MOLLUSCICIDAL EFFICACY OF MEDICINAL PLANT SOLANUM SURATTENSE AGAINST FASCIOLA VECTOR SNAIL, LYMNAEA ACUMINATA

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Abstract: Fasciolosis is one of the most serious food-borne parasitic diseases. These parasitic infections are caused by Fasciola hepatica and F. gigantica among cattle and human populations. The carrier of fascioliasis is a fresh water host snail, Lymnaea acuminata. The control of vector snails is a major tool in reducing the incidences of fasciolosis. Synthetic molluscicide causes adverse effects in the environment as well as on non target organisms. The present studies were designed for evaluation of molluscicidal efficacy of medicinal plant Solanum surattense against L. acuminata. The efficacy of S. surattense was concentration and time dependent. Toxicity experiment of dried leaf powder of S. surattense and their different organic extracts and column purified was continuously observed for 96h at different concentrations. Mortality was observed for 24, 48, 72 and 96h. Six aquariums were set up for each concentration. The control group animals were kept in the equal volume of water under similar conditions without treatment. Mortality of snails was recorded at intervals of 24h each up to 96h and lethal values were calculated. The 24h LC50 of dried leaf powder of S. surattense was 157.33mg/l and at 96h 150.26 mg/l. Among all the organic extracts, the ethanol extract of dried leaf powder of S. surattense was found more toxic. The present study revealed that the product of S. surattense has potent molluscicidal phytochemicals, which may be used as potent molluscicides for control of harmful snails.

Keywords: Fasciolosis, Lymnaea acuminata, Molluscicides, Solanum surattense.

INTRODUCTION
Fasciolosis is caused by Fasciola hepatica and F. gigantica (Mas-Coma et al., 2007; Hacariz et al., 2014). Infection of Fasciola has been reported in 81 countries in different parts of the world. It is a major worldwide zoonotic disease in ruminant's animals and human (Mas-Coma et al., 2014; Cwiklinski et al., 2016). It was estimated that between 2.4 million and 17 million people were infected around the world. However, these parasitic diseases in India are mainly caused by F. gigantica (Dalton, 1999). Fasciola is a trematode parasite belongs to the Platyhelminthes, which is a phylum of flatworms (Verma and Prakash, 2020). It has a complex lifecycle among intermediate host snails and definitive mammals hosted, including human (Carvedo and Cabad, 2020). They inhabit in the liver of cattle, sheep, goat, buffalo etc. and play an important role in growth, development and productivity of economically significant livestock (Kuchai et al., 2011; Eshetu et al., 2017; Kumar, 2021). In the northern part of Uttar Pradesh (India), fresh water snail, Lymnaea acuminata is an intermediate
Glass, Precious Electrochemidus Private Limited, Bombay, India) chromatography through a $5 \times 45$ cm column. Five milliliter fractions eluted with ethanol (95%) were collected. Ethanol was evaporated under vacuum and the remaining solids obtained were used for the determination of molluscicidal activity of each fraction.

**Determination of toxicity response**

Toxicity of different organic extracts and column purified of *S. surattense* was performed by the method of Kumar and Singh (2006). Ten snails were kept in a glass aquarium containing 3 liter of dechlorinated tap water. These experimental animals were exposed continuously for 96h to different concentrations and preparation of *S. surattense* and mortality was observed for 24, 48, 72 and 96h. Six experimental aquariums were setup for each concentration. The control groups of snails were kept in the equal volume of water under similar laboratory conditions without treatment. The mortality of snails was recorded at interval of 24h each up to 96h. The mortality of snails was established by the contraction of body within the shell, no response to touch needle probe was taken as evidence of snail death. Lethal values (LC$_{50}$), slope values, t- ratio, 'g' value and heterogeneity factor were calculated using POLO computer programme (Robertson et al., 2007).

