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EFFECT OF DIETARY STARCH AND FIBER LEVELS ON PERFORMANCE OF WEANLING NEW ZEALAND WHITE RABBITS

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ABSTRACT: *Ninety weanling New Zealand White (NZW) rabbits aging about 5 weeks with an average initial weight 655+26.3 g were used to study the influence of different levels of starch and fiber on growth performance digestion, caecotrophy and carcass. Three diets [control (C) ,low (L) or height (H)] were formulated to provide 18.3 , 10.1 and 25.8% starch ,respectively, and 13.4 ,16.4 and 10.6 % crude fiber, respectively. Live body weight and feed intake were weekly recorded individually up to 13 weeks of age.*

The results showed that daily gain, growth rate and performance index were significantly increased by 19.4, 7.37 and 55.9 points, respectively, while feed intake decreased (P<0.001) from 116 to 101 g/day as the level of starch increased from 10.1 to 25.8 % in diets. Feed conversion rate was significantly improved by decreasing the fiber levels (3.04 vs.4.17, P<0.001). Mortality rate increased from 20% in the L diet to 30% in the H diet. Digestibility coefficients of DM, OM, EE, CP and GE were increased (P<0.001) as the level of starch increased. The H diet caused a significant decrease in soft faeces excretion (25.4 vs. 15.9, P<0.001). Dressing % was increased (P<0.01) by 5.6 points due to a decrease (P<0.001) by 3.3 points in GIT in the H diet as compared with L diet. Plasma total protein, glucose, cholesterol and total lipids were significantly increased in rabbits fed H diet.

It could be concluded that the high starch (25.8%) and low fiber (10.6%) diet recorded the best growth performance and nutrient utilization.

INTRODUCTION

The carbohydrate fraction (starch and fiber) is very important in the young rabbit, mainly due to its effects on digestive transit and on substrates available for microbial activity in the hindgut. Both factors affect stability of the microbial ecosystem and gut health **(Gidenne *et al.*, 2005)**.

Starch is the main source of energy in rabbit nutrition. Also, it is used in diets to provide the high energy requirement of animals in the intensive system of rabbit provide the high energy requirement of animals in the intensive system of rabbit production **(Xiccato *et al.*, 2002).** Digestive problem linked to incomplete development of enzymatic system in young rabbits and their inability to digest starch completely was reported by **Debray *et al.*, (2003)**. Moreover, dietary starch is incompletely, hydrolyzed in the small intestine of weanling rabbits, reaching the caecum, which leads to increase mortality during past – weaning period **(Blas and Gidenne, 1998)**.

Rabbit is a non-ruminant plant eating animal and crude fiber has an important effect on keeping normal digestion. Thus, supplying high quantity of digestible fiber promoted a high fermentative activity already at weaning, which might be favorable for health. In addition, there is a sharp increase of bacterial fibrolytic activity between 21 and 25 days of age, while after weaning the fibrolytic activity did not significantly change **(Gidenne and Fortun-Lamothe, 2002)**. Crude fiber not only provides nutrients, but also has the function of maintaining micro-ecological balances of gut, promoting digestive system development raising the reproductive performance **(GU, 2002)**. In the last years, several commercial diets contained higher proportion of corn because it is more cheaper than barley. This mean that higher amount of starch reached the caecum and provoked enteritis.

Therefore, the aim of the present study was to evaluate the effects of different levels of starch and fiber on growth performance, digestibility, caecotrophy, some blood parameters and carcass traits.

MATERIAL AND METHODS

Three experimental diets were formulated to meet or exceed the nutrient requirement for growing rabbits according to **De Blas and Mateos, (1998)**. Three diets [Control(C), low (L) or high (H)] were formulated to contain 18.3, 10.1 or 25.8% starch, respectively, and 13.4, 16.4 or 10.6 % crude fiber, respectively. All diets were nearly iso- nitrogenous, iso-caloric and contained similar levels of micro-elements. Table 1 shows the ingredients and chemical composition of these experimental diets.

Ninety unsexed weanling NZW rabbits of 5 weeks of old were individually house and assigned at random to 3 groups of 30 rabbits each. Feed and water were offered *ad libitum* through out the experimental period from 5 to 13 weeks of age. Live body weight, feed conversion rate and mortality rate were calculated. Performance index was calculated according to **North, (1981)**.

