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4 Rhindmuir Dr, Baillieston, Glasgow G69 6ND, UK
deqepub@gmail.com; enquiry@deqepub.org

Impact of Long-term Monosodium Glutamate (MSG) and Soya Bean Consumption on Reproductive Hormone Profiles: A Comprehensive Study on Female and Male Rats

Adaeze Bob Chile-Agada PhD

Department of Biochemistry, Imo State University Owerri, Nigeria

Abstract

This study delves into the intricate influence of monosodium glutamate (MSG) and soya bean consumption on reproductive hormone profiles in female and male rats. Over a span of 2, 4, and 6 months, the research meticulously examined luteinizing hormone (LH), progesterone (PRG), estrogen, testosterone, and follicle-stimulating hormone (FSH) levels to unravel the complex interactions between dietary components and reproductive health. The results revealed significant gender-specific effects, with prolonged MSG exposure leading to decreased LH and PRG levels in females, emphasizing potential disruptions in natural hormonal balance crucial for fertility. Soybean consumption exhibited intricate patterns, impacting estrogen levels and suggesting a delicate interplay between soy intake and hormonal regulation in females. In males, both MSG and soya beans significantly decreased testosterone levels, indicating potential implications for spermatogenesis and reproductive function. LH levels displayed varied responses, reflecting the nuanced influence of dietary components on male reproductive hormone regulation. Additionally, soybean consumption led to intricate dynamics in FSH levels, underscoring the multifaceted impact of dietary factors on male reproductive health. These findings highlight the need for a comprehensive understanding of dietary impacts on reproductive hormones and emphasize the importance of mindful dietary choices in promoting optimal reproductive health. Further research is essential to decipher the underlying mechanisms and explore potential translational implications for human populations.

Keywords	*Monosodium Glutamate (MSG); Soya Bean Consumption; Reproductive Hormone Profiles*
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Introduction

In recent years, the intricate interplay between dietary choices and health outcomes has become a central focus of scientific inquiry. Among the myriad components of modern diets, monosodium glutamate (MSG) and soya beans have captured significant attention due to their pervasive presence in processed foods. MSG, a ubiquitous flavor enhancer, and soya beans, a versatile legume, are integral to various culinary preparations, influencing the taste and nutritional content of a wide array of food products (Yamamoto & Inui-Yamamoto, 2023; Henry-Unaeze, 2022). As the consumption of these components has escalated, concerns regarding their potential impact on reproductive health have surfaced, sparking the need for in-depth investigations.

Reproductive health stands as a cornerstone of overall well-being, playing a pivotal role in shaping individual lives and societal dynamics. Disruptions in reproductive hormone profiles, encompassing changes in luteinizing hormone (LH), progesterone (PRG), oestrogen, and follicle-stimulating hormone (FSH) levels, can have profound implications for fertility, pregnancy outcomes, and overall reproductive function (Nedresky & Singh, 2020; Choi & Smitz, 2013). Despite the existing body of research examining the immediate effects of MSG and soya bean consumption on reproductive hormones, a critical gap remains in the understanding of the long-term consequences of these dietary components.

Previous studies have primarily focused on short-term reactions, leaving a significant void in knowledge concerning prolonged exposure to MSG and soya beans (Zanfirescu et al., 2019; Nahok et al., 2021). This study seeks to address this gap by conducting an exhaustive exploration of the enduring impact of long-term MSG and soya bean consumption on reproductive hormone profiles, specifically in female and male rats. By meticulously analyzing changes in LH, PRG, oestrogen, and FSH levels over extended periods of MSG and soya bean administration, this research aims to uncover nuanced patterns and correlations between dietary habits and reproductive hormone disruptions.

Understanding the complexities of female reproductive health in relation to MSG and soya bean consumption is paramount. Similarly, unraveling the effects on male reproductive hormones is essential for a comprehensive understanding of the dietary factors influencing reproductive well-being. By elucidating the intricate relationship between prolonged MSG and soya bean consumption and reproductive hormone profiles, this study not only expands the scientific comprehension but also holds significant implications for public health policies and dietary guidelines.

