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Study the effect of labneh balls fortified with zinc salts on the proportions of nitrogenous substances, micro-textural structure, and some nutritional indicators

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ABSTRACT

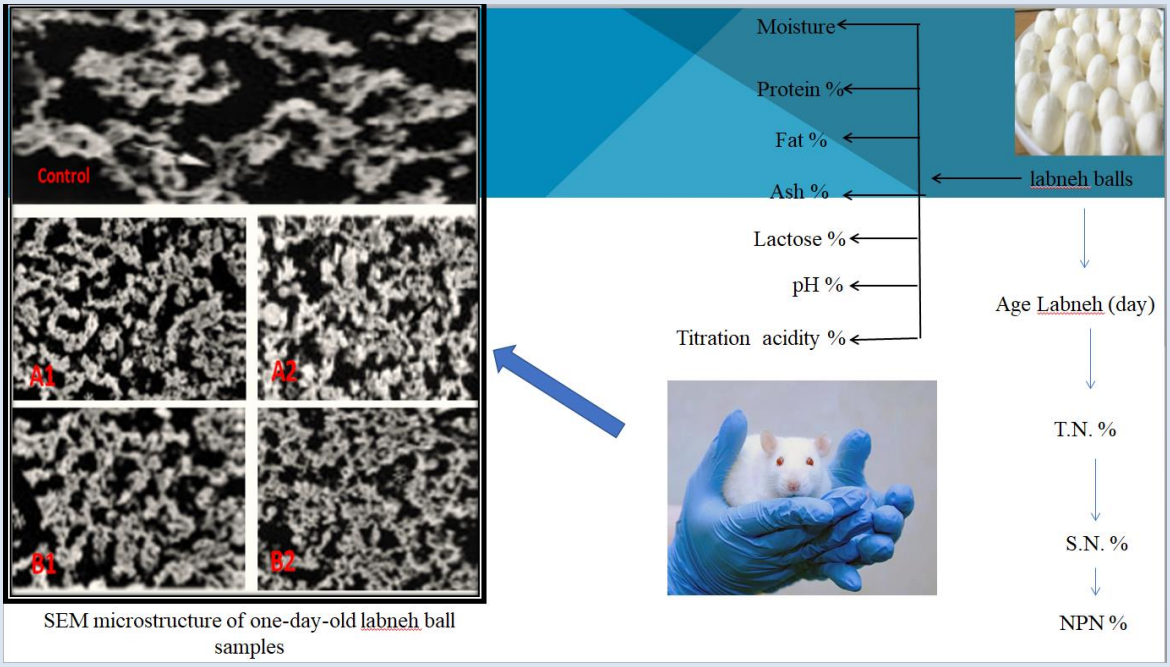
Background: Labneh is a dairy product with many of the same benefits as yogurt. The total solids percentage is raised during production by draining the whey out of the yogurt. This is done by hanging the yogurt in cloth bags until the desired texture is achieved. Labneh, after being sweetened, can be used in place of cream cheese, sour cream, or cake cream. Labneh is known to have fewer calories than common condiments such as cream cheese and sour cream. This is due to its reduced fat content Labneh is a popular cuisine all over the world, particularly in the Middle East and the Balkan nations. In conclusion, the effect of fortification was clear in the results of the nutritional experiment conducted on mice, as zinc salts had an effect in maintaining the weight gain of the experimental animals, in addition to a role in strengthening the immune system.

Objective: This study aimed to explore the effects of enhancing traditional labneh cheese with mineral salts—specifically sulfate and zinc acetate—at concentrations of 7.5 and 15 mg/kg. The focus was on evaluating the alterations in chemical composition, particularly nitrogenous compounds, and the micro-textural properties. Additionally, the study assessed how these enhancements influenced the sensory qualities of the labneh both immediately after production and following a storage period of twenty days.

Materials and Methods: Raw, whole cow's milk (12% T.S., 4% fat) was used to make labneh in the lab. After being heated to 90 °C for five minutes in a water bath, the milk was cooled to 45 °C, and a CH1 starter was added. The mixture was then incubated at 45 °C for three to four hours. The cloth was allowed to cool at room temperature for one hour after it had coagulated completely. After chilling overnight at 15 degrees Celsius, it was salted at 5 degrees Celsius for 22 hours, by placing it in a clean cloth bag and storing it in the fridge.