Digestibility trial was carried out at the end of the growth experiment using 6 males per diet to determine the nutrient digestibility coefficients and nutritive values of experimental diets. Rabbits were housed individually in metabolic cages, which allowed separation of faeces and urine. Faeces were collected individually during 5 consecutive days according to the European reference method for rabbit's digestion trials **(Perez *et al.*, 1995)**.

Caecotrophy trail was carried out using 6 males per diet to determine the excretion and chemical composition of soft faeces. Plastic collars were used to prevent caecotrophy. Soft Faeces were collected according the methods of **Carabaño *et al.*, (1989)**.

Chemical analysis was carried out for diets, soft and hard faeces, caecal content and meat samples according to methods of **AOAC (1995)** for ash, DM, CP, CF and EE. Gross energy was determined in an adiabatic bomb calorimeter. Digestibility coefficients and nutritive values of nutrients in terms of total digestible nutrient (TDN). Digestible crude protein (DCP) and digestible energy (DE) were calculated as described by **Perez *et al.*, (1995)**.

Relative contribution of soft faeces to dry matter and crude protein intake were calculated according **Fraga *et al.*, (1991)** as follows:

Relative contribution of soft faecces to DM intake

= (Soft faeces excretion, g DM / day)/ (Feed intake, g DM/ day + soft faeces excretion, g DM/ day) *100

Relative contribution of soft faeces to CP intake

= (CP excreeted in soft faeces, g/ day)/ (CP ingested in feed g/ day + CP excreted in soft faeces, g/ day) X100

Caecal turnover rate was calculated according to Garcia *et al.*, (1995) as follows:

{Soft Faeces Production (g DM/ d)/ Caecal content (g DM)} x 100

At 13 weeks of age, 6 rabbits from each treatment were randomly taken, fasted for 12 hours, weighed and slaughtered to estimate some of carcass traits according to **Blasco *et al.*, (1993)**. Carcass parts were estimated as a percent of live body weight. Caecal contents were dried at

60c° for 2 days and ground for chemical analysis. Blood samples were taken from 6 rabbits of each group to determine some blood parameters.

Date of growth performance, digestibility, caecotrophy, blood and carcass traits were statistically analyzed using the general linear model program of **SAS (1990)**. Duncan's multiple range tests performed **(Duncan, 1955)** to detect significant differences among means.

RESULTS AND DISCUSSION

Growth Performance:

The levels of starch and fiber had a significant effect on the growth performance of growing NEW rabbits from 5 to 13 weeks of age as shown in Table 2. Final body weight, daily weight gain, growth rate and performance index were significantly increased by 14.0, 19.4, 7.37 and 55.9%, respectively, as the level of starch increased from 10.1 to 25.8% and fiber level decreased from 16.4 to 10.6% in the diets. This increase in the growth performance of high starch diet (H) may be due to stimulating the weight gain **(Xiccato *et al.*, 2002)**. These results are in agreement with those obtained by **Cossu *et al.*, (2004)** who found that high corn diet (35%) had a higher ($P<0.05$) final body weight and weight gain than that in low corn diet (15%) during fattening period.

It is difficult to define the cause of this marked depression observed in daily weight gain with rabbits fed diet containing low starch and high fiber levels, but it may be concluded that part of the deleterious effects of fiber is on the digestibility of all nutrients, which descended with increase of crude fiber level in the diets **(Gu *et al.*, 2004)**.

On the contrary, feed intake was decreased ($P<0.001$) from 116 to 101 g/d as fiber level decreased from 16.4 to 10.6% in the diets. Feed conversion rate (FCR) was significantly improved by increasing the dietary starch and showed the best value of FCR in the H diet (3.04) followed by C diet (3.63), while the worst value was found in the L diet (4.17). The decrease in feed intake with increasing starch levels , may be due not only to high DE content, but also to a reduction of fiber level, which leads to an increase of retention time in the whole digestive tract **(Gidenne *et al.*, 2004b)**.