**RESULTS AND DISCUSSION**

The dried leaf powder of *S. surattense*, different organic extract and column fractions against *L. acuminata* were concentration and time dependent. The 24h LC$_{50}$ of dried leaf powder of *S. surattense* were 157.33mg/l and at 96h 150.26 mg/l (Table-1). Among all the organic extracts, the ethanolic extract of dried leaf powder of *S. surattense* was more toxic, after 24h, 48h, 72h and 96h exposure against *L. acuminata* the LC$_{50}$ values were observed 147.53, 145.82, 143.82 and 140.82mg/l, respectively (Table-1). The 24h LC$_{50}$ of the column purified fractions of dried leaf powder of *S. surattense* were 135.82 mg/l. The 96h LC$_{50}$ of column purified fraction of dried leaf powder of *S. surattense* were 122.82 mg/l (Table-1). In all treatments column purified fraction was more effective.

The t- ratio was greater than 1.96 and the heterogeneity factor was less than 1.0. The g-value was less than 0.5 at all probability levels (90, 95 and 99) (Table-1). The slope values given in Table-1 were steep and the separate estimates of LC based on each of the six replicates were found to be within the 95% confidence limits of LC$_{50}$.

The result clearly demonstrates that the dried leaf powder of *Solanum surattense* is potent source of molluscicides. The study of toxic efficacy revealed that molluscicidal components of *S. surattense* are soluble in different organic solvents and caused motility of snail, *L. acuminata*. The time and concentration dependent toxic efficacy of *S. surattense* and their different preparations may be either due to the uptake of the active moiety which progressively increases the amount of phytochemicals in snail body with increase in exposure period or it might be possible that the phytochemicals could change into more toxic forms in the snail body due to the action of various enzymes activities. The ethanolic extract of *S. surattense* was tested against *Plasmodium* which has significantly reduced their effect in infected mice (Garedaghi and Khaki, 2014). Higher toxicity of ethanol extract among other organic extracts indicates that molluscicidal phytochemicals are present in *S. surattense* and it's more soluble in ethanolic solvent.

The toxic efficacy of *S. surattense* is concentration and time dependent as the phytochemicals are dissolved in aquarium water and gradually diffuses in snail body and causes mortality with increases in exposure period. Suhas et al. (2009) reported that methanolic extract of *S. surattense* shows antibacterial activity against gram positive bacteria, *Streptococcus aureus* and *Bacillus subtilis* at 50, 75 and 100 µg/ml concentrations. Leaf extracts of *S. surattense* have larvicidal efficacy against *Culex quinquefasciatus* (Mahesh et al., 2012). It's also having a number of alkaloids (Siddiqui and Faizi, 1983), sterols (Kusano et al., 1973), saponine (Tupkari et al., 1972), flavonoids and their glycosides (Debey and Gupta, 1936), tannins, gums (Sheeba, 2010). Several tannin bearing different families of plants have molluscicidal properties (Ayoub and Yankov,
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host of *F. gigantica*, which is responsible for endemic fasciolosis (Singh and Agarwal, 1981; Kumar and Singh, 2006; Kumar *et al.*, 2011; Kumar *et al.*, 2012; Kumar *et al.*, 2013a and 2013b; Kumar and Singh, 2014; Kumar *et al.*, 2016; Kumar *et al.*, 2018; Kumar *et al.*, 2020). Some species of snails and slugs are also causing greater economical loss by damaging agricultural crops (Kumar, 2020). The control of snail population, thereby breaking the life cycle of *Fasciola* and reduce the incidence of zoonotic disease and economic loss are relevant (Kumar and Singh, 2006; Kumar *et al.*, 2009; Kumar *et al.*, 2018; Kumar, 2021). The control of snail population below threshold level by using molluscicides is well-recognized method for control of liver fluke infections. The use of synthetic molluscicides has been advocated that, it is not safer for environment (Agarwal and Singh, 1988). It should be effective for several life stages of the harmful snails, selective and harmless for non-target organism and safer for environment (Singh *et al.*, 1996).

