BIOLOGICAL INVESTIGATION OF BAEL FRUIT (*AEGEL MARMELOS*) POWDER IN THE MANAGEMENT OF HYPOCHOLESTEREMIA AMONG HUMAN SUBJECTS

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ABSTRACT

Bael (*Aegle marmelos*) is a commonly used medicinal and nutraceutical plant. Its leaves, fruits, stem, and roots have traditionally been used for a variety of medical purposes, including antioxidant, antibacterial, antidiarrheal, antidiabetic, antiproliferative, hepatoprotective, anti-inflammatory, antihyperlipidemic, antiasthmatic, and antiulcer qualities. In addition to conventional diet and medical interventions, identifying nutritious foods with potential functional benefits is critical to preventing metabolic problems. The purpose of current study was conducted to evaluate the effect of Bael Fruit powder in the management of hypercholesterolemia in human male subjects. For this purpose the Bael fruit powder was firstly analyzed for the its chemical and phytochemical composition which showed that Bael Fruit powder contains following proximate content Moisture (1.84 ± 0.030)%, Dry matter (85.13 ± 0.06)%, Nitrogen (1.35 ± 0.02)%, Crude protein (2.21 ± 0.02)%, Crude Ash (1.52 ± 0.04)%, Crude fiber (8.21 ± 0.04)% and crude fat (2.16 ± 0.04)%.along with the appreciable amount of minerals like magnesium (28.73 ± 0.4), calcium (200.9 ± 0.2), potassium (175.9 ± 1.01) respectively. Furthermore, to check its hypercholesremic effect the hypercholesterolemic human male subjects were divided into the experimental and control group in the basis of their inclusion and exclusion criteria. The experimental groups (G_1 and G_2) were given Bael fruit powder capsules of 2g/day/kg/bw to the G1 group and 4g/day/kg/bw to the G2 group for the period of 60 days. Significant reductions in lipid profiles were observed in both the experimental group and G2. Notably, the 4g/kg/bw dosage demonstrated greater reduction compared to the control group by the end of the trial. The study concluded Bael Fruit powder exhibits anti-hypercholesterolemic properties and holds promise as a therapeutic option for managing cardiovascular complications.

Keywords: Bael Fruit, herb, Hypercholesterolemia, Phytochemicals, proximate analysis.

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INTRODUCTION

Hypercholesterolemia is a chronic metabolic disorder characterized by an increase in serum cholesterol levels in the blood plasma, which consists of one or more lipids such as low density lipoprotein (LDL), triglycerides (TG), and very low density lipoprotein (VLDL), as well as a decrease in the glassy of high density lipoprotein (HDL) in plasma. Increase these lipid profiles connected with chronic ailments including heart and atherosclerosis disease. (Faisal *et al.*, 2017). According to the World Health Organization (WHO), hypercholesterolemia affects roughly 42% of the global population. The incidence of hypercholesterolemia is 40.1% among Pakistan's four provinces, with Punjab having the highest rate at 43.7% and Baluchistan having the lowest at 24.8%. According to the World Health Organization (WHO), hypercholesterolemia kills approximately 2.7 million people worldwide each year (Basit *et al.*, 2020). High cholesterol frequently accompanies conditions such as obesity, diabetes, heart disease, and hypertension. Managing these comorbidities is crucial to reduce the risk of complications associated with elevated cholesterol and leading to serious metabolic complications (Duntas and Brenta, 2010). The effect of thyroid disorders on lipid levels and metabolism.

Ayurveda medicinal plants are used to treat different diseases. Many plants have prospective to treat and reduce lipid profile including chia seeds, chamomile, moringa and lemon. Many ailments are treated using plant-based therapies all around the world (Patil et al., 2020). Bael fruit is important economically, medicinally, and nutritionally. Bael fruit contains ingredients that have been shown to offer a number of health benefits, including vitamins (including riboflavin), minerals, trace elements, energy, and phytochemicals (such flavonoids, polyphenols, and antioxidants) (Sharma and Chauhan, 2016).

During the past few decades, bael has been the subject of extensive research using cutting-edge scientific techniques to determine its medicinal properties. This has led to the discovery of a variety of bioactive compounds

that may be used to treat a wide range of illnesses, including rutacine, y-sitosterol, psoralin, xanthotoxin, scopolotein, aegelemine, aegeline, marmeline, fragrine, dictamine, cinnamide, and several derivatives of cinnamide (Bhardwaj and Nandal, 2015).

Traditional medicine has made great advances in treating numerous ailments, there is still a vital research gap regarding the integration of natural food-based medicines. Conventional medications frequently target specific symptoms or biochemical pathways, but they may cause side effects and have limited long-term usefulness. Natural foods, on the other hand, include a wealth of bioactive substances that have the ability to improve one's health.so bael fruits powder was used as natural therapy to manage the hypercholesrlimia to reduce the severe complications like CVDs and related disorders.

