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Histological and biochemical effects of microbially derived single-cell oil on the intestine of male rats

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Abstract

Objective

This study was aimed at taking into account the responses of microbially produced single-cell oil (SCO) of Alcote microorganisms on the histological and biochemical characteristics of the small and large intestines in male albino rats. The dose-dependent effects of SCO on oxidative stress biomarkers (H_2O_2), and antioxidant defense enzymes (glutathione peroxidase (GPx) and superoxide dismutase (SOD)) were considered of particular importance. The aim was to determine whether SCO supplementation acts as a positive antioxidant reaction or catalyses oxidative destruction as a result of the dose under control.

Materials and Methods

Twenty-four healthy male Sprague-Dawley rats aged 9-11 weeks and weighing 180- 200 g were randomly divided into four groups (n= 6). Group I was the control and received corn oil (2 mL/kg) and Groups II, III, and IV were administered SCO orally with 2, 4 and 8 mL/kg, respectively. The treatments were administered orally through gavage after every 48 hours and 45 days. The calculation of serum levels of H_2O_2, SOD and GPx was done using colorimetric assay kits following the anesthesia. The histological examination was performed on sections of duodenum and colon which were fixed in formalin neutral pH, paraffin embedded and stained with hematoxylin and eosin.

Results

Meaningful reduction of the H_2O_2 levels and increment in the GPx and SOD activity relative to the control group demonstrated an enhancement of antioxidant defense by moderate SCO supplementation (4 mL/kg). On the contrary, H_2O_2 level was significantly increased, and activities of antioxidant enzymes were also reduced by high dose of SCO (8 mL/kg), hypothesizing the induction of oxidative stress. The following biochemical findings were supported by histopathological results: the rats treated with 2 and 4 mL/kg of SCO showed normal duodenal and colonic architecture as compared to controls, but those treated with 8 mL/kg showed thickening of vascular walls, leukocytic infiltration, fibrosis, and villous degeneration. These findings show that SCO will react dose-dependently, i.e. protective at moderate doses, but toxic at high doses.

Conclusion

SCO produced by microbes has a dual and dose-dependent response on intestinal health. It elevates antioxidant status at moderate doses and maintains normal intestinal histology with the focus on its possible use as functional dietary supplement. However, the excessive dosages cause oxidative stress and tissue damage, which highlights the importance of dosage optimization in the safe and effective application of SCO in nutritional or therapeutic applications.

Keywords: antioxidants, histopathology, intestine, oxidative stress, single-cell oil

Paper Type: Research Paper.

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Introduction

Oleophilic microorganisms can be an alternative promising source of high quality lipids and this will satisfy the increased demand in many industries to have economical and sustainable alternatives (Thakur et al., 2024). However, irrespective of the size of organisms, be it

microscopic or macroscopic, practically any living system can synthesize lipids, and, specifically, lipid bilayers (Budzianowski, 2017). These so-called high-energy lipids are responsible as forms of storing energy and building blocks of cellular membranes. Although lipids can be deposited in adipose tissue in multicellular organisms, they can also be deposited in the lipid bilayers of fatty microorganisms (Nikolova & Gutierrez, 2020). Microbial lipids are also a potential alternative to plant and animal fats; they are considered as sustainable. An entire spectrum of microorganisms, which harbor yeasts, bacteria, algae, and fungi, would be able to produce large amounts of lipids comparable to traditional sources, such as plants, animals, and marine ones (Aasi Al-Mehmdi et al., 2019; Rajbongshi and Gogoi, 2021). These microbially produced lipids are called single-cell oils (SCOs) and can offer various benefits to more orthodox lipid sources. They are short making cycle, less labor intensive, not seasonal or climactic dependent, not dependent on arable land and can be easily industrialized. Moreover, SCOs contain polyunsaturated fatty acids (PUFAs) because most desaturase enzymes that enable the synthesis of PUFA are highly active (Ochsenreither et al., 2016). Single-cell oils are able to assume a conformation comparable to the vegetable oils and animal fats, but instead, they are favored due to their ease of production and scalability (Cohen & Ratledge, 2005). SCO production is not affected by seasonal variations, geographic location, harvest time or transportation restriction as opposed to plant and animal oils (Ratledge, 2013). Basically, microbial lipid making is carried out by culturing oleaginous microorganisms to produce microbial oil under optimized cultivation conditions with the use of agricultural or industrial waste for carbon source to lower making costs and environment impact. In microbial cell, the production of lipids involves de novo synthesis from metabolic conversion of exogenous carbon to carbohydrate or hydrocarbons that are subsequently transformed into triacylglycerols (Martínez et al., 2015). Agricultural wastes are used as fertilizers, animal bedding or feeds; however, some residues need to be appropriately managed in order to avoid environmental pollution (Khalaf et al. Mismanaged or burned, crop residues emit greenhouse gases and contribute to extremely high air pollutions (Sayegh et al., 2016). Microbial utilization (as carbon source) of such waste products therefore also offers a double advantage: less effective environmental waste with the potential to obtain value added from bio-lipids. The major intracellular lipids produced by oleaginous microorganisms are triacylglicerols (TAGs), free fatty acids, polar lipids, sterols hydrocarbons, and pigments known as single-cell oils (Madani et al.2017). Single-cell oil (SCO) is a term that may be used interchangeably with single-cell protein (SCP) when it pertains to microbial lipids (Spalvins et al., 2019). Among microbial producers, several species of microalgae are considered as hyperoleogenic, synthesizing significant amounts of lipids under favorable culture conditions. Microalgal lipids have captured significant interest of the food, pharmaceutical, chemical and cosmetic industries due to their diverse applications

