	-2.25^{bc}	-2.19^{c}	-3.08^{ab}	-3.29^{a}	0.42	0.052

Means within rows with different superscripts are significant (p<0.05) different. TMP=Total milk production, DM= Dry matter, MP= Milk production, DCP_{m} = Digestible crude protein for maintenance, DCP_{milk} = Digestible crude protein for milk production, Balance DCP = Balance of digestible crude protein. CL1= 47:303, CL2= 94:256, CL3= 188:166, CL4 = 276:74.

Latu *et al*. (2018), evaluated the utilization of digestible crude protein by breeding rabbits fed combinations of concentrate and *Stylosanthes hamata* (stylo) hay during pregnancy and lactation. Pregnant rabbit does fed 80:20 and 60:40 concentrate and stylo had similar ($p>0.05$) DCP intake, DCP requirement, DCP required for foetal growth and balance of DCP which were higher ($p<0.05$) than for rabbit does on 40:60 and 20:80 concentrate and stylo combinations (Table 44). Pregnant does showed significant increase in DCP intake, total DCP requirement for pregnancy, DCP requirement for maintenance and for foetal growth, as the level of concentrate increased. and *stylo.* decreased. Combinations of 60:40 and 80:20 concentrate and stylo had higher DCP balance (5.25 and 5.63) than 20:80 and 40:60 concentrate and stylo combinations (-1.46 and 0.95). During lactation, there was non-significant ($p<0.05$) difference in DCP intake, DCP requirement, DCP maintenance, DCP requirement for milk synthesis, balance DCP, DCP requirement per metabolic weight between the combinations (Table 45). The balance of DCP was negative on all the combinations indicating the inadequacy of the combinations to meet the lactation requirements of the rabbits.

Table 44: Protein utilization of pregnant rabbit does offered levels of concentrate and Stylosanthes hay combinations

	Concentrates and *Stylosanthes hamata* combinations (g)					
Parameter	20:80	40:60	60:40	80:20	SEM	P-value
DCP_{intake} (g/d)	10.16^{c}	14.61^{b}	21.74^{a}	23.60^{a}	9.46	0.0001
DCP_{req} (g/d)	11.62^{c}	13.67^{b}	16.49^{a}	17.97^{a}	0.20	0.0001
DCP_{m} (g/d)	7.35^{c}	7.53^{b}	7.36^{c}	8.06^{a}	0.08	0.0319
DCP_{fg} (g/d)	4.27^{c}	6.14^{b}	9.13^{a}	9.91^{a}	0.19	0.0001
BalanceDCP (g/d)	-1.46^{b}	0.95^{b}	5.25^{a}	5.63^{a}	0.29	0.0001
$DCP_{req}/LW^{0.75}$(d)	5.84^{c}	6.77^{b}	8.32^{a}	8.26^{a}	0.29	0.0001

Means within rows with different superscripts are significant ($p<0.05$) different. DCP intake = Digestible crude protein intake, DCP_{req} = Digestible crude protein required, (DCP_{m}) = Digestible crude protein for maintenance, DCP_{fg} = Digestible crude protein for foetal growth, Balance DCP = digestible crude protein balance, $DCP_{req}/LW^{0.75}$/d = digestible crude protein requirement per metabolic weight per day.

Table 45: Protein utilization of lactating does offer different combinations of concentrate and *Stylosanthes* hay combinations

Parameter	Concentrates and *Stylo* hay combinations (g)					
	20:80	40:60	60:40	80:20	SEM	P-value
DCP_{intake} (g/d)	15.60	15.83	16.64	16.02	0.49	0.8931
DCP_{req} (g/d)	19.43	20.54	20.25	19.74	0.52	0.8660
DCP_{m} (g/d)	7.58	8.55	7.61	7.56	0.43	0.7795
DCP_{milk} (g/d)	11.85	12.03	12.64	12.18	0.37	0.8933
BalanceDCP (g/d)	-3.84	-4.75	-3.61	-3.71	0.46	0.7745
$DCP_{req}/LW^{0.75}$/d	9.50	9.45	9.92	9.77	0.30	0.9208

DCP intake = Digestible crude protein intake, DCP_{req} = Digestible crude protein required, DCP_{m} = Digestible crude protein for maintenance, DCP_{milk} = Digestible crude protein for milk, BalanceDCP = Balance digestible crude protein, $DCP_{req}/LW^{0.75}$/d = digestible crude protein requirement per metabolic weight per day.

Tsavkar *et al*. (2023) examined protein partitioning of pregnant rabbit does fed levels of soyabeans cheese waste (SBW) diets supplemented with Brachiaria grass, and reported non-significant ($p>0.05$) difference in DCP intake, DCP requirement, DCP requirement for foetal growth of pregnant does however, rabbits on 20% SBW had negative balance DCP (Table 46). Protein utilization by lactating does offered levels of SBW diets (Table 47) showed non-significant ($p>0.05$) difference in DCP intake, DCP requirement, DCP for maintenance, DCP requirement for milk synthesis, and DCP requirement per metabolic weight of lactating does on the treatments. DCP intake was not sufficient for lactation as evidenced by the negative protein balance observed. This indicates mobilization of nutrients from body tissues during lactation to support lactogenesis (Toschi *et al.,* 2005).

