EFFECTS OF DIETARY NEUTRAL DETERGENT FIBER LEVELS ON FEED INTAKES, PRODUCTION PERFORMANCE AND NUTRIENTS UTILIZATION OF GROWING CROSSBRED RABBITS REARED IN MEKONG DELTA OF VIETNAM

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Effects of Dietary Neutral Detergent Fiber Levels on Feed Intakes, Production Performance and Nutrients Utilization of Growing Crossbred Rabbits Reared in Mekong Delta of Vietnam

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ABSTRACT

A study was conducted to determine the effects of different dietary neutral detergent fiber (NDF) levels on growth performance, nutrient digestibility, caecal fermentation and carcass value of crossbred (New Zealand × local) rabbits reared in Mekong delta of Vietnam. Seventy two rabbits at 8 weeks of age were randomly allocated to six treatments and three replications (2 males and 2 females per each experimental unit). The treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% (DM basis), respectively. The experimental period was 12 weeks, in which the samples collected for digestibility trial was for one week at the age of 13th week. The results showed that The DM, CP and ME intakes was numerically higher for the NDF36 and NDF39 treatments, however only their values of the NDF36 treatment were significantly higher ($P<0.05$) than the NDF42, NDF45 and NDF48 treatments. As a result the higher values of DWG and profit were higher for the NDF36 and NDF39 treatment. There were significant differences ($P<0.05$) of DMD and OMD among different treatments, but these were not found for CPD, EED, NDFD and ADFD ($P>0.05$). The DMD, OMD, NDFD and ADFD decreased with increasing dietary NDF. The nitrogen retention values decreased when increasing the dietary NDF. The conclusion was that the proper levels of dietary NDF concentration for growing crossbred rabbits from 8 to 20 weeks of age was from 36 to 39 %. Feed and nutrient intakes, growth and meat production were significantly affected by the dietary NDF levels.

Key Words: Rabbit, Fiber, Performance, Digestion, Growth Rate, Caecal Environment

INTRODUCTION

In recent years rabbit production and meat have been popular in the Mekong delta of Vietnam due to the human demands after the bird flu outbreak occurred. Rabbit production is good for commercial farm income and also for the poor producers. Crossbred rabbits (New Zealand × local) are widely raised in the Mekong delta because of a good adaptation to the local climate and feed resources. In this region researchers have studied on the utilization of available local feedstuffs for crossbred rabbits since year 2000 (Thu & Dong 2011), but studies on nutrient requirements of crossbred meat rabbits were lagged behind in the development process.

Crude fibre (CF) is an important structural matter of feed, a material of supplying energy and assuring rabbit health. The dietary CF levels not only affect feed consumption and nutrient supply, but also influence the nutrient digestion and absorption, production performance and health status of rabbits. NRC (1977) recommended that the dietary CF requirement of growing rabbits was 10-12%. AEC (1987) prescribed that the dietary CF requirement of pre-weaning rabbits was 12% and that of post-weaning rabbits was 14%. Similarly, Wang et al. (2012) indicated that the appropriate CF requirement of growing rabbits from weaned to 2.5 month-old was 14%. Currently, dietary neutral detergent fiber (NDF) or acid detergent fibre (ADF) substituting traditional CF has become a trend of fibre nutrition research, particularly for the herbivores. De Blas & Mateos (2010) suggested that the appropriate dietary NDF level for does was 32%, while this for growing rabbits varied from 20% to 35% (Gidenne et al. 2002; Tao & Li 2006; de Blas & Mateos 2010). However, studies of suitable NDF level for growing crossbred rabbits in the Mekong delta of Vietnam have been limited. Therefore the objectives of this study were to investigate the effects of different dietary NDF levels on feed and nutrient intakes, meat production and ceacum content of crossbred rabbits for the dissemination of results to producers.