(Fakas et al., 2009). Microalgae and oleaginous microorganisms argue in favor of major economic advantages compared with classical oil-producing organism, as a result to their ability to produce lipid from different sources of carbon including cost-efficient agricultural waste (Abd-AL Hussien et al., 2020). Fatty acid analyses of these microbial oils revealed that they contain high amounts of oleic, linoleic, stearic and palmitic acids in addition to palmitoleic and arachidonic acids, which are fatty acids found in edible oils (Al-Obeidi et al., 2023). These conformational resemblances increase the possibility of SCOs as replacements of traditional edible and industrial fats. Despite these benefits, the biological safety and physiological response of the requirement to consume SCO are to be evaluated carefully. Whereas a significant number of studies have focussed on optimization of SCO production and characterization of biochemical conformation, fewer have examined its possible effects to the health of mammals, solely intestinally. A gastrointestinal tract is one of the most important sites of nutrient absorption, and it is one of the main contacts of food substances and the systemic metabolism. Thus, understanding of the perception of microbial oils on intestinal histology and oxidative balance is needed to assess nutritional and toxicological properties of these oils. The current study was, therefore, aimed at examining the histological and biochemical responses of microbially derived single-cell oil on the small and large intestines of male rats, specifically, to assess the impression of different doses of SCO on the biomarkers of oxidative stress (H_2O_2) and antioxidant defense enzymes, which include glutathione peroxidase (GPx) and superoxide dismutase (SOD). Moreover, histopathological changes in the intestinal tissues were observed to explain the possible defensive or negative consequences regarding the various levels of SCO. This strategy will provide a broad impression of the positive and negative outcomes of SCO supplementation, which will contribute to the overall assessment of its safety and usefulness as a new source of lipid in nutrition and biomedical applications.

Materials and methods

Experimental animals: Rats of Sprague-Dawley adult male (180200 g 911 weeks old) were used in this study. The animals were used based on the Animal house, Department of Biology, College of Education of pure sciences University of Anbar. Experimental activities were conducted in the compliance with the international standards of handling and using laboratory animals and were accepted by the Institutional Animal Care and Use Committee (IACUC) of the University of Anbar (Approval No. 267; 26 December 2024). Before the experimentation, rats were allowed to adapt after two weeks to determine their condition of health and familiarity with the laboratory environment. The polystyrene cages with the stainless steel lids were placed in the conditions of controlled environmental factors (22 +/2 -, relative humidity 55 +/5-, and 12:12 h

light/dark period). In the course of the investigation, rats were allowed to consume tap water and a normal balanced diet in the laboratory freely.

Oil content estimation in waste samples: it was identified that oil content in the waste materials of palm frond waste, wheat bran and wheat straw using Soxhlet isolation method as standardized by Association of official Analytical Chemists (AOAC, 1990). In brief, the dried and ground samples were subjected to constant solvent isolation using the petroleum ether in nearly 6 h under Soxhlet apparatus. This solvent was then evaporated and the solvent content that was isolated was quantified using gravimetric analysis and expressed as a percentage of the original dry weight of the sample.

Oxidative balance results: To determine the activities of the plasma hydrogen peroxide (H_2O_2), superoxide dismutase (SOD), and glutathione peroxidase (GPx), the colorimetric method was used following the recommendations of the producers of the assay kits (Randox, USA). The activity of the enzymes was in units per milliliters of plasma (U/mL). Each of the assays was performed twice to be reproducible.

Design of the experiment: A random allocation of 24 healthy adult male Sprague-Dawley rats into four groups (n = 6 each) with equal mean body weights was carried out. The experiment design was as follows:

Group I (Control): Obtained corn oil (2 mL/kg); Group II (SCO-Low Dose): Obtained single-cell oil (SCO) at the dose of 2 mL/kg; Group III (SCO-Moderate Dose): Obtained SCO at dose of 4 mL/kg; Group IV (SCO-High Dose): Obtained SCO at dose of 8 mL/kg.

Treatments were done orally by intragastric gavage after every 48 h in a period of six weeks. Such experimental design was aimed to compare control and SCO-given treatment groups directly to compare dose-dependent reactions on biochemical and histopathological parameters.

Sample collection and preparation of the tissues: The samples were collected at the end of the drug treatment period during the night (24 h) with the rats' food deprived but with free access to water. To ensure that pain and suffering are minimized, animals were anesthetized by aspersion of Isoflurane. The blood samples were taken using the straight stick with sterile syringes and placed in plain tubes without the anticoagulants. The samples were clotted at room temperature (37 ºC, 30 min) and centrifuged at 3000 rpm, 10 min at o C. The serum was kept at temperatures lower than -20 ºC until its biochemical examination. Immediately after the sacrifice, the small intestine and the colon were excised on a chilled surface, the luminal contents washed off using cold normal saline, and the tissues fixed in 10% neutral-buffered formalin to be examined under a microscope. The tissues were fixed and dehydrated according to normal condition, embedded in paraffin, sectioned at 5 µm-thick using a rotatory microtome and subsequently stained using a conventional hematoxylin and eosin (H&E) protocol. The histologic

study was conducted under a light microscope (Olympus CX43, Japan) using the digital camera (Olympus DP27, 5.0 MP). The cellular and tissue alterations were documented in the micrographs of magnification x 400 (Suvarna et al., 2012).

Statistical factors: To reduce the variability, all the experimental operations and measurements were performed under the same conditions. Resultant data of biochemical assays were recorded in the mean ± standard deviation (SD). The statistical analysis, including control and treatment groups, was handled with the use of one-way analysis of variance (ANOVA) and further post-hoc tests. A p-value of 0.05 was listened to in a statistically meaningful manner.

Results

Figure 1-3 indicated that the results of the current study showed significant variations in the oxidative stress indicators and antioxidant enzyme activities across the experiment groups. The considerable reduction in the levels of hydrogen peroxide (H_2O_2) was observed in the group in which 4 mL/kg of single-cell oil (SCO) was used compared to the control group. There was also a strong advancement in the work of the antioxidant enzymes glutathione peroxidase (GPx) and superoxide dismutase (SOD) in this group. On the contrary, the control group and the group treated with 2 mL/kg of SCO did not differ significantly in terms of GPx, SOD, or H_2O_2 concentration. However, treatment with 8 mL/kg of SCO resulted in a significant increase in serum H_2O_2 with a significant decrease in both GPx and SOD activity in rats. These findings demonstrate that moderate supplementation of SCO increases the antioxidant defense system, but excessive intake leads to the production of oxidative stress through the agglomeration of reactive oxygen species (ROS). It is clear that exposure to elevated levels of some lipid mixtures may advance intracellular oxidation levels and free radical generation, exclusively hydrogen peroxide (H_2O_2) and cause oxidative devastation of cells.