As we delve into the subsequent sections, we will detail the methodology employed in this study, outlining the experimental design, data collection, and analysis methods. By systematically investigating the long-term effects of MSG and soya bean consumption on reproductive hormone profiles, this research aims to provide comprehensive insights. These insights, in turn, contribute meaningfully to the ongoing discourse on diet-related reproductive health issues, shaping healthier dietary practices and promoting reproductive well-being for individuals and communities alike.

Objectives:

1. To assess the impact of MSG and Soya Bean consumption on female reproductive hormone levels.
2. To explore the impact of MSG and Soya bean consumption on male reproductive hormone levels.

Literature Review

The relationship between soy consumption and its potential health effects, particularly in the context of reproductive health and cancer prevention, has been a subject of extensive research. Kurzer (2002) explored the impact of soy consumption on premenopausal women, suggesting potential cancer-preventive effects such as increased menstrual cycle length and elevated sex hormone-binding globulin levels, coupled with decreased

estrogen levels. However, concerns have been raised regarding the adverse effects on men's fertility, including lowered testosterone levels and semen quality. Studies in women have shown mixed results, with some indicating decreased midcycle plasma gonadotropins and trends toward increased menstrual cycle length and decreased blood concentrations of estradiol, progesterone, and sex hormone-binding globulin after soy intervention. The studies have also demonstrated decreased urinary estrogens and altered estrogen metabolite ratios, indicating potential modulation of estrogen synthesis and metabolism by soy isoflavones.

Nicholls et al. (2002) delved into the behavior of dietary isoflavones from soy in pre- and postmenopausal women, evaluating their estrogenic effects on the pituitary. The research showed that soy consumption did not exert estrogen-like effects at the pituitary level, yet a residual estrogenic effect was observed in postmenopausal subjects, highlighting the complexity of soy's impact on hormonal regulation in different populations.

Xu et al. (1998) conducted a study in premenopausal women, investigating the cancer-preventive effects of soy isoflavones. The findings suggested that increased isoflavone consumption decreased urinary excretion of various estrogens, altering metabolism away from genotoxic estrogen metabolites towards inactive forms, indicating potential cancer-preventive effects.

In a study by Oldewage-Theron & Egal (2018), the long-term effects of soy consumption on metabolic syndrome (MetS) in women were explored. The results indicated a significant reduction in the prevalence of MetS after a period of soy consumption. Despite the beneficial metabolic effects observed, a direct statistical relationship between soy protein consumption and MetS risk factors was not confirmed, necessitating further research to understand the intricate link between soy consumption and metabolic health.

These studies collectively underline the intricate nature of soy's effects on reproductive hormones, cancer prevention, and metabolic health. While promising findings have been reported, the complexity of these relationships necessitates continued research to unravel the full spectrum of soy's impact on human health, particularly concerning reproductive health and cancer prevention.

Materials and Methods

Materials

Table 1: Equipment and Sources

Equipment	*Sources*
Automatic Electrolyte Analyzer	Shimadzu UV-160A, Lakewood Carlifonia, USA
BT-3000 auto analyzer	Diamond Diagnostics Inc, Holliston, MA, USA
Centrifuge	Shimadzu UV-160A, Lakewood Carlifonia, USA
Colorimeter	Lovibond™ PFXi-995, Tintometer Limited, Amesbury, UK
Dessicator	East Biopharm, Hangzhou, Zhejiang, China
ELISA plate reader	Omega Bio-Tek Inc. - Norcross, Georgia USA
Gas Chromatography	Agilent Technologies 7890A, Santa Clara, Carlifonia, United States
Glucometer	Roche Diagnostics Indianapolis, IN, United States
Hematology Auto-Analyzer	Mindray,Boulevard, New Jersey, USA
Ichroma Machine	Shimadzu UV-160A, Lakewood Carlifonia, USA
Incubator	Shimadzu UV-160A, Lakewood Carlifonia, USA
Microscope	Shimadzu UV-160A, Lakewood Carlifonia, USA
Oven	Shimadzu UV-160A, Lakewood Carlifonia, USA
pH Meter	Uniscope , SM801A, England
Rotary Evaporator	SHB-520, Korea
Soxhlet Extractor	Uniscope , SM801A, England
Steam Bath	East Biopharm, Hangzhou, Zhejiang, China
Thermometer	East Biopharm, Hangzhou, Zhejiang, China

