

# Determination Of Blood Nutrients In Reared Grasscutter (*Thryonomys Swinderianus* Temminck, 1827) Subjected To A Complete Granulated Food In Benin.

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**ABSTRACT: OBJECTIVES:** Several studies which have suggested foods for the new environment of reared grasscutter, report the composition, zootechnical performance, digestibility of these foods. However, very few investigations reveal the constitution of blood grasscutter after having provided food for measuring of concentrations blood nutrients. The main purpose of this study is the determination and assessment of blood nutrients through hematology and biochemical parameters and C-reactive protein in reared grasscutters subjected to a complete granulated food. **METHODOLOGY:** Eight subadult Grasscutters aged six months in Benin are subjected to different foods (foods from Côte d'Ivoire and another food usually distributed in Benin). In each animal, a blood sample is taken fasting the morning in tubes with anticoagulant and without anticoagulant. Through these blood samples, haematological and biochemical parameters were determined and evaluated through comparisons of statistical tests. **RESULTS:** The results of these investigations showed that the mean values of all blood nutrients were normal compared to some studies conducted elsewhere. In addition, our work has shown that both foods do not significantly different through the evaluated blood nutrients. However, concentrations of urea ( $28 \pm 2.8$  mg/dl) and phosphorus ( $102.5 \pm 14.3$  mmol/l) are increased in grasscutter subjected to complete granulated food compared to food usually distributed in grasscutter place of rearing ( $21.3 \pm 3.8$  mg/dl and  $78.5 \pm 9$  mmol/l respectively). Furthermore, various relationships were observed between haematological, biochemical parameters, weight gain and C-reactive protein. **CONCLUSION:** The complete granulated food provides good and best content of nutrients in blood of subadult grasscutters.

**Keywords:** Grasscutter; Complete-granulated-food; Blood-nutrients; C-reactive-protein; Benin-Côte d'Ivoire

## INTRODUCTION

In Africa, south of the Sahara, grasscutters breeding (*Thryonomys swinderianus* Temminck, 1827) is an important activity in the lives of people<sup>1, 2, 3, 4</sup>. In Benin and Côte d'Ivoire for several decades, this breeding has evolved considerably in the sense of a good production of animal protein for the population<sup>5, 6, 7, 8</sup>. Researches in the field of grasscutter are making progress to improve the new environment of grasscutters which originally are wild rodents<sup>9, 10, 11, 12, 13, 14</sup>.

Sharpened investigations to cover the food needs of grasscutters in captivity have been conducted in various countries in south of the Sahara<sup>4, 15, 16</sup>. These studies could provide a healthy and balanced diet for grasscutters in all seasons. A researcher in Côte d'Ivoire formulated a complete granulated food for grasscutters according to the different physiological stages<sup>17, 11, 18</sup>. However, for this food no study on blood nutrients parameters in grasscutter was performed. Blood is a liquid tissue very important for the major functions of the body. Its main role is to lead nutrients to vital organs and remove waste outside the organism. In addition, knowledge of blood nutrients in grasscutters could help to establish the nutritional quantitative and qualitative value of the formulated complete granulated food<sup>19, 20</sup>. The proposed complete granulated food to feed grasscutters at all physiological stages is more than 90 % from natural resources. It consists of 70 % forage and 30 % of dietary supplements as grasscutters' diet in their biotope<sup>6, 17</sup>. Furthermore, an adaptation of this complete granulated food for grasscutters' food mode will allow proper performance of farm grasscutters. And this, based on the evaluation of essential blood nutrients in the grasscutter subjected to this food. Several studies to this effect have been carried out in some animals such as rabbits (*Oryctolagus cuniculus*), cattle and goats breeding<sup>21, 22, 23, 24, 25</sup>. All determined blood nutrients in this study relate the macronutrients (carbohydrates, lipids and proteins) and the micronutrients (minerals) associated with haematological parameters. The C-reactive protein, an inflammatory protein is assayed to assess the health status of grasscutters. Such an investigation is the first in the frame at grasscutters rearing with a new food from Côte d'Ivoire. Works of this kind have been conducted in Ghana, Nigeria and Senegal<sup>26, 27, 28, 29</sup>. The general objective of this work partly funded by project "Africa One" and realized in Benin and Côte

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**d'Ivoire**, is to establish another scientific basis by evaluation of the nutritional profile of Grasscutters subjected to a new formulated complete granulated food. To do this, two types of foods were selected to feed subadult grasscutters. The present study therefore specifically aims to:

- Estimate the values of haematological parameters in the reared grasscutters subjected to a complete granulated food,
- Determine the blood biochemical indicators related to the assessment of nutritional status in reared grasscutter,
- Compare the different biological parameters between the two grasscutter groups subjected to two types of food,
- Reveal the relationship between these nutrients blood weight gain and C-reactive protein.

