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# MODELS TO DETERMINE THE NITROGEN REQUIREMENTS FOR MAINTENANCE FROM NITROGEN BALANCE TRIALS WITH APPLICATION ON LOCAL GOATS

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**SUMMARY**

Four nitrogen balance trials were carried out on three mature Baladi bucks weighed 22.80 kg fed four sequential rations of different protein levels. Dietary crude protein content (CP%) were 6.82, 7.60, 10.35 and 12.66 for rations I,II,III and IV, respectively. Daily rations consisted of low (300 g) or high (600 g) levels of barley grains with ad. lib. amounts of either rice straw or berseem hay.

Three regression equations were predicted from results of nitrogen (N) balances being as follows:
N balance, mg/kg BW= -70.98+0.39 N intake, mg/kgW (r=0.79).
Fecal N, g/d= 1.28+0.13 N intake, g/d (r=0.64). Urinary N, g/d= 0.93+0.58 apparent digestible N,g/d (r=0.87).

Metabolic fecal N (MFN) was 0.26 g N/100 g DM intake and endogenous urinary N (EUN) was 0.089 gN/kgW$^{0.75}$. The average maintenance requirements of nitrogen estimated by four different methods for Baladi goats were; 220.67 mg/kgW equivalent to 3.01 g CP or 2.02 g DCP/kgW$^{0.75}$ by the graphical method, 182.00 mg/kgW equivalent to 2.49 g CP or 1.67 DCP/kgW$^{0.75}$ by the statistical method, 215.70 mg/kgW equivalent to 2.95 g CP or 1.98 g DCP/kgW$^{0.75}$ by the percentage utilization method and similar values (2.95 g CP or 1.98 g DCP/ kgW$^{0.75}$ by the factorial method. The overall average value of maintenance protein

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for goats was 2.81 g CP or 1.95 g DCP/Kg $W^{0.75}$.

**Keywords:** Nitrogen requirement, maintenance, metabolic fecal nitrogen, endogenous urinary nitrogen, goats

## INTRODUCTION

Nutritional requirements have almost not been investigated until now for Egyptian goats, probably because of the belief that goats have relatively small contribution to animal production in Egypt, and more particularly because of the common assumption that the nutritional requirements of goats are very close to those of sheep. However, species differences concerning, body weight environmental conditions, sources of feed stuffs and physiological status of animals should be considered in such comparative studies (NRC, 1981).

The present study was designed to suggest different possible models to estimate maintenance requirement of nitrogen from balance trials with application on local goat (Baladi) fed rations with different levels of dietary protein.

## MATERIALS AND METHODS

Three mature Baladi bucks aged 12-14 months with an average body weight of 22.80 were used in four Nitrogen balance (NB) trials by feeding four rations which consisted of whole barley grains with chopped rice straw or berseem hay. Experimental rations were fed sequentially according to the following table:

| Ration | Barley g/day | Rice straw | Berseem hay |
|---|---|---|---|
| I | 300 | Ad lib. | - |
| II | 600 | Ad lib. | - |
| III | 600 | - | ad. lib. |
| IV | 300 | - | ad. lib. |

The nutritive values of the experimental rations are shown in Table 1. Digestible crude protein (DCP) ranged from 3.63 to 9.31% and total digestible nutrients (TDN) from 69.41 to 78.72%. Ration I was formulated to bring

down animals into a negative NB status. Each trial lasted 4 weeks, one week for group feeding in a brick-made pen, two weeks individual feeding in metabolic crates for adjustment and adaptation followed by one week for feces and urine total collection.

Table 1. Chemical composition and nutritive value of the experimental rations

| Item | Ration | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| DM composition, % | | | | |
| OM | 92.91 | 94.96 | 93.82 | 91.23 |
| CP | 6.82 | 7.60 | 10.35 | 12.66 |
| EE | 0.61 | 0.66 | 2.01 | 3.39 |
| CF | 19.52 | 14.60 | 15.02 | 18.86 |
| NFE | 65.96 | 72.10 | 66.44 | 56.32 |
| Ash | 7.09 | 5.04 | 6.18 | 8.77 |
| Nutritive value, % | | | | |
| TDN | 69.41 | 78.72 | 78.70 | 73.29 |
| DCP | 3.63 | 5.01 | 7.69 | 9.31 |

Barley grains were offered once daily and roughages (Rice straw or Berseem hay) were offered twice to appetite. Residuals of either barley or roughages were daily collected, oven dried at 60°C and individually kept in plastic bags. Clean water was freely offered.