Water Bath	Biotechnics, Aberdeenshire, Scotland UK
Weighing Balance	South Cross Road Bradford

Table 2: Chemicals/Reagents and Sources

Chemicals/reagents	*Sources*
4-dinitrophenyl hydrazine solution	British Drug House (BDH), England
Acetic acid	Sigma Aldrich St. Louis, MO, USA
Biochemical reagent kits	Randox lab Ltd, Antrim, UK.
Butanol	Sigma Aldrich St. Louis, MO, USA
CA 19-9 ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
CA-125 ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Carbonate buffer	British Drug House (BDH), England
CEA ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Dimethylether	Sigma Aldrich St. Louis, MO, USA
Ethanol	British Drug House (BDH), England
Ethylene diamine tetraacetic acid	British Drug House (BDH), England
Follicle Stimulating Hormone test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Glutathione reductase	Qualiken fine chemicals, New Delhi, India
Hexane	Sigma Aldrich St. Louis, MO, USA
Hydrogen peroxide	Sigma Aldrich St. Louis, MO, USA
Insulin kits	Syntron Bioresearch (USA).
Luteinizing Hormone Test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Potassium phosphate buffer	Qualiken fine chemicals, New Delhi, India
Propanol	British Drug House (BDH), England
Randox liver function test kits	140 London Wall, London, England
Randox renal function test kits	140 London Wall, London, England
Sodium azide	Omega Bio-Tek Inc. - Norcross, Georgia USA
Sodium bicarbonate	British Drug House (BDH), England
Sodium hydroxide	British Drug House (BDH), England
Sodium phosphate buffer	Qualiken fine chemicals, New Delhi, India
Sodium sulphate	Sigma Aldrich St. Louis, MO, USA
Sulphuric acid	Sigma Aldrich St. Louis, MO, USA
Testosterone Test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Thiobarbituric acid	Sigma Aldrich St. Louis, MO, USA
Trichloroacetic acid	British Drug House (BDH), England

Methods

Laboratory Methodology for Hormone Level Determination

In this study, the analysis of reproductive hormone levels, specifically testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH), was conducted meticulously to ensure accuracy and reliability. The following procedures were followed for hormone level determination:

Determination of Testosterone:

Serum testosterone levels were assessed using the Accubind ELISA Microwells kit (Monobind Inc., Lakeforest, USA) following the manufacturer's instructions. Precisely 25µl of the serum reference calibrator was dispensed into designated wells, followed by the addition of 100µl of the Testosterone Enzyme Reagent. The microplate was gently swirled, covered, and excess liquid was removed using an adsorbent paper. Subsequently, 350µl of wash buffer was added and decanted three times. Following this, 100µl of the working substrate solution was added to all wells, and the microplate was incubated for fifteen minutes at room temperature. After the incubation period, 50µl of stop solution was added to each well, mixed gently, and the absorbance at 450nm was measured using a microplate

reader with a reference wavelength of 620-630nm. Testosterone concentrations in the test samples were determined by plotting a dose-response curve using GraphPad Prism software and expressed as ng/ml.

Determination of Luteinizing Hormone:

The serum luteinizing hormone levels were determined using the Acculite ELISA Microwells kit (Monobind Inc., Lakeforest, USA) as per the manufacturer's guidelines. Similar to the testosterone assay, 25µl of the serum reference calibrator was dispensed into designated wells, followed by the addition of 100µl of the L-H Conjugate Solution Reagent. The subsequent steps, including swirling, washing, substrate solution addition, stop solution addition, and absorbance measurement, were performed analogously to the testosterone assay. Luteinizing hormone concentrations in the test samples were calculated using GraphPad Prism software and expressed as mIU/ml.

Determination of Follicle Stimulating Hormone:

Serum follicle-stimulating hormone levels were analyzed using the Accubind ELISA Microwells kit (Monobind Inc., Lakeforest, USA) following the manufacturer's instructions. The procedure mirrored that of the testosterone and luteinizing hormone assays, with precise additions of serum reference calibrator, FSH Enzyme Reagent, wash buffer, working substrate solution, and stop solution. Following the incubation and mixing steps, the absorbance at 450nm was measured with a microplate reader, utilizing a reference wavelength of 620-630nm. FSH concentrations in the test samples were determined through the construction of a dose-response curve using GraphPad Prism software and expressed as mIU/ml.

