PRACTICAL RECOMMENDATIONS ON MINIMUM AND MAXIMUM FIBER LEVELS IN RABBIT DIETS

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Abstract - Sixty rabbits NZW x Calfornian. of both sexes, weaned at four weeks of age were fed on four combinations of starter- finishing isonitrogenous-isocaloric diets : 7.20-10.50,10.50-14.09,14.00-17.05,17.5-20.81% CF respectively. Growth and food intake were measured over 8 weeks. Carcass characteristics and economic evaluation were also carried out at the termination of the study. The experimental diets had significant influences on body weight and feed intake during the starter or finisher periods. Highest body weight and feed intake were recorded by rabbits of Group 3 (14.0- 17.5% CF) and that of Group 4 (17.5- 20.81% CF) respectively. Lowest weight gain and feed intake were recorded by rabbits of Group 1 which was fed on 7.2% CF during the starter-grower period and switched on 10.5% CF during the finisher one.

Feed efficiency (FE) during the starter-grower period ($p<0.01$) (4-8 weeks of age) was 2.484±0.145, 2.596±0.11, 2.740±0.06 and 3.116±0.066 feed(g)/gain(g) for Groups 1, 2, 3 and 4 respectively, while the corresponding ones of the finisher period ($p<0.01$) (8-12 weeks of age) was 2.966±0.071, 3.241±0.235, 3.420±0.026 and 4.205±0.116 respectively.

The mortality rate (MR %) during the first 4 weeks of the experimental period was: 26.67, 20.0, 6.6 and 6.6 for the experimental Groups 1, 2, 3 and 4 respectively, showing that MR was the highest ($p<0.01$) in the diet with the lowest fiber content (7.2%) and the mediate one (20%) attained with the 10.52% CF after which it decreased to reach 6.6% with the increase of CF (10.5 - 14.09 - 17.5%).

Carcass weights as percentage of live body weight were increased significantly ($p<0.01$) (52.16%) with increasing CF level up to 14% starter & 17.5% finishers after which it decreased (49.4%) by increasing CF level. Maximum profit according to the present results could be obtained by using the maximum fiber level 14% and 17.5% during Starter finisher periods respectively.

Therefore, from nutritional and economical point of view, the minimal fiber requirement of NZW x Californian. rabbits to avoid digestive disorders, increase in MR and to maximize their profit was found to be 10.52 CF during 4-8 weeks of age and 14.09% CF during 8-12 weeks, and that of the maximal fiber one was found to be 14% CF VS 17.5% CF during the same periods.

INTRODUCTION

Crude fiber is the more usual index to express the minimal fiber requirements of rabbits. Another characteristic used to express recommendations of minimum fiber level in rabbits is the indigestible fiber content of the diet (de BLAS *et al.*, 1986). This index has as an advantage its better correlation with the ballast effect of fiber; however, practical utilisation of this unit presents difficulties derived from its variability. Fiber content of the diet also had an effect on several digestive characteristics.

SPREADBURY and DAVIDSON (1978) suggested that 11.1% ADF of DM is enough to avoid digestive disorders, but this value is four units lower than that obtained in the work of de BLAS *et al.*, (1986).

In this study, an initial trial was conducted to determine the effects of varying dietary fiber levels on performance, digestibility, caecum weight and length and carcass characteristics in growing rabbits.

MATERIAL AND METHODS

Sixty rabbits NZW x Californian. of both sexes, weaned at four weeks of age were fed on eight isonitrogenous-isocaloric diets (4 starter-Grower) of 7.2, 10.52, 14.0 & 17.5%. CF and (4 finisher diets) of 10.5, 14.09, 17.5 and 20.81% CF as shown in Table 1. Growth and feed intake were measured over 8 weeks. At the termination of the study. digestibility trials were carried out to obtain the apparent digestion coefficients of each component and to calculate the nutritive values of the experimental diets. Carcass characteristics, caecum measurements and economic evaluation were also carried out.

