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Analysis Of Saraca Asoca (ROXB.) Wild. Activity In Dyslipidemia And Obesity Through Protein Docking And Network Drug Discovery

Dr. Shweta Yaragatti[1], Dr. Santhosh N[2], Dr. Soundarya RJ[3], Dr. Sri Venkata Krishnan V[4]*

[1]Assistant Professor, Department of Dravyaguna, KLE Academy of Higher Education & Research (KAHER's) Shri B.M.K Ayurveda Mahavidyalaya, Belagavi - 590003, Karnataka, India,
shwetay.kaher@kleayurworld.edu.in
[2]Postgraduate Scholar, Department of Dravyaguna, KLE Academy of Higher Education & Research (KAHER's) Shri B.M.K Ayurveda Mahavidyalaya, Belagavi - 590003, Karnataka, India,
santhoshgowdabelli79@gmail.com
[3]Assistant Professor, Department of Dravyaguna, KLE Academy of Higher Education & Research (KAHER's) Shri B.M.K Ayurveda Mahavidyalaya, Belagavi - 590003, Karnataka, India,
soundaryagrj56@gmail.com
[4]Postgraduate Scholar, Department of Dravyaguna, KLE Academy of Higher Education & Research (KAHER's) Shri B.M.K Ayurveda Mahavidyalaya, Belagavi - 590003, Karnataka, India,
srivenkatakrishnan1999@gmail.com
Corresponding author: Dr. Sri Venkata Krishnan V,
email id: srivenkatakrishnan1999@gmail.com

ABSTRACT:
In this generation, the two most prevalent lifestyle disorders are obesity and dyslipidemia. The prevalence of both conditions has been rising in recent decades, beginning around age five. High calorie diets are one of the primary reasons of this. Modern drugs used to treat both conditions have a number of adverse effects, including numbness, insomnia, and sensory distortion. Even if surgery is used to treat both conditions, the likelihood of experiencing these side effects is assured. In order to cure various ailments, plant-based therapy is the preferred option. In Indian traditional medicine, the plant Saraca asoca (Roxb.) Wild is used to treat both dyslipidemia and obesity. Therefore, using network pharmacology and molecular docking analysis, this study aimed to assess the effects of Saracca asoca phytochemicals on the disease targets of obesity and dyslipidemia. In dyslipidemia, there were nine phytochemicals, and in obesity, there were eight, although in both conditions, the total targets were thirty and thirty, respectively. In both diseases, quercetin was the prevalent phytochemical. While linoleic acid and apigenin were beneficial for dyslipidemia, epicatechin and oleic acid were proven to be effective for obesity. The molecular docking analysis exhibited the action of quercetin in both the conditions through CYP1A1 and AKR1C3 in dyslipidemia and obesity respectively. Further evaluation of Saraca asoca in pre-clinical and clinical trials will reveal its safety and efficacy for a further more step in drug discovery.

Key words: *Obesity, Dyslipidemia, In-silico analysis, Traditional medicine.*

1. INTRODUCTION:

Due to our flawed lifestyle, the prevalence of lifestyle disorders has dramatically increased in recent years. About 890 million adults (1 in 8) were obese in 2022, and another 2.5 billion people were overweight. Over 390 million children between the ages of five and nineteen suffer from childhood obesity, and 37 million children under the age of five suffer from it. It is estimated that by 2035, about 3 billion people—mostly in low- and middle-income countries—will be overweight or obese. Compared to the costs of smoking and armed war, obesity is predicted to have an annual worldwide economic impact of $2 trillion.[1] The most prevalent kind of dyslipidaemia, hypercholesterolemia, is linked to a higher risk of cardiovascular disease. In 1990, raised plasma LDL-cholesterol levels were the 15th most important risk factor for death; by 2007, that number had risen to 11th, and by 2019, it had risen to 8th. Over the previous 30 years, the prevalence of dyslipidaemias has grown worldwide. [2]

The traditional medicines which are prepared out of herbs and plants have been a boon for our disease for a very long time. One such plant which was given and which is given in the current practice of traditional medicine system of India is Ashoka (Saraca asoca (Roxb.) Wild.), this tree though has many potential effects on health-