By employing these standardized and meticulous laboratory techniques, the study ensures the accurate determination of testosterone, luteinizing hormone, and follicle-stimulating hormone levels. The stringent adherence to manufacturer guidelines, precise measurements, and advanced software analysis collectively contribute to the reliability and validity of the hormonal data collected, thereby enhancing the overall scientific rigor of the study.

Statistical Analysis

In this study, all data obtained were meticulously subjected to rigorous statistical analysis to derive meaningful conclusions. The values derived from the experiments were reported as Mean ± Standard Deviation (S.D), providing a clear and concise representation of the central tendency and variability within the data sets.

To discern differences among the treatment groups, a robust statistical method, one-way Analysis of Variance (ANOVA), was employed. ANOVA is a powerful parametric statistical technique used to compare means of two or more groups to determine if there are any statistically significant differences among them. In this analysis, the treatment groups were compared based on the measured parameters, providing crucial insights into the effects of MSG and soya bean consumption on reproductive hormone levels.

The statistical analysis was conducted utilizing the Statistical Package for Social Sciences (SPSS) version 20, a widely recognized and reliable software for statistical computations. The significance level for the analysis was set at 95% confidence interval ($p < 0.05$). This stringent criterion ensured that only results with a high level of confidence were considered significant, enhancing the reliability and validity of the study's findings.

By employing one-way ANOVA and adhering to the specified confidence level, the study aimed to uncover meaningful differences among the treatment groups. This rigorous statistical approach provided a robust foundation for drawing accurate conclusions regarding the impact of long-term MSG and soya bean consumption on reproductive hormone profiles in both female and male rats.

Results

Female Reproductive Hormone Levels

The results for the female reproductive hormones of rats administered MSG and soya beans for 2, 4, and 6 months were shown in Table 3. No significant changes were observed in the luteinizing hormone (LH) levels of rats administered MSG for 2 and 4 months when compared to the control levels while only the MD and HD administration for 6 months significantly ($p<0.05$) decreased the LH levels. Administration of soya beans produced no significant ($p>0.05$) effect on the LH levels for the 2-, 4-, and 6-months feeding period. The result for the progesterone (PRG) levels of the rats showed that the MSG and soya bean doses administered respectively for 2 and 4 months caused no significant ($p>0.05$) changes. The 4 months administration of MD and HD MSG significantly ($p<0.05$) decreased the PRG levels (13.55 and 14.10 ng/ml respectively) when compared to the control level (15.05 ng/ml) while all the soya bean doses significantly ($p<0.05$) decreased the PRG levels. The results for the 6 months administration of MSG and soya beans showed significant ($p<0.05$) decrease in the PRG levels when compared to their respective control levels. No significant change was observed in the oestrogen levels after the 2 months administration of LD, MD, and HD MSG while the LD, MD, and HD soya beans significantly ($p<0.05$) decreased the oestrogen levels (68.50, 76.00, and 56.50 pg/ml respectively) when compared to the control level (62.65 pg/ml). The administration of the extracts respectively for 4 and 6 months significantly ($p<0.05$) increased the oestrogen levels when compared to the control. The result for the FSH levels showed that the administration all the doses of MSG and soya beans for 2 and 4 months produced no significant ($p>0.05$) effect. The LD, MD, and HD administration of MSG significantly ($p<0.05$) decreased the FSH levels (79.50, 74.00, and 66.50 pg/ml respectively) relative to the control level (87.50 pg/ml) while only the 6 months HD soya bean administration, significantly ($p<0.05$) decreased the FSH levels (0.35 pg/ml) relative to the control (0.53 pg/ml).

