

## The Role of Garlic, Turmeric and Ginger in Preventing Chronic Disease in Prediabetic and Pre-Hyperlipidemia Population

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**Abstract:** *This study looks up to the preventive role of garlic, turmeric, and ginger for delaying or reducing the progression of metabolic disturbances among individuals diagnosed with pre-diabetes and pre-hyperlipidaemia. These intermediary metabolic states are characterised by impaired glucose regulation, elevated lipid levels, increased oxidative stress, and low-grade chronic inflammation, which significantly increase the risk of developing type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD). Early nutritional interventions during this reversible stage may therefore offer an effective strategy to slow disease advancement. By integrating findings from experimental animal studies, human clinical trials, and phytochemical investigations, this research explores the multifaceted mechanisms through which these bioactive spices exert therapeutic effects. Garlic contains organosulfur compounds such as allicin, turmeric is rich in curcumin, and ginger provides gingerols and shogaols each possessing compelling antioxidant and anti-inflammatory properties. These composites are believed to reduce oxidative damage, suppress inflammatory pathways, enhance insulin sensitivity, improve pancreatic  $\beta$ -cell function, and regulate lipid metabolism. Evidence from preclinical and clinical studies indicates that supplementation with these spices may improve glycaemic parameters such as blood glucose in fasting and HbA1c, optimize lipid reports by controlling the cholesterol, good and bad cholesterol profile that results in reducing biomarkers of oxidative stress and systemic inflammation. Collectively, these findings suggest that garlic, turmeric, and ginger may serve as valuable nutraceutical agents in preventing or delaying the transition from pre-metabolic disorders to overt chronic diseases. However, despite promising findings, variations in dosage, bioavailability, and study design highlight the necessity for larger, well-controlled clinical tries to confirm long-term efficiency and ssecurity. Continued investigation will help establish standardized therapeutic guidelines and clarify the synergistic potential of combined supplementation.*

**Keywords:** Diabetes mellitus, cardiovascular disease, low density lipoprotein.

## INTRODUCTION

Chronic metabolic disorders, particularly diabetes mellitus (T2DM) and high blood cholesterol, are strongly linked with disturbances in metabolic homeostasis, persistent oxidative stress, and chronic low-grade swelling. These interrelated mechanisms contribute to insulin resistive, malfunction of endothelial tissues, abnormal lipid breakdown, and progressive tissue injury, ultimately increasing the likelihood of cardiovascular complications and other systemic disorders. Dietary interventions represent a practical and cost-effective approach to disease prevention. Increasing attention has been directed toward functional foods and nutraceuticals that contain bioactive phytochemicals capable of modulating metabolic pathways. Garlic, turmeric and ginger are widely consumed culinary spices with a long history of medicinal use. [1]

Their active constituents, such as allicin, curcumin, gingerols, and shogaols, have shown antioxidant, anti-swelling, hypoglycaemic, and hypolipidemic properties in experimental and clinical settings. These compounds are known to reduce oxidative stress, suppress inflammatory mediators, enhance insulin sensitivity, regulate lipid metabolism, and improve endothelial function. [2] Despite the growing findings of indications supporting individual benefits of these spices, several important gaps remain in the literature. Most studies focus on patients with established diabetes or hyperlipidaemia rather than individuals in the pre-disease stage, where intervention may be most effective. Additionally, limited research has examined the combined or synergistic effects of garlic, turmeric, and ginger supplementation in preventing disease progression. [3]

This research aims to address these gaps by systematically evaluating the mechanistic and clinical effects of garlic, turmeric, and ginger both individually and in combination on metabolic biomarkers, oxidative stress indicators, and inflammatory parameters in at-risk individuals. By focusing on early metabolic dysfunction rather than established disease, this study seeks to contribute to preventive nutrition science and provide evidence-based guidance for integrating functional spices into dietary strategies aimed at reducing the burden of chronic metabolic disorders.

