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REPRODUCTIVE PERFORMANCE OF NEW ZEALAND WHITE BUCKS FED DIETS CONTAINING DIFFERENT TYPES OF SILAGE.

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ABSTRACT

This study aimed at investigating the effects of feeding male rabbits on diets containing different types of silage on attainment of puberty at 16 weeks of age and semen quality at 24 weeks of age. A total of 45 NZW male rabbits (6 weeks old) were allotted into 5 similar groups fed 100% complete feed diet (CFD) and was served as control group (G1) as compared to those fed 70% CFD and different types of silage (30%) including carrot roots (G2), carrot tops (G3), berseem (G4) and corn (G5) silages. All groups were fed on the tested rations from 6 weeks of age up to 34 weeks of age. At 16 weeks of age (expected age of puberty), results showed insignificant differences in testosterone concentration among the experimental groups, although there was a tendency of higher values in G2 and G5 than those in G3, G4 and G1. On the other hand, the testicular weight showed significantly the highest values in G5 and the lowest values in G3. However, males in the other groups showed moderate testicular weights. On the basis of the histological examination, testis in G4 and G5 had more developed testicular findings than that in control and G3, which showed developing testes. However, testes of males in G2 showed moderate findings. At 24 weeks of age (Mature age), bucks in G2 and G5 showed significantly the highest sperm cell concentration, and percentages of mass motility and live spermatozoa as well as the lowest sperm abnormality percentage. However, ejaculate volume did not differ significantly as affected by dietary treatment groups. Reaction time was significantly the shortest in G5 (43 sec) and G2 (42.8 sec), followed by G4 (49.5 sec), while G3 and G1 showed significantly the longest reaction time (57.5 and 59.7 sec, respectively). Total number of spermatozoa as well as live, motile and normal spermatozoa per ejaculate was significantly higher in G2, G4 and G5 than those in G1 and G3. Conception rate was higher in G1, G2, G4 and G5 than G3 (100 vs. 60%).

In conclusion, the current study indicated the possibility of feeding bucks on diets containing, 30% from each of corn, carrot roots or berseem silage to attained early puberty in male rabbits without reversible effects on their semen quality, sexual desire and conception rate at mature stages.

Keywords: Rabbit, silage, puberty, semen, quality, conception rate.

INTRODUCTION

The domestic rabbit is emerging as a viable livestock species due to its high prolificacy and growth rate and its better meat quality than other farm animals. In addition, rabbits are able to consume forages containing high levels of fiber (Cheeke, 1986). In many developing countries, good quality forage may only be available on a seasonal basis suggesting a need for forage preservation as silage or hay. Silage from tropical crops has higher levels of water-soluble carbohydrates, which make it appropriate for rabbit feeding (Partridge *et al.*, 1985).

The relationship between nutrition and reproduction is complex and often quite variable. However, nutrient supply is a component of the management system that is under the control of the farmer needs to be carefully evaluated (Boland, 2002).

Age at puberty is a major determinant of lifetime reproductive efficiency of the animal. Research conducted during the past 20 years has documented the major endocrine events leading to first ejaculation. Age at puberty is inversely related to plane of nutrition. The effect of nutrition on sexual maturation involves effects on timing of the pre-pubertal increase in LH secretion and seems to involve the LH pulse generating system located in the hypothalamus (Schillo, *et al.* 1992). Sexual maturity is reached in NZW bucks on day 129 (Cheeke, 1986; Macedo and MigueL, 1986).

Testosterone is the major secretary hormone of the mature testis. Concentration of testosterone was influencing by reducing eating time (Abd El El-Moty (1990) and dietary CP level (Ismail, 2005) in NZW bucks. It is well known that spermatogenesis is controlled directly by testosterone concentration (Hammond *et al.*, 1983 and Abdel-Khalek *et al.* 2001).

Unfortunately, no available data on reproductive performances and puberty age of male rabbits fed different types of silage under Egyptian condition. Therefore, the current study aimed to evaluate the effects of feeding male NZW rabbits on diets containing different types of silage on attainment of puberty at 16 weeks of age and semen quality of matured bucks.

MATERIALS AND METHODS

The present study was carried out on a flock of NZW rabbits belonging to Sakha Animal Production Research Station, Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture during the period from October. 2003 to May 2004.

