Chemical and biological evaluation of fortified biscuits with different concentrations of zinc or selenium

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ABSTRACT

Biscuits are a favorite snack among the younger generation. Biscuits fortified with zinc (Zn) or selenium (Se) may help to avoid several diseases that are common in developing countries. The goals of this research were to determine the chemical makeup of reinforced biscuits and to see how different fortified biscuit samples affected feed intake, body weight, feed efficiency ratio, serum lipids profile, liver, kidney functions, immunity, and liver histopathology. Forty male albino rats have been separated into eight groups: group (1) was a negative control; group (2) was fed a diet containing control biscuits without fortified; and the other groups have been fed biscuits fortified with 10, 15, and 20 mg of zinc or selenium for 28 days. The results showed that rats fed on selenium or zinc biscuits had a higher feed efficiency ratio (FER) ($P \leq 0.05$) than the control *groups. Adding zinc or selenium led to significantly improved serum liver, kidney functions, and lipid profile especially at the levels of 10 and 15% when compared with a control group. Biochemical indicators were affected more by selenium levels than zinc levels. As a result, zinc and selenium are essential minerals that must be added to food or taken as dietary supplements to fulfill their crucial functions.*

Keywords: *Fortification, thyroid hormones; liver enzymes; Immunity productions.*

INTRODUCTION

In most low-income countries and developing countries, micronutrient deficiencies are serious public health issues among preschool and school children (**Tran *et al.*, 2009)**. Fortification is the adding of a nutrient to a portion of food to enhance its quality or as a technique of administering the nutrient to a community to repair an existing nutritional insufficiency. Successful fortification programs rely on the proper selection of food vehicles and fortification compounds. According to studies on overall and available trace elements in various processed foods, whole-wheat flour has the highest overall and available trace elements, followed by semolina and unleavened bread prepared using wheat flour. Wheat flour represents the most fortified staple food because it reaches the most people, like infant formula and cereal weaning foods, chocolate drinks, breakfast cereals, and beverages for adolescents and older children **(FAO, 2003).**

Selenium is a trace element that is found naturally in a variety of foods and is also available as a dietary supplement. There are two types of Se: organic (selenomethionine and selenocysteine) as well as inorganic (selenate and selenite). Selenocysteine and selenite are both decreased to form hydrogen selenide that is then transformed into selenophosphate for the biosynthesis of selenoproteins (**Davis, 2012; Sunde, 2016).** Both types could be good sources of Se in the diet. In human and animal tissues, the majority of Se is present in the form of selenomethionine, which could be integrated into body proteins nonspecifically using the amino acid methionine. Skeletal muscle is the primary storage location for Se, which accounts for 28–46% of the overall Se pool. A deficiency of Se causes biochemical alterations that may predispose individuals who are stressed to develop certain diseases. In addition, Se insufficiency has been linked to male infertility and may have a role in Kashin-Beck illness, a kind of osteoarthritis that appears in regions of China, Tibet, and Siberia where Se levels are low (no more than 11 mcg/day). Selenium insufficiency may aggravate iodine shortages, possibly raising the incidence of infant cretinism **(Sunde, 2010; Tery and Dimond, 2018).**

Zinc is an important mineral that can be found naturally in certain foods and added to others. Zn can also be present in several cold lozenges' cold remedies. Participates in several facets of cellular metabolism. It is essential for the catalytic activity of around 100 enzymes and has a role in immunological function, synthesis of protein, healing of wounds, DNA synthesis, as well as cell division **(IMFNB, 2001**). Zinc is also essential for a healthy sense of smell and taste and helps normal development and growth throughout pregnancy, childhood, and adolescence. As the body lacks a specific Zn storage system, daily Zn intake is essential to sustain a steady state. Zinc insufficiency causes developmental retardation, appetite loss, and reduced immunological function. In more severe instances, Zn deficiency can cause loss of hair, diarrhea, delayed sexual development, impotence, hypogonadism in men, and skin and eye lesions. Loss of weight, delayed wound healing, taste anomalies, and mental lethargy are all possible side effects. Several of these symptoms are non-specific and frequently co-occur with other health problems; therefore, a medical exam is required to determine whether a zinc deficiency exists **(Nishi, 2006; Meretand 2015).**

The main goals of this research were to study the impacts of different fortified samples of biscuits with Zn or Se on some biological markers of normal male rats.