related conditions this is extensively practiced and used in various metabolic and lifestyle disorders such as PCOS/PCOD, Obesity and dyslipidaemia. Various medicinal preparations related to Indian traditional medicine has Ashoka in it which are used in case of obesity and dyslipidaemia. The main drawback of Western system of medicine is the side-effects on prolonged usage of the medications prescribed in case of both obesity and dyslipidaemia. Faecal incontinence, flatus in discharge, dysgeusia, paraesthesia, insomnia, dizziness and vomiting which are one of the few commonest side-effects of Anti-dyslipidaemic and Anti-obesity medication. [3] Lipo-suction is one of the choices for surgery also has major side effects DVT (Deep vein thrombosis), Fat embolism syndrome, Fulminant infection, thromboembolism and etc. [4]
Here comes the need of traditional medicine with more efficacy and lesser side effects, Saraca asoca (Roxb.) Wild. which has proven its effects on various activities such as Anti-cancer, Anti-microbial, hypolipidemic, cardioprotective, anti-arthritic and anti-inflammatory is a effective Ayurvedic plant that has been used since ages.[5] Though the in-vitro analysis of any plant will give its activity, the mode of action of the plant through which Phyto-targets the plant act on the disease target can come to a clear picture using in-silico analysis and molecular docking. So, we thought to opt the in-silico analysis of Saraca asoca (Roxb.) Wild. so as to study its mode of action in both dyslipidaemia and obesity.

2. MATERIALS AND METHODS:

2.1. Phytochemicals of Saraca asoca (Roxb.) Wild and related disease targets gathered from biological databases:

IMPPAT 2.0 (Indian Medicinal Plants, Phytochemistry, and Therapeutics 2.0) [6] and Dr. Duke's Phytochemical and Ethnobotanical Databases [7] both contained references to Saraca asoca followed by this literature review was done with 2 articles and the phytochemicals such as gallic acid, epicatechnin and catechin were taken from these articles.[8][5] Drug likeliness and oral bio availability were the two main criteria for selection of the phytochemicals from these databases and articles. Followed by this the canonical Smilies were obtained from PubChem database. [9] Several ADME variables were then predicted using the SwissADME database [10]. The Saraca asoca phytochemicals' target was identified using BindingDB [11], an online service that uses similarities and has a similarity score of ≥0.85. Once the disease targets associated with each phytochemical related to Saraca asoca were obtained, the target names were standardized using the UniProtKB database. [12]

2.2. Exploration of Target Genes Associated with Obesity and Dyslipidemia from GeneCard and The Human Protein Atlas (HPA) databases:

We collected data on therapeutic targets associated with obesity using the Human Protein Atlas [13] and GeneCards [14] database gateways. The phrase "obesity" and “dyslipidaemia” to identify targets. The overlapping disease targets from Saraca asoca in both obesity and dyslipidemia were filtered using the Venny 2.1.0 tool. [15]

2.3. Network construction: Protein- Protein interaction (PPI):

To understand a connection consisting of interconnecting target genes for important phytochemicals in Saraca asoca, a PPI network was built using STRING version 11.0. [16] The species we selected for reliability validation was "Homo sapiens," and a medium level of confidence was established at 0.50 FDR.

2.4. Analysis of KEGG pathway:

The possible targets of Saraca asoca effect on obesity and dyslipidemia were entered in a string database after Homo sapiens was chosen as the species, and followed by this KEGG analysis was performed. Following that, FDR was used to filter the results. A selection and outline of the pathways were made.

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2.5. Linking the Network of Disease & Phyto targets along with the phytochemicals:

After exporting and processing data about active phytochemicals, enriched pathways, and intersecting targets, Cytoscape 3.7.2 was used to construct the Saraca asoca network. [17] For the topological evaluation, the network analyser was utilized. The degree strength of the network was examined in order to determine the role and relationship between the active phytochemicals and the overlapping targets of both dyslipidaemia and obesity.

2.6. Molecular Docking analysis:

The crystal structures of the top three compounds and the three most important target proteins were obtained from the RCSB PDB [18] and Pubchem databases, respectively. Using the Biovia DS program, water molecules were eliminated and polar connections were added to stabilize the protein structures. The docking approach was employed to predict the binding relationship of top target proteins and ligands, while PyRx software [19] was utilized to automatically identify binding sites. The interaction with the best docking scores in two and three dimensions has been demonstrated using the Biovia Discovery Studio application.

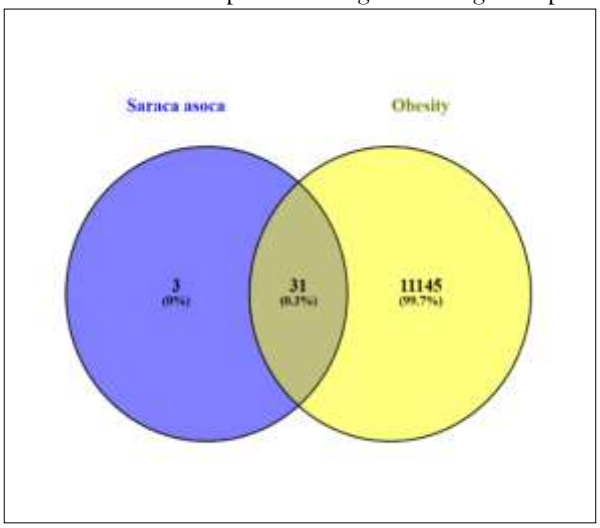
3. RESULT:

