Energy partitioning of pregnant and lactating rabbit fed combination of concentrate and *stylosanthes hamata* hay

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Abstract

The study was carried out to examine energy partitioning of pregnant and lactating rabbit offered levels of concentrate and Stylosanthes hamata hay to ascertain whether it meets their high reproductive and nutritional requirement. Forty-eight nulliparous crossbred does (New Zealand White x California and California x Chinchilla breeds) of eight months old were allocated to four dietary treatments in a completely randomised design. During gestation, 150 g/doe/day concentrate and Stylosanthes hamata hay combinations (30:120g, 60:90g, 90:60g and 120:30g) was offered while 350 g/doe/day concentrate and Stylosanthes hamata hay combinations (70:280g, 140:210g, 210:140g and 280:70g) was offered during lactation. Estimations of digestible energy during pregnancy and lactation were carried out and reference data were used to calculate for DE_{req}, DE_{m}, DE_{fg}, DE_{macc}, BalanceDE and $DE_{req}/LW^{0.75}$. Results obtained showed non-significant (P>0.05) difference among 90:60 and 120:30% concentrate and Stylosanthes hamata hay combinations in terms of DM_{intake}, DE_{intake}, DE_{req}, DE_{fg}, DE_{macc}, BalanceDE and $DE_{req}/LW^{0.75}$, but were significantly (P<0.05) higher than 30:120 and 60:90% concentrate and Stylosanthes hamata hay combinations. Rabbit in the 4th week of pregnancy had significantly (P<0.05) higher DE_{intake}, DE_{req}, DE_{fg}, DE_{macc}, BalanceDE and $DE_{req}/LW^{0.75}$ than does in the 2nd week of pregnancy. During lactation, all parameters showed non-significant (P>0.05) difference. Therefore, the diet combinations were sufficient to provide adequate digestible energy for the physiological needs of does during pregnancy and lactation.

Keywords: Rabbit does, Energy Partitioning, Pregnancy, Concentrate, *Stylosanthes hamata* hay.

Introduction

The success of animal production and reproduction is determined by several interactive factors like genetic make-up of the animal, nutrition, temperature, photoperiod and stress. Among 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 also the highest cost of production (Soenke *et al*., 2005). Feed energy concentration is the main factor responsible for ingestion of dry matter and ostensibly other nutrients such as protein, amino acid and vitamins which contributes to the animal production and total well-being, that is to say animals will eat to meet their energy needs and consequently other nutrients alongside energy (Xiccato and Trocino, 2010). Energy is not a nutrient par-se, but a quality associated with the nutrient content of feed stuffs and mixed diets (Noblet, 2007). It has been reported that reproduction and growth requires about 300 – 500kcal DE/kg more than maintenance requirement in rabbit due to high energy demand for pregnancy and lactation which usually leads to negative energy balance (Xiccato and Trocino, 2010). The knowledge of energy utilisation and physiological state of rabbits is essential for formulating diets that will meet the nutrients requirement and support intensive breeding rhythms (Toschi *et al.,* 2004). It is therefore, important to estimate precisely the energy values of feed for adapting feed supply to energy requirement of animals (Noblet, 2007). In view of the above, this experiment was designed to examine the energy partitioning of pregnant and lactating rabbit does offered levels of concentrate and *Stylosanthes hamata* hay to ascertain whether it meets their high reproductive and nutritional requirement.

Materials and methods

Experimental site

The experiment was conducted at the Unit of Swine and Rabbit Research Programme of the National Animal Production Research Institute (NAPRI), Shika, Nigeria, located in the northern Guinea savannah ecological zone. The area lies between latitude 10°11′ N and longitude 7°8′ E, and 650 meters above sea level (Ovimaps, 2014). The area receives an annual rainfall of 1100 mm, which is spread from April to October. The mean minimum and maximum temperature ranges from 12 –28°C during the cold (harmattan) season and 20 - 36°C in the hot season. Relative humidity during the rainy season is about 75% and 21% during the dry season (IAR, 2014).