## MATERIALS AND METHODS

### Food and animal treatment

The test food that we subjected to grasscutters was in a granulated form provided by the grasscutters place of rearing Research of Nangui Abrogoua University/Abidjan (Republic of Côte d'Ivoire). This food has been formulated by an ivoirien researcher<sup>17</sup>. The granulated food consisted of 70 % forage and 30 % of food supplements (Table 1). For control grasscutter, chosen food was daily distributed to the animals in grasscutters place of rearing of Non Conventional Animal Species Breeding Sub-Programm (S-PEEANC) of Zootechnical, Veterinary and Halieutic Research Laboratory (LRZVH) in Agricultural Research Centre of Agonkanmey (CRA-Agonkanmey) in the National Institute of Agricultural Research of Benin (INRAB) located in Godomey via Abomey. It also consisted of 70 % forage and 30 % of food supplements (Table 1). The experiment was carried out with eight subadult male grasscutters growing aged six months with an average metabolic weight between  $1.3 \pm 0.1$  kg and  $1.8 \pm 0.2$  kg. Animals were collected with Mr Gilbert TANKPINOU a professional grasscutter rearer in Plateau Department to southeastern Benin. Grasscutters were adapted to the experimental conditions in Non Conventional Animal Species Breeding Sub-Programm (S-PEEANC) of Zootechnical, Veterinary and Halieutic Research Laboratory (LRZVH) in Agricultural Research Centre of Agonkanmey (CRA-Agonkanmey). The eight animals were divided into two groups of four subadult grasscutters each one depending on the type of distributed food (Table 2). Each grasscutter was bred in an individual numbered rectangular parallelepiped form cage (0.7 m x 0.7 m x 0.4 m) which was performed of cement. A feeder and waterer have daily been laid available to each animal to be fed and watered *ad libitum*. A period of food adaptation and transition for ten days was observed for the four experimental animals on complete granulated food used in Côte d'Ivoire<sup>3</sup>.

### Blood samples and assays of biological parameters

For the determination of blood nutrients four ml of blood were collected on an empty stomach on each grasscutter the twelfth day of driving breeding. The blood was collected by cardiac puncture from each animal without his vital prognosis is engaged. Venojet tubes with anticoagulant

(Ethylene-Diamine-Tetra-acetic Acid or EDTA) were used to blood sample and determined immediately haematological parameters by automatic counter analyzer (Sysmex KX21N) at National Centre of University Hospital (CNHU/Cotonou, Benin) in the Laboratory of the Science and Conscience Research Group (GRSC). Blood samples obtained with vacuum tubes venojet without EDTA were centrifuged at 3000 rpm for fifth minutes and the serum collected was used to determine glucose lipid and protein profiles. They were determined by an automatic device (HITACHI 902) through reagents kits from the company Spinreact SA (Ctra.Santa Coloma, Spain) specific biochemical parameter by a colorimetric method and immunoturbidimetric immunoassay. The determination of these biochemical parameters was carried out at the Centre of University Hospital (CHU/Cocody, Abidjan/Côte d'Ivoire) in the Biochemical Laboratory, Department of Immuno-Hematology

### Statistical analysis

In order to identify possible changes in biological parameters sought, several non-parametric statistical tests were used. This is MANN-WHITNEY relate to evolution of blood nutrients between grasscutters subjected to the complete granulated food and those in the food usually distributed in grasscutter place of rearing. Relationship between weight gain C-reactive protein and grasscutters Laboratory parameters were determined by estimating SPEARMAN correlation coefficients. All these statistical analysis was performed with the computer program Statistica Statsoft Windows version 7.1<sup>30</sup>.  $p < 0.05$  was considered as indicative of significance.

