



Aegle marmelos and *Murraya koenigii*: The wonder plants against bovine infertility

RUPALI RAUTELA¹✉ and RAHUL KATIYAR²

ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh 243 122 India

Received: 17 September 2021; Accepted: 26 September 2022

ABSTRACT

Aegle marmelos and *Murraya koenigii* are the plants with impending medicinal properties. Both the plants contain various phyto-constituents that could be utilized for the treatment of various ailments in human and animal species. The *A. marmelos* and *M. koenigii* are easy to procure and their use is cost-effective which makes them important particularly in livestock health management. The plants are rich in trace minerals and antioxidants which augment nutraceutical values. In addition, recognized antibacterial and anti-inflammatory potential emphasizes *A. marmelos* and *M. koenigii* to be used against bovine infertility. The review comprises of use of *Aegle marmelos* and *Murraya koenigii* in the treatment against reproductive disorders in bovine.

Keywords: Anestrous, Antioxidant, Cow, Endometritis, Phytochemicals

Medicinal herbs are the potential source of therapeutic aids and have been used for both humans and animals all over the world since decades (Verma and Singh 2011). These plants contain certain chemical constituents that have definite physiological action on the body and constitute a defense mechanism against various infectious agents and other diseases. These green medicines or herbal drugs are healthier, have a wider margin of safety (Brull and Coote 1999, Dhankhar *et al.* 2011) and safer than allopathic ones (Brindha and Parvathy 2003). Therefore, the use of green medicine has emerged as a trend for benefiting health. Even, World Health Organization (WHO) recognized many herbal plants for their potential medicinal properties. Further, WHO recommended the use of herbal plants for treatment of human and animal health particularly in the developing countries as the resource for poor, small and marginal farmers (WHO 2003).

In Indian scenario, various plants such as *Bambusa bambos*, *Ricinus communis* (Das 2011), *Brassica napas*, *Mimosa pudica* (Kumar and Bharti 2013), *Abrus precatorius* (Lachure 2012), *Cuminum cyminum*, *Allium sativum*, *Curcuma domestica*, *Azadirachta indica* (Eswaran *et al.* 2013), *Piper nigrum*, *Cucurma aromatic* (Jagadeeswary *et al.* 2014), *Lens esculenta moench*, *Pennisetum typhoides* (Kumar *et al.* 2007) have been used to treat various causes of infertility. Similarly, *Aegle marmelos* and *Murraya koenigii* has emerged as plants

with various therapeutic potential.

Aegle marmelos (L.) Corrêa

Aegle marmelos, commonly known as Bael, is a tree under family Rutaceae. The plant is found in the sub-Himalayan region, central and southern India. *A. marmelos* is plant with many beneficial therapeutic effects as documented in traditional system of Indian medicine (Abirami *et al.* 2014). The leaves, fruits, stem and roots of *A. marmelos* have been used against various ailments as ethno medicine (Badam *et al.* 2002). The plant has several pharmacologically bioactive principles (Table 1) with anti-diarrhoeal, antidiabetic, antipyretic, hepato-protective, antifungal, anti-inflammatory, antioxidant and antibacterial properties (Sekar *et al.* 2011, Yesaswini *et al.* 2014).

Murraya koenigii (L.) Spreng

Murraya koenigii, commonly known as curry leaf and meethi neem is a deciduous plant with potential medicinal properties. The plant contains several phytochemicals (Table 2) that are a potential source of ethno medicine (Gahlawat *et al.* 2014). The plant is reported to possess pharmacological properties like antibacterial, anti-inflammatory, antioxidative, cytotoxic and antiulcer, antidysenteric, hypoglycemic, antihelminthic and antifungal (Ajay *et al.* 2011, Gahlawat *et al.* 2014).

Aegle marmelos and *Murraya koenigii* have drawn attention as a potential source of phytomedicine (Dhankhar *et al.* 2011) due to presence of bioactive principles against various ailments. A large number of recent Indian reviews have emphasized the potential of *A. marmelos* and *M. koenigii* plants for its antibacterial, anti-inflammatory and antioxidant properties (Dhankhar *et al.* 2011, Patel *et al.*

Present address: ¹Division of Animal Reproduction, Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh.

