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EFFECT OF RESTRICTED PROTEIN NUTRITION AND REALIMENTATION ON BROILER PERFORMANCE

(With 6 Tables and 4 Figures)

By

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تأثير تقليل مستوى البروتين ثم إعادة تغذيته على أداء بدارى التسمين

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أجريت هذه التجربة لدراسة تأثير تقليل مستوى البروتين ثم إعادته ثانية على أداء بدارى التسمين وذلك بإستخدام خمس برامج في المراحل العمرية المختلفة لتغذية البروتين. قسمت مائة وخمسين كتكوت عمر يوم إلى خمس مجاميع تمت تغذية الأولى (I) منها والتي أعتبرت مجموعة ضابطة على النظام الغذائي الموصى به من قبل المجلس القومس للأبحاث بأمريكا لعام ١٩٩٤ (NRC, 1994) وتم مقارنة باقي الأنظمة بها. وضع المجلس القومي للأبحاث ثلاث مستويات للبروتين في علائق الدواجن مرادفة للثلاث مراحل العمرية (صفر إلى -٣) ، (٣ إلى -٦) ، (٦ إلى - ٨أسابيع) هي ٢٣ ، ٢٠ ، ١٨% على التوالي ، أما باقي الأربع مجاميع فكانت مستويات البروتين في نفس المراحل السنية هي (٢٣ ، ١٨ ، ٣٠%) و (٢٠ ، ٢٣ ، ١٨%) و (١٨ ، ٢٣ ، ٢٠%) لكل من المجموعات الثانية والرابعة والخامسة ، أما بالنسبة للمجموعة الثالثة فقد تم إستخدام نظام إسبوعي تنازلي لمستوى البروتين يبدأ من ٢٣% بروتين خام في الأسبوع الأول وينتهي عند ١٧% في الأسبوع الثامن. أظهرت النتائج أن تقليل مستوى البروتين حتى ١٨% في كل من مرحلتي البادي والنامي لم يؤثر على أداء الدواجن وأدى إرجاع مستوى البروتين ثانية إلى زيادة جهد النمو عند الطائر وكذلك معامل التحويل الغذائي أما المجوعة الخامسة والتي تغذت على (١٨ ، ٢٣ ، ٢٠%) بروتين خام في المراحل الثلاثة للنمو كانت هي الأفضل في كل مقاييس الأداء التي تم تقيمها حيث أن نظام غذائها كان هو الأكثر إقتصادياً ، ووجد أن تقليل مستوى البروتين لم يؤثر على قيمة البروتين الكلي في مصل الدم وكذلك المناعة وكانت معدلات التصافي والتشافي بعد الذبح واحدة في كل المجاميع دون تأثير.

SUMMARY

The effect of protein restriction and realimentation on broiler performance was studied by experimenting five protein phase-feeding programs. 150 one-day old broiler chicks were divided into five groups of which the first was fed following the NRC (1994) system and considered as control for comparison. The NRC levels of protein in the three age phases (0-to 3, 3-to 6, 6-to 8 weeks) were 23,20& 18% while that of the other four groups were 23,18,20; 20,23,18; and 18,23,20 for the groups II, IV&V, in group III a descending weekly step-down system was used, starting with 23% CP and ending with 17%. The results showed that protein restriction in the starter or grower phases to 18% did not affect the performance and the realimentation increased the chick potential for growth and feed utilization. The fifth program (18,23,20% CP) was the pioneer and most economical. Protein restriction did not affect total serum protein, immunity, and the chickens showed normal dressing value.

Key words: *Broilers, protein restriction, protein realimentation.*

INTRODUCTION

Animals do not always have sufficient food available at particular times to allow a full expression of their genetic potential for growth, when this occurs growth falls. It has been shown in many experiments that when food supplies again become abundant, growth rates accelerate and exceed those achieved by comparable animals fed well and continuously. This phenomenon is known as 'compensatory growth' (Plavnik and Hurwitz 1985,1991; Zubair and Leeson, 1994; Doyle and Lesson, 1996; Lawrence and Fowler, 1997). This apparent tendency of animals to regain the position lost on their growth curves by 'storing' their growth potential is both fascinating biologically and important economically.