All mortalities of trail occurred during the first three weeks of age. It is important to note that mortality rate records with high and low starch diets were three and two times, respectively, more than control diet (Table 2). This increase in total and diarrhea mortality rates may be due to server diarrhea as a result to lower digestibility of corn starch than barley starch

(Xiccato *et al.,* 2002), which resulted in an excessive starch flow entering the caecum and increasing the digestive disorders (diarrhea). These results are in agreement with those of **Gidenne *et al.,* (2005)** who found that mortality with rabbits fed diet containing wheat was three points lower than those fed diet with maize.

Digestibility and Nutritive Values:

Starch and fiber contents accounted for the main differences in chemical composition among three diets as a result of the substitution of berseem hay with cereals (Table 1). Digestibility coefficients of DM, OM, CP, EE and GE were significantly increased by 5.8, 4.6, 4.8, 10.3 and 4.9 points , respectively, as the level of starch increased from 10.1 to 25.8% in diets, while CF digestibility was increased (P<0.01) by 7.3 points with increasing the fiber level from 10.6 to 16.4 % in diets (Table 3). The increase in the digestion of nutrients could be attributed to decrease CF level in the H diet which led to increase the caecal microbial activity by reducing the rate of passage and increasing the retention time **(Gidenne *et al.,* 2004b** and **Amber, 2007**). The decrease in CF digestibility may be due to high quantities of starch entering the caecum, which could be unfavorable to fibrolytic **(Perez *et al.,* 2000)**.

Digestion of energy (DE) and protein (DCP) were significantly increased in rabbits fed H diet as a result to their high GE and CP digestion and decreased the CF level in this diet. Dietary starch and CF showed a slight effect on the TND, but it was significant. These results are in agreement with **Xiccato *et al.,* (2002)** who found that DM, OM, CP, EE and GE digestibility were higher (P< 0.001) in the high starch diet (20.6%) than those in moderate starch diet (17%). Also, **Toa and Li, (2006)** found that apparent digestibility of energy and CP decreased (P<0.05), while NDF digestibility increased (P<0.01) with increasing the NDF level in rabbit diets.

Caecotrophy Trials:

Table 4 shows that H diet caused a significant decrease in the DM intake (94 *vs.* 108 g/d), while L diet caused a significant increase in soft faeces (SF) excretion (25.4 *vs.* 15.9g DM/d) and also in caecal contents (33.5 *vs.* 25.7g DM) as level of starch increased from 10.1 to 25.8 in the rabbit diets.

This increase in SF excretion and caecal content may be due to increase the dietary fiber level, which leads an improvement of fibrolytic bacteria activity **(Gidenne *et al.,* 2004a)**. However, rich starch diet (H) resulted in an excessive starch flow entering the caecum, which could be unfavorable to fibrolytic flora **(Perez *et al.*, 2000)**. The DM % and CP % of the SF and caecal content were decreased (P<0.001) by increasing starch and decreasing fiber levels in the diets. This decrease may be due to the change in caecal microbial activity of rabbits, which caused a reduction of bacterial biomass **(Jehl and Gidenne, 1996)**. Diets had a significant effect (P<0.001) on DM and CP contribution of the SF to total DM and CP intake , due to differences in the DM in take , SF excreted and CP % of SF among the experimental diets. The highest (P<0.001) value of caecal turnover rate (CTR) was recorded by L diet (75.8%), followed by C diet (64.7%), while the lowest value was found by H diet (61.9%). This increase in the CTR means that caecal content of rabbits fed L diet (rich fiber level) tended to remain shorter time in the caecum. This could be explained by the increased SF production in this diet. This is in accordance with **Gidenne *et al.*, (2004b)**, who found that the decrease CF level leads to an increase of retention time and a reduction of both SF production and CTR by decreasing the bacterial fibrolytic activity.

Carcass Traits and Some Blood Parameters:

The results presented in the Table 5, showed that dressing % was increased (P<0.001) by 5.6 points due to a decrease (P<0.001) by 3.3 points in the gastrointestinal tract (GIT) percentage in the rabbits fed H diet as compared with those fed L diet .This is in accordance with **Xiccato *et al.*, (2002)** who observed that dressing % was higher (P<0.05) in rabbits fed high starch diet due to lower gut incidence.