MATERIALS AND METHODS

Animals and experimental design

Seventy two crossbred rabbits (New Zealand × local) at 8 weeks of age (624±5.79 g), were randomly allocated in an experiment of complete randomized design with six treatments and three replications (2 male and 2 female rabbits per each experimental unit). Rabbits in each experimental unit were individually housed in self-made metabolism cages which can separate urine from faeces. Each cage contained a feeder and water trough to provide free access to feed and water. Table 1 gave the ingredients and chemical composition of experimental diets. The experimental diets in different treatments were formulated with crude protein of 15.6% (DM basis) and metabolizable energy (ME) of 12.1 MJ/kg. The NDF levels of six experimental diets were 33, 36, 39, 42, 45 and 48% corresponding to NDF33, NDF36, NDF39, NDF42, NDF45 and respectively. The animals were vaccinated to prevent some diseases, especially rabbit hemorrhagic diarrhea and parasite diseases.

Experimental procedures

For the feeding and digestibility trials of the study the feeds including Para grass, water spinach leaves, broken rice and oil-extracted soybean were daily offered at 8:00, 11:00 and 17:00. The experimental period was 12 weeks in which the faeces and urine samples collected for measuring nutrient digestibility and nitrogen retention was one week at the age of the 13th week. Feeds and refusals were daily collected for the chemical analysis.

Measurement taken and chemical analysis

All experimental rabbits were monthly weighed for calculating the daily gain (DWG). The daily feed consumed was weighed and recorded for measuring feed and nutrient intakes and feed conversion ratio. After finishing the study all rabbits were slaughtered to evaluate the carcass values. Then meat was analyzed for the chemical composition (DM, OM, CP, EE and ash).

The feeds and refusals were taken for analyses of DM, OM, CP, EE, NDF, ADF, and Ash following the procedures of AOAC (1990) and van Sorest et al. (1991).

Table 1. Ingredients and chemical composition of experimental diets

Ingredients, % dietary DM	Dietary treatments[1]					
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48
Para grass	0.00	11.90	27.70	51.10	59.90	72.00
Water spinach leaves	82.30	70.70	48.70	16.50	10.20	0.00
Broken rice	9.32	7.97	11.40	16.80	13.80	11.00
Oil-extracted soybean	8.38	9.45	12.20	15.50	16.10	17.00
Chemical composition[2] (% DM)						
DM	7.25	7.39	8.12	9.58	9.48	9.54
OM	87.30	87.60	88.50	89.80	89.50	89.30
CP	15.60	15.60	15.70	15.60	15.60	15.60
EE	6.80	6.75	6.60	6.33	6.45	6.54
NDF	33.00	36.20	38.70	41.80	45.00	48.30
ADF	23.40	27.40	28.80	30.40	32.60	35.30
Ash	7.25	7.39	8.12	9.58	9.48	9.54
ME (MJ/kgDM)	12.10	12.10	12.10	12.10	12.10	12.10

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DM: Dry matter; OM: Organic matter; CP: Crude protein; EE: Ether extract; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ME: Metabolizable energy

Metabolizable energy (ME) was calculated by suggestion of Maertens et al. (2002). At the beginning of the experiment two rabbits per experimental unit were weighed individually and thereafter weekly. Daily feed intakes, growth rate, and feed conversion ratios were measured and calculated. After finishing the experiment all rabbits were slaughtered for evaluating the carcass values. After slaughtering, the caecum was removed and weighed with and without its content. The pH value of caecal content was determined by a pH meter. Then these samples were filtered with three layers of muslin cloth for analyzing ammonia-nitrogen (AOAC 1990) and total volatile fatty acids (VFA) concentration suggested by Barnett & Reid (1957).

Statistical analysis

All data were primarily calculated in Excel software, then analyzed for variance using the One-way model of the Minitab software (Minitab 2010). In comparison of the treatments, these mean values were analyzed using Tukey's test (Minitab 2010).

RESULTS AND DISCUSSIONS

Feed and nutrient intakes, growth performance and income

The effects of different dietary NDF levels on feed and nutrient intake and growth performance of experimental rabbits is shown in Table 2 and 3, respectively.

