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METHODS OF IMPROVING THE EFFICIENCY
OF RESIDUAL BOWEL SEGMENTS IN RABBITS
(With 8 Tables and 7 Figures)

By

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(Received at 11/12/1990)

الطرق المحسنة لكفاءة الأمعاء الدقيقة بعد ازالة جزء

كبير منها في الأرانب

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أجريت خمس تجارب نمو وعشر تجارب هضم على ذكور الأرانب البوسكات النامية
لدراسة بعض الطرق الجراحية المستخدمة لزيادة كفاءة الجزء المتبقي من الإمعاء الدقيقة على
معاملات الهضم والقيمة الغذائية للعليقة والنمو وأيضاً الكفاءة التحويلية للغذاء.. أستخدم
أربعون أرنبا في خمس مجموعات ، الأولى للحصول على معايير للأرانب لم تجر لها اى عمليات
جراحية ، الثانية أجرى لها إزالة لحوالي ثلثي أمعائها الدقيقة ، ثم أجريت عمليات الصمام
الصناعي ، توصيل جزء عكسي ، والاثنين معا توصيل جزء عكسي مع اجراء صمام صناعي في
الجزء المتبقي من الأمعاء الدقيقة للمجموعات الثلاثة الأخرى. وأدت إزالة ٦٥٪ من الأمعاء
الدقيقة للأرانب الى انخفاض كبير في كل من معاملات الهضم والقيمة الغذائية للعليقة،
معدلات النمو وأيضا في الكفاءة التحويلية للغذاء.. بينما أدت العمليات الجراحية الثلاثة
الى تحسن كبير في جميع هذه المقاييس · وقد كانت طريقة الصمام الصناعي أحسنها جميعا
ثم طريقة توصيل جزء عكسي مع اجراء الصمام الصناعي وأخيرا طريقة توصيل جزء عكسي فقط.

SUMMARY

Five growth and ten digestibility trials were carried on growing male
Bouscat rabbits to study the effect of some methods applied for improving
the efficiency of residual small bowel segments after resection of its
65%.

Forty rabbits were divided into five groups, each of eight animals. The
first one was used for measuring the normal data concerning the digesti-
bility of the ration and its nutritive value together with the growth per-
formance. Rabbits of the second group were subjected to resection of
about two-thirds from their small intestine. Some surgical operations

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following the massive resection were applied on rabbits of the rest of the groups for increasing the efficiency of the residual small bowel segments. These operations were artificial valve, artificial valve with reverse segment and reverse segment alone.

The data obtained indicated that resection of about two-thirds of small bowel markedly depressed all the parameters studied which related to digestibility and nutritive value of the ration and also growth performance, while the surgical safeguard operations followed it, markedly improved these parameters. The artificial valve is the most efficient methods for management the disorders resulted by massive resection of small intestine, followed by artificial valve with reverse segment and finally comes the reverse segment alone.

INTRODUCTION

The small intestine represents the most important part of the alimentary tract responsible for digestion and absorption. Resection of small intestine is indicated for tretment of certain diseases affecting the small bowel (COMPSTON and CREAMER, 1977). Massive intestinal resection is indicated in cases of neoplasms, mesentric vascular occulusions, strangulations, obstruction due to volvulus, regional enteritis, extensive trauma (WESER, 1976 and KOSOVSKY et al., 1988), and Grohn's disease (COMPSTON & CREAMER, 1977 and BARROS, 1979). Massive intestinal resection was also performed to correct some conditions such as obesity (MURILLO et al., 1981).

As a result of massive small bowel resection several problems were encountered, high mortality rate (BOLBOL, 1977 and BARROS, 1979), malabsorption and loss of body weight (BOLBOL, 1977; CALLIN et al., 1979; HASSAN et al., 1981; LAYZELL and COLLIN, 1981; DEW et al., 1983; URBAN and CÁMPELL, 1984 and ALJURF, 1985), and rapid intestinal transit time (MACKBY, 1965; SCHILLER et al., 1973 and COLLIN et al., 1979).