Table 1 : Composition of the experimental diets

	Starter-Grower diets 4 to 8 week				Finisher diets 8 to 12 week			
Diets No.	1	2	3	4	5	6	7	8
CF%	7.2	10.52	14.0	17.5	10.5	14.09	17.5	20.81
Ingredient:								
Soybean meal	-	3	15.5	16.5	11.5	19	12	4.2
Clover hay	2	18.5	39	58.5	22	12	8.5	-
Clover straw	-	-	-	-	-	20	25.7	18
Wheat bran	47	40.5	26	14	19	-	-	-
Yellow corn	-	-	-	6.9	14	25	34.2	32
Barley	-	-	-	-	30	19.2	-	-
Cotton seed meal	5	4	-	-	-	-	-	-
Sunflower meal	-	-	-	-	-	-	15	32
Sorghum	26	17.5	14.5	-	-	-	-	-
Gluten meal	8	10	-	-	-	-	-	-
Yeast	4	-	-	-	-	-	-	-
Saw dust	-	-	-	-	-	-	-	9
Sunflower oil	-	-	-	-	-	-	1.1	1.15
Methionine	0.09	0.29	0.25	0.30	0.3	0.21	0.2	0.14
Venasses	5	5	4	3	2	3	2	2
Limestone	1.01	0.31	-	-	0.3	0.5	0.4	0.36
Min & Vit.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Bone meal	1.2	0.2	0.15	0.2	0.3	0.39	0.3	0.55
Salt	0.4	0.4	0.3	0.3	0.3	0.4	0.3	0.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Calculated composition:								
CP%	17.51	17.82	18.03	18.1	15.01	15.1	15.02	15.09
CF%	7.2	10.52	14.0	17.5	10.5	14.09	17.5	20.81
*DE, Kcal/kg	2549	2543	2509	2510	2936	2905	2905	2902
C/P ratio	145.6	142.3	139.2	138.7	195.6	192.4	193.4	192.3
Chemical composition:								
CP%	17.75	17.89	18.44	18.17	15.45	15.45	15.50	14.61
CF%	7.15	10.22	13.90	17.36	10.10	14.01	17.24	20.88

* Calculated according to NRC for Rabbits (1977), ALLAM (1979) and INRA (1984).

The rabbits were housed in building hutches with a stainless-steel screen (S.S.S) beneath it to allow free passage of urine and faeces, but in case of digestibility trials, the previous (S.S.S) was followed by another ones having 4 mm mesh to retain faeces but allow free passage of urine. Faeces of each rabbit were collected, weighed daily during the collection period, and dried in an electric oven at 60°C for 16 hours. The proximate analysis was carried out on representative samples of the different diets and faeces under study following the conventional methods of the A.O.A.C. (1988). Results were subjected to factorial ANOVA (Snedecor and Cochran, 1980). A regression analysis of live weight V. age for the 8-week period was carried out to obtain the weekly growth rates and a regression analysis of digestibility of DM, OM, CP, EE, CF and NFE in relation with the CF content was undertaken to clarify the relation between digestibility of each component and the CF content in the experimental diets.

RESULTS AND DISCUSSION

Growth performance and feed utilization

The average live body weight of all rabbits within the experimental groups increased with advance of age). The experimental diets had significant influence on body weight and feed intake during the starter or finisher periods as shown in Table 2. Highest body weight and feed intake were recorded by rabbits of Group 3 and. that of group 4 respectively. Lowest weight gain and feed intake were recorded by rabbits of group 1 which was fed on 7.2% CF during the starter-grower period and switched on 10.5% CF during the finisher one. The relationship between live weight and age was studied through studying the linear regression of average weekly

live weight on age (during the experimental period from 4 to 12 weeks of age) within the four groups. The following regression lines were obtained :

Group No.	Linear regression equation	r^2	significance (p<0.01)
1	$Y_1 = 141.262 x + 32.409$	0.99	xx
2	$Y_2 = 166.57 x - 70.117$	0.99	xx
3	$Y_3 = 183.774 x - 149.168$	0.99	xx
4	$Y_4 = 164.727x - 50.605$	0.99	xx

where « Y » is the expected live body weight and « X » is the age in weeks. The regression coefficient for the four regression lines were highly significant (P < 0.01). The weekly growth rate (regression coefficient) from the equations under study were : 141.262, 166.570, 183.774 and 164.727 g for groups 1, 2, 3 and 4 respectively.