Table 46: Protein Partitioning of Pregnant Does on varying levels of Soyabean Cheese Waste diets

	Level of soyabean cheese waste (%)							
Parameter	0	10	20	30	40	100	SEM	P-value
DCP_{intake} (g/d)	16.19	14.14	12.43	14.88	14.46	14.51	0.29	0.1172
DCP_{req} (g/d)	13.99	13.29	12.60	12.94	12.62	12.69	0.19	0.4156
DCP_{m} (g/d)	7.19	7.35	7.38	6.69	6.54	6.60	0.14	0.3266
DCP_{fg} (g/d)	6.80	5.94	5.22	6.25	6.08	6.09	0.12	0.1177
BalanceDCPg/d	2.20	0.85	-0.17	1.94	1.85	1.82	0.22	0.0872
$DCP_{req}/LW^{0.75}$/d	7.14	6.78	6.24	6.91	7.00	6.94	0.11	0.4545

DCP_{req} = Digestible crude protein required; (DCP_{m}) = Digestible crude protein for maintenance; DCP_{fg} = Digestible crude protein for foetal growth; Balance DCP = digestible crude protein balance; $DCP_{req}/LW^{0.75}$/d = DCP requirement per metabolic weight per day.

Table 47: Protein Partitioning of Lactating Does Offered levels of Soyabean Cheese Waste diets

	Levels of soyabean cheese waste (%)							
Parameter	0	10	20	30	40	100	SEM	P-value
DCP_{intake} (g/d)	26.60	23.15	22.31	23.31	23.54	19.29	0.47	0.132
DCP_{req} (g/d)	27.24	24.42	24.52	24.38	24.91	21.79	0.37	0.154
DCP_{m} (g/d)	7.02	6.83	7.35	6.67	7.02	7.13	0.21	0.951
DCP_{milk} (g/d)	20.22	17.59	17.67	17.72	17.90	14.66	0.36	0.131
BalanceDCPg/d	- 0.64	- 1.27	- 1.94	- 1.07	- 1.37	- 2.51	1.26	0.626
$DCP_{req}/LW^{0.75}$/d	14.36	13.30	12.35	13.79	13.19	11.30	0.18	0.563

Means within rows with different superscripts are significant ($p<0.05$) different.; DCP_{req} = Digestible crude protein required; (DCP_{m}) = Digestible crude protein for maintenance; DCP_{milk} = Digestible crude protein for milk; Balance DCP = digestible crude protein balance; DCP_{req}/LW0.75/d = digestible crude protein requirement per metabolic weight per day.

Digestible crude protein (DCP) supplied by concentrate- forage combinations were generally sufficient for pregnancy but insufficient for lactation. Positive protein status occurred during pregnancy, indicating the pregnant does, efficiently utilized dietary protein for maintenance, foetal growth, body accretion. Negative protein balance occurred during lactation across all diets indicating lactating does, were not receiving sufficient protein from the diets and were diverting nutrients heavily from body reserves toward milk synthesis. Future rabbit diets should specifically target lactation nutrition by including higher-quality protein sources in the diets.

HORMONAL RESPONSES IN REPRODUCTION

Iyeghe-Erakpotobor *et al*. (2025) evaluated progesterone, oestradiol and testosterone profiles of breeding rabbit does fed concentrate, groundnut and moringa forage meal diets. Progesterone concentration (Figure 29) was lower in adult rabbits fed groundnut forage meal diet than the concentrate and moringa forage meal diets fed rabbits. Progesterone values of 7.55 ng/mL (concentrate) and 7.22 ng/mL (moringa) are within the level for peak luteal phase concentration of 5 to 9 ng/ml while the value of 3.64 ng/mL obtained for groundnut forage meal diet was below the level for luteal phase. Folman *et al*. (1973) reported plasma levels of progesterone are 5 to 9 ng/ml at peak of the luteal phase.

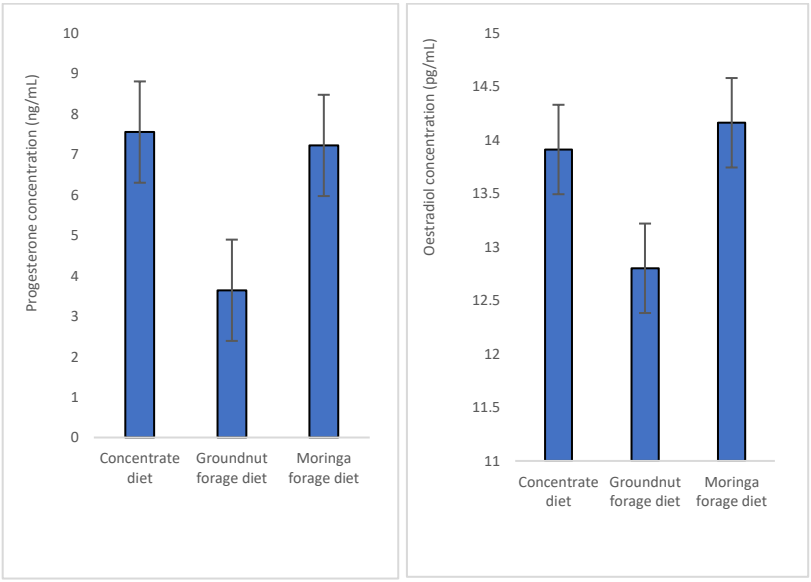


Figure 29: Progesterone and oestradiol concentrations of adult rabbits fed groundnut and moringa forage meal diets