Also, the same trend was obtained in the abdominal fat which was increased (P<0.001) by increasing the dietary starch level .This was reported by **Abdel –Azeem *et al.*, (2000)** who found rabbits fed high starch diets (20 or 28%) were significantly higher in the total non-carcass fat % than those fed high fiber diets (14 or 17%) caecal content and PH were lower (P<0.001) by 0.50 and 0.34 points, respectively, in rabbits fed H diet than in those fed L diet.

This reduction may be due to lower fiber level in this diet which leads to decrease in both the caecal weight and volatile fatty acids concentration **(Gutierrez *et al.*, 2002; Gidenne *et al*., 2004a and Tao and Li, 2006)**.

The meat content of DM, EE and ash % were significantly increased as the level of fiber increased in the diets, while CP% was significantly increased with increasing the dietary starch level. Similarly **Cossu *et al.*, (2004)** found that the meat content of heavier rabbits fed diets with high corn had more energy content, but were slightly fatter with a higher proportion of saturated fatty acid.

The blood parameters of rabbits fed the experimental diets are shown in Table 6. Plasma total protein and glucose were significantly increased in the rabbits fed H diet. This increase may be due to higher activity of proteolitic and amylolitic microflora in the caecum which led to better CP and starch digestibility **(Padilla *et al.*, 1995 and Xiccato *et al.*, 2002)**.

The same trend was found in total lipids and cholesterol, which were significantly increased with increasing the dietary starch level. On the contrary, **Abdel –Azeem *et al.*, (2000)** reported that dietary starch level did not reveal any significant differences in total protein and glucose while total lipids was significantly increased as the starch level increased.

Table 1: Formulation and chemical composition of experimental diets.

Ingredient	Dietary starch level		
	L	M	H
Berseem hay	41.4	54.9	31.3
Soybean meal (44%)	21.0	20.6	24.7
Yellow corn	14.1	15.6	40.5
Barley	17.7	-	-
Soybean oil	3.0	6.1	-
Limestone	-	-	0.5
Bone meal	1.9	1.9	2.1
Salt	0.2	0.2	0.2
Premix (1)	0.3	0.3	0.3
DL-methionine	0.2	0.2	0.2
Anti-fungi	0.1	0.1	0.1
Anti-oxidant	0.1	0.1	0.1
Total	100	100	100
Chemical analysis (% as DM):			
Ash	9.43	11.2	8.62
Crude protein (CP)	17.6	17.4	17.9
Crude fiber (CF)	13.4	16.4	10.6
Starch (2)	18.3	10.1	25.8
Dry matter (DM)	92.8	93.1	92.8
Ether extract (EE)	5.17	8.16	2.39
N-Free extract (NFE)	54.40	48.84	60.49
Digestible energy (Kcal/kg) DE	2439	2319	2618
Calcium (2)	1.25	1.28	1.22
Phosphorus (2)	0.62	0.59	0.61
Lysine (2)	0.92	0.95	0.91
Methionine (2)	0.47	0.45	0.49

(1) Each 3 Kg vitamin and mineral mixture provides: Vitamin A 12000000 IU, Vit.D3 2200000 IU, Vit. E 10000 mg, Vit.K,2000 mg, Vit.$B_1$1000mg, Vit.$B_2$4000mg, Vit.$B_6$1500mg, Vit.B_{12}10mg, Pantothenic Acid 10000mg, Niacin 20000mg, Biotin 50 mg, Folic Acid 1000mg, Choline chloride 500gm, Selenium 100mg, Manganese 55000mg, Zinc 50000mg, Iodine 1000 mg and carrier CaCo3, to 3000 gm.

(2) Calculated according to **De Blas and Mateos (1998)**

Table 2: Effect of dietary starch and fiber levels on growth performance of growing NZW rabbits from 5 to 13 weeks of age.