Plant derived molluscicides are becoming alternative source of the synthetic molluscicides because they are more acceptable, cheaper and safer for non target aquatic organisms, as well as being potentially biodegradable and eco-friendly (Marston and Hostettmann, 1985; Kumar, 2021). *Solanum surattense* (Family Solanaceae) is herbaceous weed, which is widely distributed throughout the tropical and subtropical regions of the South East Asia (Khare, 2007). *Solanum surattense* is traditionally used for leprosy, cough, fever, dropsy, dysmenorrheal hypertension, cardiac disorder, epilepsy, asthma and depression (Singh *et al.*, 1979; Vaidyaratnam, 1994; Khan and Khan, 2019). Pharmacologically, it has been evaluated for analgesic, antibacterial, antidiabetic, antinociceptive, antioxidant, antifungal and larvicidal activities (Amirtharaj *et al.*, 2015; Ramar and Nandagopalam, 2011).

Different parts of *S. surattense* are used in the treatment of various diseases like asthma, fever, bronchitis, laxative, tuberculosis, kidney disorder, cough, constipation, tooth ache, sore throat, rheumatism and gonorrhea (Yadav *et al.*, 2014). It has antioxidant, antipyretic (Muthalik *et al.*, 2003), antiulcer, antimicrobial, anti-inflammatory and anthelmintic property (Pawar and Maheshwari, 2003). The aim of present study is to evaluate the molluscicidal efficacy of *S. surattense* against fresh water host snail *L. acuminata*.

**MATERIALS AND METHODS**

**Collection of Snails**

A number of adult snails, *L. acuminata* (2.610.32 cm in length) were collected from low lying submerged fields and ponds from Muhammadabad Gohna, Mau (U.P.) India. The snails were acclimatized for 72 hours in dechlorinated tap water at 27±3°C. The pH of water was 7.2-7.1 and dissolved oxygen, free carbon dioxide and bicarbonate alkalinity were 6.3-7.3 mg/l, 5.4-6.3 mg/l and 103.0-106.0 mg/l, respectively.

**Plant and preparation of crude products**

The fresh leaves of *Solanum surattense* collected from the college campus, was identified by Dr. A.K. Singh Department of Botany, S.G.N. Government P.G. College Muhammadabad Gohna, Mau (U.P.) India. All these leaves were washed by fresh water and dried in sun light 3 to 5 days and pulverized in the electric grinder for crude powder thus obtained, was then sieved with the help of fine mesh cloth. This fine crude powder was then used for toxicity experiments against snail, *L. acuminata*.

**Extraction of organic solvent**

Five gram crude leaf powder of *Solanum surattense* were extracted with 500 ml of 98% ether, 99.7% chloroform, 98% methanol, 98% acetone and 95% ethanol at room temperature for 24h. Each preparation was separately filtered through sterilized whatman No-1 filter paper and the filtered extracts where subsequently evaporated under vacuum (Jaiswal and Singh, 2008). The leaf powder of *S. surattense* yielded 235 mg ethanol, 215 mg chloroform, 250 mg ether and 270 mg acetone extracts. The residues, thus obtained, were used for the determination of molluscicidal activity.

**Column purification**

One hundred milliliters of ethanol extract fraction of dried leaf powder of *S. surattense* were subjected to silica gel (60-120 mesh, Qualigens
Table: 1. Molluscicidal efficacy of dried leaf powder of *S. surattense* and their different organic extract, column purified against *L. acuminata* at different exposure periods.

