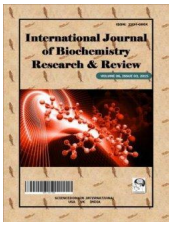

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Evaluation of the Effect of Starvation on Blood Glucose Level and Body Weight of Wistar Albino Rats

Okoro Onyinyechi Ruth[1], Eze Chinemelum Adaora[1], N. Ogugua Victor[2], Onyia Chukwuebuka Felix[3], C. Eluu Stanley[4] and Ejikeugwu Chika[5*]

[1]Department of Biochemistry, Faculty of Science, Federal University, Oye-Ekiti, P.M.B 2273, Ekiti State, Nigeria.
[2]Department of Biochemistry, University of Nigeria, Nsukka, Nigeria.
[3]Department of Science Laboratory and Technology, OSISATECH Polytechnic, Enugu, Nigeria.
[4]Department of Biotechnology, Faculty of Sciences, Ebonyi State University, Abakaliki, P.M.B 053, Ebonyi State, Nigeria.
[5]Department of Applied Microbiology, Faculty of Sciences, Ebonyi State University, Abakaliki, P.M.B 053, Ebonyi State, Nigeria.

Authors' contributions

This research work was carried out in collaboration with between all authors. Authors OOR, NOV and ECA designed the study and wrote the protocol for the methodology. Authors OCF and CES contributed in the analysis and drafting of the result. Author EC wrote the first draft of the manuscript and took care of all the correspondence. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of this study was to determine the effect of food deprivation on the body weight and blood glucose level of Wistar albino rats.
Methodology: Blood samples were collected from the rats through ocular puncture at intervals and were used for the analysis of blood glucose level. Standard procedures was used for the measurements, and blood glucose level was evaluated using the ONE TOUCH (TM) blood glucose

**Corresponding author: E-mail: ejikeugwu_chika@yahoo.com;*

monitoring system/meter.
Results: According to the duration of study for both the control and experimental animals, the body weight and glucose levels of the rats were taken before and after the starvation. There was no significant increase ($p>0.05$) in the body weights of the test animals compared with the body weights of the animals in control group at 0 hour and 6 hours of the experiment. However, there was a significant increase ($p<0.05$) in the body weights of treated rats after 12 hours when compared with the control group. After 24 hours treatment, group 2 animals (animals starved of rat feed and water) had significant increase ($p<0.05$) in their mean body weight when compared with control. There was significant increase ($p<0.05$) in the rats' body weights of group 4 treated animals (animals starved and received fruits only) compared with the control group after a period of 6 hours. There was also a significant increase ($p<0.05$) in the body weights of treated group 4 rats (animals starved and received fruits only) after 12 hours when compared with the control group. For 48 hours treatment, no significant difference ($p>0.05$) in body weight was observed. The glucose concentration increased significantly ($p<0.05$) in group 3 test animals administered water after starvation compared with the control animals at the 0 hour duration of the study. There was significant decrease ($p<0.05$) in the glucose concentration of animals (group 4) fed fruit after starvation compared with the animals (group 3) administered water after starvation at 0 hour of the experiment. However, the glucose concentrations of the animals in group 2 (starved of feed and water) and group 4 (starved + fruit) were not significant ($p>0.05$) compared with the control. The blood glucose concentrations of rats in groups 2 and 3 increased significantly ($p<0.05$) when compared with the control (group 1) within the duration of 6 hours.
Conclusion: Conclusively, this study shows that starvation has significant effect on the blood glucose level and body weight of Wistar albino rats. Such significant data (as obtainable in this study) could be extrapolated to humans with a view to unraveling the untoward consequences of starvation on the human body system.

Keywords: Starvation; blood glucose level; diabetes; Wistar rat; body weight.