Surgical approaches toward slowing intestinal transit time and increasing digestion and absorption included vogotomy and pyloroplasty (FREDRICK and CRAIG, 1964 and KELLER et al., 1965), construction of circulating small bowel loops (MACKBY et al., 1965 and CUTHBERTSON et al., 1970), reverse segment (KELLER et al., 1965 and WILLIAMS and KING, 1985), and artificial valve following colectomy and low ileorectal anastomosis (WILLIAMS and KING, 1985).

Little information is available regarding digestibility and nutritive value of rations and growth performance for rabbits either with massive small bowel resection or with the methods for increasing the efficiency of the residual small bowel segments as artificial valve, artificial valve with reverse segment and reverse segment alone, so, this work was planned to study the possibility of increasing the efficiency and so the life production of rabbits suffering from intestinal resection by applying these types of surgery.

MATERIAL and METHODS

Forty healthy male Bouscat rabbits of 8 weeks age and nearly the same weight (1130 to 1160 grams) were experimented on. The rabbits were divided into five groups of eight animals each included normal and operative groups. Animals of the first group were considered as norml while the rest were the operative ones.

1) **Normal group.** Digestibility and nutritive value of the ration and growth performance of rabbits of this group were recorded as normal data.

Operative groups. The rabbits were randomly assigned to two of four operative procedures which performed under general anaesthesia (Fig. 1).

2) **Control operation.** Rabbits in which 65% resection of the small bowel had been done, formed the control group.

3) **Artificial valve group.** Artificial valve was performed on the remaining small intestine and proximal to the anastomosis for the control operation.

4) **Reverse segment group.** Reversal of a-10 cm segment at the distal end of the residual bowel segments was performed for the control operation.

5) **Artificial valve with reverse segment group.** Reversal of a-10 cm segment and artificial valve proximal to it of the residual bowel segments were performed for the control operation.

The rabbits were housed individually in units each containing six hutches. Each individual hutch has a floor area of 60 x 65 cm2 and 45 cm height. The hutch units were located into a well ventillated room. Food and water utensils were put inside the hutches.

The food was offered twice daily at 10 A.M. and 3 P.M., while water was available ad libitum.

Postoperatively, body weight and food consumption were recorded weekly for each of the experimental groups during the period of the experiment (8 weeks).

Digestibility trials were performed on rabbits at the first and the third postoperative month for measuring the digestibility of the ration and its nutritive value.

During the collection period which lasted 10 days (SANDFORD, 1979), the food consumed was accurately measured. Thedaily amount of the undigested portion of the ration was collected, weighed and dried in hot air oven. The dried feces of each rabbit were mixed at the end of the collection period, ground and kept for chemical analysis. Food and fecal samples were analysed for moisture, crude protein, ether - extract, crude fiber and ash according to the conventional methods of AOAC (1984).

The coefficient of digestibility is merely the quantity of the nutrient ingested that is subsequently not recovered in the feces, expressed as a percentage of the intake (CRMPTON and ILOYD, 1959). Digestible protein (DP), total digestible nutrients (TDN), starch equivalent (SE) and metabolizable energy (ME) were the criteria for

measuring the nutritive value of the ration.

The nutritive value as starch equivalent was calculated according to the values cited by GHONEIM (1964), while the metabolizable energy was calculated according to that cited by ABOU-RAYA (1967) while calculations for the total digestible nutrients values were performed after MORRISON (1959).

The relative growth rate was calculated according to CRAMPTON and ILOYD (1959). The weekly feed consumption and its relation to the weight gain was considered as a criterion for calculting the feed conversion efficiency. The data were stastically analysed according to SPLEGEL (1972).

RESULTS

Ressults at the Tables (1 to 8) and Figures (1 to 7).

DISCUSSION

Disability after massive bowel resection is related not only to loss of absorptive mucosal surface but also to an abnormality. Transit of intestinal contents may be greatly accelerated, resulting in severe diarrhea. Nutrition may be improved by means of spontaneous adaptation, elemental diets, and intravenous hyperalimentation; however, some patients fail to respond, and a number of operations have been proposed to slow intestinal transit (KELLER et al., 1965; WESER, 1971; SHILLER et al., 1973 and WILLIAMS and KING, 1985).

Tables 1 & 2 presented the physical and chemical composition of the experimental ration which was fed to all the groups of rabbits.

The digestibility and the nutritive value of the ration were measured at the first and the third postoperative month to investigate the effect of different operations on the digestion and absorption of the ration. The values are presented in tables (3&4).