| Exposure periods | Values | Molluscidal preparations (mg/l) |
|------------------|--------|---------------------------------|
|                  |        | *S. surattense* dried leaf powder | Ether extract | Chloroform extract | Methanol extract | Acetone extract | Ethanol extract | Column purified |
|                  | LC$_{50}$ | 157.35 | 150.82 | 151.68 | 149.59 | 151.13 | 149.53 | 153.82 |
| 24h              | LCL     | 152.35 | 145.62 | 148.63 | 146.21 | 147.85 | 144.21 | 150.22 |
|                  | UCL     | 160.98 | 155.82 | 152.86 | 154.36 | 156.34 | 150.85 | 158.64 |
|                  | Slope Value | 1.65±0.70 | 1.45±0.33 | 1.43±0.70 | 1.23±0.35 | 1.28±0.11 | 1.60±0.71 | 1.53±0.16 |
|                  | t-ratio | 3.61 | 5.33 | 3.83 | 2.66 | 3.29 | 5.77 | 2.61 |
|                  | g-value | 0.23 | 0.29 | 0.16 | 0.26 | 0.22 | 0.24 | 0.28 |
|                  | Heterogeneity | 0.25 | 0.17 | 0.21 | 0.51 | 0.27 | 0.20 | 0.22 |
|                  | 48h     | LC$_{50}$ | 155.62 | 149.75 | 150.11 | 148.69 | 151.61 | 145.82 | 130.62 |
|                  | LCL     | 157.75 | 145.36 | 147.51 | 144.82 | 148.59 | 142.52 | 127.52 |
|                  | UCL     | 158.92 | 153.22 | 154.86 | 153.89 | 154.63 | 150.35 | 135.86 |
|                  | Slope Value | 1.55±0.27 | 1.31±0.30 | 1.28±0.75 | 1.66±0.30 | 1.27±0.35 | 1.86±0.38 | 1.70±0.43 |
|                  | t-ratio | 2.29 | 3.13 | 4.81 | 3.54 | 3.20 | 4.56 | 4.41 |
|                  | g-value | 0.18 | 0.16 | 0.25 | 0.19 | 0.17 | 0.23 | 0.32 |
|                  | Heterogeneity | 0.18 | 0.26 | 0.15 | 0.28 | 0.45 | 0.15 | 0.31 |
|                  | 72h     | LC$_{50}$ | 153.35 | 147.55 | 148.69 | 146.42 | 149.85 | 143.82 | 125.85 |
|                  | LCL     | 150.12 | 142.58 | 146.52 | 143.82 | 147.61 | 140.69 | 122.56 |
|                  | UCL     | 156.32 | 152.38 | 153.66 | 149.32 | 154.73 | 147.82 | 128.73 |
|                  | Slope Value | 1.86±0.99 | 1.74±0.13 | 1.40±0.34 | 1.44±0.55 | 1.37±0.28 | 1.88±0.74 | 1.77±0.65 |
|                  | t-ratio | 2.77 | 3.11 | 4.82 | 3.55 | 2.66 | 3.91 | 2.27 |
|                  | g-value | 0.26 | 0.11 | 0.28 | 0.12 | 0.34 | 0.25 | 0.16 |
|                  | Heterogeneity | 0.36 | 0.34 | 0.29 | 0.28 | 0.23 | 0.31 | 0.19 |
|                  | 96h     | LC$_{50}$ | 150.26 | 146.89 | 145.63 | 144.82 | 147.99 | 140.82 | 122.82 |
|                  | LCL     | 145.81 | 142.31 | 141.65 | 141.82 | 144.83 | 138.66 | 119.66 |
|                  | UCL     | 156.96 | 151.80 | 149.10 | 149.39 | 152.62 | 145.72 | 125.86 |
|                  | Slope Value | 1.85±0.70 | 1.65±0.31 | 1.29±0.95 | 1.77±0.36 | 1.46±0.83 | 1.75±0.70 | 1.86±0.77 |
|                  | t-ratio | 3.51 | 4.88 | 2.71 | 3.56 | 2.95 | 4.56 | 3.85 |
|                  | g-value | 0.17 | 0.20 | 0.19 | 0.35 | 0.28 | 0.27 | 0.19 |
|                  | Heterogeneity | 0.34 | 0.16 | 0.32 | 0.28 | 0.21 | 0.34 | 0.25 |

Six batches of ten snails were exposed different concentration of the above molluscicides. Mortality was determined after every 24h. LCL- lower confidence limits UCL- upper confidence limits.

1986). Bahuguna *et al.* (2008) described that different leaf extract of *S. surattense* like petroleum ether, aqueous alcohol and chloroform for antiulcer activity areas like pH, total acidity, free acidity and ulcer. This plant is also used in treatment of insomnia, cold, worms (Mathur and Agrawal, 2011), laxative, enlargement of liver, aphrodisiac activities (Kiritsikar and Basu, 2005; Gupta *et al.*, 2011), anti-nociceptive, molluscicidal and anti-fungal activity (Bhutani *et al.*, 2010). The anti-cancerous efficiency of *S. surattense* fruit extract might be attributed to the presence of flavanoids such as apiginene, quereciten, fisatin and luteolin, which known to be the potent inhibitors of cancer cell proliferation (Kumar and Pandey, 2014).