Most of the experiments made on various aspects of compensatory growth were conducted on herbivores as sheep (Hogg, 1991; Kamalzadeh, 1996), cattle (Park et al.,1998), horse (Lowrence and Pearce,1964) and pig (Kyrazakis et al., 1991). In ruminants and especially in cattle, compensatory growth tends to be greater when there is change in diet type as well as in the amount of food offered (Park et al., 1998 and Rossi et al., 1999). Poland et al. (1998) found that nutritional regimens of beef heifers which imposed a period of growth restriction followed by a period of growth compensation have minimal to no delay in the onset of puberty. Of all the factors considered to have a possible influence on compensatory liveweight gains, an increased appetite and efficiency of feed utilization are generally thought to be the most important in the majority of circumstances (Poland et al., 1998 and Rossi et al.,1999). However, work with mammals and birds did not indicate in general that compensatory growth is exhibited to the same extent (Berge,1991).

Leeson and Zubair (1997) studied the nutrition of the broiler chicken during period of compensatory growth by feed restriction and realimentation programs. They found that this program succeeded in improving feed effeciency and allowing full body weight recovery. Studies of Leeson and Summers (1988); Summers et al. (1990); Plavnik and Hurwitz (1991); Zubiar and Leeson (1994) have demonstrated the potential for early-life undernutrition followed by full-feeding to reduce increased fat deposition and high incidence of skeletal and metabolic diseases as ascites, sudden death syndrome and leg problems.

Poultry producers recently are interested in low crude protein diets as a means of decreasing the cost of production and slightly inhibiting growth to decrease the incidence of disorders associated with rapid weight gain (Emmert et al., 2000). Madrigal et al. (1994) examined different crude protein percentages of isocalorific feeding programs designed to modify early growth rates in broilers compared with that stated by NRC and found little difference in the performance of birds. Leeson et al. (1996) stated that the bird must preferentially meet its energy requirement, in many cases it consumes excess protein with the result that a leaner carcass produced. Conversely, if a deficiency of protein results, the bird will overconsume energy in an attempt to meet its protein requirement leading to 'fatter' bird (Lipstein et al., 1975; Zubair and Leeson, 1994). Alleman et al. (2000) found that reducing crude protein significantly reduced breast muscle proportion.

The current experiment was designed to study the growth performance of broilers as a response to restricted levels of dietary protein and realimentation in isocalorific feeding programs compared with that stated by NRC (1994). The biological and economical effect of the feeding programs will be considered, and the least-cost ones suggested.

MATERIALS AND METHODS

Birds, housing and management

One hundred and fifty one-day-old broiler chicks, of the "Cobb" strain, and averaging 53.5 g in body weight, were allocated, at random, into five groups each of 30 chicks. The chicks were reared conventionally under hygienic conditions, with each group in a separate compartment. Food and water were provided on ad libitum basis and continuous lighting was used.

The first three groups were assigned altogether, in the first week of age, to a starter diet of 23% crude protein, whenever at the beginning of the second week the third group was transferred to the third feeding program, and at the beginning of the fourth week the second group transferred to the second program, while the first group was continued to be treated by the first program-the NRC one. The fourth and fifth groups were treated following the fourth and fifth programs respectively.

The experimental period extended for 8 weeks. During the feeding period the chicks were individually weighed, food consumption weekly recorded, and significant clinical signs, if any, registered.

For the induction of an immune response in the five bird groups, they were injected subcutaneously in the neck region, by a commercially prepared killed Newcastle disease virus (NDV) vaccine (Newcavac, Intervet Inc., Millsboro, Italy, DE 19966) at the age of one day, followed by another injection at the age of 4 weeks. At the age of 3,6&8 weeks, five chicks were randomly chosen from each group for slaughter studies and blood collected for antibody titer-determination at 3&8 weeks of age.

Diets and feeding programs:

Diets were formulated to meet NRC (1994) requirement recommendations for all the nutrients but protein percent, during the three age intervals 0-to 3, 3-to 6, and 6-to8. A typical three-feed-program was followed in each of the four groups I, II, IV & V and consists of diets containing 23, 23, 20 & 18% crude protein for the period from 0-to3 weeks respectively, 20, 18, 23 & 23% from 3– to 6 weeks and 18, 20, 18 & 20% from 6-to 8 weeks at the same respective order. While group III was fed on an eight-feed-program starting with a diet of 23% crude protein and decreasing 1% unit on a week-basis and with a diet of 17% crude protein in the 8th week.

The feeding programs tested are illustrated in Table (1) showing the protein percent in the different isocalorific diets and each's code number which was inspired from the ten's place-figures of the protein levels (3-of 23%, 0- of 20% & 8- of 18%) in the NRC three-feed-program.

