# EFFECT OF DIFFERENT DIETARY STARCH LEVELS AND SEX ON PRODUCTIVE PERFORMANCE AND DIGESTIVE ENZYMES ACTIVITY OF GROWING RABBITS.

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## SUMMARY

Seventy two sexed New Zealand White rabbits (NZW) 25 days of age (36 males +36 females) were used in this experiment to study the effect of different dietary starch levels and sex on productive performance, nutrients digestibility coefficients, carcass characteristics, digestive tract measurements, blood constituents and enzymes activity. The rabbits were divided into three experimental diets containing three levels of starch {L (16%), M (19%) or H (22%)} with two sexes. Each group for each sex was subdivided into four replicates with 3 rabbits each and the initial live body weights of all experimental groups were almost similar.

The results indicated that, male rabbits can utilize from the different levels of starch (16-22%) but female rabbits cannot do that and the highest productive performance for female was dictated when fed 19% starch only. Mortality rate of growing rabbits was high in female (25%) compared with male (10.92%). However, low mortality rate was noted for rabbit fed 19% dietary starch level.

The highest digestibility coefficients were recorded for male fed 19% starch compare with those fed 16% or 22% starch. On the other hand, the highest digestibility coefficients were showed for female fed 19% starch. Low digestibility coefficients were recorded with female fed 16% or 22% starch. There were no significant effects of sex and starch levels on percentages of dressing, hot carcass and liver and liver activity enzymes (GOT and GPT). There were significant effects of treatment blood glucose, triglycerides, cholesterol and total lipid content and amylase and protease enzymes activity in the stomach, ileum and cecum. In addition, no significant effect was observed on the cellulase and carboxymethyl cellulase by the different levels of starch and sex in all segments of the digestive tract.

It may be concluded that both sexes of rabbits were able to efficiently utilize the 19% dietary starch. Moreover, the male ones could accustom the 16% or 22% dietary starch level without any deleterious effects on their performance.

***Keywords**: growing rabbit, sex, diet, starch, mortality, enzyme activity.*

## INTRODUCTION

Low dietary amount of starch is recommended in the post weaning period in order to reduce digestive problems linked to the incomplete development of the enzymatic system in young rabbits (Maertens, 1992). This fact was also supported by the work of Xiccato *et al.*, (2002), Martínez-Vallespín *et. al.*, (2011) and Trocino *et al.*, (2011), they concluded that, young rabbits were not able to digest starch completely. They added that, the starch source had no effect on growth performance, which was affected only by starch level. The same authors reported that, body weight gain and feed conversion were improved at higher level of starch compared to moderate levels, due to the increase in nutritive value and feed efficiency. However, if morbidity of young rabbits is taken into consideration, morbidity was numerically higher in rabbits fed high starch diets (12.5%) compared to rabbits fed low starch diets (4.2%) but the difference was not significant. It seems that lowering starch level in the diet of growing rabbits decrease mortality rate which is a major problem facing rabbit's producer.

The enzyme activities are indicators of digestibility coefficient for good productive performance. They increase markedly with the age of the rabbit and due to the presence of micro-organisms that will determine the ability of the rabbit to utilize different levels of starch. Amylase, protease, cellulase and

carboxymethyl cellulase are some of activities provided by the intestinal micro flora and digestive tract segments of the rabbit.

The present study aims to evaluating the effect of different levels of dietary starch and sex on productive performance, mortality rate, nutrients digestibility coefficients, carcass characteristics, digestive tract measurements, blood constituents and enzymes activity of growing rabbits.

## MATERIALS AND METHODS

This study was carried out at the Centre of Agricultural Studies and Consultations (CASC), Rabbits Production Unit (RPU), Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

***Experimental rabbits and design:***

Seventy two sexed New Zealand White (NZW) rabbits (36 males + 36 females) during the period from 25 to 81 days of age were used to examine the response of rabbits to feeding three different levels of dietary starch in the two sex in a factorial arrangement design(3*2). The rabbits were assigned randomly at six experimental treatments (12 rabbits / treatment). Each experimental group was divided into 4 replicates of 3 rabbits. The initial live body weights of all experimental groups were almost similar (371.5 + 22g).

***Rabbits management and diets:***

The animals were marked immediately after weaning. Feed and water were offered ad-libitum. Feces were removed daily. The lighting was provided 16 hr daily. The experimental rations were formulated to ensure an adequate supply of all nutrients recommended by Lebas *et al.*, (1997) for growing rabbits. Treatments design was as follows: Low (16%); moderate (19%) and high (22%) starch levels. Compositions of the diets are presented in Table (1). All diets were isocaloric, isofiberous and were provided in pelleted form.

***Measured traits:***

Live body weight (LBW) of rabbits was recorded weekly in grams and the average daily weight gain (DWG) was individually calculated. Average daily feed consumption (DFC) was recorded weekly and feed conversion ratio (g feed /g gain) was calculated. Mortality rate was recorded daily.

***Digestibility trials:***

At the end of the experimental period, apparent nutrients digestibility were determined for experimental diets. Four animals (2 males + 2 females) from each experimental group were housed individually in metabolic cages that allowed feces and urine separation. The preliminary period was 7 days and collection extended to 6 days, feed intake was accurately determined. Feces excreted daily were collected in labeled polyethylene bags and samples were taken for the chemical analysis. Proximate analysis of the experimental diets and feces samples were carried out according to the A.O.A.C. (1990).

