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Research Paper

Optimization Studies on Reaction Parameters for Silver Nanoparticle Synthesis in Medicinal Plants

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ABSTRACT: *Optimization process plays a vital role in nanotechnological research by enhancing the production of desired nanoparticles with controlled shape and size within a specific time duration. Different reaction parameters such as pH, volume, temperature, time etc. can be optimized which helps in effective synthesis rate. In the present study, optimization was carried out for silver nanoparticles synthesized using aqueous extracts from dried leaf samples ofLawsonia inermis L., Piper betle L. and Mangifera indica L. Various reaction conditions were optimized such as concentration of silver nitrate (0.5 mM - 2.5mM), ratio of extract: silver nitrate volume (1:10 – 5:10), pH (3 – 11), temperature (-20˚C - 100˚C) and reaction time (30 minutes – 36 hours). Based on the optimization studies, all three samples were observed to exhibit similar optimum conditions of 1mM silver nitrate concentration, 1:10 volume ratio, pH of 7, 37˚C temperature and time duration of 24 hours.*

KEYWORDS: *Optimization, Lawsonia inermis L., Piper betle L., Mangifera indica L., Silver nitrate concentration, Volume, Temperature, pH, Reaction time.*

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I. INTRODUCTION

Nanotechnology is a highly demanding and expanding field of science which deals with nanoparticle synthesis in the size range of 1 – 100 nm**(Khan, Y. *et al.*, 2022).** Nanoparticles synthesized through green route using plants and their derivatives as reducing and stabilizing agents has received wide attention due to their eco-friendliness, efficiency, non-toxicity, easier synthesis process and non-usage of chemical additives **(Liaqat Nida *et al.*, 2022).**Green synthesis of nanoparticle is much more effective compared to other synthetic methods due to the accumulation and broad-spectrum distribution of bioactive components within plant parts being economical and safe **(Rosman, N.S.R. *et al.*, 2021).**Various metal nanoparticles are being synthesized from diverse sources such as zinc, gold, platinum, aluminium, palladium, copper, iron nanoparticle etc. however, silver nanoparticle has gained huge attention globally due to their extensive applications in healthcare and other sectors such as in treating cancer, microbial infections, in purifying water, as drug delivery agents etc. **(Chowdhury, Silvia*et al.*, 2016).** Optimization studies are generally performed in order to increase the yield andstability of nanoparticles thereby producing desired end product with controlled shape and size **(Gonfa, Y. H. *et al.*, 2023).** Therefore, it is essential to understand the optimum reaction conditions at which the production rate will be efficacious.Differentreaction parameters can be optimized for achieving the desired synthesis rate and for attaining better stability of nanoparticles and these include concentration, time duration, pH, volume, temperature etc. **(Mehmood, A. *et al.*, 2023).** Present study was carried out with an aim to investigate and optimize suitable reaction parameters that could contribute towards effective synthesis of silver nanoparticle using aqueous extracts prepared from*Lawsonia inermis* L., *Piper betle* L. and *Mangifera indica* L. dried leaves.

II. MATERIALS AND METHODS

2.1. Preparation of aqueous extracts: Hot extraction method was employed for preparation of aqueous extracts and involves boiling the dried and powdered leaves of *Lawsonia inermis* L., *Piper betle* L. and *Mangifera indica* L. in double distilled water in the ratio of 1:10 (5 grams dried and powdered leaves in 50 mL of double distilled water) on water bath at 65˚C for about 20 – 25 minutes **(Leela.K and Anita R J Singh., 2022).**

2.2. Optimization of reaction parameters: Reaction parameters chosen for optimization study involves: concentration of silver nitrate, ratio of aqueous extract: silver nitrate volume, pH, reaction temperature and time duration. Similar conditions were followed in *Lawsonia inermis* L., *Piper betle* L. and *Mangifera indica* L.

2.2.1. Concentration of silver nitrate: Silver nitrate concentration was varied from 0.5 mM, 1 mM, 1.5 mM, 2 mM and 2.5 mM maintaining extract volume constant at 1mL.