MATERIALS AND METHODS

Materials

Chemicals

El-Gomhoriya Company, Cairo, Egypt, provided selenium, zinc, and chemical kits.

Animals

Forty male (Sprague -Dawley strain) adult healthy albino rats weighed (90 ±5g) have been collected from the Ministry of Health and Population's Laboratory of Animal Colony in Helwan, Cairo, Egypt. The rats have been housed in stainless steel cages under controlled conditions.

Diets

The basal diet was supplied by El-Gomhoryia, a company in Cairo, Egypt. Corn oil has been obtained in Cairo, Egypt, at a local market.

Technological materials

Wheat flour and other ingredients for the sweet biscuits were purchased from Cairo's local markets, Egypt.

Methods

Preparation of biscuits

Sweet biscuits were prepared by the method of **Giwa and Abiodun (2010).** For each 100 gm of refined wheat flour, 30 gm of sugar powder, 20 gm of butter, 2.0 gm of skim milk powder, 1.0 gm of salt, 0.4 gm of sodium bicarbonate, 1.5 gm of ammonium bicarbonate, 2.0 gm of dextrose, and 20 milliliters of water have been used. In a Brawn mixer (Model N50), sugar powder and butter have been mixed together for 3 minutes at 61 rpm. Salt, ammonium bicarbonate, sodium bicarbonate, and skim milk powder have been added to the water and blended at 125 rpm for an additional 8 minutes. The above cream mixture has been added to refined wheat flour and blended for 3 minutes at 61 rpm. A biscuit cutter has been used to cut the dough, which has been sheeted to a thickness of 3.5 mm (52-mm diameter). The biscuits have been baked for 8 minutes at 205 °C. Biscuit preparation has been performed utilizing wheat flour samples fortified by adding zinc sulfate and sodium selenite at the levels of 100, 150, and 200 mg /1 kg biscuit dough.

Analytical Methods

Biscuit samples were analyzed using the **A.O.A.C. (2000)** method to determine the contents (protein, fat, and ash). Total carbohydrates were calculated according to **Abd El-Latif (1990).**

Sensory analysis

Thirty members of the panel assessed the sensory qualities of biscuits. The biscuits have been assessed for various sensory aspects, with a maximum of 10 for crust look, crust color, crumb color, taste, and texture, and a maximum of 50 for total quality **(Larmond 1977).**

Experimental design and animal groups

In this study, 40 adult male healthy albino rats (Sprague-Dawley strain) weighing 90 ± 5 g have been employed. Individually, rats have been kept in stainless steel cages with wire-mesh bottoms in a temperature-controlled room (25°C) with 12-hour light/dark cycles. They had free access to water. In this study, rats were fed a normal diet for a week as an adaptation period, the basal diet as per **Reeves *et al*. (1993)**. After the adaption period, rats (the initial weight was 90±5 g) were split into eight groups at random. As a negative group, the rats in group (1) have been fed a basal diet, while the rats in the group (2) have been fed a basal diet with unfortified biscuits as a balanced group, and the remaining groups have been fed a basal diet containing 10% fortified biscuits for 6 weeks. After that, the rats were separated into six subgroups, each with five rats, as follows: 10% of biscuits are fortified with 10, 15, and 20 mg of Zn or Se.

Biological evaluation

At the end of the trial, **Chapman et al. (1959)** performed a biological assessment of the various diets by determining everyday feed intake (consumption), body weight gain (BWG), and feed efficiency ratio (FER).

Blood Sampling

Blood was taken via retro-orbital sinus puncture on the last day of the experiment under light anesthesia following an 8-hour fast and permitted for clotting for 30 min at room temperature. Samples of blood have been centrifuged for 20 min at 3000 rpm (**Schemer, 1967)**. The serum has been separated for estimating serum ALP, which was determined using **IFCC techniques (1983)**, AST, and ALT, which were carried out as stated by **Yound (1975).** Creatinine was estimated in the report of **Bohmer (1971). Fassati *et al.*, (1980)** described a method for evaluating serum uric acid. The total cholesterol levels in the serum were measured using **Seary and Bergquist's method (1960)**. **Uwajima and Shimizu (1984)** described haw determination HDL**.** Triglycerides and LDL- cholesterol were determined in the opinion of **Jacobs and Van Denmark (1960).** Thyroid hormones ((free T3 and free T4), as well as thyrotrophin and TSH, have been measured in serum by employing the radioimmunoassay (RIA) established by **Patrono and Peskar (1987).** Total immunoglobulin (IgG, IgM, IgE, and IgA) is determined by Radioimmunoassay as described by the method of **Patrono and Peskar (1987).**