Table 3: Female Reproductive Hormones of Rats Administered Monosodium Glutamate and Soya Beans

DURATION	GROUPS	LH (mIU/ml)	LH (mIU/ml)	PRG (ng/ml)	PRG (ng/ml)	E_2 (pg/ml)	E_2 (pg/ml)	FSH (mIU/ml)	FSH (mIU/ml)
		MSG	SOY	MSG	SOY	MSG	SOY	MSG	SOY
2 MONTHS									
	C	$0.54\pm0.12^{a*}$	$0.54\pm0.12^{a*}$	$11.80\pm1.16^{a*}$	$11.80\pm1.16^{a*}$	$62.65\pm3.19^{a*}$	$62.65\pm3.19^{a*}$	$0.25\pm0.04^{a*}$	$0.25\pm0.04^{a*}$
	LD	$0.57\pm0.01^{a*}$	$0.57\pm0.31^{a*}$	$10.10\pm2.54^{a*}$	$12.60\pm2.40^{b*}$	$69.50\pm1.60^{a*}$	$68.50\pm6.36^{b*}$	$0.23\pm0.05^{a*}$	$0.22\pm0.01^{a*}$
	MD	$0.49\pm0.17^{a*}$	$0.51\pm0.16^{a*}$	$13.05\pm0.91^{a*}$	$14.85\pm3.74^{b*}$	$70.00\pm1.14^{a*}$	$76.00\pm2.82^{c**}$	$0.20\pm0.03^{a*}$	$0.25\pm0.04^{a*}$
	HD	$0.51\pm0.15^{ba*}$	$0.63\pm0.38^{a*}$	$11.60\pm2.12^{a*}$	$15.15\pm6.57^{bc*}$	$66.50\pm9.19^{a*}$	$56.50\pm6.36^{d**}$	$0.21\pm0.06^{a*}$	$0.21\pm0.05^{a*}$
4 MONTHS									
	C	$0.65\pm0.03^{b*}$	$0.65\pm0.03^{a*}$	$15.05\pm0.21^{b*}$	$15.05\pm0.21^{c*}$	$86.00\pm2.82^{b*}$	$86.00\pm2.82^{e*}$	$0.38\pm0.04^{b*}$	$0.38\pm0.04^{b*}$
	LD	$0.67\pm0.06^{b*}$	$0.67\pm0.04^{a*}$	$14.40\pm1.13^{b*}$	$15.85\pm0.77^{c*}$	$78.00\pm1.41^{c*}$	$75.00\pm7.07^{ac*}$	$0.35\pm0.06^{b*}$	$0.39\pm0.05^{b*}$
	MD	$0.65\pm0.05^{b*}$	$0.71\pm0.01^{a**}$	$11.30\pm1.41^{a*}$	$13.55\pm2.05^{b*}$	$65.50\pm3.53^{a*}$	$70.5\pm2.12^{ab**}$	$0.31\pm0.02^{b*}$	$0.34\pm0.05^{b*}$
	HD	$0.65\pm0.03^{b*}$	$0.80\pm0.02^{a**}$	$10.80\pm1.41^{a*}$	$14.10\pm0.70^{b**}$	$63.00\pm4.24^{a*}$	$73.5\pm3.53^{ac**}$	$0.32\pm0.06^{b*}$	$0.36\pm0.03^{b*}$
6 MONTHS									
	C	$0.78\pm0.06^{c*}$	$0.78\pm0.06^{a*}$	$15.15\pm0.49^{b*}$	$15.15\pm0.49^{c*}$	$87.50\pm3.53^{b*}$	$87.50\pm3.53^{d*}$	$0.53\pm0.02^{c*}$	$0.53\pm0.02^{c*}$
	LD	$0.83\pm0.11^{c*}$	$0.77\pm0.02^{a**}$	$12.35\pm0.77^{c*}$	$14.55\pm0.7^{bc**}$	$75.50\pm4.94^{c*}$	$79.50\pm0.70^{c*}$	$0.48\pm0.04^{d*}$	$0.51\pm0.02^{c*}$
	MD	$0.60\pm0.12^{b*}$	$0.79\pm0.01^{a**}$	$9.45\pm0.63^{d*}$	$15.35\pm0.77^{c**}$	$76.00\pm2.82^{c*}$	$74.00\pm4.24^{ac*}$	$0.43\pm0.06^{e*}$	$0.48\pm0.03^{c*}$
	HD	$0.51\pm0.11^{ba*}$	$0.82\pm0.02^{a**}$	$9.55\pm1.20^{d*}$	$15.75\pm0.49^{c**}$	$56.00\pm5.65^{d*}$	$66.50\pm3.53^{b*}$	$0.35\pm0.02^{b*}$	$0.40\pm0.04^{d*}$

Values are means ± standard deviations n=5. Values with different superscript letter (s (a-f) $p < 0.05$) down the column or symbols (* and **) across the row for each parameter, are significantly different. MSG – Monosodium glutamate, SOY – Soya bean, LH – Luteinizing hormone, PRG – Progesterone, E_2 – Oestrogen, FSH – Follicle stimulating hormone.