It is evident from result section that the steep slope values indicate that a small increase in the concentration of different treatment which caused mortality in snails (Table-1). A t-ratio value greater than 1.96 indicates that the regression is significant. Values of heterogeneity factor less than 1.0 denote that in the replicate
tests of random sample the concentration response lines would fall within the 95% confidence limits and thus the model fits the data adequately.

CONCLUSION
It can be concluded from the above study that the medicinal plant S. surattense can be used as potent molluscicide, as it is easily available and ecologically more acceptable for livestock keepers. These results, allied to the easy preparation of the extract, low cost of application, could make the aqueous extract of S. surattense an alternative molluscicidal efficient in the control of snails populations. Further studies are required to identify the actual phytochemicals constituents that are present in the crude extract of this plant which are responsible for molluscicidal activity.

REFERENCES
1. Agarwal R. A. and Singh D. K. (1988). Harmful gastropods and their control. Acta. Hydrochim. Hydrobiol. 16:113-38.
2. Amirtharaj L. V., Srinivasan N., Abburi S., Karthikeyan K. and Mahalaxmi S. (2015). Evaluating the Analgesic Efficacy of Solanum surattense (Herbal Seed Extract) in Relieving Pulpal Pain- An in vivo study. Dentistry. 5:1.
3. Ayoub S. M. H. and Yankov L. K. (1986). The molluscicidal factor of tannin-bearing plants. Int. J. Crude Drug. Res. 24:16-18.
4. Bahuguna Y., Juyal V. and Gusain K. (2008). Pharmacological evaluation of Solanum surattense leaves for antiulcer activity. International Journal of Pharmacy Research. 1(2):253-259.
5. Bhutani K. K., Paul A. T., Fayad W. and Linder S. (2010). Apoptosis inducing activity of steroidal constituents from Solanum xanthocarpum and Asparagus racemosus. Phytomedicine. 17(10):789-793.
6. Caravedo M. A. and Cabada M. M. (2020). Human Fascioliasis: Current epidemiological status and strategies for Diagnosis, Treatment, and control. Research and Reports in Tropical Medicine. 11:149-158.
7. Cwiklinski K., O’Neill S. M., Donnelly S. and Dalton J. P. (2016). A prospective view of animal and human Fasciolosis. Parasite Immunology. 38:558-568.
8. Dalton J. P. (1999). Fasciolosis, CAB International Publishing, Wallingford, Oxon, UK. 552p.
9. Debey P. and Gupta P. C. (1936). A new flavonol glycosides from the flowers of Solanum xanthocarpum. Phytochemistry. 17:613.
10. Eshetu E., Thomas N., Awukew A., Goa A. and Butako B. (2017). Study on the prevalence of Bovine Fasciolosis and Estimated financial losses due to liver condemnation: Incase of Angacha Woreda, Kambata Tembaro Zone, Southern Ethiopia. J. Biology Agriculture and Healthcare. 7(7):78-83.
11. Garedaghi Y. and Khaki A. (2014). Evaluation of the effectiveness of ethanolic extract of Solanum surattense against Plasmodium Berghei in comparison with chloroquine in Sourian Mice using in vivo tests. Crescent Journal of Medical and Biological Sciences. 1(3):76-79.
12. Gupta R. K., Hussain T., Panigrahi G., Das A., Singh G. N., Sweety K., Faiyazuddin M. and Rao C. V. (2011). Hepatoprotective effect of Solanum xanthocarpum fruit extract against CCl4 induced acute liver toxicity in experimental animals. Asian Pacific Journal of Tropical Medicine. 4(12):964-968.
13. Hacariz O., Baykal A. T., Akgum M., Kavak P., Sagiroglu M. S. and Sayers G. P. (2014). Generating a detailed protein profile of Fasciola hepatica during the chronic stage of infection in cattle. Proteomics. 14:1519-1530.
14. Jaiswal P. and Singh D. K. (2008). Molluscicidal activity of Carica papaya and Areca catechu against the freshwater snail Lymnaea acuminata. Vet. Parasitol. 152:264-270.
15. Khan A. U. and Khan A. W. (2019). Antidepressant effect of Solanum surattense Burm. F. The Journal of Animal and Plant Sciences. 29(4):1188-1192.
16. Khare C. P. (2007). Indian Medicinal Plants, an Illustrated Dictionary. Springer, Berlin/Heidelberg, New Delhi, India. 615p.

