



## Zinc Supplementation for Non-alcoholic Fatty Liver Disease: Literature Review

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### Abstract

Non-Alcoholic Fatty Liver Disease (NAFLD) is closely associated with several metabolic factors, including dyslipidemia, insulin resistance, obesity, oxidative stress, and elevated inflammatory markers. NAFLD is also one of the most common liver diseases, in which zinc deficiency plays a key role in its pathogenesis. Zinc supplementation has been evaluated as a potential adjunctive therapy to improve clinical outcomes in patients with NAFLD. This literature review aims to discuss the possible role of zinc supplementation as an adjuvant therapy in patients with NAFLD, based on current research findings, and to contribute to the existing scientific literature.

## Introduction

Non-alcoholic Fatty Liver Disease (NAFLD) is a prevalent chronic hepatic disorder closely associated with metabolic syndrome, insulin resistance, and obesity (Godoy-Matos et al., 2020; Rinaldi et al., 2021; Cao et al., 2025). Zinc, an essential mineral required by the human body but not synthesized endogenously, plays a crucial role in hepatic lipid metabolism, anti-inflammatory processes, and antioxidant defense mechanisms (Sangubotla et al., 2025; Varra et al., 2025; Jomova et al., 2025). Recent studies have reported that zinc deficiency is prevalent among patients with NAFLD, which correlates with disease morbidity, particularly hepatic fibrosis and metabolic dysfunction (Barbara & Mindikoglu, 2021; Ito et al., 2020; Kim et al., 2020; Nishikawa et al., 2022; Tyczyńska et al., 2024). Several experimental and recent clinical trials have demonstrated that zinc supplementation may improve glucose and lipid metabolism, ameliorate hepatic steatosis, and enhance liver function. However, the current evidence remains heterogeneous, and the optimal therapeutic protocols have yet to be established (Bolatimi et al., 2023; Fogacci et al., 2024; Liu et al., 2024; Qi et al., 2020; Wei et al., 2018; Xu et al., 2023). While animal studies and some clinical trials in humans suggest beneficial effects, other research highlights the need for further investigations to elucidate optimal timing, dosing, and long-term outcomes of zinc supplementation in established NAFLD (Barbara & Mindikoglu, 2021; Bolatimi et al., 2023; Himoto & Masaki, 2018).

## Methods

This literature review employed a comprehensive literature search strategy covering publications from the past 5 to 10 years. The primary databases utilized were PubMed and Semantic Scholar. The search strategy specifically targeted studies related to zinc supplementation and NAFLD, the role of zinc in hepatic metabolism, and adjunctive micronutrient therapy for NAFLD. Out of 1,042 studies initially identified, 617 underwent in-depth screening, 225 were eligible, and 24 were included in this review.

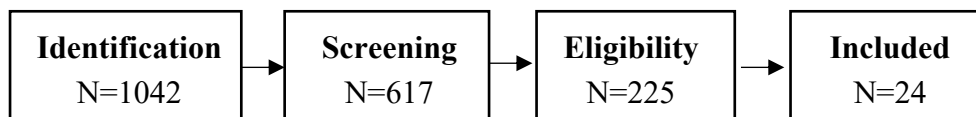


Figure 1. Flow Diagram of the Search and Selection Process for Included Studies

## Results and Discussion

### Zinc Status and NAFLD Severity

Several cross-sectional and observational studies have demonstrated that patients with NAFLD exhibit significantly lower serum zinc levels compared to healthy individuals (Ye et al., 2025; Rezaei et al., 2023). Moreover, zinc deficiency is independently associated with chronic hepatic fibrosis and metabolic disturbances (Barbara & Mindikoglu, 2021; Ito et al., 2020; Kim et al., 2020; Nishikawa et al., 2022; Tyczyńska et al., 2024). Lower zinc levels are associated with elevated hepatic enzyme concentrations, increased insulin resistance, and accelerated disease progression (Ito et al., 2020; Kim et al., 2020; Nishikawa et al., 2022).