The DM, CP and ME intakes was numerically higher for the NDF36 and NDF39 treatments, however only their values of the NDF36 treatment were significantly higher (P<0.05) than the NDF42, NDF45 and NDF48 treatments. The EE and NDF intakes were significantly different among the treatment with the highest values for the NDF36 treatment. As a result the higher values of DWG and profit were higher for the NDF36 and NDF39 treatment.

Table 2. Feed and nutrient intake (gDM/day) of rabbits fed different level of NDF

Item	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Total DM	76.700^{b}	83.100^{a}	78.600^{b}	69.600^{c}	67.300^{cd}	63.700^{d}	0.911	0.001
CP	12.000^{c}	12.900^{a}	12.400^{b}	10.800^{d}	10.500^{e}	9.930^{f}	0.062	0.001
EE	5.210^{b}	5.610^{a}	5.180^{b}	4.410^{c}	4.340^{c}	4.170^{c}	0.053	0.001
NDF	25.300^{a}	30.400^{b}	30.300^{b}	29.100^{b}	30.300^{b}	31.100^{b}	0.578	0.001
ME, MJ/day	0.924^{b}	1.000^{a}	0.950^{ab}	0.845^{c}	0.816^{cd}	0.773^{d}	0.011	0.001

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DM: Dry matter; CP: Crude protein; EE: Ether extract; NDF: Neutral detergent fiber; ME: Metabolizable energy
The data with different superscript letters in the same row differ significantly (P<0.05)

Table 3. Growth performance and economic return of experimental rabbits

Item[2]	Treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Initial live weight (g)	628.00	623.00	628.00	622.00	625.00	618.00	16.700	0.998
Final live weight (g)	2062.00^{bc}	2253.00^{a}	2178.00^{ab}	1993.00^{cd}	1903.00^{d}	1690.00^{e}	32.500	0.001
DWG (g/day)	17.10^{bc}	19.40^{a}	18.50^{ab}	16.30^{c}	15.20^{c}	12.80^{d}	0.411	0.001
Feed conversion ratio	4.50	4.29	4.26	4.26	4.42	5.00^{b}	0.100	0.002
Total cost (VND)	132,734	137,111	136,242	131,443	127,761	123,215	-	-
Income (VND)	164,933	180,267	174,267	159,467	152,267	135,200	-	-
Profit, VND	32,199	43,155	38,024	28,023	24,505	11,985	-	-

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45, and 48% DM, respectively
[2] DWG: daily weight gain; the total cost consisted of feeds, rabbits costs; profit = Income - total cost

However only the DWG of the NDF36 treatment was significantly higher ($P<0.05$) than that of the treatments of NDF33, NDF42, NDF45 and NDF48. The daily DM intake and DWG increased when the increasing dietary NDF from 33 to 36%, then they were reduced when increasing the dietary NDF from 39 to 48 %. This study also showed that there was a close relationship between DM intakes and dietary NDF levels (x, %) with

$$y = -16.8 + 5.71x - 0.085x^2 \ (R^2 = 0.857)$$

Similarly there were also close relationships between DWG and FCR, and dietary NDF levels with

$$y = 50.9 + 3.74x - 0.050x^2, R^2 = 0.94$$
$$y = 18.8 + 0.7474x + 0.0096x^2 \ (R^2 = 0.951), \text{ respectively}$$

In a study of dietary NDF for growing rabbit de Blas et al. (1985) indicated that there were significant differences in DWG in growing rabbits from 28 to 49 days of age between 30% and 21% NDF treatment. In suckling rabbits from 21 to 30 days of age a linear decrease of DWG with increasing level of fibre in the diets (de Blas et al. 1985). Gutierrez et al. (2002) reported that an increase of dietary NDF concentration from 30% to 36% led to a decrease in DWG and feed efficiency in rabbits from 25 to 39 days of age. Gidenne et al. (2002) observed the effect of a dietary fibre on the rabbit around weaning and indicated that DWG of group fed 31% NDF diet was lower than that of 19% NDF one. Rabbits at 2 to 3 months of age when feeding diets of NDF concentration from 24% to 30% led to an increase in DWG and feed efficiency and then having a decrease of DWG of NDF diets from 30% to 36% (Tao & Li 2006).

