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Effects of high monosodium glutamate on some serum markers of lipid status in male Wistar rats

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Monosodium glutamate, the sodium salt of glutamate, is a flavor enhancing food additive that may be present in packaged food without appearing on the label. This could lead to inadvertent consumption of monosodium glutamate in high concentration. The study investigated the effects of MSG on some serum markers of lipid status in adult male Wistar rats by daily oral exposure to 3 ml/kg of distilled water and 15 mg/kg of monosodium glutamate for 4 weeks. In the serum, monosodium glutamate treatment significantly ($p<0.05$) increased cholesterol and triacylglycerol concentrations, whereas it markedly decreased the computed cholesterol to triacylglycerol and alanine aminotranasferase to aspartate aminotrasferase ratios. These results suggest that exposure to high dose of monosodium glutamate (15 mg/kg), such as through its inadvertent abuse, may alter lipid status in animals by damaging high metabolic organs, such as the liver, resulting in compromised triacylglycerol and cholesterol metabolism. The possible health implications of the study are noteworthy, hence warrant follow up in humans.

Keywords: Monosodium glutamate; cholesterol; triacylgycerol; Wistar rats; lipid status; high metabolic organs.

INTRODUCTION

Monosodium glutamate, MSG, is a widely used flavor enhancing food additive that may be present in packaged foods without appearing on the label. This could lead to inadvertent consumption of MSG above the average daily intake of 1.0 g in enlightened society (Marshal, 1994).

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List of Abbreviations

MSG – monosodium glutamate
DW – distilled water
CHOL – cholesterol
TAG - triacylglycerol
ALT – alanine aminotransferase
AST – aspartate aminotransferase
ANOVA – analysis of variance
SPSS – statistical package for the social sciences

This is particularly disturbing given the reported cases of MSG-induced adverse effect in animals (Belluardo et al., 1990, Gonzalez-Burgos et al., 2004, Mozes et al., 2004), even at a relatively lower concentration (Egbuonu et al., 2009a). Although, MSG could improve the palatability of foods by exerting a positive influence on the appetite centre, it increased body weight (Rogers and Blundell, 1990, Egbuonu et al., 2010c) and adversely affected locomotor activities (Eweka and Om'Iniabohs, 2008) and the testis, causing significant oligozoosperma and abnormal sperm morphology in male Wistar rats (Onakewhor et al., 1998).

However, in humans, adverse effects of MSG appear to manifest in MSG-sensitive individuals suggesting that some people may have an MSG intolerance that causes MSG symptom complex, with symptoms such as headaches, or migraine in some individuals. In addition, MSG gives rise to a characteristic taste called *umami* (Yamaguchi and Ninomiya, 1998), which is one of the five taste qualities detected by mammals. *Umami* is not palatable in itself; nevertheless, it makes a variety of foods delectable (Yamaguchi, 1998).

The practice of adding MSG to foods with the purpose of increasing the intensity of their flavor has been favored by the increasing popularity of fast and manufactured foods. The practice might present some health risk especially to MSG-intolerant individuals. The recent use of MSG in Nigeria for laundry purposes suggests that its possible cleansing properties could predispose animals to health risks further suggesting the apparent danger in its use as a food additive, especially at high concentrations. The aim of the present study was to examine the effects of high ingestion of MSG on several markers of lipid status in male rats.

MATERIALS AND METHODS

Chemicals

A brand of monosodium glutamate (99.9% MSG), marketed by West African Seasoning Company Limited) was bought from a daily market at Nsukka, Nigeria. Other chemicals were of certified analytical grade and were used without further purification.

Animals and treatments

The animal study was conducted in accordance with the protocols approved by the local experimental animal ethics committee. A total of eight adult male Wistar rats with mean body weight of 68.30±0.5g bred at the animal house of the Faculty of Biological Sciences, University of Nigeria, Nsukka, were housed in clean stainless steel cages and in a well ventilated facility with free access to standard feed and drinking tap water. The animals were kept at room temperature (28±2^{o}C) with a 12 h daylight/ dark cycle under humid tropical conditions. After the adaptation period of a week, the rats were randomized into two groups (n=4). The control group (Group I) received distilled water (3 mL/kg dose) whereas Group II received monosodium glutamate (15 mg/kg dose) dissolved in 3 mL of distilled water. The treatment was peroral (by oral intubation) and occurred daily for 4 weeks.

The 15 mg/kg dosage of MSG to body weight was chosen hopefully to simulate possible effects of high intake of MSG in rats. The time scale of the experiment (4 weeks) was chosen to elicit measurable effect while avoiding overt toxicity or age-induced toxicity in the rats. The rats consumed the entire amount of 15 mg/kg of MSG each day. Only male Wistar rats were used in the study to control the disparity in the biotransformation rate of female rats.

Blood collection and preparation

After 4 weeks, the blood sample of the rats was collected individually by methods described previously (Egbuonu et al., 2009a). In summary, all the rats were sacrificed the next day, following an overnight fast. Blood sample was collected into labeled centrifuge tube after puncturing the ocular vein with sterile capillary tube. Blood was allowed to clot after standing for 10 min. at ambient temperature. Thereafter, the serum was separated by centrifugation at 3000 x g 10 min. The serum was aspirated individually and stored in deep freezer for the determination of serum cholesterol (CHOL) and triacylglycerol (TAG) concentrations. CHOL:TAG and alanine aminotransferase (ALT) to aspartate aminotransferase (AST) (ALT:AST) ratios were calculated from the corresponding results presented in this report and earlier report (Egbuonu et al., 2010b) respectively.