Experimental animals and management

Forty-eight nulliparous crossbred does (New Zealand White x California and California x Chinchilla breeds) of eight months old were allotted to four dietary treatments in a completely randomised design. After allotting the does to each dietary treatments, does were then introduced to bucks in their cages in a mating ratio of 1 buck: 6 does. After a successful mating was confirmed, by the buck thrusting forward and falling by its side, the does were then returned to their cages. Mating was carried out between 8:00 – 9:00am. The diets containing concentrate and *Stylosanthes hamata* hay combinations of 30:120g, 60:90g, 90:60g, 120:30g was fed during pregnancy and 70:280g, 140:210g, 210:140g, 280:70g was fed during lactation. The *Stylosanthes hamata* was harvested from the pasture farm of the Feed and Nutrition Research Programme Farm, dried at room temperature and chopped before feeding while the concentrate diet was formulated and contained crude protein of 22% and metabolisable energy of 2,600 ME/Kg (Table 1).

Table 1: Composition of concentrate diets fed to pregnant and lactating rabbit

Ingredients	Composition (%)
Maize	39.24
Groundnut	42.26
Maize offal	15.00
Bone	3.00
Salt	0.25
Vitamin/minerals premix	0.25
Total	**100.00**

*Vitamin/mineral premix content per kilogram ration: vit. A 1251 IU, vit. D3 2750 IU, vit. E 151 IU, vit. K 0.002 g, vit. B2 0.006 g, nicotinic acid 0.035 g, calcium D-pantothenate 0.01 mg, vit. B6 0.0035 g, vit. B12 0.02 g, folic acid 0.001 g, biotin 0.0005 g, vit. C 0.025 g, cholin chloride 0.39g, zinc bacitracin 0.02 g, methionine 0.2 g, avatec (lasolocid) 0.09 g, manganese 0.1 g, iron 0.05 g, zinc 0.04 g, copper 0.002 g, iodine 0.00153 g, cobalt 0.000225 g, selenium 0.0001 g.

Estimations of digestible energy during pregnancy and lactation was carried out and reference data were used in the calculation of digestible energy requirement (DE_{req}) and digestible energy required for foetal (DE_{fg}) and digestible energy required for maintenance (DE_m) according to Parigi Bini and Xiccato (1998). Does were housed individually in metal cages housed in a well-ventilated building with large open windows. Pregnant does were offered a total of 150g feed/doe/day while lactating does were offered 350g feed/doe/day. Water was given *ad libitum*. Flat bottom earthen feeders with rims were used for feeding the rabbits to avoid wastage. The experiment lasted for four months.

Data collection and statistical analysis

Data were collected and analyzed for live weight, digestible energy (intake, requirement, maintenance, foetal growth, balance and metabolic weight) on pregnancy and lactation and interaction between pregnancy phase and with the dietary treatments using the General Linear Model Procedure of SAS (1987). Orthogonal pair wise difference was used to separate significant means. Interaction effects between level of dietary treatment and stage of pregnancy were dropped because it was not significant. Below is the mathematical models used for the analysis:

Pregnancy:

$Y_{ijk} = \mu + \square_i + S_j + (\square_i * S_j) + \square_{ijk}$

Where;

Y_{ijk} = observation on the i^{th} treatment in the j^{th} stage of pregnancy,

μ = overall mean,

$\square_i$ = fixed effect of treatment

S_j = fixed effect of stage of pregnancy,

($\square_i * S_j$) = interaction between treatment and stage of pregnancy

$\square_{ijk}$ = random error with mean = 0 and σ^2

***Lactation*:**

$Y_{ij} = \mu + \square_i + \square_{ij}$

Where;

Y_{ij} = observation on the i^{th} treatment,

μ = overall mean,

$\square_i$ = fixed effect of dietary treatment,

$\square_{ij}$ = random error

Results and discussion

The energy partitioning of pregnant rabbit offered levels of concentrate and *Stylosanthes hamata* hay combinations is shown in Table 2. There were non-significant (P>0.05) differences between 90:60 and 120:30 concentrate and *Stylosanthes hamata* hay combinations in terms of DM_{intake}, DE_{intake}, DE_{req}, DE_{fg}, DE_{macc}, Balance DE and $DE_{req}/LW^{0.75}$, although these were significantly (P>0.05) higher than 30:120 and 60:90 concentrate and *Stylosanthes hamata* hay combinations, which were similar.