Animals:

A total of 45 NZW male rabbits 6 weeks old were divided into five equal groups, according to their live body weights, 9 animals in each. All male rabbits were individually housed in wire cages (60 x 50 x 40 cm). Rabbits in the control group (G1) was fed 100% complete feed diet (CFD), while those in silage groups were fed on diets containing 70% CFD and 30% silage including carrot roots (G2), carrot tops (G3), berseem (G4) and corn (G5) silage.

Experimental groups and feeding system:

Male rabbits in all groups were fed the tested diets from their weaning ages (6 weeks) up to the end of the experimental period (34 weeks of age). Feed amounts were offered to male rabbits in all groups according to recommendation of NRC (1994) for growing male rabbits. The CFD was composed of different feedstuffs as shown in table (1). Amounts of CFD for each group were offered individually at 8 a.m., the amounts of silage were offered at 12 p.m. for all silage groups.

Amounts of CFD and silage were biweekly adjusted according to the changes in live body weight (LBW) of male rabbits. Calculated chemical compositions of CFD and different types of the silage are shown in table (2).

Table (1): Composition of concentrate feed mixture used in male rabbits feeding.

Ingredient	%	Ingredient	%
Wheat bran	30.0	Limestone	1.0
Soybean meal, 44%	16.0	Premix*	0.5
Yellow corn	20.0	Sodium chloride	0.5
Barley grain	30.0	Di-Ca phosphate	2.0
Total			100

*One kg of premix contained 3.3 x 10^6 IU Vit. A; 3.3 g Vit. E; 3.3 x 10^6 IU Vit. D_3; 0.33 g Vit. K; 0.33 g Vit B_1; 1.33 Vit. B_2; 6.67 Vit B_5; 0.50 g Vit B_6; 3.3 g Vit. B_{12}; 3.3 Pantothenic acid; 0.33 Folic acid; 16.67 mg Biotin; 166.67 g Cholin; 1 g Copper; 10 g Iron; 13.3 g Mn; 15 g Zn; 0.1 g Iodine; 0.03 g Se and Carrier $CACO_3$ to 1 kg.

Table (2): Calculated chemical composition on DM basis of CFD and different types of silage used in rabbit feeding.

Item	DM %	Chemical composition (%) on DM basis					
		OM	CP	EE	CF	NFE	Ash
CFD	91.4	89.6	18.0	1.9	12.6	57.1	10.4
Carrot roots silage	54.9	88.2	15.9	2.1	14.7	55.5	11.8
Carrot tops silage	57.8	83.9	15.4	1.6	16.4	50.5	16.1
Berseem silage	53.6	89.1	17.0	2.2	15.5	54.4	10.9
Corn silage	56.1	90.4	15.5	2.1	16.0	56.8	9.6

Experimental procedures:

At 16 weeks of age, three individuals from each group were slaughtered to investigate the histological structure of the testis as an exculpated age of puberty according to Cheeke (1986) and Macedo and MigueL (1986). After slaughtering, gonads (testes) were separated and fixed in Bouin's solution. Representative samples were taken from the median part of each testis, washed, dehydrated in ascending grades of ethyl alcohol, cleared and embedded in paraffin wax. Thereafter, the samples were sectioned at 7-8 microns, stained by hematoxylin and eosin stains (H&E) and histologically examined using the routine method after Bancroft and Stevens (1982). Blood samples (5 ml) were taken from each animal from the ear vein into heparinized tubes. The samples were centrifuged at 3000 rpm for 15 minutes and the plasma were separated and frozen at - 20 °C until assaying testosterone concentration with a double antibody radioimmunoassay (Diagnostic Products Corporation Kits).

At 6 months of age, semen was collected from 6 bucks in each of the experimental groups with an artificial vagina once weekly. The ejaculate volume (ml) and percentages of motility, live and abnormal spermatozoa as well as sperm cell concentration (x10^6/ml) were recorded and calculated microscopically according to Smyth and Gordon (1967) and El-Gaafary (1987).

Conception rate of each group was carried out using two bucks showing the highest semen quality in each group to naturally served 5 does per buck, then pregnancy diagnosis was performed at 10 days after insemination and was insured by pregnancy rate at parturition.