Statistical Analysis

Triplicate samples were analyzed for each property. Data were assessed by analysis of variance (ANOVA) as outlined by **Sendecor and Cochran (1987).**

RESULTS AND DISCUSSION

The data in Table 1 demonstrates that when compared with the control biscuit, the Se and Zn content of the tested biscuit samples increased, whereas other contents did not differ in all biscuit samples, and the results were non-significant. On the other hand, fortified biscuits with Zn or Se content increased and reached 16.78±0.14 and 17.50±0.08 mg, respectively, when adding 20 mg of Se and Zn. The process of deliberately raising the amount of one or more micronutrients is known as a fortification (vitamins and minerals, for example). Foods that contain nutrients added to them which do not exist naturally or are presented at a low level in food or condiment to enhance the nutritional quality of the food supply as well as offer public health advantages with little risk to health are referred to as fortified foods (**Sunde, 2016)**.

The appearance of the crust, the color of the crust, the color of the crumb, texture, and taste of control and fortified biscuits are shown in table (2). The data show that biscuits baked with wheat flour alone had better organoleptic qualities, with no significant difference between the control sample and the fortified specimens containing 10 and 15 mg of Zn and Se. For biscuits with 20 mg of Zn and Se, the organoleptic properties showed non-significant changes in scores of all sensory properties except the taste of samples as compared with the control sample and the other fortified samples. Such results matched those of **Ogrsina and Radhac (2011)**, who found that replacing 20 mg of Se with flour affected the cookies' characteristics, especially taste. Selenium is a prooxidant that can catalyze the oxidation of vitamins A and C, which can affect the taste **(Akhtar *et al.*, 2011).** Zinc is a powerful inhibitor of glucose sweetness, but has no effect on sour, savory, or salty tastes. Taste inhibition is more likely an oral peripheral phenomenon caused by the zinc ion's physicochemical characteristics than a cognitive impact of any perceived Zn taste (**Nishi, 2006).**

The mean values of feed intake for rats fed Se and Zn at levels of 10, 15, and 20 were higher than the control group, as shown in table (3), and there was a significant effect (P $\leq$0.05) between the obtained results. The best level was the group fed on 10% biscuits with 20 mg selenium followed by the sample with 20 mg zinc while the feed intake of rats fed in the negative control group was the lowest.

For bodyweight gain, there is no significant between the rats fed on biscuits with 15, 20 % Se and Zn. Furthermore, no significant difference (P $\leq$0.05) exists between rats fed control biscuits, rats fed a basal diet, and the other groups fed 10% fortified level biscuits both two minerals.

In the case of feed efficiency ratio (FER), the fortified biscuits with Se and

Zn at the levels of 15, and 20% recorded significantly high mean values than the others, which have no significant differences between each other (P ≤0.05).

Zinc is a necessary component of many proteins and plays an important role in many important cell functions, including cell proliferation and apoptosis, free-radical defense, and the repair of DNA damage. Zn supplementation caused appetite regulation **(do Nascimento *et al.*, 2006; Cruz *et al.*, 2018).** Zinc can have a role in appetite control and serum leptin levels. It also helps to decrease oxidative stress by helping to synthesize antioxidant enzymes like superoxide dismutase as well as glutathione peroxidase. As a result, it is engaged in lipids, carbohydrates, and protein metabolism and functions as an enzyme catalyst (**Ahn *et al.*, 2014**). In earlier studies, selenium supplementation resulted in significant weight and body fat decreases in rats. Small interventional trials in people, on the other hand, have yielded inconsistent outcomes. A study of 11 males discovered that increasing selenium intake caused them to gain weight. Selenium is a strong mineral that is required for your body's proper functioning. It is important for metabolism and thyroid function, as well as helping to protect the body from oxidative stress damage **(Akhtar *et al.*, 2011).**

According to the table (4), serum AST, ALP, and ALT mean values in groups fed 20% Se and Zn were significantly higher (P ≤0.05) than those in groups fed control biscuits and those groups that received 10% zinc or selenium. For AST and ALP, there were no significant differences between groups fed on fortified biscuits at the levels of 15 and 20% and the control group.