Table 2: Energy partitioning of pregnant rabbit does offered levels of concentrate and *Stylosanthes hamata* hay combinations

	Concentrates and *Stylosanthes hamata* hay combinations (g)					
Parameters	30:120	60:90	90:60	120:30	SEM	P-value
Live weight (kg)	1.99^{b}	2.04^{a}	1.99^{b}	2.18^{a}	0.02	0.0305
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	0.0322
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
BalanceDE (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 signific ant (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, BalanceDE= Balance of digestible energy, DE_{req}/LW0.75/day = digestible energy requirement per metabolic weight per day.

The result showed that there was increase in dry matter intake (DM_{intake}), digestible energy intake (DE_{intake}), digestible energy requirement (DE_{req}), digestible energy for maintenance (DE_m), digestible energy for foetal growth (DE_{fg}), digestible energy for maternal accretion (DE_{macc}), balance of digestible energy (DE_{bal}) and digestible energy requirement per metabolic weight per day ($DE_{req}/LW^{0.75}$/day) as the amount of concentrate increased and *Stylosanthes hamata* decreased. The pregnant rabbits were in positive DE utilisation for all the parameters considered, indicative that all the combinations were adequate to satisfy the requirements for pregnancy in rabbits probably due to higher feed intake, high crude digestibility as reported by Bamikole and Ezenwa (1999) and high availability of nutrients from the *Stylosanthes hamata* hay and the concentrate which could be a sign of good performance of the combinations in terms of energy as reported by Iyeghe-Erakpotobor *et al.* (2006). The positive DE utilisation for all the parameters considered is also an indication that the *Stylosanthes hamata* hay is high in non-lignified materials (Cheeke, *et al.,* 1986). He also reported that while digestibility of protein, fibre and energy of tropical grasses is very low in rabbits, many of the tropical legumes are as digestible as temperate forages.

Table 3 shows the effect of stage of pregnancy on energy partitioning of rabbit does offered levels of concentrate and *Stylosanthes hamata* hay combinations. Rabbit does in the 4th week of pregnancy had significantly ($P<0.05$) higher DE intake, requirement, foetal growth, maternal accretion, balance and requirement per metabolic weight than does in the 2nd week of pregnancy although DE for maintenance was similar for does in the 2nd and 4th weeks of pregnancy. The increase in the dry matter and digestible energy intake in the fourth week of pregnancy can be attributed to a need to meet the high energy requirements for proper foetal growth and development and for maternal needs. This is due to the fact that in the second week of pregnancy, energy need was more for cell and organ differentiation which was not energy demanding as compared to the last period of pregnancy that involved growth of the foetus, maternal tissue accretion and maintenance. This agrees with the earlier report of Iyeghe-Erakpotobor *et al*. (2009), Latu *et al.* (2017) and Olutunmogun *et al.* (2017) that nutrient requirement increases thereby leading to high nutrient requirement in the fourth week of pregnancy. The positive digestible energy balance observed in both stages of pregnancy indicates the possibilities of maintaining pregnant rabbits on combinations of concentrate and *Stylosanthes hamata* hay without adverse effect on reproduction (Iyeghe-Erakpotobor *et al*., 2009 and Olutunmogun *et al*., 2017).

Table 4 shows the energy partitioning of lactating rabbit does offered concentrate and *Stylosanthes hamata* hay combinations. There was non-significant ($P>0.05$) difference in all the parameters considered. The rabbit does were in positive balance of DE utilisation for all the combinations of concentrate and *Stylosanthes hamata* hay.