3.1. Phytochemical analysis of Saraca asoca and related disease targets using biological databases:

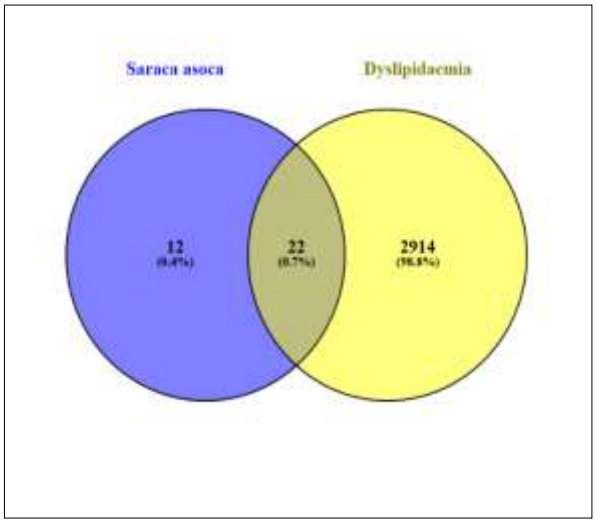
A total of 59 phytochemicals was derived from IMPPAT database, there was no available phytochemicals in Dr. Dukes Phytochemical and Ethnobotanical Databases. There were total of 19 phytochemicals obtained through the articles. In total of after sorting both the available data we got a total of 52 phytochemicals on the whole. 16 phytochemicals were selected based on their oral absorption, bioavailability, and Lipinski violation after being screened for toxicity and ADME using the SwissADME and PubChem databases. In relation to these 16 active phytochemicals, we collected and identified 34 target genes overall using the BindingDB and Uniprot databases.

3.2. Retrieval of Target Genes Associated with Obesity from the GeneCard and Human Protein Atlas (HPA) databases:

The terms "obesity" and "dyslipidemia" were used to extract curated gene-disease data from the GeneCard and HPA databases. 11243 genes linked to obesity were discovered via a comprehensive screening process that eliminated duplicate genes. A total of 2937 genes linked to dyslipidaemia were also found in the screening. With the help of the Venny 2.1.0 tool, the genes linked to obesity & dyslipidaemia and Phyto targets in Saraca asoca (34) were intersected in order to further get the overlapping gene. A total of 31 Phyto-targets were found to be in common in case Saraca asoca & obesity and in dyslipidaemia & Saraca asoca 22 targets were found to be in common and it is depicted in Fig.1 and Fig.2 respectively.



Saraca asoca in obesity Fig.1



Saraca asoca in dyslipidaemia Fig.2

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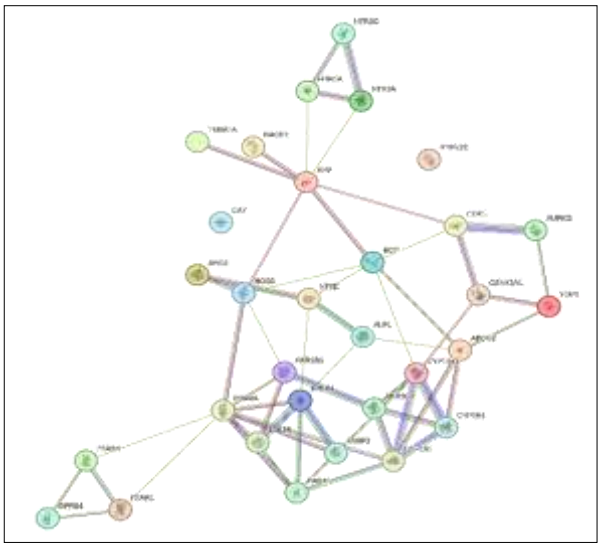
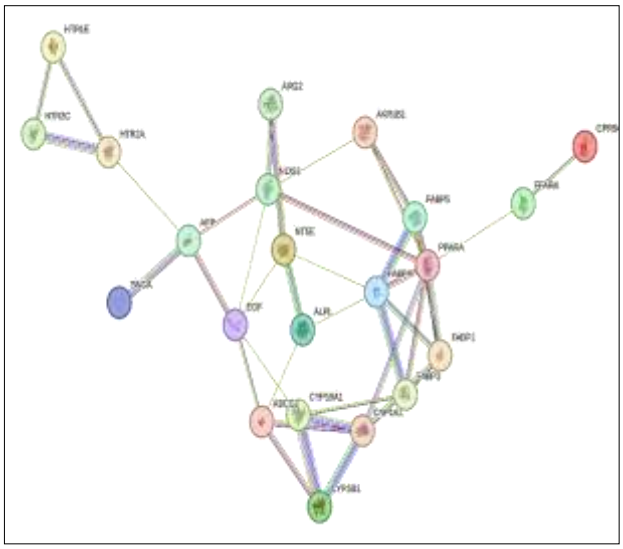
3.3. Building a network: Interaction between proteins:

A PPI network was built using the String database. 22 common targets associated with Saraca asoca in dyslipidemia (Fig.4) and 31 in obesity (Fig.3) were imported into the String platform. A medium degree of confidence, set at 0.50, was used to create the PPI network.