²Division of Livestock Production, ICAR-Research Complex for North East Hill region, Umiam, Meghalaya. ✉Corresponding author email: rautela_rupali@rediffmail.com

Table 1. Various active principles found in *Aegle marmelos*

Activity	Principle/s	Source
Antibacterial	Eugenol, Marmelosin, Cuminaldehyde	Duke 1992, Ghosh and Playford 2003, Jagetia <i>et al.</i> 2004
Antioxidant	Eugenol, Marmesinin	Arul <i>et al.</i> 1999, Geetha and Varalakshmi 2001
Anti-inflammatory	Lupeol, Skimmianine, Citral	Rastogi and Mehrotra 1998, Geetha and Varalakshmi 2001
Anticancer	Skimmianine	Takase <i>et al.</i> 1994
Analgesic	Skimmianine	Goel <i>et al.</i> 1997
Antidiuretic	Skimmianine	Goel <i>et al.</i> 1997
Hepatoprotective	Eugenol	Sherwood and Toliver-kinsky 2004
Antiulcer	Marmin, Luvangetin, Eugenol, Cineol	Misra <i>et al.</i> 1991, Hajra <i>et al.</i> 1997, Capasso <i>et al.</i> 2000
Anthelmintic	Marmelosin	Ghosh and Playford 2003
Anti-diarrhoea	Tannin	Ghosh and Playford 2003
Antiviral	Marmelide	Badam <i>et al.</i> 2002
Anti-histaminic	Citral	Santos and Rao 2001

Table 2. Various active principles found in *Murraya koenigii*

Activity	Principle/s	Source
Antibacterial	Girinimbine, Murrayanine, Marmesin-1'-O-beta-Dgalactopyranoside, Mahanine, Murrayacine, Mahanimbine, Gurjunene, Murrayanol	Reisch <i>et al.</i> 1994, Rastogi and Mehrotra 1998, Ramsewak <i>et al.</i> 1999, Pande <i>et al.</i> 2009, Kumar <i>et al.</i> 2010
Antioxidant	Mahanine, Bismurrayafoline E, Euchrestine, Bismahanine, Bispyrafoline, Isomahanine	Adesina <i>et al.</i> 1988, Song and Chin 1991, Tachibana <i>et al.</i> 2001, 2003
Antifungal	O-methyl murrayamineA, Lutein, Tocopherol, Carotene	
Anticancer	Girinimbine, Murrayanine, Marmesin-1'-O-beta-Dgalactopyranoside	Kumar <i>et al.</i> 2010
Anti-diabetic	Girinimbine, Koenoline	Bandyopadhyaya <i>et al.</i> 2002, Kok <i>et al.</i> 2012
Hepatoprotective	Mahanimbine	Dineshkumar <i>et al.</i> 2010
Anti-diarrhoea	Tocopherol, Mahanine, Girinimbine, Tocopherol Isomahanimbine, Mahanimbine, Murrayazolidine, Murrayazoline	Gupta and Singh 2007
	Kurryam, Koenine, Koenimbine	Mandal <i>et al.</i> 2010

2012, Gahlawat *et al.* 2014, Savitha and Balamurugan 2014, Nigam and Nambiar 2015, Rautela *et al.* 2017, 2018) which advocate their role as phytomedicine.

Beneficial effect of Aegle marmelos and Murraya koenigii in reproductive disorders

Endometritis: The general principle of therapy against endometritis is to reduce the uterine bacterial population, enhance uterine defense and repair mechanism and reverse the inflammatory changes (Leblanc 2008). *Aegle marmelos* and *Murraya koenigii* have antibacterial, anti-inflammatory and antioxidant properties which could be exploited for the treatment of endometritis. The zone of inhibition against bacteria derived from endometritic cows was observed when aqueous or ethanolic extract of herbal plants were used (Rautela *et al.* 2017). Earlier literatures of Abirami *et al.* (2014), Savitha and Balamurugan (2014) and Akinnibosun and Umufu (2015) further confirm the antibacterial potential of the herbal plants. Similarly, reduced inflammation using plant extract of *A. marmelos* and *M. koenigii* has been demonstrated by Arul *et al.* (1999), Maity *et al.* (2009) and Gupta *et al.* (2010). The reversal of inflammatory changes could be helpful in promoting uterine repair and regeneration. An association

between occurrence of endometritis and oxidative stress has been mentioned in recent literatures (Pande *et al.* 2013, Krishnan *et al.* 2014). The increased oxidant level either due to the poor antioxidant system of the body or generated in response to infection, declines the immune status of the animal. This allows the bacterial population to flare up and has long term negative impact on functioning of hypothalamus, pituitary and ovary (Sheldon *et al.* 2009). The antioxidant enriched *A. marmelos* and *M. koenigii* therefore, could be helpful to protect from the free radical damage and revival of the normal physiology and reproductive function.

In the study by Rautela *et al.* (2018), the therapeutic use of *A. marmelos* and *M. koenigii* against endometritis has been determined. The beneficial impact was perceived through reduction in uterine bacterial load, polymorphonuclear cell count and increase in blood levels of antioxidants in the study. The authors further suggested the use of herbal plants as alternative therapy against endometritis.