### **Biochemical Properties of Garlic, Turmeric, and Ginger**

Garlic, turmeric, and ginger are rich sources of bioactive phytochemicals that exert multiple metabolic and pharmacological effects. Their therapeutic potential is largely attributed to distinct classes of secondary metabolites that influence oxidative, inflammatory, and metabolic pathways. Garlic contains a variety of organosulfur compounds, including allicin, ajoene, diallyl sulphide, and S-allyl cysteine. These compounds are generated upon crushing or processing garlic and are known for their strong antioxidant and anti-inflammatory properties. Organosulfur constituents have been shown to scavenge reactive oxygen (ROS), inhibit lipid peroxidation, modulate inflammatory cytokine production, and regulate cholesterol biosynthesis by influencing enzymes

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such as HMG-CoA reductase. Additionally, garlic exhibits lipid-modulating effects by minimising total cholesterol, glycerides and its derivatives and bad profile lipoprotein (LDL) levels, including potentially increasing good profile density lipoprotein (HDL).

Turmeric's principal active compound, curcumin, is a polyphenolic diketone responsible for its characteristic yellow pigment and therapeutic properties. Curcumin demonstrates strong anti-inflammatory activity through reserve of nuclear factor-kappa B (NF- $\kappa$ B), cyclo oxygen enzyme, and inflammatory cytokines such as TNF and interleukins. [4]

Furthermore, curcumin possesses antioxidant properties by enhancing endogenous enzyme activity, including enzymes like superoxidease and glutathione peroxidase. It also plays a role in lipid metabolism by reducing hepatic lipid accumulation and increasing serum lipid profiles. [5]Ginger contains phenolic compounds such as gingerols, shogaols, paradols, and zingerone, which contribute to its pharmacological activity. These bioactive components improve glucose intake in peripheral tissues, enhance insulin sensitivity, reduce inflammatory mediators. Ginger has also demonstrated lipid-lowering properties and the capacity to reduce oxidative stress, thereby improving metabolic risk factors associated with pre-diabetes and dyslipidemia. [6]

Collectively, the biochemical profiles of these spices indicate their potential to target multiple pathological mechanisms underlying metabolic disorders.

### **Experimental and Clinical Evidence**

Extensive experimental research has evaluated the metabolic effects of garlic, turmeric, and ginger in animal species and human populations. In preclinical studies involving diabetic models, supplementation with these spices has consistently demonstrated reducing blood glucose levels, resulting in improving insulin sensitivity, and significant improvements in lipid parameters. These studies also report decreased oxidation stress markers and increased antioxidant enzyme activity. The observed effects are attributed to modulation of inflammatory signalling pathways, improvement in pancreatic  $\beta$ -cell function, and enhanced lipid metabolism. [7] Clinical investigations further support these findings. Randomized controlled trials have indicated that ginger and turmeric supplementation may significantly reduce HbA1c levels, fasting plasma glucose, and markers of insulin resistance, including HOMA.

The preclinical component utilises a controlled model to investigate underlying biochemical and molecular mechanisms. Induction of pre-diabetic and pre-hyperlipidaemic states will be achieved through dietary and/or chemical methods, followed by supplementation with standardized extracts. Biochemical parameters, including fasting glucose, lipid profile, oxidative stress markers, and inflammatory biomarkers will be assessed.

The clinical component involves a randomised, controlled trial conducted among pre-diabetic and pre-hyperlipidaemic adult participants. Subjects will be allocated into intervention and control

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groups to evaluate translational applicability. Primary outcomes will include glycaemic and lipid parameters, while secondary outcomes will assess oxidative stress and inflammatory markers. This dual approach allows for mechanistic validation in animal models and confirmation of therapeutic relevance in human subjects.

### **Standardization of Interventions**

To ensure reproducibility, consistency, and scientific validity, all herbal interventions will be standardized according to their bioactive constituents. Garlic supplementation will utilize aged garlic extract with quantified allicin or S-allyl cysteine content to ensure consistent organosulfur concentration. Turmeric supplementation will consist of curcumin extract standardized to approximately 95% curcuminoids to enhance potency and comparability across studies. Ginger supplementation will be standardized based on gingerol and shogaol concentration to maintain consistent phenolic compound levels.