Estimations:

Carcass yield:

The five birds slaughtered were assigned for the carcass characteristics calculated as percentage of the livebody weight, in addition to the deboned carcass at the end of the experimental period.

Immunological assays:

A blood sample was collected from each of the slaughtered chicks in the five groups, at the aforementioned settled ages, allowed to clot at ambient temperature, centrifuged for 10 minutes at 3000 rpm, and serum extracted. The serum samples (1 ml/vial) were kept frozen at –20° C until immunity parameters measured.

Total protein in serum was determined colorimetrically using Biuret reaction after Doumas (1975). The solid phase ELISA was used for the estimation of the immune response of the birds against Newcastle vaccination. The antibody formed were traced as described by Florence (1992).

Production cost:

Feeding broilers should be established on a basis of reducing the cost and increasing the net return rather than achieving the optimal performance. The cost of producing one kg livebody weight was calculated as the combined cost of feed and chick charges with no regard to the cost of litter, building and equipment charges, or any other miscellaneous ones. These calculations were considered as a matter of monetary comparison among the different feeding programs, not as real production costs expected to be put-on in farms.

Statistical analyses:

The data were analyzed by ANOVA in a one-way classification using the General Linear Models (GLM) procedure of PC STAT (1985). Means were separated using the Duncan's multiply range test option.

RESULTS and DISCUSSION

The nutrient requirements stated by NRC (1994) for market broilers are generally minimum levels that satisfy productive activities and (or) prevent deficiency syndromes. The levels of nutrients and the NRC feeding program, dividing the period into three age intervals (0- to

3, 3-to 6 and 6- to 8), were followed and recommended as thy are the most optimal.

In this study protein as the most expensive nutrient-its content in the three age-diets was tried to be reorganized, taking advantage of growth storage potential and compensatory growth as a biological phenomenon (Doyle and Lesson, 1996; Lawrence and Fowler, 1997). The suggested programs were tested on a weight gain, efficiency of feed utilization, and carcass quality-bases as the criteria of adequacy, in addition to the diet cost of broiler production.

Body weight gains:

In the first age period 0-3 weeks, Leeson and Summers (1988) and NRC (1994) suggested 23% protein, as a relatively high concentration is needed to support the rapid growth. In the present experiment this fact was not absolutely confirmed. Out of the five chick groups, the first two consuming 23% CP surpassed in the first two weeks but in the third week the high level of protein lost its privilege (Table3 and Figure1). Group V consuming 18% CP allover the three weeks attained the same rate of growth, and group IV consuming 20% was faster. The third group consuming three weekly step-down CP levels (23, 22, 21%) was the lowest in rate but the difference was not so significant. It can be concluded that in this stage of growth feeding 20 or even 18% is adequate to supply the chicks by its needs for nitrogen and essential amino acids, although the 23% protein was directed to be more supporting in the first two weeks as recommended by Leeson and Summers (1988); NRC (1994), and stressed by Plavnik and Hurwitz (1989) for the higher requirements of the essential amino acids.

In the second feeding period (3-6 wk) the fourth group fed the 20% and the fifth one fed the 18%- starters stored a growth potential high enough to attain the highest weights 1279 & 1328g respectively compared with the first three groups (1221,1159.8&1200.8g). The more severe restriction in the fifth group (18%) in the starter period compared with that of the fourth (20%) resulted in greater rate of growth after protein realimentation (to 23%), a finding which coincides with that cited by Lawrence and Fowler (1997). The results add a fact that protein restriction increases the ability of the chicken to absorb some amino acids (Gous, 1977) when the limiting nutrient is supplied in the recovery period, and it is not a matter of growth compensation but a matter of potential increasing.

The supply of high protein-diet during the recovery period after a period of diet restriction was stressed by Fontana et al. (1992) who found that protein might be a limiting nutrient during the recovery after a period of restriction. Even if the restriction of the protein was to a level that limits and decreases the growth, the bird can compensate in the recovery period (Leeson and Summers, 1988).

In the third period (6-8wk) the second stage-high level of protein in the fourth and fifth groups (23%) changed to 18% in the 4th and 20% in the 5th, in spite of that, the chicks of both groups maintained its surpassing growth rate and attained 1857.5&1932.3g compared with the first 3 groups which attained 1735.0, 1772.5 & 1752.5g in a respective order. A result which was explained by some researchers as Wilson and Osbourn (1960) who stated that the more severe the restriction, the greater the initial rate of gain immediately after realimentation. Concerning the age during the different stages, Plavnik and Hurwitz (1991) suggested that the response to any nutrient is most likely to be maximized immediately following the period of restriction, and it seems to be reasonable to assume that such responses will diminish with age.