1. INTRODUCTION

Studies have shown that starvation and malnutrition constitute the gravest single threat to the world's public health due to their significant health implications [1,2]. The ability to withstand and recover from periods of nutritional stress (starvation) is an important adaptation for survival of any organism that must sporadically endure periods of limited food supply in their environment [3]. Under certain pathological conditions, reactive oxygen species (ROS) production is increased and the level of antioxidant substances and enzymes are reduced [4]. This creates an imbalance in the oxidative status of the system; and the imbalance between ROS production and its removal constitutes the process called oxidative stress [5]. Starvation according to Kalm and Semba [6] refers to the physiologic state that results when food intake is chronically inadequate. And malnutrition involves the deficiency of not only the macronutrients (e.g. protein and carbohydrates), but also the sub-physiological concentration of most micronutrients. Many antioxidant defense systems depend on micronutrients or are micronutrients themselves [7]. The role of oxidative stress is clear and well known in the pathogenesis of acquired malnutrition [8]. In their natural environments, most organisms are faced with limited food supplies; the ability of organisms to withstand food deprivation is therefore critical to their survival [2,9]. Survival during fasting depends on a number of finely coordinated hormonal and biochemical adjustments including initial maintenance of blood sugar by mobilization of stored glycogen [10]. In general, starvation induces a wide range of responses that alter gene expression, biochemical activities, physiological and behavioral responses; as wells as a reduction of body and liver weight of the animal [11,12]. During starvation essential metabolic processes are maintained at the expense of accumulated endogenous energy reserves, which sometimes results in a loss of weight [13]. It is reported that starvation produces a marked accumulation of ROS and results in cell death [14,15]. Therefore, starvation studies may be useful predictors to determine energetic and metabolic requirement of living systems [16]. The pathogenesis of oedema and anaemia commonly found in children with protein energy malnutrition has been suggested to be caused by an imbalance between the production of free radicals which is possible in malnourished

and starved animals [17,18]. It is in view of these facts that this study determined the effect of food deprivation in rats; a critical factor that induces a delay in the development of some vital functions in mammals, especially in the inducement of oxidative stress and other factors produced in malnourished and starved animals [19].

2. MATERIALS AND METHODS

2.1 Experimental Animals

Wistar albino rats of male and female sexes were the experimental animals used for this present; and the average age of the albino rats was 12 weeks old. The rats were obtained from the animal house of the Faculty of Biological Sciences, University of Nigeria, Nsukka (UNN), Enugu, Nigeria; and all the albino animals were acclimatized for two weeks under standard laboratory conditions prior to the start of experimentation. The albino rats were housed in wire-meshed cages at ambient temperature with 12 hour day–night cycle and fed with commercial rat pelletized growers feed and water.

2.2 Experimental Design

Forty Wistar rats of both sexes were divided into control group of four rats and three groups of three rats each. The first, being control (n = 4) was maintained on normal rat pelletized growers feed and water. The experimental animals formed the second, third and fourth groups; and each of the group contained 3 rats and had 4 types of time period associated with it. So, each group contained 12 rats (n = 12).

- Group 1 animals were the control group (fed with the normal rat diet and water).
- Group 2 animals were starved of rat feed and water.
- Group 3 animals were starved but received only water.
- Group 4 animals were starved but received fruits (carrots).

Groups 2, 3 and 4 were differently starved according to time duration and then blood samples were collected through ocular puncture i.e. by orbital bleeding technique and the blood samples were used for analyzing all parameters and blood glucose level. The body weight and glucose levels of the rats were taken before and after the starvation. Several parameters were assayed using the serum of the rats from the various groups gotten by allowing whole blood to clot and spinning it for its separation. Enough blood was collected at intervals through ocular puncture for all the below mentioned parameters. The rats were kept under anesthesia and sacrificed.

2.3 Blood Glucose Assay

ONE TOUCH (™) blood glucose monitoring system/meter and test strips (Lifescan Inc, Johnson-Johnson Company, Milpitas California, USA) was used for the blood glucose assay as was described previously [18]. The One-Touch glucometer was essentially a reflectance meter. The amount of light reflected in reagent area of the dextrostix measured in a readout meter scale was a measure of the concentration of glucose in the blood. Snips were made on the tail of the animal to release blood on the sensitive spot on the glucometer. The method is based on the reaction of glucose and oxygen in the presence of glucose oxidase to yield gluconic acid and hydrogen peroxide. Hydrogen peroxide subsequently oxidizes the dyes in a reaction mediated by peroxidase producing a blue coloured form of the dyes. The intensity of the blue colour is proportional to the glucose concentration in the sample and is measured and read by the ONE TOUCH meter.

2.4 Body Weight

According to duration of study both control and the experimental animals were weighed before the stress was forced on them and after the stress. Therefore, the difference in body weight was recorded and compared as was previously described [2,18].