***Blood samples, carcass traits and measurement of digestive enzyme activities:-***

At the end of the growth trial, four animals (2 males + 2 females) randomly chosen rabbits (81 days of age) representing each group were slaughtered according to the standard technique of Cheeke *et al.*, (1987). Blood samples were collected at slaughtering in heparinized glass tubes (4 samples per each treatment group). Blood plasma was separated by centrifugation at 3000 rpm for 15 minutes. The collected plasma was stored at -20°C until assay. Values of glucose, total Lipid, cholesterol, triglycerides and liver enzymes activity (GOT and GPT) were estimated by using commercial Kits. After blood samples were taken, the carcass traits were estimated. Dressing percentage included relative weights of carcass, giblets and head were recorded. The same located segments of their digestive tract (stomach, ileum and cecum) were emptied by gentle squeezing, contents of individual segments were taken, mixed and about 1g of the mixed content was immediately diluted with 10 ml of distilled water. All samples were centrifuged for 10 minutes. The supernatant fluid was taken and stored in sealed bottles at -20°C until analyzed. Enzymes activity in digestive content of stomach, ileum and cecum of rabbits were determined as follows: amylase (Osman, 1982), protease (Malik and Singh, 1980), cellulase (Halliwell, 1958) and carboxymethyl cellulase (Mandels and Waber, 1969).

**Table (1): Composition of the experimental diets and their chemical analyses.**

| Ingredients | Levels of starch and protein (%) | | |
|---|---|---|---|
| | 16% | 19% | 22% |
| Yellow corn | 4.75 | 20.60 | 5.00 |
| Barley | 11.5 | 20.6 | 29.7 |
| Soy bean meal (44%) | 7.35 | 4.00 | 0.70 |
| Corn gluten meal (60%) | 3.00 | 5.00 | 9.00 |
| Wheat bran | 30.50 | 19.75 | 9.00 |
| Clover hay | 37.50 | 40.25 | 43.10 |
| Vegetable oil | 2.00 | 1.00 | 0.10 |
| Bone meal | 1.00 | 1.00 | 1.00 |
| Limestone | 1.50 | 1.50 | 1.50 |
| Salt | 0.50 | 0.50 | 0.50 |
| Rabbit premix* | 0.30 | 0.30 | 0.30 |
| DL-methionine | 0.10 | 0.10 | 0.10 |
| Chemical analysis: | | A. Determined Values (%) | |
| DM | 88.65 | 88.51 | 88.39 |
| CP | 16.10 | 16.09 | 16.10 |
| CF | 14.09 | 14.05 | 14.03 |
| EE | 4.72 | 3.56 | 2.51 |
| NFE | 44.97 | 46.28 | 47.47 |
| ASH | 8.60 | 8.36 | 8.12 |
| Starch | 16.08 | 19.13 | 22.01 |
| Total Sugar | 5.99 | 6.31 | 6.59 |
| NDF | 36.36 | 35.57 | 34.83 |
| ADF | 20.98 | 21.35 | 21.77 |
| | | B. Calculated Values | |
| DE (Kcal / Kg) | 2698 | 2715 | 2735 |
| Methionine (%) | 0.35 | 0.41 | 0.45 |
| Lysine (%) | 0.86 | 0.84 | 0.87 |
| Calcium (%) | 1.49 | 1.51 | 1.54 |
| Total phosphorous (%) | 0.71 | 0.70 | 0.79 |
| Methionine + Cystine (%) | 0.62 | 0.66 | 0.65 |

**Each 3kg of rabbits premix contained:-*
*Vit. A 12000000 IU; Vit.$D_3$ 2000000IU; Vit. E 10000 mg; Vit.$K_3$ 2000 mg; Vit.$B_1$1000 mg; Vit.$B_2$ 5000 mg; Vit.$B_6$ 1500 mg; Vit.$B_{12}$ 10 mg; Biotin 50 mg; Choline Chloride 250000 mg; Pantothenic acid 10000 mg; Nicotinic acid 30000 mg; Folic acid 1000 mg; Manganese 60000 mg; Zinc 50000 mg; Iron 30000 mg; Copper 10000 mg; Iodine 1000 mg; Selenium 100 mg; Cobalt 100mg and $CaCO_3$ to 3000 mg.*

***Statistical analysis:***

The values were analyzed statistically using two-way analysis of variance method according to SAS (1998). Duncan's new Multiple Range procedure was followed to separate means (Duncan, 1955). The model applied was: $Y_{ijk}=\mu+S_i+P_j+(SP)_{ij}+E_{ijk}$

Where: $\mu$= general mean. $S_i$= dietary starch effect, $P_j$= sex effect, $(SP)_{ij}$= starch by sex interaction effect and $E_{ijk}$= experimental error.

## RESULTS AND DISCUSSION

***Nutrients digestibility coefficients:-***

The results of apparent digestibility and nutritive values for the experimental diets are presented in Table (2). Male rabbit irrespective of the starch levels and rabbits fed moderate starch level in the rations regardless sex significantly increased DM, OM, CP, EE, and NFE, Starch and Sugar digestibility coefficients and nutritive values (TDN and DCP). The same results were observed by Blas and Gidenne, (2010), De Blas *et al.*, (1999), Gidenne and García, (2006) and Gidenne *et al.*, (2010). The feeding

behaviour of the young rabbit is greatly modified between 2 and 5 weeks of age, and may impact with the digestive health of the young before weaning further studies are required to explore the mechanisms underlying the control of the feeding behaviour of the young and the relations with digestive health (Gidenne *et al.*, 2007). The improvement in the nutrient apparent digestibility and the nutritive value of diets with increasing starch (110–170 g/kg) was quite obvious (Trocino *et al.*, 2011).