Results: The experiment revealed a non-significant rise in nitrogenous substances for the control group versus the zinc-treated labneh. However, there were no notable differences in nitrogen content between the control and zinc-enhanced groups. The treatment labneh balls were less white than the control treatment balls, suggesting that the fortification process with zinc salts caused this difference. Increased cohesion and hardness of the manufactured Labneh compared to the control treatment had an apparent effect on the micro-textural structure of the treated Labneh, as the interstitial spaces were reduced, and the casein tissue closed. In addition to its role in bolstering the immune system, the results of the nutritional experiment on rats showed that zinc salts influence maintaining the weight increase of the trial animals.

Keywords: Labneh balls, zinc salts, texture, flavor, chemical composition, body weight.



SEM microstructure of one-day-old labneh ball samples

INTRODUCTION

Labneh, a delightful dairy delight, shares many benefits with yogurt. Its unique production involves increasing the total solids by carefully draining whey from yogurt, a process traditionally done by suspending the yogurt in cloth bags to reach the perfect consistency. Once sweetened, labneh transforms into a versatile substitute for cream cheese, sour cream, and even cake cream, often with the added advantage of being fat-free or very low in fat. This results in a significant calorie reduction, with a mere ten calories per tablespoon of the fat-free variety. Renowned for its role in home cooking and impressive shelf life, labneh enjoys widespread popularity, gracing tables from the Middle East to the

Balkan nations with its creamy goodness.[3]. Traditionally, yogurt reached its rich texture by being strained through bags, but modern methods like ultrafiltration, reverse osmosis, centrifugation, and robotics have revolutionized its production. [5]. Depending on the protein concentration and total solids-raising methods, Labneh's rheological characteristics can range widely. Malnutrition causes deficiencies or imbalances in one or more key micronutrients, such as vitamins and minerals, which are experienced by many people, especially in impoverished nations. More than one third of the global population is deficient in essential nutrients, and those people face major effects such as learning and employment difficulties, weight loss, and a decrease in intelligence. Therefore, developed nations have adopted a policy of intervening to enrich foods with these microelements, employing a variety of methods to increase their quantities. These include the regular use of nutritional supplements and dietary measures that promote the regular consumption of foods rich in these microelements and enhance their absorption and availability during the meal. Compared to the price of ready-made nutritional supplements, the cost of fortification is inexpensive because it occurs in commonly consumed foods like cereals or dairy products like yogurt and cheese [6]. One of the most important minerals for human health is zin, which is often overlooked. More than two hundred enzymes require it as a cofactor, including the red blood cell enzyme, carbonic anhydrase, which is necessary for the deposition of calcium salts in bones, teeth, and other tissues. Zinc helps prevent heart disease, improves immunity, lessens inflammation, and slows the aging process. Zinc is essential for normal growth and development. Pregnant women require 12 milligrams (mg) if they are younger than 18 years old and 11 milligrams (mg) if they are older than 18, according to the RDA. 1–3-year-olds require 3 mg. Nitrogenous matter, a key component in dairy, is crucial for cheese's delightful flavor, aroma, and texture. Soluble nitrogen and non-protein nitrogen levels are prime indicators of ongoing protein breakdown, enhancing these sensory qualities over time. Cohesion, softness, elasticity, product stability, and brittleness are only some of the structural and textural attributes that can be influenced by adjusting the dairy product's precise structural composition. Consumers, on the other hand have specific quality expectations, including that foods have certain functional features [7]. It is established that fortifying processed cheese should not alter the cheese's flavor, texture, or consistency [8]. Fortifying processed cheese with low doses of additional zinc 40mg/kg milk did not significantly alter its sensory features, as reported by [9]. Significant enhancements in flavor, texture, and overall sensory appeal were observed following treatment with substantial quantities of zinc and iron. In this investigation, we hope to learn how enhancing labneh balls with zinc salts modifies their microbial composition, sensory qualities, and nutrient profile.

