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Development of a Manila Tamarind-based Hepatoprotective Instant Soup Mix: GC-MS Characterization for Seperation, Identification and Quantification of Bioactive Compounds

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ABSTRACT

Background: Maintaining liver health is crucial, particularly through dietary sources that offer hepatoprotective and antioxidative benefits. Manila tamarind (*Dipteryx odorata*), known for its antioxidant, anti-inflammatory and hepatoprotective properties, shows promise as a functional food ingredient for liver health support. This study aimed to develop an instant soup mix enriched with Manila tamarind, carrot, onion, white pepper and sago, providing a convenient, nutrient-dense option for consumers.

Methods: Three soup formulations were created, each with varying concentrations of Manila tamarind powder (10 g, 20 g and 30 g). A 10-member sensory evaluation panel assessed the formulations for taste, color, texture and overall acceptability. Statistical analysis (ANOVA) was performed to confirm significant differences across formulations. Nutritional profiling was conducted to determine the fiber and fat content of the soup mix. The DPPH radical scavenging assay was used to evaluate the antioxidant activity of the soup mix. Molecular docking analysis was performed to identify key compounds within the soup mix and their binding affinities with liver-regulating receptors, such as PPAR-α.

Result: The sensory evaluation panel favored the 20 g variant for its optimal balance of taste, color, texture and overall acceptability. ANOVA confirmed significant differences across formulations. Nutritional profiling revealed that the soup mix is high in fiber and low in fat, aligning with liver-supportive dietary recommendations. The DPPH radical scavenging assay demonstrated moderate, dose-dependent antioxidant activity, suggesting potential to reduce oxidative stress linked to hepatic damage. Molecular docking analysis revealed that key compounds within the soup mix, including glycidol and dihydroxyacetone, have favorable binding affinities with liver-regulating receptors, such as PPAR-α. These findings underscore the potential of the Manila tamarind-based soup mix as a functional food to support liver health and mitigate oxidative stress associated with hepatic disorders.

Key words: Antioxidant activity, Functional food, Hepatoprotective, Liver diseases, Manila tamarind, Molecular docking.

INTRODUCTION

Liver diseases, including fatty liver disease, cirrhosis and hepatitis, represent significant global health challenges, with diet and lifestyle playing crucial roles in their prevention and management. Hepatic disorders often develop gradually and are influenced by various factors, including poor dietary habits, environmental exposures, lifestyle factors and genetic predispositions (Adewusi and Afolayan, 2010; Mohanty *et al*., 2022; Ahsan *et al*., 2009). Consuming a diet rich in antioxidants and anti-inflammatory compounds has been shown to benefit liver health by reducing oxidative stress and inflammation, key contributors to liver damage and disease progression. In particular, hepatoprotective foods with bioactive compounds can support liver function and may counteract the adverse effects of modern, highly processed diets, which are often high in sugars, unhealthy fats and chemical additives (Deshwal *et al*., 2011).

Manila tamarind (*Dipteryx odorata*), a tropical fruit with established hepatoprotective and medicinal properties, has shown promise in liver health applications. Rich in antioxidants, Manila tamarind aids in neutralizing free radicals, reducing oxidative stress- a key factor in hepatic inflammation and fibrosis. Its anti-inflammatory properties also make it potentially valuable for managing liver inflammation, while studies suggest that its bioactive components may offer benefits in lipid metabolism, potentially reducing hepatic fat accumulation (Shukla and Jain, 2017; Venu *et al.,* 2016). Additionally, Manila tamarind demonstrates significant anti-ulcer properties and has traditionally been used for ailments associated with liver and digestive health, such as abdominal pain and dysentery (Aksoy and Sozbilir, 2012). Nutrient-rich, with high levels of vitamin C, potassium and dietary fiber, this fruit supports overall well-being and provides a robust foundation for a functional food aimed at liver health.

This study aimed to develop an instant soup mix using Manila tamarind, intended as a convenient and nutritious

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food option to support liver health. The soup which is simple and fast making as mentioned as instant food is easily digestible, free from microbial contamination and makes our body hydrated and also convenient to eat (Lakshmi *et al*., 2016).