## RESULTS

### Description of haematological parameters

The results of haematological values obtained were for five out of eight blood samples aulacodinets. The three blood samples from other grasscutters subjected to the test food could not be determined because of the coagulation of blood samples. The mean values associated with standard errors in hematological parameters of these five grasscutters are summarized in Table 3. Expressed relative dispersion by the coefficients of variation was evolved to varying degrees in the different haematological parameters. Thus, the number of red blood cells, hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and the rate of lymphocyte presented dispersions relatively low. In contrast, the number of leukocytes and thrombocytes indicated higher dispersions. In Table 4, the number of red blood cells, mean corpuscular volume and mean corpuscular hemoglobin showed significantly lower mean values compared to those of young grasscutters and wild Grasscutters. However, hemoglobin and mean corpuscular hemoglobin concentration indicated values close to those of young grasscutter Grasscutter and wild. In the same vein, the mean leukocyte count which was similar to that of young grasscutter was very low compared to the value observed in wild grasscutters (Table 4).

### Changes in blood biochemical nutrients

Values describing the biochemical parameters of all eight grasscutters of the blood nutrients study in grasscutters on complete granulated food and their controls are indicated in Tables 5. In this table, the comparison of biochemical parameters between the two groups of animals showed no statistically significant difference except urea ( $p = 0.03$ ) and phosphorus ( $p = 0.03$ ). These two blood nutrients indicated higher concentrations in grasscutters on complete granulated food ( $28 \pm 2.8$  mg/dl and  $102.5 \pm 14.3$  mmol/l, respectively) than in controls ( $21.3 \pm 3.8$  mg/dl and  $78.5 \pm 9$  mmol/l, respectively). In the same way, the rate of glucose ( $340.8 \pm 74.2$  mg/dl) and total cholesterol ( $111.8 \pm 12.3$  mg/dl) in the grasscutters on complete granulated food were more increased compared to values of control grasscutters ( $272.8 \pm 98.5$  mg/dl and  $96.5 \pm 34$  mg/dl, respectively) although statistically there was no difference ( $p > 0.05$ ). However, the observed values of triglycerides ( $77.5 \pm 52.2$  mg/dl) and transaminases ( $216.5 \pm 93.6$  U/l,  $57.5 \pm 15.2$  U/l, respectively) were higher in controls than in grasscutters on the complete granulated food ( $66.3 \pm 28.9$  mg/dl,  $155.5 \pm 58.5$  U/l and  $38.5 \pm 22.2$  U/l, respectively). The results observed in our study showed significant concentrations of glucose, Triglycerides, HDL cholesterol, transaminase (GOT), potassium, chlorine, calcium and phosphorus in the blood of subadult grasscutters compared to young grasscutters and wild grasscutter. In contrast, the rate of total protein, urea, creatinine, total cholesterol, transaminase (GPT) and magnesium were low compared to other types of grasscutters reported in Table 6.

### Correlation between the final weight of the animals, C-reactive protein and main nutrients blood

Spearman coefficients summarized in Table 7, were significant for mean corpuscular volume (MCV,  $p = 0.01$ ), mean corpuscular hemoglobin concentration (MCHC,  $p = 0.03$ ) and leukocytes ( $p = 0.04$ ). Indeed, the mean corpuscular volume (MCV) and weight gain have been positively correlated. In contrast, the leukocyte counts and weight gain have been negatively correlated. Similarly, C-reactive protein was negatively correlated with the mean corpuscular hemoglobin concentration (MCHC). All these correlations were considerable between haematological parameters weight gain and C-reactive protein because all observed coefficients were close to 1 and -1 (Table 7). In addition, the results of the study indicated that weight gain and MCV have reported an increasing relation. It was opposite to the number of leukocytes that presented a decreasing relation with weight gain. Moreover, another decreasing relation was observed between C-reactive protein and mean corpuscular hemoglobin concentration (MCHC). At the level of blood biochemical nutrients, no significant correlation ( $p > 0.05$ ) was observed between weight gain and blood nutritional indicators in different control grasscutters (Table 8). However, significant correlations have been reported between weight gain and total cholesterol ( $p = 0.02$ ), chlorine concentrations ( $p = 0.04$ ), magnesium ( $p = 0.02$ ) and phosphorus ( $p = 0.003$ ) in subadult grasscutters on the complete granulated. In fact, total cholesterol, chlorine and phosphorus indicated positive correlations with weight gain of grasscutters. They revealed high increasing relation ( $r = 0.9$ ). In contrast, weight gain and the magnesium concentration showed a negative

correlative. Therefore, these biological indicators have shown a high decreasing relation ( $r = -0.9$ ) in grasscutter on complete granulated food. In control grasscutters, only total cholesterol and C-reactive protein showed a significant correlation ( $p = 0.04$ ). This observed relation was positive high and increasing ( $r = 0.9$ ) between this biochemical parameter and C-reactive protein (Table 8). However, a negative, high and decreasing relation has been reported ( $r = -0.9$ ) in grasscutters on complete granulated food and C-reactive protein.