Item	Experimental Diets			SEM	Sig.
	C	L	H		
Initial body weight(g)	645	656	665	26.3	NS
Final body weight(g)	2281^{b}	2214^{c}	2524^{a}	42.6	**
Daily weight gain(g)	29.2^{b}	27.8^{c}	33.2^{a}	0.42	***
Feed intake (g/d)	106^{b}	116^{a}	101^{c}	0.39	***
Feed/gain(g/g)	3.63^{b}	4.17^{a}	3.04^{c}	0.029	***
Growth rate (%)	111.8^{b}	108.6^{c}	116.6^{a}	0.76	***
Performance index (%)	62.8^{b}	53.1^{c}	82.8^{a}	1.16	***
No. of dead rabbits	3	6	9	-	-
Total mortality (%)	10	20	30	-	-
Diarrhea mortality (%)	6.67	13.3	20	-	-

^{A,b,c} means the same row with different superscripts are significantly different (p<0.05).
C=control diet, L= low starch level, H= high starch level.
SEM= standard error of mean, Sig. = significant, NS= non significant, ** = p<0.01, ***= p<0.001.

Table 3: Effect of dietary starch and fiber levels on apparent digestibility coefficients and nutritive values of growing NEW rabbits.

Item	Experimental Diets			SEM	Sig.
	C	L	H		
<u>Digestibility coefficient:</u>					
DM	67.2^{b}	64.8^{c}	70.6^{a}	0.49	***
OM	66.7^{b}	65.3^{c}	69.9^{a}	0.54	***
CP	75.5^{b}	73.6^{c}	78.4^{a}	0.65	***
CF	24.5^{b}	26.9^{c}	19.6^{a}	2.15	***
EE	81.2^{b}	76.6^{c}	86.9^{a}	0.69	***
GE	65.2^{b}	63.6^{c}	68.5^{a}	0.75	***
<u>Nutritive values (%):</u>					
TDN	59.6^{b}	58.2^{c}	60.4^{a}	0.79	*
DCP	13.29^{b}	12.81^{c}	14.03^{a}	0.072	***
TE (kcal / g)	2.439^{b}	2.319^{c}	2.618^{a}	0.023	***

^{A,b,c} means in the same raw with different superscripts are significantly different (p<0.05).
C= control diet, L = law starch and high fiber levels, H= high starch and law fiber levels,
SEM = standard error of mean, Sig. = significant, * = p<0.01, *** = p<0.001.

Table 4: Effect of dietary starch and fiber levels on soft faeces excretion and caecal content of growing NZW rabbits.

Item	Experimental diets			SEM	Sig.
	C	L	H		
DM intake (g/d)	98^{b}	108^{a}	94^{c}	3.19	**
Soft faeces excretion (g DM / d)	19.6^{b}	25.4^{a}	15.9^{c}	0.56	***
Chemical composition of soft faeces:					
DM %	29.2^{b}	32.6^{a}	27.9^{c}	0.75	***
CP %DM	30.4^{b}	32.5^{a}	26.7^{c}	0.49	***
Relative contribution of soft faeces to:					
DM intake	16.7^{b}	19.0^{a}	14.5^{c}	0.39	***
CP intake	25.7^{b}	29.0^{a}	20.1^{c}	0.52	***
Caecal content (g DM)	30.3^{b}	33.5^{a}	25.7^{c}	0.39	***
Chemical composition of caecal content:					
DM %	35.2^{b}	37.3^{a}	31.6^{c}	0.56	***
CP %DM	28.4^{b}	30.9^{a}	24.9^{c}	0.28	***
Caecal turnover rate (%)	64.7^{b}	75.8^{a}	61.9^{c}	1.29	***

^{A,b,c} means in the same raw with different superscripts are significantly different (p< 0.05).
C= control diet, L = low starch and high fiber levels, H= high starch and low fiber levels,
SEM = standard error of mean, Sig. = significant, ** = p<0.01, ***= p<0.001

Table 5: Effect of starch and fiber levels on carcass traits of growing NZW rabbits.

Item	Experimental Diets			SEM	Sig.
	C	L	H		
Dressing (%)	57.5^{b}	55.9^{c}	61.5^{a}	112	**
GIT (%) BW	23.2^{b}	25.7^{a}	22.4^{c}	0.69	***
Abdominal fat (%) BW	3.11^{b}	2.73^{c}	3.82^{a}	0.11	***
Caecal content (%) BW	5.86^{b}	6.04^{a}	5.54^{c}	0.07	***
PH	6.23^{b}	6.35^{a}	6.01^{c}	0.04	***
Meat composition (%):					
DM	24.4^{b}	26.8^{a}	23.6^{c}	0.45	**
CP	69.4^{b}	67.3^{c}	70.9^{a}	0.68	**
EE	22.1^{b}	23.6^{a}	19.7^{c}	0.46	**
Ash	3.05^{b}	3.65^{a}	2.25^{c}	0.59	**

^{A,b,c} means in the same raw with different superscripts are significant different (P<0.05).
C=control diet, L= low starch and high fiber levels, H=High starch and Low fiber levels,
SEM=standard error of means, Sig. =Significant, **= P<0.01, ***= P<0.001.