17. Kiritikar K. R. and Basu B. D. (2005). Indian Medicinal Plant. 2nd ed. Dehradun: Bishen Singh Mahendra Pal Singh.1759-1762.

18. Kuchai Z. M., Chishti M. M., Zaki R. A., Darmuzffer S. T., Ahmad J. and Tak H. (2011). Some Epidemiological aspects of Fascioliasis among cattle of Ladakh. Global Veterinarian. 7(4):342-346.

19. Kumar P. (2020). A Review-On Molluscs as an Agricultural Pest and their control. International Journal of Food Science and Agriculture. 4(4):383-389.

20. Kumar P. (2021). Effect of Medicinal plant Potentilla fulgens against fecundity, hatchability and survival of Fasciola host snail Indoplanorbis exustus. Indian Journal of Scientific Research. 11(2):19-24.

21. Kumar Pradeep and Singh D. K. (2006). Molluscicidal activity of Ferula asafoetida, Syzygium aromaticum and Carum carvi and their active components against the snail Lymnaea acuminata. Chemosphere. 63:1568-1574.

22. Kumar P. and Singh D. K. (2014). In vitro anthelmintic activity of Allium sativum, Ferula asafoetida, Syzygium aromaticum and their active components against Fasciola gigantica. Journal of Biology and Earth Sciences. 4(1):B57-B65.

23. Kumar P., Kumari S. and Singh D. K. (2016). In vitro activity of different phytochemicals in binary combinations against Fasciola gigantica. Current Life Sciences. 2(3):58-63.

24. Kumar P., Kumari S., Singh R. N. and Singh D. K. (2020). Fasciola larvae: Anthelmintic activity of medicinal plant Potentilla fulgens against sporocyst, redia and cercaria. Asian Journal of Advances in Research. 3(3):24-30.

25. Kumar P., Singh V. K. and Singh D. K. (2009). Kinetics of enzyme inhibition by active molluscicidal agent ferulic acid, umbelliferone, eugenol and limonene in the nervous tissues of snail Lymnaea acuminata. Phytotherapy Research. 23(2):172-177.

26. Kumar P., Singh V. K. and Singh D. K. (2012). Enzyme activity in the nervous tissue of Lymnaea acuminata fed to different bait formulations. American Journal of Chemistry. 2(2):89-93.

27. Kumar P., Singh V. K. and Singh D. K. (2011). Combination of molluscicides with attractant carbohydrates and amino acid in bait formulation against the Snail Lymnaea acuminata. European Review for Medical and Pharmacological Science. 15:550-555.

28. Kumar P., Singh V. K. and Singh D. K. (2013a). Feeding of binary combination of carbohydrates and amino acids with molluscicides baits and their effects on reproduction of Lymnaea acuminata. Advances in Biological Research. 7(2):42-49.

29. Kumar P., Singh V. K. and Singh D. K. (2013b). Reproduction of Lymnaea acuminata fed to bait containing binary combination of amino acid with molluscicides. Journal of Biology and Earth Science. 3(1):B65-B71.

30. Kumar P., Sunita K. and Singh D. K. (2018). Molluscicidal activity of different organic root extract of Potentilla fulgens against liver fluke vector snail Indoplanorbis exustus. Asian J. Anim. Sci. 12:30-35.

31. Kumar S. and Pandey A. K. (2014). Medicinal attributes of Solanum xanthocarpum fruit consumed by several tribal communities as food: an in-vitro antioxidant, anticancer and anti HIV perspective. BMC Complement Altern Med. 14:112.

