Assiut Vet. Med. J. Vol. 39 No. 77, April 1998

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FEED INTAKE AND DIGESTIBILITY OF NUTRIENTS IN RATIONS, WITH SEVERAL FEED COMBINATIONS, BY TILAPIA FISH (*O.niloticus*)

(With 3 Tables and One Figure)

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(Received at 29/3/1998)

معدل استهلاك العليقة ومعاملات هضم العناصر الغذائية في علائق اسماك البلطي النيلي المكونة من مواد العلف المختلفة

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في هذه الدراسة تم حساب معاملات الهضم لبعض العلائق المكونة من عدة مواد علف وذلك لوضع صورة كاملة عن هضم العناصر الغذائية مثل البروتين والدهون والالياف ومستخلص خالي النتروجين بالاضافة الي الطاقة في سمك البلطي النيلي. تم اجراء عدد ١٤ تجربة هضم باستخدام ١٤ عليقة مختبرة مكونة من مواد العلف المختلفة (مسحوق كل من السمك واللحم ومخلفات الدواجن ودودة الارض وفول الصويا وكسب القطن وزرق الدواجن بالاضافة الي الذرة ونخالة القمح ومخلفات المطاحن والدريس). غذيت الاسماك مرتين يوميا لمرحلة الشبع وقد استغرقت هذه الدراسة ٣٠ يوما. تم تجميع عينات البراز عن طريق سحبه من الاحواض مباشرة.

وقد اظهرت هذه الدراسة النتائج الاتية:

تراوحت معاملات هضم البروتين للعلائق بين ٨٠-٩١٪ وقد تاثرت هذه المعاملات بمصدر البروتين في العليقة واعطت العلائق المحتوية علي نسب عالية من كل من مسحوق السمك وفول الصويا اعلي معدلات هضم.

- بلغ متوسط معاملات هضم الدهون ٨٤٪ وكانت اعلي من المتوسط في العلائق ذات المحتوي العالي من الدهون.
- بالنسبة للمواد الكربوهيدراتية وجد ان متوسط معاملات الهضم لمستخلص خالي النتروجين كانت ٧٨٪ والالياف ٧٩٪ وقد اعطت العلائق التي احتوت في تركيبها علي مسحوق كسب القطن ومخلفات المطاحن ودريس البرسيم اقل معدلات هضم.
- معاملات هضم الطاقة في العلائق المختلفة كانت ٦١-٧١٪ بلغت اعلاها في العلائق المحتوية علي زيت السمك.

وعليه يمكن الاسترشاد بمعاملات هضم العناصر الغذائية التـي تـم الحصـول عليهـا عنـد تكوين علائق لاسماك البلطي النيلي.

SUMMARY

The digestion coefficient of several different combinations were determined in this study by tilapia (*O.niloticus*) fish in order to extract the proximate figures for the digestibility of different nutrients (organic matter, protein, fat, fibre, nitrogen-free extract and energy). Fourteen digestion experiments were performed using 14 experimental rations which formulated from different feedingstuffs (fish, meat, poultry by-products, earthworm, soybean, cottonseed and poultry manure meals; corn, wheat bran, middlings and berseem hay). Fish were fed twice daily to satiation and the experiments were lasted for one month. Faecal samples were collected by syphoning and filtration of the faecal matter from the aquarium. The amount of feed consumption for fish satiation depends on the quality of diets according to fibre percentage or imbibition ability of water. The digestibility of crude protein over a range of 80-91% ($\bar{x}$ =86%) by tilapia which depends on the source of protein, and the rations with high percentages of fish meal and soybean meal had the highest digestion coefficients. The digestion coefficient for fat ranged from 83 to 85% ($\bar{x}$ =84%), and the diets containing high levels of fat gave high values for digestibility of fat. For carbohydrates, the digestion coefficient of nitrogen-free extract ranged from 73% to 87% ($\bar{x}$ =78%), while for fibre from 71 to 85% ($\bar{x}$ =79%) , and diets which contained cottonseed meal, wheat middlings and berseem hay had the lower carbohydrates digestibility. The digestion coefficient for energy ranged from 61 to 71% ($\bar{x}$ =66%) and the ration contained fish oil gave high values. It could be concluded that, these average figures can be used as a guide in the formulating diets to satisfy tilapia fish needs.