Results of histology of the duodenum: A histological study on the duodenal tissues showed that the morphological differences among the treatment groups were distinct at the end of the duodenum. Control group was normal in histological structure, intact goblet cell (GC), intact lamina propria (LP) in the villi and a clear muscular layer (ML) (Figure 4). Both 2mL/kg and 4mL/kg SCO treatment groups compared to the control group had intact duodenal tissues with normal distribute of goblet cell and intact villous structures without detectable degenerated lesions (Figures 5 and 6). The group fed the 8 mL/kg SCO on the other hand experienced serious histopathological alterations. According to these changes, it was determined that the vascular wall is deeply thickened (TW), the leukocytic inflammation is very intense (LI), and the most villous epithelial cells are necrobiotic (Figure 7). The postulations of such pathological results are that

intestinal mucosal homeostasis can be disrupted when in excess of a SCO intake and that it also predisposes inflammatory response.

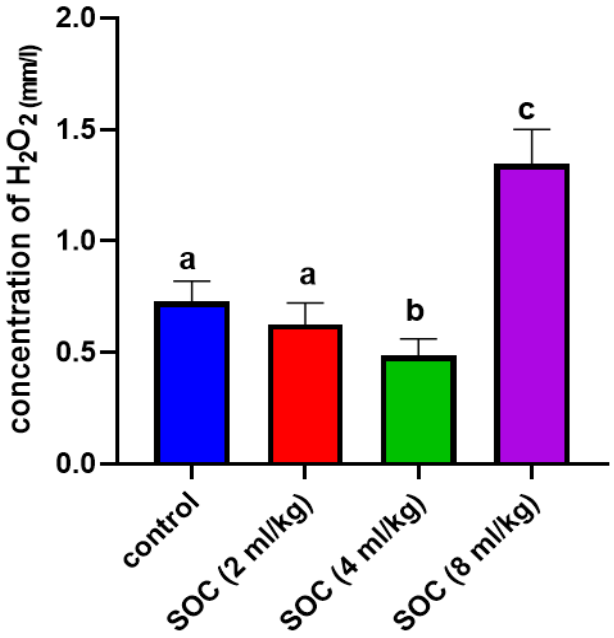

Figure 1. Single-cell oil (SCO) reacted with concentration of hydrogen peroxide on the blood serum of the albino rats

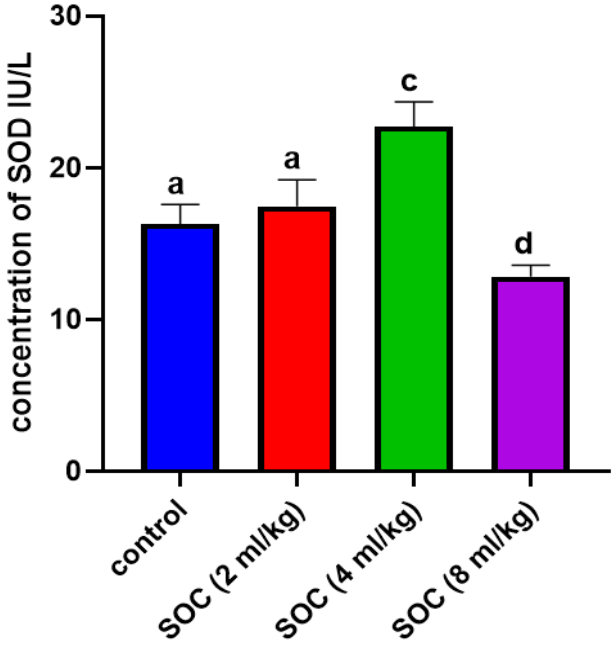

Figure 2. Effects of single cell oil on SOD concentration in the albino rat blood serum

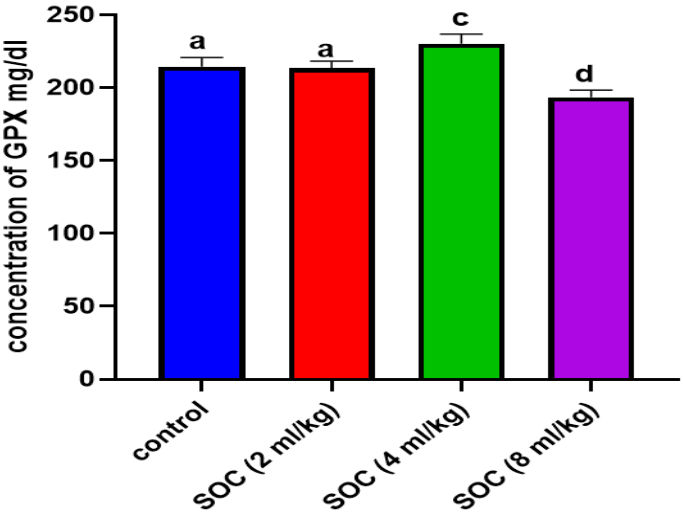

Figure 3. Single-cell oil on glutathione peroxidase (GPx) concentration on the blood serum of albino rats

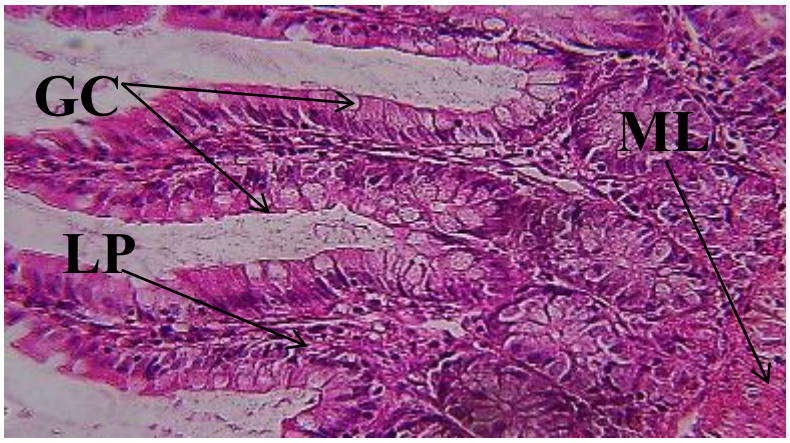

Figure 4. Duodenum of the control group showing normal goblet cells (GC), lamina propria (LP) of villi, and muscular layer (ML) (H&E, ×400)