Selenium is a vital trace element that is required for liver health. An animal study found that exposure to Se causes higher serum liver enzyme concentrations, Kupffer cell activation, liver insulin resistance, and liver triglyceride levels compared to controls **(Ilyas *et al.*, 2014).**

Zinc is an essential component of several liver enzymes that are essential for liver function maintenance. Individuals having chronic liver diseases (CLDs) frequently have reduced Zn levels that drop even more as the fibrosis in the liver progresses. Zinc treatment was linked to improved AST and alanine ALT levels. Intriguingly, sufferers with reduced Zn levels had lower levels of liver enzymes after zinc supplementation. By causing oxidative stress, Zn deficiency causes damage to cells and tissues by modifying particular signal cascades, causing damage to enzymes, mitochondria, and ribosomal structures **(Park *et al.*, 2018).**

The impact of feeding rats on control biscuits and biscuits with different levels of Zn and Se on renal function was shown in Table (5). The mean values of creatinine and uric acid in all groups were significantly ($P \leq 0.05$) lower than those in the control biscuits. There is no significant difference between the groups fed biscuits with different levels of Se and Zn and the negative control group. Zinc participates in several facets of cellular metabolism. It is essential for almost 100 enzymes to catalyze their activities and has an important role in immunity, synthesis of protein, healing of wounds, synthesis of DNA, and division of cells. Zinc is also essential for good smell and taste, as well as normal development and growth throughout pregnancy, childhood, and adolescence. Because the body lacks a specific zinc storage system, a daily dose of Zn is needed to maintain a steady state. In the progression and development of T_2D, Zn plays a critical role. Most likely through antioxidative mechanisms, Zn supplementation for twelve weeks may lower the excretion of albumin as well as urea and creatinine levels in diabetic microalbuminuria patients. Lower Zn levels are associated with an increased glomerular filtration rate and decreased microalbuminuria. Zinc excretion in the urine ranges from 89 to 910 micrograms per gram of creatinine on a daily basis. High urine Zn levels combined with low serum Zn levels may be produced via hepatic cirrhosis, neoplastic illness, or enhanced catabolism **(Kumar *et al*., 2014; Lchten and Cosins, 2019).** The results of **Guidi *et al*. (2017)** suggested that Se supplementation had a positive effect on the glomerular filtration rate and hypothesized that Se may be engaged in the kidney's vascular regulatory mechanism. Selenium is an antioxidant that may prevent injury during renal by limiting oxidative injury.

The average levels of total cholesterol, triglycerides, HDL, and LDL, which are affected by control biscuits and the samples with different levels of Zn and Se, are shown in table (6). Adding Zn and Se at different levels to biscuits led to keeping the mean values of lipid profile in the normal range. There are no significant differences (P ≤0.05) between the fortified biscuits and the control groups. However, there are significant differences (P ≤0.05) between the control biscuits and the others, except for VLDL-c, which has no difference between all tested groups. It was discovered in a prospective investigation that individuals with higher selenium concentrations had a bigger decline in overall cholesterol and a bigger increase in HDL-c from baseline to follow-up exam than those with lower selenium concentrations, implying that appropriate dietary selenium intake may be a possible preventive measure. In earlier studies, low selenium levels have been linked to an increased risk of cardiovascular disease. High selenium concentrations, on the other hand, can induce serum lipid concentrations to rise excessively high, particularly if selenium levels in the blood are already high. People having a normal selenium level showed decreased total and LDL cholesterol concentrations in some such studies. Total cholesterol concentrations have been decreased by up to 8%, while non-HDL cholesterol concentrations have been decreased by roughly 10%. Moreover, as compared to individuals with decreased Se levels, triglycerides have been decreased by up to 10%. Another study found a U-shaped association between selenium concentrations and triglycerides, indicating that people having very high and low Se levels exhibited higher triglyceride concentrations as well **(Stranges *et al.*, 2010; Guidi *et al.*, 2017).** Supplementing with Zn has a favorable impact on plasma lipid measurements. Supplementing with Zn lowered total cholesterol, LDL cholesterol, as well as triglycerides significantly. As a result, it has the potential to decrease atherosclerosis-related mortality and morbidity. In atherosclerotic men, a study found a lower Zn/Cu ratio and a strong link between copper concentrations total and LDL cholesterol. In other research, low dietary Zn and low plasma Zn concentrations have been linked to diabetes and the CAD risk factors of high blood pressure and hypertriglyce-ridemia. These two studies' findings contradict the concept that higher zinc concentration increases the risk of CHD by increasing LDL cholesterol, and triglycerides. The previous study discovered that moderately high, long-term Zn and copper supplementation had no effect on lipid metabolism, as measured by serum measures of total cholesterol, estimated LDL cholesterol, triglycerides, and HDL cholesterol **(Kumar *et al.*, 2014; Hooper *et al.*, 2018; Lchten and Cosins, 2019).**

