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Evaluation of Cardioprotective effect of *Musa balbisiana*: A Clinical Study

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Abstract:

Heart ailments continue to be the leading causes of death around the world and include Hypertension, Atherosclerosis, and Myocardial stress. Under the category of Hridaya Roga in Ayurveda, such disorders are caused due to tridoshas especially, the imbalance of Vata (irregular circulation of blood) and Kapha (obstruction of blood channels or Srotas).

In the category of Kaphaja Nanatmaja Vyadhi is Dhamani Pratichaya which according to Acharya Chakrapani Dutta means Dhamani Upalepa and Siraja Granthi. These two categories might be compared with Atherosclerosis and Arterial embolism. Both such types of problems are prevalent in patients of Hyperlipidaemia where there are fat particles in the blood vessels leading to constrictions in vessels. At the same time, there is a possibility of embolisms in vessels.

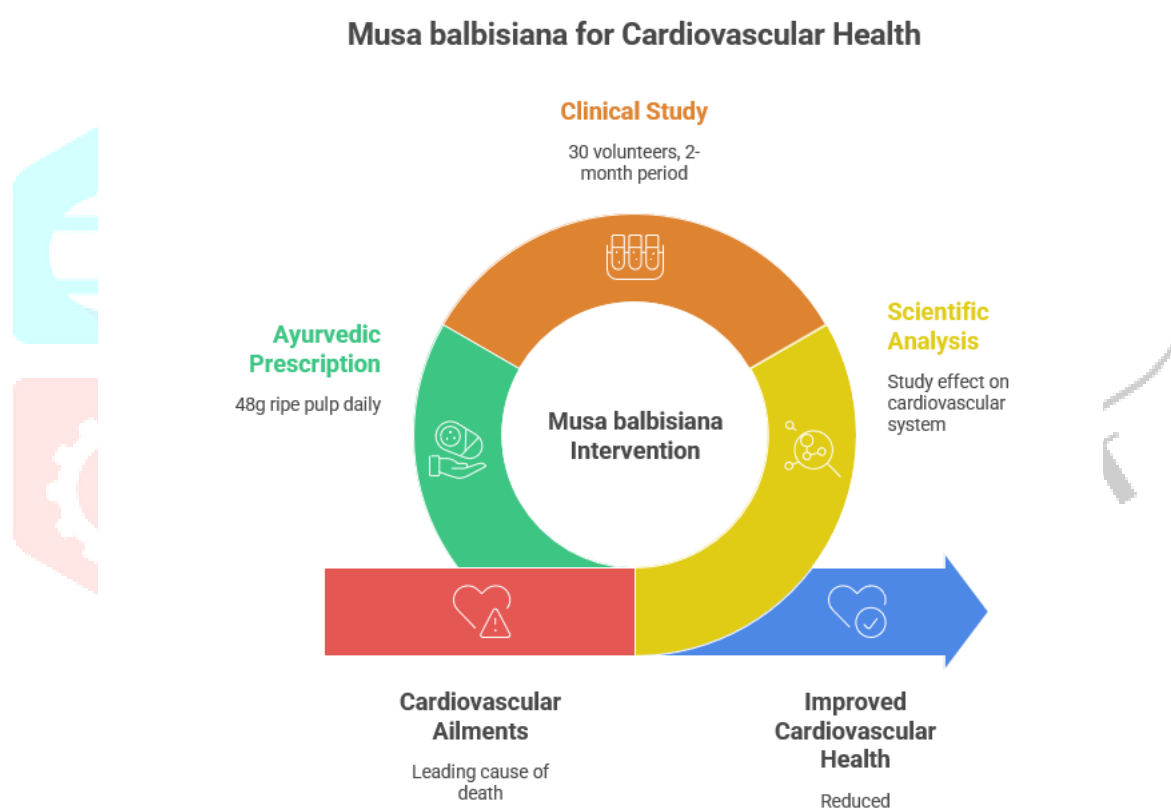
Musa balbisiana (commonly known as bhimkol), which is abundantly grown only in the Northeast region, particularly in Assam, is a unique species of Banana, which is greatly loved by all the social strata due to its high nutritive value and availability throughout the year (Borborah et al., 2016). *Musa balbisiana* is extraordinarily abundant in seeds and fibrous flesh, which contains a considerable amount of potassium (395.20 ± 9.5 mg/100g) and polyphenols such as rutin and quercetin, which are necessary for the maintenance of cardiovascular stability (Sarma et al., 2022). Earlier researches have shown that *Musa balbisiana* possesses antioxidant property along with several phytochemicals, which have various pharmacological actions such as antidiabetic, antibacterial, anticancer, and hepatoprotective activities (Swargiary et al., 2021).