Chemical composition of feedstuffs and feces was determined according to A.O.A.C. (1984). Energy of feeds and feces was determined using adiabatic oxygen bomb calorimeter. Urinary N was determined by the micro-kjeldahl method (A.O.A.C., 1984). Four models were applied to determine the nitrogen requirement for maintenance from the balance trials:

**1- Graphical method**

The method developed by Majumdar (1960) and Sengar (1980) with goats fed rations providing at least three levels of dietary protein to bring N balance from an negative to positive value was used.

In the present study N balance (mg/kg W) was plotted against daily intake for each individual animal. Lines joining these points cut the ordinate at three points.

The highest (a) and the lowest cut points (b) represent the daily maximum and minimum N intakes (mg) that would result in zero balances (N equilibrium). The average of these two values represent the nitrogen maintenance requirement as mg/Kg W.

**2- Statistical method**

The method was based on the close relationship between N intake and either N output (Sengar, 1980) or N balance (Singh and Mudgal, 1991). The N requirement was statistically approximated by the regression of N balance on intake. The N intake (X) was taken as independent variable and the N balance (Y) as dependant one for each individual animal.

**3- Percentage utilization method:**

The method was based on the following formula:

$$\text{N requirement, g= N intake, mg/kgW} \pm \left(\frac{\text{N balance, mg/kgW}}{\text{\% N utilization}} \times 100\right)$$

with + or -sign for animals with - and + N balances, respectively. The percentage utilization method could only be applied when sets of N balance trials are carried out on the same animal fed different protein levels. Data in Table 5 were calculated according to this method as described by Sengar (1980).

**4- Factorial method**

Nitrogen requirements for maintenance were determined according to Harris-Mitchell method as reported by Sengar (1980) as:

$$\text{N, maintenance requirement} = \frac{\text{EUN + MFN}}{\text{BV x TD}}$$

where

EUN= endogenous urinary N (g/d)
MFN= metabolic fecal N (g/d)
BV = biological value (%)
TD = the true digestibility (%) of the dietary protein.

The MFN is dependent upon both dry matter intake and out put, and was estimated by regressing fecal N (g/d) on dietary N (g/d), and then extrapolating the resultant regression line to zero intake of N. The MFN was expressed as g N per 100 g DM intake. The EUN was calculated by regressing urinary N loss on apparent

digestible N intake (ADNI) as reported by Reynolds (1981). The correlation between ADN and urinary N was based on the following relationships:

N intake = N retained + N out put

N intake = fecal N + ADNI

N output = fecal N + urinary N

So that, when N retained is zero (at maintenance) N out put equals N intake, and by substitution: fecal N + ADNI = fecal N + urinary N Therefore, at the maintenance level ADNI is equal to urinary N. The EUN was expressed as g N per $kgW^{0.75}$.

Analysis of variance, regression and correlation analysis were carried according to SAS (1990). Duncan's Multiple Range Test was used to separate means in Table 2.