Key words: *Tilapia Fish - Feed combinations - Digestibility.*

INTRODUCTION

Knowledge of nutrient digestibility of the various feedstuffs used in formulating fish diets is desirable so that effective substitution of one ingredient to another may be achieved. Together with chemical analysis ,digestibility determination may allow a more thorough estimation of the nutritive value of a particular protein and energy sources in a complete diet for fish.The different feeds and constituents of feed vary in their digestibility. .Thus ,in order to arrive at the true value of any particular feed ,it is necessary to know not only the chemical composition of that feed ,but the amount of each constituent which digested by the animal. Digestibility coefficients of individual feedstuffs are useful indicator of their potential ,but when included in a compound feed mixture ,the resultant digestibility is not necessarily the mean of the constituents (Lang, 1980), owing to that, digestibility of a feed is influenced not only by its own composition ,but also by the composition of the other feed consumed with it (El-Talty, 1973; McDonald et al. ,1973 and Abd-Ellah ,1990) .Information on nutrient digestibility has lagged far behind the many advances that have been made in fish nutrition during the last few years. Only a limited number of investigators have attempted to conduct this type of studies because of many technical difficulties. It is apparent that, for example the absence of reliable energy values for tilapia in the literature acts as a constraint on feed manufactures wishing to produce competitive least cost formulations for this species .It is also clear that the measurment of digestible energy (DE) values of feedstuffs for tilapia requires considerable technical care and the use of micro-analytical procedures .This is due primarily to the small samples of feces obtainable in feeding trials ,and the influence on DE of test feedstuff substitution level and adaptation of this fish to diets. These difficulties make it unrealistic for manufactures of commercial diets for tilapia to undertake routine digestibility trials of locally available feedstuffs in the developing countries where tilapia are farmed .For several important fish groups such as tilapia ,comprehensive tables of energy and protein values are not yet available .In these cases ,diets are usually formulated on the basis of feedstuffs energy and protein values published for poultry and pigs. Fundemental differences in physiology ,feeding behaviour and metabolism between birds, mammals and fish raise doubts over the validity of such values for fish production. Even within the class species ,differences between fish species are considerable; carnivorous salmonids utilize dietary carbohydrates less well than herbivorous carp (Hilton et al. ,1982) or tilapia (Anderson et al.,1984). Many investigations have been concerned with the problems of digestibility measurments in fishes, and extensive data on factors affecting digestibility have been reported (Brett and Groves, 1979; Steffens, 1985).

In this study and due to the difficulty in measuring digestibility of feeds in fish, either by direct or indirect methods; and the digestibility of a feed is influenced not only by its own composition, but also by the composition of other feeds consumed with it; the digestibility of several different combinations was measured in order to extract either approximate figures for the digestibility of nutrients, or pointers to the extent expected.

MATERIALS & METHODS

Fourteen digestion experiments were performed, using 14 different rations, for testing and extract the apparent digestibility of the several major nutrients in fish.

A-Fish :

Four hundreds and twenty (420) Tilapia fish (*O.niloticus*), weighing 100 gm on the average, were obtained from River Nile ,Assiut. They were randomly grouped into 28 equal groups and stocked each in rectangular glass aquarium supplied with aerated, fresh water.The water quality remained stable for dissolved oxygen (7.0 ± 0.5 mg/L), pH (8.1±0.9) and temperature

(26.0±1.5 °C) throughout the experimental periods. Each experimental diet was tested with two replicate aquaria.

B-Experimental diets:

In formulating the fourteen diets, different feeds were intentionally nominated to be used. Seven feedstuffs, fish, meat, poultry by-products, earthworm, soybean, cottonseed and poultry manure meals; were used selectively or alternatively as the main sources of protein. They varied in their protein percentage from as low as 23% in poultry manure to as high as 61% in fish meal. The rest of the feedstuffs; corn, wheat bran, middlings and berseem hay, were used as the main sources of carbohydrates and energy. The diets were divided into three groups according to the protein supplements used.