MATERIALS AND METHODS

Raw cow's milk was obtained from a milk processor from the village of Al-Dhahab Al-Abyad / Abu Ghraib District / Baghdad. Sensory and laboratory tests of raw milk were conducted to ensure the safety of the received milk, according to [10].

Manufacturing labneh in the traditional way: "In the lab, we crafted labneh using raw, whole cow's milk boasting a 12% total solids content and 4% fat. After being heated to 90 °C for five minutes in a water bath, the milk was cooled to 45 °C, and CH1 starter was added. The mixture was then incubated at 45 °C for three to four hours. The cloth was allowed to cool at room temperature for one hour after it had coagulated completely. After chilling overnight at 15 degrees Celsius, it was salted at 5 degrees

Celsius for 22 hours [11] by placing it in a clean cloth bag and storing it in the fridge. We transferred the contents of the filter bag to a new plastic container and froze it at 15°C for future use. Next, we created labneh balls using five different methods. The first treatment, which served as the control, had labneh with 7.5 mg/kg of zinc sulfate. In treatment A2, we added 15 mg/kg of zinc sulfate to the labneh. In treatment B1, we used zinc acetate with 7.5 mg/kg of labneh, and in treatment B2, we added 15 mg/kg of zinc acetate. Finally, we carefully hand-rolled the labneh into small, uniformly sized balls. It was then sealed in containers and kept at a temperature of 15 °C until the necessary tests could be performed. The created Labneh was tested for its nitrogenous chemical percentages, microscopic structure, and sensory assessment both immediately after production and after 20 days of storage at 15 °C. Microscopic structure was studied using the method described in [12], and total nitrogen, soluble nitrogen, and non-protein nitrogen (NPN) were estimated using [13]. Nitrogenous compound percentages were measured at 1, 10, and 20 days of age. One day after production, we conducted a sensory examination.

Sensory tests: Sensory evaluation was conducted one day after manufacturing; the samples were evaluated according to the method of [14], where the flavor was given 60 degrees, texture 30 degrees, appearance 10 degrees, and total 100 degrees. This was done by a tasting committee consisting of ten arbitrators.

Nutritional experiment (laboratory animals): For this experiment, researchers employed 40 male Albino BALB/C mice they got from the National Centre for Drug Research and Control in Baghdad. At five weeks of age, the mice included in the study weighed a mature 26±2 g. The animal enclosures had controlled airflow, temperatures 25-25.5 °C, and lights (12-12 hours of darkness and illumination daily). Mice were randomly assigned to one of four groups to examine the effects of dietary additions of 100 and 200 g of zinc acetate on daily and total weight gain, as well as the level and number of white blood cells (WBCs) and hemoglobin Hb concentration. Plastic mice cages were used to house the mice.

In addition, mice had access to sterilized water and food on an "as needed" (ad libitum) basis. Their diets were conditioned to the experimental conditions by being left in cages for three days before the start of the experiment. During the trial, we weighed the animals and their food twice a week for each group. Ten mice were split evenly among four groups and housed in specially designed breeding cages for the experiment. All treatments were initially given the same food for three days; after that the first group was the only one to continue with the original diet and they served as the experiment's negative control, or "C-" group. Following 28 days on a high-fat diet, the following was served to the other three groups: The C^+ positive control group was fed a high-fat diet throughout the experiment; Group B1 was fed a high-fat diet and dosed with 7.5 mg/day of labneh solution fortified with zinc acetate throughout the experiment; Group B2 was fed a high-fat diet and dosed with 15 mg/day of labneh solution fortified with zinc acetate throughout the experiment.

Preparing diet for mice: The diet for feeding the mice was prepared according to the nutritional and physiological requirements of [15]. The materials were mixed well to use them in feeding the experimental animals [16]. The components of the diet were mixed, the milk fat and cholesterol were added separately to the electric mixer gradually to ensure a homogeneous distribution of the treatments with the original diet.Small pieces were then made from the homogeneous diet (15 grams per piece) and dried in an electric oven at 50 °C,

then placed in tightly sealed plastic boxes in the refrigerator at a temperature of 4-7 °C.

