*Original Research Article*

# Mathematical Modelling (SEIPR) of the Therapeutic and Pharmacological Efficacy of Mango Leaf (Mango (Mangifera Indica L.) against selected ravaging infections in third World countries.


## Abstract:

*Mangifera indica leaf* is *a* commonly used herb in traditional medicine. Although, review articles on this plant are already published. Thisarticle is presented to compile all the updated information on its therapeutic and pharmacological efficacy against ravaging infection in third world countries. In addition, to introduce the mathematical model that connects all the necessary parameters and variables on the therapeutic and pharmacological efficacy of the mango leaf to cure the ravaging infections. The basic reproductive number of the model was obtained. This parameter was obtained to show that, the use of the mango leaf can cure the ravaging infections mathematically such that, as the use of the mango leaf increases, the rate of the ravaging infection among the populace reduces. It is a fact that, the medicinal plant is a good source of medicine for developing countries especially in the third world like Africa and Asia, taking Nigeria as a case study. This write-up is premeditated from the fact that, there should be a cure for ravaging ailments like High blood pressure, diabetes and etc. without the use of conventional medicine.We should be able to use the local herbs for the known health debacle without any side effects. As scientists, we decided to research various medicinal plants that can be used. During the process of search, mango leaf shines like a bright star and there is a need to make thorough and further searchlight to the wonderful medicinal plant, because of its various therapeutic uses on ravaging infections in Nigeria.



**Keyword;** Pharmacologically,Therapeutic Efficacy, Mango Leaf (Mango (Mangifera Indica L.), Mathematical Modelling, Basic Reproductive Number.


## Introduction

***Mangifera indica***, commonly known as Mango, is a specie of flowering plant in the family Anacardiaceae[1]. Mangoes are believed to have originated from the region between northwestern Myanmar, Bangladesh and India. It is a large fruit-tree, capable of growing to a height and crown width of about 30 meters (100 ft) and trunk circumference of more than 3.7 plants that meters (12 ft.) [2].

*M. indica* were domesticated separately in South Asia and Southeast Asia over centuries, resulting in two distinct genetic populations in modern mangoes – the "Indian type" and the "Southeast Asian type". Mangoes have since been introduced to other warm regions of the world [3].

**Plate 1. Mango Leaf (Mango (Mangifera indica L.)(4)**

The chemical constituent of mango leaf is another important subject of discussion and the therapeutic importance of mango leaf. Mangiferin (a pharmacologically active hydroxylated xanthone(C-glycoside) is extracted from mango at high concentrations from the young leaves, bark and from old leaves [5]. Allergenic urushiols and phenolic substances are present in the fruit peel and can trigger contact dermatitis in sensitized individuals.

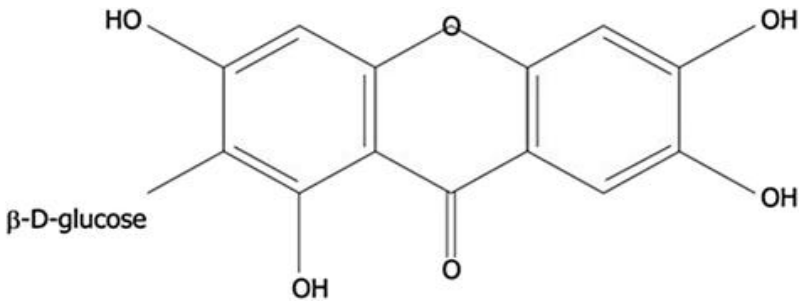


**Fig 1: Chemical structure of mangiferin[6].**

The leaf and flower yield an essential oil containing humulene, elements, ocimene, linalool, nerol, and many others. The fruit pulp contains vitamins A and C, β-carotene and xanthophylls[5]. An unusual fatty acid, cis-9, cis-15-octadecadienoic acid was isolated from the pulp lipids of mango[6], Phenolic Antioxidants, Free Sugars and Polyols isolated and analyzed from Mango (MI) Stem Bark.

## 1. Mathematical Formulation

The SEIPR mathematical model is partitioned into compartments of susceptible population class (S), the exposed population class (E), the infected population class (I), the class of population who believes in the therapeutic and pharmacological efficacy of mango leaf (P) and thetemporary recovered population class after being cured by the mango leaf (R). The proportion of Λare the incoming population into the susceptible class [22]. This compartment reduces due to the expiration of duration of pharmacological efficacy of the mango leaf at the rate ω and also by natural death at the rate of μ. The susceptible population increases at the rate of δ due to the coming in of the people from the temporary recovered class as a result of the expiration of the duration of pharmacological efficacy of the mango leaf at the rate ω. The susceptible population also reduces due to the natural death rate μ and infection with contact rate of infection β. The population dynamics of the exposed population class at the latent period grows with the incidence rate of βSI. This class reduces by natural death rate μ and occasional breakdown of the exposed people at the latent period into infected class at the rate of σ. The class of people with the therapeutic and pharmacological efficacy of mango leaf denoted by P, but, because the efficacy of the mango leaf is not one hundred percent such that it can wane at the rate of ω, the recovery class increases with temporary immunity at the rate of δ which are transferred back to the susceptible class and decreases by natural death rate μ.