Male Reproductive Hormone Levels

The male reproductive hormones of rats administered monosodium glutamate and soya beans were presented in Table 4. The 2-, 4-, and 6-months administration of LD MSG and soya bean produced no significant ($p>0.05$) effect on the testosterone levels while the MD and HD MSG and soya bean significantly ($p<0.05$) decreased the testosterone levels of the rats. The LD, MD and HD MSG and soya bean significantly ($p<0.05$) decreased the luteinizing hormone of the male rats when administered for 2 months while no significant ($p>0.05$) effect was observed with 4 months administration. For the 6 months administration, the MSG doses significantly ($p<0.05$) decreased the luteinizing hormone levels of the male rats (0.73, 0.54, and 0.52 mIU/ml respectively) relative to the control level (0.82 mIU/ml) while only the MD and HD soya bean significantly ($p<0.05$) increased the luteinizing hormone level (0.70 and 0.60 mIU/ml respectively). The result for the FSH level showed no significant ($p>0.05$) change observed for 2 months administration of LD, MD, and HD MSG and soya bean. At 4 and 6 months, only the administration of MD and HD MSG significantly ($p<0.05$) increased the FSH level while only the HD soya bean significantly ($p<0.05$) increased the FSH level.

Table 4: Male Reproductive Hormones of Rats Administered Monosodium Glutamate and Soya Beans

DURATION	GROUPS	Ttos (ng/ml)	Ttos (ng/ml)	LH (mIU/ml)	LH (mIU/ml)	FSH (mIU/ml)	FSH (mIU/ml)
		MSG	SOY	MSG	SOY	MSG	SOY
2 MONTHS							
	C	$4.48\pm0.00^{a*}$	$4.48\pm0.00^{a*}$	$0.82\pm0.04^{a*}$	$0.82\pm0.04^{a*}$	$0.32\pm0.05^{a*}$	$0.32\pm0.05^{a*}$
	LD	$4.25\pm0.19^{a*}$	$4.86\pm0.09^{a**}$	$0.56\pm0.09^{b*}$	$0.73\pm0.23^{b**}$	$0.28\pm0.05^{a*}$	$0.30\pm0.04^{a*}$
	MD	$2.59\pm0.15^{b*}$	$3.61\pm0.26^{b**}$	$0.45\pm0.05^{c*}$	$0.71\pm0.11^{b**}$	$0.30\pm0.03^{a*}$	$0.31\pm0.01^{a*}$
	HD	$0.92\pm0.09^{c*}$	$3.25\pm0.19^{b**}$	$0.42\pm0.06^{c*}$	$0.70\pm0.07^{b**}$	$0.33\pm0.04^{a*}$	$0.29\pm0.03^{a*}$
4 MONTHS							
	C	$4.40\pm0.36^{a*}$	$4.40\pm0.36^{a*}$	$0.74\pm0.05^{d*}$	$0.80\pm0.05^{a*}$	$0.45\pm0.02^{b*}$	$0.45\pm0.02^{be*}$
	LD	$4.20\pm0.26^{a*}$	$4.66\pm0.11^{a**}$	$0.71\pm0.04^{d*}$	$0.82\pm0.02^{a**}$	$0.40\pm0.04^{b*}$	$0.40\pm0.04^{bc*}$
	MD	$3.12\pm0.08^{d*}$	$3.61\pm0.28^{b**}$	$0.71\pm0.02^{d*}$	$0.85\pm0.04^{a**}$	$0.36\pm0.03^{a*}$	$0.42\pm0.02^{b**}$
	HD	$3.14\pm0.14^{d*}$	$3.30\pm0.28^{b*}$	$0.70\pm0.01^{d*}$	$0.82\pm0.01^{a**}$	$0.31\pm0.05^{a*}$	$0.38\pm0.03^{b**}$
6 MONTHS							
	C	$6.78\pm0.35^{e*}$	$6.78\pm0.35^{c*}$	$0.82\pm0.02^{a*}$	$0.82\pm0.02^{a*}$	$0.69\pm0.04^{c*}$	$0.69\pm0.04^{d*}$
	LD	$6.50\pm0.27^{e*}$	$6.82\pm0.12^{c*}$	$0.73\pm0.03^{d*}$	$0.80\pm0.02^{a**}$	$0.62\pm0.06^{c*}$	$0.64\pm0.02^{d*}$
	MD	$5.72\pm0.28^{f*}$	$5.68\pm0.37^{d*}$	$0.54\pm0.04^{b*}$	$0.70\pm0.02^{b**}$	$0.53\pm0.05^{d*}$	$0.67\pm0.03^{d**}$
	HD	$4.41\pm0.12^{a*}$	$5.12\pm0.17^{d**}$	$0.52\pm0.03^{b*}$	$0.60\pm0.02^{c**}$	$0.44\pm0.06^{b*}$	$0.50\pm0.06^{e**}$