### Primary Outcome Measures

Experimental studies have demonstrated that zinc supplementation can attenuate hepatic lipid accumulation by enhancing lipolysis, promoting autophagy (lipophagy), and modulating key metabolic pathways, such as the  $Zn^{2+}$ /MTF-1/PPAR $\alpha$  and  $Ca^{2+}$ /CaMKK $\beta$ /AMPK pathways (Wei et al., 2018; Xu et al., 2023). Zinc also plays a regulatory role in  $\beta$ -catenin signaling, which influences both lipolysis and lipogenesis (Xu et al., 2023). These mechanisms are supported by animal trials that show improvements in hepatic steatosis and metabolic profiles with zinc supplementation (Qi et al., 2020; Wei et al., 2018; Xu et al., 2023).

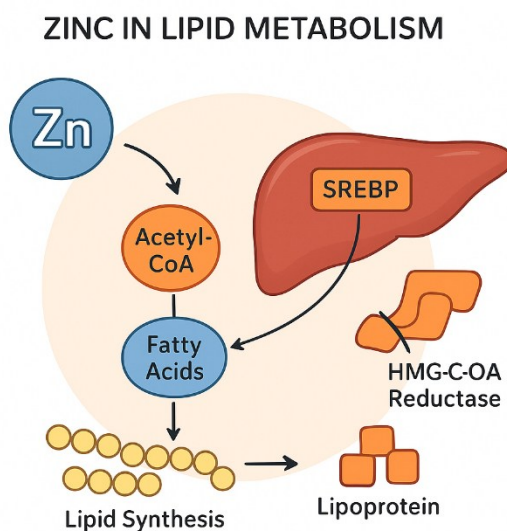


Figure 2. Flow Diagram of the Search and Selection Process for Included Studies

### Clinical and Preclinical Supplementation Studies

Clinical trials and animal studies have yielded variable results (Sadiq et al., 2025; Soleimani et al., 2025; Noshadi et al., 2025). Several randomized controlled trials and nutraceutical interventions often combining zinc with other therapeutic agents have demonstrated improvements in hepatic lipid indices, lipid profiles, and liver function among patients with NAFLD or metabolic syndrome (Cao et al., 2025; Fogacci et al., 2022, 2024). However, other studies involving patients with confirmed NAFLD have reported limited or non-significant benefits from short-term zinc supplementation (Sheikh et al., 2025). These findings suggest

that the timing of administration, disease stage, and duration of intervention are critical determinants of zinc supplementation efficacy (Bolatimi et al., 2023; Himoto & Masaki, 2018).

### Zinc Deficiency, Comorbidities, and Related Micronutrients

Zinc deficiency in patients with NAFLD is frequently aggravated by comorbid conditions such as obesity, diabetes, and chronic inflammation (Yang et al., 2025; Reytor-González et al., 2025; Jimenez Jimenez et al., 2025). These comorbidities contribute to increased zinc requirements and impaired zinc absorption (Barbara & Mindikoglu, 2021; Himoto & Masaki, 2018; Nishikawa et al., 2022; Tyczyńska et al., 2024). Interactions with other micronutrients, such as selenium and copper, as well as the role of zinc in protein metabolism and immune function, are emphasized as critical aspects to be considered in the comprehensive therapeutic management of patients with NAFLD (Barbara & Mindikoglu, 2021; Himoto & Masaki, 2018; Katayama, 2020; Palladini et al., 2022).