2.2.2. Ratio of aqueous extract: silver nitrate volume: Ratio of extract: silver nitrate volume was varied from 1:10, 2:10, 3:10, 4:10 and 5:10 with concentration of silver nitrate optimized at 1mM.

2.2.3. pH: pH of the reaction mixture was varied from 3, 5, 7, 9 and 11 using sodium hydroxide and hydrochloric acid maintaining the acid and alkaline pH with optimized 1mM silver nitrate concentration and 1:10 volume ratio.

2.2.4. Reaction temperature: Temperature of the reaction mixture was varied from -20˚C, 4˚C, 37˚C, 60˚C and 100˚C with optimized 1mM silver nitrate concentration, 1:10 volume ratio and pH 7.

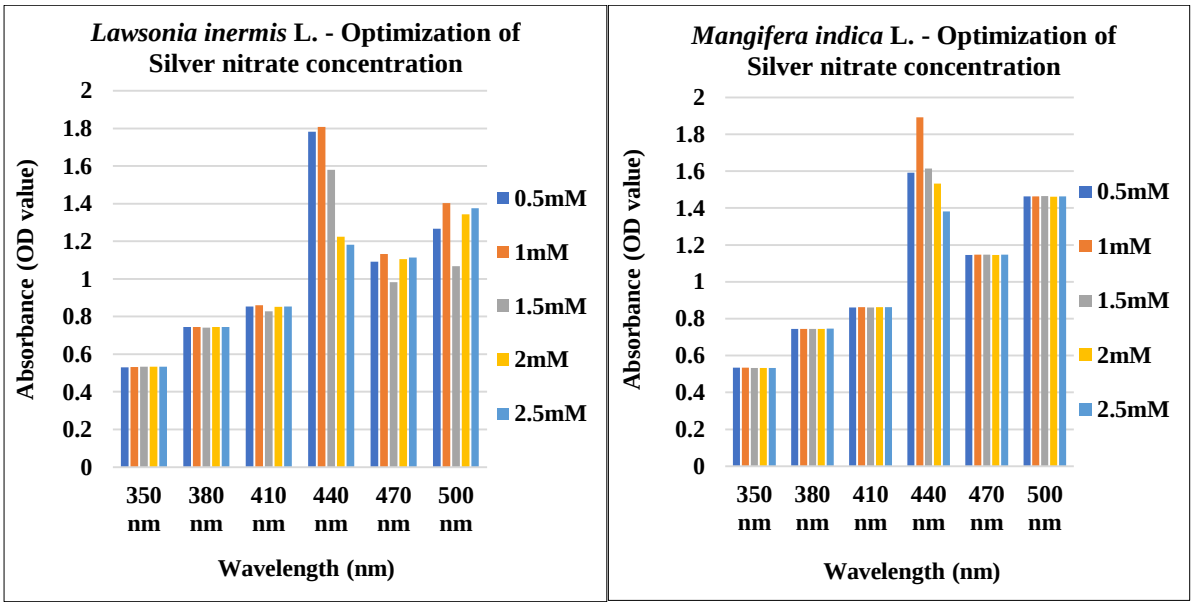
2.2.5. Time duration: Reaction time of the mixture was varied from 30 minutes, 24 hours and 36 hours with optimized conditions of 1mM silver nitrate concentration, 1:10 volume ratio, pH 7 and temperature of 37˚C.

Absorbance of the reaction mixtures were monitored by UV-Visible spectrophotometer in the wavelength range of 350 nm – 500 nm and based on the absorbance peak obtained optimum conditions were determined**(Noor Najmi Bonnia *et al.*, 2020).**

III. RESULTS AND DISCUSSION

Optimization study was carried out for different reaction parameters and includes silver nitrateconcentration (0.5mM - 2.5mM), ratio of extract : silver nitrate volume (1:10 - 5:10), pH (3 - 11), temperature (-20^0 C - 100^0 C) and reaction time (30 mins - 36 hrs). It was performed to identify and optimize the best conditions at which nanoparticle synthesis rate would be effective **(Figures 1 – 5).**