By incorporating high-antioxidant ingredients such as Manila tamarind, carrot, onion and white pepper, this formulation may help combat oxidative stress and provide additional hepatoprotective benefits (Pandey *et al.,* 2011; Alam, 2015; Shaker *et al.,* 2009). Through nutritional analysis, antioxidant assays and molecular docking studies, this research investigates the hepatoprotective potential of the Manila tamarind-based soup mix, focusing on its ability to mitigate liver damage and support liver function.

MATERIALS AND METHODS

Selection and pre-processing of ingredients

Manila tamarind, carrots, onions, white pepper and salt were sourced locally in Trichy, India and selected for freshness. Manila tamarind fruits were peeled and the pulp was sun-dried, followed by oven drying at 70°C for 15-18 hours. Carrots and onions were cleaned, chopped and dried in a hot air oven at 55°C for 16 hours. White peppercorns were cleaned, chopped and dried at 65°C for 5-6 hours. Salt was sieved to ensure uniform particle size.

Formulation of the soup mix

The dried ingredients were ground into a fine powder, then blended to create three soup mix variations containing different amounts of Manila tamarind powder (10 g, 20 g, 30 g) while keeping other ingredient quantities constant. The soup mixes were packaged in airtight containers.

Preparation and sensory evaluation

The soup was prepared by adding 1 tsp of the mix to 100 mL of boiling water. A 10-member panel evaluated the appearance, color, texture, taste and overall acceptability of each variation using a 9-point hedonic scale. Analysis of Variance (ANOVA) was used to assess differences between the variations.

Nutrient analysis

The selected variation underwent analysis to determine its carbohydrate, protein, fat, moisture, ash and fiber content.

. **Carbohydrates:** Determined by the anthrone method, with absorbance measured at 620 nm.
. **Protein:** Assessed by Bradford's method with absorbance at 595 nm.
. **Fat:** Measured *via* the vanillin method, absorbance at 490 nm.
. **Fiber:** Determined using the AOAC 992.16 method.

DPPH radical scavenging activity

A 0.1 mM DPPH solution was prepared and ascorbic acid standards were tested alongside the soup mix solutions. The DPPH assay involved adding 1 mL of each solution to 3 mL of DPPH, incubating in the dark for 30 minutes and measuring absorbance at 517 nm. Radical scavenging activity was calculated and plotted to assess antioxidant potential.

Drug-likeness prediction

Phytochemicals from the soup mix underwent analysis through the SWISSADME tool to predict pharmacokinetic properties, including GI absorption, blood-brain barrier permeability, lipophilicity, solubility, metabolism (CYP450 interactions) and drug-likeness criteria based on Lipinski's Rule of Five.

Molecular docking analysis

Ligands were obtained from PubChem and receptors from the Protein Data Bank (PDB). Using PyRx, ligand and receptor files were converted to PDBQT format. Docking was performed with Vina Wizard in PyRx, targeting known active site residues. Binding affinities were analyzed and visualization was conducted with BIOVIA Discovery Studio to assess ligand-receptor interactions.

RESULTS AND DISCUSSION

Sensory evaluations of the three soup mix variations

The sensory evaluations of the three soup mix variations reveal distinct consumer preferences and highlight areas for product refinement given in Graph 1. For Variation 1, the appearance received a favourable score of 7.4, suggesting visual appeal, while the color scored highest at 7.55, indicating it was particularly attractive to the panelists. However, the taste, with a score of 7.08, was noted as an area for potential improvement, as was the texture, which scored 7.35, indicating that the soup's consistency was generally pleasing. The overall acceptance rating of 7.45 suggests a moderate satisfaction with room for flavour enhancements to improve appeal. Variation 2, containing 20 g of Manila tamarind powder, emerged as the most preferred formulation. Scoring highest in both color and taste at 8.65, Variation 2 demonstrated strong positive feedback, with appearance also scoring highly at 8.45 and texture at 8.35, though with slight room for improvement in mouthfeel. The overall acceptance score of 8.51 confirmed Variation 2 as the most balanced and favoured option, supporting its potential palatability alongside its hepatoprotective focus. In contrast, Variation 3 was rated favourably for taste (7.7) but received lower scores for appearance (7.05) and color (7.1), with texture at 7.2, indicating moderate satisfaction but room for visual enhancements. Overall, this comparative analysis underscores that Variation 2 successfully balanced aesthetic appeal and flavour, while Variations 1 and 3 could benefit from targeted improvements in visual and taste attributes to maximize consumer acceptance and enjoyment.