Thus, an effort has been made to scientifically analyse the effect of *Musa balbisiana* on the cardiovascular system in relation to hyperlipidemia.

The sample size comprised 30 volunteers who were subjected to the study to determine the efficacy of ripe pulp of *Musa balbisiana* as an anti-lipidemic drug for a period of two months. Before conducting the study, the volunteers' blood samples were collected and analysed for their lipid profile, which was later repeated after administering the ripe pulp of *Musa balbisiana* in an appropriate dose.

As per the recommendation of the Ayurvedic Encyclopedia, 48 gms of ripe pulp of *Musa balbisiana* was prescribed to the volunteers on empty stomach after breakfast. The study has produced highly positive outcomes in the management of elevated triglycerides and low-density lipoprotein cholesterol (LDL). But an increase in high-density lipoprotein cholesterol (HDL) was also observed during the study.

Keywords: Hyperlipidemia, Sthaulya, Atherosclerosis, Medaroga, Cardiovascular diseases, Cholesterol, Ama



1. Introduction

1.1) The Global Evolution of Cardiovascular Pathology

Cardiovascular disease is no longer an issue affecting only the elites since it has evolved from a disease of the elite to a global issue transcending all financial frontiers (Swargiary et al., 2021). Cardiovascular diseases are diverse and involve a broad spectrum of disorders, including coronary artery diseases, cerebrovascular diseases, and peripheral artery diseases. Cardiovascular disease can be defined as a progressive inflammatory disease that arises due to endothelial dysfunction, systemic hypertension, and lipid oxidation (Kumari et al., 2020). The pathophysiology of cardiovascular disease is linked to oxidative stress and inflammation. According to Sarma et al., 2022, oxidative stress leads to the increased production of reactive oxygen species, inflammation, expression of inflammatory mediators such as $\text{TNF-}\alpha$ and $\text{TGF-}\beta$.

β , and mitochondrial dysfunction during cellular metabolism. These mechanisms directly contribute to endothelial dysfunction and atherosclerotic plaque formation.

According to Kumari et al., 2020, pathological features in cardiovascular diseases such as cardiac hypertrophy are accompanied by upregulation of pathological markers such as ANP, BNP, and β -MHC as well as higher expression of collagen-1 gene expression that causes cardiac fibrosis. Inflammation and oxidative stress were identified as key factors involved in the pathophysiology of heart diseases.

However, another equally important element of cardiovascular pathophysiology is associated with its metabolic feature. As illustrated by the studies conducted by Kalita et al., 2016, a metabolic disturbance is associated with increased levels of lipid metabolism such as those seen in diabetes mellitus, which results in high blood levels of cholesterol (36.2% increase), triglycerides (54.5% increase), and low-density lipoproteins (50.94% increase).

Furthermore, Gurumayum et al., 2023 described that cardiovascular disease pathogenesis is characterized by an altered cellular bioenergetics pathway, with low ATP synthesis capability, defective respiration process, and poor glycolysis. Such cellular dysregulation results in impaired cardiac contractility and enhanced sensitivity to ischemia.