Statistical analysis: The statistical analysis of the studied data included the use of the Statistical Analysis System [17] to compare significant differences between means and to determine the impact of various treatments on various characteristics of the Labneh using a Complete Random Design (CRD).

RESULTS AND DISCUSSION

The pH of raw, whole cow's milk is 6.1, and it has a titration acidity of 0.14 (based on lactic acid). Additionally, its protein and fat percentages are 3.81 and 3.23%, respectively, while its ash and lactose percentages are 0.63 and 4.48%. This information is displayed in Table 1. These percentages are similar to those observed by other researchers [18], hence they're considered acceptable for milk.

Table 1. Composition of raw milk used in manufacturing labneh balls.

Chemical composition of raw milk						
Moisture %	Protein %	Fat %	Ash %	Lactose %	pH %	Titration acidity %
87.85	3.81	3.23	0.63	4.48	6.40	0.14

Labneh balls made for the control treatment and the treatments of adding zinc salts A1, A2, B1, and B2 immediately after production and during storage at a temperature of (1 + 5) °C at ages 1, 10, and 20 are shown in Table 2, along with the values for total nitrogen, soluble nitrogen, and the ratio between the two.

The percentage of total nitrogen (T.N.) in the labneh balls of the control treatment right after manufacturing was 2.80%. These results align with [19] (2.68%), [20] (2.62%), and are close to [21]'s findings of 2.35% in zinc-fortified fresh cheese. Overall, there were no significant differences in total nitrogen compounds between the control treatment and the zinc-fortified cheese. However, over a 20-day storage period, there was a gradual, non-significant increase in T.N. levels for all treatments. Specifically, the T.N. content in the control treatment was slightly higher compared to the zinc salts addition treatments. For treatments A1, A2, B1, and B2 immediately after manufacturing, the T.N. percentages were 2.76, 2.76, 2.77, and 2.69%, respectively. After twenty days, they became 2.79, 2.79, 2.80, and 2.79%, respectively. This gradual increase in T.N. aligns with the rise in protein percentage [22-23], attributed to moisture loss and increased whey exudation [24].

Table 2. Percentages of nitrogen components in the Labneh of the control treatment and the zinc salts addiction treatments

Treatment,	Age of the Labneh (day)	Total nitrogen T.N. %	S.N. %	(NPN) %
Labneh of control treatment C+	1	2.80	0.26	0.250
	10	2.84	0.28	0.255
	20	2.86	0.29	0.260
A1	1	2.76	0.26	0.250
	10	2.77	0.27	0.255

Treatment,	Age of the Labneh (day)	Total nitrogen T.N. %	S.N. %	(NPN) %
100/mg zinc sulphate	20	2.79	0.300	0.256
A2	1	2.76	0.28	0.251
200/mg zinc	10	2.76	0.29	0.254
sulphate	20	2.79	0.31	0.257
B1	1	2.77	0.28	0.252
100/mg zinc	10	2.79	0.31	0.255
acetate	20	2.80	0.32	0.258
B2	1	2.69	0.29	0.252
200/mg zinc	10	2.76	0.32	0.257
acetate	20	2.79	0.34	0.260

Soluble nitrogen (S.N.): According to Table 2, the S.N. percentage in the labneh balls used in the control group just after production was 0.26 %. With an S.N. content of 0.314 %, these findings are very similar to those of [25]. In addition, [26] found that as moisture was lost from the labneh balls, the percentage of S.N. increased very marginally. The results also show that there is a non-significant increase in the percentages of S.N. in the control treatment during the storage period, with the percentage of S.N. increasing to 0.29% after twenty days of storage. Although the percentage of S.N. in treatments A1, A2, B1, and B2 right after production is 0.26, 0.28, and 0.29 %, respectively, there is a nonsignificant increase in S.N. during the storage period and for all treatments to which zinc was added. Twenty days later, it had risen to 0.30%, 0.31%, 0.34 %, and 0.35%. With longer periods of storage, the proportion of S.N. increases [27]. This is because psychrophilic bacteria, unlike the bacteria that produce them, are resistant to pasteurization and even sterilization temperatures [28,29], and their protease enzymes are responsible for the fermentation process [30].