As a comparison between the normal and resected rabbits (tables 3 & 4), the data obtained indicated that the digestibility of the ration and its nutritive value were markedly depressed at the first and the third posoperative months those rabbits undergoing 65% resection. The nutritive values of the ration were highly depressed by 3%, 19%, 19%, 806 kcal/Kg; 3%, 20%, 20%, 854 kcal/Kg for digestible protein, total digestible nutrients, starch equivalent, and metabolizable energy respectively at the first and the third postoperative months. This can be interpreted, as the massive small bowel resection affected greatly the digestibility of nutrients which reflected on the nutritive value of the ration. This finding was similar to that found by BOLBOL, 1977; COLLIN et al., 1979; HASSAN et al., 1981; LAYZELL and COLLIN, 1981; DEW et al., 1983; URBAN and CAMPELL, 1984; and AL-JURF et al., 1985 who reported that the resection of small intestine accelerted the intestinal transit time and consequently depressed the digestion and absorption.

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Moreover, it could be seen from tables 3 & 4 that the resected rabbits fail to improve the digestibility of the ration and its nutritive value by spontaneous adapt- ation after the first postoperative month. The digestibility coefficients of most nutrients at the third postopertive month remain the same or slightly decreased except for the crude protein which is slightly improved. A matter reflected on the nutritive value of the ration as the values for TDN, SE and ME which were, obviously slightly lowered with the resected group and the DP still the same (Fig. 2 & 3). These findings came in agreement with that found by SCHILLER et al. (1973) who reported that some patients fail to respond after intestinal resection, and in contrast to WESER (1971) who suggested that nutrition may be improved by means of spontaneous adaption.

In an attempt to slow intestinal transit, enhance absorption and improve function, artificial valve, artificial valve with reverse segment, and reverse segment alone. The data in Tables (3 & 4) show gradual but progressive digestibility together with nutritive value of the ration had developed in all rabbits with an evident increase in those of group 2 who have treated by artificial valve after resection. One obvious criticism might be that, the reverse segment method was insufficient to produce the desired effect.

The changes in the digestibility of the ration and its nutritive value with the surgical safeguard groups can be explained by improving digestion and absorption which reflected on the nutritive value of the ration. This discussion was agreed with that mentioned by KELLER et al., 1965; CUTHBERTSON et al., 1970 and WILLIAMS & KING, 1985 who reported that those operations delayed the intestinal transit time and improved the digestion and absorption. The data obtained also showed that the reverse segment method have had minimal clinical trial in the treatment of massive bowel rsection (Figs. 2 & 3). Moreover, the digestibility and the nutritive value were better in the artificial valve rabbits than those of artificial valve with reverse segment and reverse segment alone.

The efficiency of the ration was measured by recording the weights of the rabbits at the start and end of the experiment, so, the obtained body weights at the end of the experiment were about 2234, 1300, 2146, 1904 and 1947 grams fro groups 1,2,3,4 and 5 respectively (Table 5). The resected group recorded the lowest body weight and it was clearly demonstrated that the three operative methods, reverse segment, artificial valve with reverse segment and artificial valve after massive resection produced marked and progressive sustained improvement in the body weight development which was more prominant in those who have artificial valve (Fig. 4).

Statisical analysis showed high significant differences between groups 2,3 & 4 and the control one. While thedifferences between groups 2,3, & 4 and the normal one were not significant.

Regarding the absolute and relative growth rates and the feed conversion effi- ciency (Tables 6 & 7), indicated that the resected group registed the lowest values, a matter which may be interpreted as severe malnutrition. Gradual improvement could

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be seen in the growth rate and the efficiency of feed utilization with the operative methods followed intestinal resection with the best results recorded by the group of artificial valve (Figs. 5, 6 & 7).

Tables (7 & 8) show the average feed consumption and the digestible energy (kcal/Kg) needed for one gram live body weight increase in the five groups. It could be seen that the rabbits with massive bowel resection increased their food intake greatly but still the lowest in growth rate and those animals needed more kilocalories of digestible energy for each one gram live body weight increase. The results obtained also showed that the average feed consumption and the digestible energy needed were gradually decreased with the rest of the operative groups.