Statistical analysis:

Results were statistically analyzed according to Snedecor and Cocharn (1982). However, the significant differences among treatments were tested using Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Attainment of puberty at 16 weeks of age:

Testosterone concentration and testicular weight:

At 16 weeks of age, concentration of testosterone in blood plasma and the testicular weight were taken as an indicator for onset of puberty in male rabbits at this age.

Data in table (3) clearly showed insignificant differences in testosterone concentration among the experimental groups, although there was a tendency of higher values in males of carrot roots and corn silage groups than those in the other groups.

The present concentration of testosterone in blood plasma of males in all experimental groups are similar to that reported on NZW males at 18 wk of age, being 2.85 ng/ml (Abd Elmoty, 1991) and higher than the normal level of NZW rabbits (1-2 ng/ml) as reported by Berger, *et al.*, 1982 and Tharwat, 1990).

Table (3): Average testosterone concentration (ng/ml), testicular weight (g) and relative testicular weight (g/kg) of NZW male rabbits in different experimental groups.

Item	Experimental group				
	Control	Carrot roots	Carrot tops	Berseem	Corn
estosterone (ng/ml)	2.71±0.12	2.85±0.11	2.71±0.12	2.74±0.10	2.82±0.12
esticular weight (g)	$6.89±0.4^{bc}$	$6.45±0.5^{bc}$	$5.34±0.7^{c}$	$7.62±0.0.6^{ab}$	$8.92±0.7^{a}$
elative testicular weight (g/kg)	3.30	3.02	2.47	3.30	4.27

A, B and C: Means denoted within the same row are significantly (P<0.05) different.

On the other hand, the testicular weight showed significantly (P<0.05) the highest values in males fed corn silage diet and the lowest values in those fed carrot tops silage diet. However, males in the other groups showed moderate testicular weights.

The significantly heavier testicular weight in males of corn silage group was associated with the highest testicular weight relative to live body weight and a tendency of highest testosterone concentration. Such finding may indicate the beneficial effects of feeding male rabbits on diet containing corn silage to improve the testicular weight rather and in turn the testosterone concentration (Table 3). In this respect, Abd Elmoty (1991) found that the testicular weight in male rabbits increased from 3.04 at 14 weeks to 4.30 at 18 wk of age.

Decreasing the plasma testosterone level can be attributed to the observed decrease in the testicular weights in rats (Moustafa (1990). Many authors reported similar pattern of changes in testicular weight and testosterone levels (Lazar *et al.*, 1983; Mahmoud, 1984 and Abd Elmoty (1991) in rabbits and Courot and Ortavant, 1981 in rams).

Histological structure of the testis at 16 weeks of age:

The histological examination of the testis in all experimental group males revealed that the proportional area of the interstitial stromal tissue was the greatest in control and carrot tops silage groups (Plates 1 and 3, respectively), moderate in carrot roots silage group (Plate 2) and the smallest in berseem and corn silage groups (Plates 4 and 5, respectively). This was reflected in compact and dense semeniferous tubules (ST) and numerous interstitial cells (ISC) in the stromal tissue in berseem and corn silage groups (Plates 4 and 5, respectively), less compact ST and moderate number of ISC in carrot roots silage group (Plate 2) and scattered ST and less ISC in control and carrot tops silage groups (Plates 1 and 3, respectively).