The reduction in digestion coefficients associated with high level of starch may be due to overload carbohydrates (Cheeke *et al.*, 1986). And consequently, increasing bacteria activity which caused enterotoxaemia (Lebas and Maitre, 1989; Peeters *et al.*, 1993; Blas *et al.*, 1994 and Maertens, 1995). The reduction of TDN % in groups fed high level of starch was due to the decreasing digestibility coefficients of CP and NFE in these groups. The results indicated that, there was no significant effect of starch levels on CF, NDF and ADF digestibility coefficients. This agrees with the findings of El-Sanhoury, (2005), who found that, there was no effect of starch level on CF digestibility.

***Digestive enzyme activities:***

Data recorded in Table (3) clearly indicate that, the activity of amylase was lower in the stomach than in ileum and cecum. While the protease activity was significantly higher in stomach, ileum and stomach of the rabbits fed for moderate starch levels in the diet and male rabbit. However, no significant difference was observed in cellulase and carboxymethyl cellulase activities as affected by the different levels of starch and sex in all segments of the digestive tract. From the previous results, it was concluded that markedly higher values with 19% starch and male rabbit in all segments of the digestive tract. These results agree with El-Sanhoury (2005) who found that, carboxymethyl cellulase (CMCase) was absent in the contents of stomach and small intestine of rabbit fed on different levels of starch in diets. The author also, reported that the level of starch in the diets had no effect on activities of cellulase and xylanase enzymes.

The total enzymatic activity in the small intestinal content assessed the digestive potential really in contact with nutrients. This potential increased sharply up to 42 days of age for lipids, but enzymes responsible for starch and protein digestion still peaked at 52 days of age, as found previously by Debray *et al.* (2003). For instance, the increase in amylase activity in the small intestinal content may be related to the higher starch intake with age (Gidenne *et al.*, 2007). It probably resulted from an increased production of α-amylase by the pancreas (Debray *et al.*, 2003). Gidenne *et al.* (2007) found that amylase intestinal activity was reduced after weaning for young fed the low fibre:starch ratio diet. Furthermore the maltase activity was slightly reduced with the increased starch intake. Accordingly, this inhibition of amylolytic potential resulted in a decreased digestibility of dietary starch.

***Growth performance of growing rabbits:-***

Growth performance data of growing NZW rabbits as affected by different levels of starch and sex are presented in Table (4). Results indicated that, levels of starch and sex significantly ($P \leq 0.01$) affected live body weight (LBW) and daily body weight gain (DBWG) from 25-53, 53-81 and 25-81 days of age. Rabbits fed high level of starch (22%) during the first growth period (25-53d.) recorded significantly ($P \leq 0.01$) the lower LBW and DBWG. This decrease was irrespective of sex and could be due to the effect of overloading carbohydrate. The high level of carbohydrate in rabbit diets would promote enteritis causing a proliferation of bacteria (Gidenne *et al.*, 1998). The digestion of starch improved regularly from 25 to 50 days old, in agreement with (Gidenne *et al.*, 2007). Starch is the main dietary energy source in rabbit feeding and is included, mostly from cereals, at rather high levels (170–200 g/kg) in diets for fattening and reproducing rabbits in order to maximize daily growth, reduce feed intake and optimize feed efficiency (De Blas and Mateos, 2010).

Male and female rabbits were significantly ($P \leq 0.01$) in the results of LBW and DBWG in all experimental periods. This is probably due to the good enzymes activity for male compare with female.

The obtained results show that, during the first growth period, LBW and DBWG of the rabbits were highest with 19% starch for male (1275 and 31.57g, respectively). This result was in harmony with the results of enzymes activities, digestibility coefficients and blood parameters.

**Table (2): Effect of different levels of starch and sex on nutrients digestibility and nutritive values.**

| | | Digestibility Coefficients | | | | | | | | Nutritive values | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | Starch | DM | OM | CP | CF | EE | NFE | NDF | ADF | Starch | Sugar | TDN | DCP |
| Male | L | 57.3±0.77 | 62.7±1.19 | 69.0±0.53 | 23.7±0.93 | 78.7±1.40 | 76.7±0.91 | 41.5±0.97 | 21.8±1.3 | 84.5±0.96 | 93.9±0.53 | 67.0±0.58 | 12.7±0.17 |
| Male | M | 63.9±0.38 | 64.3±0.67 | 76.0±0.53 | 23.0±0.61 | 87.0±1.89 | 82.7±0.92 | 40.5±1.20 | 22.3±1.4 | 87.4±0.77 | 96.9±0.43 | 71.0±1.00 | 14.9±0.18 |
| Male | H | 57.9±0.84 | 62.3±1.20 | 70.3±1.19 | 23.6±0.41 | 74.0±1.15 | 78.7±1.18 | 42.3±1.12 | 22.1±1.1 | 84.4±0.65 | 94.2±0.87 | 67.3±0.33 | 13.0±0.29 |
| Female | L | 50.9±0.47 | 53.7±1.20 | 68.3±0.67 | 21.9±0.43 | 69.7±0.33 | 76.3±0.86 | 42.5±1.16 | 23.3±1.0 | 79.5±0.85 | 88.9±0.55 | 64.3±0.96 | 12.8±0.12 |
| Female | M | 59.6±0.44 | 58.3±1.02 | 70.3±0.67 | 22.0±0.91 | 74.7±1.20 | 77.7±0.96 | 42.0±0.95 | 22.1±1.2 | 82.4±1.00 | 91.9±0.37 | 71.7±1.05 | 13.6±0.23 |
| Female | H | 52.6±0.70 | 57.0±0.88 | 68.7±1.40 | 21.9±1.01 | 68.3±0.67 | 74.3±0.96 | 42.0±0.93 | 22.3±1.1 | 79.4±0.96 | 89.2±0.93 | 65.0±0.58 | 12.3±0.24 |
| Main effects: | | | | | | | | | | | | | |
| Effect of sex | | | | | | | | | | | | | |
| Male | | 59.70$^{a}$ | 63.10$^{a}$ | 71.78$^{a}$ | 23.45 | 79.89$^{a}$ | 79.35$^{a}$ | 41.41 | 22.05 | 84.73$^{a}$ | 94.97$^{a}$ | 68.44$^{a}$ | 13.52$^{a}$ |
| Female | | 54.37$^{b}$ | 56.33$^{b}$ | 69.1$^{b}$ | 21.93 | 70.90$^{b}$ | 76.10$^{b}$ | 42.16 | 22.59 | 79.73$^{b}$ | 89.97$^{b}$ | 66.99$^{b}$ | 12.90$^{b}$ |
| Effect of starch | | | | | | | | | | | | | |
| L | | 54.10$^{b}$ | 58.19$^{b}$ | 68.65$^{b}$ | 22.83 | 74.19$^{b}$ | 76.49$^{b}$ | 41.96 | 22.55 | 81.99$^{b}$ | 91.36$^{b}$ | 65.65$^{b}$ | 12.76$^{b}$ |
| M | | 61.75$^{a}$ | 61.30$^{a}$ | 73.17$^{a}$ | 22.50 | 80.84$^{a}$ | 80.19$^{a}$ | 41.23 | 22.19 | 84.85$^{a}$ | 94.39$^{a}$ | 71.34$^{a}$ | 14.25$^{a}$ |
| H | | 55.25$^{b}$ | 59.67$^{ab}$ | 69.5$^{b}$ | 22.75 | 71.17$^{c}$ | 76.50$^{b}$ | 42.17 | 22.21 | 81.86$^{b}$ | 91.66$^{b}$ | 66.17$^{b}$ | 12.63$^{b}$ |
| Significance | | | | | | | | | | | | | |
| Sex | | ** | ** | ** | NS | ** | ** | NS | NS | ** | ** | ** | ** |
| Starch | | ** | ** | ** | NS | ** | ** | NS | NS | ** | ** | ** | ** |
| Se*St | | ** | ** | ** | NS | ** | ** | NS | NS | ** | ** | ** | ** |