Table 1. Authors & Journals that Appeared Most Frequently in the Included Papers

Type	Name	Papers
Author	T. Himoto	(Himoto & Masaki, 2018)
Author	C. Hogstrand	(Wei et al., 2018; Xu et al., 2023)
Author	F. Fogacci	(Fogacci et al., 2022, 2024)
Journal	<i>Nutrients</i>	(Fogacci et al., 2022, 2024; Himoto & Masaki, 2018; Hosui et al., 2018; Nishikawa et al., 2022)
Journal	<i>International Journal of Molecular Sciences</i>	(Bolatimi et al., 2023; Palladini et al., 2022; Tyczyńska et al., 2024)
Journal	<i>PLoS ONE</i>	(Kim et al., 2020)

Current studies indicate that zinc deficiency is commonly observed among patients with NAFLD and is closely associated with disease progression, particularly the development of hepatic fibrosis and metabolic dysfunction (Barbara & Mindikoglu, 2021; Ito et al., 2020; Kim et al., 2020; Nishikawa et al., 2022; Tyczyńska et al., 2024). Mechanistic studies in animal and molecular models provide strong evidence supporting the role of zinc in enhancing insulin sensitivity, modulating key metabolic pathways, and reducing hepatic lipid accumulation (Qi et al., 2020; Wei et al., 2018; Xu et al., 2023). Several clinical trials, including randomized controlled trials, have demonstrated that zinc supplementation, particularly when administered as part of multi-nutrient interventions, can improve hepatic lipid indices and metabolic parameters in specific populations (Cao et al., 2025; Fogacci et al., 2022, 2024). However, these findings have not been consistently demonstrated across all cases. Some studies involving patients with confirmed NAFLD or those in advanced disease stages have shown minimal benefits from zinc supplementation, emphasizing the importance of timing, dosage, and appropriate patient selection in optimizing therapeutic outcomes (Bolatimi et al., 2023; Himoto & Masaki, 2018).

The quality of available scientific evidence remains variable. Robust mechanistic data are primarily derived from experimental animal studies, while moderate-level evidence originates from human observational and interventional studies (Dubínski et al., 2025; Mayer et al., 2025; Further research, particularly large-scale cross-sectional studies with rigorous design, is still required to determine the efficacy, optimal dosage, and long-term safety of zinc supplementation in patients with NAFLD (Barbara & Mindikoglu, 2021; Bolatimi et al., 2023; Himoto & Masaki, 2018). Additionally, the interactions between zinc and other micronutrients, as well as the impact of comorbidities on the condition of NAFLD patients, warrant further investigation.

## Claims and Evidence Table

Table 2. Key Claims and Support Evidence Identified in these Papers

CLAIM	EVIDENCE STRENGTH	REASONING	PAPERS
Zinc deficiency is common in NAFLD and correlates with disease severity	Evidence strength: Strong (9/10)	Multiple large observational studies and meta-analyses support this association.	(Barbara & Mindikoglu, 2021; Ito et al., 2020; Kim et al., 2020; Tyczyńska et al., 2024; Xu et al., 2023)
Zinc supplementation improves hepatic lipid metabolism and reduces steatosis in animal models	Evidence strength: Strong (8/10)	Consistent findings in animal studies with mechanistic support for lipid metabolism improvement.	(Katayama, 2020; Liu et al., 2024; Qi et al., 2020; Wei et al., 2018)
Zinc supplementation improves liver function and metabolic parameters in some human studies	Evidence strength: Moderate (6/10)	Some RCTs and clinical trials show benefit, but results are inconsistent and often combined with other agents	(Cao et al., 2025; Fogacci et al., 2022, 2024; Hosui et al., 2018)
Short-term zinc supplementation does not reverse established NAFLD in animal models	Evidence strength: Moderate (5/10)	Recent animal studies show limited effect in advanced disease, suggesting timing and duration are critical.	(Bolatimi et al., 2023; Himoto & Masaki, 2018)
Zinc supplementation may reduce risk of hepatocellular carcinoma in chronic liver disease	Evidence strength: Moderate (4/10)	Observational and retrospective studies suggest benefit, but causality is not established.	(Bañares et al., 2024; Hosui et al., 2018)
The optimal dose, duration, and patient selection for zinc supplementation in NAFLD remain unclear	Evidence strength: Weak (3/10)	Lack of large, high-quality RCTs and heterogeneity in study designs.	(Bañares et al., 2024; Barbara & Mindikoglu, 2021; Bolatimi et al., 2023; Himoto & Masaki, 2018)

