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Original Research Article

Impact of maternal feed rationing during pregnancy on meat quality attributes of rabbit offspring

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Abstract

Young rabbits does fed *ad libitum* diets often show parturition problems such as dystocia and abnormal presentation, resulting in reduced numbers of kits. This can be linked to excessive fatness of the does. Several studies have documented the effect of feed restriction on rabbits, but only limited information exist on the carryover effect of maternal feed restriction exerts on meat quality attributes of the offspring produced from such restriction. This study evaluated the influence of maternal feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit kits. Seventy-five rabbits, consisting of sixty 20-week-old does and 15 mature bucks, were used in the experiment. Treatments consisted of two levels of feed restriction (0 and 15%) applied at three different periods during pregnancy (15–19, 20–24, or 25–29 days) with or without vitamin E dietary inclusions (0 and 300 mg/kg). The pregnant does were divided into twelve treatment groups, each containing five replicates of one rabbit each. The experiment was in a 2 × 3 × 2 factorial layout in a completely randomised design. After kindling (between days 28–31 of pregnancy) the resulting kits (a total of 180 kits) were arranged on treatment basis of their mothers and managed for a period of 56 days; that is 15 kits per treatment, each replicated 5 times (each replicate contained 3 kits). After 56 days of experiment, the data were collected on meat pH, total cholesterol, crude fat, crude protein, thermal shortening and refrigeration loss. Feed restriction during pregnancy with or without dietary vitamin E (no addition and 300 mg/kg) resulted in a significant ($p < 0.05$) influence on meat quality attributes of growing rabbits as total cholesterol (555.00 ± 6.06) decreased in the meat of rabbits whose mothers were feed-restricted during pregnancy. On the other hand, maternal feed rationing with or without vitamin E did not significantly ($p > 0.05$) affect the crude protein and thermal shortening of their slaughtered offspring. In conclusion, maternal feed rationing during pregnancy can be adopted as a feeding strategy in manipulating meat quality indicators of growing rabbits as total cholesterol concentrations decreased which is a good indicator that the meat is safer and better for consumers in order to prevent health-related challenges.

Keywords: feed restriction; **v**itamin E; rabbit does; offspring; cholesterol; crude fat; crude protein; thermal shortening; refrigeration loss

INTRODUCTION

Food security especially with reference to animal protein needs has been a recurring constraint faced by governments in different developing countries of the world. As an illustration, the mean consumption of animal protein in Nigeria is estimated at 4.5 g/head/day as against least requirement of 35 g/head/day

recommended by the Food and Agricultural Organization of the United Nations (Muhammad and Balogun, 2007). It is therefore evident that the problem of food insecurity (with emphasis on protein intake) in most developing countries needs to be addressed urgently in order to correct its attendant health implications on the populace. To meet the increasing demand for animal protein, emphasis needs to be given to micro-livestock such as rabbit production thanks to its easy management relative to other farm animal species.

Rabbit farming is attractive because of its high production potentials, good mothering ability and adaptability to diverse environmental conditions and excellent rate of roughage utilisation (Zerrouki et al., 2004). Rabbit meat is a white meat, valued for its nutritional content, medicinal and dietary properties; low-fat, lower saturated fatty acid and cholesterol content compared to meat of other animal species (Hernández, 2008). Feeding strategies for growing rabbits have been widely studied with the aim to produce animals with a higher body weight and lean body mass along with lower feed intake and better feed conversion rates (Abdel-Wareth et al., 2015; Tůmová et al. 2016; Alabiso et al., 2017); they comprise various levels of feed restrictions affecting not only their carcass characteristics but also their digestive health (Gidenne and Fougier, 2009; Gidenen et al., 2009). Dalle Zotte and Szendro (2011) reported that diet feeding can also influence meat cholesterol content in rabbit and considering the potential human health implications of cholesterol intake, this aspect is relevant and all feeding strategies must be directed to achieving the lowest cholesterol content.