Nutrients digestibility and nitrogen balance

The effects of different dietary NDF on the total tract apparent digestibility of nutrients and nitrogen balance of experimental rabbits was shown in Table 4.

There were significant differences ($P<0.05$) of DMD and OMD among different treatments, but these were not found for CPD, EED, NDFD and ADFD ($P>0.05$). The DMD, OMD, NDFD and ADFD decreased when increasing the dietary NDF. There were significant differences ($P<0.05$) in nitrogen intake (NI) and nitrogen retention (NR) among the treatments. The NI and NR decreased when increasing dietary NDF. The regression function between DMD (y, %) and dietary NDF levels (x, %) was

$$y = -1.06x + 112 \ (R^2 = 0.980),$$

NDFD (y, %) and dietary NDF levels (x, %) was

$$y = -0.695x + 83.3 \ (R^2 = 0.946)$$

and ADFD (y, %) and dietary NDF levels (x, %) was

$$y = -0.967x + 77.4 \ (R2 = 0.915)$$

Table 4. Total tract apparent digestibility of nutrients (%) and nitrogen retention of experimental rabbits

Item[2]	Treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
DMD	77.500^{a}	73.200^{ab}	70.600^{ab}	67.300^{ab}	65.500^{ab}	60.100^{b}	2.890	0.015
OMD	77.800^{a}	73.800^{ab}	71.500^{ab}	68.700^{ab}	61.100^{ab}	62.200^{b}	2.910	0.024
CPD	79.700	79.900	79.600	80.500	79.500	79.300	2.640	0.999
EED	93.900	93.700	93.900	93.100	93.200	93.300	0.513	0.745
NDFD	60.700	57.000	56.500	54.100	53.700	48.400	4.460	0.536
ADFD	43.600	42.500	41.500	36.700	36.000	28.000	6.290	0.535
N intake (g)	1.370^{b}	1.530^{a}	1.510^{a}	1.410^{b}	1.280^{c}	1.220^{c}	0.008	0.001
N retention (g)	0.791^{a}	0.791^{a}	0.725^{ab}	0.550^{ab}	0.439^{ab}	0.389^{b}	0.083	0.013
N retained percentage	57.600	51.700	47.900	39.000	34.200	31.900	5.900	0.055

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DMD, OMD, CPD, EED, NDFD and ADFD: total tract digestibility of DM, OM, CP, EE, NDF and ADF
The data with different superscript letters in the same row differ significantly ($P<0.05$)

and NR percentage (y, %) and dietary NDF levels (x, %) was

$$y = -1.74x + 114.6$$
$$(R^2 = 0.966)$$

In the study, when increasing dietary NDF, generally the DMD, OMD, NDFD and ADFD decreased. These results were similar to those showed by other authors such as de Blas et al. (1985) indicated that nutrient digestibility was dropped when dietary NDF level was from 31 to 41% and Rodriguez et al. (2011) also reported that DMD, OMD and NDFD were dropped when increasing dietary NDF level from 37 to 46%.

Carcass values and meat quality

The effect of different dietary NDF on meat production and quality were shown in Table 5.

There were no significant differences in carcass, lean meat and thigh meat percentages, and fresh meat nutrients composition among different treatments ($P>0.05$). However, weights of carcass, meat and thigh meat weight of NDF36 and NDF39 were numerically somewhat higher than the NDF42, NDF45 and NDF48 treatments.

Caecal development and fermentation activity

The effects of different dietary NDF levels on caecum development and fermentation of experimental rabbits is shown in Table 6.

Caecum content weight (y) significantly decreased when increasing dietary NDF (x) with regression function

$$y = 331 – 5.12 x$$
$$(R^2 = 0.864, SE = 13.7, P = 0.009)$$

and there were a significant difference among different treatments ($P<0.001$). The digestive system of the rabbit is characterized by the relative importance of the caecum when compared with other species.