## Conclusion

Zinc deficiency is commonly observed in patients with NAFLD and is closely associated with poorer metabolic profiles and more adverse hepatic histological features. Although preclinical studies and several clinical trials have demonstrated that zinc supplementation may improve the degree of hepatic steatosis and metabolic parameters in patients with NAFLD, the existing evidence in established NAFLD remains inconsistent. The optimal supplementation strategy has yet to be determined. Therefore, further research is warranted to elucidate the therapeutic role of zinc supplementation in the management of NAFLD. Future research is warranted to focus on large-scale, long-term randomized controlled trials, mechanistic studies in humans, and evaluations of the role of zinc supplementation when combined with other therapies or micronutrients. Overall, zinc supplementation shows potential in improving metabolic parameters and hepatic function in patients with NAFLD. However, further high-quality

research is needed to establish its clinical benefits and to determine the optimal supplementation strategy.

## Research Gaps

Although mechanistic data and early clinical findings have shown positive results, a lack of large-scale, long-term, randomized controlled trials remains to evaluate zinc supplementation in patients with NAFLD, particularly across diverse patient populations and at different stages of the disease. The effects of zinc supplementation when combined with other micronutrients, as well as its role in advanced hepatic fibrosis or cirrhosis, also remain insufficiently investigated.

## Research Gaps Matrix

Table 3. Heatmap of Research Coverage by Study Type and Topic; Gaps Indicate Areas for Future Research

Study Topic / Attribute	Animal Models	Human Observational	Human RCT	Advanced Disease	Combination Therapy
Zinc status & NAFLD severity	3	5	1	2	GAP
Zinc supplementation effects	6	2	3	1	2
Mechanistic pathways	7	GAP	GAP	GAP	GAP
Combination with other nutrients	2	1	2	GAP	3
Long-term outcomes	GAP	1	1	GAP	GAP

## References

- Bañares, J., Aceituno, L., Ruiz-Ortega, L., Pons, M., Abraldes, J. G., & Genescà, J. (2024). Zinc Supplementation to Improve Prognosis in Patients with Compensated Advanced Chronic Liver Disease: a Multicenter, Randomized, Double-Blind, Placebo-Controlled Clinical Trial. *Hepatology Communications*, 8(11). <https://doi.org/10.1097/HC9.0000000000000524>
- Barbara, M., & Mindikoglu, A. L. (2021). The Role of Zinc in the Prevention and Treatment of Nonalcoholic Fatty Liver Disease. *Metabolism Open*, 11, 100105. <https://doi.org/10.1016/j.metop.2021.100105>
- Bolatimi, O. E., Head, K. Z., Luo, J., Gripshover, T. C., Lin, Q., Adiele, N. V., Watson, W. H., Wilkerson, C., Cai, L., Cave, M. C., & Young, J. L. (2023). Can Zinc Supplementation Attenuate High Fat Diet-Induced Non-Alcoholic Fatty Liver Disease? *International Journal of Molecular Sciences*, 24(2), 1763. <https://doi.org/10.3390/ijms24021763>
- Cao, B., Zhou, J., Xia, B., Li, X., Wang, R., Xu, Y., & Li, C. (2025). Therapeutic Potential of a Choline-Zinc-Vitamin E Nutraceutical Complex in Ameliorating Thioacetamide-Induced Nonalcoholic Fatty Liver Pathology in Zebrafish. *PLOS One*, 20(5), e0324164. <https://doi.org/10.1371/journal.pone.0324164>
- Cao, X., Wang, N., Yang, M., & Zhang, C. (2025). Lipid accumulation and insulin resistance: Bridging metabolic dysfunction-associated fatty liver disease and chronic kidney disease. *International journal of molecular sciences*, 26(14), 6962. <https://doi.org/10.3390/ijms26146962>