Table 2 : Effect of feeding different levels of crude fiber on rabbit performance.

	Group 1	Group 2	Group 3	Group 4	Significant
CF % Starter	7.15	10.22	13.90	17.36	cont. of
CF % finisher	10.1	14.01	17.24	20.81	differences
No. of rabbits :	10	12	14	14	
Initial body weight (g) at 4 week	621.67	620.33	628.67	632.00	n.s
S.E. ±	±8.09	±4.891	±6.68	±5.46	
Daily live weight gain (g/day):					
(4-8) week.	17.119 B	22.471 A	24.811A	23.405 A	**
S.E. ±	±0.85	±0.851	±1.055	±0.966	
(8-12) week.	23.15 B	23.814AB	25.483 A	22.23 B	*
S.E. ±	0.637	±1.08	±0.86	±0.5	
Feed Intake (g/day):					
(4-8) week.	42.53 C	58.341 B	67.985 A	72.93A	**
S.E. ±	±1.423	±4.834	±0.49	±1.48	
(8-12) week.	68.657 B	77.178 B	87.152 A	93.482A	**
S.E. ±	±2.657	±3.869	±0.80	±2.86	
Feed efficiency (Feed(g)/gain(g)):					
(4-8) week	2.484 B	2.596 B	2.740 A	3.116 A	**
S.E. ±	±0.145	±0.11	±0.06	±0.066	
(8-12) week.	2.966 B	3.241 B	3.42 B	4.205 A	**
S.E. ±	±0.071	±0.235	±0.026	±0.116	
Energy intake (K cal/DE/kg/day):					
(4-8) week	108.409 C	148.361 B	170.574 A	183.054 A	**
S.E.±	±3.629	±12.29	±1.253	±3.715	
(8-12) week	201.56 B	224.202 B	253.176 A	271.284 A	*
S.E.±	±7.79	±11.241	±2.326	±8.31	
Energy efficiency (DE intake/gain):					
(4-8) week	6.33 B	6.602 B	6.875 AB	7.821A	**
S.E.±	±0.363	±0.280	±0.138	+0.165	
(8-12) week	8.706 B	9.415 B	9.935 B	12.204A	**
S.E.±	±0.210	±0.683	±0.075	+0.335	
Mortality rate %					
(4-8) week	26.67A	20.0B	6.6C	6.6C	**
(8-12) week	9.09	0.00	0.00	0.00	
Dressing weight %	50.81B	51.84A	52.16A	49.40C	**
S.E.±	±0.22	±0.15	±0.15	±0.52	
Net return, pound	6.584	7.554	8.219	7.235	
Economic efficiency	502.6	497.63	501.77	432.0	

A, B, C and D Means within the same row showing different letter are significantly different (P < 0.05).
n.s. non significantly ; * (P < 0.05) ** (P < 0.01).

The present data of average live weight are in good agreement with those obtained by ABOUL-ELA *et al.* (1979) and RADWAN and ALLAM (1979). The relative growth rate (RGR) values fluctuated widely throughout the experimental periods (4-12 weeks of age) . During the starter grower period (4-8 weeks of age) group 3 (14% CF) recorded the highest ($p<0.01$) (27.648) while that of group 1 (7.2% CF) recorded the lowest one (19.279). The RGR values during the finisher period ($P<0.01$) (8-12 weeks of age) decreased with the increase of CF in the diets to reach the lower one (12.187) with group 4(20.81% CF). Also RADWAN and ALLAM (1979) found that the high levels of dietary CF, i.e. 20.03 and 24.07% caused growth retardation. Feed efficiency (FE) during the starter-grower period ($P<0.01$) (4-8 weeks of age) was: 2.484±0.145, 2.596±0.11, 2.740±0.06 and 3.116±0.066 feed(g)/gain(g). of groups 1, 2, 3 and 4 respectively, while the corresponding ones of the finisher period ($P<0.01$)(8-12 weeks) was : 2.966±0.071, 3.241±0.235,3.420±0.026 and 4.205±0.116 respectively. Assuming the least FE equals 100% (group 1), the relative one for group 2, 3 and 4 would be : 105, 110 & 125 during the starter period and 109, 115 and 142 during the finisher one showing an increase of 5-42% in FE as CF increase in the diet. energy efficiency utilization (EEU) as shown in Table 2.