*$^{a,b,c}$ Means within the same effect and column with no common superscript differ significantly ($p \leq 0.05$). NS: Non-significant **: ($P \leq 0.01$).*

*St = Starch levels % {16(L), 19(M) and 22(H)} Se = Sex*

**Table (3): Effect of different levels of starch and sex on digestive enzyme activities of growing rabbits.**

| | | Stomach | | | | Ileum | | | | Caecum | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Se | St | Amylase | Cellulase | CMC | Protease | Amylase | Cellulase | CMC | Protease | Amylase | Cellulase | CMC | Protease |
| M | L | 0.34±0.13 | 0.45±0.11 | 0.0048±0.0014 | 3.13±0.07 | 0.52±0.03 | 2.33±0.27 | 0.82±0.09 | 2.77±0.05 | 1.42±0.05 | 2.25±0.33 | 0.071±0.016 | 1.87±0.12 |
| M | M | 0.54±0.09 | 0.62±0.14 | 0.0064±0.0015 | 3.98±0.08 | 0.61±0.04 | 2.57±0.28 | 0.86±0.14 | 2.95±0.07 | 2.15±0.07 | 2.53±0.28 | 0.081±0.009 | 2.18±0.06 |
| M | H | 0.28±0.15 | 0.46±0.10 | 0.0044±0.0018 | 3.01±0.07 | 0.50±0.03 | 2.28±0.26 | 0.79±0.11 | 2.63±0.08 | 1.46±0.03 | 2.30±0.23 | 0.075±0.013 | 1.91±0.10 |
| F | L | 0.23±0.13 | 0.35±0.14 | 0.0042±0.0017 | 3.09±0.08 | 0.43±0.02 | 2.21±0.19 | 0.69±0.10 | 2.37±0.09 | 1.37±0.06 | 1.87±0.21 | 0.041±0.010 | 1.54±0.11 |
| F | M | 0.43±0.14 | 0.55±0.12 | 0.0058±0.0013 | 3.55±0.06 | 0.53±0.03 | 2.23±0.33 | 0.77±0.15 | 2.83±0.06 | 1.85±0.04 | 2.14±0.18 | 0.058±0.014 | 1.98±0.08 |
| F | H | 0.19±0.09 | 0.34±0.13 | 0.0039±0.0014 | 2.95±0.06 | 0.41±0.02 | 2.09±0.25 | 0.68±0.05 | 2.25±0.06 | 1.40±0.02 | 1.77±0.25 | 0.049±0.008 | 1.73±0.09 |
| Main effects: | | | | | | | | | | | | | |
| Effect of sex | | | | | | | | | | | | | |
| M | | 0.39 | 0.49 | 0.0052 | 3.37[a] | 0.54[a] | 2.39 | 0.82 | 2.78[a] | 1.68[a] | 2.36 | 0.076 | 1.99[a] |
| F | | 0.28 | 0.41 | 0.0046 | 3.20[b] | 0.46[b] | 2.18 | 0.71 | 2.48[b] | 1.54[b] | 1.93 | 0.049 | 1.75[b] |
| Effect of starch | | | | | | | | | | | | | |
| L | | 0.29 | 0.40 | 0.0045 | 3.11[b] | 0.48[b] | 2.27 | 0.76 | 2.57[b] | 1.40[b] | 2.06 | 0.056 | 1.71[b] |
| M | | 0.49 | 0.59 | 0.0061 | 3.77[a] | 0.57[a] | 2.40 | 0.82 | 2.89[a] | 2.00[a] | 2.34 | 0.070 | 2.08[a] |
| H | | 0.24 | 0.38 | 0.0042 | 2.98[b] | 0.46[b] | 2.19 | 0.74 | 2.44[b] | 1.43[b] | 2.04 | 0.062 | 1.82[b] |
| Significance | | | | | | | | | | | | | |
| Se | | NS | NS | NS | ** | ** | NS | NS | ** | ** | NS | NS | ** |
| St | | NS | NS | NS | ** | ** | NS | NS | ** | ** | NS | NS | ** |
| Se*St | | NS | NS | NS | ** | ** | NS | NS | ** | ** | NS | NS | ** |