1- The two-supplement group: This group was represented by five rations in which the soybean meal ranged from 31 to 50% and the fish meal from 7 to 20% and both altogether from 51 to 57% of the diets and supplying from 85 to 87% of the dietary protein. In the five diets, corn and wheat bran were the main sources of the non-protein nutrients.
2- The three-supplement group: In this group four diets were formulated in which the plant protein source soybean meal was replaced by the cottonseed meal which is lesser in quality and high in indigestible fibres. Its percentages ranged from 29 to 45%, while the fish meal from 3 to 12% and meat meal from 3 to 8%. The three feeds all together form from 44 to 51% and sharing by 71-75% of the dietary protein. Wheat middlings were the main source of the other major nutrients.
3- The five-supplement group: In this group, five feedstuffs shared the main supply of protein. Of which one is of plant origin (soybean meal) while the others are of animal origin of which three are unconventional feeds (fish meal, poultry by-products, earthworm meal and poultry manure). The plant feedingstuff ranged from 10 to 11%, while the others from 9-

14, 10-15, 7-12 and 5-10% in respective order. The soybean meal shared by a percentage ranged from 14.8 to 16.3% of the dietary protein, whilethe others by 64 to 66.5%. The other major nutrients were supplied by corn, berseem hay and fish oil.

The 14 diets were each supplemented by 1% vitamin mixture and 2% mineral mixture to satisfy the needs for these nutrients. All dietary ingredients were finely ground and thoroughly mixed with the addition of a few drops of water until the diet began to clump and then pelleted by forcing it through a mincer, freezed at -20°C till the time of use (El-Sayed and Teshima ,1992).

As to the chemical composition and nutritive value, the experimental diets in the three groups were mixed so as to have approximately the same protein (about 30%) and energy levels (about 4000 Kcal GE/Kg). As far as fat and fibre percentages for the first group of the diets varied from 2.77 to 3.49% in fat and 3.47 to 4.65% in fibre, levels which are on the lower (fat) or moderate limit (fibre) of the optimal levels. The second group, while it had nearly the same levels of fat (2.72-3.29%) it contained nearly double the amount of fibre (9.15-10.61%) and so exceeding the maximum limit of the suitable percentages. This was achieved by the inclusion of large amounts of cottonseed meal and wheat middlings. In the third group of the diets, the fibre was fixed at nearly the same level of the second group (7.81-9.05%), while the fat was doubled about 5 folds (13.27-15.24%).

The rations were mixed as to satisfy the needs for tilapia suggested by NRC (1993).The chemical composition of the different feeds is shown in table (1), while the physical and chemical composition of the diets are shown in Table (2).

The food was offered to the fish twice daily at 8.00 am and 5.00 pm till satiety at each time, and the feed intake was recorded.

C-Digestibility trials :

One month digestion trials were conducted in each experiment. The period was divided into 15 days as a preliminary period and 15 days as a collection period .Mechanical removal of solids from the aquarium water is probably the most widely used method for obtaining fecal material. Soon after the fish are fed,the aquarium is flushed to remove any uneaten feed. Fecal matter were collected by syphoning from the aquarium over long periods. Feces from each group transfered to petri-dishes and dried at 105 °C to constant weight. Subsequently they were ground in a mortar and stored in airtight tubes until required for analyses (Anderson et al. ,1991).

D-Analytical procedures:

Feedstuffs and fecal samples were dried and finely grounded for analyses. Analyses were conducted on duplicate samples of ingredients and feces.Proximate analyses were performed according to (AOAC, 1984) with NFE (nitrogen free-extract) being determined by difference.Gross energy content was determined directly by using an Automatic Adiabatic bomb calorimetery .