3.1. Optimization of Silver nitrate concentration (0.5mM - 2.5mM):



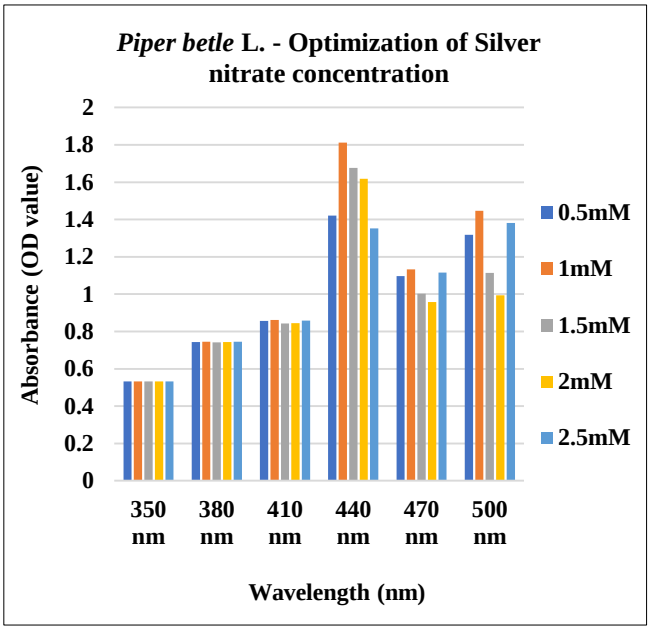
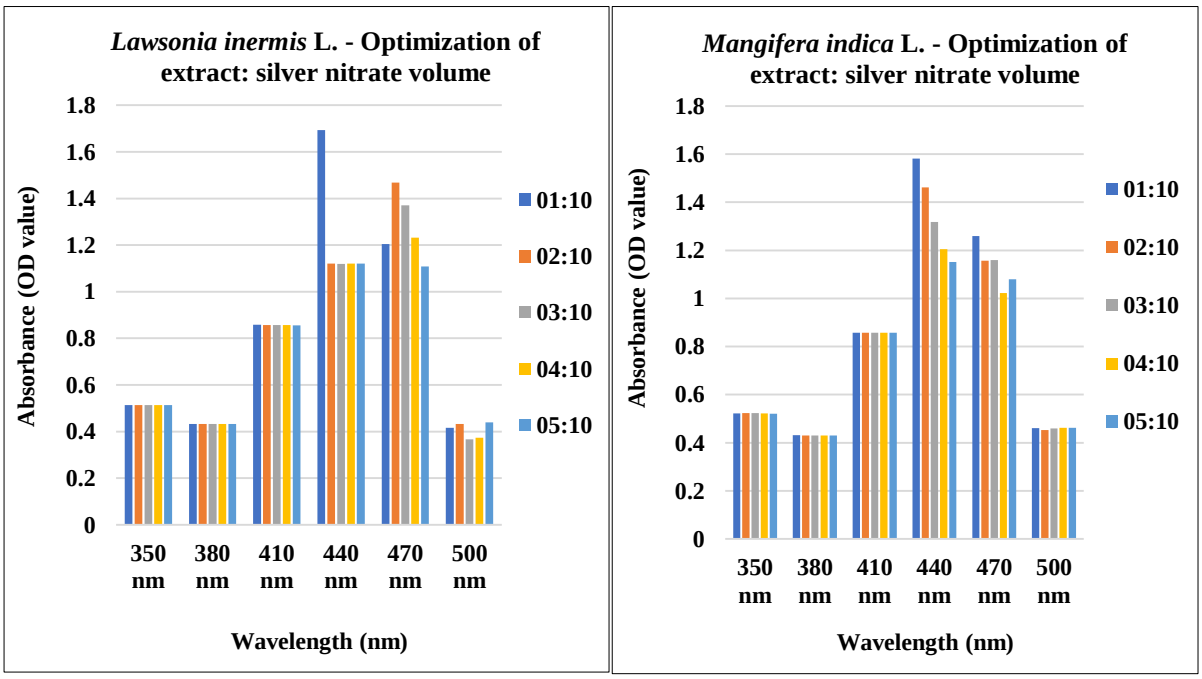