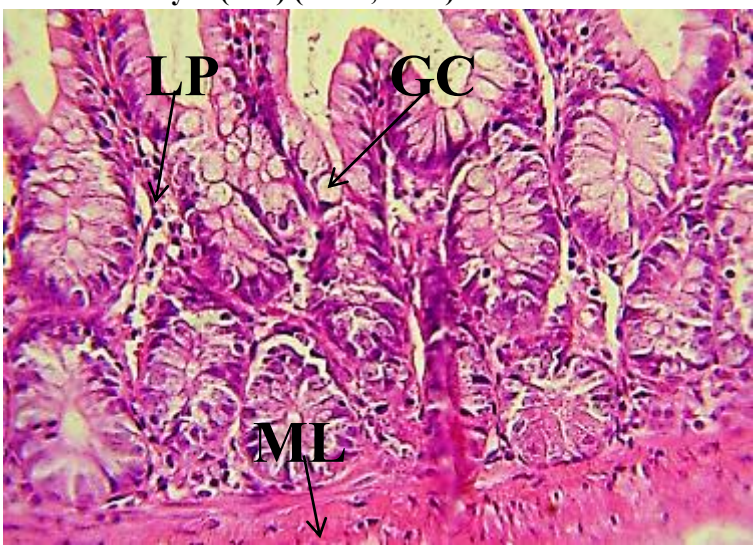

Figure 5. Duodenum of rats receiving SCO (2 mL/kg) showing normal morphology of GC, LP, and ML (H&E, ×400)

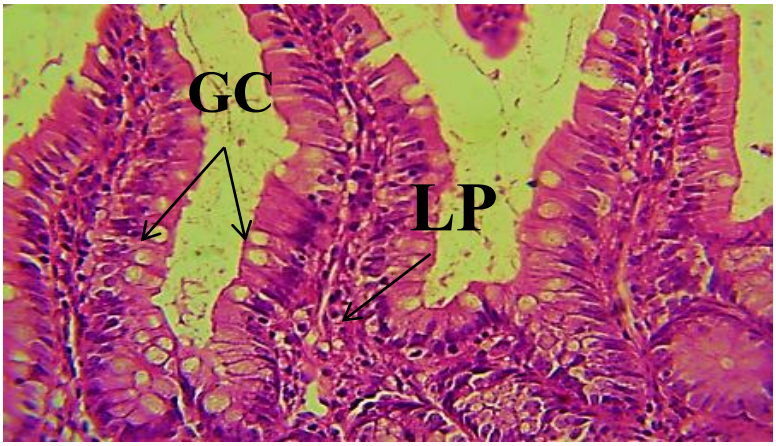

Figure 6. Duodenum of rats given treatment with SCO (4 mL/kg) exhibiting intact GC and LP structures (H&E, ×400)

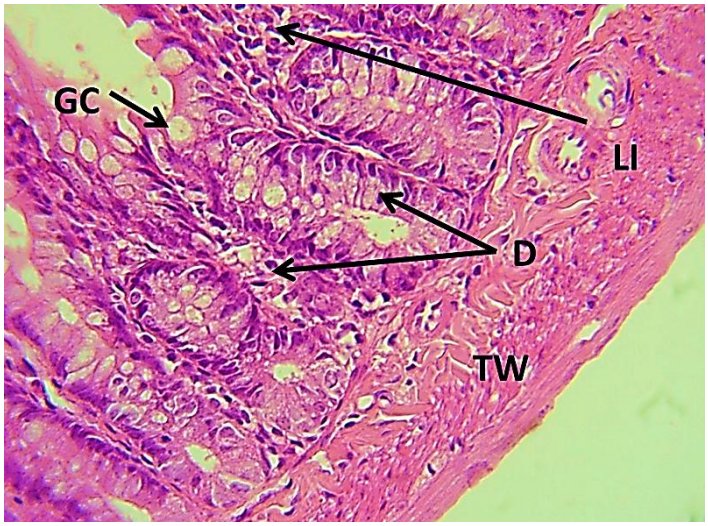

Figure 7. Duodenum of rats given SCO (8 mL/kg) showing vascular wall thickening (TW), leukocytic infiltration (LI), and villous cell degeneration (D) (H&E, ×400)

Histological findings of the Colon: The biochemical findings were supported by the microscopic analysis of colonic tissues. The control group represented a normal histology that had well-arranged crypts (CP), lots of goblet cells (GC), absorptive cells (AC), and splanchnic cells (SC) (Figure 8). The treatment group (2 ml/kg) of SCO had a near normal histologic appearance and was almost similar to the control group with normal crypts and epithelial structures (Figures 8 and 9). The condition grouped with 4 mL/kg of SCO showed mild histological analysis, having minor oscillations in epithelial cells arrangement and slightly thickened crypt walls (Figure 10). However, the treatment group with 8 mL/kg of SCO exhibited severe histopathological changes as established by lymphocytic infiltration, fibroblast growth (F), and the onset of fibrotic mechanisms in the mucosal layer (Figure 11). These are the results of inflammatory and reparative alterations outcome of oxidative stress-induced tissue damage.

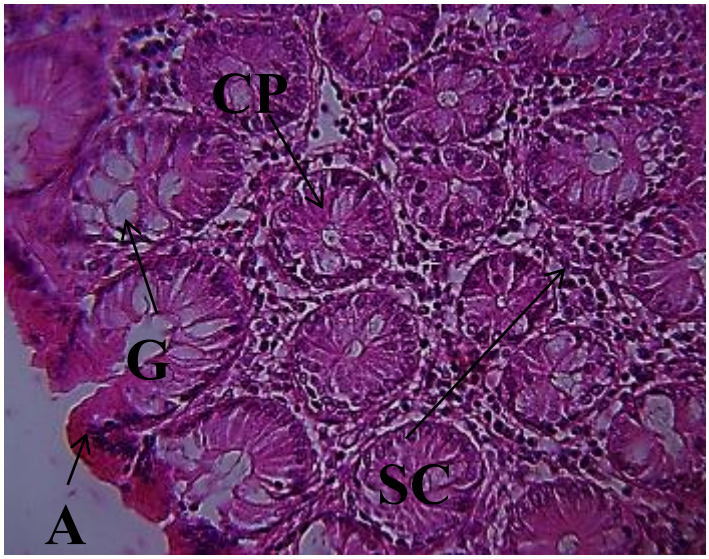

Figure 8. Colon of the control group showing crypts (CP), absorptive cells (AC), goblet cells (GC), and splanchnic cells (SC) (H&E, ×400)