The ANOVA Table 1 supports the observations of Graph 1. The Between Groups row shows that the variance among the soup mix variations is statistically significant, with an F-statistic of 44.07, which is much higher than the critical

value (F crit) of 4.2565. The P-value is very low (2.24E-05), indicating that the differences observed are unlikely to be due to random chance. Thus, there is a statistically significant difference between the three soup mix variations across the criteria tested.

Based on the scores and the statistical analysis, Variation 2 is the preferred option across all evaluated criteria, as it consistently received the highest ratings for appearance, color, taste, texture and overall acceptance. The ANOVA test confirms that the differences between the variations are significant, reinforcing the conclusion that Variation 2 is the most favored soup mix.

Studied sensory properties of composite soup mix powder and three variation reported that, the addition of pepper, and cumin seeds powder increased the score for almost all the parameters as compare to control. These results show the incorporation of ingredients has important inspiration on sensory parameters of the established products (Sankararao *et al.,* 2016).

Proximate analysis of the developed soup mix

The proximate analysis of food is essential for determining its nutritional content, which can guide both product development and consumer awareness regarding its dietary benefits. The soup mix developed was analyzed for four main macronutrients-carbohydrates, protein, fat and fiber-using standard biochemical methods and presented in Table 2.

Carbohydrate content (anthrone method)

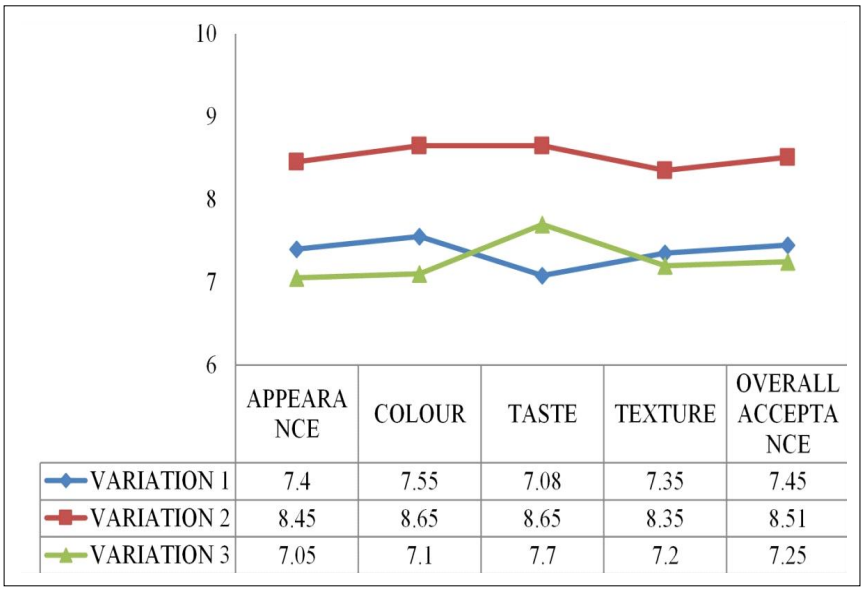
The carbohydrate content in the soup mix was found to be 7.14 mg per gram. In this method, carbohydrates are first hydrolyzed to simple sugars, which react with the Anthrone reagent under acidic conditions to produce a colored complex measurable by spectrophotometry. A study investigates the antidiabetic effects of Manila tamarind seeds in streptozotocin-induced diabetic rats, demonstrating its potential in managing blood sugar levels.

Protein content (bradford method)

The protein content was measured as 0.49 mg per gram using the Bradford method, which is based on the binding of Coomassie Brilliant Blue dye to proteins. This method is sensitive and rapid, suitable for assessing the protein concentration in food samples. Protein in the soup mix provides essential amino acids necessary for body repair, growth and maintenance.

Fat content (vanillin method)

Fat content was detected as 0.16 mg per gram using the Vanillin method. This method involves the reaction of unsaturated fatty acids with vanillin, producing a measurable color complex. Although relatively low in fat,



	APPEARANCE	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTANCE
VARIATION 1	7.4	7.55	7.08	7.35	7.45
VARIATION 2	8.45	8.65	8.65	8.35	8.51
VARIATION 3	7.05	7.1	7.7	7.2	7.25

Graph 1: Sensory evaluation of all three variation soup mix.

