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Effects of diet containing monosodium glutamate on organ weights, acute blood steroidal sex hormone levels, lipid profile and erythrocyte antioxidant enzymes activities of rats

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ABSTRACT

Objective: To study the effects of diet containing monosodium glutamate on visceral organ weights, acute blood steroidal sex hormone levels, serum lipid profile (SLP) and erythrocyte antioxidant enzymes activities of Wistar rats.

Methods: The Wistar rats were grouped into two groups of six rats each. The ones in Group 1 (control group) were placed on water and pelletized standard guinea feed *ad libitum*, whereas Group 2 was regarded as test group [Wistar rats (WR)-monosodium glutamate (MSG) group] and the Wistar rats received water, compounded diet of MSG and pelletized standard guinea feed *ad libitum*. After 33 days of feeding study, rat body weight was obtained. Rats were sacrificed and the incisions were made into the thoracic cavity and blood samples were drawn by cardiac puncture as a terminal event. Plasma was assayed for estradiol and testosterone concentrations, SLP and erythrocyte peroxidase and catalase activities. Visceral organ weights were also measured.

Results: WR-MSG exhibited marginal alterations in blood estradiol and testosterone concentrations. Elevation of serum triacylglycerol concentration in WR-MSG was corresponded to 77.7%. Increases in serum concentrations of very low-density lipoprotein cholesterol and low-density lipoprotein cholesterol in WR-MSG were corresponded to 70.6% and 41.0% respectively. Erythrocyte peroxidase and catalase activities showed marginal alterations. Alterations in visceral organs-to-body weights ratios were not profound.

Conclusions: Blood testosterone and estradiol concentrations were not significantly ($P > 0.05$) altered, which may not be connected with the low dose of MSG in the diet. Marginal alterations of SLP did not indicate atherogenicity in WR-MSG. The visceral organs were not atrophic or hypertrophic because of the comparatively low dose of MSG consumed by WR-MSG and the duration of the feeding experiment.

1. Introduction

In vertebrates, normal blood sex hormone profile and general reproductive function are coordinated by the hypothalamus-pituitary-gonadal (HPG) axis[1,2]. The endocrine system of vertebrates forms part of the intertwined and well-coordinated regulatory schemes to maintain homeostasis of the internal environment and control body functions such as reproduction. Estradiol and testosterone, among other endocrine secretions, are steroidal sex hormones that control the development and functions of reproductive system and auxiliary organs. Steroidal sex hormones act by first binding to sex hormone-binding globulins in cells that constitute or remotely connected with the reproductive system, which impacts on their bioactivity[2,3]. In diagnostic pathology, a measure of plasma testosterone/estrogen ratio may provide useful insights into the etiology of hindered steroidogenesis and serves as a monitor to corrective treatment associated with reproductive disorders and infertility[4].

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All experimental procedures involving animals were conducted in accordance to the standard principles of Laboratory Animal Care of the United States National Institutes of Health (NIH, 1978) and approved by the Ethical Committee of Department of Biochemistry, Federal University of Technology, Owerri, Nigeria (Ethics Approval Number: ODVC/REN/990/15).

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Serum lipid profile (SLP) is a bioanalytical term that defines the proportionate blood lipid concentrations in vertebrates, which in turn provides useful prognostic information of predisposition of individuals to arteriosclerosis and associated cardiovascular morbidity and mortality[5–9]. Major lipid components of the blood of dietary and endogenous sources include lipoproteins, triacylglycerol (TAG), free fatty acids and cholesterol. Disarrangement of blood lipid profile may be elicited by several factors such as defective gene, consequences of diet and drug administrations or disorders that encompass diabetes and hepatic dysfunction[10–12].

Two enzymes form ubiquitous and integral components of erythrocyte antioxidant defense system against reactive oxygen species. Catalase, present in peroxisome of aerobic cells, degrades hydrogen peroxide to water and oxygen. However, a study showed that a relatively higher peroxidase activity was carried out by membrane-bound catalase rather than the cytosolic type[13]. Superoxide dismutase, glutathione reductase and glutathione peroxidase are other collections of erythrocyte enzymatic antioxidant defense systems. Reduced glutathione and vitamin E are non-enzymic systems which are also involved in scavenging reactive oxygen species in order to minimize a build-up of oxidative stress in erythrocytes[14–16].