The capacity of the caecum is approximately 49% of the total capacity of the digestive tract (Carabano et al. 2010). The caecum plays an important role in the digestion of fiber. Garcia et al. (1999) and Gidenne *et al.* (2002) also indicated that the caecal content weight dropped when dietary NDF increased. However, it should be considered that the live weight of rabbits also contributed to this reduction of the ceacal weight in the present study.

Table 5. Carcass value and meat quality of experimental rabbits

Variable[2]	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Live weight (g)	2043^{ab}	2227^{a}	2073^{ab}	1907^{b}	1933^{b}	1863^{b}	57.2	0.007
Carcass weight (g)	973	1030	1015	937	927	860	36.3	0.056
Carcass percentage (%)	47.6	46.3	49.0	49.1	48.0	46.2	1.26	0.458
Lean meat weight (g)	722	766	738	580	667	600	72.8	0.408
Lean meat percentage (%)	74.2	74.4	72.7	60.5	71.9	69.8	6.38	0.652
Thigh meat weight (g)	387	417	376	357	370	339	21.9	0.272
Thigh meat percentage (%)	39.7	40.4	37.0	38.4	39.9	39.4	1.73	0.760

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45, and 48% DM, respectively
[2] DM: Dry matter; OM: Organic matter; CP: Crude protein

Table 6. Fermentation activities in ceacum of experimental rabbits

Variable[2]	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Ceacal weight (g)	167^{a}	160^{ab}	114^{bc}	105^{c}	101^{c}	96.7^{c}	10.5	0.001
pH	6.18	5.90	6.27	5.81	6.02	6.00	0.121	0.157
NH_3-N (mg/100ml)	59.6^{d}	63.7^{d}	69.3^{cd}	91.6^{a}	86.7^{ab}	75.4^{bc}	3.14	0.001
VFA (mM)	114^{b}	122^{b}	133^{ab}	153^{a}	128^{b}	117^{b}	4.53	0.001

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] NH_3-N, ammonia-nitrogen; VFA, total volatile fatty acid
The data with different superscript letters in the same row differ significantly (P<0.05)

The pH value of caecal content was not significantly different (p>0.05) among different treatments. The pH of caecal content may evaluate the extent of caecal fermentation and was negatively correlated to the diarrhea rate of rabbit. There were significantly different in the NH_3-N and VFA concentration of caecum among different treatments ($p < 0.001$). The NH_3-N and VFA concentration of caecum gradually increased when increasing the dietary NDF increased from 33 to 42%, then they decreased when increasing the dietary NDF from 42 to 48%. Volatile fatty acids were main products of carbohydrate fermented by micro-organism, so the concentration of VFA may evaluate fermentation extent and activity of micro-organism. Volatile fatty acids were rapidly absorbed by hindgut and supplied energy.

CONCLUSION

The conclusion was that the proper levels of dietary NDF concentration for growing crossbred rabbits from 8 to 20 weeks of age was from 36 to 39 %. Feed and nutrient intakes, growth and meat production were significantly affected by the dietary NDF levels. Increasing dietary NDF levels from 39 % could decrease the feed intake, nutrient digestibility, nitrogen retention and daily weight gain. The ceacal N-NH_3 and VFAs values in the present study did not support for the results of nutrient intakes, growth rate and meat production.

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Effects of dietary neutral detergent fiber (NDF) levels on feed intakes, production performance and nutrients utilization of growing crossbred rabbits reared in Mekong delta of Vietnam

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Conclusion

The proper levels of dietary NDF concentration for growing crossbred rabbits from 8 to 20 weeks of age was from 36 to 39 %. Feed and nutrient intakes, growth and meat production were significantly affected by the dietary NDF levels. Increasing dietary NDF levels from 39 % could decrease the feed intake, nutrient digestibility, nitrogen retention and daily weight gain. The ceacal N-NH3 and VFAs values in the present study did not support for the results of nutrient intakes, growth rate and meat production.

Crossbred rabbit

Para grass (*Brachiaria mutica*

Introduction

Currently, dietary neutral detergent fiber (NDF) or acid detergent fibre (ADF) substituting traditional CF has become a trend of fibre nutrition research, particularly for the herbivores. De Blas and Mateos (2010) suggested that the appropriate dietary NDF level for does was 32%, while this for growing rabbits varied from 20% to 35% (Gidenne *et al.*, 2002; Tao and Li, 2006 and de Blas and Mateos, 2010).