Figure 1: Optimization of Silver nitrate concentration

Optimization study was performed for silver nitrate concentration wherein, the concentration of silver nitrate was varied from 0.5 mM to 2.5 mM **[0.5 mM, 1 mM, 1.5 mM, 2 mM and 2.5 mM]** and the reaction was monitored at a wavelength range of about 350 nm – 500 nm. The absorbance was found to increase from 350 nm – 440 nm and all three samples displayed similarity in the absorbance value from 350 nm – 410 nm at all concentrations while, exhibited a higher absorption peak at 1mM concentration in the wavelength of 440 nm. Absorbance was found to decrease at 470 nm followed by a slight increase at 500 nm with 1 mM exhibiting the highest peak among all the tested concentrations. Based on the study carried out,**concentration of silver nitrate was optimized at 1 mM in all the three plant samples(Figure 1).**

3.2. Optimization of ratio of aqueous extract: silver nitrate volume (1:10 - 5:10):



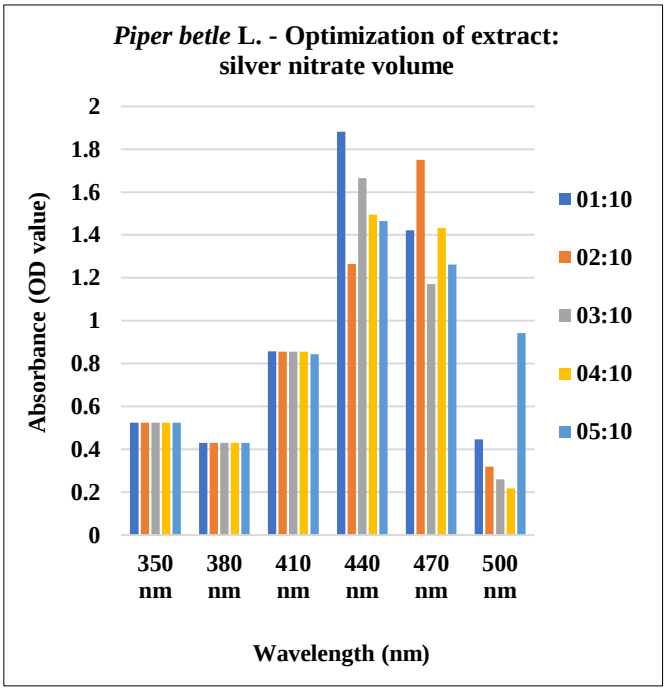
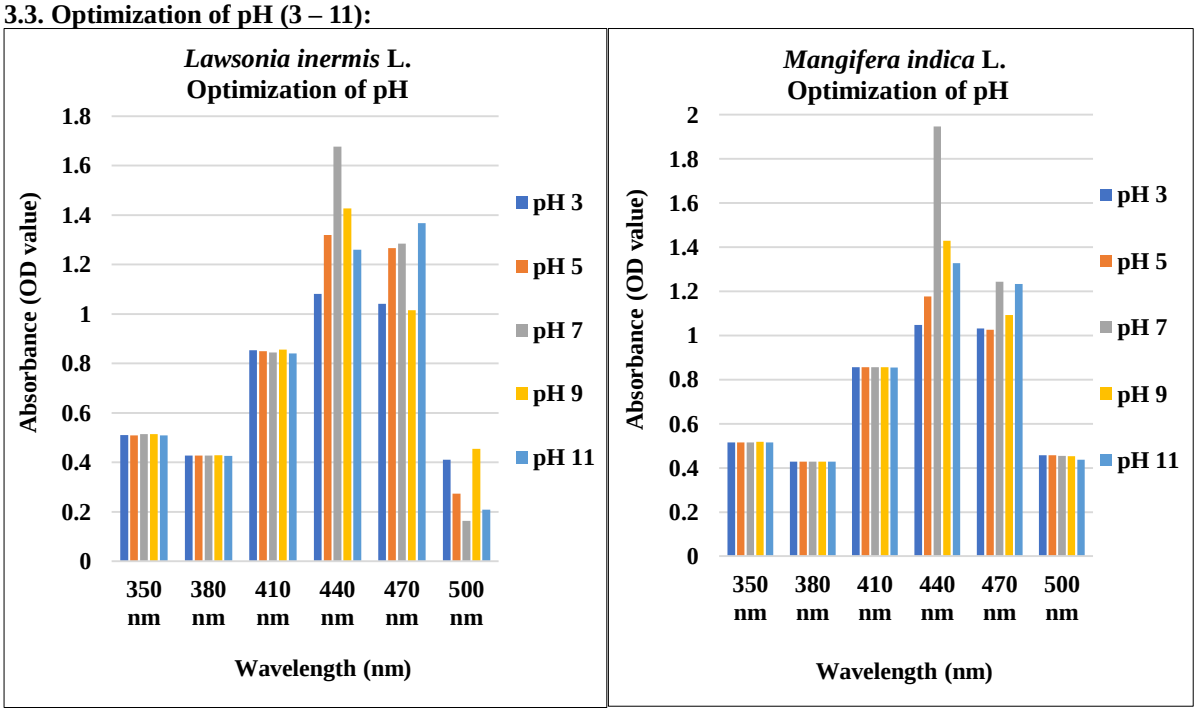