- Dubiński, P., Odzimek-Rajska, M., Podlewski, S., & Broła, W. (2025). Emerging Insights into the Role of the Microbiome in Brain Gliomas: A Systematic Review of Recent Evidence. *International Journal of Molecular Sciences*, 27(1), 444. <https://doi.org/10.3390/ijms27010444>
- Fogacci, F., Giovannini, M., Di Micoli, V., Grandi, E., Borghi, C., & Cicero, A. F. G. (2024). Effect of Supplementation of a Butyrate-Based Formula in Individuals with Liver Steatosis and Metabolic Syndrome: A Randomized Double-Blind Placebo-Controlled Clinical Trial. *Nutrients*, 16(15), 2454. <https://doi.org/10.3390/nu16152454>
- Fogacci, F., Rizzoli, E., Giovannini, M., Bove, M., D'Addato, S., Borghi, C., & Cicero, A. F. G. (2022). Effect of Dietary Supplementation with Eufortyn® Colesterolo Plus on Serum Lipids, Endothelial Reactivity, Indexes of Non-Alcoholic Fatty Liver Disease and Systemic Inflammation in Healthy Subjects with Polygenic Hypercholesterolemia: The ANEMONE Study. *Nutrients*, 14(10), 2099. <https://doi.org/10.3390/nu14102099>
- Godoy-Matos, A. F., Silva Júnior, W. S., & Valerio, C. M. (2020). NAFLD as a continuum: from obesity to metabolic syndrome and diabetes. *Diabetology & metabolic syndrome*, 12(1), 60. <https://doi.org/10.1186/s13098-020-00570-y>
- Himoto, T., & Masaki, T. (2018). Associations between Zinc Deficiency and Metabolic Abnormalities in Patients with Chronic Liver Disease. *Nutrients*, 10(1), 88. <https://doi.org/10.3390/nu10010088>
- Hosui, A., Kimura, E., Abe, S., Tanimoto, T., Onishi, K., Kusumoto, Y., Sueyoshi, Y., Matsumoto, K., Hirao, M., Yamada, T., & Hiramatsu, N. (2018). Long-Term Zinc Supplementation Improves Liver Function and Decreases the Risk of Developing Hepatocellular Carcinoma. *Nutrients*, 10(12), 1955. <https://doi.org/10.3390/nu10121955>
- Ito, T., Ishigami, M., Ishizu, Y., Kuzuya, T., Honda, T., Ishikawa, T., Toyoda, H., Kumada, T., & Fujishiro, M. (2020). Correlation of Serum Zinc Levels with Pathological and Laboratory Findings in Patients with Nonalcoholic Fatty Liver Disease. *European Journal of Gastroenterology & Hepatology*, 32(6), 748–753. <https://doi.org/10.1097/MEG.0000000000001587>
- Jimenez Jimenez, A. M., Michalkova, H., Krizkova, S., Barreto de Melo Rego, M. J., Adam, V., & Merlos Rodrigo, M. A. (2025). New insights into the role of metallothioneins in obesity and diabetes: Molecular Biology. *International Journal of Obesity*, 49(10), 1958-1972. <https://doi.org/10.1038/s41366-025-01850-1>
- Jomova, K., Alomar, S. Y., Valko, R., Nepovimova, E., Kuca, K., & Valko, M. (2025). The role of redox-active iron, copper, manganese, and redox-inactive zinc in toxicity, oxidative stress, and human diseases. *EXCLI journal*, 24, 880. <https://doi.org/10.17179/excli2025-8449>
- Katayama, K. (2020). Zinc and Protein Metabolism in Chronic Liver Diseases. *Nutrition Research*, 74, 1–9. <https://doi.org/10.1016/j.nutres.2019.11.009>
- Kim, M. C., Lee, J. I., Kim, J. H., Kim, H. J., Cho, Y. K., Jeon, W. K., Kim, B. I., & Sohn, W. (2020). Serum Zinc Level and Hepatic Fibrosis in Patients with Nonalcoholic Fatty Liver Disease. *PLOS ONE*, 15(10), e0240195. <https://doi.org/10.1371/journal.pone.0240195>
- Liu, Y., Qin, X., Chen, T., Chen, M., Wu, L., & He, B. (2024). Exploring the Interactions between Metabolic Dysfunction-Associated Fatty Liver Disease and Micronutrients: from Molecular Mechanisms to Clinical Applications. *Frontiers in Nutrition*, 11. <https://doi.org/10.3389/fnut.2024.1344924>