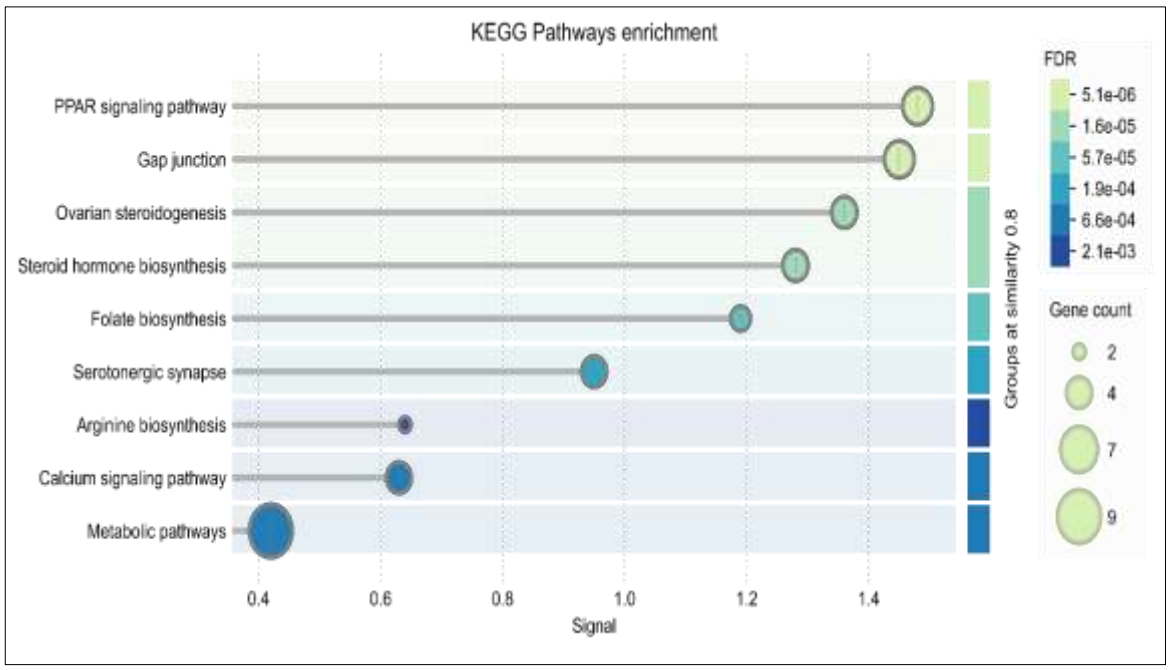
PPI of Saraca asoca in Obesity Fig.3.



PPI of Saraca asoca in Dyslipidemia Fig. 4

3.4. Analysis of the pathways obtained from STRING:

Using the STRING database, KEGG functional enrichment analysis was performed to look into the signalling pathways. A total of 9 pathways in obesity and 11 pathways in dyslipidaemia was obtained and scrutiny of these pathways were done so as to know how does Saraca asoca acts through this pathway in the selected disease. These pathways of Obesity and Dyslipidaemia are attached in Fig.5 and Fig.6 respectively. There were 6 common pathways for both the disease among the obtained pathways.