Table 2. Intakes and digestibilities of the experimental rations by goats

| Item | Ration | | | | SE | Sign. |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| No.of animals | 3 | 3 | 3 | 3 | | |
| Body weight, kg | 22.25 | 23.33 | 23.63 | 22.00 | 0.54 | NS |
| Intake, g/d | | | | | | |
| DM | 383.68b | 528.19a | 559.91a | 470.92ab | 32.75 | * |
| TDN | 266.33c | 415.81a | 440.65a | 345.13b | 21.16 | * |
| DCP | 13.94c | 26.48b | 42.54a | 44.36a | 3.42 | ** |
| DE, Mcal | 1.20c | 1.89a | 1.98a | 1.52b | 0.09 | * |
| Intake, $g.kgW^{0.75}$ | | | | | | |
| DM | 37.48c | 49.75ab | 52.21a | 46.21b | 2.65 | * |
| TDN | 26.01c | 39.16ab | 41.09a | 33.88b | 1.66 | * |
| DCP | 1.36c | 2.49b | 3.97a | 4.33a | 0.27 | ** |
| DE, Kcal | 116.67c | 180.00a | 183.33a | 150.00b | 6.87 | * |
| Digestibility,% | | | | | | |
| DM | 69.30c | 80.61a | 82.06a | 77.31b | 0.98 | ** |
| OM | 74.48c | 82.35a | 83.45a | 78.41b | 0.90 | ** |
| CP | 53.32b | 66.09a | 73.91a | 74.15a | 2.67 | ** |
| EE | 27.36b | 65.47a | 24.02b | 40.96ab | 8.81 | * |
| CF | 57.88 | 58.24 | 56.85 | 54.40 | 2.85 | NS |
| NFE | 82.00c | 89.11b | 92.71a | 89.29b | 1.72 | ** |
| Energy | 72.33c | 81.64a | 81.81a | 76.90b | 0.99 | ** |

NS = not significant * P<0.05 ** P<0.01

$^{a,b,c}$ Means bearing different superscripts in the same row differed significantly (P<0.05).

## RESULTS AND DISCUSSION

Results of nutrients intakes and digestibilities shown in Table 2 indicated that intakes of DM, TDN and digestible energy were significantly ($P<0.01$) lower for rations containing rice straw (I and II) than rations containing berseem hay (III and IV) except EE digestibility of ration III. Nutrients digestibilities were significantly ($P<0.01$) higher for rations containing high level of barley grains (rations II and III). Crude protein digestibility was significantly ($P<0.01$) lower in low protein diet (I). Crude fiber digestibility was not affected by dietary protein level. The experimental rations provided required energy needed for maintenance of goats (NRC, 1981), while CP or DCP/kgW$^{0.75}$ were below the maintenance level in ration I, marginal in ration II and nearly 1.5 time the maintenance level in rations III and IV (NRC, 1981).

Nitrogen requirement for maintenance of experimental goats calculated from results of N balance trials (Table 3) was between 182.00 to 220.67 mg N/kgW. The highest value of N requirement was detected by the graphical method (Fig. 1) and the lowest value was detected by the statistical method. (Table 4). Very close values being, 215.7 and 216.06 mg N/kgW were detected by the percentage utilization method (Table 5) and the factorial method (Table 6).

Table 3. Body weight,(Kg), nitrogen intakes and balances (g/head/day) of goats fed the experimental rations

| Ration | Anim. No. | Body wt. | NI | FN | UN | NB |
|---|---|---|---|---|---|---|
| I | 1 | 22.25 | 4.22 | 1.98 | 2.32 | -0.08 |
| | 2 | 21.75 | 4.23 | 1.85 | 2.66 | -0.28 |
| | 3 | 22.75 | 4.09 | 2.03 | 2.60 | -0.54 |
| II | 1 | 23.50 | 6.76 | 2.62 | 3.58 | 0.56 |
| | 2 | 23.25 | 6.32 | 2.10 | 3.15 | 1.07 |
| | 3 | 23.25 | 6.19 | 1.85 | 3.18 | 1.16 |
| III | 1 | 23.50 | 10.03 | 3.29 | 3.57 | 3.17 |
| | 2 | 23.25 | 8.51 | 1.57 | 5.30 | 1.64 |
| | 3 | 24.15 | 9.63 | 2.50 | 5.49 | 1.64 |
| IV | 1 | 20.00 | 7.10 | 1.93 | 3.18 | 1.99 |
| | 2 | 23.00 | 11.80 | 3.08 | 7.43 | 1.29 |
| | 3 | 23.00 | 9.71 | 2.20 | 4.42 | 3.09 |