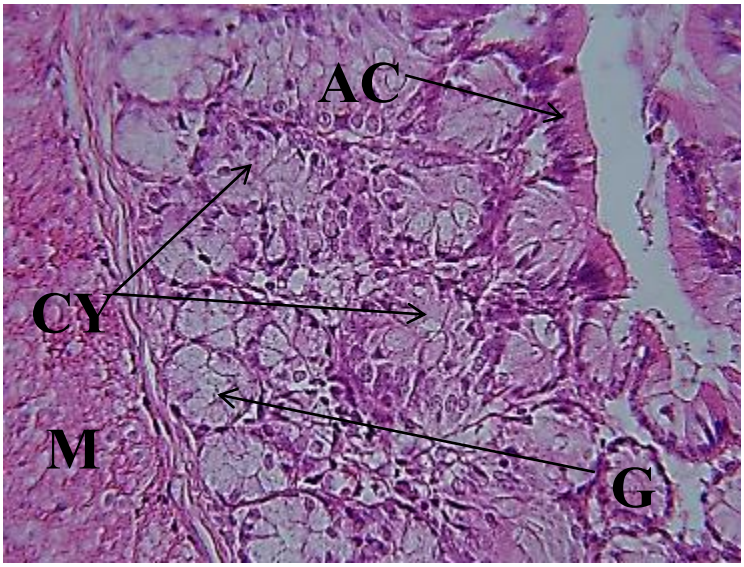

Figure 9. Colon of rats given treatment with SCO (2 mL/kg) showing normal crypts (CP), AC, and GC adjacent to the muscle layer (ML) (H&E, ×400)

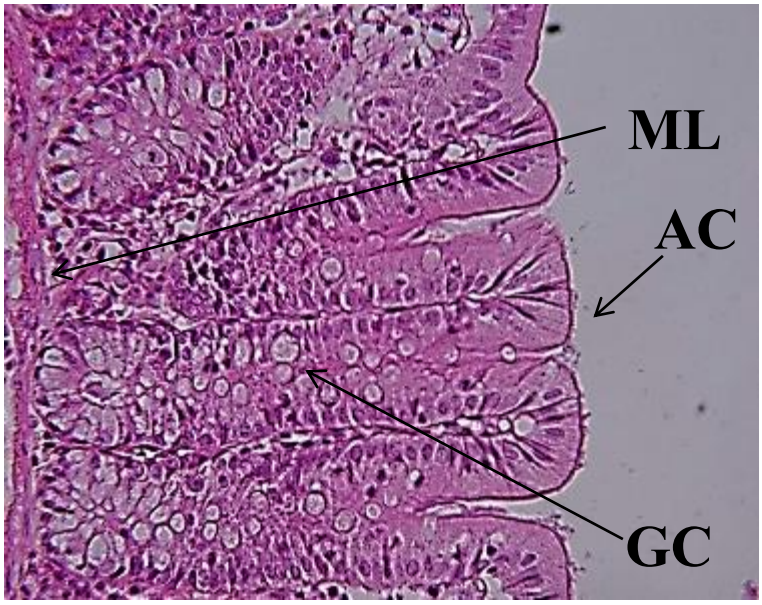

Figure 10. Colon of rats given treatment with SCO (4 mL/kg) displaying regular absorptive cells (AC) and GC adjacent to ML (H&E, ×400)

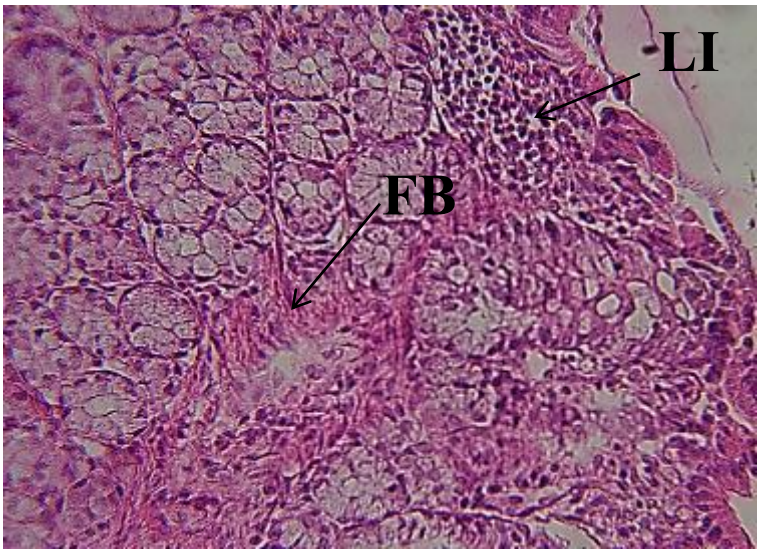

Figure 11. Colon of rats given SCO (8 mL/kg) exhibiting lymphocytic infiltration and fibroblast proliferation (F), indicating the onset of fibrosis (H&E, ×400)

Discussion

The gastrointestinal tract plays a fundamental role in the absorption of nutrients, metabolism and immune control making it very susceptible to the conformation of diets and microbial relationships. The current study involved an experiment on the responses of microbially derived single-cell oil (SCO) to the histological integrity and biochemical parameters of both the small and large intestines in male rate. The given discussion explains the received results against the existing literature highlighting the possible physiological processes behind the observed alterations and assessing both the positive and negative impacts of the SCO supplementation.