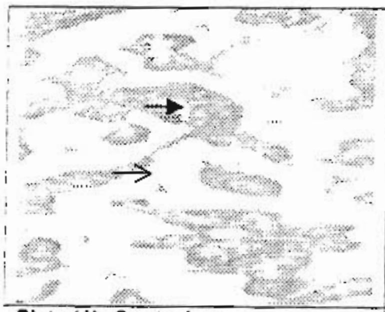

Plate (1): Control group

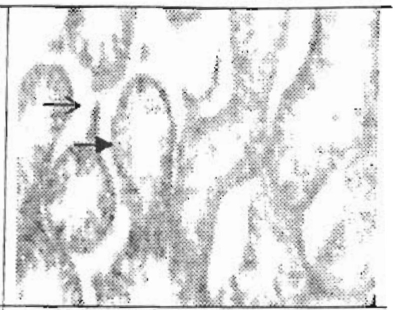

Plate (2): Carrot roots silage

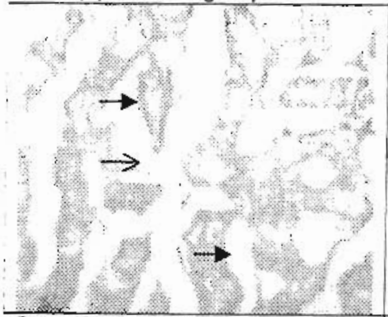

Plate (3): Carrot tops silage

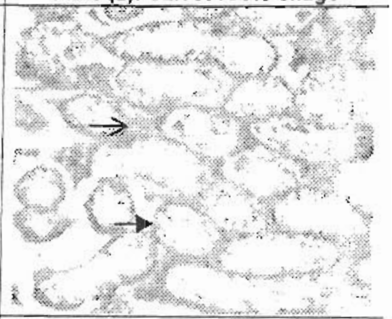

Plate (4): Berseem silage

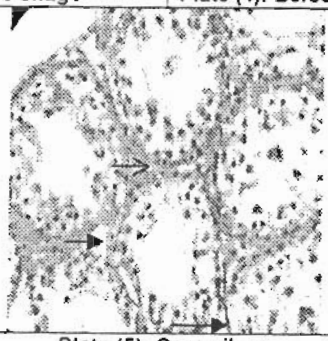

Plate (5): Corn silage

Plates (1-5): Cross-section in the testis of male rabbits at 16 weeks of age showing parenchymal (⟼) and interstitial tissues (⟶). (x40, H&E Stain)

The semeniferous tubules was irregular in shape having higher and empty antrum, thin spermatogenic layer in testis of control and carrot tops silage groups (Plates 6 and 8, respectively), oval having moderate antrum and spermatogenic layer thickness in carrot roots (Plate 7) and circular in shape, having narrow antrum with few spermatozoa and thick spermatogenic layer in berseem and corn silage groups (Plates 9 and 10, respectively).

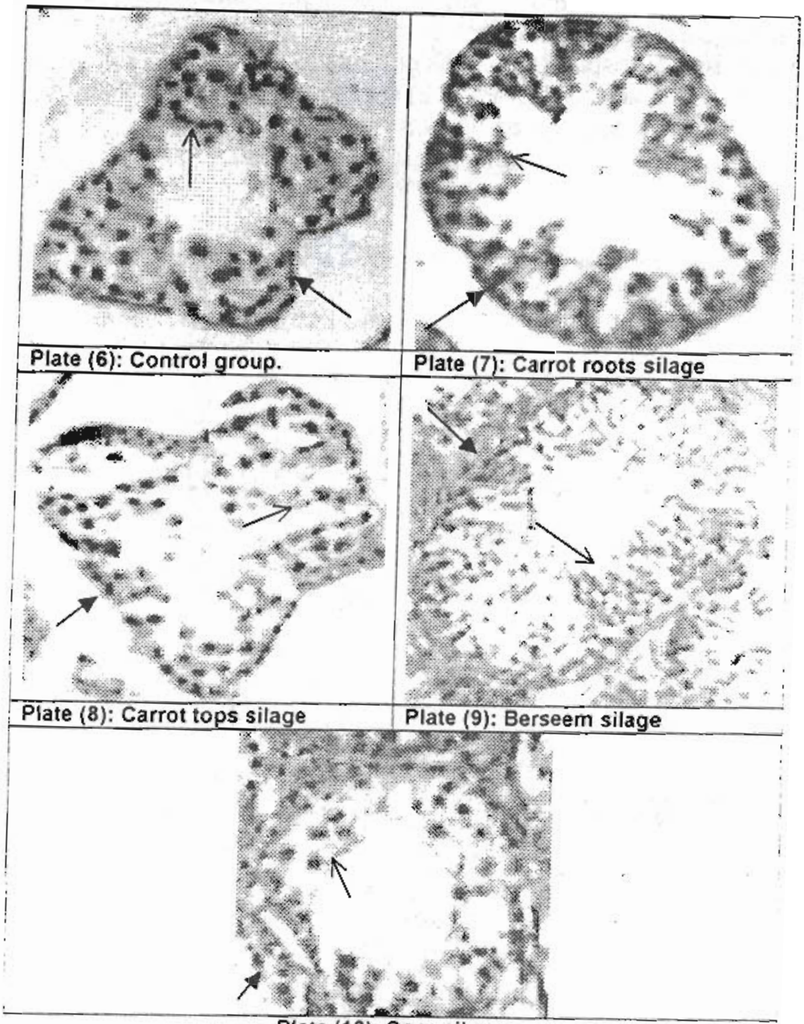

Plate (6): Control group.