Determination of serum CHOL concentration

Serum CHOL concentration was determined by a slight modification of the colorimetric method of Zlatkis et al. (1953). Five mL of ethanol was added to 0.1 mL of serum sample. The content was shaken and centrifuged for 5 min at 3000 x g and the resultant supernatant was aspirated into another tube. Then, 2 mL of chromogen was added to the tube and the sample was allowed to stand for 40 min. after which the absorbance was measured at 550 nm.

Determination of serum TAG concentration

Serum TAG concentration was determined by the method of Calson (1963). This was based on the principle that glycerol obtained after alkaline hydrolysis of the glycerides could be measured colorimetricaly at 570 nm.

Determination of serum ALT and AST activities

Serum alanine aminotransferase and aspartate aminotransferase activities were determined by the method of Reitman and Frankel (1957) as already described (Egbuonu et al., 2009b; 2010a).

Ratios of corresponding markers of toxicity could yield further diagnostic information (Egbuonu et al., 2010a). In particular, significant reduction of more than 1 in the computed serum ALT:AST ratio might be a consequence of severe hepatic necrosis (Mondofacto, 2010), and significant damage of other high metabolic organs besides the liver (Egbuonu et al., 2010b). Thus, CHOL:TAG and AST:ALT ratios were computed in the present study as further means for detecting organ damage.

Statistical analysis

All data collected were analyzed by one-way analysis of variance (ANOVA) as described (Egbuonu et al., 2009b) using the Statistical Package for the Social Sciences (SPSS version 11; SPSS Inc., Chicago, IL., USA). Data in the text and tables were presented as means and standard errors of the mean. Significance was accepted at $p<0.05$.

RESULTS

In comparison with control, MSG treatment significantly ($p<0.05$) increased serum CHOL concentration (111.46 mg/100mL), representing an increase of 7.69% while it markedly increased serum TAG concentration (853.66 mg/100mL), which represents an increase of 364.4% (Table 1).

As presented in Table 2, MSG treatment significantly ($p<0.05$) decreased the computed serum CHOL:TAG (0.13) and ALT:AST (2.75) ratios, representing decreases of 76.78% and 21.65% respectively.

Table 1. Influence of DW and MSG on serum CHOL and TAG concentrations

Measurement	CHOL (MG/100ML)		TAG (MG/100ML)	
	DW (I)	MSG (II)	DW (I)	MSG (II)
Mean	103.50	111.46*	183.82	853.66*
SEM	0.10	0.09	0.18	0.27
Relative mean (%)	100	107.69	100	464.40
Difference relative to control (%)	0	+7.69	0	+364.40

Results are mean±SEM for n=4; *Significantly different from control ($p<0.05$)

Table 2. Influence of DW and MSG on serum CHOL:TAG and ALT:AST ratios

Measurement	CHOL:TAG ratio		ALT:AST ratio	
	DW (I)	MSG (II)	DW (I)	MSG (II)
Mean	0.56	0.13*	3.51	2.75*
SEM	0.18	0.06	0.21	0.15
Relative mean (%)	100	23.21	100	78.35
Difference relative to control (%)	0	–76.78	0	–21.65

Results are mean±SEM for n=4; *Significantly different from control ($p<0.05$)

DISCUSSION

MSG treatment for 4 weeks significantly ($p<0.05$) increased the serum CHOL concentration. This perhaps indicates altered cholesterol metabolism and the attendant risk of cardiovascular disease in the rats (Egbuonu et al., 2010c). In addition, MSG treatment markedly increased serum TAG concentration, indicating apparent breakdown in triacylglycerol metabolism that probably resulted in an enhanced mobilization of free fatty acids from the peripheral fat depots (Bopanna et al., 1997). The regulation of TAG is driven by the availability of free fatty acids (Schummer et al., 2008). An enhanced lipolysis could, as a consequence, enhance the rapid biosynthesis of plasma TAG that may overwhelm the functional ability of the very low density lipoprotein (VLDL) to transport the accumulating TAG back to the adipose tissue, leading to the increased serum TAG concentration observed in the present study.

Generally, elevated serum CHOL and TAG concentrations indicate hyperlipidemia. Hyperlipidemia was associated with insulin resistance and type 2 diabetes mellitus (Nikkila, 1984; Huuponen et al., 1984, Schummer et al., 2008), atherogenesis (AACE, 2000), and coronary artery disease (CAD) (LaRosa, 1997, Jeppesen et al., 1998, Assman et al., 1998) which constitute components of the metabolic syndrome (Palaniappan et al., 2001). Thus, the possible up regulation in CHOL and TAG synthesis by MSG (15 mg/kg) resulting in their elevation in the serum may predispose animals to various health risks. However, the results of the present study on serum cholesterol appear to vary with that of Ahluwalia and Malik (1989), who found no change in serum cholesterol in their study with adult male mice.

Ratios of corresponding markers of toxicity could yield further diagnostic information (Egbuonu et al., 2010a). MSG treatment elicited a marked decrease in the calculated serum CHO:TAG ratio, suggesting that contribution to the possible hyperlipidemia probably resulted from compromised TAG, more than CHOL, metabolism. This is apparently supported by the marked increase in serum TAG concentration recorded in the present study. The significant reduction of more than 1 in the computed serum ALT:AST ratio following MSG treatment might be a consequence of severe hepatic necrosis (Mondofacto, 2010), and significant damage of other high metabolic organs besides the liver (Egbuonu et al., 2010b). The apparent multiple organ damage probably resulted in compromised functional capacity of the major organs to regulate sterol metabolism leading to the significant increase in the serum CHOL and TAG concentrations as observed in the present study.

Thus, the study suggests that exposure to high dose of MSG (15 mg kg^{-1}), such as through its inadvertent abuse, may alter lipid status in animals by damaging high metabolic organs resulting particularly to impaired TAG and CHOL metabolism.

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