SCO is a fatty microbial product that has the ability to go through with metabolic oxidation which results in free radical formation the ability to start lipid peroxidation. Subsequently, the end-product of lipid peroxidation is malondialdehyde (MDA), which is sensitive to oxidative stress and appears in serum (Al-Obeidi et al., 2024). Membranes of cells are particularly prone to oxidative damage due to the abundance of polyunsaturated fatty acids (PUFAs) in these cell membranes and the fact that the numerous double bonds within them are vulnerable to radical reactions. The resulting lipid peroxidation chain reactions increase the level of MDA and contribute to destabilization of membranes, dysfunction of cells, and inflammation (Di Meo & Venditti, 2020). Here, overproduction of reactive oxygen species (ROS) such as hydrogen peroxide (H_2O_2) and lack of antioxidant protection may also contribute to the enhancement of oxidative damage. The imbalance between the production of ROS and antioxidant capacity, also known as oxidative stress, affects the β-oxidation of fatty acids and the increase in lipid peroxidation (Recknagel et al., 2020). Surprisingly, the SCO 4 mL/kg treatment had a significant reduction of serum H_2O_2 concentration, significant gains in the antioxidant enzymes; glutathione peroxidase (GPx) and superoxide dismutase (SOD) activities when compared to the rats fed with corn oil in the current study. The rate of lipid peroxidation was mild in the corn oil control group. This antioxidant increase can be explained by the presence of bioactive compounds of SCO, the sole large content of unsaturated fatty acids, the presence of α-linolenic acid as well as linoleic acid, which scavenges ROS antioxidant enzymes (Armenta & Valentine, 2013). It can be reasonable that some of the SCO components can activate endogenous antioxidants or directly counteract free radicals, reducing oxidative damage. In addition to that, SCO can include secondary metabolites or cofactors that could increase biosynthesis or recycling of antioxidants in serum (Sayegh et al., 2016). However, when given greater doses of SCO (8 mL/kg), a decrease in GPx activity was reported in the animals, compared to the health control group. This observation could be attributed to different mechanisms. An enhanced rate of glutathione (GSH) depletion, a tripeptide, which forms a key non-enzymatic antioxidant and substrate of GPx, may be one of the great factors. In case of high-oxidative stress, GSH is rapidly oxidized to disulfide (GSSG) and hydrolyzed, reducing the total amount of reduced glutathione at the disposal of the cell (Razzaq et al., 2020). Moreover, oxidative stress may also inhibit the activity of the glucose-6-phosphate dehydrogenase (G6PD) enzyme, which is responsible in the production of the NADPH to preserve GSH in its reduced form through the Glutathione reductase enzyme. Therefore, a reduced G6PD activity can reduce the levels of NADPH and, hence, a reduced GSH/GSSG ratio and reduced antioxidant capacity (Perez-Roses et al., 2016). Since GSH can be directly converted to GSSG through the action of GPx during the process of peroxide detoxification, the activity of GPx is bound to be limited by the shortage of GSH (Gulcin, 2020). This interdependence of reactions demonstrates that oxidative load that is too much can deplete antioxidants reserves, which have the resultant effect of leaving the tissue vulnerable to oxidative damage. Conversely, the moderate-dose group animals (second and third groups) did not show any significant biochemical or histological changes after SCO supplementation. Under this observation, SCO can be employed as a protective impression in the correct proportions to boost the efficiency of the antioxidant enzymes and reduce agglomeration of ROS, which are hydrogen

peroxide only. SCO might prevent lipid peroxidation and preserve membrane integrity, as well as cell degeneration (Al-Obeidi et al., 2024). The findings are conjoined with the past researches that show that moderate intake of unsaturated microbial oils can stimulate antioxidant processes and redox homeostasis in the intestinal tissues. Nevertheless, the occurrence of pathological lesions in the intestinal tissues of rats in the highest dose of SCO paint the potential high dose toxicity of the compound. The cause of the pathogenic processes may be the excessive production of the hydrogen peroxide and additional oxidative stress that is beyond the capabilities of the native antioxidant defenses. Overload of the unsaturated fatty acids can spontaneously oxidize to give lipid hydroperoxides and reactive aldehydes that destroy cell membranes and organelles. This mechanism justifies the observed cellular necrosis and constructional destruction in the intestinal tissues in line with past outcomes which has shown that excessive dosage of lipid-containing supplements can lead to cytotoxic effects which are supra-physiological (Carvalho et al., 2015). High doses of SCO exposure therefore appears to induce oxidative stress manifested by the high amount of hydrogen peroxide and the creation of ROS. Besides the fact that this state of oxidative imbalance destroys the lipids of the membrane and the mitochondrial structures, it can also interfere with the condition of the immune homeostasis. Unregulated ROS generation has also been reported to suppress immune activity by preventing the progression of signaling molecule, enzyme inactivation and autoimmune responses. These upheavals can be involved in vascular injury, hemoglobin structure alteration and decrease in oxygen supply to the tissues. Also, the subsequent rise of the peroxisomal activity during the oxidative stress may additionally lead to the heightened cellular toxicity and metabolic imbalance that leads to the accumulation of harmful intermediates and cell debris (Abd Manan et al., 2012). All these findings mark the dual aspect of SCO: at moderate doses, it was able not only to reinforce antioxidant defense, but also to maintain the structure of the intestine; within high doses, it might saturate the defense mechanism and lead to oxidative and inflammatory damage. The histological analysis is employed to supplement biochemical findings to have morphological information on dose-dependent responses. At lower levels of SCO, the intestinal mucosa showed normal structure, intact villi and intact lining of epithelia indicating the existence of adaptive mechanisms or protective mechanisms. Conversely, exposure to high dose triggers a response of villous atrophy, epithelial perturbation and inflammatory infiltration-pathological characteristics of the damage caused by oxidative stress. These morphological variations are connected to biochemical indications of lipid peroxidation and enzyme loss and also argue in favor of the connection between oxidative disturbance and tissue damage.

Conclusion: Finally, the present research demonstrates that the dose-responsive changes of single-cell microbial oil on the intestinal physiology are observable. A moderate level of supplementation enhances the antioxidant efficiency, decreases measures of oxidative stress and preserves histological integrity but excess causes oxidative damage, loss of enzymes and tissue pathology. The findings indicate the necessity to find the highest levels of doses to be used in order to make sure that SCO is used with maximum efficacy as a nutrient and therapeutic to minimize toxicity. Future research should aim at elaborating on the molecular pathways through which SCO can regulate the redox homeostasis and also isolate particular bioactive substances

which can trigger such reactions. These researches can result in the safe utilization of microbial oils as handy dietary elements with antioxidant and antiphlogmatic effects. We show that, despite the ability of single-cell oil to act as protective antioxidant agent in moderate concentrations, it induces much oxidative and histological damage when delivered in high concentrations. It thus needs to be optimized by dose to render it safe and useful in nutritional applications.

Author contributions

Authors were involved equally to the design, execution, and analysis of the investigation. Wassan D. Musa Al-Obeidi was the party in charge of the project conception, design, and supervision. Dhafer F. Al-Rawi worked on the experimental work and data collection, and Loay H. Ali was engaged in the creation of the first manuscript and statistical analysis. The final copy of the manuscript was read and revised by all the authors.