However, not only in the postnatal growth period but also in adult animals feed restriction may be of importance in order to reduce the excessive fatness of young does (Dalle Zotte et al., 2004). The aim of feed restriction of female rabbits before the first mating is to increase their performance and to prevent excess fat accumulation (Adeyemi et al., 2012). Replacement does fed *ad libitum* diets with high energy content during the rearing periods often show parturition problems auch as dystocia (Fortun-Lamothe and Lebas, 1996). Limiting the quantity of feed is advantageous because it helps to reduce the cost of feeding and helps in preventing post-weaning digestive disorders without affecting the growth performance of the animals (Dalle Zotte et al., 2005).

Vitamin E is an important antioxidant that cannot be synthesised by most mammals and it must be supplemented for it is particularly efficient at quenching free radicals at cellular and sub-cellular sites of metabolic activity (Parker, 1991). Its effect on growth performance and meat quality was reported in growing rabbits (Dalle Zotte et al., 2020). How there is a dearth of information on its effects in pregnant does and the influence of maternal feed restriction during pregnancy on the offspring's meat quality. Therefore this study aimed at evaluating the carryover effect maternal feed rationing and vitamin E inclusion during pregnancy exert on meat quality attributes (total cholesterol, crude fat, crude protein, thermal shortening and refrigeration loss) of rabbit offspring.

MATERIAL AND METHODS

Experimental site

The experiment was carried out at the Rabbitry Unit of the Directorate of University Farms, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State. The site is located in the rain forest vegetation zone of South-Western Nigeria on latitude 7°13′49.46″N, longitude 3°26′11.98″E and altitude 76 m above the sea level. The climate is humid with a mean annual rainfall of 1037 mm and mean temperature and humidity of 34.7 °C and 83 %, respectively (Ogun Oshun River Basin Development Authority; Agro metrological weather station data).

Experimental rabbits and management

Ethical Approval: All procedures guiding animal welfare were strictly adhered to following the rules and regulations of Animal Welfare Committee of College of Animal Science and Livestock Production, Federal University of Agriculture Abeokuta.

A total of one hundred and eighty (180) weaned rabbits comprising of New Zealand white and Chinchilla breeds were used for the experiment. At the time of weaning 15 kits were selected and arranged based on maternal treatment basis. The kits were fed *ad libitum* throughout the experiment. The percentage composition of the concentrate diet fed to the offspring consisted of: maize 48.00, fish meal 2.00, soybean meal 3.00, wheat offal 10.00, groundnut cake 14.00, rice husk 20.00, bone meal 1.50, oyster shell 1.00, salt 0.25, vitamin and mineral premix 0.25. Determined analyses were as follows: metabolisable energy (kcal/kg) 2591.80, ash (%): 2.74, crude fibre: 15.50, crude protein: 15.80, nitrogen free extract: 40.50.

Experimental design

Treatments consisted of two levels of feed restriction (0 and 15%) at three different periods (15–19, 20–24, 25–29 days) during pregnancy with or without vitamin

E inclusions (0 and 300 mg/kg). The resulting offspring after kindling were divided into twelve treatment groups each containing five replicates of three rabbits in each replicate. The experiment was laid out in a 2 × 3 × 2 factorial layout in a completely randomised design.

Data collection

Meat quality analysis

After 8 weeks of experiment, one rabbit was selected from each replicate for meat analysis making a total of sixty rabbits. Feed was withdrawn for 12 hours prior to slaughter. The rabbits were stunned, bled, dressed by skinning, eviscerated and splitted. Fifty grams of meat sample from the thigh muscle (*m. quadriceps femoris*) was collected from each rabbit and used in determining meat analysis. The meat quality analysis comprised pH, cholesterol, refrigeration loss, thermal shortening, meat crude protein and crude fat.