### DISCUSSION

The determined nutrient values in grasscutter blood during our investigations are normal. Moreover, results indicate significant differences in blood nutrient between the two types of study foods. These differences between the values of blood nutrients are revealed at the biochemical nutritional indicators. A comparison of haematological parameters is not performed between the two grasscutter groups because of the coagulation of some blood samples (three in number) in animals subjected to the complete granulated food. Observations from studies suggest a rapid coagulation of blood samples in grasscutters<sup>28,31</sup>. This general observation of blood samples from the grasscutters could be explained by a characteristic of hemostasis in these rodents. The observed variations of haematological parameters in grasscutters are normal. Compared to other studies, these changes are justified by several factors including age, sex, pregnancy, lactation, infections, environment, different seasons of the year and especially the diet of these animals<sup>20</sup>. This could explain the reported differences between subadult grasscutters from Benin and young wild grasscutters of Nigeria<sup>28,32</sup>. Moreover, a study revealed a hypochromic macrocytic anaemia based on mean corpuscular hemoglobin concentration (MCHC) between 19.8 and 27 mg/dl in infected grasscutters with *Trypanosoma congolense* and *Trypanosoma vivax*. MCHC values in control animals are between 33 and 34 mg/dl<sup>33</sup>. These values are similar to those observed in subadult grasscutters subjected to the test food. In the same vein, the hematocrit values (43-49 %), mean corpuscular volume (62-65 fl), white blood cells (4.2 to 4.9  $10^6/l$ ) and lymphocytes (45 to 48 %) in the controls of these Nigerian authors are similar to ours<sup>33</sup>. However, infected grasscutters with trypanosomes showed a decrease in white blood cells (leukopenia) between 1.9 and 2.8  $10^6/l$ . This finding is contrary to values of leukocytes in uninfected grasscutters of this study ( $6.5 \pm 2.1$   $10^6/l$ ). Some animals such as rabbits and jerboa also indicated changes in haematological parameters such as grasscutters of this study during pregnancy, different seasons and food rationing<sup>34, 35, 36</sup>. Thus in Saudi Arabia, an author reported a decrease in the red blood cells, hemoglobin, mean corpuscular volume (MCV), leukocytes and lymphocytes in pregnant rabbits compared to nonpregnant rabbits<sup>34</sup>. Conversely, these haematological parameters increased during the month of January compared to other months of April, July and October. Haematological parameters in the blood are produced from blood nutrients which are usually blood biochemical parameters. Their concentrations in the blood regulate the synthesis of major haematological parameters<sup>19</sup>. The observed mean values of haematological parameters in this study are normal compared to other