In table (7), it could be noticed that administration of 10% fortified biscuits with Se at the levels of 10, 15, and 20% caused significant changes in serum concentra-tions of free T4, T3, and Thyroid Stimulating Hormone (TSH) hormones compared to the control group fed on control biscuits. All tested levels of fortified biscuits with Zn resulted in non-significant changes in thyroid hormone serum levels. Zinc is necessary for the production of thyroid hormones. For healthy levels of T3, T4, and TSH, optimal zinc content is required. Zinc is essential for thyroid hormone metabolism; zinc insufficiency can lead to lower thyroid hormone concentrations and a slower rate of resting metabolism. Zn is also required for deiodinase, an enzyme that transforms T4 into functional T3. T3 cannot be produced if zinc levels are low or absent in the body. Thyroid hormone synthesis requires Zn and other trace metals like Cu and Se, and deficiencies in these could lead to hypothyroidism. Thyroid hormones, on the other hand, are required for Zn absorption; therefore, hypothyroidism may lead to a deficiency of acquired Zn **(Hooper *et al.*,2018; Juliana *et al.*, 2019).**

Selenium, a mineral required for thyroid hormone synthesis, protects the thyroid from oxidative stress damage. Selenium is abundant in the thyroid, and a lack of it can result in thyroid dysfunction. Selenium supplementation has been proven in many studies to lower thyroid peroxidase antibodies (TPO) and the intensity of hypothyro-idism symptoms **(Vincenzo *et al.*, 2009; Duntas and Benvenga, 2015)**

From table (8), it could be observed that the administration of the tested control biscuits and fortified biscuits samples had an effect on immunological production. The biscuits were fortified with Se and Zn with significant increases in serum levels of immunological profile compared to both control groups. All the groups fed on biscuit samples with Se at different levels had significant changes in serum concentration of immune-logical production than biscuits fortified with Zn. Selenium is essential for the immune system's health. This antioxidant aids your body in reducing oxidative stress, which decreases inflammation and boosts immunity. Increased Se levels in the blood have been linked to improving immune response in studies. Selenium has an antiviral impact by modulating antioxidant defenses, redox signaling, as well as redox homeostasis. Selenium, either alone or in conjunction with other nutrients, accelerates the cellular antiviral immune responses and promotes resistance to several viruses, including influenza A **(Li and Beck, 2007)**. Zinc is an essential mineral for the human body in a variety of ways. Zinc strengthens the immune system; aids wound healing and promotes proper growth. Zinc is required for the immune system to function properly. Zinc regulates pathogen elimination, and a deficiency may decrease this function. Zinc is also required for the production or activation of certain immune system cells. Zinc may aid in the relief of common cold symptoms. Researchers discov ered that taking a zinc acetate lozenge with 13.3 mg of zinc every 2–3 hours helped people with cold symptoms clear up faster. Zinc is required for the development and activation of T-lymphocytes in the body. People with low Zn levels have lower lymphocyte proliferation responses to mitogens as well as other negative immune changes that could be rectified with Zn supplementation. Such changes in immune function could explain why reduced Zn levels have been linked to a greater susceptibility to pneumonia as well as other infections in the elderly and children in developing nations **(Wintergerst *et al.*, 2007; Singh and Das, 2016).**

CONCLUSION

Selenium and zinc are two micronutrients that are essential for human health. Deficiencies in these two nutrients are still a problem worldwide, particularly among children in developing nations. Selenium and zinc had a good effect on the biochemical parameters of rats.