Oestradiol (Figure 29) concentration was lower in adult rabbits fed groundnut forage meal diet than the concentrate and moringa forage meal diets. Oestradiol values of 14.16 pg/mL (moringa forage), 13.91 pg/mL (concentrate) and 12.8 pg/mL (groundnut forage). This indicates more larger follicles in moringa and concentrate than groundnut forage fed rabbits. These values are lower than 17.5±2.1 pg/mL reported by Marongiu and Corrado (2013) for non-suckling rabbit does. Serum oestrogen level in rabbits is influenced by the number of large follicles (Fleming *et al*., 1984). Testosterone concentration (Figure 30) was higher in adult rabbits fed the concentrate diet than those fed groundnut and moringa forage meal diets. The values of 4.8 ng/mL (concentrate), 3.55 ng/mL (groundnut) and 3.53 ng/mL (moringa) are similar to the values of 3.90±0.43 ng/mL obtained by Iyeghe-Erakpotobor *et al*. (2015b) for groundnut forage meal diet and 3.37±0.57 and 3.75±0.73 ng/mL obtained by El-kashef (2022) for moringa forage.

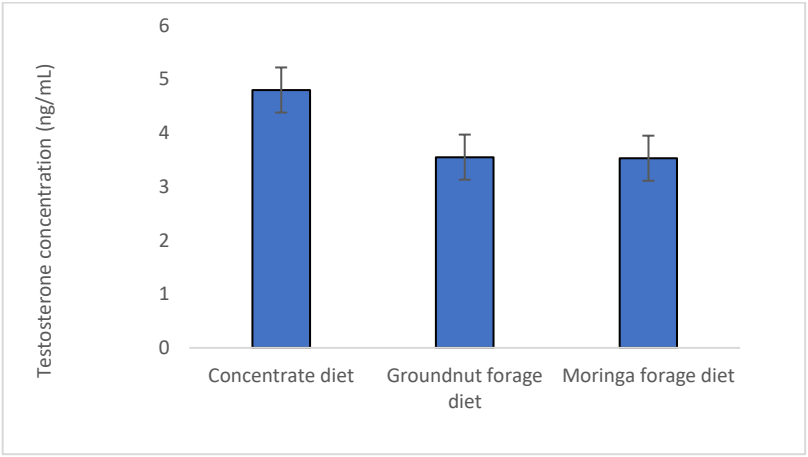


Figure 30: Testosterone concentration of adult rabbits fed groundnut and moringa forage meal diets

Groundnut forage increased testosterone concentration in mice (Jia *et al.,* 2020), boars (Chen *et al.,* 2018) and broiler breeder roosters (Abbaspour *et al.,* 2019). Moringa leaf meal also significantly increased testosterone concentration in buck rabbits (Gouda *et al.,* 2020) and in male and female rats (Ogunsola *et al.,* 2017). This indicates the ability of groundnut and moringa forages to modulate gonadotrophin-releasing hormone in the hypothalamus, which in turn stimulates the anterior pituitary to produce the gonadotrophin hormones released into the blood and thus increase testosterone level (Ekaluo *et al.,* 2013). In addition, flavonoids, alkaloids and other phytochemical content in moringa and groundnut forages increased testosterone hormone concentration (Alabi *et al.,* 2017). It is concluded that both forages can adequately replace the concentrate in adult rabbit diets without affecting reproductive performance. Different forage types influenced reproductive hormone profiles of rabbits differently. Concentrate and moringa positively forage influenced progesterone and oestradiol levels than groundnut forage meal diet. Nutrition did not only affect growth and reproduction directly but also influenced hormonal production and in effect reproductive performance.

GENERAL TAKE HOME LESSONS

1. Rabbits are efficient converters of low-cost feed resources

2. Forages can partially replace expensive concentrates by substantially reducing feed costs and increasing profitability of the rabbit production system.

3. Groundnut haulm and lablab forages produced good feed intake, growth rates, feed cost reduction, and feed efficiency, making them promising forages for rabbit production in the tropics.

4. Optimum performance of rabbits requires a careful balance of nutrients supply from the concentrate and forages, because neither extremely high concentrate nor extremely high forage systems consistently produced the best overall outcomes. Hence, the most efficient systems involve moderate concentrate levels. There is need for strategic forage supplementation to meet the nutrient requirement for all phases of production.

5. Economic efficiency is central to good productivity for meeting the needs of smallholder farmers, resource-poor producers and developing economies.

6. Local feed resources have untapped potential for the utilization of unconventional feed ingredients and agro-industrial by-products to support rabbit production.

7. Rabbit production can support sustainable agriculture through waste recycling, sustainable livestock systems, reduced feeding costs and improved food security.

8. Practical feeding recommendations for smallholder rabbit farmers are cost effective using locally available feed resources sustainable for rabbit production.

Finally, I would like to state that **"The rabbit is not merely a minor livestock species, but a powerful instrument for sustainable nutrition, food security, poverty alleviation, and agricultural transformation in Nigeria and the tropics."** The necessity to include it in mainstream livestock production and development by all stakeholders (farmers, government and scientists) cannot be over emphasized and would go a long way in reducing the animal protein deficit and produce healthier Nigerians within a short time scale.