An efficient antioxidant defense mechanism is critical in cardiovascular well-being. Hoang et al., 2023 highlighted the importance of antioxidant ability, where poor antioxidant potential quantified by high IC₅₀ values ($>112.57 \mu\text{g/mL}$ for DPPH and $>14.49 \mu\text{g/mL}$ for ABTS) was associated with cardiovascular disease risk. The study found that anti-inflammatory potential, with IC₅₀ greater than $187.91 \mu\text{g/mL}$, is necessary for preserving cardiovascular equilibrium.

The multifaceted pathophysiology of cardiovascular disease, encompassing oxidative stress, inflammatory response, metabolic disturbance, and cellular bioenergetics dysfunction, requires multi-targeted treatment strategies. Hence, the incorporation of natural molecules with varied biological properties is beneficial in cardiovascular disease management (Swargiary et al., 2021).

1.2 *Musa balbisiana*: The Ancestral Cardiotonic

The *Musa balbisiana* species of wild bananas has great significance both in terms of plant evolution and in traditional medicine (Davey et al., 2013). The contribution of *Musa balbisiana* is seen in providing the B-genome in cultivated banana species along with increased vigor and stress resistance (Wang et al., 2019). This plant has been traditionally utilized for strengthening heart activities, regulating high blood pressure, and increasing circulation in cardiovascular processes in traditional medicines like Ayurvedic practices (Mertens et al., 2022). *Musa balbisiana* can be found in numerous countries of Southeast Asia, including India, Thailand, Philippines, and Indonesia, and exhibits significant variability in genetics (Mertens et al., 2022). The cardiotonic property of the plant can be greatly explained in terms of the abundance of phytonutrients it contains in its structure (Sarma et al., 2022). These substances include flavonoids, phenolic acids, saponins, dietary fibre, potassium, vitamin C, vitamins from B-complex, and other useful minerals. Genetically, over 36,000 functional genes were identified, which participate in the synthesis of bioactive substances, including ethylene and starches (Wang et al., 2019; Shetty SM et al, 20126). Additionally, *Musa balbisiana* has other phytonutrients, including tannins, alkaloids, glycosides, plant sterols (β -sitosterol), fatty acids, and terpenoids (Hoang et al., 2023).

Pharmacologically, *Musa balbisiana* has been found to possess both the hypo-glycemic and hypo-lipidemic activities that form the basis of the cardioprotective actions of the herb. The high levels of the resistant starch and pectins help slow down glucose absorption, whereas the bioactive components of the fruit work against the carbohydrate digestive enzymes such as the α -amylase and α -glucosidase (Gopalan et al., 2018). The experimental data shows that there is a considerable decrease (62.5%) in the levels of fasting blood glucose in animal models suffering from diabetes (Kalita et al., 2016). Moreover, *Musa balbisiana* works

against the lipid levels by inhibiting the absorption of cholesterol and stimulating the secretion of bile acids. The levels of total cholesterol show an impressive reduction by 36.2%, triglyceride reduction by 54.5%, and LDL levels by 50.94%, hence avoiding fatty deposition in arteries and preventing the development of atherosclerosis (Kalita et al., 2016).

1.3 Ayurvedic review of hyperlipidemia:

High levels of serum cholesterol, triglyceride, LDL, and/or reduction in HDL levels define hyperlipidemia, which increases the chances of cardiovascular disorders.

Even though the term hyperlipidemia is not found in any of the ancient ayurvedic texts, clinically, it shows close similarities with Meda Roga and Sthaulya, which are classified under Santarpanjanya Vyadhi, i.e., diseases caused by over-nourishment.

According to Chapter 23 (Santarpanjanya Adhyaya) of the Sutrasthana of Charaka Samhita, indulgence in excessive consumption of Guru, Snigdha, and Madhura substances results in an imbalance of Kaphadosha, followed by an excessive production of Meda Dhatu.

Similarly, according to Sutrasthana Chapter 21 (Astouninditiya Adhyaya), Sthaulya refers to a condition where there is excessive accumulation of Meda, along with decreased physical activities and improper metabolism.

