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REPRODUCTIVE TRACT MORPHOMETRY OF HYLA RABBITS FED DIET CONTAINING GRADED LEVELS OF WATERMELON RIND AND WHEAT OFFAL AS ABSORBENT

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Abstract

The evaluation of breeding and fertility potential of animals demands understanding of basic morphometric characteristics of their reproductive organs which, among other factors, may be affected by nutrition. This study was conducted to assess the effects of feeding graded levels of watermelon rind and wheat offal as absorbent on morphometric characteristics of the reproductive organs of Hyla rabbits. Forty-five Hyla rabbits of both sexes (15 bucks and 30 does) with nine animals per treatment (3 bucks and 6 does in each treatment) in a completely randomized design were randomly assigned to the dietary treatment containing 0 %, 10 %, 20 %, 30 %, and 40 % of watermelon rind and wheat offal. The data collected included weight and length of the reproductive tract of the rabbits. The morphometric characteristics of reproductive tract of the rabbits were not significantly affected by the dietary treatment, however, there were significant effect ($p > 0.05$) of the dietary treatment on the weight of the left oviduct, paired oviduct, and the paired ovary of the rabbits. The experimental diets significantly affected ($p < 0.05$) penis length and width, the right spermatic cord and the length of the right scrotal. The diets had no significant effect ($p<0.05$) on the weight of reproductive tracts of buck except on the paired spermatic cord. The experimental diets can be a good alternative for the highly competitive and costly grains in the diet of Hyla rabbits without any adverse effect on the growth of reproductive organs and consequently on the fertility and other activities related to reproduction of Hyla rabbits.

Keywords: morphology, rabbits, reproduction, watermelon rind, wheat offal

INTRODUCTION

Several studies have reported potentials of rabbit meat in order to alleviate the problem of animal protein supply (Ajayi et al., 2007). The socio-economic importance of rabbit rearing lies in their genetic potentials, feed utilization efficiency, low space requirements, low competition with humans for grains, and a high nutritive value of their meat (Arijeniwa et al., 2000). Rabbits possess a high reproductive rate and rapid growth (Cheeke, 1986) Additionally, they are characterized with a short gestation, early sexual maturity and ability to rebreed several times within a year (Sharp et al., 2007). Hyla rabbits are usually bigger in size, have rapid growth and good adaptability which suited well to the variety of environmental and production systems in Nigeria.

Over the years, the production of rabbits and other livestock have been difficult due to challenges related to the feed availability.

Conventional feedstuffs are in high demand by humans, which makes it challenging to find affordable and readily available feed for animals. This has led to the need of cheaper alternative feedstuffs in order to mitigate the challenges of feed availability. The rising cost of conventional animal feed has led researchers to investigate alternative options, including the use of forage and agricultural by-products as feed for the livestock. The watermelon pulp is usually consumed by man while the rinds and seeds are discarded and considered as wastes. The watermelon waste is one the agricultural by-products which are abundant in minerals and/or vitamins that can be fed to animals such as rabbits. Olosunde et al. (2023) reported about the potential of utilization of watermelon rinds in combination with wheat offal (vegetable carrier) as an alternative feed ingredient. Utilizing watermelon wastes in combination with wheat offal in rabbit production diets will not only ensure a good means of disposing watermelon waste but also reduce environmental pollution while the wheat offal serves as absorbent that speed up the drying of watermelon during processing.

Several studies have been conducted on the effects of various agricultural by-products on the reproductive tract morphometry both on female rabbits (Ozung *et al*., 2011) and male rabbits (Ahemen et al. 2015). However, there is a deficiency of information on sexual dimorphism of reproductive tract morphometry of rabbits fed watermelon rind with wheat offal as vegetable-carrier. Thus, this study was conducted to evaluate the reproductive tract morphometry of Hyla rabbits fed diets containing graded levels of watermelon waste and wheat offal as absorbent.

MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farm, Federal College of Animal Health and Production Technology, Ibadan, Nigeria. Forty-five adult Hyla rabbits (20 weeks old) of both sexes (30 females and 15 males) with average weight of 1820 g and 1890 g, were used for experiment. They were housed individually in wooden cages measuring 50 cm × 35 cm × 40 cm (width × length × height) and equipped with feeding and watering troughs. The cages were cleaned and disinfected before the arrival of animals. The rabbits were allowed for two-weeks acclimatization period during which they were fed with control diet and were given a prophylactic treatment with Oralmectin against endo- and ectoparasites before being allotted to the experimental diets.