The objectives of this study were to investigate the effects of different dietary NDF levels on feed and nutrient intakes, meat production and ceacum content of crossbred rabbits for the dissemination of results to producers.

Materials and methods

Seventy two crossbred rabbits balanced in sex (New Zealand x Local) at 8 weeks of age (624 ± 5.79 g), allocated in an experiment of complete randomized design with six treatments and three replications.

The experimental diets in different treatments were formulated with crude protein of 15.6 % (DM basis) and metabolizable energy (ME) of 12.1 MJ/kg. The NDF levels of six experimental diets were 33, 36, 39, 42, 45 and 48 % corresponding to NDF33, NDF36, NDF39, NDF42, NDF45 and respectively.

Para grass, water spinach leaves, broken rice and oil-extracted soybean were daily offered. The experimental period was 12 weeks, in which nutrient digestibility and nitrogen retention was measured was for one week at the age of the 13th week.

Results and discussion

Table 1. Feed and nutrient intake (gDM/day), growth and economic analysis of rabbits fed different levels of NDF.

Item	Dietary treatments						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Intake, g DM								
Total DM	76.7^{b}	83.1^{a}	78.6^{b}	69.6^{c}	67.3^{cd}	63.7^{d}	0.911	0.001
CP	12.0^{c}	12.9^{a}	12.4^{b}	10.8^{d}	10.5^{e}	9.93^{f}	0.062	0.001
EE	5.21^{b}	5.61^{a}	5.18^{b}	4.41^{c}	4.34^{c}	4.17^{c}	0.053	0.001
ME, MJ/day	0.924^{b}	1.00^{a}	0.950^{ab}	0.845^{c}	0.816^{cd}	0.773^{d}	0.011	0.001
Growth and Economic return								
Final LW, g	2062^{bc}	2253^{a}	2178^{ab}	1993^{cd}	1903^{d}	1690^{e}	32.5	0.001
DWG, g/day	17.1^{bc}	19.4^{a}	18.5^{ab}	16.3^{c}	15.2^{c}	12.8^{d}	0.411	0.001
FCR	4.50	4.29	4.26	4.26	4.42	5.00^{b}	0.100	0.002
T. cost, VND	132,734	137,111	136,242	131,443	127,761	123,215		
Income, VND	164,933	180,267	174,267	159,467	152,267	135,200		
Profit, VND	32,199	43,155	38,024	28,023	24,505	11,985		