- Mayer, J. M., Botros, M., Grace, E., & Haddas, R. (2025). Functional Biomarkers Associated with Risk of Low Back Pain in Firefighters: A Systematic Review. *Journal of Functional Morphology and Kinesiology*, 10(4), 441. <https://doi.org/10.3390/jfmk10040441>
- Nishikawa, H., Asai, A., & Fukunishi, S. (2022). The Significance of Zinc in Patients with Chronic Liver Disease. *Nutrients*, 14(22), 4855. <https://doi.org/10.3390/nu14224855>
- Noshadi, N., Sabet, S. S., Sanaie, S., Mahmoodpoor, A., Tutunchi, H., Naghshi, S., ... & Ebrahimi-Mameghani, M. (2025). The effects of seven-strain probiotic supplementation on cell adhesion molecules, oxidative stress and antioxidant parameters in patients with traumatic brain injury: a randomised controlled clinical trial. *British Journal of Nutrition*, 133(7), 892-900. <https://doi.org/10.1017/S0007114524003234>
- Palladini, G., Di Pasqua, L. G., Cagna, M., Croce, A. C., Perlini, S., Mannucci, B., Profumo, A., Ferrigno, A., & Vairetti, M. (2022). MCD Diet Rat Model Induces Alterations in Zinc and Iron during NAFLD Progression from Steatosis to Steatohepatitis. *International Journal of Molecular Sciences*, 23(12), 6817. <https://doi.org/10.3390/ijms23126817>
- Qi, Y., Zhang, Z., Liu, S., Aluo, Z., Zhang, L., Yu, L., Li, Y., Song, Z., & Zhou, L. (2020). Zinc Supplementation Alleviates Lipid and Glucose Metabolic Disorders Induced by a High-Fat Diet. *Journal of Agricultural and Food Chemistry*, 68(18), 5189–5200. <https://doi.org/10.1021/acs.jafc.0c01103>
- Reytor-González, C., Frias-Toral, E., Nuñez-Vásquez, C., Parise-Vasco, J. M., Zambrano-Villacres, R., Simancas-Racines, D., & Schiavo, L. (2025). Preventing and managing pre-and postoperative micronutrient deficiencies: a vital component of long-term success in bariatric surgery. *Nutrients*, 17(5), 741. <https://doi.org/10.3390/nu17050741>
- Rezaei, S. M. A., Mohammadi, F., Eftekhari, M. H., Ejtehadi, F., Ghaem, H., & Mohammadipoor, N. (2023). The effects of zinc supplementation on the metabolic factors in patients with non-alcoholic fatty liver disease: a randomized, double-blinded, placebo-controlled clinical trial. *BMC nutrition*, 9(1), 138. <https://doi.org/10.1186/s40795-023-00776-z>
- Rinaldi, L., Pafundi, P. C., Galiero, R., Caturano, A., Morone, M. V., Silvestri, C., ... & Sasso, F. C. (2021). Mechanisms of non-alcoholic fatty liver disease in the metabolic syndrome. A narrative review. *Antioxidants*, 10(2), 270. <https://doi.org/10.3390/antiox10020270>
- Sadiq, I. Z., Usman, A., Muhammad, A., & Ahmad, K. H. (2025). Sample size calculation in biomedical, clinical and biological sciences research. *Journal of Umm Al-Qura University for Applied Sciences*, 11(1), 133-141. <https://doi.org/10.1007/s43994-024-00153-x>
- Sangubotla, R., Syed, S., Mastan, A., Lakshmi, B. A., & Kim, J. (2025). Zinc-Mediated Defenses Against Toxic Heavy Metals and Metalloids: Mechanisms, Immunomodulation, and Therapeutic Relevance. *International Journal of Molecular Sciences*, 26(19), 9797. <https://doi.org/10.3390/ijms26199797>
- Sheikh, M. Y., Younus, M. F., Shergill, A., & Hasan, M. N. (2025). Diet and lifestyle interventions in metabolic dysfunction-associated fatty liver disease: A comprehensive review. *International Journal of Molecular Sciences*, 26(19), 9625. <https://doi.org/10.3390/ijms26199625>
- Soleimani, G., Conelea, C. A., Kuplicki, R., Opitz, A., Lim, K. O., Paulus, M. P., & Ekhtiari, H. (2025). Targeting VMPFC-amygdala circuit with TMS in substance use disorder: A mechanistic framework. *Addiction Biology*, 30(1), e70011.