Non-protein nitrogen (NPN): According to Table 2, the percentage of NPN in the control treatment just after production was 0.250%, which is greater than the result achieved [31,32]. The results show that the percentage value of NPNs increased to 0.260 percent after twenty days of storage. Treatments A1, A2, B1, and B2 that received zinc additions right after production had NPN values of 0.250, 0.251, 0.252, and 0.252 %.After 20 days, these values increased to 0.256, 0.257, 0.258, and 0.260% [33,34]. The rise in these levels during storage was caused by proteases produced by Psychrophilic bacteria [33-36], however, microbially generated enzymes already present in milk play a crucial role in elevating NPN and S.N. levels. This rise in numbers is indicative of a situation in which the percentage of NPN rises during storage because of the activity of microbial protease residues, particularly those of psychrophilic bacterial enzymes [36]. The values of S.N. and NPN percentages likewise showed a progressive increase with increasing storage time. This is because the cheese lost moisture as its storage time lengthened. the ripening time has a positive correlation with the nitrogen content in made cheese. Even though there is a difference in

content with ripening periods, this variation can be explained by the change in cheese's moisture content [37].

Study of microscopic structure with Scanning Electron Microscopy (SEM) microscope: The microscopic structure of labneh balls produced from cow's milk was studied using the (SEM) microscope at two different concentrations of zinc sulfate and zinc acetate at one day's age and with a magnification of 5000X. The letters A1 and A2 represent the treatments of Labneh to which zinc sulfate was added. In contrast, the letters B1 and B2 represent the treatments of Labneh to which zinc acetate was added, in addition to the positive control treatment (Labneh without any addition).