The watermelon wastes (rinds) were collected mainly from different fruit markets in Ibadan, Oyo state, Nigeria, and were thoroughly washed to remove sand and other particles. The watermelon rinds were sliced into smaller pieces, ground into a paste, and mixed with the sun-dried for 3 days wheat offal as absorbent. The ratio of ingredients in the mixture was 1:1. The sample was stored in an air-tight container before mixing with other feed ingredients before being used in the final formulations of the rabbit diet. The five experimental diets which were formulated included 0 %, 10 %, 20 %, 30 %, and 40 % of watermelon rind and wheat offal (WRWO). The dietary treatments are abbreviated as follows: T_1 – Without watermelon rind and wheat offal, T_2 – 10 % inclusion of watermelon rind and wheat offal, T_3 – 20 % inclusion of watermelon rind and wheat offal, T_4 – 30 % inclusion of watermelon rind and wheat offal and T_5 – 40 % inclusion of watermelon rind and wheat offal (Table 1).

A total of nine rabbits were randomly allotted into each of the five dietary treatments which were replicated three times with three animals per replicate using a completely randomized design. The diets were fed to the rabbits based on 4 % of their body weight on a dry matter basis. The gross composition of experimental diets presented in Table I was chemically analyzed for the proximate components as described by AOAC (2000).

At the end of the sixteen (16) weeks experiment, two does and bucks were randomly selected from each of the experimental diet. The rabbits were euthanized by cervical dislocation and immediate bleeding by jugular section. After being euthanized, a median laparotomy was carried out to remove their reproductive tracts as reported by Hernández et al., (2010). Fat, tissues, and other parts connected to the reproductive tracts were trimmed off. Each component of the reproductive tract was carefully removed for morphometric evaluation. The weight of reproductive tract was measured using a digital weighing scale with a minimum sensitivity of 0.01g (Smart 500g/0.01g High Precision Balance Weighing Digital). The linear measurements of the reproductive tract were taken with a flexible calibrated tape and vernier caliper.

The data were subjected to statistical analysis using One Way Analysis of Variance (ANOVA), of SAS version 9.3.1 (2004). Means were compared using Duncan Multiple Range Test.

Table 1. Gross composition of experimental diets

Ingredients	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**
Maize	40.00	30.00	20.00	10.00	0.00
WRWO	0.00	10.00	20.00	30.00	40.00
Soybean meal	5.50	5.50	5.50	5.50	5.50
Palm kernel cake	30.00	30.00	30.00	30.00	30.00
Groundnut cake	5.00	5.00	5.00	5.00	5.00
Rice bran	12.00	12.00	12.00	12.00	12.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Salt	2.00	2.00	2.00	2.00	2.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100	100

WRWO: watermelon rind and wheat offal meal

RESULTS AND DISCUSSION

The proximate composition of the experimental diets is presented in Table 2. The results showed that there were significant effects ($p < 0.05$) of the experimental diets on the dry matter, crude protein, crude fibre, nitrogen free extract (NFE) and total ash. The dry matter of the experimental diets ranged from 84.95 - 90.26 %, crude protein 12.46 - 16.08 %, crude fibre 7.05 - 8.30 %, nitrogen free extract 41.02 - 53.89 % and total ash 7.28 - 13.87 %. Furthermore, the inclusion of 10 % of WRWO (T_2) showed the highest moisture content, 30 % inclusion of WRWO meal (T_4) had the highest value of crude protein, 0 % inclusion of WRWO meal (T_1) had the highest value of dry matter and nitrogen free extract, while 40% inclusion of WRWO meal (T_5) had the highest value of crude fibre and total ash. The crude protein range was lower than 17-20 % similarly to the report of Lebas et al. (1997).

The result of morphometric characteristics of female reproductive tracts revealed that there was no significant effect ($p < 0.05$) of the dietary treatments on the morphometry of the female reproductive tract (Table 3). Rabbits that were not fed diets containing WRWO meal (T_1) recorded the longest ovaries and oviducts for both the right

and left reproductive organs of the rabbits while rabbits fed 10 % inclusion of WRWO meal recorded shortest values for left ovary and left oviduct. However, there were fluctuations in the results across the dietary treatments for the traits measured. Bitto et al. (2006) reported a similar result with does feed pawpaw peel meal. Ozung et al. (2011) reported a significant effect ($p < 0.05$) of cassava peel meal on the right oviduct of female rabbits.