RESULTS

The feed intake was recorded while the coefficients of digestibility for the organic matter, protein, fat, fibre, nitrogen-free extract and energy of the different rations were calculated. Table (3) shows the feed intake in grams/group and digestion coefficients of different nutrients . Calculating the mean of consumption in each group, no much deviations within each group are noted to the degree that an overall mean for consumption can be extracted. The digestibility of the several nutrients protein, fat, carbohydrates expressed as crude fibre and nitrogen-free extract , organic residue and energy were calculated. The protein in the first group was digested at a high level reaching 90% and with unsignificant deviations, as the SE was 0.17. In the second and third groups the coefficient was decreased due to the change in the protein sources, but the decrease did not exceed 12% in group 3 when the protein came from a variety of feeds including in addition to fish meal and soybean meal, the poultry by-products, earthworm meal, poultry manure, and the hay which is high in indigestible fibres.

DISCUSSION

A- Feed intake:

Ingredients used in making the 14 diets satisfied the required physical, palatibility, and quality properties, a fact that can be confirmed by the consumption of nearly equal amounts from the diets in spite of having several varities of feeds and at variable percentages. The diets were consumed at an average of 276gm in the diets of the first group which have on the average 3% fat and 4% fibre. In comparison with the other 9 diets (groups 2&3), the diets of the first group are characterised by a high percentage of soybean meal (31-50%) which has an imbibition ability of 15.5 ml water/10cm^3 feed as compared with the other feeds (corn,3.4; wheat bran,9.2; fish meal, 4.6; meat meal, 1.2) as reported by Elham (1990), a property which aid in increasing the bulkiness and decreasing feed intake when compared with the other two groups. The other factor which may share causing the increase in intake in the other two groups is the high fibre content (9.2-10.6% in group 2 and 7.8-9.0% in group 3), which may improved the gastric evacuation time. The high fat content of the third group which reaches from 13.3 to 15.2% appears to have no effect on intake as long as the energy density remains constant. Conclusively, the amount of feed consumption for fish satiation depends on the quality of diets according to fibre percentage or imbibition ability of water as far as the results of this study.

B- Digestibility of the nutrients:

The data on digestibility of various feeds by tilapia are rather incomplete and methods for measurment either directly or indirectly still facing serious problems and difficulties. In addition, there are so many factors, other than the fish itself, which may affect digestibility as water temperature, amount of feed and feeding frequency. The digestion coefficient of a feed is influenced by the composition of the other feeds consumed with it and this associative effect of feeds represents a serious objection to the determination of digestibility of concentrates by difference. All these concepts lead to the great value which may be achieved when an approximated figures or means, for the digestibility of the several nutrients, could be extracted.

In this study besides the measurement of the digestibility of crude protein, fat, crude fibre and nitrogen-free extract, that of organic matter and energy was also performed. The last two summarize the digestibility of all the different crude nutrient fractions.

1- Crude protein:

With respect to the fed rations, the achievement of crude protein digestibility over a range of 80-91% ($\overline{x}$ = 86%) by the tilapia depends on the form of the protein source. Rations with fish meal and soybean meal forming more than 85% of the rations dietary protein (group 1) have the highest coefficients (91%) because tilapia digest up to 85% and 94% of fish meal and soybean meal protein respectively (Popma, 1982). In group 2, the soybean meal was replaced by cottonseed meal, and fish meal was partly replaced by meat meal causing a slight decrease in digestibility but still it was at an above average level (88%). It appears that in spite of cottonseed meal having high content of indigestible fibre, it did not affect the digestibility of the crude protein, but it did affect that of the organic matter. In the third group the digestibility reached a level lower than the average by about 6 units and it appears that it is due to the quality of the protein and its processing and due to the high fibre content of the berseem hay meal.

2- Crude fat:

The average fat digestibility is 84% by tilapia fish. Pure fat supplied as vegetable oils, and also fish oils are highly digested by fish (Takeuchi et al., 1979) and because of that, rations of the third group which contain from 9 to 11% fish oil showed a digestibility of only 1 unit above the average. This might be due to, the diets of group 1&2 having low fat content averaging from 2.7-3.5% compared as the 13-15% in the diets of group 3. This low fat content increases the possibility of obtaining imprecise results in determining its digestibility.