Figure 2: Optimization of Ratio of extract: silver nitrate volume

Optimization study was performed for ratio of extract: silver nitrate volume wherein, the ratio was varied from 1:10 to 5:10 **[1:10, 2:10, 3:10, 4:10 and 5:10]** and the reaction was monitored at a wavelength range of about 350 nm – 500 nm. The absorbance was found to increase at 350 nm with a decrease at 380 nm and further increased from 410 nm – 440 nm and all three samples displayed similarity in the absorbance value from 350 nm – 410 nm at all ratios while, exhibited a higher absorption peak at 1:10 ratio in the wavelength of 440 nm. Absorbance was found to slightly decrease at 470 nm and reached lowest at 500 nm with 1:10 ratio exhibiting the highest peak among all the tested ratios. Based on the study carried out, **ratio of extract: silver nitrate volume was optimized at 1:10 in all the three plant samples(Figure 2).**

3.3. Optimization of pH (3 – 11):



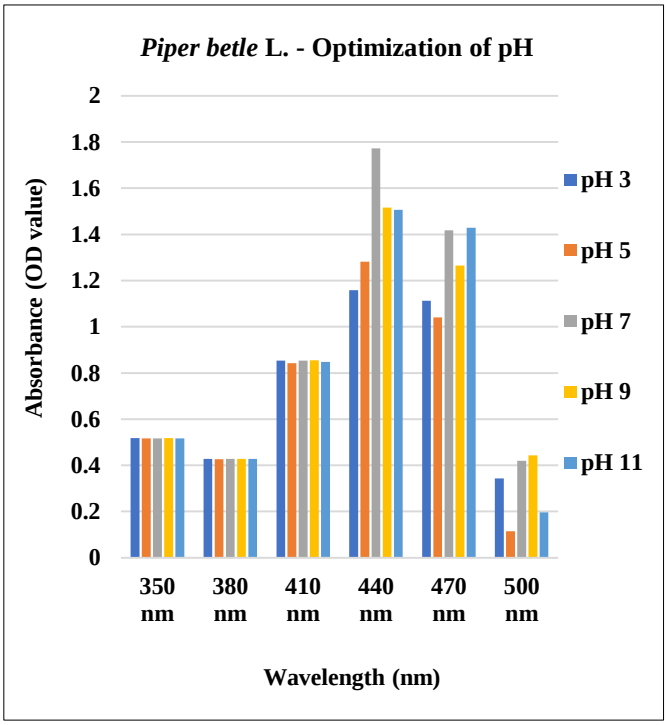
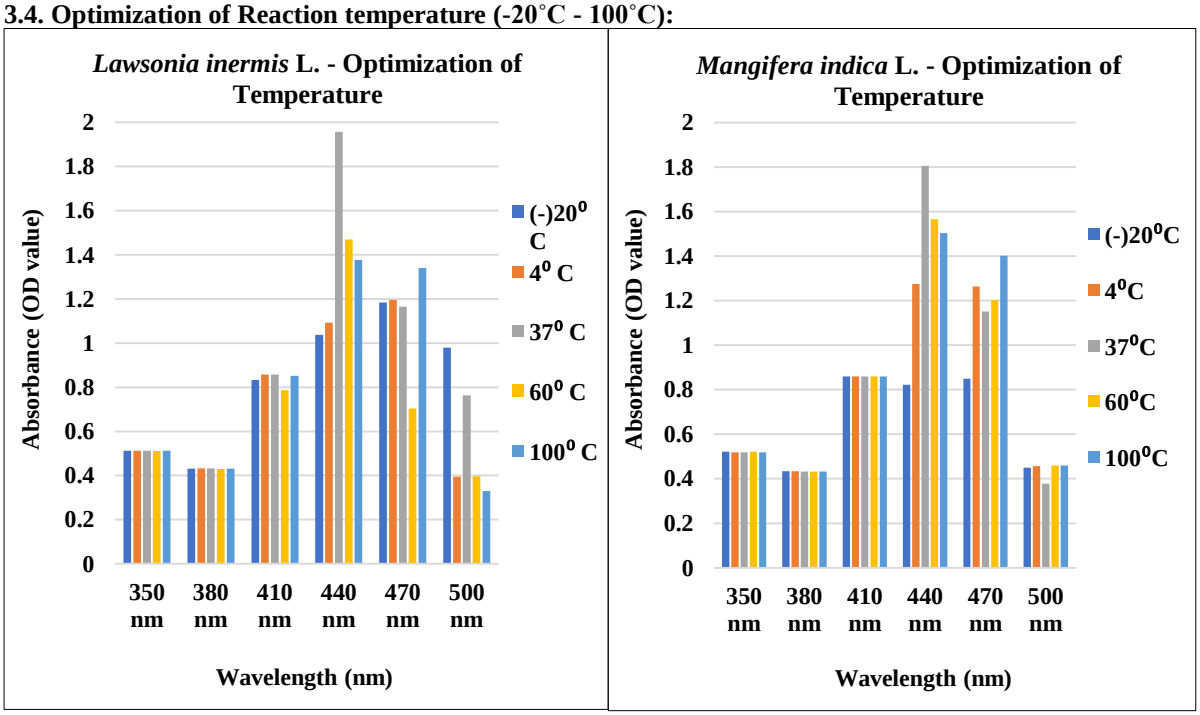


Figure 3: Optimization of Reaction pH

Optimization study was performed for pH wherein, the pH was varied from 3 - 11 **[pH 3, 5, 7, 9 and 11]** and the reaction was monitored at a wavelength range of about 350 nm – 500 nm. The absorbance was found to increase at 350 nm with a decrease at 380 nm and further increased from 410 nm – 440 nm and all three samples displayed similarity in the absorbance value from 350 nm – 410 nm at all pH while, exhibited a higher absorption peak at pH 7 in the wavelength of 440 nm. Absorbance was found to slightly decrease at 470 nm and reached lowest at 500 nm with pH 7 exhibiting the highest peak among all the tested pH ranges. Based on the study carried out, **pH was optimized at 7 in all the three plant samples(Figure 3).**