Plate (7): Carrot roots silage

Plate (8): Carrot tops silage

Plate (9): Berseem silage

Plate (10): Corn silage

Plates (6-10): Cross-section in the testis of male rabbits at 16 weeks of age showing semineferous tubule (→) and spermatogenic (→) layer. (x100, H&E Stain)

On the basis of the histological examination, testis in berseem and corn silage groups was more developed than that in control and carrot tops silage groups, which showed developing testes. However, testes of males fed on carrot roots silage showed moderate development. These findings may indicate incidence of early puberty in males fed berseem and corn silage diets earlier than those fed carrot roots; carrot tops silage diets and the control diet.

The relationship between nutrition and reproduction is complex and often quite variable. However, nutrient supply is a component of the management system that is under the control of the farmer needs to be carefully evaluated (Boland, 2002). Age at puberty is a major determinant of lifetime reproductive efficiency of the animal. Research conducted during the past 20 years has documented the major endocrine events leading to first ejaculation. The critical event seems to be a prepubertal increase in pulsatile LH secretion. Environment influences timing of puberty onset. The effect of nutrition on sexual maturation involves effects on timing of the pre-pubertal increase in LH secretion and seems to involve the LH pulse generating system located in the hypothalamus. The precise mechanism by which nutrition influences pulsatile LH secretion has not been elucidated, but signals reflecting metabolic status seem to be involved (Schillo, *et al.* 1992).

In accordance with the present finding in the testes of all groups, Leeson and Leeson (1970) found that about day 84 all ST in testis of rabbits were fully active, Sexual maturity is reached in NZW bucks on day 129 (Cheeke, 1986; Macedo and MigueL, 1986).

The present results concerning the testicular weight and testosterone concentration of male rabbits at 16 weeks of age indicated the beneficial effects of feeding male rabbits on berseem or corn silage diets on incidence of puberty.

Physical semen characteristics and sexual desire of mature bucks:

Data in table (4) show that sperm cell concentration, and percentages of mass motility, livability and abnormality of spermatozoa significantly ($P<0.05$) differed, however, ejaculate volume did not differ significantly as affected by dietary treatment groups.

Generally, bucks in carrot roots and corn silage groups significantly ($P<0.05$) showed the best semen characteristics among dietary treatment groups. However, bucks fed berseem silage diet ranked the second one. Yet, those fed carrot tops diet was nearly similar to the control bucks, which showed significantly ($P<0.05$) the poorest semen characteristics among dietary groups (Table 4).

Table (4): Effect of dietary treatment on different physical semen characteristics and reaction time (sec) of NZW male rabbits.

Semen characteristics	Control	CFD plus silage of			
		Carrot roots	Carrot tops	Berseem	Corn
Ejaculate volume (ml)	0.52±0.08	0.50±0.01	0.53±0.07	0.52±0.07	0.51±0 08
Sperm cell concentration (x 10^6/ml)	56.4±2.5^c	190 8±3.1^a	155.6±3.2^c	177.8±2.9^b	193 1±3.1^a
Sperm mass mortality (%)	56.1±1.5^c	68.3±1.8^a	61.0±1.9^{bc}	66.7±2 1^{ab}	67.1±1.8^a
Live sperm (%)	74.4±1.4^b	81.4±1.3^a	77.0±1.2^b	80.1±1.6^a	81.3±1.4^a
Sperm abnormality (%)	16.1±1.1^a	12.0±0.9^b	15.7±0.9^a	12 3±0.9^b	11.7±0.8^b
PH value	6.03±0.04^c	6.22±0.05^b	6.08±0 04^c	6.43±0.04^a	6.44±0.03^a
Reaction time (sec)	59.67±3 4^a	42.83±3.5^b	57.49±2.6^a	49.47±2.8^{ab}	43.27±2 6^b

A, B and C: Means denoted within the same row are significantly ($P<0.05$) different.