Medadhatvagni imbalance could be equated with disordered lipid metabolism, while the blockage of Medavaha srotas is responsible for hyperlipidemia and atherosclerosis.

Atherosclerosis may be linked with Dhamani Pratichaya. Dhamani Pratichaya is an Ayurvedic term mentioned in Charaka Samhita which implies the pathological state of swelling and prominence of dhamanis (arteries) due to the formation of excessive Kapha and Meda elements within the body. This disease arises due to the consumption of heavy and unctuous foods coupled with lack of movement in the body, thereby causing vitiation of doshas leading to the obstruction of channels (srotas) and thickening of arteries. This condition depicts a pathological state involving the circulation of Rasa and Rakta. From an Ayurvedic point of view, Dhamani Pratichaya signifies a problem related to metabolic imbalance and srotorodha.

The management modalities for this disease are langhana, Lekhana, regulation of diet and vyayama (physical activity), and Vamana-Virechana.

2. Methodology

The present study is an attempt to investigate the cardioprotective and anti-lipidemic potential of *Musa balbisiana*, along with understanding Dhamani Pratichaya as a concept in the management of hyperlipidemia. The study was carried out with the help of a clinical trial in patients having hyperlipidemia through appropriate laboratory test techniques. This study was carried out in the Government Ayurvedic College and Hospital (GACH), Assam.

A total of 30 subjects were selected randomly from the Out Patient Department (OPD) and In-Patient Department (IPD) of the GACH hospital. Subjects whose ages ranged between 20-70 years irrespective of any gender difference were included in this study. Subjects who had agreed to participate in the study after being assured of confidentiality through informed consent were selected in this study. Assessment was done both before and after the intervention of each and every subject depending upon their medical history, subjective and objective assessment.

Lipid profile parameters such as total cholesterol, triglycerides, LDL (Low Density Lipoprotein) and HDL(High Density Lipoprotein) were analysed both before and after the study period for all the subjects. *Musa balbisiana* intervention involved giving 48 gms of ripe pulp of *Musa balbisiana* to all the subjects per day.

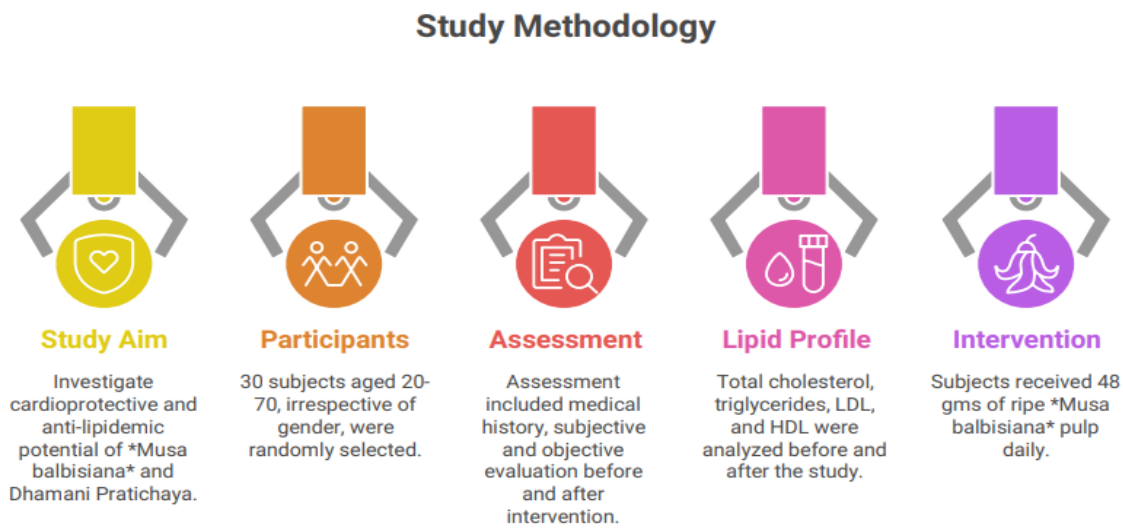


Fig 2: Representation of Study Methodology

3. Results:

Lipid Profile Analysis

The mean values of lipid profile parameters before and after the intervention are presented below. Values are expressed as mean ± standard deviation (SD).