KEGG pathways of Obesity. Fig. 5

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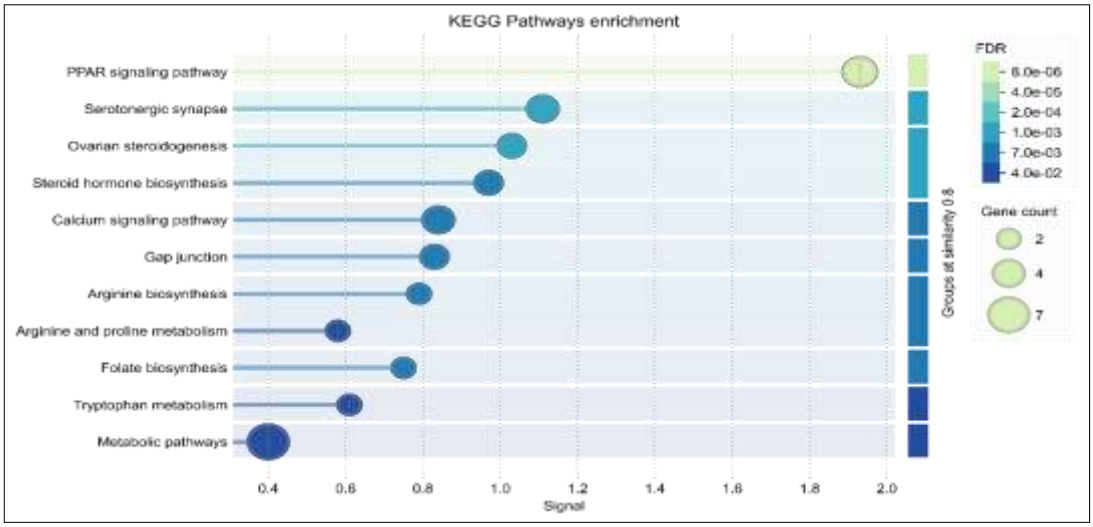
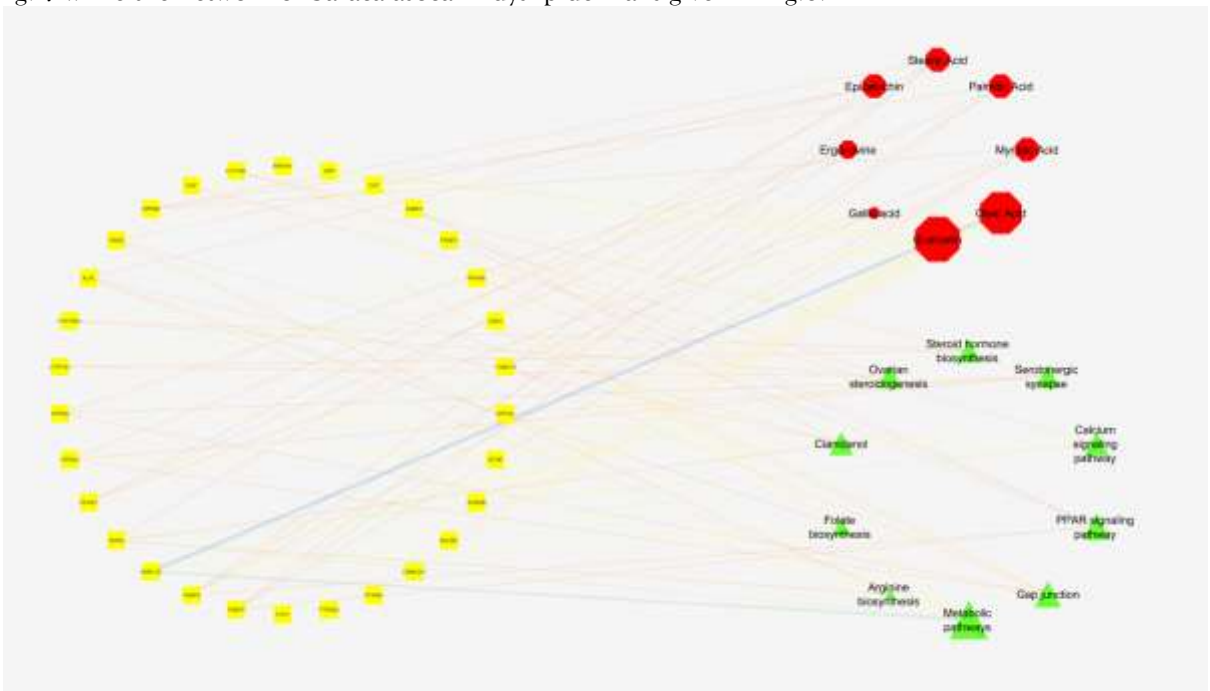


KEGG pathways of Dyslipidemia Fig. 6

3.5. Network construction:

The construction of the network was done using the software Cytoscape 3.7.2 in both the disease with obesity having a total of 8 phytochemicals, 9 pathways and 30 targets. Dyslipidemia had a total of 9 phytochemical, 11 pathways and 31 targets while doing the network construction. The network of Saraca asoca in obesity is given in Fig. 7 while the network of Saraca asoca in dyslipidemia is given in fig.8.