2.5 Statistical Analysis

The results were expressed as mean ± SD and tests of statistical significance were carried out using student t-test and both one-way and two-way analysis of variance (ANOVA). The means were separated using Duncan Multiple Test. The statistical package used was Statistical Package for Social Sciences (SPSS); version 17.

3. RESULTS

The results of the mean body weights of rats in all the test groups were not significantly different ($p>0.05$) compared with the control at 0 hour of the experiment (Fig. 1). It was observed that there was no significant difference ($p>0.05$)

between the control and the treated groups after 6 hours. However, there was a significant increase ($p<0.05$) in the body weights of treated rats after 12 hours when compared with the control group. After 24 hours treatment, group 2 animals had significant increase ($p<0.05$) in their mean body weight when compared with control. For 48 hours treatment, no significant difference ($p>0.05$) in body weight was observed. There was significant increase ($p<0.05$) in the rats' body weights of group 4 treated animals compared with the control group after a period of 6 hours. There was also a significant increase ($p<0.05$) in the body weights of treated group 4 rats after 12 hours when compared with the control group. After 24 hours treatment, group 2 had a significant increase ($p<0.05$) when compared with control. For 48 hours treatment, no significant difference ($p>0.05$) in body weight was observed. The glucose concentration increased significantly ($p<0.05$) in group 3 test animals administered water after starvation compared with the control animals at the 0 hour duration of the study (Fig. 2). There was significant decrease ($p<0.05$) in the glucose concentration of animals (group 4) fed fruit after starvation compared with the animals (group 3) administered water after starvation at 0 hour of the experiment. However, the glucose concentrations of the animals in group 2 (starved of feed and water) and group 4 (starved + fruit) were not significant ($p>0.05$) compared with the control. The blood glucose concentrations of rats in groups 2 and 3 increased significantly ($p<0.05$) when compared with the control (group 1) within the duration of 6 hours.

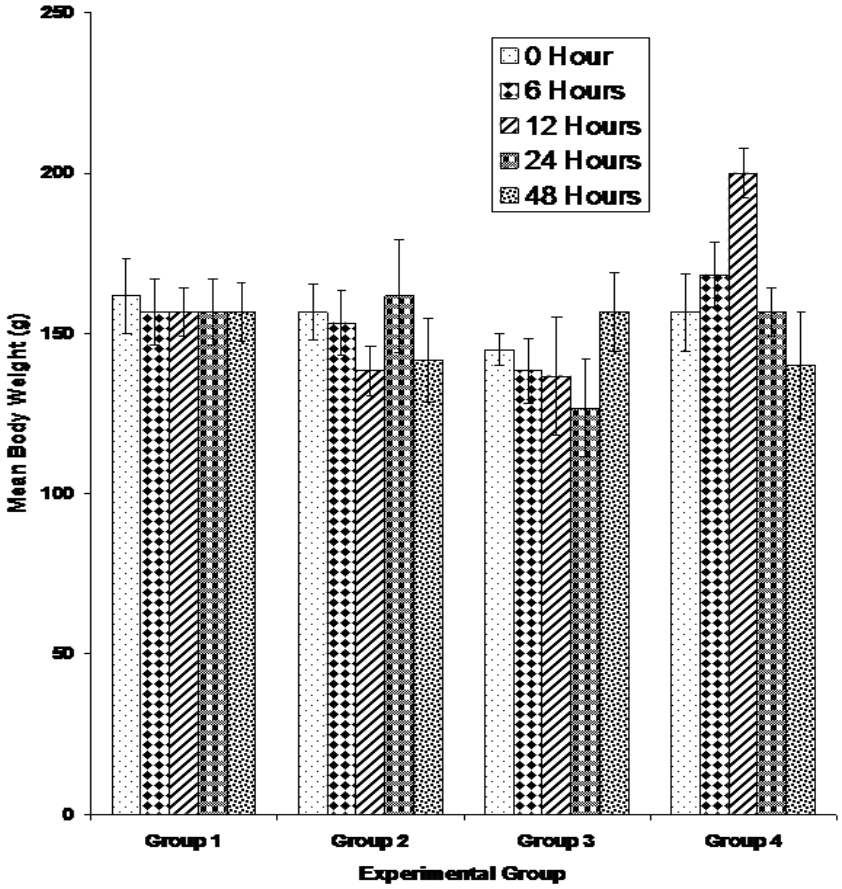

Fig. 1. Effect of starvation on the body weights of Wistar albino rats at various time intervals