values reported by authors through some content of biochemical parameters<sup>26, 28, 31, 33</sup>. Concentrations of biochemical parameters in grasscutters of this investigation do not change depending on the type of food which is served. This observation could be explained by the nutrient composition of each food that would be similar. The two types of foods contain mostly for grasscutter breeding, 70 % forage and 30 % of dietary supplements. However, differences were observed to concentrations of urea and phosphorus. The variation of these two biochemical parameters could be justified by essential compounds content in forages and dietary supplements. Urea concentration which characterizes renal function is higher in grasscutters on complete granulated food compared to the grasscutters fed with classical ration of LRZVH's grasscutters place of rearing. This concentration of urea in the grasscutters on complete granulated food with regard to the values obtained can't alter the vital organs that are the kidneys<sup>28, 32</sup>. Moreover, it would make sense to control in this nitrogenous waste in these grasscutters on complete granulated food in the long term. Moreover, the rate of phosphorus is considerably higher in grasscutter on test food. This food provides a high concentration of phosphorus in grasscutters. This would promote good of bone formation and teeth in young and subadult grasscutters. However, a high concentration of this micronutrient may deteriorate renal function in older animals<sup>21</sup>. In the same way, hyperphosphataemia is often reported in hypervitaminosis D, hemoconcentration, rickets and osteomalacia<sup>37, 38</sup>. Conversely, a decrease in phosphorus is observed in inadequate dietary intake. For glucose, total protein and creatinine, the present study shows high values compared to those obtained by Nigerian researchers<sup>28,32</sup>. This variation of blood biochemical nutrients could be justified by the provision of food, emotion, climate change or altitude<sup>22</sup>. As haematological parameters, biochemical parameters changes in grasscutters are also influenced by several factors<sup>20</sup>. These same observations are also reported in some animal breeding<sup>33</sup>. The nutrients status of grasscutters' meat much appreciated by the population is due to the concentrations of nutrients in the blood<sup>31, 39, 40, 41, 42</sup>. Blood nutrients which are distributed in different organs and tissues are brought by the proper and appropriate diet of grasscutters<sup>43</sup>. This reason justifies the interest of many studies on food in order to cover the food needs of grasscutters<sup>44, 45</sup>. The foods formulated to feed grasscutters provide nutrients such as macro-and micronutrients that end up in the blood and meat. This set of determined blood nutrients also expresses the state of grasscutters' health. This health status is evaluated by weight and an inflammatory protein indicating various relationships between these two parameters and blood nutrients. Observed normal rates of C-reactive protein suggest that all grasscutters subjected to two types of foods are a great health. Normal values of hematological and biochemical parameters recorded in grasscutters following the trial are due to the distribution of a balanced diet covering nutritional needs. Different correlations between weight gain and blood recorded nutrients are also indicators of the quality of the distributed food<sup>41, 43</sup>.

## CONCLUSION

Determined blood nutrients in the subadult grasscutters subjected to different types of foods indicate overall normal average values of macronutrients (glucose, triglycerides, total cholesterol and total proteins) and micronutrients (different searched ions). These blood nutrients assessed through hematological and biochemical parameters were indicated no significant differences except for concentrations of urea and phosphorus. These two blood nutrients are increased in subadult grasscutters on the complete granulated food. Urea and phosphorus can at concentrations above standards alter the essential large functions of grasscutters. This is why even if the granulated food can solve the difficulty to feed the grasscutters in all seasons increase animal performance and have good digestibility of certain nutrients, it would be good idea to continue the evaluation of blood nutrients to understand the better changes of urea and phosphorus. In addition, the concentrations of the protein inflammation, C-reactive protein correlate with blood nutrient showed a good health status of grasscutter in our work. Furthermore, an investigation into the different metabolisms of macronutrients and micronutrients in a large sample of grasscutters of all ages and different sexes may clearly elucidate the blood nutrients and to establish their standard which still does not exist yet.

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**Table 1:** Centesimal composition of food rations

N°	food ingredients	Rate of the ration (%)	
		Experimental (Traore. 2010)	Classic (Mensah <i>et al.</i> . 2007)
1.	<i>Panicum maximum</i>	35.00	35.00
2.	<i>Pennisetum purpureum</i>	35.00	35.00
3.	<i>Leucaena leucocephala</i>	3.00	4
4.	<i>Moringa oleifera</i>	3.00	4
5.	Wheat bran	0	7
6.	Soyabean meal	3.00	0
7.	Cassava chips	4.00	0
8.	spent grains of Brewery	4.00	0
9.	Maize grain	10.00	13
10.	giant snails' ashes of shell	0.50	1.50
11.	Cooking salt	0.50	0.50
12.	vitamin premix	2.00	0
<b>Total</b>		<b>100</b>	<b>100</b>

**Table 2:** Weight characteristics of study grasscutters

Animals	Control grasscutters	Grasscutters with test food
Initial body liveweight	1.9 ± 0.2	1.5 ± 0.1
Final body liveweight	2.2 ± 0.3	1.9 ± 0.1
Initial metabolic liveweight	1.6 ± 0.1	1.3 ± 0.1
Final metabolic liveweight	1.8 ± 0.2	1.6 ± 0.1
Weight gain/Body liveweight	0.2 ± 0.1	0.3 ± 0.1
Weight gain/metabolic liveweight	0.3 ± 0.2	0.4 ± 0.1