Network of Saraca asoca in obesity. Fig. 7

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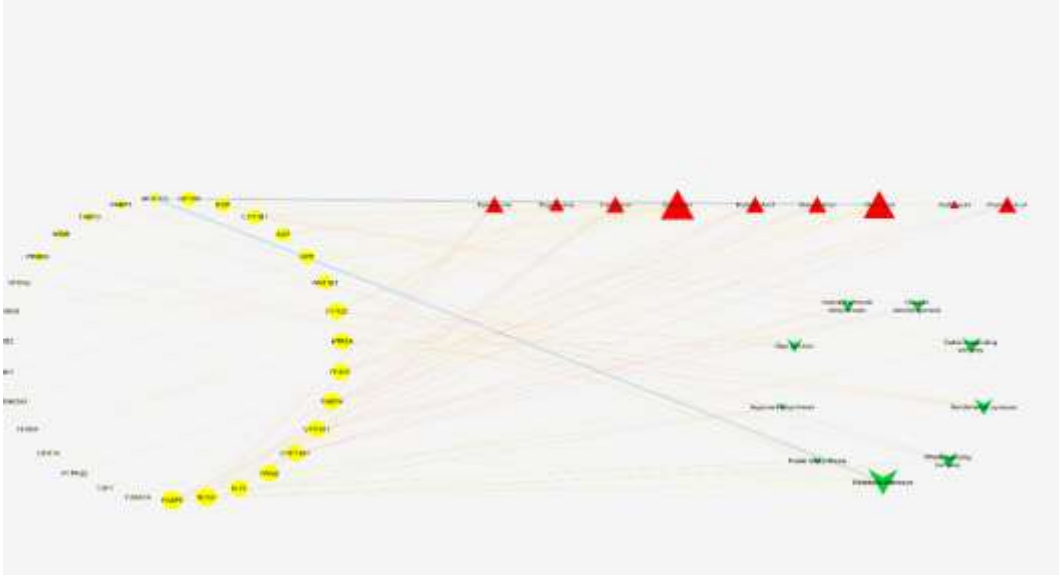

Network of Saraca asoca in Dyslipidemia Fig.8

3.6. Analysis of Molecular docking:

The validity of the networks connecting the three hub targets and bioactive phytochemicals, as well as potential binding procedures have been studied using docking of molecules. Three phytochemicals of dyslipidemia i.e. Quercetin, Apigenin and Linoleic acid showed good interaction with the three targets CYP1A1, FABP4 and FABP5. While in obesity the three phytochemicals that is quercetin, epicatechin and oleic acid showed good interaction with the three targets AKR1C3, FABP4 and FABP5. The binding energies were kept at the rate of ≥ 5 and these targets and phytochemicals were chosen. The interaction between the phytochemicals and targets are given in the table 1 and 2.

Phytochemical	Binding affinity		
	FABP4 (6ljt)	FABP5 (5ura)	AKR1C3 (4dbs)
Quercetin	-7.9	-8.2	-9.5
Oleic acid	-6.2	-5.3	-6.9
Epicatechin	-7.8	-7.8	-9.7

Table.1. Protein docking of Saraca asoca in Obesity

Phytochemical	Binding affinity		
	FABP4 (6ljt)	FABP5 (5ura)	CYP1A1 (4i8v)
Quercetin	-7.9	-8.2	-10.4
Linoleic acid	-5.8	-6.1	-5.3
Apigenin	-8.1	-8.3	-7.3

Table.2. Protein docking of Saraca asoca in Dyslipidaemia

4. DISCUSSION:

The bark of Saraca asoca has a warty, occasionally fractured surface and is dark brown, grey, or nearly black with reddish wood. The bark has a bitter, sweet, and astringent flavour and is smooth with round lenticels and channelled. The leaves are lengthy, corky at the base, bitter, and glabrous. The dense axillary corymbs of orange and yellow blooms are visible throughout the year, although they are particularly conspicuous from January to March. They are aromatic, staminate, hermaphrodite, and have an astringent flavor. [20] An in-vivo study on Saraca asoca has proven its effectiveness in obesity, when it was given in Wistar female rats the results also demonstrate that by preventing weight growth, taking extract supplements at a dose of 400 mg/kg can help maintain current

body weight. Additionally, each extract reduced TG, total cholesterol, and LDL cholesterol levels in the blood. The decrease in serum lipid profiles indicated that each extract might lessen the accumulation of fat in tissues by delaying the release of lipids into the bloodstream. These results support the hypothesis that the extracts may reduce the level of obesity caused by a high fat diet by blocking intestinal absorption of dietary fat by inhibiting pancreatic lipase activity. [21] So through these studies we came across the effects of Saraca asoca in obesity and dyslipidaemia but still the mechanism of action of the plant in both the disease is unknown, but after construction of the network in Cytoscape software we came to know there were several phytochemicals and targets with different degree of affinity so the mechanism of action of each phytochemicals, targets and the pathway through which Saraca asoca works on obesity and dyslipidemia is discussed here.

4.1. Mechanism of action of Phytochemicals derived in Network:

Quercetin in obesity:

Quercetin's inhibitory effects on inflammation and adipogenesis were confirmed in a study using a mouse model. Quercetin decreased mice's body weight by over 40% while suppressing the expression of cytokines linked to inflammation, adipogenesis, and lipogenesis. Quercetin may be a viable therapeutic agent for other metabolic illnesses by reducing obesity and inflammation induced by obesity. Quercetin reduces lipid accumulation not only in cell models but also in animal models. [22]

Oleic acid in obesity:

Body weight, energy expenditure, and fat balance may all be impacted by diets high in Oleic acid. Crucially, after consuming meals high in Oleic acid, abdominal fat and obesity can be decreased. Mechanistically, by promoting AMP-activated protein kinase signalling, meals high in Oleic acid may modulate diet, weight and energy expenditure. The inhibition of the nucleotide-binding oligomerization domain-like receptor 3/caspase-1 inflammasome pathway, the stimulation of oleoylethanolamide synthesis, and maybe the suppression of stearoyl-CoA desaturase 1 activity are other hypothesized mechanisms. [23]