Values are means ± standard deviations n=5. Values with different superscript letter(s) (a-f) down the column or symbols (* and **) across the row for each parameter, are significantly different ($p < 0.05$). MSG - Monosodium glutamate., SOY – Soya bean, Ttos – Testosterone, LH – Luteinizing hormone, FSH – Follicle stimulating hormones.

Discussion of Findings

The findings of this study contribute significantly to the ongoing discourse surrounding the intricate relationship between soy consumption and reproductive hormone levels, as well as its potential implications for cancer prevention and metabolic health. In the context of the extensive literature reviewed, the results align with the diverse spectrum of effects observed in previous research, highlighting the multifaceted and context-dependent nature of soy's impact on human physiology.

In this investigation, the meticulously examined the effects of prolonged exposure to monosodium glutamate (MSG) and soya beans on reproductive hormone levels in both female and male rats. The observed changes, including decreased luteinizing hormone (LH) and progesterone (PRG) levels in females and lowered testosterone levels in males, raise pertinent questions about the potential consequences of soy consumption on fertility, especially in men. These findings echo some of the concerns expressed in human studies, specifically regarding the potential adverse effects of soy phytoestrogens on reproductive hormones and semen quality, as noted in the study by Kurzer (2002).

The observed alterations in hormone levels bring to the fore the necessity of understanding the nuanced effects of soy consumption on reproductive health in diverse populations.

Contrasting the findings in this study, previous research in women has provided modest support for the beneficial effects of soy consumption, particularly in premenopausal women. Kurzer's (2002) study, for instance, suggested potential cancer-preventive effects in premenopausal women, indicating increased menstrual cycle length and decreased estrogen levels. However, these effects were not consistently mirrored in the female rat subjects. Similarly, the study by Xu et al. (1998) demonstrated potential cancer-preventive effects in women, indicating a shift in estrogen metabolism away from genotoxic metabolites. While these specific metabolic alterations were not reflected in this study, they underscore the complex interplay between soy components and human physiology. These contradictions emphasize the need for comprehensive investigation into the mechanistic underpinnings of soy's effects on estrogen metabolism, taking into account the potential variations across different populations and hormonal contexts.

Moreover, the study conducted by Nicholls et al. (2002) delved into the behavior of dietary isoflavones from soy in pre- and postmenopausal women. The research indicated that soy consumption did not exert estrogen-like effects at the pituitary level, yet a residual estrogenic effect was observed in postmenopausal subjects. This residual effect raises intriguing questions about the long-term consequences of soy consumption, especially in postmenopausal women, and prompts further exploration into the persistent impact of soy phytoestrogens on hormonal regulation.

In a somewhat divergent vein, the study by Oldewage-Theron & Egal (2018) explored the long-term effects of soy consumption on metabolic syndrome (MetS) in women. While not directly related to reproductive hormone levels, the results indicated a significant reduction in the prevalence of MetS after a period of soy consumption. Despite the positive metabolic effects observed, a direct statistical relationship between soy protein consumption and MetS risk factors was not confirmed, underscoring the intricate and multifactorial nature of metabolic health outcomes associated with soy intake.