MATERIALS AND METHODS

Collection and preparation of raw material: Bael fruit also known as *Agele Marmelos,* dried herb was procured from pansar store. The *Agele Marmelos* fruit was detached from tree and washed thoroughly. The pulp of *A.Marmelos* was discarding from the peel, and cut it into pieces and then dried through solar hybrid connective dry method, which have connected to solar energy. The dry fruit was slog into adequate powder and kept in it tightly closed container at instance temperature (Sarkar *et al.,* 2020)

Chemical and phytochemical composition of Bael fruit powder

Proximate analysis of Bael fruit powder: Using the AOAC technique, the following proximate analyses of bael fruit powder were performed: moisture content, ash, dry matter, crude protein, crude fat, crude fiber, and nitrogen-free extract (NFE) (Garcia-Amezquita et al., 2018).

Minerals determination: Atomic absorption spectrophotometry was used to examine the following minerals: calcium, magnesium, and potassium (Nakharuthai et al., 2020).

Phytochemical screening of Bael fruit powder: Total flavonoids content (TFC), total phenolic content (TPC), and DPPH were determined by phytochemical analysis of Bael fruit powder using the following technique (Naz et al., 2016). DPPH was measured in mg of Gallic acid equivalents (mg GAE/g) per g of dry weight basis of the sample.

Investigation of therapeutic potential of bael fruit powder in management of hypercholesterolemia

Selection of Subjects: 30 hypercholesterolemic human male subjects of age 35-55 years were randomly selected from the general community.

Exclusion criteria: The age of subjects below 35 years along with BMI below 25kgm were not be included in the study. The subjects were not having any other disease except hypercholesterolemia.

Inclusion criteria: Hypercholesterolemic subjects on the basis of their lipid profile were 35-50 years with a body mass index (BMI) of 25-39.9kgm

Study duration: The study was conducted for period of 60 days.

Treatment groups and treatment plan: Human male subjects were divided into three groups consisted equal 10 subjects each group in which G0 were considered as control group was not received any dose and G1 and G2 were considered as experimental group were receiving dose of 2g/kg/bw and 4g/kg/bw respectively of Beal fruit powder in the form of gelatin capsule every day after meal for the period of 60 days

Table 1: **Treatment plan.**

Groups	Title	Treatment
G0	Control group	No treatment/placebo
G1	Treated group 1	Capsule with Bael fruit powder of 2g/kg/bw
G2	Treated group 2	Capsule with Bael fruit powder of 4g/kg/b

Collection of blood samples: Blood samples from the human participants were taken both before and after the study to analyze their lipid profiles and hematological indicators following the method outlined by Means et al. (2023).

Statistical analysis: Data from many investigations were statistically examined using the Analysis of Variance Technique (ANOVA) to determine the level of significance, and the experimental results were further studied to investigate the level of significance ($p<0.05$).

RESULTS

The study was accompanied to examine the therapeutic potential of Bael fruit powder against hypercholesterolemia to check its effectiveness in lowering lipid profile.

Proximate composition of Bael fruit powder: To check the composition of raw material Bael fruit powder were firstly analyzed for its proximate composition and result showed that it contained the following content of moisture (11.2±0.31) %, ash (8.9±0.63) %, nitrogen free

extract (47.5±2.71) %, crude Protein (18.37±0.42) %, crude fiber (13.45±1.02) %, and crude fat (0.62±0.32) % respectively and shown in table 2.

Table 2: P**roximate % composition of Bael fruit powder.**

Proximate features	Composition
Moisture	1.84 ± 0.03
Dry matter	85.13 ± 0.06
Nitrogen	1.35 ± 0.02
Crude protein	2.21 ± 0.02
Crude Ash	1.52 ± 0.04
Crude fiber	8.21 ± 0.04
Crude fat	2.16 ± 0.04

Mineral analysis: In the current study, Bael fruit powder was analyzed for the determination of mineral content by using the atomic absorption spectrophotometry following the method described by AOAC (1990) Results showed that Bael fruit contains magnesium (28.73 ± 0.4), calcium (200.9± 0.2), potassium (175.9 ± 1.01) respectively. These results are shown in mg in 100g in figure 1.

Phytochemical screening of Bael fruit powder: Phenolic and flavonoids are the major components of antioxidant profile and parameter of medicinal plants and herbs that can be used for treatment of various types of diseases. The bael fruit powder carried a significant amount of TPC (238.13±1.89) and TFC (376.45 ± 2.14) and DPPH (76.35 ± 2.89) respectively by method prescribed by Folin-Ciocalteumethod showed in table 3.