Muscle pH determination

Approximately 10 g of meat samples from the hind leg was weighed and placed in a clean sauce pan. The pH meter was switched on and allowed to warm for 5 minutes. The procedure was carried out according to the procedure of Kim et al. (2009).

Determination of refrigeration loss of the meat

$$\text{Refrigeration loss (g)} = \text{Weight before chilling (g)} - \text{Weight after chilling (g)}$$

$$\text{Refrigeration loss (\%)} = \frac{\text{Weight before chilling} - \text{Weight after chilling}}{\text{Weight before chilling}} \times 100$$

Thermal shortening

Thermal shortening analysis was carried out using the procedure of Sobczak et al. (2005).

Crude protein determination

Crude protein was determined using the Kjeldahl method and conversion of nitrogen to crude protein by factor 6.25 (AOAC, 2000).

Crude fat determination

Crude fat determination was carried out by Bligh and Dyer method according to AOAC (2000).

Statistical analysis

The experimental layout was in a 2 × 3 × 2 factorial arrangement and data collected were subjected to completely randomised design using statistical software SAS (1999). The data followed normal distribution. Significantly ($p < 0.05$) different means were separated using Duncan multiple range test of the same statistical package.

RESULTS

Table 1 shows the effects of level and period of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit offspring. The levels of feed restriction during pregnancy had significant ($p < 0.05$) effect on meat pH, and total cholesterol concentration of rabbit offspring. Whereas a higher pH value was obtained for the offspring of does on 15% feed restriction during pregnancy, higher total cholesterol was observed for offspring of does at no feed restriction during pregnancy. On the other hand, crude fat, crude protein, thermal shortening and refrigeration loss did not significantly ($p > 0.05$) influenced the levels and periods of feed restriction with or without the addition of vitamin E in the maternal diet during pregnancy.

Interaction effect between levels and periods of feed restriction during pregnancy on meat quality of rabbit offspring is presented in Table 2. Significant ($p < 0.05$) differences were obtained on meat pH and crude fat of the offspring restricted during foetal development. The pH value was significantly ($p < 0.05$) higher in slaughtered rabbits from does on 15% feed restriction between days 15–19 as well as days 20–24 of gestation. Crude fat of the meat obtained was significantly ($p < 0.05$) higher for offspring of does on 15% feed restriction between days 25–29 of pregnancy. Crude protein, thermal shortening and refrigeration loss of meat were not significantly ($p > 0.05$) affected by the levels and periods of feed restriction with or without the addition of vitamin E in the diet during pregnancy.

Table 3 depicts the interaction effect between levels of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit offspring. The levels of feed restriction and vitamin E inclusion during pregnancy significantly ($p < 0.05$) influenced the pH, total cholesterol concentrations, and crude fat of slaughtered rabbits. The pH mean values were higher for offspring of does on 15% feed restriction during pregnancy without vitamin E. Total cholesterol concentration was significantly ($p < 0.05$) higher for slaughtered rabbits of does at no feed restriction with or without vitamin E inclusion. However, the 15% feed restriction without vitamin E inclusion resulted in significantly ($p < 0.05$) lower total cholesterol concentration than in the no restricted ones. Crude protein, thermal shortening and refrigeration loss of meat were not significantly ($p > 0.05$) affected by the levels and periods of feed restriction with or without the addition of vitamin E in the diet during pregnancy.

Table 1. Effects of level and period of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbits offspring