Table 1: ANOVA summary table for differences in sensory evaluation scores among soup mix variations.

Source of variation	SS	df	MS	F	P-value	F crit
Between groups	3.8761	2	1.9381	44.0746	2.24E-05	4.2565
Within groups	0.3958	9	0.044			
Total	4.2719	11				

the soup mix can still contribute to the intake of essential fatty acids, though it would not serve as a primary fat source.

Fiber content (AOAC method 992.16)

Dietary fiber was estimated to be 52 mg% using the AOAC 992.16 method, a recognized standard for dietary fiber measurement. Fiber is crucial for digestive health, aids in preventing constipation and contributes to satiety, potentially assisting with weight management. The high fiber content in this soup mix is notable and adds to its potential health benefits, especially for those seeking high-fiber foods. Study on Antidiabetic activity of Pithecellobium dulce Benth. seeds in streptozotocin-induced diabetic rats explain the anti diabetic property of the manila tamarind (Pandey *et al.,* 2011).

The proximate composition suggests that this soup mix is predominantly a source of dietary fiber, with moderate carbohydrate content and lower levels of protein and fat. Such a profile could make the soup mix a suitable option for those looking to increase fiber intake without significantly raising caloric intake from fats or sugars as suggested in studies (Ganesan *et al.,* 2018; Newairy *et al.,* 2007; Simon *et al.,* 2020). The proximate analysis revealed high fiber content, beneficial for managing hepatic fat accumulation and overall liver health.

Proximate study of selected sample were found high in protein 0.48 mg\gram ash 9.79%, very low in fat 0.16 mg\gram and carbohydrate value 7.14 mg\gram and fiber 52 mg\gram which make the established soup as an proper choice to fulfill nutritional demand of regulars. Instant soup mixes packed in aluminium foil was found to be successfully stored for 120 days at room temperature without any major changes, in physicochemical, microbial and organoleptic parameters which is an appropriate choice to fulfill nutritional demand of consumers (Faruk Ansari *et al*., 2020).

DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity

Graph 2 illustrates the DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity of two substances: the developed soup mix and ascorbic acid, across different concentrations (50, 100, 150, 200 and 250 µg/mL). The y-axis represents the percentage of inhibition (radical scavenging activity), while the x-axis shows the concentration in µg/mL.

Ascorbic acid (orange bars)

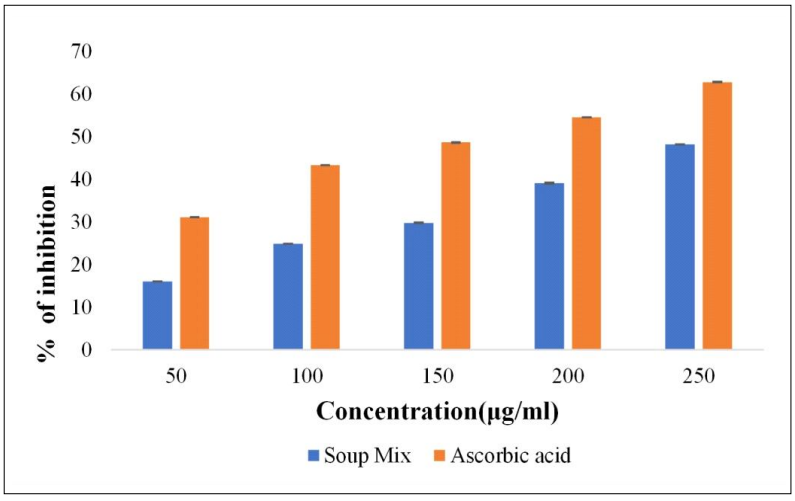
Ascorbic acid, known for its antioxidant properties, demonstrates a strong radical scavenging activity across all concentrations. It shows a higher percentage of inhibition compared to the soup mix at each concentration level, increasing steadily from around 40% at 50 µg/mL to nearly 60% at 250 µg/mL. This consistent rise indicates that ascorbic acid is effective at neutralizing free radicals even at lower concentrations.

Soup mix (blue bars)

The soup mix also displays DPPH radical scavenging activity, but with lower inhibition percentages compared to ascorbic acid. Starting at around 20% inhibition at 50 µg/mL, the activity increases gradually, reaching just below 50% at the highest concentration (250 µg/mL). While the soup mix shows antioxidant activity, its efficacy is less pronounced than that of ascorbic acid.