*[a,b,c] Means within the same effect and column with no common superscript differ significantly ($p \leq 0.05$). NS: Non-significant **: ($P \leq 0.01$).*

*CMC =Carboxy Methyl Cellulase Se = Sex ( M = Male F = Female ) St = Starch level ( L = Low M= Medium H = High)*

**Table (4): Effect of different levels of starch and sex on growth performance, clostridia number and mortality rate of growing rabbits.**

| | | 25-53 days | | | | 53-81 days | | | | 25-81 days | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Se | St | LBW | DWG | DFC | FCR | LBW | DWG | DFC | FCR | DWG | DFC | FCR | Clostridia ($*10^4$) | MR |
| M | L | 1186±10 | 29.24±0.5 | 69.13±1.9 | 2.36±0.01 | 1801±18 | 21.95±0.2 | 85.8±1.1 | 3.91±0.02 | 25.59±0.4 | 77.47±1.1 | 3.03±0.03 | 966±57.74 | 8.03 |
| M | M | 1275±27 | 31.57±0.7 | 76.53±1.8 | 2.42±0.04 | 1955±24 | 24.29±0.3 | 88.67±1.0 | 3.65±0.04 | 27.93±05 | 82.6±1.0 | 2.96±0.02 | 1638±33.33 | 8.03 |
| M | H | 1073±16 | 25.42±0.7 | 61.9±1.7 | 2.44±0.04 | 1774±27 | 25.05±0.2 | 78.37±1.1 | 3.13±0.04 | 25.23±0.4 | 70.14±1.2 | 2.78±0.04 | 2433±57.75 | 16.7 |
| F | L | 1132±9.8 | 26.86±0.3 | 69.43±1.6 | 2.58±0.02 | 1748±19 | 21.99±0.2 | 84.1±0.9 | 3.82±0.01 | 24.43±0.3 | 76.77±1.1 | 3.14±0.04 | 1296±57.74 | 25 |
| F | M | 1218±25 | 30.28±0.4 | 70.1±1.9 | 2.32±0.02 | 1919.±21 | 25.02±0.2 | 85.9±1.0 | 3.43±0.04 | 27.65±0.3 | 78.0±1.0 | 2.82±0.02 | 2011±115.8 | 16.7 |
| F | H | 1016±19 | 23.09±.8 | 60.93±1.8 | 2.64±0.02 | 1608±22 | 21.14±0.3 | 80.2±1.0 | 3.79±0.05 | 22.11±0.6 | 70.57±1.0 | 3.19±0.03 | 3031±91.20 | 33.3 |
| Main effects: | | | | | | | | | | | | | | |
| Effect of sex | | | | | | | | | | | | | | |
| M | | 1177.9$^a$ | 28.74$^a$ | 69.19 | 2.41$^b$ | 1833.7$^a$ | 23.76$^a$ | 84.28 | 3.55$^b$ | 26.25$^a$ | 76.74 | 2.92$^b$ | 1679$^b$ | 10.92 |
| F | | 1122.1$^b$ | 26.74$^b$ | 66.82 | 2.51$^a$ | 1758.1$^b$ | 22.72$^b$ | 83.40 | 3.68$^a$ | 24.73$^b$ | 75.11 | 3.05$^a$ | 2113$^a$ | 25 |
| Effect of starch | | | | | | | | | | | | | | |
| L | | 1159.2$^b$ | 28.05$^b$ | 69.28$^b$ | 2.47$^b$ | 1774.4$^b$ | 21.97$^c$ | 84.95$^b$ | 3.87$^a$ | 25.01$^b$ | 77.12$^b$ | 3.09$^a$ | 1131$^c$ | 16.52 |
| M | | 1246.5$^a$ | 30.93$^a$ | 73.32$^a$ | 2.37$^c$ | 1922.6$^a$ | 24.67$^a$ | 87.29$^a$ | 3.54$^b$ | 27.79$^a$ | 80.30$^a$ | 2.89$^c$ | 1825$^b$ | 12.37 |
| H | | 1044.2$^c$ | 24.26$^c$ | 61.42$^c$ | 2.54$^a$ | 1690.8$^c$ | 23.10$^b$ | 79.29$^c$ | 3.46$^c$ | 23.67$^c$ | 70.36$^c$ | 2.99$^b$ | 2732$^a$ | 25 |
| Significance | | | | | | | | | | | | | | |
| Se | | ** | ** | NS | ** | ** | ** | NS | ** | ** | NS | ** | ** | |
| St | | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | |
| Se*St | | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | |

*$^{a,b,c}$ Means within the same effect and column with no common superscript differ significantly ($p \leq 0.05$). NS: Non-significant **: ($P \leq 0.01$).*
*LBW= Live body weight, DWG= Daily weight gain, DFC= daily feed consumption, FCR= Feed conversion ratio and MR= Mortality rate.*
*St = starch level {L (16%), M (19%) H (22%)} Se = sex {M (male) and F (female)}.*