As compared to the control group, percentage of mass motility significantly ($P<0.05$) increased by about 21.7 and 19.6%, percentage of live spermatozoa significantly ($P<0.05$) increased by about 9.4 and 9.4%, and percentage of sperm abnormality significantly ($P<0.05$) decreased by about 25.5 and 27.3%, in carrot roots and corn silage groups, respectively as compared to the control group (Table 4).

These results indicated pronounced improvement in physical semen characteristics in all tested groups as compared to the control one, except those fed carrot tops diet.

Regarding the effect of dietary treatment on pH values of the semen (Table 4), it was found that semen produced by bucks in corn, berseem and carrot roots silage groups showed significantly ($P<0.05$) higher pH values than the control bucks. However, that in carrot tops silage group was nearly similar to the control group. This indicated a negative relationship between pH values and sperm cell concentration in the semen of all groups studied (Hafez and Hafez, 2002).

Sexual desire of bucks was determined in term of reaction time (Table 4). The present results of reaction time indicated significant effect of dietary treatment on reaction time of bucks, being significantly ($P<0.05$) the shortest in bucks fed corn (43.3 sec) and carrot roots (42.8 sec) silage diets, followed by those fed berseem (49.5 sec). While, those fed carrot tops and the control bucks showed significantly ($P<0.05$) the longest reaction time (57.5 and 59.7 sec, respectively).

Concerning the changes in different semen characteristics throughout collection weeks, it was observed that ejaculate volume showed fluctuated trend in all dietary groups. However, sperm cell concentration and percentages of sperm motility and live sperm were almost higher as well as sperm abnormality percentage was lower at most collection weeks in carrot roots, corn and berseem silage groups than carrot tops silage and the control groups (Figure 1).

Total sperm output of mature bucks:

Concerning the effect of dietary treatment group on sperm production shown in table (5), it was observed that sperm out puts in terms of total number of spermatozoa, live and motile spermatozoa significantly ($P<0.05$) increased and number of abnormal spermatozoa per ejaculate significantly ($P<0.05$) decreased for bucks fed carrot roots, berseem and corn silage groups as compared to those fed the control diet. Meanwhile those in carrot tops showed nearly similar values to the control group.

In spite the significant ($P<0.05$) difference between berseem and each of corn and carrot roots silage groups in sperm cell concentration, being the lowest in berssem silage group (Table 4), total out puts of different types of spermatozoa did not differ significantly in berseem, corn and carrot roots silage groups (Table 5) as a result of the insignificant increase in ejaculate volume among dietary treatment groups.