Key: Group 1: Control (Normal feed and water)
Group 2: Starved of feed and water
Group: Starved but given water
Group 4: Starved but fed with fruits

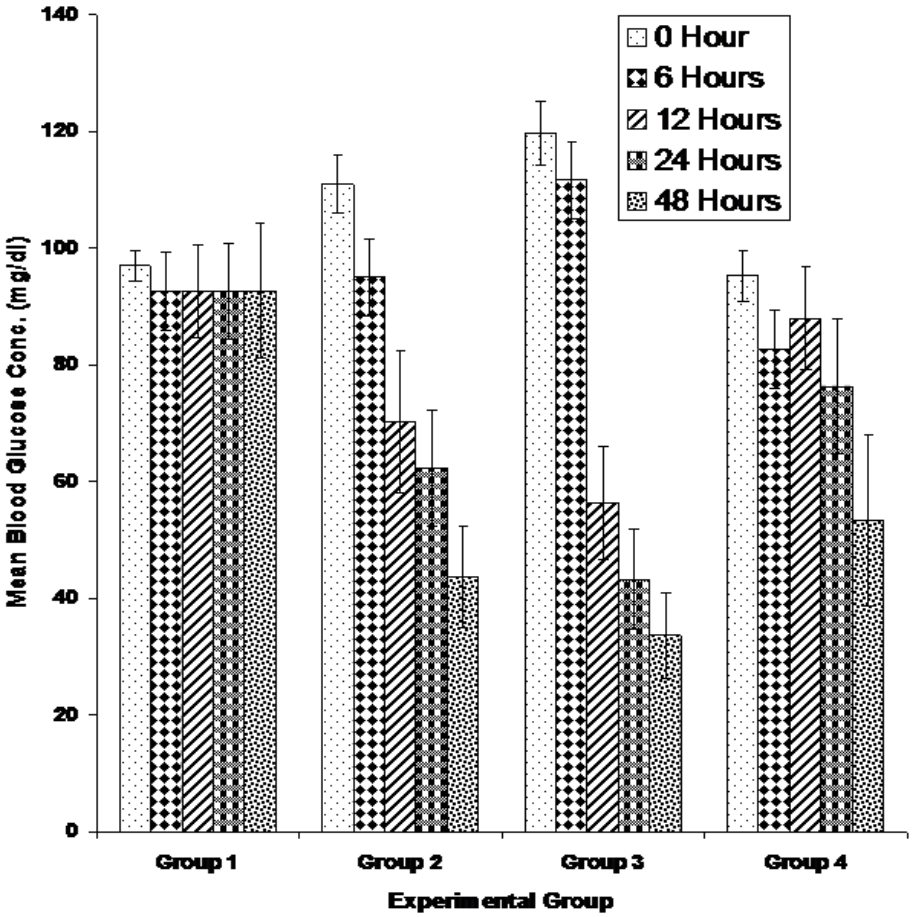

Fig. 2. Effect of starvation on mean blood glucose concentrations of Wistar albino rats at various intervals

Key: Group 1: Control (Normal feed and water)
Group 2: Starved of feed and water
Group: Starved but given water
Group 4: Starved but fed with fruits

However, there was no significant difference ($p>0.05$) in the glucose concentrations between the control animals and group 4 animals after 6 hours. Significant increase ($p<0.05$) in the blood glucose concentrations of animals in group 4 after 6 hours of starvation was also observed when compared with the control. Non-significant differences ($p>0.05$) were observed between the control and test groups 2 (starved of feed and water) and 3 (starved but received water) after a duration of 12 hours. However, there was no significant difference ($p>0.05$) between the blood glucose concentrations of the control and the test groups after 24 and 48 hours. There was also significant elevation ($p<0.05$) of blood glucose concentration in the animals of group 3 (starved but received water) compared with the animals in the control group after 6 hours' starvation. The blood glucose level decreased significantly ($p<0.05$) in group 3 animals compared with the control after 12 hours of starvation as recorded at the end of the experiment. Significant reduction ($p<0.05$) in the concentrations of blood glucose after the experiment was observed under 24 hour duration in groups 2 (starved of feed and water) and 3 (starved but received water) when compared with the group 1 Control (Fig. 2). The concentrations of blood glucose after the experiment were significantly ($p<0.05$) elevated in the group 3 compared with the group 4 (starved but received fruit only). Under the 48-hour period of starvation, significant ($p<0.05$) reduction of glucose concentrations was noticed in all the test groups (groups 2, 3 and 4) as