**Table 3:** Description of haematological parameters in all experimental animals

Haematological parameters	Means $\pm$ Standard deviation	Minimum	Maximum	Coefficients of variation (%)
Blood red cell count				
Red cells blood ( $10^{12}/l$ )	7.6 $\pm$ 0.6	7	8.4	7.5
Hemoglobin (g/dl)	14.2 $\pm$ 0.9	13.2	15.3	6.0
Hematocrit (%)	42.8 $\pm$ 2.5	40.5	46.7	5.9
Erythrocyte indices				
MCV (fl)	56.3 $\pm$ 1.7	54.9	59.3	3.0
MCH (pg)	18.7 $\pm$ 0.8	18.2	20.2	4.5
MCHC (g/dl)	33.2 $\pm$ 0.6	32.8	34.1	1.9
Leukocyte parameters				
Leucocytes ( $10^6/l$ )	6.5 $\pm$ 2.1	3.6	8.6	32.4
lymphocytes (%)	77.2 $\pm$ 11.3	65.1	91.4	14.7
Thrombocyte parameters				
Thrombocytes ( $10^6/l$ )	544.8 $\pm$ 251.4	184	884	46.1

MCV: Mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration

**Table 4:** Comparison of haematological parameters with other studies

Haematological parameters	Reared subadult grasscutters (Present study, N = 5)	Reared young grasscutters, N=10 <sup>a</sup>	Wild grasscutters N=100b
Blood red cell count			
Red cells blood ( $10^{12}/l$ )	7.6 $\pm$ 0.6	12.4 $\pm$ 0.5	16.4 $\pm$ 0.3
Hemoglobin (g/dl)	14.2 $\pm$ 0.9	12.4 $\pm$ 1.7	14.2 $\pm$ 0.5
Hematocrit (%)	42.8 $\pm$ 2.5	ND	ND
Erythrocyte indices			
MCV (fl)	56.3 $\pm$ 1.7	66.8 $\pm$ 10.5	71.9 $\pm$ 4.2
MCH (pg)	18.7 $\pm$ 0.8	20.5 $\pm$ 5	20.4 $\pm$ 1.9
MCHC (g/dl)	33.2 $\pm$ 0.6	28.6 $\pm$ 1.9	34.2 $\pm$ 1.5
Leukocyte parameters			
Leucocytes ( $10^6/l$ )	6.5 $\pm$ 2.1	6.1 $\pm$ 1.1	12.9 $\pm$ 1.8
lymphocytes (%)	77.2 $\pm$ 11.3	4.9 $\pm$ 1*	10.3 $\pm$ 1*
Thrombocyte parameters			
Thrombocytes ( $10^6/l$ )	544.8 $\pm$ 251.4	ND	ND

N: Total number of used animals, MCV: Mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, \*: The rate of lymphocytes is expressed in  $10^6/l$ , a: Reported study<sup>28, 32</sup>.