Generally, it can be concluded that resection for 65% of the small bowel accelerated the intestinal transit time, altered digestion and absorption thereby, decreasing the digestibility and the nutritive value of the ration and the growth performance, while the surgical safeguard procedures followed it, improved these parameters. The different parameters were better with artificial valve rabbits than in those artificial valve with reverse segment and reverse segment alone.

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Tabl1 (1) : The physical composition of the ration.

Ration ingredients	percentage (%)
Crain sorghum	20.20
Wheat bran	15.00
Common salt	00.50
Berseem hay	64.30

Table (2): The chemical composition of the ration and its ingredients.

Item		DM %	OM %	CP %	EE %	CF %	NFE %	Ash %	Ca* %	P* %	DE** (Kcal/kg)
Feedingstuffs:											
Crain sorghum	As fed	90.05	87.76	10.50	2.25	3.40	71.61	2.29	0.03	0.29	3100
	Dry	100.00	97.46	11.66	2.50	3.78	79.52	2.54	0.03	0.32	3480
Wheat bran	As fed	90.20	85.70	11.95	2.94	10.10	60.71	4.50	0.14	1.16	3200
	Dry	100.00	95.01	13.25	3.26	11.20	67.31	4.99	0.16	1.29	3600
Berseem hay	As fed	90.07	77.87	17.25	1.32	18.55	40.75	12.20	1.30	0.20	440
	Dry	100.00	86.45	19.15	1.47	20.60	45.23	13.55	1.44	0.22	2200
Calculated ration:											
	As fed	90.14	81.16	15.01	1.80	14.63	50.60	8.98	0.86	0.36	1389
	Dry	100.00	90.04	16.65	2.00	16.23	55.16	9.96	0.95	0.40	1541

DM = Dry matter   CP = Crude protein   CF = Crude fiber   Ca = Calcium

OM = Organic matter   EE = Ether-extract   NFE = Nitrogen-free extract

P = Phosphorus   DE = Digestible energy

* = The data obtained from Cullison (1979), table 37.

** = The data obtained from Cheeke (1987), appendix (1).

Table (3): The digestion coefficients of nutrients and the nutritive value of the ration (at the first postoperative month).

Groups	Digest. trials	Digestion coefficients						Nutritive value (DMB)			
		DM %	OM %	CP %	EE %	CF %	NFE %	DP %	TDN %	SE %	ME (Kcal/kg)
Normal	1	90.22	90.55	90.74	90.45	83.55	92.27	15.11	81.79	81.36	3472.00
Resection	2	68.41	69.93	71.44	68.41	33.95	79.37	11.89	62.68	62.47	2666.00
Resection+AV	3	85.40	86.12	85.04	85.47	74.78	89.43	14.16	77.68	77.34	3300.00
Resection+RS	4	79.81	80.69	82.18	80.12	62.83	85.10	13.68	72.72	72.35	3087.00
Resection+AV+RS	5	81.01	81.95	82.04	82.17	67.24	85.73	13.66	73.84	73.48	3135.00

DP = Digestible protein
TDN = Total digestible nutients
DMB = Dry matter basis
RS = Reverse segment

SE = Starch equivalent
ME = Metabolizable energy
AV = Artificial valve

Table (4): The digestion coefficients of nutrients and the nutritive value of the ration (at the third postoperative month).

Groups	Digest. trials	Digestion coefficients						Nutritive value (DMB)			
		DM %	OM %	CP %	EE %	CF %	NFE %	DP %	TDN %	SE %	ME (Kcal/kg)
Normal	1	90.07	90.49	91.49	90.60	84.14	91.75	15.23	81.62	81.27	3468.00
Resection	2	67.16	68.69	72.90	67.82	33.93	76.83	12.14	61.54	61.26	2614.00
Resection+Av	3	85.09	85.76	86.92	84.35	70.29	89.64	14.47	77.33	76.95	3283.00
Resection+RS	4	77.71	78.82	81.48	77.92	68.16	80.48	13.57	70.92	70.48	3007.00
Resection+AV+RS	5	83.49	84.22	87.16	83.99	65.66	88.38	14.51	75.93	75.51	3222.00

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Table (5): The average body weight development of the rabbits (in grams).