The chicks fed on the NRC program (1st group) gained in the 8 weeks 1681.6 which when considered as 100% the other groups will score 102.2,101.0,107.3 & 111.7% respectively, pointing to the fourth and fifth systems of feeding as the best from the growth performance point of view. Many authors have described how animals and birds that had been restricted in growth exhibited greater rates of gain once the restriction was removed (Mersmann et al., 1987; Kyriazakis et al., 1991 for animals and Plavnik and Hurwiz 1985, 1991; Zubair and Leeson, 1994 for poultry).

Feed intake and conversion efficiency:

In the first three weeks of age the low-crude protein starter-groups (IV & V) recorded increased feed consumption when compared with the other three groups in which it was nearly equal (Table 4 and Figure 2). Lipstein et al. (1975) stated that broilers would try to eat and meet their particular requirement for protein and/or essential amino acids. This explanation seems not to fit with our findings as the consumption did not relate to the protein concentration and in the 20% -starter consumption was greater than the 18% -one. The difference in consumption is more related to the final chick weight and the statement of Lipstein et al. might be correct in levels of protein % lower than that used in this experiment. In the other two feeding periods intakes were nearly equal in spite of the difference in protein concentration, with the highest values scored by group IV (23%CP) and the lowest by group III (20%CP). In the whole experimental period the five groups consumed an average of 30.0 to 33.6 g diet / bird daily.

By reviewing the feed consumption in the three feeding periods no correlation could be extracted either with the level of dietary protein or the rate of growth. In spite of the increase in feed intake due to the decrease in protein concentration in starters of groups IV & V, in the second stage there is equality between the groups consuming the 20% (group1) or the 23-% growers (groups IV&V) and which followed a restricted percentages (20&18% respectively). The same inconsistency is clear in the third period (6-8 wk) and the 20%-groups either preceded by 18% (group II) or 23% (group V) were nearly equal while the 17-18%-finishers varied from 1.465 to 1.655g (groups I, III, IV).

It is a matter of efficiency of utilization more than the rate of consumption. Table 4 and figure 3 showed that restriction of dietary protein in starters by feeding 20%in the 4th group and 18% in the 5th one instead of 23% in the first two groups did not have a negative effect but conversely a positive one noted in the second period in which an abundant supply of protein is resupplied. The third group followed the same trend.

In the third feeding period realimentation of protein in group II (from 18% to 20%) improved the efficiency and the conversion index decreased from 2.85 to 2.55. On the other hand, decreasing the level of the protein from 23% to 18% in the fourth group resulted in no effect while decreasing to 20% improved the efficiency or allowed the grower realimentation improvement to continue. The third group showed the lowest efficiency and highest index (2.94). These results agreed with the fact mentioned by Leeson and Summers (1988); Ryan et al. (1993); Zubair and Leeson (1994) and Bikker et al. (1994) that there is little doubt that the broiler chickens can perform quite well on diets of low protein content, when body weight and gross feed efficiency are the main parameters of concern, and the broiler chicken appears to be able to benefit a period of early "undernutrition" in that subsequent compensatory growth results in no overall loss weight, and will likely improve feed utilization.

Any way, it is the feed cost of weight gain in the whole fattening period that to be considered. The fifth system is the pioneer and the other four systems were nearly equal and cost more feed for every kg gain by about 9.6% on the average. It was also suggested by Zubair and Leeson (1994) that increased growth after undergoing nutritional stress by consuming a diluted diet was due, in the same way, to better nutrient utilization resulted in improved compensatory gain and feed efficiency during the realimentation period.

Protein intake and protein efficiency ratio:

Protein is the most expensive nutrient and it is wise to calculate how many grams the chick gains in weight for every gram protein consumed (McDonald et al., 1982).

As the weight gain in the first stage of feeding either increased (as in group IV) or did not get affected by the low dietary level of protein (as in group V) and the rate of feed intake was not greatly changed, the protein efficiency indexes (Table 4 and Figure 4) were especially high (2.98&2.73) in group V (18% CP) and group IV (20% CP) respectively and following frankly the low level of protein intake. Parr and Summers (1991) were concerned with the protein intake, they reported that with diets similar in essential amino acids balance, young broilers will eat to satisfy their protein not their energy requirements.