**Table 5:** Biochemical changes according to type of food

Biochemical parameters	Total animals N = 8	Extreme values (minimum and maximum)	Control animals N = 4	Extreme values (minimum and maximum)	Animals on granulated food. N = 4	Extreme values (minimum and maximum)	p values
Glucide							
Glucose (mg/dl)	306.8 ± 88.5	169-432	272.8 ± 98.5	169-406	340.8 ± 74.2	263-432	0.3
Proteins							
total protein (mg/dl)	52.7 ± 10.4	29.4-62	49.6 ± 14.5	29.4-61	55.8 ± 4.3	52-62	0.4
urea (mg/dl)	24.6 ± 0.05	17-32	21.3 ± 3.8	17-26	28 ± 2.8	26-32	<b>0.03</b>
Creatinine (mg/dl)	13.3 ± 1.8	10-16	13.5 ± 2.5	10-16	13 ± 0.8	12-14	0.7
Lipids							
Triglycerides (mg/dl)	71.9 ± 0.4	34-150	77.5 ± 52.2	38-150	66.3 ± 28.9	34-97	0.7
Total cholesterol (mg/dl)	104.1 ± 0.3	61-133	96.5 ± 34	61-133	111.8 ± 12.3	100-128	0.4
HDL cholesterol (mg/dl)	38.3 ± 0.04	31-44	36.5 ± 4	31-40	40 ± 3.7	36-44	0.2
Enzymes							
Transaminase GOT (U/l)	186 ± 79.3	93-349	216.5 ± 93.6	140-349	155.5 ± 58.5	93-234	0.3
Transaminase GPT (U/l)	48 ± 20.3	16-68	57.5 ± 15.2	35-67	38.5 ± 22.2	16-68	0.2
Inflammation							
C reactive proteine	4.6 ± 0.5	4-5	4.5 ± 0.6	4-5	4.8 ± ± 0.5	4-5	0.5
Ions							
Sodium (mmol/l)	144.5 ± 4.3	140-153	143.8 ± 3	140-147	145.3 ± 5.7	140-153	0.6
Potassium (mmol/l)	9.3 ± 1.2	7.8-10.6	9.7 ± 1.1	8.1-10.6	8.9 ± 1.2	7.8-10.2	0.3
Calcium (mmol/l)	165 ± 24.4	125-196	164.5 ± 29.5	125-196	165.5 ± 22.8	133-184	0.9
Chlorinee (mmol/l)	105.6 ± 2.7	103-111	104.5 ± 1.3	103-106	106.8 ± 3.4	104-111	0.2
Magnesium (mmol/l)	28.7 ± 2.6	24.9-32.4	28.1 ± 2.2	24.9-29.6	29.2 ± 3.3	25.5-32.4	0.6
Phosphorus (mmol/l)	90.5 ± 16.9	66-119	78.5 ± 9	66-86	102.5 ± 14.3	87-119	<b>0.03</b>

N: Total used of animals; HDL: High density lipoprotein or HDL. GOT: Glutamyl oxaloacetic transaminase or glutamate oxalacetat transaminase. GPT glutamyl pyruvic transaminase or glutamate transaminase Pyruvat

**Table 6:** Comparison of biochemical parameters with other studies

Biochemical parameters	Reared subadult grasscutters (Present study. N = 5)	Reared young grasscutters N=10 <sup>aa</sup>	Wild grasscutters N=100 <sup>ba</sup>	<sup>o</sup> Other grasscutters. N = NC
Glucide				
Glucose (mg/dl)	306.8 ± 88.5 (169-432)	137.6 ± 5.9	92.7 ± 9	167 ± 31 (113-26)
Proteins				
total protein (mg/dl)	52.7 ± 10.4 (29.4-62)	50 ± 0.2	73 ± 0.3	58.3 ± 6.9 ND
urea (mg/dl)	24.6 ± 0.05 (17-32)	27 ± 6.9	21.9 ± 2.8	53 ± 10 (36-77)
Creatinine (mg/dl)	13.3 ± 1.8 (10-16)	13 ± 0.2	12 ± 0.1	19 ± 4 (13-29)
Lipids				
Triglycerides (mg/dl)	71.9 ± 0.4 (34-150)	ND	ND	52 ± 30 (19-115)
Total cholesterol (mg/dl)	104.1 ± 0.3 (61-133)	126.1 ± 16.05	195.7 ± 5.5	67 ± 20 (41-99)
HDL cholesterol (mg/dl)	38.3 ± 0.04 (31-44)	ND	ND	27 ± 10 (14-74)
Enzymes				
Transaminase GOT (U/l)	186 ± 79.3 (93-349)	96 ± 28	105 ± 20	ND
Transaminase GPT (U/l)	48 ± 20.3 (16-68)	ND	87 ± 9	ND
Inflammation				
C reactive proteine	4.6 ± 0.5 (4-5)	ND	ND	ND
Ions				
Sodium (mmol/l)	144.5 ± 4.3 (140-153)	147.7 ± 2.5	138.6 ± 2.9	146.7 ± 2 (144-152)
Potassium (mmol/l)	9.3 ± 1.2 (7.8-10.6)	5.7 ± 0.7	4.3 ± 0.2	4.6 ± 0.7 (2.6-5.6)
Calcium (mmol/l)	165 ± 24.4 (125-196)	109 ± 2.3	98 ± 3.2	110.3 ± 7.6 (97-123)
Chlorinee (mmol/l)	105.6 ± 2.7 (103-111)	ND	ND	98.5 ± 8 (71-116)
Magnesium (mmol/l)	28.7 ± 2.6 (24.9-32.4)	ND	ND	36.2 ± 6.2 (29-56)
Phosphorus (mmol/l)	90.5 ± 16.9 (66-119)	ND	ND	49.9 ± 3.8 (43-56)