Table 6: Effect of starch and fiber levels on some blood parameters of growing NZW rabbits.

Item	Experimental Diets			SEM	Sig.
	C	L	H		
Total protein (g/dI)	**5.69^{b}**	**5.02^{c}**	**6.13^{a}**	**0.05**	*****
Glucose (mg/dI)	**82.7^{b}**	**74.6^{c}**	**91.5^{a}**	**3.29**	******
Total lipids (g/L)	**5.22^{b}**	**4.82^{c}**	**6.89^{a}**	**0.14**	*****
Cholesterol (mg/dI)	**88.5^{b}**	**79.6^{c}**	**95.2^{a}**	**5.62**	******

^{A,b,c} means in the same raw with different superscripts are significantly different (P<0.05).
C=control diet, L= low starch and high fiber levels, H=High starch and Low fiber levels,
SEM=standard error of means, Sig. =Significant, **= P<0.01, ***= P<0.001

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الملخص العربى

تأثير مستويات النشا والألياف فى العليقة على الأداء الانتاجى للأرانب النيوزيلندى الأبيض المفطومة

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أجريت الدراسة على 90 ارنب نيوزيلندى أبيض مفطوم عمره 5 أسابيع بمتوسط وزن 655± 26.3جرام لدراسة تأثير المستويات المختلفة من النشا والالياف على الاداء الانتاجى والهضم وعملية الاجترار الكاذب وصفات الذبحية.

تم عمل ثلاثة علائق كنترول ومنخفضة ومرتفعة فى النشا تحتوى على 18.3% ، 10.1% ،25.8 على الترتيب وتحتوى على 13.4 % ،16.4 % ، 10.6 % الالياف على الترتيب تم تسجيل وزن الجسم الحى والعلف المستهلك أسبوعيا وبشكل فردى حتى عمر 13 أسبوع .

أوضحت النتائج زيادة كلا من الزيادة اليومية فى وزن الجسم ومعدل النمو ودليل الاداء معنويا بمقدار 19.4 ، 7.37 ، 55.9 نقطة على التوالى بينما أنخفض العلف المستهلك معنويا من 116 الى 101 جرام /يوم زيادة مستوى النشا فى العلف من 10.1 الى 25.8 % كما أظهرت النتائج تحسن معنوى فى معدل الكفاءة الغذائية بانخفاض مستوى الالياف فى العليفة (3.04 مقابل 4.17) كما لوحظ ارتفاع نسبة النفوق من 20 % الى 30 % مع زيادة نسبة النشا فى العلائق وارتفاع معامل هضم المادة الجافة والبروتين الخام والدهن والطاقة الكلية بينما أنخفض معامل هضم الالياف الخام مع زيادة مستوى النشا فى العلائق .تسبب العليقة المرتفعة فى النشا فى زيادة المادة الجافة المستهلكة (94مقابل 108 جرام/يوم) بينما العليقة المنخفضة فى النشا والمرتفعة فى الألياف أدت زيادة الروث الطرى (25.4 مقابل 15.9 جرام مادة جافة/يوم).

ارتفعت نسبة التصافى معنويا بمقدار 5.6 نقطة وذلك يرجع لانخفاض القناة الهضمية بمقدار 3.3 نقطة فى العليقة المرتفعة فى نسبة النشا كما لوحظ ارتفاع محتوى بلازما الدم من البروتين الكلى والجلوكوز والكوليستيرول والليبيدات الكلية بزيادة نسبة النشا وانخفاض مستوى الألياف فى العلائق.

مما سبق يتضح ان العليقة المرتفعة فى النشا (25.8%) والمنخفضة فى الالياف (10.6%) حققت أحسن كفاءة للاداء الانتاجى والاستفادة من العناصر الغذائية.