3-Nitrogen-free extract (NFE):

In the diets of the first group the NFE reached from 42-43% ($\bar{x}$ = 42.54) of which 65% come from the easily digestible corn starch and about 29% from the soybean meal soluble carbohydrates. This indicates that the nutrient should be digested at a high coefficient a concept which coincides with the result obtained as the digestibility reaches about 86% with a standard error of 0.61. The case was different in the second and third group where the digestibility reaches 73-74%. In the diets of the second group, the cottonseed meal supplied about 30% and wheat middlings 69% of the total NFE which reached only 38.71%. In third group, the NFE reached only 27.25% due to the inclusion of a large percentage of feeds of animal origin which reachs about 46% in addition to 21% berseem hay meal. So we can incriminate cottonseed meal and wheat middlings in the second group and berseem hay meal in the third one, to be the cause of lowering the digestibility of NFE.

4- Crude fibre:

As to the crude fibre in the diets of group 2 the percentage reached 9.86% of which 98% are supplied by the cottonseed meal and wheat middlings, while in group 3 it reached 8.22% of which 79% are supplied by hay and poultry manure. It appears that the fibres in the cottonseed meal are less digestible than that of hay and poultry manure.

5- Organic matter and energy:

The digestibility of the organic matter and energy summarize the digestibility of all the nutrients all together and conclusively we can point that tilapia species is efficient in digesting protein, fat, fibre,NFE and energy and so the average figures are 86, 84, 79, 78 and 66% (in respective order) can be used as guide in formulating diets for tilapia satisfying its needs from these nutrients.

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Table(1):Chemical composition of the feedingstuffs used in formulating of experimental diets(on as-fed basis).

Feedingstuffs	Chemical analysis (%)							
	DM*	OM*	Protein	Fat	Fibre	NFE*	Ash	GE(Kcal/Kg)
Fish meal	93.0	72.0	61.1	6.70	0.60	4.20	20.40	4416
Meat meal	93.0	67.1	52.9	7.50	3.10	3.60	25.90	3814
Poultry-by products	95.0	78.7	57.5	14.50	2.96	3.74	16.30	4960
Earthworm meal	90.0	79.0	63.0	8.30	2.60	5.10	11.00	4127
Soybean meal	89.0	83.0	44.5	1.90	6.50	30.10	6.00	4185
Cottonseed meal	94.0	86.9	40.2	1.40	13.50	31.80	7.10	4320
Poultry manure	92.0	72.19	23.2	1.84	13.85	33.30	19.81	1195
Corn,ground	87.0	85.5	9.5	3.40	2.50	70.10	1.50	3871
Wheat bran	89.0	82.9	15.5	3.20	11.30	52.90	6.10	3720
Wheat middlings	88.0	82.9	15.8	3.60	9.61	53.89	5.10	3925
Berseem hay meal	92.0	81.3	18.1	3.00	26.80	33.40	10.70	1273

*DM:Dry matter,OM:organic matter, NFE:nitrogen-free extract, GE:Gross energy.

Table(2): Composition of the three diet-groups used in the digestion experiments.