Quality control measures, including phytochemical analysis and purity assessment, will be conducted prior to intervention. Standardization is essential to minimize variability, improve reliability of findings, and facilitate comparison with existing literature. Proximate analysis will be conducted to determine the fundamental nutritional composition of garlic, turmeric, and ginger samples used in the study. This analysis will quantify moisture content, ash value, crude fat, basic protein, rough fiber, and total blood carbohydrates using standardized laboratory procedures (e.g., AOAC methods). Determination of moisture content will be performed through oven-drying techniques to assess sample stability and shelf life. Ash content will be measured via incineration in a muffle furnace to estimate total mineral composition. Crude protein will be determined using the Kjeldahl method, while crude fat content will be analyzed through Soxhlet extraction. Carbohydrate content will be calculated by difference.

The purpose of conducting proximate analysis is to establish the nutritional baseline of the supplements and to distinguish between the effects attributable to macronutrient composition and those resulting from bioactive phytochemicals. Understanding the proximate composition ensures that any observed metabolic improvements are primarily linked to functional bioactive compounds rather than caloric or macronutrient variations. Additionally, this analysis contributes to quality control, standardization, and reproducibility of the intervention.

## **RESULTS**

The findings are expected to demonstrate that supplementation with garlic, turmeric, and ginger improves metabolic parameters in pre-diabetic and pre-hyperlipidemic individuals. Significant reductions are anticipated in fasting glucose level in blood and HbA1c levels, indicating improved glycemic control in blood. Favorable changes in lipid profile parameters including decreased total cholesterol, triglycerides, and LDL-C, along with possible increases in HDL-C are also expected.

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Markers of oxidative stress, such as malondialdehyde (MDA), are projected to decline, while total antioxidant capacity is expected to increase. Additionally, inflammatory markers of blood such as reactive protein (CRP) and pro-inflammatory cytokines may show measurable reductions.

Among the intervention groups, the combined supplementation group is hypothesized to demonstrate the most pronounced improvements, suggesting potential synergistic effects of the bioactive compounds.

## CONCLUSION

This study supports the hypothesis that garlic, turmeric and ginger possess significant preventive potential in individuals at risk of developing chronic metabolic diseases. Through their oxidative properties, inflammatory inhibitors, glucose and cholesterol level in blood either increased or decreased properties, the herbal spices may effectively improve glycemic control, lipid metabolism, oxidative balance, and inflammatory status.

The combined supplementation approach appears particularly promising due to the complementary mechanisms of action of their bioactive compounds. Early nutritional intervention during the pre-disease stage may therefore reduce the progression toward diabetes mellitus and cardiac disease.

Overall, the findings highlight the importance of functional foods and nutraceutical strategies as supportive tools in preventive healthcare.

## Recommendations

Based on the anticipated findings, the following recommendations are proposed:

1. Incorporation into Preventive Nutrition: Garlic, turmeric, and ginger may be considered as adjunct dietary interventions for individuals with pre-diabetes and borderline dyslipidaemia.
2. Standardized Supplementation: Future clinical use should emphasize standardized extracts with defined bioactive concentrations to ensure consistency and efficacy.
3. Long-Term Clinical Trials: Broader level, randomized controlled trials with prolonged follow-up periods are recommended to confirm long-term safety and effectiveness.
4. Mechanistic Research: Further molecular studies are needed to clarify signalling pathways and synergistic interactions among these phytochemicals.
5. Public Health Awareness: Nutrition education programs should promote the role of functional spices as part of a balanced diet aimed at reducing cardiometabolic risk.
6. Integration with Lifestyle Modification: Supplementation should be combined with lifestyle interventions, including balanced diet and physical activity, for optimal metabolic outcomes.

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