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Table 1: Chemical composition of biscuits fortified with zinc, and selenium as compared to control biscuit (per100g dry weight basis).

Samples	Protein (g)	Fat(g)	Ash(g)	Total carbohydrates (g)	Zinc (mg)	Selenium (µg)
Control biscuits	9.48± 0.16 [a]	17.63± 0.21 [a]	0.81± 0.02 [d]	65.08± 1.08[c]	0.15± 0.02[d]	0.18± 0.01 [d]
Biscuits with 10mg zinc	9.48± 0.06 [a]	17.61± 0.17 [a]	9.22± 0.11 [c]	73.69± 1.25 [b]	7.41± 0.07 [c]	0.18± 0.05 [d]
Biscuits with 15mg zinc	9.48± 0.022[a]	17.53± 0.15 [a]	14.39± 0.03 [b]	75.37± 1.35 [b]	12.57± 0.1 [b]	0.18± 0.11 [d]
Biscuits with 20 mg zinc	9.48±0 .023 [a]	17.12± 0.25 [a]	18.52± 0.01 [a]	77.83± 0.98 [a]	16.78± 0.14 [a]	0.19± 0.16 [d]
Biscuits with 10mg selenium	9.48± 0.08[a]	17.24± 0.13 [a]	10.13± 0.02 [c]	75.00± 1.11 [a]	0.15± 0.09 [d]	8.13± 0.09 [c]
Biscuits with 15mg selenium	9.48± 0.23 [a]	17.20± 0.19 [a]	14.36± 0.05 [b]	76.13± 1.26 [a]	0.15± 0.08 [d]	12.51± 0.12 [b]
Biscuits with20 mg selenium	9.48± 0.13	17.16± 0.25	19.48± 0.08 [a]	78.56± 1.23 [a]	0.15± 0.16 [d]	17.50± 0.08 [a]

Table (2): Sensory properties of control biscuit and fortified biscuits samples with zinc and selenium

Organoleptic properties	Control biscuits	Biscuits with zinc			Biscuits with selenium		
Properties	**Without additive**	**10%**	**15%**	**20%**	**10%**	**15%**	**20%**
Crust appearance	9±0.01[a]	9±1.23[a]	9±0.04[a]	9±0.35[a]	9±0.85[a]	9±0.11[a]	**9±1.21[a]**
Crust color	9±0.15[a]	9±1.25[a]	9±0.14[a]	9±0.42[a]	9±0.02[a]	9±0.06[a]	**9±1.05[a]**
Crumb color	9±0.12[a]	9±1.20[a]	9±0.05[a]	9±0.74[a]	9±0.04[a]	9±0.47[a]	**9±0.95[a]**
Texture	9±0.09[a]	9±0.99[a]	9±0.55[a]	9±0.01[a]	9±0.22[a]	9±0.29[a]	**9±0.03[a]**
Taste	**9±0.03[a]**	**9±0.06[a]**	**9±1.27[a]**	**8±1.03[b]**	**9±0.28[a]**	**9±0.94[a]**	**8±1.24[b]**

Values are mean ±SD. Values in the same row with the same superscript letters do not differ statistically.

Table (3): The effect of control biscuits and fortified biscuits on rat feed intake, body weight, and feed efficiency ratio.

Groups Parameters	G 1	G 2	G3	G4	G5	G6	G7	G8
Feed intake g/d	11.39[d] ±0.38	11.97[c] ±0.03	12.18[c] ±0.38	12.54[b] ± 0.35	12.78[b] ± 0.35	12.88[b] ±0.41	13.04[a] ± 1.14	**13.4[a] ± 2.41**
BWG g/6 weeks	40.27[b] ±2.51	41.58[b] ±5.71	43.12[b] ±3.46	45.17[a] ±4.82	47.28[a] ±4.69	43.92[b] ±2.40	46.97[a] ±4.02	**49.99[a] ±2.09**
FER	**0.084[b] ± 0.011**	**0.083[b] ±0.02**	**0.084[b] ± 0.007**	**0.086[a] ± 0.016**	**0.088[a] ±0.031**	**0.081[b] ± 0.007**	**0.086[a] ± 0.016**	**0.089[a] ±0.031**

Values are mean ±SD. Values in the same row with the same superscript letters do not differ statistically.