In the second feeding stage the efficiency index also increased as dietary protein intake decreased (groups II & III) and conversely decreased as dietary protein intake increased (groups IV & V). This means that the improvement due to realimentation was not to the same extent in protein efficiency as that in body weight gain. It followed the amount of protein taken more than a restriction-recovery concept. However, NRC (1994) and Emmert et al. (2000) indicated that it is preferable to maintain a correct balance of amino acids as dietary crude protein concentrations are reduced, which allows superior growth performance to be obtained at substantially lower crude protein levels than are required.

The last stage of feeding (6-8wk) showed an equality among all the levels used 17-18%, 18% and 20% . Collectively while the first four systems showed efficiency ranging from 2.23-2.38, the fifth was the highest (2.43) to be nominated. These results agreed with Yang and Chung (1999) who concluded that the compensatory nutrition regimen after a period of nutrient or feed restriction improved performance and persistency of modulation of cell metabolism, differentiation and proliferation.

The following table,illustrates the performance in the whole experimental period,and shows that the fifth system in which the dietary protein was 18% as starter, 23% as grower and 20% as finisher proved to

Item	Groups No./ diet code				
	I/308	II/380	III/8-levels	IV/038	V/830
Weight gain "g"	1681.6	1719.1	1699.1	1804.1	1878.8
Feed intake "kg"	3.87	3.83	3.84	4.14	3.93
Protein intake "g"	764	752	719	848	824.3
Feed conversion index	2.30	2.23	2.26	2.29	2.09
Protein efficiency index	2.25	2.32	2.38	2.25	2.43

be the best from the performance point of view with an increase of weight reaching to 12%, and an increase in protein intake by 7.9%, costing 9% less food and also 9% less protein for 1kg livebody weight production.

Total serum protein, antibody titers and carcass dressing value:

The total protein values shown in table 5 revealed no significant difference among groups, however at the end of the growing period (6th week) the 5th group recorded a significantly high values. There is no explanation for the increased level, however the serum proteins followed the dietary one as explained by Leveille and Sauberlich (1961) who stated that serum proteins are affected by the level of protein nutrition.They added that most serum proteins are synthesized in the liver from amino acids derived from the food or the catabolism of tissues. In our experiment the level of ration protein was not low enough to exert a significant effect and as far as our results indicate a level as low as 18% protein in any age period from 0-8 wk is sufficient to supply the essential amino acids for synthesis of serum proteins.

Immunity was determined by detection of the antibody titers against Newcastle disease virus, the results showed no significant difference between groups either at the 3rd or the 8th week of age. In spite of the statement of Bhargava et al. (1971) that the level of antibody production is influenced by such nutritional factors as protein and amino acids, and optimal antibody production may not be obtained at the same nutrient level as optimum growth, the levels tested in the five chick groups were not low enough to confirm this fact.

Slaughter studies revealed no difference among groups in the carcass dressing value, which coincide with the findings of Leeson et al. (1996), and the lean meat production was nearly the same in all groups.

The economical study

The feed cost in the different groups depends on the cost of the different ingredients and the amount of the diet consumed.

Table 6 illustrated that the first 3 groups are about to be equal where one kg of diet costed from 2.9-3.0 pounds, while the last two groups showed the highest cost (3.25 & 3.13). The reason for the last tow groups is the feeding of the richest diet in protein (23%) as a grower where the feed intake during 3-week period was about more than 2.5 times the feed intake from the starter (with 20 or 18% CP). The cost of feed intake still is not the final criterion but the cost of each kg of livebody produced, in which group II showed the better bargain and have the low feed and low live weight costs, while group V in spite of the high cost of feed it scored the cheapest live weight production. Such findings agreed with Leeson et al. (1996) who explained that relatively low protein levels had little effect on early growth rate in broilers, as body weight of birds is initially reduced with lower-protein starter diets, although again by age there is considerable compensation. Taking into account the reduced cost of lower-protein content, economic analysis for his trial showed the lowest protein diets to yield the least feed cost per unit gain.

Other numerous studies (Plavnik et al., 1986; McMurtry et al., 1988; Jones and Farrell, 1992) have shown that full growth performance can be achieved within shorter times by restriction and realimentation enabling broilers to reach market weight at earlier ages. This is important from a commercial point of view since broilers are marketed at a wide range of ages and body weights depending on the market need.