Parameters	Levels of feed restriction		Periods of feed restriction			Vitamin E inclusion	
	0% (n = 60)	15% (n = 60)	15–19 days (n = 20)	20–24 days (n = 20)	25–29 days (n = 20)	No addition (n = 30)	300 mg/kg (n = 30)
pH	5.76 ± 0.29[b]	6.25 ± 0.35[a]	6.06 ± 0.39	6.06 ± 0.41	5.90 ± 0.41	6.08 ± 0.44	5.92 ± 0.35
Total cholesterol (mg/l)	603.80 ± 7.08[a]	555.00 ± 6.06[b]	573.30 ± 8.16	573.30 ± 8.16	578.30 ± 5.95	562.70 ± 6.18	596.10 ± 7.44
Crude fat (%)	0.74 ± 0.10	0.80 ± 0.10	0.78 ± 0.12	0.77 ± 0.12	0.76 ± 0.10	0.78 ± 0.11	0.76 ± 0.10
Crude protein (%)	20.12 ± 1.27	20.11 ± 1.38	20.17 ± 1.27	19.99 ± 1.42	20.17 ± 1.33	19.95 ± 1.34	20.27 ± 1.29
Thermal shortening (cm)	1.62 ± 0.64	1.40 ± 0.62	1.46 ± 0.60	1.51 ± 0.62	1.55 ± 0.71	1.52 ± 0.61	1.50 ± 0.66
Refrigeration loss (%)	8.53 ± 5.88	8.76 ± 4.06	9.01 ± 5.20	7.73 ± 5.22	9.20 ± 4.84	7.96 ± 4.92	9.33 ± 5.09

[a, b]: Means in the same row with different superscripts differ significantly ($p < 0.05$)

Table 2. Interaction effect between levels and periods of feed restriction during pregnancy on meat quality of rabbits offspring

Levels of feed restriction	0% (n = 60)			15% (n = 60)		
Periods of feed restriction	15–19 days	20–24 days	25–29 days	15–19 days	20–24 days	25–29 days
Parameters						
pH	5.82 ± 0.30[bc]	5.80 ± 0.27[bc]	5.66 ± 0.32[c]	6.30 ± 0.32[a]	6.31 ± 0.37[a]	6.13 ± 0.39[ab]
Total cholesterol (mg/l)	605.00 ± 8.45	585.00 ± 7.06	621.60 ± 6.40	541.60 ± 7.13	571.60 ± 5.19	551.60 ± 6.43
Crude fat (%)	0.78 ± 0.12[ab]	0.77 ± 0.12[ab]	0.68 ± 0.05[b]	0.78 ± 0.13[ab]	0.78 ± 0.12[ab]	0.84 ± 0.07[a]
Crude protein (%)	19.86 ± 0.85	19.78 ± 1.14	20.70 ± 1.48	20.48 ± 1.61	20.20 ± 1.54	19.65 ± 1.03
Thermal shortening (cm)	1.73 ± 0.67	1.73 ± 0.70	1.40 ± 0.60	1.20 ± 0.41	1.30 ± 0.51	1.70 ± 0.83
Refrigeration loss (%)	7.05 ± 5.93	9.11 ± 5.78	9.43 ± 6.72	10.98 ± 3.87	6.35 ± 4.68	8.96 ± 2.50

[a, b, c]: Means in the same row with different superscripts differ significantly ($p < 0.05$)

Table 3. Interaction effect between levels of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit offspring

Levels of feed restriction	0% (n = 60)		15% (n = 60)	
Vitamin E inclusion	300 mg/kg	No addition	300 mg/kg	No addition
Parameters				
pH	5.76 ± 0.28[c]	5.75 ± 0.31[c]	6.08 ± 0.35[b]	6.41 ± 0.28[a]
Total cholesterol (mg/l)	603.30 ± 8.98[a]	604.40 ± 5.08[a]	588.80 ± 5.98[a]	521.10 ± 4.04[b]
Crude fat (%)	0.76 ± 0.10[ab]	0.72 ± 0.11[b]	0.75 ± 0.10[ab]	0.84 ± 0.09[a]
Crude protein (%)	20.12 ± 1.22	20.11 ± 1.40	20.42 ± 1.41	19.80 ± 1.35
Thermal shortening (cm)	1.62 ± 0.45	1.62 ± 0.82	1.37 ± 0.83	1.42 ± 0.33
Thermal shortening (%)	16.22 ± 4.52	16.22 ± 8.21	13.77 ± 8.39	14.22 ± 3.38
Refrigeration loss (%)	8.80 ± 5.59	8.26 ± 6.49	9.87 ± 4.82	7.65 ± 3.01