Data availability statement

The datasets generated and/or analyzed via the current investigation are available from the corresponding author upon reasonable request.

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Ethical considerations

Laboratory animal research was confirmed by Scientific Research Ethics Committee of Anbar University based on the Approval No. 267, dated 26 December 2024. Everything had been done in the view of the prevailing international codes of ethics that strive to limit suffering of animals.

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Conflict of Interest

The authors state that they do not have any conflict of interests regarding the study, writing or publication of the article.

References

Aasi Al-Mehmdi, M. D., & Al-Rawi, D. F. J. (2019). Determination of optimal conditions for the production of single cell protein (SCP) by *Pseudomonas aeruginosa* bacteria using hydrocarbon residues (used motor oil). *Biochemical and Cellular Archives, 19*(2), 4323–4329. https://www.connectjournals.com/pages/articledetails/toc030592

Abd Manan, N., Mohamed, N., & Shuid, A. N. (2012). Effects of low-dose versus high-dose γ-tocotrienol on bone cells exposed to hydrogen peroxide-induced oxidative stress and apoptosis. *Evidence-Based Complementary and Alternative Medicine, 2012,* 680834. https://doi.org/10.1155/2012/680834

Abd-Al Hussien, S. D., & Al-Rawi, D. F. J. (2020). Using paper waste and local bacterial isolates to produce biomass and cellulase enzyme: A study on waste recycling. *Indian Journal of Forensic Medicine and Toxicology, 14*(4), 1900–1906. https://doi.org/10.37506/ijfmt.v14i4.11822

Al-Obeidi, W. D. M., Ali, L. H., & Al-Rawi, D. F. (2024). The effects of single cell oil (sco) produced from bacillus subtilus on certain histological and physiological changes in laboratory rats. *Anbar Journal of Agricultural Sciences*, *22*(1), 429-454. https://ajas.uoanbar.edu.iq/article_183744.html

Al-Obeidi, W. D. M., Al-Rawi, D. F., & Ali, L. H. (2023). Production of single-cell oil from a local isolate *Bacillus subtilis* using palm fronds. *International Journal of Biomaterials, 2023,* 8882842. https://doi.org/10.1155/2023/8882842

Armenta, R. E., & Valentine, M. C. (2013). Single-cell oils as a source of omega-3 fatty acids: An overview of recent advances. *Journal of the American Oil Chemists' Society, 90,* 167–182. https://doi.org/10.1007/s11746-012-2154-3

Budzianowski, W. M. (2017). High-value low-volume bioproducts coupled to bioenergies with potential to enhance business development of sustainable biorefineries. *Renewable and Sustainable Energy Reviews, 70,* 793–804. https://doi.org/10.1016/j.rser.2016.11.260

Carvalho, A. K., Rivaldi, J. D., Barbosa, J. C., & de Castro, H. F. (2015). Biosynthesis, characterization and enzymatic transesterification of single cell oil of *Mucor circinelloides* – A sustainable pathway for biofuel production. *Bioresource Technology, 181,* 47–53. https://doi.org/10.1016/j.biortech.2014.12.110

Cohen, Z., & Ratledge, C. (2005). *Single cell oils: Microbial and algal oils.* 2nd Edition Academic Press and AOCS Press. https://www.amazon.com/Single-Cell-Oils-Microbial-Algal/dp/1893997731

Di Meo, S., & Venditti, P. (2020). Evolution of the knowledge of free radicals and other oxidants. *Oxidative Medicine and Cellular Longevity, 2020,* 9829176. https://doi.org/10.1155/2020/9829176

Fakas, S., Papanikolaou, S., Galiotou-Panayotou, M., Komaitis, M., and Aggelis, G. (2009) Biochemistry and biotechnology of single cell oil. in New Horizons in Biotechnology (Pandey, A., and Larroche, C. eds.), Asiatech Publishers. pp 38-60 https://www.academia.edu/614453/Biochemistry_and_biotechnology_of_single_cell_oil

Gulcin, İ. (2020). Antioxidants and antioxidant methods: An updated overview. *Archives of Toxicology, 94,* 651–715. https://doi.org/10.1007/s00204-020-02689-3

Khalaf, N. Z., Al-Rawi, D. F., & Al-Ani, M. Q. J. (2023). Investigation of efficient local bacterial isolates producing L-methioninase. *Vol. 55 No. 4 (2023): Journal of Communicable Diseases* https://doi.org/10.24321/0019.5138.202350

Madani, M., Enshaeieh, M., & Abdoli, A. (2017). Single cell oil and its application for biodiesel production. *Process Safety and Environmental Protection, 111,* 747–756. https://doi.org/10.1016/j.psep.2017.08.027.

Martínez, E. J., Raghavan, V., González-Andrés, F., & Gómez, X. (2015). New Biofuel Alternatives: Integrating Waste Management and Single Cell Oil Production. *International Journal of Molecular Sciences*, *16*(5), 9385-9405. https://doi.org/10.3390/ijms16059385

Nikolova, C., & Gutierrez, T. (2020). Use of microorganisms in the recovery of oil from recalcitrant oil reservoirs: Current state of knowledge, technological advances and future perspectives. *Frontiers in Microbiology, 10,* 2996. https://doi.org/10.3389/fmicb.2019.02996

Ochsenreither, K., Glück, C., Stressler, T., Fischer, L., & Syldatk, C. (2016). Production strategies and applications of microbial single cell oils. *Frontiers in Microbiology, 7,* 1539. https://doi.org/10.3389/fmicb.2016.01539

Pérez-Rosés R, Risco E, Vila R, Peñalver P, Cañigueral S. Biological and Nonbiological Antioxidant Activity of Some Essential Oils. J Agric Food Chem. 2016 Jun 15;64(23):4716-24. doi: 10.1021/acs.jafc.6b00986.

Rajbongshi A, Gogoi SB. A review on anaerobic microorganisms isolated from oil reservoirs. World J Microbiol Biotechnol. 2021 Jun 2;37(7):111. doi: 10.1007/s11274-021-03080-9.