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REFERENCES

Abbaspour B, Sharifi S.D., Ghazanfari S., Honarbakhsh S., Mohammadi-Sangcheshmeh A. (2019). The effect of l-arginine and flaxseed on plasma testosterone concentration, semen quality and some testicular histology parameters in old broiler breeder roosters. *Theriogenology*; **128**:101-109.

Adeyemi, A.A., Ewuola, E.O. and Tewe, O.O. (2014). Testosterone, Libido Assessment and Semen Characteristics of Rabbits Fed Supplemental *Moringa oleifera* Leaf Meal. *Nigerian Journal of Animal Science*, **16**(1): 13-19.

Ahmad, Hauwa'u Ali 2010. Utilization of soya bean cheese waste diets on reproductive performance of breeding does. B.Agric. Project. Dept. of Animal Science. BUK, Kano.

Akinola, J.O and Odedire, J.A. (2019). A glossary terms used in tropical pasture science. Published by OAU press, Ile-Ife, Nigeria. Pg 19 and 34

Alabi, Q.K., O.S. Olukiran., Ma. Adefisayo, and B.A. Fadeyi. (2017). Effects of treatment with Nauclea latifolia root decoction on sexual behaviour and reproductive functions in male rabbits. *Journal of Dietary Suppliment*. **15**(5): 649 – 664.

Ana-Maria Plotuna, Ionela Hotea, and Emil Tirziu. 2025. Improving the Nutritional Properties of Rabbit Meat Through Dietary Supplementation with Linseed Meal, Fodder Yeast, and Selenium Yeast. *Applied Science*. 2025, 15, 5427 https://doi.org/10.3390/app15105427

APMD 2026. African Pastoral Markets Development Platform National Livestock Socio-Economic Contribution Brief Draft. Nigeria, April 2026.

Arnarson, A. 2024. 8 signs and symptoms of protein deficiency. Reviewed by Jared Meacham. Nutrition. Healthline. Heaithline.com. Retrieved on 23rd May, 2026.

Ayeni, M.D., Manga, T.A., Aledare, J.S., and Alhassan, Y. J. 2025. Technical Efficiency and Constraints to Rabbit Production in Kwara State Nigeria. Journal of Arid Agriculture. Vol. **26**(2): 24-34. https://jaaunimaid.ng/index.php/home/article/view/84

Ayo-Ajasa, O.Y., Ekunseitan, D.A., Alarima, C.I., Busari, A.O., Oose, M.O., Adewole, F.A., and Tegbeyale, L.T. 2025. Analysis of rabbit production practices by farmers in Ogun state, Nigeria. Journal of Agricultural Science and Environment. **25**:21-38

Bamikole MA, Ezenwa I, 1999. Performance of rabbits on guinea grass and verano stylo hays in the dry season and effect of concentrate supplementation. *Animal Feed Science and Technology*. **80**(1): 67-74.

Chen, J.Q., Li, Y.S, Li, Z.J., Lu, H.X., Zhu, P.Q., and Li, C.M. (2018). Dietary L-arginine supplementation improves semen quality and libido of boars under high ambient temperature. *Animal*. Vol **12**(8):1611-1620. https://doi.org/10.1017/S1751731117003147

Dalle Zotte, Antonella. 2014. Rabbit farming for meat purposes. Animal Frontiers. October 2014, Vol. **4**, No. 4: 62-67. doi:10.2527/af.2014-0035. Downloaded from https://academic.oup.com/af/article/4/4/62/4638826 by guest on 31 October 2025

Ekaluo, U.B., F.A. Erem, I.S. Omeje, E.V. Ikpeme, Y.B. Ibiang, and B.E. Ekanem., (2013). Aqueous leaf extract of guava: a non-toxic male fertility booster. IOSR *Journal of Environmental Science Toxicological Food Technology,* **3** (2): 33-35.

Ekpo, J. S., Etuk, I. F., and Solomon, I. P. 2008. Influence of sex on growth and carcass traits of rabbits fed unpeeled cassava tuber meal, peeled cassava tuber meal and cassava peel meal as energy sources. *Journal of Agriculture, Forestry and the Social Sciences*. **6** (1). http://ajol.info/index.php/joass/article/view/48634.

El-kashef, M. M. A. (2022). Effect of *Moringa oleifera* leaves on Physiological Response, Hormonal Changes and Semen Quality of Male Rabbits under North Sinai Conditions. *Egyptian Journal of Rabbit Science*, **32** (2): 105-119.

Francis WR, and Worheide G (2017). “Similar ratios of introns to intergenic sequence across animal genomes”. Genome Biology and Evolution. **9** (6): 1582-1598.

Goetsch, A. L., Detweiler, G., Sahlu, T., Hayes, J. and Puchala, R. 2003. Effects of separate offering of forage and concentrate on feed intake and growth of Alpine doelings. *Small Ruminant Research* **48**(3): 209-216.

Gouda, N. H; H.M. El-kelawy; M.N. Ll-Gafaary and H. Ibrahim. 2020. utilization of moringa oleifera as a new rabbits feed. 3- effect of dietary inclusion of moringa oleifera hay on reproductive performance of buck rabbits. *Egy. J. of Rabbit Sci*., **30**(1): 61- 73.