compared with the Control. On the other hand, non-significant difference ($p>0.05$) in the glucose concentrations was noticed among the control within the durations of 0, 6, 12, 24 and 48 hours respectively. Group 2 under 6-hour duration was found to be significant ($p<0.05$) when compared with group 2 of 12, 24 and 48 hours (Fig. 2).

4. DISCUSSION

This work investigated the effects of starvation on blood glucose level and body weight of Wistar albino rats. Living organisms including albino rats and humans tend to lose weight when faced with limited food supplies; and the ability of organisms to withstand food scarcity is therefore critical to their survival. The survival of an organism during food deprivation (generally known as starvation for the purpose of this study) depends in part on the internal hormonal and biochemical adjustments such as the maintenance of optimal blood sugar by the mobilization or breakdown of stored glycogen when the glucose level of the body drops [2,5,12,20]. Starvation induces a wide range of responses that may also alter the gene expression, biochemical activities, physiological and behavioral responses of the starved organism especially if the period of starvation and/or malnutrition is not halved, and food taken to assuage the hunger. In such scenarios, starvation therefore results in a reduction of body weight; and during starvation essential metabolic processes are maintained at the expense of accumulated endogenous energy reserves, which sometimes results in a loss of weight in the starved animals. This work elucidated the significant changes in body weight ($p<0.05$) between normal animals and starved ones. There was no significant increase ($p>0.05$) in the body weights of the test animals compared with the body weights of the animals in control group at 0 hour of the experiment. This indicates that signal of starvation was received by all the experimental rats; thus making them to lose weight. Also, the starved rats that were administered fruit increased in weight than the control because fruits serve as energy source. Food deprivation lasting for 12 hours led to the reduction of body weight in animals starved of feed and water (group 2) and animals starved of water (group 3) respectively. Body weight of animals starved of water decreased in 24 hours when compared with the initial body weight. For animals starved of fruits, it decreased in 24 and 48 hours. During early starvation, weight loss becomes rapid but it gradually slowed down without noticeable changes as the starvation period progressed. Studies has shown that survival during starvation is dependent upon mechanisms that limit oxidative loss of pyruvate in non-neuronal tissues of the body; and that energy expenditure over the day decreases in starvation and starving individuals voluntarily diminish their spontaneous movements [21,22]. However, the glucose concentration increased significantly ($p<0.05$) in group 3 animals administered water after starvation compared with the control animals at the 0 hour duration of the study. It also shows significant decrease ($p<0.05$) in the glucose concentration of animals (group 4) fed fruit compared with the animals (group 3) administered water after starvation at 0 hour of the experiment. This could be attributed to the increase in glucose concentration which stimulates insulin secretion. This suggests that by 0 hour time interval, hepatic gluconeogenesis was sufficient to drive or maintain the output of the starvation; and this result is at par with that of previous studies [21-23]. The short-term fasting results indicated a general significant decrease ($p<0.05$) of glucose concentrations in blood of rats during starvation durations of 12-48 hours when compared with the initial glucose level. Normalization of plasma glucose concentration results probably from an increase in gluconeogenesis and a decrease in glucose utilization after a certain short term fasting as was reported by Lamosova et al. [23]. Glucose is normally the sole energy source for certain key tissues, including the central nervous system. The provision of glucose (gluconeogenesis) during starvation is essential for the sustenance of key cellular and metabolic activities in the starved animals [22,23]. The trigger that induces the initial metabolic adaptations during starvation is the arterial glucose level, which begins to fall in humans within 15 hours of fasting. Data resulting from studies on the effect of starvation on the blood glucose level and weight of albino rats could be extrapolated to humans with a view to unraveling the untoward consequences of such ventures on the human body system.

5. CONCLUSION

Conclusively, this study shows that starvation has significant effect on the blood glucose level and body weight of Wistar albino rats. Such significant data (as obtainable in this study) could be extrapolated to humans with a view to unraveling the untoward consequences of starvation on the human body system.