The model equation is given in the form systems of ordinary differential equation as follows:

$$\frac{dS}{dt} = \Lambda + (1-m)A + \delta R(t) - \beta S(t)I(t) - (\mu+\eta)S(t), \qquad S(0) = S_0 \qquad (1)$$

$$\frac{dE}{dt} = \beta S(t)I(t) + \eta S(t) - (\mu+\sigma)E(t), \qquad E(0) = E_0 \qquad (2)$$

$$\frac{dI}{dt} = \sigma E(t) + cP(t) - (\mu+\tau)I(t), \qquad I(0) = I_0 \qquad (3)$$

$$\frac{dP}{dt} = mA + \tau I(t) - (\mu+\omega+c)P(t), \qquad P(0) = P_0 \qquad (4)$$

$\frac{dR}{dt} = \omega P(t) - (\mu + \delta)R(t), \qquad R(0) = R_0 \qquad (5)$

in which S(t), E(t), I(t), P(t) and R(t) represent the population of susceptible class, exposed class but not yet infected, the infected class, the therapeutic and pharmacological efficacy class and the temporary recovered class respectively. The parameters in the mathematical model are positive and the Tables 1 and 2 provide the definitions for the model parameters. The model assumes a varying population of N(t) so that N(t)= S(t)+E(t)+I(t)+P(t)+R(t) and it is given in the form; $N(t) = D + Ce^{-\mu t}$ for D = $\frac{\Lambda + A}{\mu}$. From the above system of equations (1) to (5), we use the following conceptthat: $\frac{dS}{dt} = 0$, $\frac{dE}{dt} = 0$, $\frac{dI}{dt} = 0$, $\frac{dP}{dt} = 0$ and $\frac{dR}{dt} = 0$. Also, let $\frac{S(t)}{N} = s(t)$, $\frac{E(t)}{N} = e(t)$, $\frac{I(t)}{N} = i(t)$, $\frac{P(t)}{N} = p(t)$ and $\frac{R(t)}{N} = r(t)$ to get the following re-scaled system of equations as:

$\frac{ds}{dt} = \Lambda + (1 - m)A + \delta r(t) - \beta s(t)i(t) - (\mu + \eta)s(t), \qquad s(0) = s_0 \qquad (6)$

$\frac{de}{dt} = \beta s(t)i(t) + \eta s(t) - (\mu + \sigma)e(t), \qquad e(0) = e_0 \qquad (7)$

$\frac{di}{dt} = \sigma e(t) + cp(t) - (\mu + \tau)i(t), \qquad i(0) = i_0 \qquad (8)$

$\frac{dp}{dt} = mA + \tau i(t) - (c + \mu + \omega)p(t), \qquad p(0) = p_0 \qquad (9)$

$\frac{dr}{dt} = \omega p(t) - (\mu + \delta)r(t), \qquad r(0) = r_0 \qquad (10)$

Table 1: The interpretation of the parameters in the equations

| Model Parameters | Definitions |
|---|---|
| Λ | Recruitment rate of people into the susceptible class |
| A. | Number of people with ravaging infections |
| m. | Fraction of people who are using mango leaf to cure the ravaging infections |
| (1 – m) | Fraction of people who are not using mango leaf to cure the ravaging infections |
| μ. | The mortality or death rate of the people |

| | |
|---|---|
| τ. | Rate at which the infected are being cured with mango leaf |
| β. | Transmission coefficient |
| ω. | Rate at which the re – infection occurs |
| σ. | Rate at which the exposedbecome infected with the ravaging infections |
| c. | Rate at which the therapeutic and pharmacological efficacy of the mango leaf occurs |
| δ. | Rate at which re-infection of the infections occurs |
| η. | Rate at which the susceptible infants are exposed to the diseases |

Table 2: Variables and definition of sub-population used as variables

| Variables | Definition |
|---|---|
| $N_0$ | Initial value of the total population at time t |
| $S_0$ | Initial value of the susceptible at time t |
| $E_0$ | Initial value of the exposed at time t |
| $I_0$ | Initial value of the infected at time t |
| $P_0$ | Initial value of the therapeutic and pharmacological efficacy of mango leaf at time t |
| $R_0$ | Initial value of the temporary recovered at time t |

In the next section, the basic reproductive number of the mathematical model shall be obtained using the next generation matrix [16].