Hong, J.C., Steiner, T., Aufy, A., Lien, TF. 2012. Effects of supplemental essential oil on growth performance, lipid metabolites and immunity, intestinal characteristics, microbiota and carcass traits in broilers. *Livestock Science*. **144**:253-262.

Honig, A.C., Inhuber, V., Spiekers, H., Windish, W., Gotz, K., Schuster,M., and Ettle, T. 2022. Body composition and composition of gain of growing beef bulls fed rations with varying energy concentrations. Meat Science 2022 Feb;184:None. Doi:10.1016/j.meatsci.2021.108685

Hube F, and Francastel C (2015). “Mammalian Introns: When the Junk Generates Molecular Diversity”. International Journal of Molecular Sciences. **16**(3): 4429-4452.

Iddi S., Kasolo J.N. and Bryaruhanga Y.B. (2013) The effect of consuming groundnuts on serum testosterone levels and lipid profile in male rats. *Tanzanian Medical Journal* **26**: 2.231.

Iyeghe G. T., Abdulmalik M., Osinowo O. A., Adeyinka I. A. and Nwagu B. I. 1996. Genetic and environmental factors affecting litter size, gestation length and weaning weight in rabbits. *Journal of Animal Production Research.***15 & 16**: 81-89

Iyeghe-Erakpotobor, G. T. 2006. Performance of grower rabbits fed concentrate and Stylosanthes (verano) combinations under tropical conditions. *Animal Science Journal*. Vol **77**(1):71-78.

Iyeghe-Erakpotobor, G. T. 2007. Effect of concentrate and forage type on performance and digestibility of growing rabbits under sub-humid tropical conditions. *Asian Journal of Animal and Veterinary Advances*. **2**(3):125-132.

Iyeghe-Erakpotobor, G T. 2009. Performance of rabbits on stylo and groundnut haulms. *Nig. J. Anim. Prod.* **36** (2):288-296.

Iyeghe-Erakpotobor, G. T. 2012. Utilization of *Arachis hypogea* (groundnut) and *Lablab purpureus* (lablab) forage meal fed sole or mixed by growing rabbits. *Tropicultura*. **30**(4):199-203.

Iyeghe-Erakpotobor G. T. and Adeyegun E. 2012. Evaluation of growing rabbits fed diets containing varying levels of groundnut forage meal (*Arachis hypogea)*. *Journal of Applied Agricultural Research.* **4**(2). 41-51.

Iyeghe-Erakpotobor, G T, Adeosun, Y G, Sekoni A A and Esievo L O. 2008. Reproductive performance of rabbit does on concentrate to forage (*Stylosanthes hamata*) combinations. *Livestock Research for Rural Development.* Volume **20**, Article # 178.Retrieved November 11, 2008, from http://www.lrrd.org/lrrd20/11/iyeg20178.htm

Iyeghe-Erakpotobor, G. T., and Ashworth, C. J. 2003. Relationship between live weight, liver weight and progesterone metabolism of Large White X Landrace and Meishan pigs in early pregnancy. *ASSET*. **3**(2): 1-9.

Iyeghe-Erakpotobor, G T. and Esievo, L O. 2008. Utilization of varying levels of soybean cheese waste meal and lablab hay by growing rabbits. *Trop. J. Anim. Sci.* **10** (supplement):64-69.

Iyeghe-Erakpotobor, G. T. and Esievo, L. O 2010. Performance of growing rabbits fed varying levels of soybean cheese waste diet and lablab hay. *Nigerian Journal of Animal Production* **37**(2): 173-183.

Iyeghe-Erakpotobor, G. T. and Muhammad, I.R. 2007. Performance of rabbit breeding does fed concentrate and lablab combinations during pregnancy and lactation. *Journal of Animal and Veterinary Advances.* **6**(3): 358-363.

Iyeghe-Erakpotobor, G. T and Nwagu F.O. 2014. Energy and protein utilization for growth in rabbits fed lablab and groundnut forage meal diets. *Journal of Animal Production Research*. **26**: 62-78

Iyeghe-Erakpotobor, G. T. and Yakubu, S. T. 2009. Effect of replacement of concentrate with lablab forage meal on performance of growing rabbits. *Trop. J. Anim. Sci.* **11**:71-87.

Iyeghe-Erakpotobor, G. T., Abdulmalik, M.E., Uguru, J. and Abeke, F. 2002. Determination of optimum concentrate and forage combination for small holder feeding of rabbits. *Tropical Journal of Animal Science.* **5**(1):181-187.

Iyeghe-Erakpotobor, G. T., Adeyegun, E. and Titus, S. Y. 2011. Performance of growing rabbits fed groundnut and lablab forage meal diet. *J. Anim. Prod. Res*. **24**:50-59.

Iyeghe-Erakpotobor, G. T., Aliyu, R., Uguru, J. 2006a. Evaluation of concentrate, grass and legume combinations on performance and nutrient digestibility of grower rabbits under tropical conditions. *African Journal of Biotechnology*. **4**(20):2004-2008

Iyeghe-Erakpotobor, G. T., and Muhammad, I. R. 2004. Performance of breeding does fed concentrate and lablab combinations during pregnancy and lactation. IN: *Sustaining livestock production under changing economic fortunes.* Eds: Proc. 29th Ann. Conf. NSAP. Usmanu Danfodio University, Sokoto, Nigeria. 21st-25th March 2004. Pg 191-194.