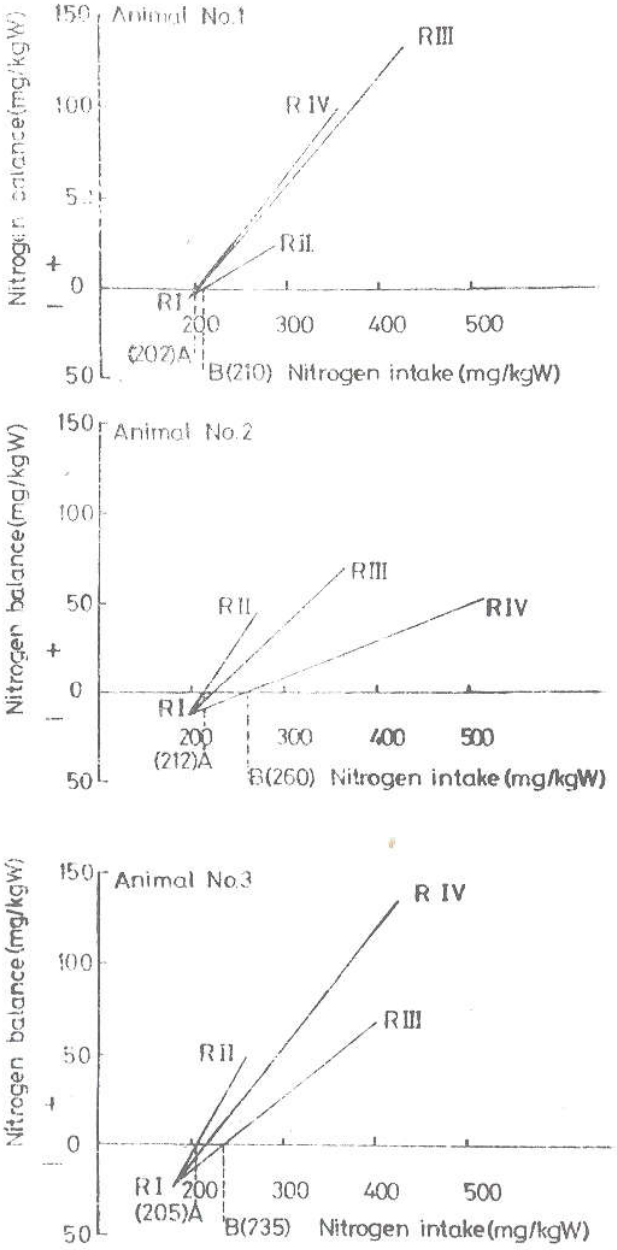


**Fig. 1. Nitrogen requirement for maintenance calculated by the graphical methods.**

Crude protein or DCP required for maintenance calculated for goats were 3.01 or 2.02, g/Kg $W^{0.75}$, respectively as assessed by the graphical method, 2.49 or 1.69 by the statistical method and 2.95 or 1.98 by either the percentage utilization method or factorial method.

Table 4. Correlations and regressions from nitrogen metabolism trials by goats fed experimental rations

| Regression equations: | | (n) | (r) |
|---|---|---|---|
| N balance,mg/kgW | = - 70.98+0.39 N intake,mg/kgW | 12 | 0.79 |
| Fecal N, g/d | = 1.28+0.13 N intake,g/d | 12 | 0.64 |
| Urinary N,g/d | = 0.93+0.58 ADNI ,g/d | 12 | 0.87 |
| Predicted values by the extrapolation method: | | | |
| N requirement for maintenance | = 182.00 mgN/kgW | | |
| Metabolic fecal N | = 0.26 g/100g DM intake | | |
| Endogenous urinary N | = 0.089 g/kg$W^{0.75}$ | | |

Table 5. Maintenance requirements of nitrogen of goats calculated by the percentage utilization method

| Animal (mg/Kg W) | Ration | NI | NB | N utilization | N requirement No. |
|---|---|---|---|---|---|
| | | --(mg/kg)-- | | (%) | (mg) |
| 1 | I | 189.7 | -3.6 | - | - |
| | II | 287.7 | 23.8 | 28.0 | 202.7 |
| | III | 426.8 | 134.9 | 58.4 | 195.8 |
| | IV | 355.0 | 99.5 | 62.4 | 195.5 |
| 2 | I | 194.5 | -12.9 | - | - |
| | II | 271.8 | 46.0 | 76.2 | 211.4 |
| | III | 366.0 | 70.5 | 48.6 | 220.9 |
| | IV | 513.0 | 56.1 | 21.7 | 254.5 |
| 3 | I | 179.8 | -23.7 | - | - |
| | II | 266.2 | 49.9 | 85.2 | 207.6 |
| | III | 398.8 | 67.9 | 41.8 | 236.4 |
| | IV | 422.2 | 134.3 | 65.2 | 216.2 |
| Overall average nitrogen requirement (mg/kgW) | | | | | 215.7 |