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Table (1): Feeding programs, codes, and protein levels (%) in the three feeding phases

Program No.	Code	Starter 0-to 3wk	Grower 3-to 6wk	Finisher 6-to 8wk
I	308*	23	20	18
II	380	23	18	20
III	8-levels	23,22,21	20,19,18	18,17
IV	238	20	23	18
V	830	18	23	20

*The NRC (1994) program recommended three descending protein levels for the three age periods. The starter highest level 23% which designated by the figure "3", the second level 20% by "0", and the third level 18% by "8". The sequence of the figures translates the feeding program. The "8-levels" program has a weekly step-down (one unit-percent) program with the exception of the 6th and 7th weeks.

Table (2) : Composition (Percent or Kcal/Kg) and cost (L.E./Kg) of the experimental diets

Item	Starters (CP %)					Growers (CP %)				Finishers (CP %)		
	23	22	21	20	18	23	20	19	18	20	18	17
Physical composition												
Yellow corn,ground	48.80	52.20	55.75	59.40	66.30	44.70	55.43	58.80	62.17	56.40	63.3	66.82
Soybean meal	36.31	33.45	30.50	27.50	21.70	43.75	34.75	31.94	29.13	34.56	28.74	25.8
Fish meal, Herring	4.00	4.00	4.00	4.00	4.00	-	-	-	-	-	-	-
Plant oil	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00
Dried fat *	4.75	4.11	4.39	2.62	1.31	4.88	3.95	3.29	2.62	3.57	2.24	1.55
Dicalcium phosphate ($CaHPO_4 \cdot 2H_2O$)	2.12	2.12	2.12	2.12	2.12	1.94	1.94	1.94	1.94	1.63	1.67	1.67
Limestone, ground	0.20	0.36	0.42	0.72	1.03	0.02	0.24	0.40	0.56	0.25	0.57	0.73
Common salt	0.45	0.45	0.45	0.45	0.45	0.38	0.38	0.38	0.38	0.31	0.31	0.31
Sand	0.37	0.31	0.37	0.19	0.09	0.38	0.31	0.25	0.20	0.28	0.17	0.12
Supplement Kg/ton												
DL-methionine	0.40	0.65	0.90	1.15	1.64	-	0.72	0.75	1.22	-	-	0.22
L-lysine	-	-	0.16	0.85	2.2	-	-	-	0.47	-	-	-
Premix #	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Calculated chemical composition												
Crude protein	23.00	22.02	21.04	20.03	18.05	23.01	20.00	19.04	18.09	20.00	18.03	17.02
Methionine & cystine	0.90	0.90	0.90	9.90	0.90	0.72	0.72	0.70	0.71	0.64	0.60	0.60
Lysine	1.23	1.15	1.10	1.10	1.10	1.30	1.08	1.04	1.00	1.07	1.03	0.87
Calcium	1.06	1.06	1.02	1.06	1.06	0.90	0.88	0.88	0.88	0.78	0.80	0.80
Nonphytate phosphorus	0.47	0.47	0.47	0.47	0.47	0.36	0.36	0.36	0.36	0.31	0.31	0.31
ME (Kcal/Kg)	3200	3200	3201	3200	3200	3200	3201	3201	3200	3200	3201	3201
Cost	0.887	0.874	0.860	0.851	0.833	0.820	0.777	0.760	0.751	0.757	0.722	0.710

* product of SUPER'S DIANA, S.L., Cira, Barcelona (9% Ca & 7560 Kcal ME/Kg).

Each3 Kg of vitamin and mineral premix (Galaxy Mix, Galaxy Egypt) contains: Vit.A 12,000,000 IU, Vit.D3 22,000,00 IU, Vit.E 20,000mg, Vit.K 40,00mg, Vit.B1 1150mg, Vit.B2 6250mg, Vit.B6 1850mg, Vit.B12 10,00mg, Pantothenic acid 24,160mg, Biotin 2500mg, Niacin 30,620mg and Folic acid 1060mg, Copper sulphate 17,000mg, Ferrous sulphate 10,3500mg, Magnesium sulphate 14,750,0mg, Cobalt sulphate 500mg, Calcium iodide 500mg, Zinc oxide 69,500mg, Sodium selenate 230mg and Calcium carbonate up to 3 kg.