Table 2: Proximate analysis of the developed soup mix.

Parameters analysed	Experimental method	Values
Carbohydrate	Anthrone	7.14 mg/gm
Protein	Bradford	0.49 mg/gm
Fat	Vanillin	0.16 mg/gm
Fiber	AOAC 992.16	52 mg %



Graph 2: DPPH radical scavenging activity.

Comparison

The graph clearly illustrates that ascorbic acid has stronger antioxidant activity than the soup mix at each tested concentration. However, the increasing trend in inhibition for both substances suggests that the soup mix also contains antioxidant components, albeit less potent than ascorbic acid. A related study conducted discusses the antioxidant and anti-inflammatory properties of Manila tamarind leaves, highlighting their potential in preventing chronic diseases (Bayram *et al.,* 2021).

The DPPH radical scavenging assay results indicate that the developed soup mix possesses antioxidant properties, although it is less effective than ascorbic acid. This antioxidant activity may be beneficial in reducing

Table 3: SWISSADME analysis of all phytocompounds.

Name	Violations (Lipinski's Ro5)	Bioavailability Score	Pharmacokinetics
Glycidol	0	NO	0.55 (Satisfied)
Glyceraldehyde	0	NO	0.55 (Satisfied)
2-Pyrrolidinone, 4-hydroxy-5-methyl (isomer 1)	0	NO	0.55 (Gilow)
Acetamide, N,N'-carbonylbis-	0	NO	0.55 (Satisfied)
4-Cyclopentene-1,3-dione	0	NO	0.55 (Satisfied)
Dihydroxyacetone	0	NO	0.55 (Satisfied)
2-Propenamide, N-methyl-	0	NO	0.55 (Satisfied)
1,4-Butanediol	0	NO	0.55 (Satisfied)
2-Cyclopenten-1-one, 2-hydroxy-	0	NO	0.55 (BBBHIGH)
1,2-Ethanediol, monoacetate	0	NO	0.55 (Satisfied)
2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	0	NO	0.85 (Satisfied)
Cyclohexane, 1,1-dimethoxy-	0	NO	0.55 (BBBHIGH)
2,6-Diamino-3H-pyrimidin-4-one	0	NO	0.55 (Satisfied)
1,2-Pentanediol	0	NO	0.55 (Satisfied)
Undecane	MLOGP	YES	0.55 (Gilow and CYP+)
3-Amino-2-oxazolidinone	0	NO	0.55 (Satisfied)
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	0	NO	0.85 (Satisfied)
2-Butanone, 4-hydroxy-3-methyl-	0	NO	0.55 (Satisfied)
5-Hydroxymethylfurfural	0	NO	0.55 (Satisfied)
3-(Methoxymethoxy) butanoic acid	0	NO	0.85 (Satisfied)
Diethyl Phthalate	0	NO	0.55 (BBBHIGH and CYP1+)
6-Acetyl-β-D-mannose	0	NO	0.55 (Gilow and P-GP+)
1,3-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	MLOGPISHIGH; Lipinski's Rule not satisfied		

Table 4: Docking analysis through PyRx virtual screening tool.

Name	Binding energy (kcal/mol)	Contact residues	Binding interactions
Glycidol	-3.2	THR283, GLU286, MET220	H-Bond
Glyceraldehyde	-4.1	ASP419, HIS416, PHE423, LEU422	H-Bond
Acetamide, N,N'-carbonylbis-	-5.3	THR283	H-Bond
4-Cyclopentene-1,3-dione	-4.4	TYR334, THR283	H-Bond
Dihydroxyacetone	-3.8	ASP419, ILE420	H-Bond
2-Propenamide, N-methyl-	-3.8	HIS416, LEU412, PRO417	H-Bond and CH-Bond
1,4-Butanediol	-3.9	PHE423, ASP419	H-Bond
2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	-5.7	LEU412, PHE423, ILE420	H-Bond and Alkyl
2,6-Diamino-3H-pyrimidin-4-one	-5.0	PRO417, HIS416, ASP419, PHE423	H-Bond
1,2-Pentanediol	-4.5	LEU422, ARG409	H-Bond and Alkyl
3-Amino-2-oxazolidinone	-4.2	HIS416, ASP419, PHE423	H-Bond
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	-5.1	GLU286, ILE317, MET320, LEU321	H-Bond and Alkyl
2-Butanone, 4-hydroxy-3-methyl-	-4.3	THR283, ASN219, TYR334	H-Bond and π-σ
5-Hydroxymethylfurfural	-4.7	THR283, GLU286, MET320	H-Bond and π-S
3-(Methoxymethoxy) butanoic acid	-4.4	THR283, GLU286	H-Bond and CH-Bond