Ratledge, C. (2013). Microbial oils: an introductory overview of current status and future prospects. OCL, 20 6 (2013) D602. https://doi.org/10.1051/ocl/2013029

Razzaq, Z. U., Khan, M. K. I., Maan, A. A., & Rahman, S. U. (2020). Characterization of single cell protein from *Saccharomyces cerevisiae* for nutritional, functional and antioxidant properties. *Food Measure* 14, 2520–2528 (2020). https://doi.org/10.1007/s11694-020-00498-x

Recknagel, R. O., Glende, E. A., & Britton, R. S. (2020). Free radical damage and lipid peroxidation. In *Hepatotoxicology* (pp. 401–436). CRC Press. 10.1201/9780367812041-9

Sayegh, F., Elazzazy, A., Bellou, S. *et al.* Production of polyunsaturated single cell oils possessing antimicrobial and anticancer properties. *Ann Microbiol* 66, 937–948 (2016). https://doi.org/10.1007/s13213-015-1176-0

Spalvins, Kriss, et al. "Single Cell Oil Production from Waste Biomass: Review of Applicable Industrial By-Products" Environmental and Climate Technologies, vol. 23, no. 2, Riga Technical University, 2019, pp. 325-337. https://doi.org/10.2478/rtuect-2019-0071

Suvarna, K. S., Layton, C., & Bancroft, J. D. (2012). Bancroft's theory and practice of histological techniques (7th ed.). Churchill Livingstone. https://www.amazon.com.au/Bancrofts-Theory-Practice-Histological-Techniques/dp/0702042269

Thakur V, Baghmare P, Verma A, Verma JS, Geed SR. Recent progress in microbial biosurfactants production strategies: Applications, technological bottlenecks, and future outlook. Bioresour Technol. 2024 Sep;408:131211. doi: 10.1016/j.biortech.2024.131211.

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اثرات بافت‌شناسی و بیوشیمیایی روغن سلولی تک‌یاخته مشتق از میکروارگانیسم‌ها بر روده موش‌های نر

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چکیده

هدف: این پژوهش با هدف بررسی اثرات روغن سلولی تک‌یاخته (SCO) مشتق از میکروارگانیسم‌های *Alcote* بر ویژگی‌های بافت‌شناسی و بیوشیمیایی روده کوچک و بزرگ در موش‌های نر آلبینو انجام شد. تمرکز ویژه‌ای بر بررسی اثرات وابسته به دوز SCO بر شاخص‌های استرس اکسیداتیو (H_2O_2) و آنزیم‌های دفاع آنتی‌اکسیدانی شامل گلوتاتیون پراکسیداز (GPx) و سوپراکسید دیسموتاز (SOD) صورت گرفت. هدف این بود که مشخص شود آیا مصرف SCO اثرات آنتی‌اکسیدانی مفید دارد یا بسته به دوز مصرفی موجب آسیب اکسیداتیو می‌شود.

مواد و روش‌ها: بیست‌وچهار موش نر سالم نژاد *Sprague–Dawley* در سن ۹ تا ۱۱ هفتگی و با وزن ۱۸۰ تا ۲۰۰ گرم به‌صورت تصادفی به چهار گروه (هر گروه $n = 6$) تقسیم شدند. گروه I به عنوان کنترل، روغن ذرت (۲ میلی‌لیتر بر کیلوگرم) دریافت کرد، در حالی که به گروه‌های II، III و IV به ترتیب روغن SCO با دوزهای ۲، ۴ و ۸ میلی‌لیتر بر کیلوگرم به‌صورت خوراکی تجویز شد. تجویزها هر ۴۸ ساعت یک‌بار به مدت ۴۵ روز انجام گرفت. پس از بیهوشی، سطوح سرمی H_2O_2، SOD و GPx با استفاده از کیت‌های رنگ‌سنجی اندازه‌گیری شدند. نمونه‌های دوازدهه و کولون در فرمالین بافری خنثی تثبیت، در پارافین قالب‌گیری و با هماتوکسیلین و ائوزین رنگ‌آمیزی شدند تا ارزیابی بافت‌شناسی انجام گیرد.

نتایج: مصرف متوسط SCO (۴ میلی‌لیتر بر کیلوگرم) به‌طور معنی‌داری موجب کاهش سطح H_2O_2 و افزایش فعالیت GPx و SOD در مقایسه با گروه کنترل شد که نشانگر بهبود دفاع آنتی‌اکسیدانی بود. در مقابل، دوز بالای SCO (۸ میلی‌لیتر بر کیلوگرم) به‌طور قابل‌توجهی سطح H_2O_2 را افزایش و فعالیت آنزیم‌های آنتی‌اکسیدانی را کاهش داد، که بیانگر القای استرس اکسیداتیو است. یافته‌های بافت‌شناسی نیز این نتایج بیوشیمیایی را تأیید کردند: موش‌هایی که ۲ و ۴ میلی‌لیتر بر کیلوگرم SCO دریافت کردند، ساختار طبیعی دوازدهه و کولون مشابه گروه کنترل داشتند، در حالی‌که در گروه دریافت‌کننده ۸ میلی‌لیتر بر کیلوگرم، ضخیم شدن دیواره عروق، نفوذ لکوسیتی، فیبروز و تخریب پرزها مشاهده شد. این یافته‌ها نشان می‌دهند که اثرات SCO وابسته به دوز است؛ در دوزهای متوسط اثر محافظتی دارد، اما در دوزهای بالا مضر واقع می‌شود.

نتیجه‌گیری: روغن سلولی تک‌منشأ مشتق از میکروارگانیسم‌ها اثرات دوگانه و وابسته به دوز بر سلامت روده دارد. در دوزهای متوسط، وضعیت آنتی‌اکسیدانی را بهبود داده و ساختار طبیعی بافت روده را حفظ می‌کند، که پتانسیل آن را به‌عنوان مکمل غذایی عملکردی برجسته می‌سازد. با این حال، مصرف بیش از حد آن موجب استرس اکسیداتیو و آسیب بافتی می‌شود، که بر ضرورت تعیین دوز بهینه برای استفاده ایمن و مؤثر از SCO در کاربردهای تغذیه‌ای یا درمانی تأکید دارد.

کلمات کلیدی: آسیب‌شناسی بافتی، آنتی‌اکسیدان‌ها، استرس اکسیداتیو، روده، روغن سلولی تک‌یاخته

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