Understanding the complexities of soy's effects on reproductive hormones and metabolic health necessitates a nuanced approach that considers various factors, including the specific soy components involved, the duration of consumption, and the individual's hormonal context. This study, while shedding light on some aspects of this intricate relationship, also highlights the need for continued research to unravel the underlying mechanisms and explore potential interactive effects with other dietary components. Moreover, the diversity of responses observed among different populations emphasizes the importance of investigating specific subpopulations that might exhibit heightened sensitivity to soy phytoestrogens, as suggested by Nicholls et al. (2002). These subpopulations could hold valuable clues to the variability in soy's impact on human health outcomes.

In conclusion, these findings contribute valuable insights to the existing body of knowledge, emphasizing the intricate and multifaceted nature of soy's impact on reproductive hormone levels and metabolic health. As we navigate this complex landscape, future research efforts should delve deeper into the underlying mechanisms, explore potential interactions with other dietary factors, and consider the diverse responses among different demographic groups. By unraveling the complexities of soy's effects on human physiology, we can inform public health guidelines and interventions more effectively, ensuring the promotion of optimal reproductive and metabolic health across diverse populations. Through continued exploration and a holistic understanding of soy's influence on human health, we can pave the way for more tailored and effective dietary recommendations, ultimately enhancing the well-being of individuals worldwide.

Implications and Further Research:

The findings of this study underscore the intricate and gender-specific effects of MSG and soya bean consumption on reproductive hormone levels in both female and male rats. These results warrant further exploration into the underlying mechanisms driving these alterations and their potential implications for human reproductive health. Additionally, considering the complexities of dietary components and their impact on hormone regulation, future

research should delve into the interactive effects of multiple dietary factors, providing a comprehensive understanding of the intricate web of influences on reproductive hormones. These insights are invaluable not only for scientific understanding but also for shaping dietary guidelines and public health interventions, ensuring the promotion of optimal reproductive health for individuals across diverse populations.

Conclusion

In conclusion, this comprehensive study has provided valuable insights into the complex interplay between monosodium glutamate (MSG) and soya bean consumption and reproductive hormone levels in female and male rats. The findings revealed intricate and gender-specific effects on key reproductive hormones, shedding light on the potential implications for reproductive health.

In female rats, prolonged exposure to MSG and soya beans led to significant alterations in luteinizing hormone (LH), progesterone (PRG), oestrogen, and follicle-stimulating hormone (FSH) levels. Notably, MSG administration resulted in decreased LH and PRG levels, indicating potential disruptions in the natural hormonal balance crucial for reproductive function. Soybean consumption exhibited complex dynamics, with both decreases and subsequent increases in oestrogen levels, emphasizing the intricate influence of dietary soy intake on hormonal regulation in females. FSH levels, essential for follicular development, exhibited nuanced responses, further highlighting the need for a comprehensive understanding of the dietary impact on female reproductive health.

In male rats, the study demonstrated significant decreases in testosterone levels in response to higher doses of MSG and soya beans. Luteinizing hormone (LH) levels exhibited varied patterns, indicating a complex interaction between dietary components and male reproductive hormone regulation. Follicle-stimulating hormone (FSH) levels showed intricate dynamics, emphasizing the multifaceted influence of dietary factors on male reproductive health.

These findings underscore the importance of understanding the effects of dietary choices on reproductive hormone profiles. The study's outcomes have implications for both scientific research and public health interventions, emphasizing the need for mindful dietary habits to promote optimal reproductive health. As reproductive health is crucial for overall well-being and the sustainability of populations, the insights gained from this study contribute significantly to the broader understanding of the impact of diet on reproductive hormone regulation.

Further research is warranted to elucidate the underlying mechanisms driving these hormonal alterations, explore interactive effects with other dietary components, and assess the translational relevance of these findings to human populations. By continuing to investigate the intricate relationship between dietary factors and reproductive health, we can develop informed guidelines and interventions, fostering a healthier future for individuals and communities worldwide.

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