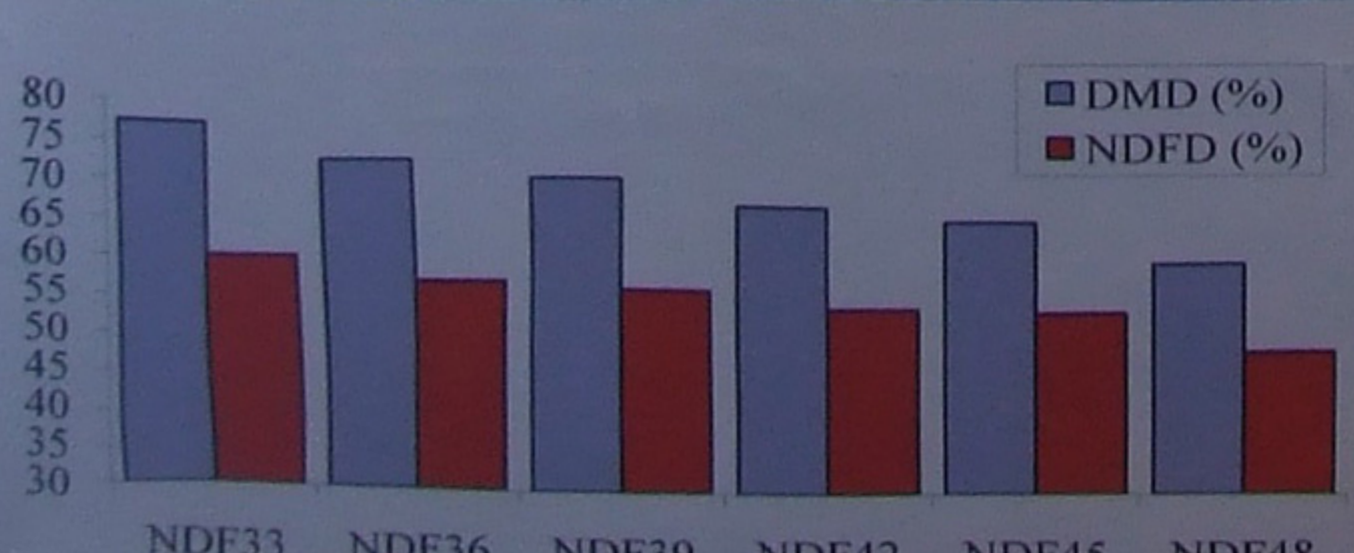

Fig 1. Apparent digestibility of DM and NDF (%) of different treatments

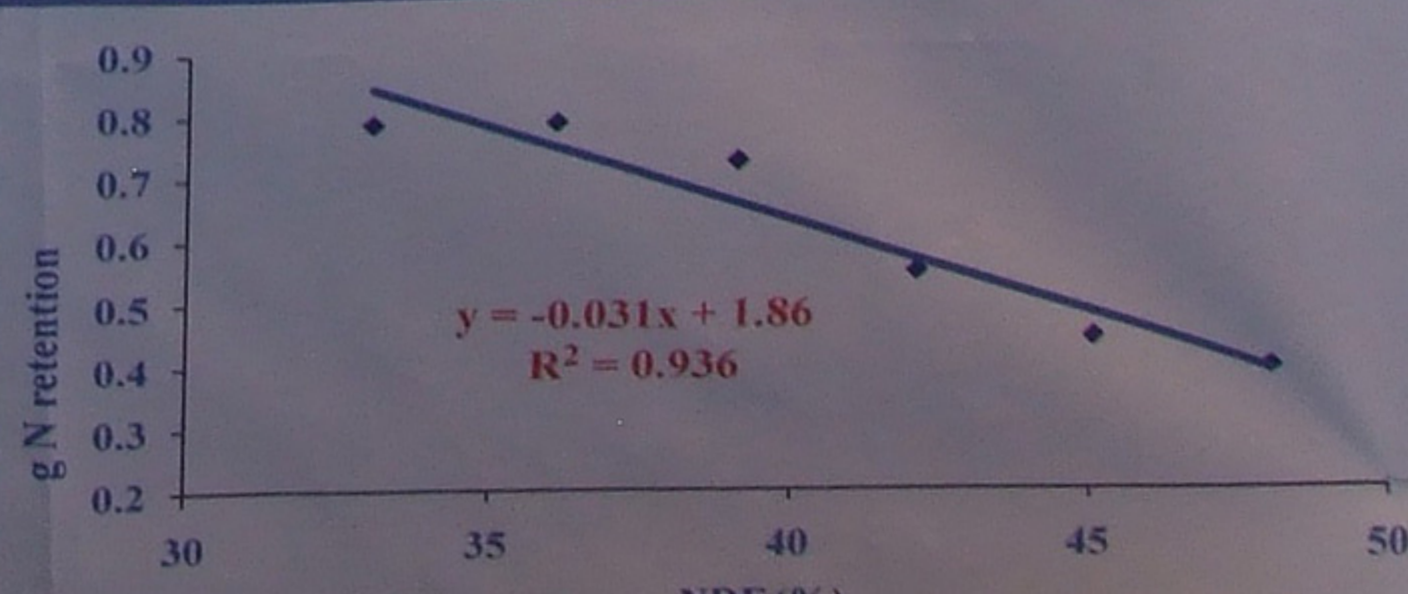

Fig 2. Nitrogen retetion (g/day) of rabbits fed different NDF levels (%)