Table (4) the effect of control biscuits and fortified biscuits on theliver enzymes of rats

Groups / Parameters	G1	G 2	G3	G4	G5	G6	G7	G8
AST(U/L)	35.1[a] ±0.27	30.2[b] ±1.11	32.1[b] ±2.56	35.3[a] ±0.21	37.7[a] ±0.25	32.5[b] ±0.16	36.5[a] ±0.01	**37.7[a] ±0.05**
ALT(U/L)	29.8[c] ±0.31	27.9[c] 1.11±	29.2[c] ±0.52	34.4[b] ±2.05	37.7[a] ±1.25	32.1[b] ±0.82	35.4[b] ±2.65	**39.7[a] ±0.05**
ALP (U/L)	**64.1[a] ±0.17**	**60.7[b] ±2.01**	**63.7[a] ±1.16**	**64.7[a] ±6.16**	**66.7[a] ±1.15**	**63.7[a] ±0.32**	**64.7[a] ±0.26**	**65.7[a] ±0.15**

Values are mean ± SD. Values in the same row with the same superscript letters do not differ statistically.

Table (5): The effect of control biscuits and fortified biscuits on the rat's creatinine and uric acid

Groups / Parameters	G 1	G 2	G3	G4	G5	G6	G7	G8
Creatinine mg/dl	0.69[b] ±0.31	0.96[a] ±0.21	0.69[b] ±0.14	0.70[b] ±0.07	0.71[b] ±0.21	0.69[b] ±0.14	0.70[b] ±0.07	**0.72[b] ±0.21**
Uric Acid mg/dl	**0.95[b] ±0.15**	**1.05[a] ±0.22**	**0.92[b] ±1.2**	**0.92[b] ±1.00**	**0.95[b] ±2.5**	**0.92[b] ±1.2**	**0.92[b] ±1.00**	**0.95[b] ±2.5**

Values are mean ±SD. Values in the same column with the same superscript letters do not differ statistically.

Table (6). The effect of control biscuits and fortified biscuits on total cholesterol triglycerides, HDL-c, and LDL-c in rats.,

Groups / Parameters	G 1	G 2	G3	G4	G5	G6	G7	G8
Total cholesterol	99.44^{b} ±1.19	110.73^{a} ±2.15	101.36^{b} ±0.12	101.69^{b} ±0.13	101.25^{b} ±3.21	101.32^{b} ±0.12	101.62^{b} ±0.13	**102.23^{b} ±3.21**
Triglycerides	126.48^{b} ±0.13	129.8^{a} 0.03±	126.68^{b} ±0.63	126.4^{b} ±2.01	126.06^{b} ±1.56	126.48^{b} ±0.63	126.14^{b} ±2.01	**125.96^{b} ±1.56**
HDL-c	53.94^{a} ±0.12	33.87^{b} ±1.15	55.92^{a} ±0.03	56.89^{a} ±0.04	57.94^{a} ±0.05	55.92^{a} ±0.03	56.89^{a} ±0.04	**57.94^{a} ±0.05**
LDL-c	20.2^{b} ±1.17	50.9^{a} ±4.34	20.1^{b} ±0.91	19.5^{b} ±0.74	19.1^{b} ±0.91	20.1^{b} ±0.91	19.5^{b} ±0.74	**19.1^{b} ±0.91**
VLDL-c	**25.30^{a} ±2.07**	**25.96^{a} ±3.21**	**25.34^{a} ±1.97**	**25.3^{a} ±3.01**	**25.21^{a} ±2.33**	**25.3^{a} ±1.37**	**25.2^{a} 3±3.11**	**25.19^{a} ±2.45**

Values are mean ±SD. Values in the same column with the same superscript letters do not differ statistically.