[a, b, c]: Means in the same row with different superscripts differ significantly ($p < 0.05$)

Table 4. Interaction effect between periods of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit offspring

Vitamin E inclusion	300 mg/kg			No addition		
Periods of feed restriction	15–19 days (n = 20)	20–24 days (n = 20)	25–29 days (n = 20)	15–19 days (n = 20)	20–24 days (n = 20)	25–29 days (n = 20)
Parameters						
pH	6.10 ± 0.36	5.86 ± 0.35	5.81 ± 0.34	6.01 ± 0.45	6.25 ± 0.40	5.98 ± 0.50
Total cholesterol (mg/l)	578.30 ± 9.53[ab]	576.60 ± 6.05[ab]	633.30 ± 5.98[a]	568.30 ± 7.41[ab]	580.00 ± 6.42[ab]	540.00 ± 4.85[b]
Crude fat (%)	0.72 ± 0.12	0.82 ± 0.11	0.73 ± 0.05	0.84 ± 0.10	0.73 ± 0.11	0.78 ± 0.13
Crude protein (%)	20.46 ± 0.92	20.08 ± 1.70	20.26 ± 1.34	19.88 ± 1.58	19.90 ± 1.24	20.08 ± 1.44
Thermal shortening (cm)	1.13 ± 0.24	1.50 ± 0.65	1.86 ± 0.83	1.80 ± 0.70	1.53 ± 0.66	1.23 ± 0.42
Thermal shortening (%)	11.33 ± 2.42	15.00 ± 6.54	18.66 ± 8.35	18.00 ± 6.92	15.33 ± 6.65	12.33 ± 4.27
Refrigeration loss (%)	12.11 ± 5.04	7.31 ± 5.74	8.58 ± 3.87	5.91 ± 3.31	8.15 ± 5.16	9.81 ± 5.96

[a, b,] :Means in the same row with different superscripts differ significantly ($p < 0.05$)

Table 4 shows the interaction effect between periods of feed restriction and vitamin E inclusion during pregnancy on meat quality of rabbit offspring. The periods of feed restriction during pregnancy and vitamin E inclusion had significant ($p < 0.05$) effect on total cholesterol concentration. Total cholesterol concentration of slaughtered rabbits whose mothers were restricted between 25–29 days of gestation with vitamin E inclusion recorded the highest mean value. Meat pH, crude fat, crude protein, thermal shortening and refrigeration loss of meat were not significantly ($p > 0.05$) affected by the levels and periods of feed restriction with or without the addition of vitamin E in the diet during pregnancy.

DISCUSSION

The effect of levels and periods of feed restriction and vitamin E inclusion during pregnancy on meat quality of slaughtered rabbits shows that significant difference was obtained on muscle pH for levels of feed restriction. This result could be attributed to feed restriction applied during pregnancy that had an effect on muscle fibre characteristics of growing rabbits. This result corroborates the findings of (Dalle Zotte et al., 2005) that reported significant difference in *biceps femoris* muscle when feed rationing was carried out in growing rabbits compared to the *ad libitum* fed groups. Total cholesterol concentration of slaughtered rabbits was significantly affected by the levels of feed restriction of does during pregnancy. Lower total cholesterol concentration obtained for slaughtered rabbits from does restricted during pregnancy could be due to feed restriction applied during pregnancy on the rabbit does. Total cholesterol concentration in this present study are within the range of values reported by Eid et al. (2010) and Nistor et al. (2013) in *ad libitum* fed rabbits to be 671.80 mg/l ± 0.09 and 564.00 mg/l ± 0.92, respectively. Crude protein and crude fat of slaughtered rabbits were not significantly influenced by levels, periods of feed restriction and vitamin E inclusion during their foetal development. The values obtained in this study were lower than those reported by Pla et al. (2004) in hindleg muscles of rabbits to be 21.24 g/100g and 3.0 3g/100g of edible rabbit meat.