Concerning the second growth period (53-81d.), it was observed that, raising the dietary starch increased LBW and DBWG which could be due complete development of the enzymatic system as the rabbits grow up (Table 4). Accordingly the digestion system was able to digest carbohydrates high efficient. This leads to an increase in energy intake and with increase of LBW accordingly. It seems that, rabbits' requirement of starch was high during the second growth period whereas, the low level of starch (16%) decreased DBWG. This fact was also supported by the work of Singh *et al.*, (1997). Xiccato *et al.*, (2011) have found no effect on live weight gain when soluble fibre replaced starch. After switching to commercial finishing diet, lower live weight gain was observed in animals previously fed less starch–more NDSF diets, even though feed intake expressed relative to metabolic weight at 49 days of age was similar than in those previously fed more starch–less NDSF ($-0.5 \pm 1.4$ g DM $kg^{-0.75}$ $day^{-1}$, $P > 0.1$); this fact could be explained by live weight overestimating body weight at 49 days of age in animals fed these diets, as a consequence of increased digestive contents. Differences in live weight at 60 days of age as consequence of NDSF replacing starch in weaning diets reflected both lower weight at weaning and lower live weight gain during the full growing period.

The results indicated also that, during the second growth period (53-81d.), DBWG of the rabbits recorded the highest values with 22% starch and male being (25.05 g/day). Generally, the overall results show that, during the whole growth period, DBWG of the rabbits was highest with 19% starch and male being (27.93g/day).

On the other hand, sex had no significant effect on daily feed consumption (DFC) regardless of starch levels. However, daily feed consumption was considerably higher in rabbits fed moderate level of starch (19%) during the second growth period (53-81d.) than the same levels during the first growth period (25-53d.). It was observed that, as starch level of the ration increased from 19 to 22% DFC significantly decreased in the overall growth period (25-81d.) was detected. These results agree with Parigi Bini *et al.*, (1990) and Nizza and Moniello, (2000) who reported that, the high level of starch in the diet decreased DFC. Concerning overall growth period (25-81d.), it is obvious that, DFC of the rabbits was low with 22% starch and male being (70.14g/day). Xiccato *et al.* (2011) have reported replacement of starch with soluble fibre having no effect on feed intake in growing rabbits.

The effects of different levels of starch and sex on feed conversion ratio (FCR) are shown in Table (4). The best FCR was recorded significantly ($P \leq 0.01$) for rabbits fed moderate level of starch (19%) compared with the low and high levels in the first and overall growth periods of the experiment. Similar results were obtained by Xiccato *et al.*, (2002) who found that, 20.6% level of starch improved FCR than 17% starch level. Starch digestion in young rabbit exhibits pronounced differences compared with adults, attributable to the relative importance of intestinal digestion and caecal fermentation on overall fecal digestibility (Blas and Gidenne, 1998).

The feed conversion ratio improved for rabbit male at all experimental periods irrespective of the different starch levels.

From the overall results, it could be concluded that 22% starch and male gave the best feed conversion ratio (2.78 g feed/g gains).

The interaction between different levels of starch and sex (Table, 4) showed highly significant effects on LBW, DBWG, DFC and FCR. These parameters increased significantly ($P \leq 0.01$) for growing male NZW rabbit fed diet containing 19% level of starch.

***Number of clostridia and mortality rate.:***

Analysis of variance showed a significant difference ($P < 0.01$) for *Clostridum spiroforme* count among all levels of starch at the end of experimental period regardless of sex. It seems that the values of *Clostridia* number increased by increasing the level of starch in diets (Table 4). Low dietary starch levels (80–100 g/kg) are recommended during the post-weaning period to avoid caecal overload of undigested starch, which has been considered a longstanding major cause of digestive-related diseases (Trocino *et al.*, 2011).

Regardless of starch, the count of *Clostridum spiroforme* was high in female than male. It may be due to that male had strong health compared with female.

*Clostridum spiroforme* produces watery diarrhea in rabbits and causing death within a few hours after first symptoms (Brooks, 1988). Our results are in complete agreement with the results of Cheeke and Patton (1980), and Cheeke *et al.* (1986). The capacity for starch hydrolysis in the small intestine seems

negatively related to the starch intake, and not totally compensated by hydrolysis from the caecal microbial flora. (Gidenne *et al.*, 2007).

On the other hand, Lelkes (1988) found *Clostridum spiroforme* in young rabbits fed large amount of starch. These results could be explained that, insufficient amount of the enzyme amylase was not produced in the foregut of these animals and, consequently, starch traveled indigested to the cecum in the hindgut where it was digested to form glucose; this glucose in the hindgut appeared to cause a population explosion of *Clostridum spiroforme*.

Mortality rate was one of the mean objectives of this study. Results in Table (4) showed that mortality rate was higher with the high level of starch (22%) followed by those given diets containing 16% starch (25% and 16.52%, respectively). The lowest mortality rate was recorded for rabbits fed on the diets containing 19% dietary starch (12.37%) regardless of sex.

Concerning the sex, it could be noted that, female was high mortality in this experimental compared with male. It could be due to the number of *Clostridia* in female was higher than male.

In agreement with the previous results, DeBlas *et al.*, (1995), Pote *et al.*, (1980) and El-Sanhoury M. H., (2000) reported that minimal was achieved for a concentration of 19% starch in rabbit diets.

When rabbits were fed on diets containing high levels of carbohydrates, the immediate increase in feed intake may cause carbohydrate overload, and induce enterotoxaemia (Cheeke and Patton, 1980). Blas and Gidenne (2010) failed to find a direct relationship between the dietary starch level and mortality rate. In very young rabbits (until 35 d), some authors found a lower mortality level when dietary starch (110–170 g/kg) and the starch to ADF ratio (0.68–1.01) were increased (Feugier *et al.*, 2006).