Table 7: **The effect of control biscuits and fortified biscuits on thyroid hormones of rats.**

Groups Parameters	G 1	G 2	G3	G4	G5	G6	G7	G8
T3 (ng/dl)	60.75± 5.55^{c}	60.01± 4.96^{c}	62.38± 3.63^{c}	62.76± 4.35^{c}	63.80± 3.63^{c}	62.86± 4.35^{c}	71.38± 3.63^{b}	**78.80± 3.63^{a}**
T4 (ng/dl)	1.05± 0.03a	1.02± 0.06^{d}	1.82± 0.05^{c}	2.02± 0.03^{b}	2.17± 0.02^{b}	2.12± 0.03^{b}	2.82± 0.05^{a}	**2.97± 0.02^{a}**
TSH (mIU/L)	0.005± 0.001^{a}	0.007± 0.002^{a}	0.006± 0.001^{a}	0.005± 0.003^{a}	0.004± 0.002^{b}	0.004± 0.003^{b}	0.003± 0.001^{b}	**0.003± 0.002^{b}**

Values are mean ±SD. Values in the same row with the same superscript letters do not differ statistically.

Table (8): The effect of control biscuits and fortified biscuits on immunological productions of rats

Immunological Profile mg/dl	G1	G2	G3	G4	G5	G6	G7	G8
IgE	60.17[b] ±0.05	60.5 [b]±0.2	61.87 [b]±1.34	65.54[a] ±1.05	67.76[a] ±0.05	62.99[b] ±1.11	66.76[a] ±0.05	**67.99 [a] ±1.11**
IgM	101.2 [a] ±0.005	101.65[a] ±0.65	106.33 [b] ±3.5	112.33 [c] ±10.96	119.66 [b]±9.6	107.66 [b] ±2.5	115.66 [b]±9.6	**127.66 [b] ±2.5**
IgA	101.1[c] ±0.1	109.5[b] ±0.5	109.5[b] ±1.5	111.33 [b] ±2.08	118.5 [a] ±1.5	111.06[b] ±6.02	118.5 [a] ±1.5	**121.06 [a] ±6.02**
IgG	**1100.0 [b] ±9.05**	**778.36[e] ±2 0.85**	**1075.66 [d] ±25.16**	**1089.9[c] ±10.87**	**1090C ±15.4**	**1085.66[c] ±6 .27**	**1095[b] ±15.4**	**1116.66 [a] ±6 .27**

Values are mean ±SD. Values in the same row n with the same superscript letters do not differ statistically.

التقييم الكيميائي والبيولوجي للبسكويت المدعم بتركيزات مختلفة من الزنك أو السيلينيوم

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الملخص العربي

البسكويت هو وجبة خفيفة مفضلة لدى جيل الشباب. قد يساعد البسكويت المدعم بالزنك والسيلينيوم في تجنب العديد من الأمراض الشائعة في البلدان النامية. كانت أهداف هذا البحث هي تحديد التركيب الكيميائي للبسكويت المقوى ومعرفة كيف أثرت عينات البسكويت المدعمة المختلفة على تناول الغذاء ووزن الجسم ونسبة كفاءة التغذية ودهون المصل ووظائف الكبد و الكلى والمناعة. تم فصل أربعين من ذكور الجرذان البيضاء إلى ثماني مجموعات: المجموعة (1) كانت المجموعة الضابطة السلبية ؛ تم تغذية المجموعة (2) بنظام غذائي يحتوي على بسكويت غير مدعم ؛ وتم تغذية المجموعات الأخرى بالبسكويت المدعم بـ 10 و 15 و 20 ملجم من الزنك أو السيلينيوم لمدة 28 يومًا. أظهرت النتائج أن الفئران التي تم تغذيتها على البسكويت المدعم بالسيلينيوم أو الزنك كانت لها نسبة كفاءة تغذية أعلى ($P \leq 0.05$) من المجموعات الضابطة. أدت إضافة الزنك أو السيلينيوم إلى تحسن كبير في وظائف الكبد والكلى والدهون في الدم خاصة عند مستويات 10 و 15 ٪ مقارنة بمجموعة التحكم. تأثرت المؤشرات البيوكيميائية بمستويات السيلينيوم أكثر من مستويات الزنك. نتيجة لذلك ، يعد الزنك والسيلينيوم من المعادن الأساسية التي يجب إضافتها إلى الطعام أو تناولها كمكملات غذائية لأداء وظائفها الحاسمة.

الكلمات المفتاحية: *التعزيز، هرمونات الغدة الدرقية- إنزيمات الكبد- منتجات المناعة.*