-Choline chloride was added to all diets at the rate of 0.5 kg/ton

Table (3) : Body weight development of broilers during the experiment

Period or age in weeks	Group No./ diet code				
	I/308	II/380	III/8-Levels	IV/038	V/830
Body weight "g"					
0	53.45±2.01				
1	125.33±2.21 ^{a}			115.00±2.27 ^{b}	109.83±2.54 ^{b}
2	90833±4.44 ^{a}		206.17±5.22 ^{a}	197.33±5.94 ^{ab}	186.67±6.47 ^{b}
3	403.00±11.941 ^{ab}		390.83± 7.54 ^{b}	427.67± 12.08 ^{a}	405.00± 4.20 ^{ab}
4	582.80± 17.57 ^{b}	565.80± 22.76 ^{b}	572.80± 17.92 ^{b}	678.00± 19.67 ^{a}	651.00± 19.02 ^{a}
5	8447.00± 16.53 ^{b}	861.20± 18.82 ^{b}	861.60± 17.29 ^{b}	880.20± 19.80 ^{ab}	921.20± 17.10 ^{a}
6	1221.00± 31.58b ^{c}	1159.80± 26.30 ^{c}	1200.80± 27.94 ^{bc}	1279.20± 33.08 ^{ab}	1328.00± 24.80 ^{a}
7	1520.00± 35.39 ^{ab}	1478.50± 49.95 ^{b}	1507.50± 55.55 ^{b}	1578.50± 42.04 ^{ab}	1645.00± 33.04 ^{a}
8	1735.00± 32.68 ^{c}	1772.50± 39.99 ^{bc}	1752.50± 42.24 ^{bc}	1857.50± 50.49 ^{ab}	1932.25± 33.22 ^{a}
Weight gain "g"					
0-3	349.55		337.38	374.22	351.55
3-6	818.00	756.80	809.97	851.53	923.00
6-8	514.00	612.70	551.70	578.30	604.25
Total gain (0-8)	1681.55	1719.05	1699.05	1804.05	1878.80

-Values are means ± SE.
-Means within a row with no common superscripts differ significantly ($P \leq 0.05$).

Table (4) : Feed and prsotein intake and the utilization efficiency

Period in weeks	GroupNo./ diet code				
	I/308	II/380	III/8-levels	IV/038	V/830
Feed intake (Kg)					
0-3	0.616		0.613	0.683	0.656
3-6	1.790	1.656	1.609	1.797	1.740
6-8	1.465	1.561	1.620	1.655	1.530
Total 0-8	3.871	3.833	3.842	4.135	3.926
Feed conversion index (kg diet/kg gain)					
0-3	1.76		1.82	1.83	1.87
3-6	2.19	2.19	1.99	2.11	1.89
6-8	2.85	2.55	2.94	2.86	2.53
Total 0.8	2.30	2.23	2.26	2.29	2.09
Protein intake (Kg)					
0-3	141.7		133.0	136.6	118.0
3-6	358.0	298.1	302.2	4 13.3	400.2
6-8	293.7	312.2	282.8	297.9	306.0
Total 0-8	763.4	752.0	719.0	847.8	824.3
Protein efficiency index (kg gain/kg protein intake)					
0-3	2.46		2.54	2.73	2.98
3-6	2.29	2.54	2.68	2.06	2.31
6-8	1.95	1.96	1.94	1.94	1.98
Total 0-8	2.23	2.32	2.36	2.25	2.43

Table (5) : Serum total protein , antibody titers and dressing value

Age in weeks	Group No. / diet code				
	I/308	II/380	III/8-levels	IV/038	V/830
Total protein (g/dl)					
3	3.89±0.10		3.89±0.24	3.89±0.22	3.56±0.18
6	4.18±0.52 [b]	3.89±0.27 [b]	4.19±0.44 [b]	4.24±0.32 [ab]	5.33±0.31 [a]
8	5.21±0.23	5.47±0.23	5.40±0.21	5.21±0.59	5.46±0.24
Antibody titers					
3	0.789±0.10		0.908±0.16	0.820±0.04	0.812±0.07
8	1.12±0.08	1.12±0.09	1.13±0.10	1.37±0.2	1.20±0.10
Dressed carcass %					
8	68.60±0.80	67.67±1.75	67.99±1.11	67.37±1.15	67.53±1.36
Lean meat %					
8	61.90±1.13	61.67±0.73	61.23±0.39	62.03±0.24	62.40±0.31

-Values are means ±SE .
-Means within a row with no common superscripts differ significantly ($P \leq 0.05$).