Weeks	Rabbit groups				
	1 (normal)	2 (control) *	3	4	5
0	1162.50	1157.50	1147.50	1159.40	1130.87
1	1277.50	1030.00	1235.00	1192.50	1144.00
2	1471.37	1035.00	1364.34	1338.30	1298.00
3	1589.13	1150.00	1524.37	1565.00	1382.00
4	1695.63	1225.00	1658.79	1598.30	1510.00
5	1816.25	1340.00	1832.00	1686.60	1657.00
6	1950.00	1400.00	1928.28	1788.30	1820.00
7	2078.75	1450.00	2047.14	1885.00	1900.00
8	2234.38	1300.00	2145.70	1904.00	1946.60

* Five rabbits died during the experiment.
   Statistical analysis showed significant differences between groups 1 & 2 (P > 0.01) and between groups 3 & 4 & 5 and the control one (P > 0.01).
   Statistical analysis showed also no significant differences between groups 3, 4 & 5 and the normal one (group 1).

Table (6): The average weight gain (in grams) and the relative growth rate (R.C.R).

Group 1		Group 2		Group 3		Group 4		Group 5	
Weight gain	R.C.R	Weight gain	R.G.R	Weight gain	R.C.R	Weight gain	R.C.R	Weight gain	R.C.R
1071.88	63.11	142.50	11.60	998.20	60.62	744.60	48.61	815.73	53.26

Table (7):The average feed intake (in grams) and the feed conversion efficiency (F.C.E).

Group 1		Group 2		Group 3		Group 4		Group 5	
Food intake	F.C.E	Food intake	F.C.E	Food intake	F.C.E	Food intake	F.C.E	Food intake	F.C.E
8374	7.81	11198	78.58	9125	9.14	11073	14.87	10558	12.94

Table(8):Kilocalories of digestible energy needed for one gram live body weight increase.

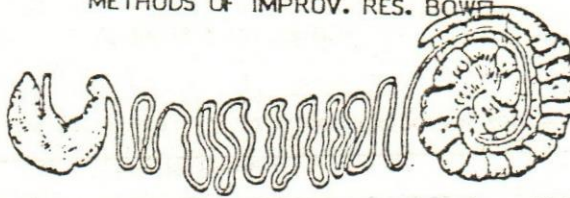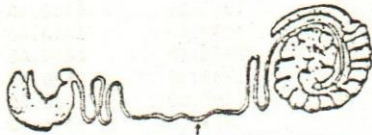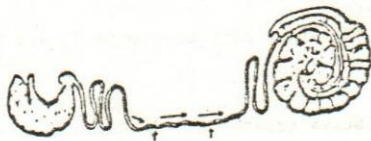| Group 1	Group 2	Group 3	Group 4	Group 5
10.851	109.151	12.697	20.656	17.978

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Diagram showing arrangment of small intestine in rabbit.

Control operation group, 65% intestinal resection.

Artificial valve group.

Layers of small intesti

Removal of serosa an
longitudinal muscle
layer.

Suturing of sero
long. muscle wit
inversion of muc
& circular m.layer

Reverse segment group.

Before resection.

Transection of a se
ent.

Rotation of it 180
degree.

Anastomosis
the segment.

Artificial valve with reverse segment group.

Fig.(1): Diagrams showing the different operations groups.