- Tyczyńska, M., Hunek, G., Szczasny, M., Brachet, A., Januszewski, J., Forma, A., Portincasa, P., Flieger, J., & Baj, J. (2024). Supplementation of Micro- and Macronutrients—A Role of Nutritional Status in Non-Alcoholic Fatty Liver Disease. *International Journal of Molecular Sciences*, 25(9), 4916. <https://doi.org/10.3390/ijms25094916>
- Varra, F. N., Theodosis-Nobelos, P., Varra, V. K., & Varras, M. (2025). Mechanistic Insights into Antioxidant Interventions Targeting Obesity-Induced Oxidative Stress in the Pathogenesis and Complications of Type 2 Diabetes Mellitus. *Current Issues in Molecular Biology*, 47(12), 1063. <https://doi.org/10.3390/cimb47121063>
- Wei, C., Luo, Z., Hogstrand, C., Xu, Y., Wu, L., Chen, G., Pan, Y., & Song, Y. (2018). Zinc Reduces Hepatic Lipid Deposition and Activates Lipophagy Zn<sup>2+</sup>/MTF-1/PPAR $\alpha$  and Ca<sup>2+</sup>/CaMKK $\beta$ /AMPK Pathways. *The FASEB Journal*, 32(12), 6666–6680. <https://doi.org/10.1096/fj.201800463>
- Xu, Y.-C., Zheng, H., Hogstrand, C., Tan, X.-Y., Zhao, T., Song, Y.-F., Wei, X.-L., Wu, L.-X., & Luo, Z. (2023). Novel Mechanism for Zinc Inducing Hepatic Lipolysis Via the HDAC3-Mediated Deacetylation of  $\beta$ -Catenin at Lysine 311. *The Journal of Nutritional Biochemistry*, 121, 109429. <https://doi.org/10.1016/j.jnutbio.2023.109429>
- Yang, Z., Li, J., Zhang, J., & Sun, C. (2025). Magnesium Deficiency: The Insidious Executor of the Liver Disease. *Journal of the American Nutrition Association*, 44(5), 439-453. <https://doi.org/10.1080/27697061.2024.2443063>
- Ye, M., He, Y., Xia, Y., Zhong, Z., Kong, X., Zhou, Y., ... & Li, Q. (2025). Association between serum zinc and non-alcoholic fatty liver disease and advanced liver fibrosis: NHANES 2011–2016. *Biological Trace Element Research*, 203(3), 1305-1316. <https://doi.org/10.1007/s12011-024-04261-x>