It is interesting to note that few studies concerning nutritional studies have not been conducted for local goats yet. Results from several studies conducted on foreign goat breeds indicated that, the maintenance requirement of CP/kg$W^{0.75}$ was ranged from 2.12 (Itoh et al., 1979) to 3.40 (Sengar, 1980). The NRC (1981) standards represented mean of seven studies, being 2.82

g DCP or 4.15 g CP/kgW$^{0.75}$ with an average digestibility of 68 percent of total dietary protein.

Table 6. Maintenance requirements of nitrogen of goats calculated by the factorial method

| Ration | Animal No. | Body weight | EUN g | MFN g | BV % | TD % | N requirement mg/kgW |
|---|---|---|---|---|---|---|---|
| I | 1 | 22.25 | 0.91 | 1.03 | 56.9 | 77.5 | 197.7 |
| | 2 | 21.75 | 0.90 | 1.03 | 48.4 | 80.6 | 227.5 |
| | 3 | 22.75 | 0.93 | 0.97 | 44.9 | 74.1 | 251.0 |
| II | 1 | 23.50 | 0.95 | 1.45 | 53.0 | 82.7 | 233.0 |
| | 2 | 23.25 | 0.94 | 1.37 | 60.5 | 88.4 | 185.8 |
| | 3 | 23.25 | 0.94 | 1.35 | 60.6 | 91.9 | 176.9 |
| III | 1 | 23.50 | 0.95 | 1.61 | 68.6 | 83.3 | 190.6 |
| | 2 | 23.25 | 0.94 | 1.23 | 46.6 | 96.0 | 208.6 |
| | 3 | 24.15 | 0.97 | 1.57 | 48.0 | 90.3 | 242.7 |
| IV | 1 | 20.00 | 0.84 | 1.03 | 62.3 | 87.3 | 171.9 |
| | 2 | 23.00 | 0.93 | 1.44 | 36.0 | 86.1 | 332.4 |
| | 3 | 23.00 | 0.93 | 1.25 | 60.2 | 90.2 | 174.6 |
| Overall average nitrogen requirement (mg/kgW) | | | | | | | 216.1 |

In the present study, values of protein requirement for maintenance of local goats (Baladi) fed rations with an average digestibility of 66.87% of total protein were approx. 30% lower than values recommended by the NRC (1981). However, similar values were reported on castrated males (2.1 g DCP/kgW$^{0.75}$) or dry females (1.9 g DCP/kgW$^{0.75}$) by using the factorial method as reported by Brun-Bellut et al. (1987) and (1991).

Experiments carried out on Indian breeds showed higher protein requirement for maintenance of goats. Reported values were 2.69 DCP/kg W$^{0.75}$ for maintenance of non-producing goats (Singh and Mudgal, 1985).

The same authors (1991) recorded values on male Indian Beetal goats ranging from 2.5 to 2.6 g DCP/kgW$^{0.75}$ by either N balance or graphical methods.

Discrepancies of values among the studies for protein maintenance requirements of goats could be related to numerous factors namely; 1- level of dietary protein and protein intake (Hadjipanayiotou, 1991), 2- breed and sex of animals (Sengar, 1980), 3- physiological status of animals (Singh and Mudgal, 1985) and 4- the method followed to calculate required protein (Sengar, 1980). Moreover, number of animals and minimum variations in body weight and age should also be considered.