Table 2. Proximate analysis of experimental diets

Parameters (%)	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**	**SEM (±)**
Moisture	9.74^{d}	11.05^{a}	9.90^{cd}	10.06^{c}	10.41^{b}	0.75
Dry Matter	90.26^{a}	84.95^{d}	90.10^{ab}	89.94^{b}	89.59^{c}	0.39
Crude Protein	12.46^{e}	15.05^{c}	15.69^{b}	16.08^{a}	14.61^{d}	0.56
Crude fiber	7.18^{cd}	7.05^{d}	8.04^{b}	7.22^{c}	8.30^{a}	0.05
N F E	53.89^{a}	45.85^{b}	43.57^{c}	43.52^{c}	41.02^{d}	0.04
Total ash	7.28^{d}	9.30^{c}	9.20^{c}	10.95^{b}	13.87^{a}	0.11

$^{a, b, c, d, e}$ means of different superscripts along the same row are statistically significant ($P < 0.05$);
WRWO: watermelon rind and wheat offal meal; SEM (±) – Standard error of mean;
NFE: Nitrogen Free Extract

Table 3. Morphometric characteristics of the female reproductive organs of Hyla does fed varying dietary levels of watermelon waste and wheat offal meal (mean ± SEM)

Variables (cm)	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**
Cervix	0.53 ± 0.24	0.55 ± 0.24	0.50 ± 0.24	0.63 ± 0.30	0.60 ± 0.28
Left uterine horn	13.25 ± 2.11	17.50 ± 2.01	13.75 ± 2.19	14.50 ± 2.26	16.00 ± 2.32
Right uterine horn	12.5 ± 1.91	16.50 ± 2.33	13.00 ± 2.20	15.00 ± 2.30	16.50 ± 2.35
Left ovary (mm)	4.25 ± 0.98	2.19 ± 0.24	2.61 ± 0.24	2.91 ± 0.24	3.22 ± 0.34
Right ovary (mm)	4.00 ± 0.90	2.01 ± 0.20	2.50 ± 0.21	3.45 ± 0.30	3.22 ± 0.30
Left oviduct	10.50 ± 2.02	8.51 ± 1.98	6.53 ± 1.02	9.04 ± 2.02	7.00 ± 1.56
Right oviduct	9.52 ± 2.10	8.90 ± 1.72	6.00 ± 1.56	9.23 ± 2.01	6.34 ± 1.56

$^{a, b, c}$ means of different superscripts along the same row are statistically significant ($P < 0.05$);
WRWO: watermelon rind and wheat offal meal; SEM: Standard Error of Mean

The organ weights of the reproductive tracts of rabbit does fed graded levels of meal containing WRWO meal is presented in Table 4. The result revealed significant effects ($p>0.05$) of the dietary treatments on the weight of the left oviduct, paired oviduct, and paired ovary of the rabbits. The rabbits fed diet with 30 % inclusion of WRWO meal showed the highest values in the weight of cervix, left uterine horn, right uterine horn, paired uterine horn, left oviduct, right oviduct and paired oviduct. The non-significant effect of the dietary treatments on the reproductive tract morphometry of the rabbits implies that the inclusion of WRWO in the diet may not affect the development of these organs and reproductive processes of the female rabbits.

The significant effects ($p > 0.05$) of the dietary treatments on the weight of the left oviduct, paired oviduct, and paired ovary of the rabbits were similar to the significant effect ($p < 0.05$) of cassava peel meal on the right paired oviduct reported by Ozung et al. (2011). However, Bitto et al. (2006) reported a non-

significant effect of pawpaw peel meal on the weight of the reproductive tracts of rabbit does. Generally, there were fluctuations in the weight of reproductive tracts of the female rabbits across all the dietary treatments. This is an indication that the dietary treatment may not have any effect on the reproductive performance of these rabbits.