## 2. BASIC REPRODUCTIVE NUMBER OF THE MODEL

It is easy to see that the region $\{(S,E,I,P,R): S > 0, E \geq 0, I \geq 0, P \geq 0, R \geq 0\}$ is positively invariant for the model. Summing up the five equations in the model, we have,

$$\frac{d(S+E+I+P+R)}{dt} = \mu[\frac{\Lambda+A}{\mu} - (S+E+I+P+R)] \quad (11)$$

The basic reproductive number, $R_0$, is defined as the expected number of secondary cases produced by a single infection in a completely susceptible population. $R_0$ is a dimensionless number and not a rate which would have units of per time. Hefferman et al (2005) provided a nice readable introduction for calculating $R_0$ in structured population models [17, 18]. Using the next generation matrix method, the basic reproductive number is defined as the spectral radius of the next generation matrix of the form $\rho(FV^{-1})$, where F is a nonnegative matrix that consists of the rate of new infections and matrix V consists of the rate of recovery, deaths and other transitions from one compartment to another given in the form $F = \frac{\partial F_i(x_0)}{\partial x_j}$ and $V = \frac{\partial V_i(x_0)}{\partial x_j}$where $x_0$ is the disease free equilibrium state and $R_0$ is the dominant eigenvalue of the matrix $(FV^{-1})$ [16]. Consider the system of equations (6) to (10). Let the vector disease states be represented by $X_i = (s, e, i, p, r)^T$, (i = 1,2,3,4,5) such that at the disease free equilibrium point $x_0 = (1,0,0,0, 0)$. Hence, the Jacobian matrix for equations (7) to (9) is given as

$$J = \begin{pmatrix} -(\mu+\sigma) & \beta & 0 \\ \sigma & -(\mu+\tau) & c \\ 0 & \tau & -(c+\mu+\omega) \end{pmatrix}, \quad (12)$$

with

$$F = \begin{pmatrix} 0 & \beta & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (13)$$

and

$$V = \begin{pmatrix} \mu+\sigma & 0 & 0 \\ -\sigma & \mu+\tau & -c \\ 0 & -\tau & (c+\mu+\omega) \end{pmatrix}. \quad (14)$$

Therefore, the basic reproductive number of the mathematical model (6) to (10), denoted by $R_0$ is given in the form,

$$R_0 = \rho(FV^{-1}) = \frac{\sigma\beta(c+\mu+\omega)}{\mu^3+\mu^2(c+\omega+\sigma+\tau)+\mu(c\sigma+\omega\sigma+\omega\tau+\sigma\tau)+\omega\sigma\tau}. \quad (15)$$

In the context of epidemiology modelling, it is generally known that, if $R_0 < 1$, the disease-free equilibrium is locally asymptotically stable and the disease will be eradicated from the community with time among the populace using the curable measures like mango leaf.Thus, the basic reproductive number $R_0$ is a threshold quantity that determines when an infection invades a population or does not [19, 20, 21].

## 3. Results and Discussion

From the mathematical expressions obtained above, we can now discuss some infections that the mango leaf can be cured in the third world countries. The ravaging infections include diabetes, blood pressure, weight gains etc.

**Diabetes** is one of the most common diseases in Nigeria and other third-world countries. We need to follow the school of thought that foreign medicine should not be used to control diseases, we should be able to use our God's given medicinal plants for the control of diabetes, The tender mango leaves contain tannins and anthocyanidins which may be helpful in the treatment of diabetes. In powdered forms of dry mango leaf, this may be used in the treatment of angiopathy diabetes as well as retinopathy diabetes. Mango dry leaf contains 3 beta taraxerol which is along with ethyl acetate help in the treatment of hyperglycemia in the human brain, this will help proper brain function during cerebral activity. For pharmacological and therapeutic uses of mango leaf against diabetes, Drinking mango leaf tea around 2 times a day, maybe the dosage for the treatment of diabetes. Simply boil around 10 to 15 leaves of the mango tree, Leave the water overnight to cool, and drink it on an empty stomach in the morning (7).

**Blood pressure** is another health debacle in third-world countries like Nigeria. The use of conventional medicine like Visoprim(5mg), Neffediprine (5mg, and Amlodipine(5/10mg), may not be the answer to the control of high blood pressure. It was observed that there is a hidden side effect generated by these conventional tablets as time goes on. i.e later in life, Mango leaf may be the answer to high blood pressure. The health benefits of mango leaves also include maintaining blood pressure levels. leaves contain nutrients that are much helpful in reducing blood pressure levels. It is quite effective in making the blood vessels strong which is essential in the treatment of varicose veins (8). For pharmacological and therapeutic uses of mango leaf against blood pressure. Tea made from mango leaves around should be taken two times a day.