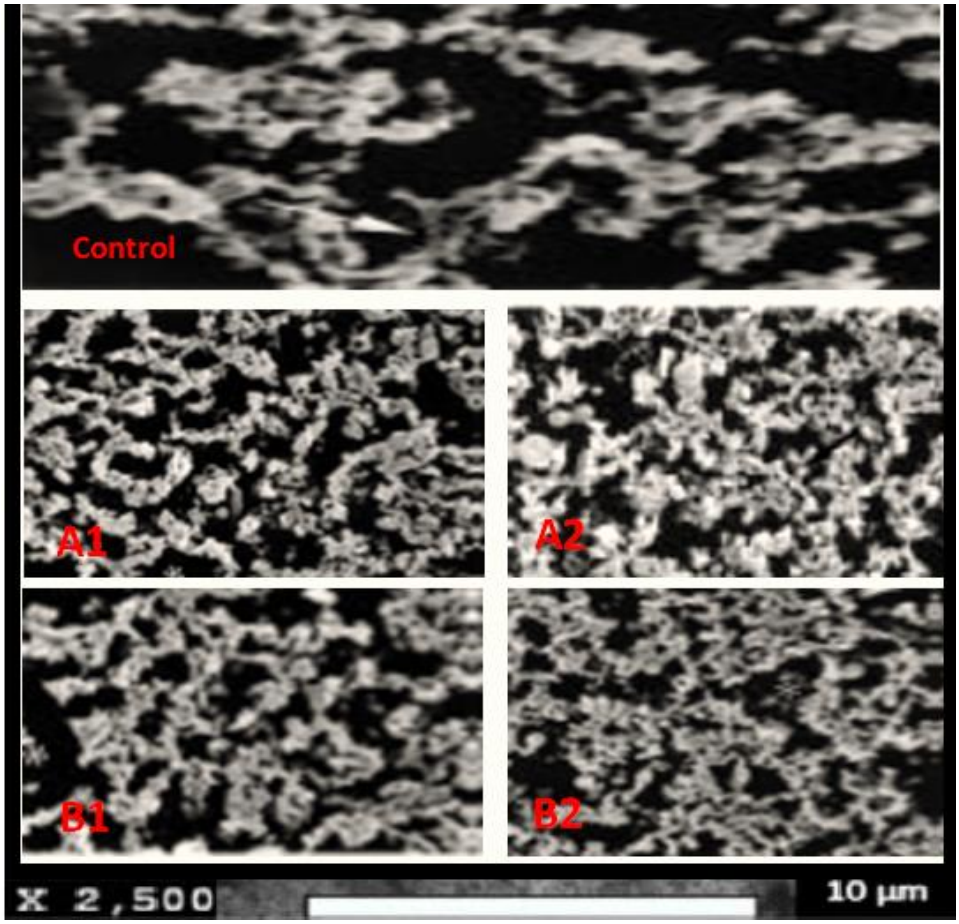


Figure 1. SEM microstructure of one-day-old labneh ball samples

The images resulting from the SEM in Figure (1) of the labneh balls at the age of 1 day showed the presence of unequal interstitial voids in the casein tissue of the control sample. These voids are present due to the presence of serum and some air in the labneh tissue before the freeze-drying procedure. The treatment had an open casein tissue. The images of treatment A1, which were characterized by the presence of smaller interstitial voids in the casein tissue, were also characterized by some interstitial voids. Still, they were smaller in size than the control treatment. The reason is due to the presence of zinc sulfate, which works to increase the excretion of the serum from the labneh mass and gives a compact texture. Whereas treatment A2 was characterized by the

presence of smaller voids and a compact casein tissue due to the addition of zinc sulfate at a higher concentration than the treatment above, as the exudation of the serum gives a more compact texture [38]. Additionally, treatment B1 had smaller interstitial voids and the casein tissue was more compact than the control treatment and the treatments with zinc acetate added. This is due to the addition of zinc acetate. Treatment B2 contained small interstitial voids and a more compact texture than the previous treatments, which gives a closed, non-open microscopic structure due to the exudation of the serum and the increase in the cohesion and hardness of the tissue. indicated that zinc salts led to an increase in the cohesion and hardness of the fortified soft cheese and give a compact and closed texture [39].

Sensory tests: Sensory evaluation was conducted one day after manufacturing, The samples were evaluated according to the method of [14], where flavor was given 60 degrees, texture 30 degrees, appearance 10 degrees, and total 100 degrees. This was done by a tasting committee consisting of 10 arbitrators.

Table 3. Sensory evaluation of treatments at 1 day of age

Treatment	Appearance 10	Texture 30	Flavor 60	Total
Labneh of control treatment C+	10	24	55	89
A1 7.5/mg zinc sulphate	9	26	56	91
A2 15/mg zinc sulphate	9	26	55	90
B1 7.5/mg zinc acetate	9	28	56	93
B2 15/mg zinc acetate	9	27	58	94

Table 3 shows that the positive control treatment, which stood out due to its brilliant white color, scored lower than the other treatments on the attributes of texture and flavor. The sensory evaluation characteristics were similar between treatments A1 and A2, except the color characteristic, which was lower in both treatments than in the control. It had a stronger texture and flavor than the control treatment but was yellower in color. Treatments B1 and B2 scored highest in the sensory evaluation due to their excellent texture and robust flavor, as well as their less-white appearance compared to the control treatment and their pale-yellow hue. This agrees with what we have seen before [40]. Labneh balls strengthened with sulfate salts and zinc acetate had a clear effect on the fine texture of the labneh treatments, with the interstitial voids being smaller and the casein tissue being closed as a result of the increased cohesion and hardness of the manufactured Labneh. However, the process had no discernible effect on the values of nitrogenous compounds compared to the control

treatment. Adding salts to labneh made it more yellow, hence the control treatment stood out visually as the whitest in the sensory evaluation. Adding salts to Labneh makes it more cohesive and harder, which improves its texture and flavor compared to the untreated control.

Nutritional experiment: Labneh supplemented with zinc acetate: Determine its influence on mouse body weight.