oxidative stress when consumed, though ascorbic acid remains a stronger antioxidant benchmark. The increasing inhibition with higher concentrations suggests that the antioxidant activity of the soup mix is dose-dependent. antioxidant analysis *via* the DPPH assay showed dose-dependent radical scavenging activity, suggesting the soup mix's capability to reduce oxidative stress, a key contributor to liver disease progression (Rodriguez *et al.,* 2016; Jaramilo *et al.,* 2023).

Compounds identified from the GC-MS analysis

The compounds identified from the GC-MS analysis were subjected to drug likeness prediction and the findings are summarized in Table 3.

The compounds highlighted in Table 3 did not satisfy Lipinski's Rule of Five or exhibited poor pharmacokinetic properties, resulting in their exclusion from further analysis. Consequently, 16 compounds that demonstrated the requisite drug-like properties were selected for molecular docking analysis against Peroxisome Proliferator-Activated Receptor Alpha (PPAR-α) using the PyRx virtual screening tool (Thomsen and Christensen, 2006; Eldesoky *et al*., 2018). The docking results are presented in Table 4.

PPAR-alpha (Peroxisome proliferator-activated receptor alpha) is a nuclear receptor that plays a critical role in regulating lipid metabolism, inflammation and energy homeostasis. It is predominantly expressed in tissues with high fatty acid oxidation rates, such as the liver. The activation of PPAR-alpha has demonstrated therapeutic potential for treating hyperlipidemia and hepatitis due to its regulatory effects on lipid metabolism and inflammatory responses.

Anti-hepatitic activity

Activation of PPAR-alpha exerts anti-inflammatory effects in the liver, which are beneficial for managing hepatitis. Chronic hepatitis is associated with inflammatory processes that can lead to liver fibrosis, cirrhosis and severe complications. PPAR-alpha activation modulates inflammatory gene expression, thereby helping to reduce liver inflammation and oxidative stress (Hanwell *et al.,* 2012).

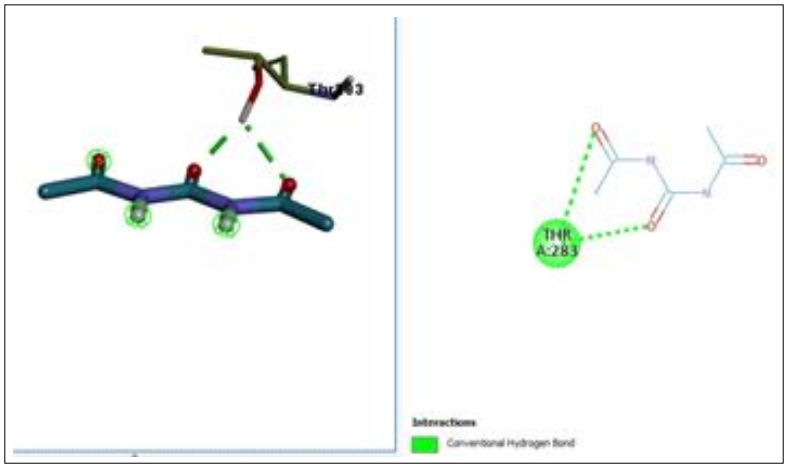


Fig 1: Interaction between PPAR-α and Acetamide, N, N'-carbonylbis-ligand.