ND: not determined; NC: Number used of animals is not known, α: Extreme values are not known, δ: physiological state of animals is not known<sup>3</sup>, the extreme values are in brackets in the table, N: Total used of animals, HDL: High density lipoprotein or HDL, GOT: Glutamyl oxaloacetic transaminase or glutamate oxalacetat transaminase, GPT glutamyl pyruvic transaminase or glutamate transaminase Pyruvat, a: Reported study<sup>28, 32</sup>

**Table 7:** Correlation coefficients between the final weight, C-reactive protein and haematological parameters

Haematological parameters	Correlation coefficients	
	weight gain	C reactive Proteine
Blood red cell count		
Red cells blood ( $10^{12}/l$ )	-0.8 (0.2)	0.3 (0.7)
Hemoglobin (g/dl)	-0.4 (0.6)	-0.2 (0.8)
Hematocrit (%)	-0.5 (0.5)	0.2 (0.8)
Erythrocyte indices		
MCV (fl)	<b>0.9 (0.01)</b>	-0.4 (0.6)
MCH (pg)	0.9 (0.1)	0.7 (0.3)
MCHC (g/dl)	0.4 (0.6)	<b>-0.9 (0.03)</b>
Leukocyte parameters		
Leucocytes ( $10^6/l$ )	<b>-0.9 (0.04)</b>	0.4 (0.6)
lymphocytes (%)	-0.5 (0.5)	0.8 (0.2)
Thrombocyte parameters		
Thrombocytes ( $10^6/l$ )	0.9 (0.09)	-0.1 (0.9)

The p values are in parentheses, ND: not determined

Table 8: Correlation coefficients between the final weight, C-reactive protein and biochemical parameters

Biochemical parameters	Correlation coefficients			
	weight gain		C reactive Proteine	
	Control	Food test	Control	Food test
Glucide				
Glucose (mg/dl)	-0.3 (0.7)	-0.03 (0.9)	-0.7 (0.3)	0.3 (0.7)
Proteins				
total protein (mg/dl)	-0.7 (0.3)	0.9 (0.1)	0.8 (0.2)	<b>-0.9 (0.04)</b>
urea (mg/dl)	0.9 (0.1)	-0.5 (0.5)	-0.1 (0.7)	0 (1)
Creatinine (mg/dl)	-0.03 (0.9)	-0.3 (0.7)	-0.7 (0.3)	0.8 (0.2)
Lipids				
Triglycerides (mg/dl)	0.7 (0.3)	0.9 (0.1)	-0.8 (0.2)	-0.7 (0.3)
Total cholesterol (mg/dl)	-0.04 (0.9)	<b>0.9 (0.02)</b>	<b>0.9 (0.03)</b>	-0.9 (0.1)
HDL cholesterol (mg/dl)	-0.5 (0.5)	0.2 (0.8)	0.9 (0.1)	0.7 (0.3)
Enzymes				
Transaminase GOT (U/l)	-0.3 (0.7)	0.1 (0.9)	-0.8 (0.2)	0.2 (0.8)
Transaminase GPT (U/l)	0.3 (0.7)	-0.4 (0.6)	-0.7 (0.3)	0.7 (0.3)
Ions				
Sodium (mmol/l)	0.9 (0.1)	0.4 (0.6)	0.1 (0.9)	-0.9 (0.1)
Potassium (mmol/l)	0.5 (0.5)	-0.5 (0.5)	0.7 (0.3)	0.5 (0.5)
Calcium (mmol/l)	0.4 (0.6)	0.8 (0.2)	0.8 (0.2)	-0.5 (0.5)
Chlorinee (mmol/l)	-0.9 (0.1)	<b>0.9 (0.04)</b>	0 (1)	-0.8 (0.2)
Magnesium (mmol/l)	0.02 (0.9)	<b>-0.9 (0.02)</b>	-0.7 (0.3)	0.8 (0.3)
Phosphorus (mmol/l)	-0.7 (0.3)	<b>0.9 (0.003)</b>	0.8 (0.2)	-0.8 (0.2)

The p values are in parentheses. HDL: High density lipoprotein or HDL. GOT: Glutamyl oxaloacetic transaminase or glutamate transaminase oxalacetat. GPT glutamyl pyruvic transaminase or glutamate transaminase Pyruvat