ETHICAL APPROVAL

Ethical clearance was sought from the ethical committee of the Department of Biochemistry, University of Nigeria Nsukka, Nigeria for the use of the laboratory animals; and the research was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki on the use of human and/or animal specimens for research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Vaisman N, Sklan D, Dayan Y. Effect of moderate semi-starvation on plasma lipids. International Journal of Obesity. 1990;14: 989-996.
2. Wang T, Hung CC, Randall DJ. Annual Review in Physiology, 68: 040104 - 105739; In press published Online October 19; 2005.
3. Stuck KC, Watts SA, Wang SY. Biochemical responses during starvation and subsequent recovery in post larval pacific white shrimp, *Penaeus vannamei*. Marine Biology. 1996;125:33-45.
4. Lemberg A, Schreier L, Romay S, et al. Involvement of serum apolipoprotein AI and B_{100} and lecithin cholesterol acyl transferase in alcoholic cirrhotics. Annals of Hepatology. 2007;6(4):227-232.
5. Wu D, Cederbaum AI. Alcohol, oxidative stress, and free radical damage. Alcohol Research and Health. 2003;27:277-84.
6. Kalm, Semba. They starved so that others be better fed: Remembering ancel keys and the minnesota experiment. The Journal of Nutrition. 2005;135:1347-1352.
7. Evans P, Halliwell B. Macronutrient: oxidants/antioxidant status. Journal of Nutrition. 2001;85(2):567-574.
8. Tatli MM, Vural H, Koc A, et al. Altered antioxidant status and increased lipid peroxidation in marasmic children. Pediatrics International. 2000;42:289-292.
9. Gray JV, Petsko GA, Johnston GC, et al. Microbial and Molecular Biology Revision. 2004;68:187-206.
10. Savendahl L, Underwood LE. Fasting increases serum total cholesterol, LDL cholesterol and Apolipoprotein B in Healthy, Nonobese Humans. Journal of Nutrition. 1999;129:2005-2008.
11. Barthel, Grit. Hepatotoxicity of valproate in isolated rat hepatocytes: Influence of prooxidative Agents and starving. Freien Universitat Berlin. Objekt-metadaten @ Dissertation line, Berlin. 1998;2.
12. Steffens W. Principles of fish nutrition. Ellis Horwood, Chichestor. 1989;384.
13. Lynch AM, Moore M, Craig S, et al. Analysis of interleukin- 1 beta-induced cell signaling activation in rat hippocampus following exposure to gamma irradiation. Journal of Biology and Chemistry. 2003; 278:51075-51084.
14. Kang S, Song J, Kang H, et al. Insulin can block apoptosis by decreasing oxidative stress via phosphatidylinositol 3-kinase and extracellular signal-regulated protein kinase-dependent signaling pathways in $HepG_2$ cells. European Journal of Endocrinology. 2003;148:147-155.
15. Guderley H, Lapointe D, Bedard M, et al. Metabolic priorities during starvation: enzyme sparing in liver and white muscle of Atlantic cod, *Gadus morhua* L. Comp. Biochemical Physiology. 2003;135:347-356.
16. Ashour MN, Salem SI, El-Gadban HM. Antioxidant status in children with protein energy malnutrition (PEM) living in Cairo. European Journal of Clinical Nutrition. 1999;53:669-673.
17. Marks V, Dawson A. Rapid stick method for determining blood glucose concentration. British Medical Journal. 1965;1:25-29.
18. Wannemacher W, Dinterman E. Total body protein catabolism in starved and infected rats. Journal of Clinical Nutrition. 1977;30: 1510-1511.
19. Keys A, Brozek J, Henschel A. The biology of human starvation minneapolis. University of Minnesota Press. 1950;174.
20. Cahill GF Jr. Starvation in man. New England Journal of Medicine. 1970;282: 668-675.
21. Adibi SA. Metabolism of branched-chain amino acids in altered nutrition. Metabolism. 1976;25:1287.
22. Cederbaum AI. Role of lipid peroxidation and oxidative stress in alcohol toxicity. Free Radicals. Biology and Medicine. 2003;7:537-539.

23. Lamosova M, Macajova M, Zeman M. Effects of short term fasting on selected physiological functions in adult male and female Japanese Quait. Acta Vet. Brno. 2004;73:9-16.

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