Feedingstuffs	Group 1					Group 2				Group 3				
	1	2	3	4	5	1	2	3	4	1	2	3	4	5
A-physical composition:														
Fish meal	7	10	11	15	20	12	6	6	3	14	9	13	9	12
Meat meal	--	--	--	--	--	3	8	3	3	--	--	--	--	--
Poultry by-products	--	--	--	--	--	--	--	--	--	10	15	10	10	10
Earthworm meal	--	--	--	--	--	--	--	--	--	7	7	7	12	7
Soybean meal	50	45	43	38	31	--	--	--	--	10	10	11	10	10
Cottonseed meal	--	--	--	--	--	29	32	40	45	--	--	--	--	--
Poultry manure	--	--	--	--	--	--	--	--	--	5	5	5	5	10
Corn,ground	38	39	35	42	44	--	--	--	--	22	22	15	21	19
Wheat bran	2	3	8	2	2	--	--	--	--	--	--	--	--	--
Wheat middlings	--	--	--	--	--	53	51	48	46	--	--	--	--	--
Berseem hay meal	--	--	--	--	--	--	--	--	--	20	20	25	20	20
Fish oil	--	--	--	--	--	--	--	--	--	9	9	11	10	9
Vitamin mixture*	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mineral mixture**	2	2	2	2	2	2	2	2	2	2	2	2	2	2
B-Chemical composition:														
Dry matter (%)	85.85	85.95	86.10	86.09	86.25	87.85	87.98	88.21	88.36	88.68	88.78	89.11	88.64	88.81
Organic matter (%)	80.73	80:44	80.26	80.00	79.53	79.86	79.73	80.92	81.42	79.36	79.66	79.50	79.80	78.95
Crude protein (%)	30.45	30.32	30.43	30.38	30.51	28.95	28.82	28.92	28.78	30.03	29.86	30.12	30.04	29.09
Crude Fat (%)	**2.77**	**2.96**	**3.01**	**3.22**	**3.49**	**3.35**	**3.29**	**2.92**	**2.72**	**13.42**	**13.81**	**15.24**	**14.44**	**13.27**
Crude Fibre (%)	**4.47**	**4.31**	**4.65**	**3.84**	**3.47**	**9.17**	**9.51**	**10.14**	**10.61**	**7.81**	**7.92**	**9.05**	**7.89**	**8.43**
Ash (%)	5.12	5.51	5.84	6.09	6.72	7.99	8.16	7.29	6.94	9.32	9.12	9.61	8.84	9.86
NFE (%)	43.04	42.85	42.17	42.56	42.06	38.39	38.20	38.94	39.31	28.10	28.07	25.09	27.43	27.56
GE (Kcal/Kg)	3947	3946	3938	3953	3958	3977	3954	3991	3996	4172	4199	4225	4250	4027

*Each Kg of vitamins mix. contains:Vit.A,2000,000 IU:vit.D ,20,000 IU ;vit.E,10,000 IU ;vit.K ,0.5g ;vit.B1 ,1.8g ;vitB2 ,3.6g ,vitB12 ,0.09g ;pantothenic acid ,10g ,nicotinic acid .27g;folic acid ,0.55g ;biotine.0.15g and choline,130g.

**Each Kg of mineral mix. contains :Manganese,60g ;iron,80g ;copper,5g ;zinc.40g ;selenium,0.15g and iodine,0.35g.

Table (3):Feed intake and digestibility of the nutrients in the experimental rations of the three groups.

Diets	Feed intake(g)	Digestion coefficient (%)					
		OM	Protein	Fat	Fibre	NFE	Energy
Group 1:							
1	279	87.66	90.74	83.85	86.92	85.83	66.96
2	276	88.17	90.64	83.39	84.54	87.45	66.68
3	282	89.09	90.91	83.47	86.74	88.43	65.41
4	270	88.11	89.98	83.27	85.58	87.38	65.36
5	275	87.17	90.94	84.12	84.05	85.03	65.73
Mean±SE	276±2.01	88.04±0.31	90.64±0.17	83.62±0.15	85.57±0.57	86.82±0.61	66.03±0.33
Group 2:							
1	330	79.49	87.77	83.04	70.69	74.94	61.70
2	325	78.55	87.11	82.55	71.78	73.37	61.07
3	303	77.93	87.83	82.79	71.10	72.19	61.48
4	338	79.94	88.68	82.88	71.35	75.48	60.97
Mean±SE	324±7.49	78.98±0.45	87.85±0.32	82.82±0.10	71.23±0.22	74.00±0.74	61.31±0.17
Group 3:							
1	326	78.62	80.33	85.53	80.52	73.33	72.05
2	320	78.37	80.07	85.61	79.61	72.64	72.01
3	312	77.86	79.67	84.54	79.28	71.13	72.52
4	318	78.39	79.09	85.15	79.51	73.73	72.27
5	305	77.37	79.54	84.17	79.54	71.09	70.93
Mean±SE	316±3.58	78.12±0.22	79.74±0.21	85.00±0.28	79.69±0.21	73.38±0.54	71.96±0.27