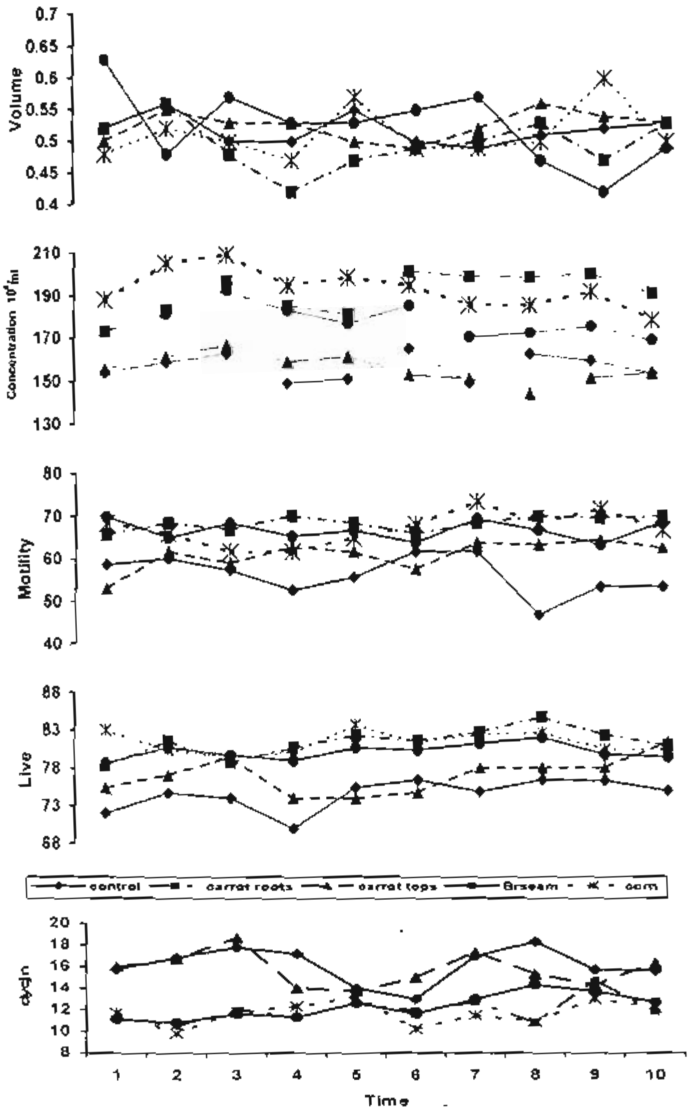

Figure (1): Average values of different physical semen characteristics of bucks during different collection weeks.

Table (5): Effect of dietary treatment group on sperm out puts per ejaculate of NZW bucks.

Semen characteristics (x 10^6/ml)	Control	CFD plus silage of			
		Carrot roots	Carrot tops	Berseem	Corn
Total sperm output	81.02 ± 2.3^b	94.81 ± 2.1^a	81.64 ± 12.2^b	93.24 ± 2.4^a	98.93 ± 2.6^a
Live sperm	60.35 ± 2.6^b	77.19 ± 3.2^a	62.86 ± 3.1^b	74.65 ± 3.1^a	80.44 ± 3.2^a
Motile Sperm	45.43 ± 4.2^b	64.77 ± 3.7^a	49.80 ± 3.6^b	62.29 ± 3.8^a	66.34 ± 4.1^a
Abnormal sperm	25.20 ± 0.9^a	22.85 ± 0.8^b	24.49 ± 0.9^a	21.77 ± 0.9^b	22.50 ± 0.9^b

A, B and C: Means denoted within the same rows are significantly (P<0.05) different.

In accordance with the present results, Abo El-Ezz *et al.* (1986) found that replacement of 30% from the CFD by vegetable wastes containing carrot roots insignificantly improved sperm abnormality percentage from 6.76 to 5.29%. The pronounced improvement in total sperm out puts of bucks fed berseem silage may be related to the higher CP level in berseem silage diet than the other groups (17.0 vs. 15.4-15.9%). In agreement with this finding, Hemid and Tharwat (1995) found that increasing CP level from 15 to 17.5% increased ($P<0.05$) of mass motility and sperm concentration and decreased ($P<0.05$) percentages of dead sperm and sperm abnormality. However, ejaculate volume and mass motility percentage did not differ significantly. Also, Ahmed *et al.* (1991) indicated that ejaculate volume increased significantly by increasing CP level from 11.39 to 16.45%.

It is of interest to note that the insignificant differences in ejaculate volume may be associated without any effects of the dietary treatments on size of the accessory glands and/or their activity in production of the seminal plasma. Louis *et al.* (1994) mentioned that the significant ($P<0.05$) increase in ejaculate volume by increasing CP level may be in relation with increasing activity of the accessory glands undergoing the testosterone concentration as a result of dietary CP level. However, Abdel-Khalek (2005) found associated increase in ejaculate volume with increasing weight and measures of the accessory glands.

Spermatogenesis is controlled directly by testosterone concentration (Hammond *et al.*, 1983 and Abdel-Khalek *et al.* 2001) and directly or indirectly by thyroid hormones (Nalbandov, 1970). The improvement in sperm concentration may be attributed to indirect effect of the dietary treatment on increasing the testicular weight and volume, and in turn on number of sperm produced per gram of the testicular mass (Mansour *et al.*, 1989). The marked development in testicular histogenesis in carrot roots and corn silage groups may be due to the thicker spermatogenic cells in the semeniferous tubules occurring early in these groups as compared to the other groups.

The pronounced increase ($P<0.05$) in percentages of mass motility in semen of bucks fed carrot roots may attributed to marked ($P<0.05$) increase in percentages of live spermatozoa and clear reduction ($P<0.05$) in sperm abnormality percentage.