The high mortality rate recorded for rabbits fed on low dietary starch diet (16%) may be due to insufficient amount of glucose produced or disturbance in gastric acidity or loss of neonatal bacterial activity or microorganism's unbalanced (Lelkes, 1988 and El-Sanhoury M. H., 2000).

Mortality rate during the growth trial was high values till 70–80% had been reported by (Le Bouquin *et al.*, 2009). Results of current study closely agree with those obtained in several works recently reviewed by Blas and Gidenne (2010) indicating that, even if dietary fibre meets essentially the requirements proposed by Gidenne and García (2006) to prevent digestible troubles in young rabbits during post-weaning period, increasing levels of low- or high-digestible fibre replacing starch reduce mortality rate. The beneficial effect of both replacements seems to be additive, since reduction in mortality rate was stronger when made simultaneously.

In conclusion, the results obtained proved that the use of dietary starch level not more than 19% is of almost importance to reduce the post-weaned mortality rate.

***Blood constituents:-***

Mean values of blood constituents of all experimental treatments and sexes presented in Table (5). The highest values of glucose, triglycerides and cholesterol were recorded for rabbits given diet containing the high starch level (22%). While, the lowest values were achieved for rabbits given the low starch diet 16%). However, the obtained results were within the normal ranges (Fox *et al.*, 1984 and Chiericato *et al.*, 1985). Gascon and Verde (1985) reported that, the reduction in blood glucose level may be considered as an indication for health rabbits.

Concerning the effect of sex on total lipid and its fractions, the results obtained herein showed that, female rabbits had higher total lipid and triglycerides and lower total cholesterol comparable to male rabbits.

No significant effects ($P>0.05$) were detected in the liver activity enzymes (GOT and GPT) values due to feeding diets containing different levels of starch. As well male and female rabbits were significantly different. These results are in harmony with Abdel- Azeem *et al.*, (2000) and El-Sanhoury (2005).

The interaction between sex and starch level was highly significant for all estimated blood parameters except the GOT and GPT.

**Table (5): Effect of different levels of starch and sex on blood constituents.**

| Sex | Starch | Glucose (g/l) | Total Lipid (mg/100ml) | Triglycerides (mg/dl) | Cholesterol (mg/100ml) | GOT (u / l) | GPT (u / l) |
|---|---|---|---|---|---|---|---|
| Male | L | 1.50±0.06 | 379±15.03 | 97±2.99 | 85±1.68 | 30.70±0.75 | 9.14±0.16 |
| Male | M | 1.60±0.06 | 381±13.50 | 116±2.64 | 87±3.10 | 31.21±0.71 | 9.62±0.40 |
| Male | H | 1.62±0.03 | 431±17.59 | 149±2.66 | 99±4.52 | 30.98±1.10 | 9.65±0.61 |
| Female | L | 1.34±0.06 | 427±17.43 | 177±3.90 | 67±4.76 | 28.00±0.78 | 9.50±0.32 |
| Female | M | 1.36±0.03 | 484±16.04 | 190±3.72 | 66±1.93 | 30.30±1.60 | 9.99±0.11 |
| Female | H | 1.50±0.01 | 482±17.61 | 194±1.67 | 77±1.71 | 30.10±0.49 | 9.36±0.34 |
| Main effects: Effect of sex | | | | | | | |
| Male | | 1.57[a] | 397[b] | 120.67[b] | 90.33[a] | 30.96 | 9.47 |
| Female | | 1.40[b] | 465[a] | 187.00[a] | 70.00[b] | 29.53 | 9.62 |
| Effect of Starch | | | | | | | |
| L | | 1.41[c] | 403[c] | 137[c] | 76[b] | 29.37 | 9.32 |
| M | | 1.51[b] | 433[b] | 153[b] | 77[b] | 30.76 | 9.81 |
| H | | 1.59[a] | 458[a] | 172[a] | 88[a] | 30.63 | 9.51 |
| Significance | | | | | | | |
| Sex | | ** | ** | ** | ** | NS | NS |
| Starch | | ** | ** | ** | ** | NS | NS |
| Se*St | | ** | ** | ** | ** | NS | NS |

*[a,ba,b,c] Means within the same effect and column with no common superscript differ significantly (p≤0.05). NS: Non-significant ** (P≤ 0.01). Starch levels % {16(L). 19(M) and 22(H)} Se = Sex*