Table 4. Weight of reproductive tract of Hyla rabbit does fed varying dietary levels of watermelon rind and wheat offal meal (Mean ± SEM)

Variables (g)	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**
Cervix	0.30 ± 0.05	0.30 ± 0.05	0.30 ± 0.05	0.40 ± 0.08	0.35 ± 0.05
Left uterine horn	0.94 ± 0.23	1.46 ± 0.14	1.50 ± 0.16	2.09 ± 0.94	1.94 ± 0.24
Right uterine horn	1.01 ± 0.26	2.01 ± 0.42	0.96 ± 0.23	2.46 ± 0.48	1.51 ± 0.58
Paired uterine horn	1.95 ± 0.27	3.46 ± 0.92	2.46 ± 0.61	4.45 ± 0.96	3.46 ± 0.900
Left oviduct	0.21 ± 0.03 [b]	0.20 ± 0.03 [b]	0.22 ± 0.03[b]	0.87 ± 0.05 [a]	0.60 ± 0.04 [a]
Right oviduct	0.14 ± 0.02	0.17 ± 0.03	0.14 ± 0.02	0.94 ± 0.06	0.89 ± 0.04
Paired oviduct	0.35 ± 0.03 [a]	0.37 ± 0.03 [a]	0.36 ± 0.03 [a]	1.91 ± 0.07 [b]	1.49 ± 0.06 [b]
Left ovary	0.36 ± 0.04	0.10 ± 0.01	0.10 ± 0.001	0.29 ± 0.03	0.32 ± 0.03
Right ovary	0.51 ± 0.04	0.10 ± 0.01	0.10 ± 0.01	0.45 ± 0.03	0.32 ± 0.03
Paired ovary	0.87 ± 0.12 [a]	0.20 ± 0.01 [b]	0.20 ± 0.01 [b]	0.74 ± 0.12 [a]	0.64 ± 0.12 [a]

[a, b,] means of different superscripts along the same row are statistically significant ($P < 0.05$);
WRWO: watermelon rind and wheat offal meal; SEM: Standard Error of Mean

Table 5 shows the morphometric characteristics of reproductive tracts of Hyla rabbit bucks fed graded levels of WRWO as absorbent. The experimental diets significantly affected ($p < 0.05$) the penis length and width, the right spermatic cord and the right scrotal length of the rabbits. The longest penis, right spermatic cord, right scrotum and widest penis were recorded in rabbits that were not fed the experimental diets, rabbits fed 40 % inclusion of WRWO and rabbits fed 30 % inclusion of WRWO. The result further revealed that there was no significant effect ($p > 0.05$) of the experimental diets on the left spermatic cord, left scrotal length, right scrotal width, left scrotal width, right testis and left testis. There was, however, insignificant increase in the testicular parameters along the experimental diets. It was also observed from the result that the left testicular parameters are higher than the right testicular parameters across the experimental diets.

Although, in the published reports there is a lack of information that have taken the penile length measurements of the non-erect rabbit penis, but some previous studies focused mainly on the erect penile length (McCullough, 2008; Park et al., 2011). The results obtained for length of penis of rabbits in this study were within the range reported by Olabu et al. (2014). The authors reported the mean non-erect penile length of 27 and 30 mm for castrated and non-castrated rabbits, respectively. The increase in the testicular values could be an indication of increase in spermatozoa production by these rabbits as reported by Oyeyemi et al. (2002). The higher the testicular value corresponds to the higher the capacity of the cells during spermatogenesis if there is no abnormality. According to Perry & Petterson (2001), the testes size, length and width are good indicators of both the present and future sperm production. The results of the present study are also similar to the observation of Bitto & Gemade (2001) who found that up to 30% inclusion of pawpaw peel meal had no significant effect on the testicular and epididymal morphometry of male rabbits. Abu et al. (2016) also reported an

insignificant ($p > 0.05$) decrease in the morphometric dimensions of testes and epididymis of experimental rabbits. On the other hand, Ajayi et al. (2009) observed a significant effect of blood-wild sunflower leaf meal mixture diet on the testicular length of experimental rabbits. The values of testicular length obtained in this study are similar to the range of 2.26-4.40 cm reported by Ajayi et al. (2009) and Ahemen et al. (2013) in rabbits. These values were however, not significantly ($p>0.05$) influenced by the experimental diets.

The weight of reproductive tract of Hyla buck rabbits fed varying dietary levels of WRWO showed that there were significant effects ($p > 0.05$) of the experimental diets on the weight of paired spermatic cord of the rabbits (Table 6).