-Dressing value = $\frac{\text{carcass weight}}{\text{Livebody weight}} \times 100$

Table (6) : Cost of meat production (L.E./Kg) in the different broiler groups

Period in weeks	Group No./ diet code				
	I/ 308	II/ 380	III/ 8.wk	IV/ 038	V/ 830
Cost of feed intake					
0-3	0.546		0.533	0.581	0.547
3-6	1.391	1.244	1.223	1.474	1.427
6-8	1.058	1.182	1.182	1.161	1.158
Total 0-8	2.995	2.972	2.917	3.25	3.132
Cost of 1 Kg LBW*					
0-3	1.561		1.577	1.557	1.558
3-6	1.702	1.645	1.527	1.730	1.550
6-8	2.058	1.930	2.105	2.065	1.915
Total 0-8	1.774	1.712	1.736	1.784	1.674

* LBW: livebody weight.

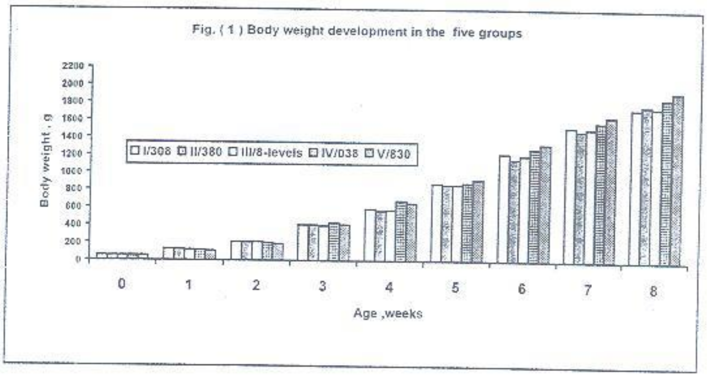
Fig. (1) Body weight development in the five groups
Body weight , g
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
I/308
II/380
III/8-levels
IV/038
V/830
0
1
2
3
4
5
6
7
8
Age ,weeks

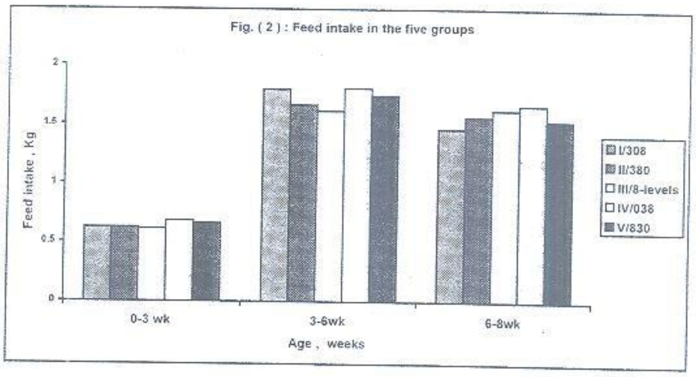
Fig. (2) : Feed intake in the five groups
Feed intake , Kg
2
1.5
1
0.5
0
I/308
II/380
III/8-levels
IV/038
V/830
0-3 wk
3-6wk
6-8wk
Age , weeks

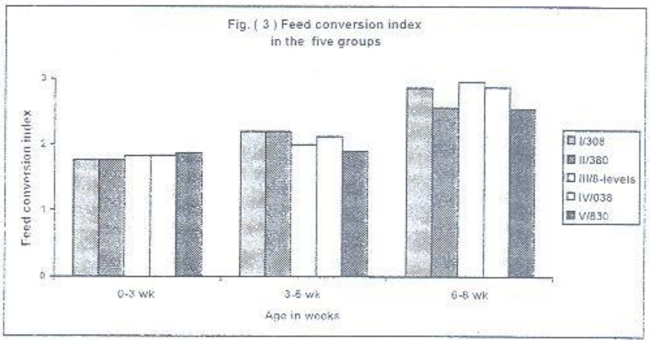

Fig. (3) Feed conversion index in the five groups

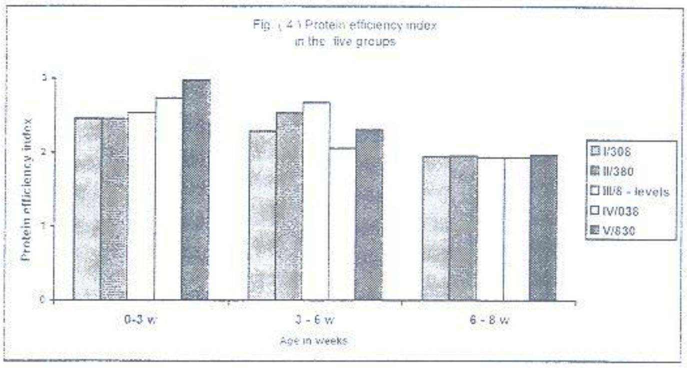

Fig. (4) Protein efficiency index in the five groups