Interaction effect between levels and periods of feed restriction during pregnancy on meat quality of slaughtered rabbits shows that meat pH value was affected by levels and periods of feed restriction during pregnancy. We assume that the differences obtained on pH values of the meat were due to the feed restriction applied during pregnancy. Crude protein was not affected by the levels and periods of feed restriction during pregnancy. This result supports the findings of (Dalle Zotte et al., 2005) that reported no significant difference in the crude protein levels of hindlegs of growing rabbits.

The interaction effect on levels of feed restriction and vitamin E inclusion during pregnancy on meat quality of slaughtered rabbits shows that higher muscle pH value was obtained for rabbits offspring whose mothers were restricted during pregnancy without vitamin E and this could be attributed to feed restriction applied on their does during pregnancy; the result obtained in this study is within the range reported by Apata et al. (2012) in growing rabbits. Total cholesterol was significantly influenced by levels of feed restriction and vitamin E inclusion. The result obtained is lower than values reported by Dalle Zotte et al. (2016) in growing rabbits. Result obtained on crude fat level in this study is lower than that reported by Apata et al. (2012) to be 2.80 ± 0.05% in differently stunned rabbits. The result obtained on crude protein is lower than values reported by Hernández and Dalle Zotte (2010) for crude protein of hindlegs and carcass of growing rabbits.

Interaction effect between levels and periods of feed restriction with or without vitamin E inclusion during pregnancy on meat quality of growing rabbit shows higher muscle pH was obtained from the meat of growing rabbits whose does were restricted during pregnancy. The result obtained on pH in this study is slightly higher than the report by Apata et al. (2010), i. e. 6.20 ± 0.05 in growing rabbits. Total cholesterol was significantly influenced by the levels and periods of feed restriction with or without vitamin E inclusion during pregnancy. The result obtained in this study is lower than what was reported by Dalle Zotte et al. (2016) to between 60.0 to 63.6 in the hindlegs of rabbit meat. The result obtained on crude fat of growing rabbits in this study is lower than what was reported by Simonova et al. (2010) to be 1.40g/100 g of edible meat in *ad libitum* fed growing rabbits. Thermal shortening of meat was significantly affected by levels and periods of feed restriction with or without vitamin E inclusion during pregnancy. This result is lower than what was reported by Apata et al. (2012) to be 35.09% ± 3.44 to 43.89% ± 3.29 in differently stunned rabbits fed *ad libitum*.

Crude protein of meat from growing rabbits restricted during pregnancy was not affected. The result obtained in this study for crude protein was lower than what was reported by and Apata et al. (2012) to be 22.25% ± 0.12 for crude protein. This result further corroborates the findings of Dalle Zotte (2010) that

reported no significant difference in the crude protein values of meat of growing rabbits after maternal feed rationing. Refrigeration loss of meat was not affected by the levels and periods of feed restriction with or without E inclusion during pregnancy. This result is contrary to the findings of Apata et al (2012) that reported significant difference in differently stunned rabbits to be 0.35–3.80%.

CONCLUSION

It can be concluded that maternal feed rationing during pregnancy with or without vitamin E inclusion affected significantly several meat quality attributes of growing rabbits. Feed rationing on rabbit does during pregnancy with or without dietary vitamin E inclusion did not significantly influence the crude protein, thermal shortening and refrigeration loss in the meat of growing rabbit offspring. Maternal feed rationing during pregnancy can be adopted as a feeding strategy in manipulating meat quality indicators of growing rabbits as total cholesterol of growing rabbits whose mothers were restricted during pregnancy decreased which is a good indicators of healthier meat that is beneficial to consumers to prevent health related challenges.

CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to research, authorship and publication of this article.

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