Table 5. Morphometric characteristics of reproductive tracts of Hyla rabbit bucks fed graded levels of watermelon rind with wheat offal as absorbent (mean ± SEM)

Parameters (cm)	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**
Penis length	2.83 ± 0.50^{a}	2.33 ± 0.35^{ab}	2.00 ± 0.35^{b}	2.17 ± 0.30^{b}	2.00 ± 0.35^{b}
Penis width (mm)	6.05 ± 0.25^{b}	8.43 ± 0.27^{b}	10.66 ± 0.30^{a}	11.35 ± 0.30^{a}	11.29 ± 0.25^{a}
Right Spermatic cord	3.50 ± 0.20^{b}	3.75 ± 0.21^{b}	3.50 ± 0.20^{b}	5.25 ± 0.24^{a}	5.50 ± 0.30^{a}
Left Spermatic cord	5.01 ± 0.31	5.00 ± 0.31	4.50 ± 0.29	5.55 ± 0.31	5.80 ± 0.33
Right Scrotal length	4.25 ± 0.31^{b}	3.75 ± 0.21^{b}	5.50 ± 0.33^{b}	7.75 ± 0.40^{ab}	8.00 ± 0.41^{a}
Left scrotal length	4.25 ± 0.30	5.50 ± 0.30	6.00±0.34	6.50±0.39	6.25±0.39
Right scrotal width	3.50 ± 0.19	4.25 ± 0.20	3.50 ± 0.19	4.70 ± 0.20	5.75 ± 0.20
Left scrotal width	3.25 ± 0.19	3.75 ± 0.20	3.75 ± 0.20	5.25 ± 0.25	5.75 ± 0.26
Right Testis	2.50 ± 0.20	3.50 ± 0.30	3.58 ± 0.50	4.25 ± 0.50	4.50 ± 0.50
Left Testis	3.00 ± 0.30	3.55 ± 0.25	4.00 ± 0.50	4.41 ± 0.50	4.53 ± 0.50

[a, b,] means of different superscripts along the same row are statistically significant ($P < 0.05$),
WRWO: watermelon rind and wheat offal meal; SEM (±): Standard error mean

Table 6. Weight of reproductive tract of Hyla rabbit bucks fed varying dietary levels of watermelon rind and wheat offal meal (mean ± SEM)

Parameters (g)	**T_1 0% WRWO**	**T_2 10% WRWO**	**T_3 20% WRWO**	**T_4 30% WRWO**	**T_5 40% WRWO**
Penis weight	3.31 ± 0.05	3.19 ± 0.05	2.71 ± 0.03	2.56 ± 0.03	2.67 ± 0.03
Right spermatic cord	0.61 ± 0.01	0.83 ± 0.01	0.50 ± 0.01	0.55 ± 0.01	0.89 ± 0.01
Left spermatic cord	0.90 ± 0.02	0.92 ± 0.02	0.61 ± 0.02	0.70 ± 0.02	0.99 ± 0.02
Paired spermatic cord	1.51 ± 0.03^{a}	1.75 ± 0.03^{a}	1.11 ± 0.03^{b}	1.25 ± 0.03^{b}	1.88 ± 0.03^{a}
Paired testis	4.05 ± 0.31	3.81 ± 0.20	4.15 ± 0.32	4.39 ± 0.38	4.02 ± 0.31
Right testis	1.54 ± 0.02	1.78 ± 0.03	1.84 ± 0.03	1.90 ± 0.31	1.83 ± 0.03
Left testis	2.51 ± 0.15	2.03 ± 0.05	2.31 ± 0.06	2.49 ± 0.11	2.19 ± 0.06

[a, b] means along the same rows with different superscripts are significantly different ($p<0.05$),
WRWO: watermelon rind and wheat offal meal; SEM: Standard Error of Mean

However, the weight of penis, right spermatic cord, left spermatic cod, right testis, left testis and paired testis were not significantly affected ($p > 0.05$) by the experimental diets. Morphometric assessment is crucial for predicting buck rabbit`s sperm production,

storage potential and fertilizing ability (Ansa & Imasuen, 2015). The weight of testes obtained in this study were within the range of values earlier recorded by Ladipo et al. (2015) and Abu et al. (2016) for male rabbits fed dietary Cerium oxide and *Tephrosia bracteolata* leaf meal, respectively. This finding also agrees with the report of Ogunlade et al. (2006) who observed non-significant differences in the testis weight among rabbits fed fumonisin contaminated diets.

CONCLUSION

In conclusion, the watermelon rind with wheat offal as absorbent up to 40 % inclusion in rabbit diets may not affect reproductive organs growth and consequently the fertility and other activities related to reproduction of both male and female Hyla rabbits. Although, the replacement of maize with different percentages of WRWO yielded conflicting results in the experimental groups, the morphological indicators were consistently lower compared to the control. Further research is needed to assess whether this could affect the reproductive functions.

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