Iyeghe-Erakpotobor, G. T., and Muhammad, I. R. 2008. Intake of tropical grass, legume and grass-legume mixtures by rabbits. *Tropical Grasslands*. **42**(2): 112-119.

Iyeghe-Erakpotobor, G. T., Okunlola, B.O., and Barje, P. P. 2015a. Effect of forage type and level, palm oil supplementation and sex on performance of weaner rabbits. *J. Anim. Prod. Res.* **27**:145-156.

Iyeghe-Erakpotobor, G. T., Okunlola, B.O., and Barje, P. P. 2015b. Effect of forage type, palm oil supplementation and sex on serum progesterone and testosterone profile of weaner rabbits. *J. Anim. Prod. Res*. **27**:56-65.

Iyeghe-Erakpotobor, G. T; Balogun, R. O., Abdulmalik, M. E. and Adeyinka, I. A. 2001. Influence of breed and environmental factors on litter parameters of rabbits raised in a semi-humid environment. *Nigerian Journal of Animal Production*. **28**: 14-19.

Iyeghe-Erakpotobor, G. T.; Abdulmalik, M. E., Uguru, J. O. and Abeke, F. O. 2002. Determination of optimum concentrate and forage combination for small holder feeding of rabbits. *Trop. J. Anim. Sci*. **5**(1): 181-187.

Iyeghe-Erakpotobor, G. T., Osuhor, C.U. and Olugbemi, T.S. 2006b. Performance and digestibility of weaner rabbits fed graded levels of soybean cheese waste/maize offal diet and brachiaria grass hay. *African Journal of Biotechnology*. **5**(17):1579-1583.

Iyeghe-Erakpotobor, G T, Sekoni, A. A. and Esievo, L O. 2009. Nutrient intake and digestibility of rabbit does fed varying levels of concentrate and lablab during pregnancy. *Nig. J. Anim. Prod*. **36** (2):275-287.

Iyeghe-Erakpotobor, G. T., Tudunwada, I. K., Tijjani, A., Muhammad, I. R. and Bello, N. 2012. Influence of level of groundnut haulms and feeding system on performance of growing rabbits. *Nigerian Journal of Animal Production* **39**(1): 64-73.

Iyeghe-Erakpotobor, G.T., Mbaduga, L., Sabo, M. N., and Okunola, B. O. 2013. Performance of growing rabbits fed groundnut forage meal diets with or without palm oil. *Journal of Animal Production Research*. **25**: 37-44.

Iyeghe-Erakpotobor, G.T., Bisong, K.O., Ibiwoye, K.O., Daudu, V. M. and Nwagu, O.F. 2023. Rabbit Research in the National Animal Production Research Institute (NAPRI). IN: Livestock Industry: Contributions of the Society for Animal Production, 1973-2023. 50th Anniversary Commemorative book. Eds A.O.K Adesehinwa, D. J.U Kalla, T.S. Olugbemi, H.O. Obikaonu, M. I. Ghude and G. T. Iyeghe-Erakpotobor. Published by the Nigerian Society for Animal Production. Nigeria. Pp 457-494.

Iyeghe-Erakpotobor, G.T., Nwagu, O.F., Ibiwoye, K.O., Barje, P.P., and Daudu, O. 2025. Feed intake and hormonal (progesterone, oestradiol and testosterone) profiles of adult rabbits fed groundnut and moringa leaf meal diets. Proc. 50th Conf., Nig. Soc. For Anim. Prod. 16-20 March, 2025, Federal Univ., of Lafia, Nigeria. Pp428-432

Jia, X., Li Z. Ren, X., Dai, P., Li Y., and Li, C. 2020. L-Arginine alleviates the testosterone reduction in heat-treated mice by upregulating LH secretion, the testicular antioxidant system and expression of steroidogenesis-related genes. *Reproduction, Fertility and Development*. **32**(10):885-892. https://doi.org/10.1071/RD19303

Latu, M. Y., Olutunmogun, A. K., Barje, P. P. and Iyeghe-Erakpotobor, G. T. 2017. Protein partitioning of pregnant and lactating rabbit does fed combinations of concentrate and lablab hay. *Journal of Animal Production Research,* **29**(1):154-160.

Latu, M. Y., Tsavkar, D.T., Olutunmogun, A. K., Barje, P. P. and Iyeghe-Erakpotobor, G.T. (2018). Protein partitioning of pregnant and lactating rabbit does fed combination of concentrates and *Stylosanthes hamata* hay. *Nigerian Journal of Animal Science,* **20**(3): 99-105.

Laxmi, P J., Ramesh Gupta, B., Gnana Prakash, M., Ekambaram, B., and Amareswari, P. 2009. A study on the performance of fryer rabbits under different systems of rearing. *Livestock Research for Rural Development.* http://www.lrrd.org/lrrd21/8/cont2108.htm.

Lebas, F., Coudert, P., Rouvier, R. and Rochambeau, H. 1986. *The rabbit husbandry, health and production.* FAO, Rome.