**Table (6): Effect of different levels of starch and sex on carcass and digestive tract measurements.**

| Sex | Starch | Dressing % | Carcass % | Liver % | TFW% | FSW % | ESW % | FCW% | ECW% | Caecum Length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Male | L | 64.9±0.75 | 55.2±0.41 | 2.10±0.02 | 1.41±0.013 | 3.23±0.09 | 1.07±0.02 | 4.12±0.07 | 1.20±0.10 | 1.74±0.03 |
| Male | M | 65.8±0.81 | 55.98±0.51 | 2.07±0.10 | 1.67±0.013 | 3.51±0.06 | 1.02±0.02 | 4.95±0.08 | 1.22±0.12 | 1.89±0.01 |
| Male | H | 66.0±0.91 | 55.97±0.32 | 2.18±0.05 | 1.58±0.014 | 3.75±0.13 | 1.08±0.03 | 4.97±0.07 | 1.27±0.04 | 1.92±0.07 |
| Female | L | 64.6±0.99 | 55.1±0.15 | 2.13±0.06 | 1.56±0.012 | 3.53±0.11 | 1.11±0.06 | 4.84±0.12 | 1.20±0.04 | 1.82±0.02 |
| Female | M | 65.8±0.98 | 55.96±0.66 | 2.40±0.13 | 1.68±0.011 | 3.37±0.16 | 1.12±0.06 | 4.96±0.09 | 1.22±0.04 | 1.89±0.16 |
| Female | H | 64.9±0.80 | 55.29±0.39 | 2.44±0.11 | 1.51±0.012 | 4.09±0.07 | 1.10±0.05 | 5.02±0.05 | 1.29±0.05 | 1.93±0.06 |
| Main effects:- | | | | | | | | | | |
| Effect of Sex | | | | | | | | | | |
| Male | | 65.56 | 55.72 | 2.12 | $1.55^{b}$ | 3.50 | 1.06 | $4.68^{b}$ | 1.23 | 1.85 |
| Female | | 65.09 | 55.45 | 2.32 | $1.58^{a}$ | 3.66 | 1.11 | $4.94^{a}$ | 1.24 | 1.88 |
| Effect of starch | | | | | | | | | | |
| L | | 64.76 | 55.12 | 2.11 | $1.47^{c}$ | $3.38^{b}$ | 1.09 | $4.48^{b}$ | 1.20 | $1.78^{b}$ |
| M | | 65.78 | 55.97 | 2.23 | $1.68^{a}$ | $3.44^{b}$ | 1.07 | $4.96^{a}$ | 1.22 | $1.89^{a}$ |
| H | | 65.41 | 55.63 | 2.30 | $1.54^{b}$ | $3.92^{a}$ | 1.09 | $5.00^{a}$ | 1.28 | $1.93^{a}$ |
| Significance | | | | | | | | | | |
| Se | | NS | NS | NS | ** | NS | NS | ** | NS | NS |
| St | | NS | NS | NS | ** | ** | NS | ** | NS | ** |
| Se*St | | NS | NS | NS | ** | NS | NS | ** | NS | NS |

*$^{a,b,c}$ Means within the same effect and column with no common superscript differ significantly ($p \leq 0.05$).*

*TFW= total fat weight FSW, ESW= full and empty stomach weight and FCW, ECW= Full and empty caecum weight.*

*Starch levels % {16(L), 19(M) and 22(H)}*

*Carcass characteristics:-*

The effect of sex and different starch levels on carcass traits are presented in Table (6). The results showed insignificant effects ($p>0.05$) of sex and starch levels on dressing, hot carcass and liver percentages. This agrees with the findings of Ouhayoun (1998), El-Sanhoury (2000) and Nizza and Moniello (2000) who found that carcass traits were slightly affected by dietary starch level.

As shown in Table (6), the percentage of total fat weight revealed a direct significant increase due to starch level. Moreover, female rabbits had higher fat weight than males, this results support the current findings of total blood lipids and triglycerides. Concerning the digestive tract parts (%), the dietary starch levels and sex did not affect weights of both stomach and cecum. These results are partially agreed with Trocino *et al.*, (2011) who reported that, increase of dietary starch linearly increased slaughter weight (SW) and carcass weight. The proportion of the gastrointestinal tract was linearly decreased and the dressing percentage increased, as well as dissectible fat.

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## تأثير مستويات مختلفة من نشا العليقة والجنس على الأداء الإنتاجي للأرانب النامية.

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تم استخدم 72 أرنب مجنس من سلالة النيوزيلاندى الأبيض عمر 25 يوم (36 ذكر و 36أنثى) لمعرفة تأثير المستويات المختلفة من نشا العليقة و الجنس على الأداء الإنتاجي للأرانب النامية والمعاملات الهضمية و وصفات الذبيحة و قياسات القناة الهضمية و خصائص الدم و النشاط الأنزيمى.تمت تغذية على 3 علائق تجريبية تحتوى على 3 مستويات من النشا هي منخفض (16%) ومتوسط (19%) و عالي (22%) مع كلا الجنسين في تصميم عشوائي متداخل. وكانت أهم النتائج المتحصل عليها كالتالى:-

1 – تستطيع ذكور الأرانب الأستفادة من كل المستويات المختلفة من النشا (16- 22%) بينما لم تستطع الأناث الأرانب تحقيق ذلك وكان أعلى انتاج عند مستوى نشا 19% فقط.

2 – سجلت إناث الأرانب النامية اعلى نسبة نفوق (25%) مقارنا بذكور الأرانب (10.92%) بغض النظر عن تأثيرمستوى النشا فى حين كانت أقل نسبة نافق للأرانب المغذاه على مستوى 19% نشا فى العليقة بغض النظر عن تأثير الجنس.

3 – كانت أفضل معاملات هضمية لذكور الأرانب المغذاه عل مستوى 19% نشا بالمقارنة بنظيرتها المغذاه على كلاً من 16% أو 22% نشا.

4 – تم تسجيل أفضل معاملات هضمية للأناث المغذاه على 19% نشا بينما كانت أقلها بالنسبة للأناث المغذاه على مستويات 16% أو 22% نشا.

5 – لا توجد تأثيرات معنوية لمستويات النشا و الجنس علي نسبة التصافي والنسبة المئوية للذبيحة و الكبد و إنزيمات نشاط الكبد (GOT & GPT).

6- هناك تأثيرات معنوية للمعاملة على سكر الدم والترای جلسريد و الكلوسترول ومحتوى البيدات الكلية و النشاط الأنزيمى للأميلاز والبروتيز فى المعدة و الأمعاء و الأعور.

7- لم يكن هناك تأثر للمستويات المختلفة من النشا والجنس على النشاط الأنزيمى للسليوليز و الكربوكسى ميثيل سليولييز فى القناة الهضمية.

نستخلص من هذه الدراسة أن كلا الجنسين من الأرانب يكون لديهم المقدرة على الأستفادة بكفائة من مستوى نشا 19% فى العليقة. فضلاعن أن الذكور تستطيع أن تستهلك مستوى 16% أو 22% نشا في العليقة بدون أى تأثير ضار على الأداء.