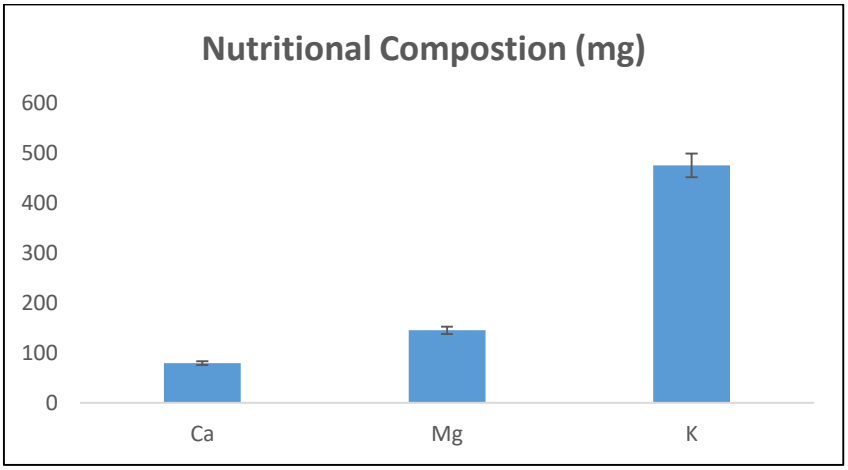

Figure 1: Mineral composition of Bael fruit

Table 3: Phytochemical analysis of Bael Fruit powder

Antioxidant	Antioxidant content (mg GAE/g)
TFC	376.45 ± 2.14
TPC	238.13 ± 1.89
DPPH	76.35 ± 2.89

Investigating the therapeutic potential of bael fruit powder: The purpose of this study was to determine the possible therapeutic advantages of Bael fruit powder in lowering high lipid profiles in 30 hyperlipidemia male individuals. The control group (G0) got no therapy, while treatment groups 1 (G1) and 2 (G2) were given Bael fruit powder in capsule form at doses of 2g/kg/day and 4g/kg/day, respectively, for 60 days. Blood samples were collected from each individual prior to the trial, one month later, and at the conclusion of the study for lipid profile analysis (including HDL, LDL, triglycerides, and total cholesterol).

Effects on serum cholesterol of experimental subjects: In response to Bael fruit powder capsules, the results revealed a substantial ($p<0.05$) decrease in blood cholesterol levels in both treatment groups. The total cholesterol level in group 1 decreased from 221.8±9.89 mg/dl to 198.3±19.3 mg/dl, while the serum cholesterol level in group 2 decreased from 229.3±16.6 mg/dl to 194.4±20.2 mg/dl. The patients who were receiving Bael fruit powder dose 4g/day in G2 showed better results than 2g/d in G1 and G0 showed a significant rise in cholesterol levels.

Table 4: Mean ± S.D for serum cholesterol level of male subjects.

Groups	0 Days	After One Month	After two Month
G0e	225.7 ± 9.26	225.7± 9.26	225.7 ± 9.26

G1	221.8±9.89	207.5 ± 7.48	198.3 ± 19.3
G2	229.3±16.6	211.2 ± 18.1	194.4 ± 20.2

Effects on serum triglycerides level of male subjects: Both experimental groups showed significant results reduce in triglyceride levels from 181.9±14.28mg/dl to 146.6±8.81 mg/dl in G1 and from 209.1±20.65 mg/dl to 134.1±14.1 mg/dl G2 and G0 not show significant results as shown in table 5.

Effects on serum HDL (High Density lipoproteins) levels in male subjects: HDL was increased in the experimental group G1 and G2 as compared to G0. G1 shows a change in HDL from 36.2±4.21 mg/dl to 48.8±7.25 mg/dl and G2 shows an increase in HDL from 43.9±7.93 mg/dl to 58.7±8.82 mg/dl and G0 show no significant results as shown in table 6.

Effects on serum LDL (Low density lipoproteins) levels in human male subjects: LDL was decreased in experimental groups G1 and G2 as compared to G0. G1 shows a change in LDL from133.3±18.08 mg/dl to 102.9±10.45 mg/dl in G1 and from 140.4±16.53 mg/dl to98.6±11.4 mg/dl in G2 and G0 show no significant results as shown in table 7.

Table 5: Triglycerides level in human male subjects.

Groups	0 Day	After one month	After two month
G0	167.3±10.1	168.4±10.1	167.3±10.2
G1	181.9±14.28	166.7±12.98	146.6±8.81
G2	209.1±20.65	160.1±10.79	134.1±14.1

Table 6: HDL level in male subjects.