Boiled mango leaves in either a warm state or cold one on empty stomach early in the morning, this will be very helpful to reduce the scourge of High blood pressure. It should be noted that patients with low blood pressure should take caution in the use of mango leaves to control low blood pressure, this may be a major health hazard (9).

**Weight gain** and loss is one of the major challenges in both developing and developed countries in the world. Populate in the third world countries may not be affected by these health challenges because of inadequate of fatty and pretentious foods, more carbohydrate food, this is not the same with the developed countries, with more fatty and proteinous food (Sandwiches and etc). Therapeutic use of mango leaf should be encouraged to populate in developed countries. Mango leaves come with a number of essential nutrients that help in reducing weight. For example, the enzyme papain boosts digestion, it also increases and eliminates the production of leptin hormone and regulates the accumulation of fats in the body. The pharmacological active elements in the mango leaf reduce the desire to eat more food and thereby reduces weight and weight loss(10). For pharmacological and therapeutic uses of mango leaves against weight loss, add mango leaves to your diet for around a month. Drinking mango leaf water on an empty stomach or mango leaf tea therapeutic dose (11).

**Gall and Kidney Stones** are one of the killer diseases in third world countries, it has killed over 40,000 patients in Nigeria and other places. There is a need to find a lasting solution for these ravaging diseases. Surgical operation is not the panacea to this infection, our medicinal plants may be the solution. The mango leaf powder benefits also include the treatment of kidney stones and gall stones and the use of mango leaves twice a day, which helps to dissolve the kidney stones and also helps to remove the harmful toxin in the human system. For pharmacological and therapeutic uses of mango leaf against Gall and Kidney Stones, the patient should take dry Powder mango leaves in water. Keep the water overnight and drink it on an empty stomach every morning (12).

**Dysentery** may be caused by different factors, it may be as a result of microbial ingestion, this includes Staphylococcus aureus, Vibro cholera and etc, this may be difficult to hurdle unless the use of antibiotics. If there are no antibiotics, we can result using natural medicinal plants like Mango leaves. The mango leaves contain many phytochemicals that are active against the different degrees of microorganisms. These phytochemicals are easily metabolized in the human system and they play a major role in the physical well-being of the human system example of

these phytochemicals are tannins, Saponin, alkaloids, and flavonoids. For pharmacological and therapeutic uses of mango leaf against Dysentery, The patient should take dry Powder mango leaves twice times in a day. if bleeding is observed along with Dysentery, this situation can be cured in a natural way by taking the dry Powder mango leaves twice times in a day (13).

A cough, also known as pertussis, is a voluntary or involuntary act that clears the throat and breathing passage of foreign particles, microbes, irritants, fluids, and mucus; it is a rapid expulsion of air from the lungs. Coughing can be done deliberately or as part of a reflex. The infection is in the upper respiratory tract and affects the throat, this is known as a URTI or URI (upper respiratory tract infection), the best way to treat cough is Codeine, dextromethorphan, and other cough suppressants are often used by people with coughs. The medicinal uses of mango tree leaves include the treatment of cough and cold. Mango leaves contain flavonoids and antioxidant properties, Flavonoids in mango leaves help in the treatment of cold and cough effectively. Along with cough and cold, the leaves are also effective for asthma. Mangiferin is one of the phytochemicals present in the leaves of a mango leaf. It showed activity against, *Bacillus pumilus, B. cereus, Staphylococcus aureus, S. citreus, Escherichia coli, Salmonella agona, Klebsiella pneumoniae,* and *Saccharomyces cerevisiae*. the basic reason it has activity against cough and cold(14). For pharmacological and therapeutic uses of mango leaf against Cough and Cold, Add some honey to the water which helps in curing cough properly and also soothes the throat. drink warm boiled water containing mango leaves (15).

## 4. Conclusion

*Mangifera indica* (MI), also known as mangohas been an important herb in the Ayurvedic and indigenous medical systems for over 4000years. According to Ayurveda, varied medicinal properties are attributed to different parts of mango leaves. Such as antidiabetic, anti-oxidant, anti-viral. Pharmacologically and medicinally important chemicals such as mangiferin, being a polyphenolic antioxidant and a glucosyl xanthone, it has strong antioxidant, immunomodulation, ,hypotensive, activities. It encourages third-world countries to use mango leaves.

**NOTE:**

The study highlights the efficacy of "Ayurved" which is an ancient tradition, used in some parts of India. This ancient concept should be carefully evaluated in the light of modern medical science and can be utilized partially if found suitable.

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