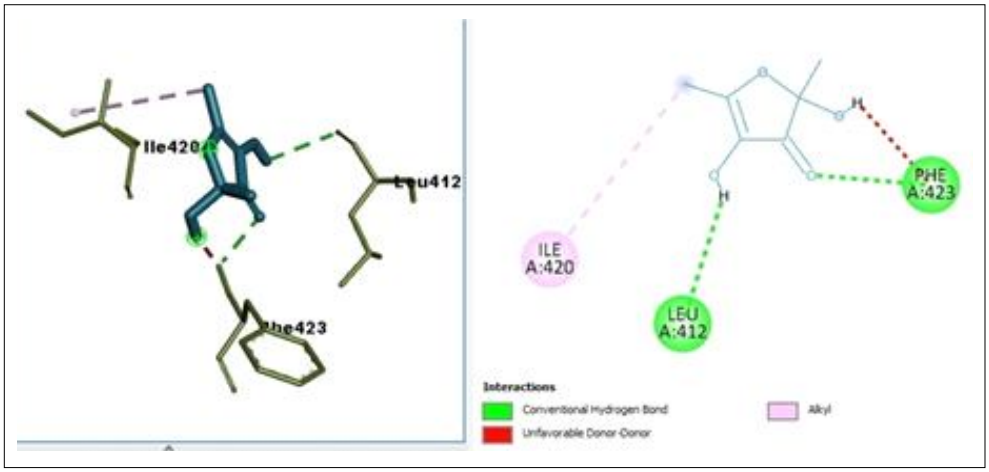


Fig 2: Interaction between PPAR-α and 2, 4-Dihydroxy-2, 5-dimethyl-3(2H)-furan-3-one ligand.

Promising Ligands for Anti-Hepatitic Activity

Acetamide, N,N'-carbonylbis- (Binding Energy: -5.3 kcal/mol)

This compound interacts through hydrogen bonding with THR283, suggesting a moderate binding affinity that could sufficiently activate PPAR-alpha, potentially downregulating pro-inflammatory cytokines and thereby reducing liver inflammation.

4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- (Binding Energy: -5.1 kcal/mol)

This ligand forms hydrogen bonds and hydrophobic interactions (alkyl) with key residues THR283, GLU286, MET320 and LEU321, which may enhance stability and effective activation of PPAR-alpha, contributing to anti-inflammatory and hepatoprotective effects.

2,6-Diamino-3H-pyrimidin-4-one (Binding Energy: -5.0 kcal/mol)

This ligand exhibits hydrogen bonding with residues such as PRO417, HIS416, PHE423 and ASP419, potentially enhancing PPAR-alpha activation and aiding in the modulation of inflammatory responses in the liver.

Anti-lipidemic activity

PPAR-alpha (peroxisome proliferator-activated receptor alpha) is a crucial regulator of lipid metabolism, promoting fatty acid oxidation and reducing triglyceride levels in the liver and blood. Its activation can significantly lower serum triglycerides and cholesterol, making it essential for managing dyslipidemia and preventing fatty liver disease.

Promising ligands for anti-lipidemic activity

Several compounds demonstrated favourable binding energies and interaction profiles

- **2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one (Binding Energy: -5.7 kcal/mol):** Forms hydrogen bonds and alkyl interactions with PHE423, LEU412 and ILE420, suggesting enhanced lipid metabolism.
- **2,6-Diamino-3H-pyrimidin-4-one (Binding Energy: -5.1 kcal/mol):** Exhibits hydrogen bonding with key residues, indicating potential lipid-modulating effects.

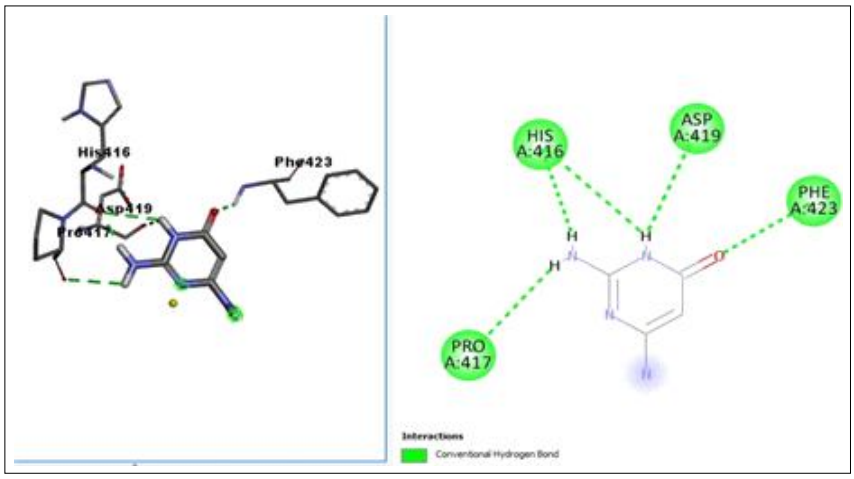


Fig 3: Interaction between PPAR-α and 2,6-Diamino-3H-pyrimidin-4-one ligand.