Epicatechin in obesity:

Epicatechin's primary pharmacological impact is myostatin inhibitory activity, which has been previously stated in both phytochemical and animal model research. The change in myostatin is directly related to the Sarcopenic Obesity. Epicatechin may be a viable option for treating Sarcopenic Obesity and its associated complications, according to preclinical and clinical research. [24]

Quercetin in Dyslipidaemia:

Quercetin's antihyperlipidemic effects could be due to multiple mechanisms. The epithelial cholesterol transporter Niemann-Pick C1-like 1 (NPC1L1) is downregulated by quercetin, which specifically inhibits intestinal cholesterol absorption and may reduce increased blood cholesterol levels. Supplementing mice with quercetin alleviated dyslipidemia by reducing oxidative stress, increasing PPARα expression, and improving the expression of many genes related to lipid metabolism. [25]

Apigenin in Dyslipidaemia:

The way apigenin lowers blood fat is correlated with the mRNA levels of the three key proteins involved in cholesterol metabolism (HMG-CoAR, CYP7A1, and LDL-R). In the liver, CYP7A1 is an essential enzyme that transforms cholesterol into bile acid. LDL-R is an important receptor that helps the liver absorb LDL-C. In contrast to the normal control group, the model group's mice's liver mRNA levels of CYP7A1, HMG-CoAR, and LDL-R sharply decreased after being fed a high-fat diet. Apigenin may cause the expression levels of these genes to resemble normal levels. [26]

Linoleic acid in Dyslipidaemia:

By affecting the crucial proteins and enzymes involved in lipid synthesis, linoleic acid may affect lipid regulation. But by boosting the expression of the peroxisome proliferator-activated receptor (PPAR), an enzyme that is essential for fatty acid oxidation and lipid metabolism, and lowering the expression of the vital enzymes fatty acid synthase (FAS) and HMG-CoA-Hydroxy-3-Methylglutaryl CoA Reductase (HMG-CoAR) in lipid synthesis, n-3

PUFA consumption may reduce TG accumulation. LA may regulate blood lipid levels in a number of ways. By increasing the expression of the LDL receptor (LDLR) in the liver, dietary ingestion of LA reduced liver adipogenesis. By increasing LDLR on liver cells and decreasing blood levels of proprotein convertase subtilisin/kexin type 9 (PCSK9), the LA-rich diet enhanced the blood's capacity to eliminate LDL. [27]

4.2. Action of the targets:

Fatty acid binding protein (FABP5 & FABP4) in obesity:

FABP4/5 is a non-viral gene delivery strategy that targets mature adipocytes specifically and simultaneously mutates FABP4 and FABP5 using the oligopeptide (ATS9R). For possible future therapeutic usage to increase patient compliance, FABP4/5 was administered intraperitoneally and subcutaneously to an obese animal model. The dual gene effectiveness of both approaches in visceral adipose tissues was startling. In a mouse model of type 2 diabetes caused by a high-fat diet, dual gene silencing also successfully improved insulin sensitivity, decreased obesity, and restored hepatic metabolism. Targeted-dual gene silencing of FABP4/5 in adipose tissues shown beneficial effects against liraglutide and synergistic effects to overcome obesity and obesity-induced metabolic diseases, indicating vast potential for future translational research. [28]

Aldoketoreductase 1C3 (AKR1C3) in obesity:

Characterizing AKR1C3 expression in adipose tissue and adipocytes and looking into its possible connection to the metabolic syndrome were the goals of this investigation. Using microarray analysis, the levels of AKR1C3 expression in adipose tissue were somewhat lower in obese individuals with metabolic syndrome than in healthy obese individuals. AKR1C3 mRNA levels in adipose tissue decreased both during and after diet-induced weight loss in comparison to pre-diet levels. Prior to beginning the diet, there was a correlation between the expression of the AKR1C3 gene and the amounts of leptin in the serum and adipose tissue mRNA. Additionally, AKR1C3 expression was higher in large adipocytes than in small adipocytes. It is correlated with leptin levels and may be impacted by metabolic diseases. Additionally, AKR1C3 expression is dramatically decreased in response to diet-induced weight loss. [29]

CYP1A1 (Cytochrome 450 1A1) in Dyslipidaemia:

In rats, CYP1A1 deletion blocked the cholesterol metabolic network, causing cholesterol and cholesteryl ester to build up. On the one hand, the promotion of lipogenesis and activation of the LXRα–SREBP1–SCD1 pathway were caused by the increase in cholesterol level. However, the buildup of cholesterol may also be a factor in the inhibition of CES1, which ultimately leads to a rise in the deposition of cholesteryl esters. Crucially, CYP1A1 activation may be able to reverse the deposition of cholesterol in rat models of hypercholesteremia. The significant function that CYP1A1 plays in maintaining cholesterol homeostasis was discovered in this work, opening up new avenues for the management of hypercholesterolemia. [30]