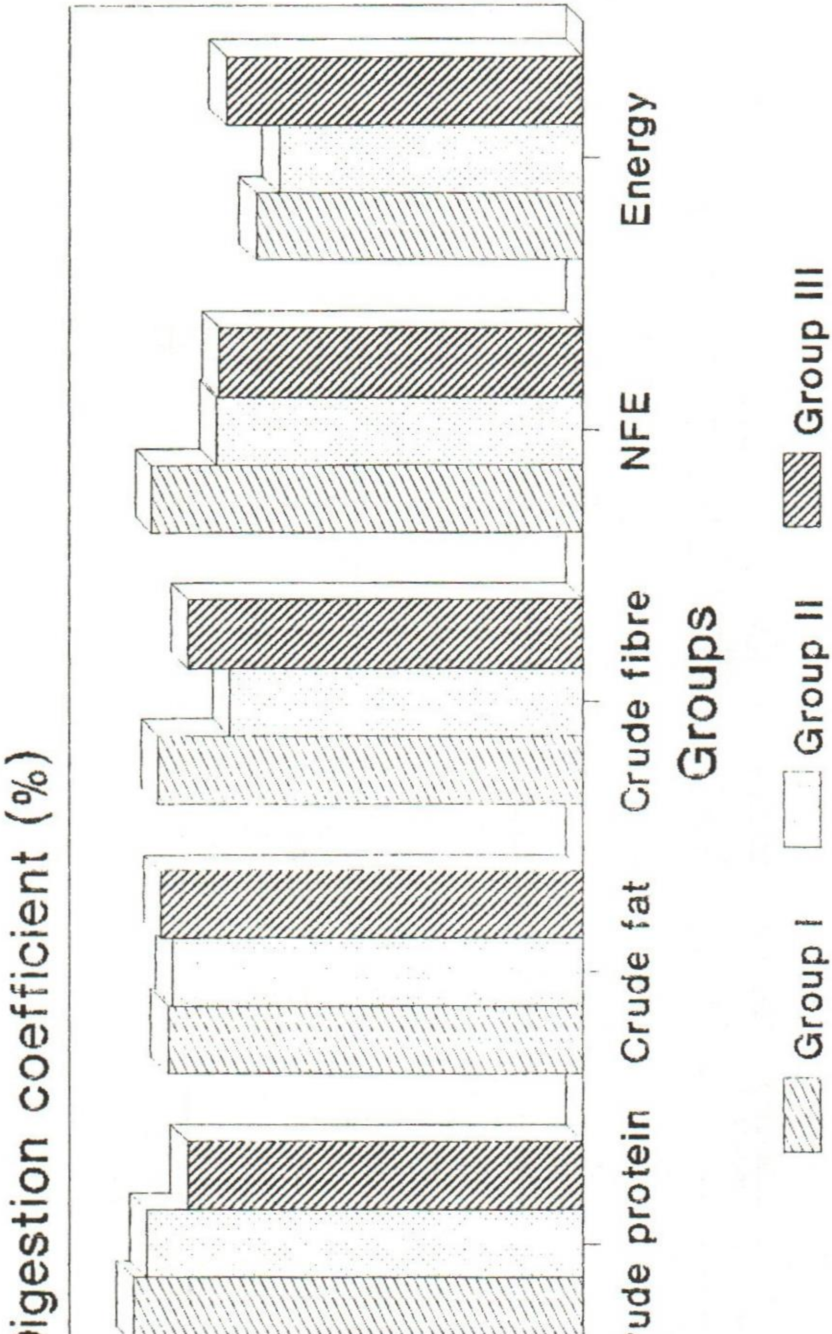

Fig.(1):Digestion coefficients for different nutrients in the three groups.