Table 3: Effect of Stage of Pregnancy on Energy partitioning of Pregnant Rabbit Does offered levels of concentrate and *stylosanthes hamata* hay combinations

	Stage of pregnancy (week)			
Parameters	2	4	SEM	P value
Live weight (kg)	2.03	2.07	0.02	0.3928
DM_{intake} (g/d)	116.07[b]	139.16[a]	3.28	0.0014
DE_{intake} (kj/d)	2301.01[b]	2748.96[a]	14.45	0.0008
DE_{req} (kj/d)	1426.95[b]	1579.54[a]	19.03	0.0003
DE_m (kj/d)	713.64	724.46	7.80	0.3403
DE_{fg} (kj/d)	713.31[b]	852.18[a]	18.75	0.0008
DE_{macc} (kj/d)	1127.50[b]	1346.99[a]	29.64	0.0008
BalanceDE (kj/d)	874.06[b]	1169.31[a]	43.76	0.0021
DE_{req}/LW0.75 (d)	705.81[b]	764.70[a]	10.88	0.0119

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

Table 4: Energy partitioning by lactating does fed different concentrate and *stylosanthes hamata* hay combinations

	Concentrates and *Stylosanthes hamata* hay combinations (g)					
Parameters	**70:280**	**140:210**	**210:140**	**280:70**	**SEM**	**P-value**
Live weight (kg)	2.60	3.16	2.62	2.60	0.23	0.7499
DM_{intake} (g/d)	124.74	123.13	127.03	116.36	3.54	0.8003
DE_{intake} (kj/d)	4822.82	4523.79	4555.64	3676.10	165.00	0.1890
TMP (kg)	3.21	3.36	3.34	3.41	0.09	0.8932
TDE_{req} (kj/d)	2920.96	3127.63	3004.94	3043.68	87.36	0.8586
DE_m (kj/d)	880.78	993.81	883.87	878.47	49.85	0.7795
DE_{milk} (kj/d)	2040.18	2133.83	2121.08	2165.21	54.34	0.8951
E_{milk}	1285.31	1344.31	1336.28	1364.08	34.23	0.8952
BalanceDE (kj/d)	1901.86	1396.16	1550.73	632.42	213.27	0.3289
$LW^{0.75}$ (d)	2.04	2.31	2.05	2.04	0.12	0.7785
$DE_{req}/LW^{0.75}$ (d)	1426.92	1426.36	1463.83	1505.22	36.06	0.8766
LWT3 (g)	2.60	3.16	2.62	2.60	0.61	0.7499
E_{milk} FE (kj/d)	809.74	846.91	841.86	859.37	57.05	0.8952
E_{milk} BE (kj/d)	475.57	497.40	494.42	504.71	33.51	0.8951
BE_{retain} (kj/d)	609.70	637.69	633.88	647.06	42.96	0.8952

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, balanceDE = 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 retain.

The positive result obtained in this study is contrary to the report of Xiccato and Trocino (2010) that body energy balance of lactating does is always negative and that great energy accretion through milk in lactating does is not fully compensated for by voluntary DE intake, especially in primiparous does. The positive result obtained in this study may be as a result of high energy content of the combinations as well as the high DM intake and high DE intake. The fact that lactating does on all combinations had positive balance of energy indicates that these combinations are suitable for lactation.

Conclusion

The study showed that the concentrate and *stylosanthes hamata* hay combinations were all sufficient to provide the necessary digestible energy to meet the physiological needs of rabbit does during pregnancy and lactation phases. However, dietary combinations of 90:60 and 120:30 concentrate and *Stylosanthes hamata* hay offered during pregnancy had better performance than 30:120 and 60:90 combinations.

Acknowledgement

The authors wish to express their gratitude to the Executive Director, National Animal Production Research Institute, Shika-Zaria for releasing the facilities used for the study. The contributions of staff of the Rabbitry and Central Laboratory Unit, NAPRI are well appreciated.

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Received: 29th August, 2018
Accepted: 10th February, 2019