3.4. Optimization of Reaction temperature (-20˚C - 100˚C):



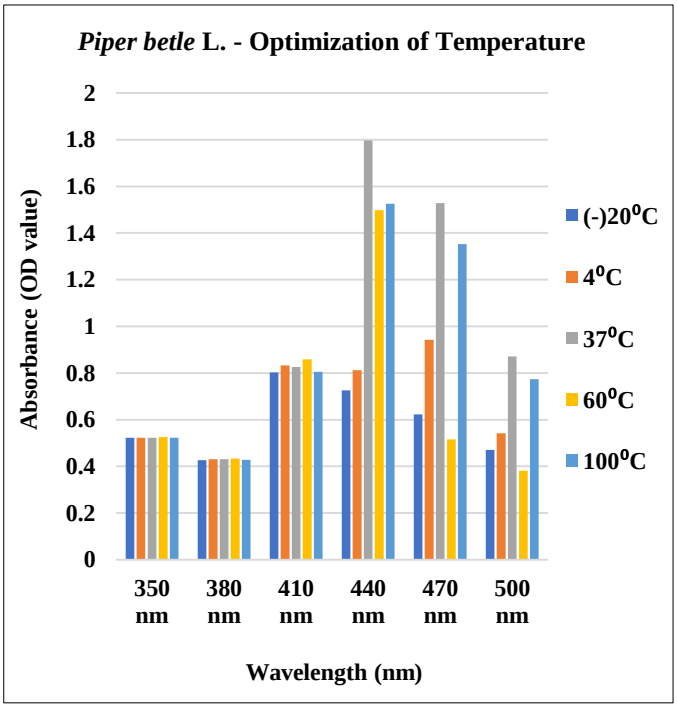
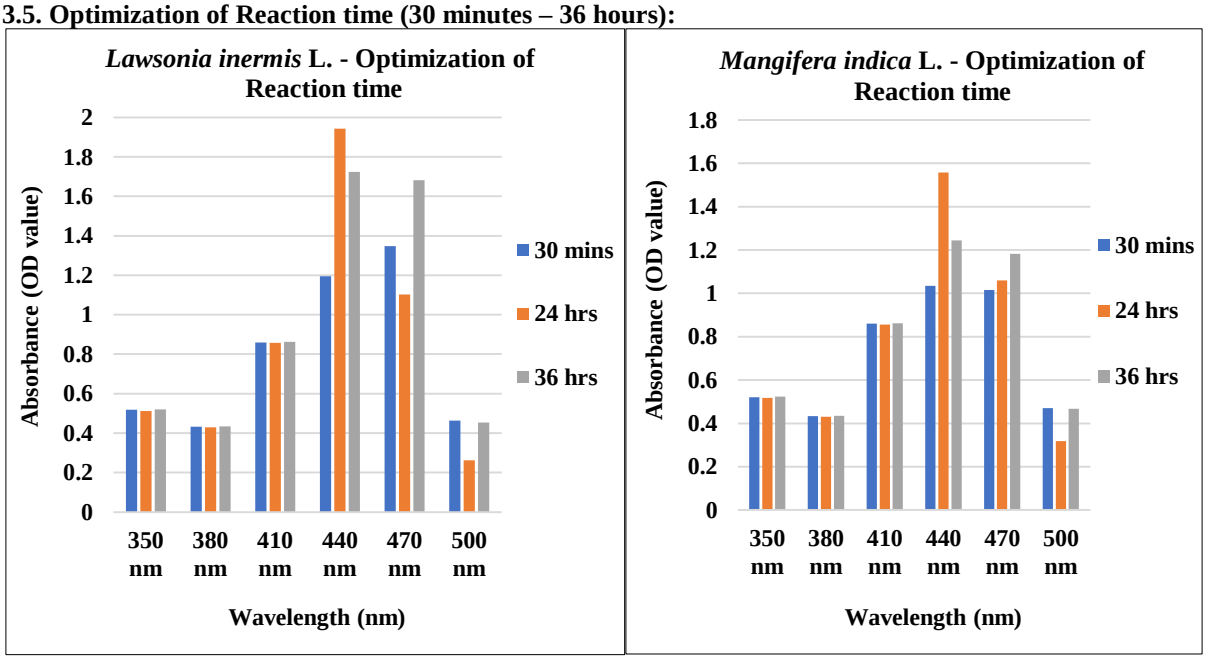


Figure 4: Optimization of Reaction temperature

Optimization study was performed for reaction temperature wherein, the temperature was varied from -20˚C to 100˚C **[-20˚C, 4˚C, 37˚C, 60˚C and 100˚C]** and the reaction was monitored at a wavelength range of about 350 nm – 500 nm. The absorbance was found to increase at 350 nm with a decrease at 380 nm and further increased from 410 nm – 440 nm and all three samples displayed similarity in the absorbance value from 350 nm – 410 nm at all temperatures while, exhibited a higher absorption peak at 37˚C in the wavelength of 440 nm. Absorbance was found to slightly decrease at 470 nm and reached lowest at 500 nm exhibiting highest peak at 37˚C among all the tested temperature ranges. Based on the study carried out, **reaction temperature was optimized at 37˚C in all the three plant samples(Figure 4).**