In this study, mice on a high-fat diet supplemented with 7.5 mg of zinc acetate daily experienced weight loss, highlighting zinc's potential role in mitigating obesity-related risks for metabolic disorders and chronic diseases, corroborating the findings of [41]. If the labneh treatment that had zinc acetate added to it had the highest results in the sensory evaluation, the study could move on. Mice groups fed either a standard diet (C- negative control group) or a high-fat diet (C+ group) are compared in Table 4, along with the effect of Labneh supplemented with zinc acetate on both the daily and final weight gain rates. The experiment was conducted over a period of 28 days. Group B1 and B2 ate a high-fat diet and were given oral doses of a therapeutic labneh product enriched with zinc acetate at the concentrations of 7.5 and 15 mg/1 kg/day, respectively, which performed best in the sensory assessment trial. The results show that the C+ group of mice gained weight at a faster rate than the C- group of mice did. Their daily weight gain averaged 0.3471 g, and their total weight gain after 28 days was 9.72 g, both significantly higher than the C- group's results of 0.2439 g/day for daily gain and 6.83 g for final gain. The nature of the diets given to the C- and C+ groups explain the noticeable disparities in outcomes. C+ patients gained more weight because their diet was heavier in fat. The final weight gain of the high-fat diet group of mice after 28 days was 6.09 g [42], noted that the final weight gain of the standard diet group of mice was 4.89 g. Consistent with the findings of [43], the group of mice fed a high-fat diet gained significantly more weight 6,110 g after 28 days than the group fed a conventional diet 3,210 g. This conclusion agreed with the findings of [44], who found that rabbits given a diet high in cholesterol weighed more than their control group counterparts.

Although the diet was high in fat, the results show that dosing with Labneh containing zinc acetate decreased weight gain directly proportional to the concentration of zinc acetate consumed, with the B1 treatment group of mice averaging a daily weight gain of 0.2492 g and a final weight gain of 6.98 g. For the B2 therapy group, the average daily weight gain was 0.2303 g, with a final weight gain of 6.45 g [45]. Zinc acetate has been shown to play an effective role in contributing to reducing weight gain and at the same time maintaining normal growth, with a noticeable increase in this group compared to the C-group, or it may be the reason for the decrease in weight in the B1 and B2 treatments, as compared to the C+ group. Zinc supplements, when combined with a healthy diet and exercise, have been shown to help patients with obesity lose weight, increase their white blood cell count, lower their insulin resistance, and curb their appetite. Zinc may enhance leptin production and avert hyperplasia, while its role in guarding against genetic mutations linked to obesity is notable. The mechanisms behind zinc's effectiveness in weight loss are likely due to its regulation of appetite, which it achieves by modifying hypothalamic neurotransmitter metabolism and influencing the leptin signaling system.

Table 4. Average weight gain of the experimental rat group after 28 days.

Treatment	Body weight (g)		Body weight gain after 28 days (g)	Average daily weight gain (g)
	Average starting weight (g)	Average weight after 28 days (g)		
Negative control C- fed a standard diet	26.43	33.26	6.83	0.2439
Positive control C+ fed a diet with fat	25.88	35.60	9.72	0.3471
B1 Fed on a high-fat diet +7.5 mg of zinc acetate/day	25.11	32.09	6.98	0.2492
B2 Fed on a high-fat diet + 15 mg of zinc acetate/day	25.61	32.06	6.45	0.2303
LSD value	3.022	3.173	2.088	0.135
(P0.05)				

After 28 days into the trial, there was a statistically significant difference P0.05 between the C+ therapy and the rest of the treatments, however, there were no significant differences (p>0.05) in the average weight of the mice at the outset. Final gain and rate of daily weight gain were significantly different between treatments C+ and C-, although there was no difference between treatments B1 and B2 and treatment C-.