Conception rate:

It is of interest to not that values of conception rate paralleled results of semen quality and sexual desire of bucks in different dietary groups, being higher (100%) in all groups, except those fed carrot tops silage diet (60%).

In conclusion, the current study indicated the possibility of feeding bucks on diets containing, 30% from each of corn, carrot roots or berseem silage to attained early puberty in male rabbits without reversible effects on their semen quality, sexual desire and conception rate at mature stages.

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الكفاءة التناسلية لذكور الأرانب النيوزلاندى المغذاة علي علائق محتوية على أنواع مختلفة من السيلاج.

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يهدف هذا البحث إلي دراسة تأثيرات تغذية ذكور الأرانب علي علائق محتوية علي أنواع مختلفة من السيلاج علي البلوغ الجنسى وكذلك جودة السائل المنوي. استخدم في هذه الدراسة ٤٥ أرانب ذكر نيوزلاندى أبيض عمر ٦ أسابيع قسمت إلي خمس مجموعات تجريبية، المجموعة الأولي غذيت علي ١٠٠% عليقة مصنعة بينما المجاميع الأخرى غذيت علي ٧٠% عليقة مصنعة و٣٠% سيلاج (المجموعة الثانية غذيت علي سيلاج الجزر والمجموعة الثالثة علي سيلاج عروش الجزر والمجموعة الرابعة علي سيلاج البرسيم والمجموعة الخامسة علي سيلاج الذرة الكامل). وغذيت كل المجاميع من عمر ٦ أسابيع وحتى عمر ٣٤ أسبوع ويمكن تلخيص النتائج المتحصل عليها كالتالي:-

١-عند عمر ١٦ أسبوع (عمر البلوغ المتوقع):-

- لم تظهر فروق معنوية في تركيزهرمون التستوستيرون في كل المجموعات، بالرغم من وجود ارتفاع في المجموعتين الثانية والخامسة مقارنة بباقي المجموعات. بينما أوضحت النتائج زيادة أوزان الخصية معنويا في المجموعة الخامسة وانخفاضها في المجموعة الثالثة ، بالرغم أن أوزان الخصية في المجموعات الأخرى كانت متوسطة. وكذلك كان هستولوجى الخصية أكثر تطورا في المجموعة الرابعة والخامسة مقارنة بالكنترول والمجموعة الثالثة والتي مازالت في مراحل التطور بينما المجموعة الثانية كان التطور الهستولوجى للخصية متوسط.

٢-وعند عمر ٢٤ أسبوع (عمر النضج الجنسي):-

- أظهرت ذكور المجموعة الثانية والخامسة زيادة معنوية في تركيز الحيوانات المنوية والنسبة المنوية للحيوانات المنوية الحية والمتحركة وانخفاض نسبة الحيوانات المنوية الشاذة مقارنة بباقي المجموعات التجريبية الأخرى، بينما حجم القذفة لم يتأثر معنوية بالمعاملات الغذائية المختلفة.
- تأثر زمن الجمع معنويا فكان أقصر في المجموعة الخامسة (٤٣ ثانية) والمجموعة الثانية (٤٢,٨) وتلاهم المجموعة الرابعة (٤٩,٥ ثانية) بينما المجموعة الثالثة والأولى أظهرت زمنا أطول معنويا (٥٧,٥ و٥٩,٧ ثانية على الترتيب).
- كما ارتفع معنويا العد الكلى للحيوانات المنوية الحية والمتحركة والطبيعية لكل قذفة في المجموعات الثانية والرابعة والخامسة مقارنة بالمجموعتين الأولي والثالثة.
- ومعدل الخصوبة أرتفع معنويا في المجموعات الأولى والثانية والرابعة والخامسة مقارنة بالمجموعة الثالثة (١٠٠% مقابل ٦٠%).

وتوصى هذه الدراسة بأن تغذية ذكور الأرانب النيوزلاندى الأبيض علي سيلاج الجزر والذرة والبرسيم بنسبة ٣٠% قد بكر البلوغ الجنسي وأظهرت تأثيرات حسنة علي جودة السائل المنوي ومعدل الخصوبة فى مرحلة النضج.