Marongiu, M. L. and Corrado D. 2013. Preliminary study on factors influencing rabbit doe reproductive efficiency: Effect of parity, day of mating, and suckling on ovarian status and estrogen levels at day 6 of pregnancy. *Canadian Journal of Veterinary Research*. 2013 Apr; 77(2): 126–130

Meshreky, S.Z. and Shaheed, I.B., (2003). Efficiency of vitamin E and selenium administration on growth performance, puberty and some anatomical and histopathological traits of female genitalia in New Zealand white rabbits. *Egyptian Journal of Nutrition & feeds*, 6 (Special Issue): 299-312.

Meshreky, S.Z., Mervat, M., Arafa, M. A., Abo, W. and Gad Alla S.A.Z, (2007). Male and female rabbits' performance traits as affected by dietary aflatoxin contamination and its detoxification. *Egyptian Journal of Rabbit Science*, **17**(1): 2742

Muzvondiwa, J. V., Kamamda, M.T., Nyamukanza, C.C and Mutisi, C. 2011. Effect of protein and energy levels on faecal progesterone concentration in Sabi ewes during oestrus cycle. Livestock Research for Rural Development. **23**(5):2011.

Nayananjalie, W. A. D. 2021. Role of farm animals and its contribution tp ecosystems. Sri Lankan Journal of Agriculture and Ecosystems. **3** (1): 1-4.

Nwagu, Flora O. 2025. Reproductive performance, hormonal profile of some reproductive gene (AR and ESR1) expression of rabbits fed groundnut, lablab and Moringa forage meal based diets. Ph.D. Animal Science Department, Ahmadu Bello University, Zaria. Pp 274.

Nwagu, F. O., and Iyeghe-Erakpotobor, G. T. 2012. Protein and energy partitioning for growth by rabbits fed soybean cheese waste diet and lablab hay. *Nigerian Journal of Animal Production* **39**(1): 54-63.

Nwagu, F. O., Nwagu, B. I and Iyeghe-Erakpotobor, G. T. 2010. Partitioning of protein for growth by rabbits fed groundnut and Stylosanthes forages supplemented with concentrate. *Nigerian Journal of Animal Science.* **12**: 93-101.

Nwagu, F. O., and Iyeghe-Erakpotobor, G. T. 2013. Energy partitioning for growth by rabbits fed groundnut and stylosanthes forages supplemented with concentrate. Nigerian Journal of Animal Production. **40**(1): 37-47. DOI: 10.51791/njap.v40i1.619

Nwagu, O. F., Ibiwoye, K.O., Barje, P.P., Daudu, O.M., and Iyeghe-Erakpotobor, G. T. 2024. Hormonal response of growing rabbits fed groundnut, lablab and moringa forage meal based diets. Proceedings of the 29th Conference of Animal Science Association of Nigeria. 8 – 12 September 2024, Lagos, Nigeria. Pp 219-222.

Ogunsola, O.A., Owolabi, J.O., Fabiyi, O.S., Nwobi, N.L., Faluyi, B. and Akinbola, A.S. 2017. Moringa Plant Parts Consumption Had Effects on Reproductive Functions in Male and Female Rat Models. *Journal of Dental and Medical Sciences*, **16**: 82–86.

Ojewole, G.S., Ukachukwu, S.N. and Abasiekong, S.F. (1999). Performance of growing rabbits fed sole concentrates forage diet. *Journal of Sustainable Agriculture and Environment,* 51-55.

Olutunmogun, A. K., Latu, M. Y., Ereke, S., Iyeghe-Erakpotobor, G. T. and Barje, P.P. 2017. Energy partitioning of pregnant and lactating rabbit does fed combinations of concentrate and lablab hay. *Journal of Animal Production Research.* **29**(2):208-214.

Onifade, A.A., Abu O.A., Obiyan R.I., Abanikannda O.T.F., 1999. Rabbit production in Nigeria: Some aspects of current status and promotional strategies. *World Rabbit Science*, vol. **7**(2), 51- 58.

Oyawoye EO, Oyikin ME, Shehu Y, 1990. Studies in the nutrition of rabbits. 1. Chemical evaluation of some tropical legumes as replacements for alfalfa in rabbit diets. *Journal of Applied Rabbit Research.* **13**(1): 32-34.

Patterson, D.J., Perry, R.C., Kiracofe, G.H., Bellows, R.A., Staigmiller, R.B. and Corah, L.R. (1992). Management considerations in heifer development and puberty. *Journal of Animal Science*, **70**: 4018-4035.

Paufler, S. 1985. Reproduction. *A compendium of rabbit production appropriate for conditions in developing countries.* Schriftenreihe der GTZ, No. 169. Eschborn, 1985. Pg 115-130.

Presidential Livestock Reforms Implementation Committee. Inception Report. Federal Republic of Nigeria. August 2024. Leabooks Minna. 152p; ISBN; 978-978-76912-2-9

Presidential Task Force. 1992. Alternative Formulation of Livestock Feeds. *Report and Recommendation.* Vol. 1: 15 pp.

Price Cory, 2025. Most Populous Animals on Earth. WorldAtlas. Worldatlas.com. Updated 24/06/2025.