32. Kusano G., Beisler J. and Sato Y. (1973). Steroidal constituents of Solanum xanthocarpum. Phytochemistry. 12:397-401.

33. Mahesh K. P., Murugan K., Kovandan K., Panneerselvam C., Prasanna K. K., Amerasan D., Subramaniam J., Kalimuthu K. and Nataraj T. (2012). Mosquitocidal activity of Solanum xanthocarpum fruit extract and copepod Mesocyclops thermocyclopoides for the control of dengue vector Aedes aegypti. Parasitol Res. 111(2):609-18.
34. Marston A. and Hostettmann K. (1985). Plant mollusccicides. Phytochemistry. 24:639-652.
35. Mas-Coma S., Bargues M. D. and Valero M. A. (2007). Plant borne trematode Zoonoses: Fascioliasis and fasciolopsiasis. In: Murrell, Fried (Eds.), World Class Parasites: Food-Borne Parasites, Fish and Plant-Borne Parasites. Springer Verlag, New York. 22:293-334.
36. Mas-Coma S., Bargues M. D. and Valero M. A. (2014). Diagnosis of human fascioliasis by stool and blood techniques: update for the present global scenario. Parasitology. 141(1):1918-1946.
37. Mathur D. and Agrawal R. C. (2011). Withania coagulans: A review on the morphological and pharmacological properties of the shrub. World Journal of Science and Technology. 1(10):30-37.
38. Muthalik K., Paridhavi K. and Rao M. U. N. (2003). Antipyretic and analgesic effect of leaves of Solanum surattense Linn in rodents. Indian Journal of Pharmacology. 35:312-315.
39. Pawar P. K. and Maheshwari V. L. (2003). Agarobacterium rhizogene mediated hairy root induction in two medicinally important members of family Solanaceae. Indian Journal of Biotechnology. 3:414-417.
40. Ramar K. and Nandagopalan V. (2011). Rapid in vitro propagation of medicinally important plant Solanum surattense. Int. J. Pharm. Life Sci. 2:499-501.
41. Robertson J. L., Russell R. M., Preciter H. K. and Savin N. E. (2007). Bioassay with arthropods data, 2nd Eds. Taylar and Francis, CRC Press. 1-224p.
42. Sheeba E. (2010). Antibacterial activity of Solanum surattense Burm. F. Kathmandu University Journal of Science Engineering and Technology. 6:1-4.
43. Siddiqui S. and Faizi S. (1983). Studies in the chemical constituents of the fresh berries of Solanum xanthocarpus. Journal of Chemical Society of Pakistan. 5:99-101.
44. Singh A., Singh D. K., Mishra T. N. and Agarwal R. A. (1996). Molluscicide of Plant origin. Bio. Agric. And Horti. 13:205-252.
45. Singh M. P., Malla S. B., Rajbhandari S. B. and Manandhar A. (1979). Medicinal plants of Nepal-retrospects and prospects. Econ. Bot. 33:185-198.
46. Singh O. and Agarwal R. A. (1981). Toxicity of certain pesticides to two economic species of snails in northern India. Journal of Economic Entomology. 74:568-571.
47. Suhas P., Vijaya J., Prasanna S. and Sudhir S. (2009). Screening of whole plant extract of Solanum surattense for antibacterial activity. Int. J. of Pharmaceutical Sciences. 1(1):110-114.
48. Tupkari S. V., Saoji A. N. and Deshmukh V. K. (1972). Phytochemical study of Solanum xanthocarpum. Planta Med. 22:184-187.
49. Vaidyaratnam P. V. (1994). Indian medicinal plants: a compendium of 500 species. Madras: Orient Longman Ltd. 59-64.
50. Verma A. K. and Prakash S. (2020). Status of Animal Phyla in different Kingdom Systems of Biological Classification. International Journal of Biological Innovations. 2 (2): 149-154. https://doi.org/10.46505/IJBI.2020.2211.
51. Yadav A., Bhardwaj R. and Sharma R. A. (2014). Free radical scavenging potential of the Solanum surattense Burm F.: An important medicinal plant. Int. J. of Pharmacy and Pharmaceutical Sciences. 6(3):39-42.