Fatty acid binding protein 4/5 (FABP4/5) in Dyslipidaemia:

Recent onset Baseline FABP4 levels in plasma were associated with atherosclerotic disease. There is evidence that women are more vulnerable than men. The highest tertile of FABP4 had a 2.54-fold increased relative risk of illness development for women. Elevated levels of plasma FABP4 may be a sign of metabolic disruption that could predict the development of atherosclerotic disease in women. [31]. In animal models, FABP4/5 inhibitors improved dyslipidemia. There are some of the most potent and thoroughly researched FABP4/5 inhibitors on the market. These compounds are part of the expanding group of FABP4 inhibitors, which can be employed as tools to study the biology of FABP4/5 and as models for future drug development. [32]

4.3. Pathway & its mechanism in disease:

RAS pathway in dyslipidemia:

Patients with CAD are often at high risk for atherosclerotic disease due to dyslipidemia. Clinical study data point to the possibility of lipoprotein-neurohormonal interactions that could negatively impact the ultrastructure and function of blood vessels. Preclinical data indicate that aberrant lipid levels, most likely through the synthesis of ox-LDL, up-regulate RAS. However, when RAS is activated, reactive oxygen species are released, LDL is

transcriptionally up-regulated, and macrophages, smooth muscle cells, and endothelial cells absorb more ox-LDL. The following are typical consequences of both RAS and dyslipidemia:
1. Reactive oxygen species production and release
2. Programmed cell death, or apoptosis
3. Expression of cytokines and adhesion molecules. [33]

PPAR signalling pathway in obesity:
The data showed that the groups under study had varied patterns of PPARG expression. PPARG may play a regulatory role in absolute fat mass accumulation and the development of obesity, given its strong association with the lipid profile and demographic traits (BMI, hipline, and WC) of obese people. Furthermore, PPARG's participation in the insulin signaling pathway and its potential pathophysiological significance in the development of obesity issues may be explained by the association between its transcript and glycemic control profile in diabetic obese people. All of these findings point to the possibility that the possible alteration in PPARG expression could yield more information about obesity. [34]
Thus, with the above said references we came to know how does Saraca asoca acts on obesity and dyslipidemia with the pathway, targets and the phytochemicals. The docking of the phytochemicals and targets also found out that Quercetin is acting in case of both Obesity and Dyslipidaemia with lowest binding affinity i.e. CYP1A1 and AKR1C3 in dyslipidaemia and obesity respectively. Linoleic acid though showed higher degree while network construction has highest binding energy and the results of protein docking were not satisfactory. This study does, however, have a number of shortcomings. First, our similarity-based method for examining likely targets of bioactive compounds was not as reliable due to the quality of the databases that were available at the time. Additionally, target prediction techniques only cover a few hundred to thousands of targets, which may introduce biases into the enrichment. Safety and effectiveness assessments, which will be needed, and those can only be determined through pre-clinical and clinical trials instead.

5. CONCLUSION:
The Bio-informatics has drastically reduced the time of drug discovery. Proper selection of the drug which will act on a particular disease is needed and through Protein docking and network drug discovery we can come to a conclusion that this particular drug will act on this particular disease in certain pathway using the Phyto-targets of the plant which will bind to the disease target and help in easy recovery of the ailment.
Lifestyle disorders are having a high prevalence in the society, with this prevalence, safer and result yielding drug is the main moto of medicinal society. Saraca asoca has proven its efficacy in both obesity and dyslipidemia with a good number of phytochemicals such as Quercetin, Apigenin and Linoleic acid in dyslipidaemia, while in obesity it does the anti-obesity activity with the help of Quercetin, Epicatechin and Oleic acid.
Though the main aim of the study whether Saraca asoca's has activity on obesity and dyslipidaemia is proved in this work, still the study lacks in areas such as part used, dosage, toxicity, mode and time of administration. These lacunas can be full-filled with the help of in-vitro, in-vivo and followed by these a clinical trial on human subjects will be required to bring the real outcome of this study.

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Nil

CONFLICT OF INTEREST:
There is no conflict of interest.

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Abbreviations:

1. LDL – Low Density Lipoprotein
2. PCOS/PCOD – Poly Cystic Ovarian Syndrome/ Disease
3. IMPPAT - Indian Medicinal Plants, Phytochemistry, and Therapeutics
4. ADME – Absorption, Distribution, Metabolism and Excretion
5. PDB – Protein Data Bank
6. HPA – Human Protein Atlas
7. PPI – Protein – Protin Interaction
8. KEGG – Kyoto Encyclopedia of Genes and Genomes