The MFN and EUN calculated in the present study as 2.60 g/Kg DM intake and 0.089 g/Kg $W^{0.75}$, respectively (Table 4) were lower than those reported by Sengar (1980) as 4.20 g MFN/1Kg DM intake and 0.128 g EUN/kg$W^{0.75}$ for Indian breeds of goats fed N-free or N-low diets. Lower values were reported for female non-lactating West African dwarf goats, being 0.34 g MFN/100 g DM intake and 0.10 g EUN/kg$W^{0.75}$ (Adeloye, 1992). The inconstant values of MFN or EUN among the studies could be attributed to that MFN is related to the food intake and defined as the fecal N excreted per kg of food intake when N-free diets are given. However, it is very difficult to keep a ruminant animal on a N-free diet for a long period. As N becomes limiting, food intake eventually decreased and hence MFN will also decrease. On the other hand, Orskov (1982) mentioned that fecal N could increase if more carbohydrate substrate was fermented in the large intestine and the quantity of MFN is at least twice as great as the EUN. Moreover, the partitioning between EUN and MFN could be involved because the mechanism of nitrogen recycling in ruminants enable animals to trap nitrogen in the rumen as microbial protein which could appear in the feces. The mechanism of N recycling was found much efficient in goats raised on low-protein rations (Obara and Shimbayashi, 1980). In the present study, predicted values of MFN and EUN seemed to be within the normal range recorded for the species.

It could be concluded that protein maintenance requirements determined by the factorial method or nitrogen percentage utilization gave similar values comparable to those calculated by the graphical method but higher than those found when statistical methods was applied. The average values of N requirements for maintenance for Baladi goats were 2.81 g CP or 1.95 g DCP/Kg $W^{0.75}$. Further studies with larger sample size may be needed to establish protein requirements not only for goats but also for other ruminant species under different production activities.

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# نماذج لتقدير الإحتياجات الحافظة من النيتروجين من تجارب موازين النيتروجين مع التطبيق على الماعز المحلية

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أجريت أربع تجارب ميزان نيتروجين على ثلاثة جداء بلدية تامة النمو تزن ٢٢ كجم غذيت على أربع علائق تحتوى مستويات بروتين متدرجه. كانت هذه المستويات الأربعة ٦,٨٢، ٧,٦٠، ١٠,٣٥ و ١٢,٦٥٪ بروتين خام للعليقة الأولى، الثانية، الثالثة والرابعة على التوالى. وقد تكونت العليقة اليومية من مستوى منخفض (٣٠٠ جم) أو مستوى عالى (٦٠٠ جم) من الشعير مع التغذية لحد الشبع على قش الأرز أو دريس البرسيم.

تم إستنباط ثلاث معادلات إنحدار من نتائج تجارب موازين النيتروجين كما يلى:

ميزان النيتروجين (مجم/كجم وزن حى)=-٠,٣٩+٧٠,٩٨ النيتروجين المأكول مجم/كجم وزن حى (ر=٠,٧٩) نيتروجين الروث جم/يوم= ٠,١٣+١,٢٨ النيتروجين المأكول جم/يوم (ر=٠,٦٤) نيتروجين البول جم/يوم = ٠,٥٨+٠,٩٣ النيتروجين المهضوم ظاهريا جم/يوم (ر=٠,٨٧)

وقد وجد أن نيتروجين الروث التمثيلى بلغ ٠,٢٦ جم/١٠٠ جم ماده جافة مأكولة و نيتروجين البول الداخلى ٠,٠٨٩ جم/ حيز جسم تمثيلى (و٠,٧٥)، ومتوسط الإحتياجات من النيتروجين المقدرة بالطرق الأربع للماعز البلدى كانت على الترتيب ٢٢٠,٦٧ مجم /كجم وزن حى التى تعادل ٣,٠١ جم بروتين خام أو ٢,٠٢ جم بروتين خام مهضوم /كجم و٠,٧٥وذلك بإستخدام الطريقة البيانية وقدرت الإحتياجات ١٨٢,٠٠ مجم/كجم وزن حى التى تعادل ٢,٤٩ جم بروتين خام أو ١,٦٧جم بروتين خام مهضوم /كجم و٠,٧٥ بالطريقة الإحصائيه قدرت الإحتياجات أيضا لتكون ٢١٥ مجم/كجم وزن حى بإستخدام طريقة النسبة المئوية للإستغادة من النيتروجين ونفس الرقم تم الحصول عليه بتطبيق الطريقة العددية وهو يعادل ٢,٩٥ جم بروتين خام أو ١,٩٨جم بروتين خام مهضوم /كجم و٠,٧٥

وبذا يكون المتوسط العام للإحتياجات الحافظة من النيتروجين للماعز البلدى تعادل ٢,٨١ جم بروتين خام أى ١,٩٥ جم بروتين خام مهضوم / كجم و٠,٧٥