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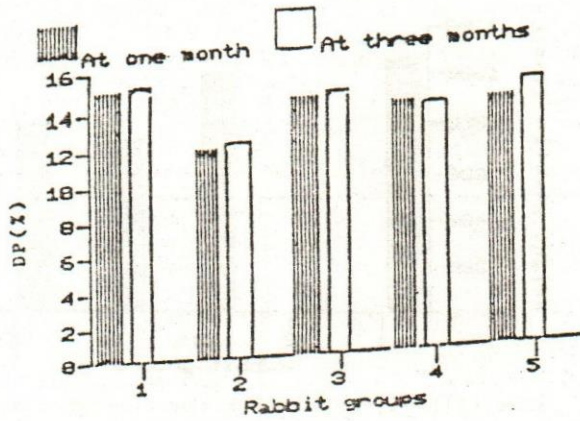
Fig.(2): The nutritive value (DP%) of the ration.
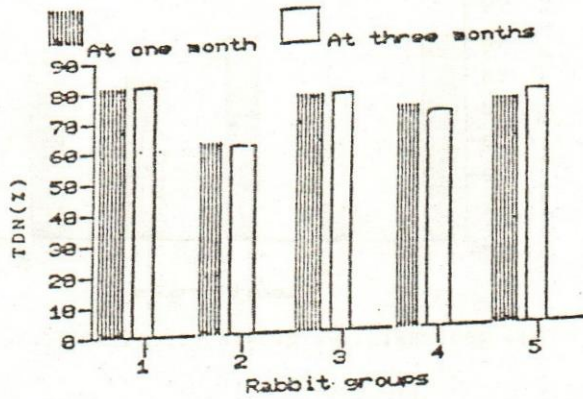
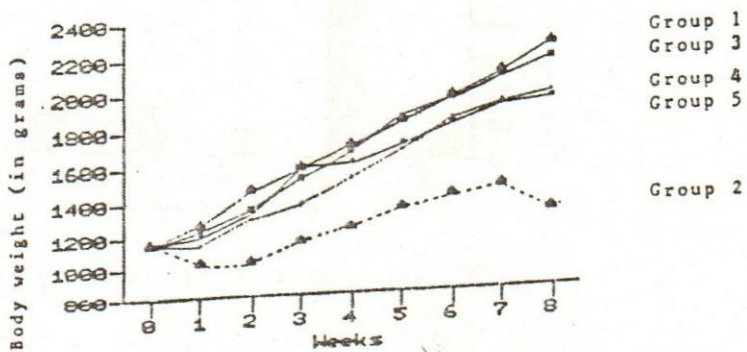

Fig.(3): The nutritive value (TDN%) of the ration.

Fig.(4) : Groth curves of rabbits in the five groups.
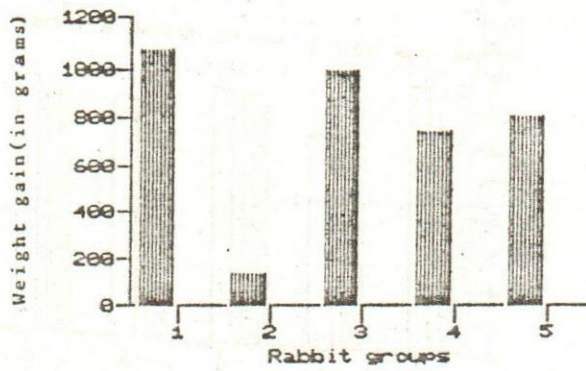
METHODS OF IMPROV. RES. BOWEL

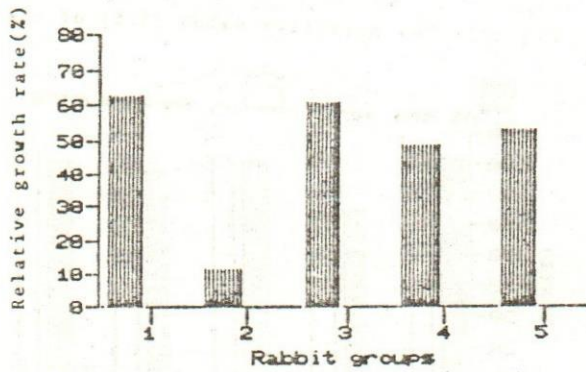Fig.(5):Weight gain for the five groups.

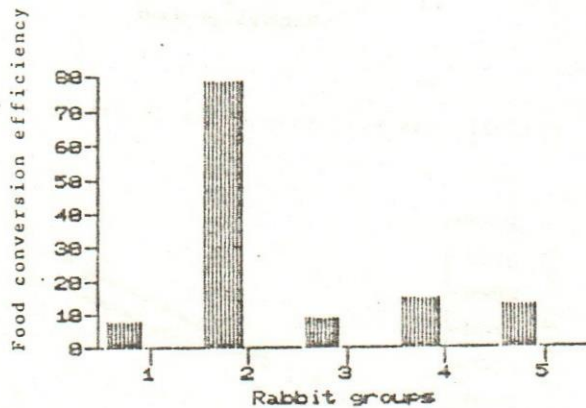
Fig.(6): Relative growth rate(%) for the five groups.

Fig.(7):Feed conversion efficiency for the five groups.