Rossi, R., Pastorelli, G., Cannata, S., Tavaniello, S., Maiorano, G., and Corino, C. (2013). Effect of long term dietary supplementation with plant extract on carcass characteristics meat quality and oxidative stability in pork. *Meat Sci*. 2013; 95:542–548

Sabo, M. N., Mbadugha, N. L., Abubakar, S. A., and Iyeghe-Erakpotobor, G. T. 2016. Effect of replacement of concentrate with lablab forage meal with or without palm oil on performance and carcass characteristics of rabbits. *J. Anim. Prod. Res*. **28**(2):207-215.

Sandford, J. C. 1986. The domestic rabbit. 3rd Edition. Granada Publishing Ltd. New York.

Sanni, S.A. Alhassan, S. Muhammad I. R. and Iyeghe-Erakpotobor, G. T. 2009. Economic implications of feeding concentrate and forage (stylosanthes, groundnut haulms and lablab) to growing rabbits. *J. Anim. Prod. Res*. 21, 22 & 23:103-109.

Sanni, A.A., Arowolo, R.O.A. and Olayemi, F.O. 2012. Preliminary study on effect of castration and testosterone replacement on testosterone level in the New Zealand male rabbit. African Journal of Biotechnology. 11(43): 10146-10148. http://www.academicjournals.org/AJB.

Sanni, S.A., Iyeghe-Erakpotobor, G. T. and Ajala, M.K. 2005. Economic evaluation of grower rabbits production fed different combinations of concentrate and Stylosanthes. Proc. 10th Ann. Conf.., Anim. Sci. Ass. Of Nigeria (ASAN). University of Ado-Ekiti, Nigeria. September 12th-15th 2005. Pg 76-78.

Shahnaz, Khanum, A., Hussain, M., Alli, M., Kausar, R. and Cheema, A.M. (2000). Age at puberty in female Dwarf goat kids and estrous cycle length on the basis of hormone. *Parkistan Veterinary Journal*. **20**(2):71-76.

Soenke, M., Jacob, A. and Roland, O.B. 2005. Using net energy for diet formulation. Potential for the Canadian pig industry, *Advances in pork production*, **16**: 119-129.

The State of Food Security and Nutrition in the World 2025. UNICEF-WHO-The World Bank:Joint Child Malnutrition Estimates (JME) Levels and Trends-2025 Edition. UNICEF.org August 8, 2025. Retrieved on 20/01/2026

Toschi, I., Cesari, V., Grilli, G. and Castrovilli, C. (2005). Effect of intake level and diet composition on digestibility in nulliparous pregnant rabbits does. *Italian Journal of Animal Science*, **4**(2): 529-531.

Tsavkar, D. T., Latu, M. Y., Olutunmogun, A. K., Barje, P.P. and Iyeghe-Erakpotobor, G. T. 2019. Energy partitioning of pregnant and lactating rabbit fed combination of concentrate and *Stylosanthes hamata* hay. *Nig. J. Anim. Prod*. **46**(1):94-100.

Tsavkar, D. T., Latu, M. Y., Olutunmogun, A. K., Iyeghe-Erakpotobor, G. T. and Barje, P.P. 2023. Protein partitioning of pregnant and lactating rabbit does fed soyabean cheese waste and congo grass (Brachiaria ruziziziensis) hay diets. *Journal of Animal Production Research* **35**(2):70-77.

Umar, A.U., Rekwot, Z. G., Yahuza, Y., Ahmed, EM., Umar, H.A., Umar, Z.A., Ahmed, S., and Al-Habib, I.K. 2026. Animal protein consumption, women's education and livestock distribution: A zonal analysis of Nigeria's nutrition paradox. 9th All Africa Conference of Animal Agriculture (AACAA). Shehu Musa Yar'Adua Centre, Central Business District, Abuja, Nigeria. 9th-13th August 2026. Pg 19-20.

Velenzuela-Grijalva, N.V., Pinelli-Saavedra, A., Muhlia-Almazan, A., Dominguez-Diaz, D., and Gonzalez-Rios, HG. 2017. Dietary inclusion effects of phytochemicals as growth promoters in animal production: a review. *Journal of Animal Science and Technology*. **59**:8-24. Doi 10.1186/s40781-0133-9. Retrieved on Researchgate on 14/10/2024

World Food Programme. 2024. West and Central Africa faces deepening food crisis – UN agencies call for enhanced humanitarian action and lasting hunger solutions. 20 December 2024. www.wpf.org. Via Cesare Giulio Viola, 68, 00148 Rome RM, Italy. Retrieved on 21 January 2026.

Worldometer.2026. Population of Nigeria (2025 and historical). Nigeria Population Forecast. www.Worldometers.info. Retrieved on 20th January, 2026.

Xiccato, G. and Trocino, A. (2010). Feed and energy intake in rabbit and consequences on farm global efficiency. *The 6th International Conference on Rabbit Production in hot climate,* Assiut, Egypt, Pp 1-16.

Xiccato, G., Gernardini, M., Castellini, C., Dalle Zotte, A., Quenaque, P., Trocino, A. 1999. Effect of postnatal feeding on the performance and energy balance of female rabbits at different physiological status. *J. Anim. Sci*. **77**: 416-426.

Zhou, H.; Li, M.; Zi, X.; Xu, T.; Hou, G., 2011. Nutritive value of several tropical legume shrubs in Hainan province of China. *J. Anim. Vet. Adv.,* **10**(13):1640-1648 https://doi.org/10.3923/javaa.2011.1640.1648.



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