3.5. Optimization of Reaction time (30 minutes – 36 hours):



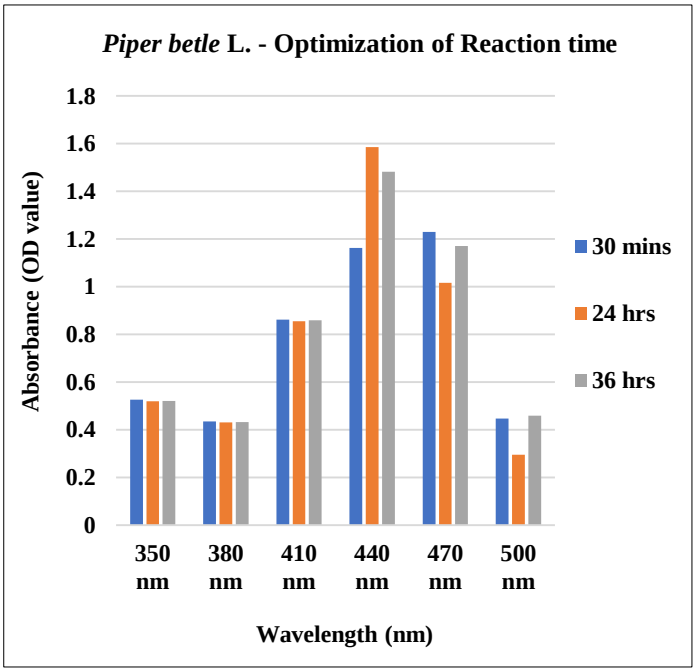


Figure 5: Optimization of Reaction time

Optimization study was performed for time duration wherein, the reaction time was varied from 30 mins to 36 hours **[30 mins, 24 hours and 36 hours]** and the reaction was monitored at a wavelength range of about 350 nm – 500 nm. The absorbance was found to increase at 350 nm with a decrease at 380 nm and further increased from 410 nm – 440 nm and all three samples displayed similarity in the absorbance value from 350 nm – 410 nm at all reaction times while, exhibited a higher absorption peak at 24 hours in the wavelength of 440 nm. Absorbance was found to slightly decrease at 470 nm and reached lowest at 500 nm with 24 hours exhibiting the highest peak ofall time durations. Based on the study carried out, **reaction time was optimized at 24 hours in all the three plant samples(Figure 5).** Optimized reaction conditions involve - **concentration of silver nitrate = 1 mM**; **ratio of extract: silver nitrate volume = 1:10**; **pH = 7**; **temperature = 37˚C** and**reactiontime = 24 hours.**

VermaA *et al.*, 2017 has reported silver nanoparticle synthesis using *Solanum nigrum* leaf aqueous extracts with optimization studies on different reaction parameters such asextract: silver nitrate ratio, temperature, pH and reaction time wherein, the optimum conditions were observed to be 5:95 ratio, 4 hours of reaction time, pH 7 and temperature of 70˚C.**Singh, Amrita *et al.*, 2019** has reported optimization studies for parameters such as temperature, pH, concentration and reaction time towards silver nanoparticle synthesis using *Hibiscus rosasinensis* leaf aqueous extracts wherein, the optimized conditions were observed to be pH 6, 30 minutes reaction time, 5mM concentration of silver nitrate and temperature of 70˚C.

IV. CONCLUSION

In this study, various reaction parameters such as silver nitrate concentration (0.5 mM – 2.5 mM), ratio of extract: silver nitrate volume (1:10 – 5:10), pH (3 – 11), temperature (-20˚C - 100˚C) and reaction time (30 minutes – 36 hours) were optimized towards silver nanoparticle synthesis in *Lawsonia inermis* L., *Piper betle* L. and *Mangifera indica* L.Optimum conditions were observed to be 1mM concentration of silver nitrate, 1:10 ratio of extract: silver nitrate volume, pH 7, temperature of 37˚C and reaction time of 24 hours. Optimized parameters were found to be comparably similar in all three plant samples. Thus, optimization study proves to be useful towards synthesis of nanoparticle aiding in better stability, morphology, yield and size thus preventing agglomeration of particles. Further studies can also be carried out on other reaction parameters thereby improving their synthesis rate.

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