Table 1: Status of mean lipid profile before and after the intervention:

Parameter	Before Treatment (mg/dl)	After Treatment (mg/dl)	Difference (mg/dl)	% Change
Total Cholesterol	175 ± 5.2	148 ± 4.8	27	15.4% ↓
Triglycerides	178 ± 6.1	130 ± 5.5	48	27.0% ↓
HDL Cholesterol	40 ± 3.2	50 ± 3.6	+10	25.0% ↑
LDL Cholesterol	130 ± 4.9	98 ± 4.3	32	24.6% ↓

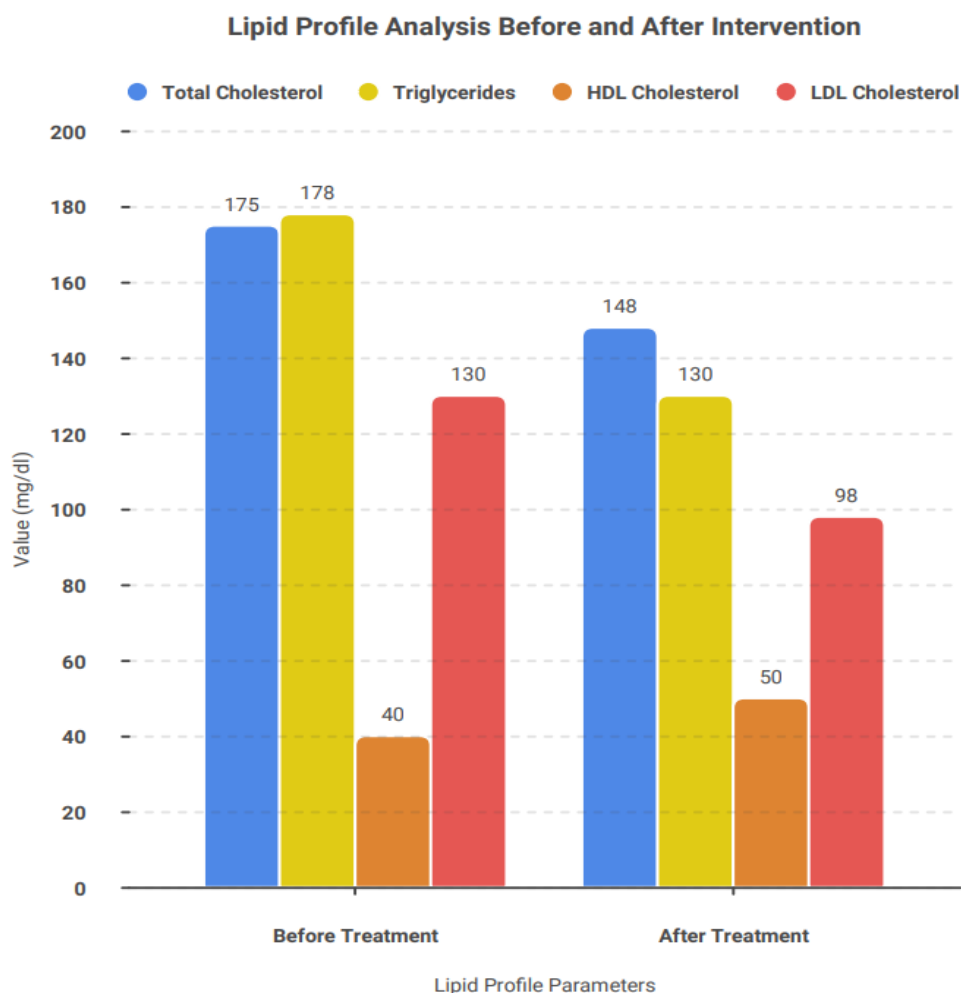


Fig 3: Lipid profile parameters before and after intervention

4. Discussion and Conclusion

The results obtained in this study clearly point out that administration of *Musa balbisiana* for 60 days resulted in significantly improved lipid profile parameters. There was a clear decline in total cholesterol levels from 175 ± 5.2 mg/dl to 148 ± 4.8 mg/dl (−15.4%), triglycerides from 178 ± 6.1 mg/dl to 130 ± 5.5 mg/dl (−27.0%), and LDL cholesterol levels from 130 ± 4.9 mg/dl to 98 ± 4.3 mg/dl (−24.6%). On the other hand, there was an appreciable increase in HDL cholesterol levels from 40 ± 3.2 mg/dl to 50 ± 3.6 mg/dl (+25.0%).

The results obtained are consistent with the previous reports. Kalita et al. (2016) have also described significant hypolipidemic activity of *Musa balbisiana* by lowering total cholesterol (36.2%), triglycerides (54.5%), and LDL cholesterol (50.94%) levels in diabetes-induced animals. The biological mechanisms underlying these activities may include bioactive substances having properties such as antioxidative capacity, decreasing generation of ROS, and reducing pro-inflammatory cytokines such as TNF- α and TGF- β levels; they increase mitochondrial activity and ATP synthesis (Sarma et al., 2022). Compounds, like apiforol, have also been described to have very potent antiglycating potential ($IC_{50} = 114.23 \pm 0.567$ $\mu\text{mol L}^{-1}$) and also facilitate glucose utilization (Gopalan et al., 2018). Genomic analysis by Wang et al. (2019) is also in favor of this report by describing the higher rate of synthesis of bioactive components due to gene duplication involved in ethylene and starch metabolism.

Further proof of cardioprotective action may be attributed to the downregulation of gene expression of indicators for cardiac hypertrophy, namely ANP, BNP, β -MHC, and collagen-1, as well as the reduction