The mortality rate % (MR) during the first 4 weeks of the age was 26.67, 20.0, 6.6 and 6.6 for the experimental groups, 1, 2, 3 and 4 respectively, showing that MR was the highest ($P<0.01$) in the diet with the lowest fiber content (7.2%) and the mediate one (20%) attained with the 10.52% CF after which it decreased to reach 6.6% with the increase of CF (10.5 - 14.09 - 17.5%).

Digestibility and nutritive values of the experimental diets

Digestibility of DM %, OM %, CP % and CF % of starter-grower diets decreased as the CF content in these diets increased (7.2 - 17.5% CF) as shown in Table 3. These values were the highest in the lowest CF (7.2%) and the lowest in the highest one (17.5%). CHEEKE (1987) reported that the digestibility of fiber was between 15% and 60% for feeds high in cellulose and lignin (e.g. alfalfa or grass) and for nonlignified material such as beet pulp, respectively. He added that it is desirable to use feeds with a low content of indigestible fractions which could have high digestibility and consequently high nutritional value. The recommended levels of CF are 10-17% which avoid reduced growth and the restriction of energy intake that occurs with levels in excess of 17% (De BLAS *et al.* 1986). The NFE digestibility was increased as CF level increased in the diets (7.2-17.5% CF). Results of EE digestibility, were without any special trend. The minimal fiber level obtained in this work (10.52% CF) is close to that of De BLAS *et al.* (1986):11.7% CF and to the recommendations or NRC (1977). The CF digestibility in finisher diets is lower than that in starter-grower diets (as shown in Table 4), and the vice versa with NFE digestibility. It is worthy noting that CF digestibility was decreased by increasing the CF content in the diets from 10.1 up to 20.88%. The feeding values or DCP, TDN and DE for the starter- grower diets were ranged from 12.41 13.93, 52.92, 56.16 and 2357-2509 Kcal DE/kg, respectively and the corresponding ones for the finisher diets was : 10.39 - 11.31%, 59.44-66.01 and 2610-2894 Kcal DE/kg diet respectively.

Table 3 : Influence of fiber levels and low energetic concentration on digestibility of starter diets compound in (NZW x cal) rabbits.

Diet No.	Apparent digestion coefficients %						Nutritive values		
	DM%	OM%	CP%	EE%	CF%	NFE%	DCP%	TDN%	DE (Kcal/kg)
Diet 1 (7.15CF%)	65.46A ±0.38	66.32A ±0.128	78.48A ±0.33	65.28A ±0.27	43.72A ±0.48	65.1B ±0.27	13.93A ±0.06	56.16A ±0.04	2509.85A ±10.93
Diet 2 (10.22CF%)	64.41A ±0.572	65.02AB ±0.173	74.74B ±0.99	67.5A ±0.87	39.49AB ±1.12	66.59AB ±0.78	13.37B ±0.18	55.95A ±0.13	2495AB ±14.87
Diet 3 (13.9CF%)	61.99AB ±0.96	62.87BC ±1.30	71.16C ±0.87	59.87A ±1.81	33.6BC ±1.2	67.77AB ±1.3	13.12B ±0.16	54.01AB ±0.99	2411.5AB ±12.76
Diet 4 (17.36CF%)	58.98B ±0.912	60.83C ±0.31	68.32D ±0.32	63.25A ±1.51	28.98C ±1.323	69.77A ±1.07	12.41C ±0.063	52.9B ±0.68	2357.47B ±20.77
Significant of difference	*	*	**	n.s	**	n.s	**	*	*

A, B, C and D Means within the same column showing different letter are significantly different ($P < 0.05$).
n.s. non significantly * ($P < 0.05$) ** ($P < 0.01$).