The impact of zinc acetate-fortified yogurt on white blood cell (WBC) and hemoglobin (Hb) counts. According to Table 5, after 28 days of eating yogurt fortified with zinc acetate, mice in groups C-, C+, B1, and B2 had significantly higher WBC counts and hemoglobin levels than mice in the C-treatment and C+ treatment groups 7.9 x 103 and 11.3. 103 cells/ml, respectively and B2-treatment groups 13.9 x 103 and 13.9 x 103 cells/ml. The statistical analysis shows that treatments B1 and B2 differ significantly (P>0.05) from treatments C+ and C-. Additionally, treatments B1 and B2, which were supplemented with zinc acetate, show a greater increase in white blood cell count compared to treatment C+. This demonstrates that zinc acetate plays a role in elevating white blood cell counts, which in turn aids the body in fighting off infections and viruses like the common cold and influenza as well as the deadliest cancer cells. The immune system is sensitive to zinc fluctuations and all immunological responses can be traced back to zinc in one way or another [46]. Supplementation with zinc for five weeks improved the immunological response rate in children with zinc deficiency [47], while supplementation with zinc for 48 days improved lymphocyte counts in adults. Enzymes, antioxidants, immune system cells, etc. rely on zinc for their activation and structural stability [48]. Optimal zinc intake was demonstrated to restore the body's normal immune response and lower infection risk [49], found that after 30 days of supplementation

with selenium and zinc at a concentration of 100 g /day, the WBC count in mice increased to 8.320 x 103/ml from a pre-supplementation level of 5.990 x 103/ml. Zinc and selenium, especially at the recommended dosage, boost the immune response, increase immune globulins, and enhance the overall picture of the blood and its many components [50]. When comparing treatments, treatment B2 had the highest hemoglobin concentration (12.2 g/dL), while treatment C+ had the lowest (9.7 g/dL; P>0.05). Treatment B1 resulted in 11.4 g/dL, while treatment C- resulted in 12.1 g/dL.

A statistically significant difference (P>0.05) was found between the various treatments. This suggests that selenium, as compared to the C+ therapy given a high-fat diet, boosted the hemoglobin percentage to the normal limit. Along with iron and vitamin B12, zinc plays a crucial role in RBC development [51]. showing a link between zinc deficiency and anemia, particularly in pregnant women and young children [52-54]. Patients with iron-deficiency anemia benefited more from a combination of zinc and iron supplementation than from iron alone [55]. Patients with chronic renal disease have benefited from zinc treatment. Zinc supplementation, however, has been shown to enhance hemoglobin levels in dialysis patients [56].

Table5. The WBC count and Hb for the experimental rat group after 28 days

Treatment	WBC count cells/mm 3	g/L
Negative control C- fed a standard diet	7.9×10^3	12.1
Positive control C+ fed a diet with fat	11.3×10^3	9.7
B1 Fed on a high-fat diet +7.5 mg of zinc acetate/day	12.7×10^3	11.4
B2 Fed on a high-fat diet + 15 mg of zinc acetate/day	13.9×10^3	12.2
LSD value	3.082*	2.116*
(P0.05)		

Zinc acetate fortification at 7.5 and 15 mg/day was associated with higher hemoglobin percentages compared to the C+ treatment and normal hemoglobin levels compared to the C- treatment, according to the current study. Since this had a beneficial effect and is a sign of excellent health, the importance of zinc acetate is increased. Zinc supplementation increased hemoglobin and red blood cell counts in pregnant women with anemia [57]. Zinc deficiency in rats, mice, and humans may be associated with anemia, and zinc

supplementation influences hemoglobin synthesis [58]. They found that fish with added zinc boosted erythrocyte production [59,61].

CONCLUSION

This study indicates that fortification with zinc salts did not affect the values of the proportions of nitrogen substances and fortification with zinc salts led to a reduction in the whiteness of the labneh balls Fortification influenced the microstructure of the treatments, and the nutritional experiment on mice showed clear effects. The addition of zinc salts helped maintain the weight gain of the experimental animals and played a role in strengthening their immune system.

Abbreviations: WBC: White blood cells; Hb**:** Hemoglobin; SEM: Scanning Electron Microscopy; CRD: Complete Random Design; nw: nitrogen water; NPN: non-protein nitrogen**.**

Authors Contribution: Firas Najm Ismael: Formal analysis; Methodology; Project administration; Suhair Ali Hussein**:** Funding acquisition; Validation; Omar Salah Ahmed Almuharib: Writing-original draft. Kifah Saed Abbas Doosh: Data curation; Formal analysis; Methodology; Sara Thamer Hadi: Project administration.

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