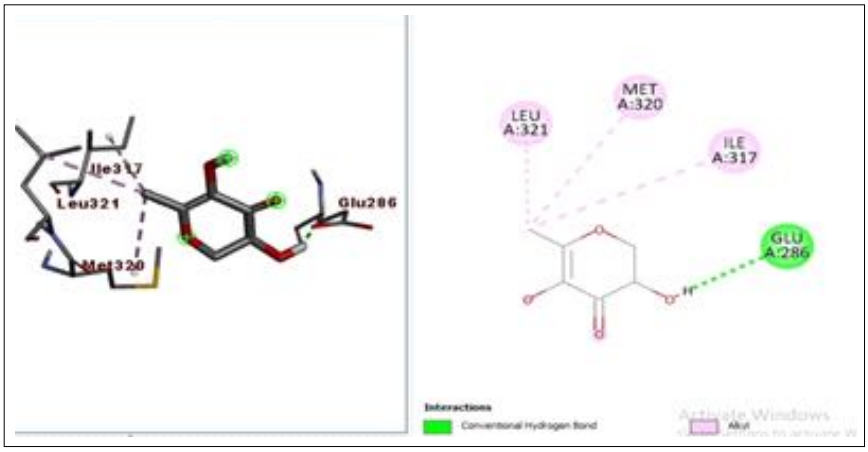


Fig 4: Interaction between PPAR-α and 4H-Pyran-4-one, 2,3-dihydro-3, 5-dihydroxy-6-methyl-ligand.

- **Acetamide, N,N'-carbonylbis- (Binding Energy: -5.3 kcal/mol) and 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- (Binding Energy: -5.1 kcal/mol):** Both compounds interact with THR283, GLU286 and MET320, crucial for PPAR-alpha activation, leading to improved fatty acid catabolism.

Role of specific residues

Key residues like PHE273 facilitate hydrophobic interactions that stabilize ligand binding, while hydrogen bonds with HIS440 and ASP464 promote effective receptor activation. Ligands that engage both types of interactions are promising candidates for anti-lipidemic therapy (Hajovsky *et al.,* 2012).

Dual therapeutic potential

Compounds like Acetamide, N,N'-carbonylbis- and 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- show potential for dual activity by binding to PPAR-alpha, thereby reducing hepatic inflammation and lipid levels.

Their interactions induce conformational changes in the receptor, enhancing its function in lipid metabolism. Fig 1-4 illustrate significant binding interactions, highlighting the therapeutic potential of these ligands for further investigation in anti-lipidemic and anti-inflammatory therapies.

Further discussion would center on the potential of Manila tamarind's bioactive compounds in the soup to protect hepatocytes from oxidative damage, emphasizing findings from molecular docking and interaction studies (Diaz *et al.,* 2020). Compounds that demonstrated favourable binding with liver-associated receptors, such as PPAR-α, are highlighted as potentially reducing hepatic inflammation and promoting fatty acid metabolism.

CONCLUSION

This study successfully developed a Manila tamarind-based instant soup mix tailored to support liver health, leveraging the hepatoprotective properties of antioxidant-rich ingredients. Sensory evaluations showed a preference for the 20 g Manila tamarind variant, indicating high consumer acceptability. Nutritional analysis highlighted the soup mix as a high-fiber, low-fat option, supporting liver health goals like improved digestion and reduced hepatic fat accumulation. The antioxidant capacity, as demonstrated by the DPPH assay, showed dose-dependent radical scavenging activity, which may aid in reducing oxidative stress-a contributor to liver damage. Molecular docking results revealed that active compounds in the soup mix, including glycidol and dihydroxyacetone, exhibited strong binding affinities with PPAR-α, a receptor involved in lipid metabolism and inflammation regulation in the liver. This suggests the soup mix's potential to support liver health through multiple mechanisms. Future research could explore long-term impacts of regular intake on liver health and additional pharmacokinetic evaluations of active compounds.

Conflict of interest

There were no documented conflicts of interest by the authors of the paper.

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