With regard to caecum weight/body weight ratios values were($p<0.01$) : 1.87±0.58, 1.88±0.02, 2.01±0.04 and 2.32±0.03 for groups 1, 2, 3 and 4 respectively and the corresponding ones for caecum length/body weight ratios values were : 1.87±0.01, 1.74±0.02, 1.47±0.02 and 1.42±0.03 respectively showing that while the first ratios increase, the second ones decrease. These results are in agreement with those reported by HOOVER and

HEITMANN (1972) who referred the change in caecum weight per unit body weight to the greater quantity of fiber in diet. Ratios of caecum lengths/ caecum weights ($p<0.01$)were: 1.002±0.04, 0.92±0.02, 0.73±0.02 and 0.61±0.02 for groups 1, 2, 3 and 4 respectively. It is worthy noting that these ratios decrease as ratios of CF increase in diets. These results agree with those of RADWAN (1990) who found that composition and type of diet cause a change in caecal weight.

Table 4 : Influence of fiber levels and low energetic concentration on digestibility of finisher diets in (NZWxcal)rabbits.

Diet No.	Apparent digestion coefficients %						Nutritive values		
	DM%	OM%	CP%	EE%	CF%	NFE%	DCP%	TDN%	DE (Kcal/kg)
Diet 5(10.10CF%)	72.88A ±2.74	73.95A ±0.58	73.42A ±1.27	83.15AB ±1.54	34.08A ±1.01	78.81A ±2.35	11.31A ±0.19	66.01A ±1.4	2894A ±3.52
Diet 6(14.01CF%)	69.81AB ±0.20	71.52A ±0.12	72.99A ±0.38	81.52B ±0.25	32.15A ±0.51	80.73A ±0.28	11.28A ±0.06	64.99A ±0.16	2849.74AB ±20.46
Diet 7(17.24CF%)	65.35BC ±0.50	67.68B ±0.61	71.46A ±0.71	84.47AB ±0.74	27.56B ±0.74	78.94A ±1.018	11.08A ±0.11	62.75A ±0.67	2757.65B ±29.12
Diet 8(20.88CF%)	62.29C ±1.45	63.26C ±3.23	71.14A ±0.22	85.28A ±0.600	18.68C ±1.01	78.62A ±2.5	10.39B ±0.04	59.44B ±0.04	2610.83C ±36.83
Significant of difference	*	**	n.s.	n.s.	**	n.s.	**	*	*

A, B, C and D Means within the same column showing different letter are significantly different ($P < 0.05$).
n.s. non significantly * ($P < 0.05$) ** ($P < 0.01$).

The following regression equations were obtained for digestibility of DM, ON, CP, EE, CF and NFE in the eight diets as a function of their fiber content :

Items	Regression equations: Starter-Grower diet (4-8 weeks)	p	Finisher diets (8-12 weeks)	P
DMD	70.493 - 0.640 CF $r^2 = 0.97$	**	83.372-1.015 CF $r^2 = 0.99$	**
OMD	70.373 - 0.544 CF $r^2 = 0.99$	**	84.745 - 1.005 CF $r^2 = 0.98$	**
CPD	85.216 - 0.99 CF $r^2 = 0.99$	**	76.198 - 0.250 CF $r^2 = 0.93$	**
EED	68.986- 0.412 CF $r^2 = 0.32$	ns	79.655 + 0.254 CF $r^2 = 0.50$	n.s
CFD	54.215 - 1.461 CF $r^2 = 0.99$	**	50.211 - 1.42 CF $r^2 = 90$	**
NFED	61.931 + 0.442 CF $r^2 = 0.98$	**	80.199 - 0.059 CF $r^2 = 0.08$	n.s