Groups	0 Day	After one month	After two month
G0	31.1±3.67	31.1±3.67	31.1±3.67
G1	36.2±4.21	43.7±6.15	48.8±7.25
G2	43.9±7.93	52.1±8.06	58.7±8.82

Table 7: LDL level in male subjects

Groups	0 Day	After one month	After two month
G0	170±9.37	170±9.37	170±9.37
G1	133.3±18.08	116.9±10.49	102.9±10.45
G2	140.4±16.53	119.5±8.81	98.6±11.4

DISCUSSION

To evaluate the nutrition composition of bael fruit powder proximate composition were observed firstly as its basic tool. The criteria that make up proximate analysis include crude fiber, crude protein, crude fat, moisture content, and ash content. It was discovered that Bael fruit powder has an 11.2% moisture content. This figure represents the amount of water that the powder contains. Ash content reflects the inorganic components such as minerals and trace elements. NFE, which includes carbohydrates other than fiber, was estimated to be 47.5% This value highlights the carbohydrate content in Bael fruit powder Bael fruit powder contains 18.37% crude protein. Protein is essential for various physiological processes in the body. Crude fiber contributes to dietary fiber, which is important for digestive health. This suggests that it is not a significant source of dietary fat. In a separate study, the protein content of Bael fruit was calculated to be 1.8%. This conclusion is consistent with our research, which likewise showed a modest protein concentration (Sharma et al., 2022).

Another study found a greater crude protein level of 4.7 g/100 g in Bael fruit pulp Current results is slightly lower, but they nonetheless validate Bael's protein content. Overall, Bael fruit powder appears to be a decent source of minerals, carbs, and dietary fibre, making it an important supplement to any diet (Sharma et al., 2022). The mineral requirements of the human body are enormous. Weight change between control and treatment groups However, their absence can cause a number of health problems in the body, such as osteoporosis, arthritis, and tooth decay. The current Results showed that Bael fruit contains magnesium (28.73 ± 0.4) mg/100g, appreciable amount of calcium (200.9± 0.2) mg/100g, potassium (175.9 ± 1.01) mg/100g respectively this finding align with the existing knowledge about Bael fruit's mineral content, emphasizing its health benefits (Rana, 2023). Antioxidants plays a crucial role in neutralizing free radicals and reducing oxidative stress and can be helpful

in management of different metabolic disorders so the current results showed the appreciable quantity of whole phenolic profile of bael fruit powder of TPC (238.13±1.89) and TFC (376.45 ± 2.14) and DPPH (76.35 ± 2.89) respectively Previous research has emphasized the antioxidant properties of Bael fruit. Its phenolic and flavonoid content aid in this activity Bael's antioxidant characteristics make it beneficial to health and wellness. Bael fruit powder can serve as a natural antioxidant source. Incorporating Bael into dietary or therapeutic practices may help combat oxidative stress-related diseases. The existing research manifest that bael fruit powder demonstrates anti-hypercholesterolemia properties as it decreases the level of total cholesterol, triglycerides, LDL and HDL (Jadczak et al., 2019). So Bael fruit powder was checked to lowering high lipid profiles in 30 hyperlipidemia male individuals. The control group (G0) got no therapy, while treatment groups 1 (G1) and 2 (G2) were given Bael fruit powder in capsule form at doses of 2g/kg/day and 4g/kg/day, respectively, for 60 days. Blood samples were collected from each individual prior to the trial, one month later, and at the conclusion of the study for lipid profile analysis (including HDL, LDL, triglycerides, and total cholesterol), which showed that experimental group that were receiving the doses of bael fruit powder showed the significant reduction in overall lipid profile of human male patents specifically the G2 that was receiving 4g/d/kg/bw of bael fruit powder showed more positive results as compared to G1 so these doses did not cause any problem during the whole period of study so it is safe for human consumption and can be used in treatment of different diseases Nutritional analysis, a critical step in maintaining food safety, is an essential component of the quality control process. It is the basis for detailed investigations during sample preparation. After analyzing my sample, the overall assessment shows considerable effects (Sarkar, 2020).

Conclusion: The rising prevalence of hyperlipidemia, which is linked to sedentary lifestyles, dietary patterns, and eating habits, has driven a quest for effective treatment options. In the modern era, herbal medicines have grown in popularity as an alternative to conventional pharmaceuticals. Herbal medicines are typically seen to be safer than chemical drugs since they may have fewer adverse effects. These natural remedies utilize plants' healing capabilities, providing a comprehensive approach to health and wellness. In current research the bael fruit powder was used as natural therapy for the management of elevated cholesterol levels which proved that it contains bioactive compounds that exhibit antilipidemic effects. These compounds help regulate lipid metabolism and reduce lipid levels in the blood specially the high fiber content aids in preventing cholesterol buildup in arteries along its antioxidants protect against oxidative stress, which can contribute to lipid peroxidation and cholesterol accumulation. so it is conclude from the current study that incorporating bael fruit powder into the diet may help manage elevated cholesterol levels and promote overall cardiovascular well-being.

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