Sodium glutamate or monosodium glutamate (MSG) is a major dietary component, which intensifies the savory flavor in foods worldwide[17–19]. It has a daily consumption rate of 300–4 000 mg/day in developed countries[20,21]. The toxicity concerns and secondary physiologic effects following intake of MSG have been controversially discussed[22,23]. LD_{50} of sodium glutamate in rats ranges between 15 000 and 18 000 mg/kg of body weight[24,25]. Meanwhile, certain chemical agents and dietary components perturb blood physiologic homeostatic parameters, such as distortion of plasma testosterone/estrogens concentrations with attendant hormonal imbalance and reproductive disorders, alterations in blood lipid profile associated with the development of atherogenicity as well as provoking the overwhelming level of oxidative stress[4,9,26–33]. Furthermore, dietary component may alter the weights of visceral organs, which is diagnostic for the atrophic or hypertrophic dysfunctional organs[34]. Accordingly, the present preliminary study investigated the ability of diets containing the sodium salt of glutamic acid to change blood testosterone and estradiol levels and lipid profile as well as its capacity to compromise erythrocyte peroxidase and catalase activities. Investigations to ascertain the capacity of MSG-containing diet to distort weights of visceral organs in Wistar rats were also carried out.

2. Materials and methods

2.1. MSG tablets

Branded tablets of commercially available MSG were bought from Ekenuwa Main Market in Owerri Municipal Local Government Area, Owerri, Nigeria and designated as AGX665. The tablets were pulverized to fine powder using ceramic mortar and pestle. Finally, the ground samples were stored in sterile bottles with screw caps until used for preparation of the rats' diets.

2.2. Preparation of rats' diets

The test diet was prepared by compounding specified quantity of AGX665 with standard guinea feed purchased from United Africa Company Nigeria Plc., Jos, Nigeria. According to the manufacturer's instruction, the corresponding concentration of MSG in compounded diets was 0.39 g/100 g feed sample.

2.3. Handling of rats

The use of animals for research in the present study approved by the Ethical Committee of Department of Biochemistry, Federal University of Technology, Owerri, Nigeria (Ethics Approval Number: ODVC/REN/990/15). The Animal House of Department of Biochemistry, Federal University of Technology, Owerri, Nigeria provided the male albino Wistar rats. The rats accessed to water and pelletized standard guinea feed *ad libitum* for 2 weeks in acclimatization period and were housed in well-ventilated metal cages and under room temperatures of (28 ± 2) °C, 30%–55% of relative humidity on a 12-h light/12-h dark cycle. Handling of the rats complied with the standard principles of Laboratory Animal Care of the United States National Institutes of Health (NIH, 1978).

2.4. Animal feeding experiment

Male Wistar rats (n = 12) of 90 days old in average weight of (98.2 ± 1.1) g were categorized into two groups of six rats each. The rats of two groups were deprived of feed and water for 6 h before commencement of feeding experiment, which lasted for 33 days. In Group 1, Wistar rats (control group) were given water and pelletized standard guinea feed *ad libitum*, whereas in Group 2, Wistar rats (WR) (WR-MSG group) were given water and compounded diet of MSG *ad libitum*.

At the end of the feeding period, the rats of two groups were deprived of feed and water for 12 h[20]. After that, they were weighed and subsequently sacrificed by cervical dislocation and blood samples of them were drawn by cardiac puncture. The blood samples were measured for plasma estradiol and testosterone concentrations, SLP, erythrocyte peroxidase and catalase activities. Furthermore, the rats were dissected and the heart, kidneys, liver and spleen were excised for evaluation of visceral organs weights.

2.5. Erythrocyte haemolysate

The blood samples were collected in Na_2EDTA tubes and sample bottles. Blood corpuscles were separated from plasma in the anti-coagulant test tubes using centrifugation method (1 500 r/min at 4 °C for 10 min)[20]. Serum was obtained from coagulated blood samples using bench centrifuge. The plasma and serum samples were collected by aspiration using Pasteur pipette and transferred into sterile sample bottles. The preparation of erythrocyte haemolysate for measurement of peroxidase and catalase activities was according to previous methods[35].

2.6. Biochemical analyses

2.6.1. Estradiol and testosterone

Measurements of plasma estradiol and testosterone concentrations were according to previous methods of Dhindsa *et al.*[2].

2.6.2. SLP/atherogenic index

Measurements of SLP and atherogenic index were according to standard methods of Ibegbulem *et al.*[36].