**($P<0.01$).

Carcass characteristics of slaughtered rabbits- Carcass weights as percentage of live body weight were increased significantly($p<0.01$)(52.16%) with increasing CF level up to 14% for starter & 17.5% for finisher. after which it decreased (49.4%) by increasing CF level. ABDEL-RAHMAN (1975) reported dressing percentages: 49.02, 47.35 and 40% with Giza white rabbits, at 13 weeks old fed on rations containing 11.87, 16.64 and 21.41% respectively. Also RADWAN and ALLAM (1979) reported that the carcass quality of the rabbits fed on low levels of CF (11.86 and 16.88%) were nearly similar and superior than those for rabbits fed on the high levels of CF (20.03 and 24.07%).

Economic evaluation - From economical point of view, the net return (NR) is the difference between selling price of gain and its feed cost per period. The total NR at the termination of the fattening period (4-12 weeks of age) reached: 6.584, 7.554, 8.219 and 7.235 Pound/rabbit of groups 1, 2, 3 and 4 respectively. The corresponding economic efficiency was : 502.6, 497.63, 501.77 and 432 for the experimental groups 1, 2, 3 and 4 respectively.
Therefore, from nutritional and economical point of view, minimal fiber requirement of NZW x Californian. rabbit to avoid digestive disorders, increase in MR and to maximize their profit was found to be 10.52 CF during 4-8 weeks of age and 14.09% CF during 8-12 weeks, and that of the maximal fiber one was found to be 14% CF vs 17.5% during the same periods.

REFERENCES

ABDEL-RAHMAN G.A., 1975. The effect of roughage level on growth and carcass composition of rabbits M.Sc. Thesis. Fac. Agric., Zagazig Univ., Egypt.

ABOU ELA S.S., SHEHATA O., ABDEL-MALIK A.A., ABDEL-RAHMAN G.A., 1979. Effect of dietary roughage levels upon the performance of growing Flemish giant rabbits. *Res. Bull.* **No. 65**. Fac. Agric. Zagazig Univ, Egypt.

ALLAM E., 1979. Comparative study with Ruminants and Rabbits using different levels of roughage and concentrates. M.Sc. Thesis Fac. Agric. Zag. Univ.

A.O.A.C., 1988. Official Methods of analysis 13th Edition association of official analytical chemists, Washington, USA.

CHEEKE P.R., 1987. Rabbit feeding and nutrition San Diego, CA. *Academic Press. Inc.*, Florida, M.S.A.

DE BLAS C.,. SANTOMA G, CARABAÑO R., FRAGA M.J., 1986. Fiber and Starch levels in fattening rabbit diets. *J. Anim. Sci. 1986.* **63**, 1897-1904.

HOOVER W.H., HEITMANN R.N., 1972. Effect of dietary fiber levels on weight gain caecal volume and volatile fatty acid production in rabbits. *J. of Nut.*, **102(3)**, 375-379.

INRA : Institut National de la Recherche Agronomique, 1984. L'alimentation des animaux monogastriques: *Porc., Lapin, Vollailles. INRA*, Paris, France.

NRC, 1977. National Research Council. Nutrient Requirements of rabbits, *2nd Ed. Washington, DC.*

RADWAN. M.A., ALLAM E., 1979. Effect of feeding rations with different levels of crude fiber on performance of growing rabbits. *Agric. Res. Rev., Egypt.* **57**, 207-215.

RADWAN M.S., 1990. Nutritional studies on rabbits and Rats with special reference to sources of dietary fiber Ph.D. Thesis. Collage of Cardiff (UWCC), Wales, Univ. U.K.

SNEDECOR G.W., COCHRAN W.G., 1980. Statistical Methods. Iowa state Univ. Press, Ames, Iowa. USA.

SPREADBURY D., DAVIDSON J., 1978. A study of the need for fiber by the growing New Zealand white Rabbit, *J. Sci. Food Agric.*, **29**, 640-648.