of inflammation and oxidative stress (Kumari et al., 2020; Sarma et al., 2022). Antioxidant effect is provided by phytochemicals such as flavonoids, saponins, chlorogenic acid, gallic acid, p-hydroxybenzoic acid, vanillic acid, and ascorbic acid. Additionally, recent research has found other valuable phytoconstituents in the plant (Gurumayum et al., 2023).

In accordance with the principles of Ayurveda, normalization of the lipid profile is achieved through the restoration of the balance in Meda dhatu and the cleansing of Medovaha srotas. Lekhana effect facilitates the reduction of Kapha and Meda that contributes to normalization of cholesterol and triglyceride levels. High level of HDL demonstrates appropriate functioning of Agni and the lack of Ama formation. Cardioprotective effect corresponds to Hridaya balya action and prevents Dhamani Pratichaya, whereas antioxidative action protects Rasa and Rakta dhatus from pathological changes.

When compared with other existing lipid-lowering medications, Musa balbisiana possesses an effective treatment regime without any toxic effects. Besides antidiabetic and antimicrobial qualities, it also offers cardiovascular benefits making it even more significant for clinical use (Swargiary et al., 2021). Since it is readily accessible and a common remedy in northeast India, its clinical usefulness cannot be overlooked.

In summary, the current investigation supports the use of the Musa balbisiana as an herbal treatment and proves its positive effect on cardiovascular health. The ingestion of ripe fruit pulp leads to favorable changes in the lipogram that makes this drug promising in preventing or treating hyperlipidemia. The combination of modern science and Ayurvedic medicine principles proves even greater significance of its clinical utility. Nevertheless, further research involving many subjects should be conducted before this medication becomes a standardized product.

Conflict of Interest:

It is mentioned by the authors that there are no conflict of interests on the part of the researchers in relation to this study.

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Ethical Approval:

The experimental design used in this study has been approved by the Institutional Ethics Committee at the Government Ayurvedic College and Hospital, Assam. Written informed consent has been taken from all the subjects before involving them in the experiment.

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