Anestrus: The resumption of estrous cycle following phytotherapy with *Aegle marmelos* and *Murraya koenigii* has been documented by Dutt *et al.* (2018). The feeding of the herbal mixture resulted in expression of cyclicity in cow

(Mehrotra *et al.* 2005), goat (Dutt *et al.* 2010) and buffalo (Dutt *et al.* 2011). Further, the effect was more pronounced with feeding of both herbal plants in combination rather than individually (Dutt *et al.* 2018). Earlier literatures have reported 85.71 and 60% estrus induction rate with 83.33 and 66.7% pregnancy rate following herbal treatment with *A. marmelos* and *M. koenigii* in anestrus goats and buffaloes, respectively (Dutt *et al.* 2010, 2011). The authors explained that the combination of herbal plants might have triggered gonadotropin hormones from anterior pituitary which might be responsible for restoration of cyclicity in anestrus animals.

The higher concentration of reactive oxygen species (ROS) has detrimental effect on ovarian function. The ROS impairs protein synthesis required for follicular growth and development, threatening maturation and ovulation (Derar *et al.* 2011). The documented activity of both the plants might have overwhelmed the oxidant levels resulting in restoration of cyclic activity in animals.

Delayed puberty: An induction of estrus behaviour has been observed in delayed pubertal heifers following supplementation of *Aegle marmelos* in combination with *Murrayakoenigii* (Kumar *et al.* 2016, Kumawat *et al.* 2016). A 90.9 and 92.3% onset of cyclicity following feeding of herbal mixture has been reported by Das *et al.* (2016) and Kumawat *et al.* (2016), respectively in delayed pubertal heifers. The former author further observed 54.1% pregnancy rate in herbal treated group as compared to control (16.7%) animals. The effect is attributed to phytoestrogens, mineral content and antioxidants available in the leaves of the plants. The available antioxidant might have augmented folliculogenesis by preventing ROS induced apoptosis of oocytes. The phyto-constituents might have stimulated steroidogenic activity of hypothalamus, facilitated follicular growth and steroid production resulting in onset of cyclicity (Jondhale *et al.* 2009, Nandini *et al.* 2010, Kumar *et al.* 2012). Further, the active principles of the plants may aid in follicular development particularly between dominance and ovulation resulting in resumption of estrus. The elucidation is also supported by study of Mehrotra *et al.* (2003) who reported advancement of puberty in female rats following supplementation of herbal mixture. The above observations point out potential of *A. marmelos* and *M. koenigii* in induction of estrus and fertility in delayed pubertal animal.

Conclusion

Aegle marmelos and *Murrraya koenigii* contain numerous phyto-constituents that have been proved to have beneficial activity in terms of health and medicine. The plants draw attention as a source of green medicine as these are inexpensive and easily available to the famers. The *A. marmelos* and *M. koenigii* have antibacterial, anti-inflammatory and antioxidant potential that hold future promise for the treatment of endometritis, anestrus and delayed puberty in bovine that has been documented in earlier literatures. However, their effect on other

reproductive disorders is required to be explored so that maximum utilization of the plants can be done.

REFERENCES

- Abirami S K G, Vivekanandhan K, Hemanthkumar R, Prasanth S and Ravi kumar J. 2014. Study of antimicrobial potential of *Aegle marmelos*. *Journal of Medicinal Plants Studies* **2**: 113–16.
- Adesina S K, Olatunji O A, Brgenthal D and Reisch J. 1988. New biogenetically significant constituents of *Clausena anisata* and *Murrraya koenigii*. *Pharmazie* **43**: 221–22.
- Ajay S, Rahul S, Sumit G, Paras M, Mishra A and Gaurav A. 2011. Comprehensive review: *Murrraya koenigii* Linn. *Asian Journal of Pharmacy and Life Science* **1**: 417–25.
- Akinnibosun F I and Umufu J A. 2015. Assessment of the phytochemical and antibacterial properties of the synergy of *Murrraya koenigii* and *Telfaria occidentalis* ethanolic leaf extracts. *International Journal of Research Studies in Biosciences* **3**: 80–89.
- Arul V, Kumaraguru S, Dhananjayan R. 1999. Effects of aegeline and lupeol-the two cardioactive principles isolated from the leaves of *Aegle marmelos* Corr. *Journal of Pharmacy and Pharmacology* **51**: 252.
- Badam L, Bedekar S S, Sonawane K B and Joshi S P. 2002. *In vitro* antiviral activity of bael (*Aegle marmelos* Corr) upon human coxsackie viruses B1-B6. *Journal of Communicable Diseases* **34**: 88.
- Bandyopadhyaya S, Roy K C, Roy M, Pal B C, Bhadra R, Das K and Bhattacharya S. 2002. Herbal composition of blend of active components prepared form *Murrraya koenigii* and *Piper betle* useful for blocking of 5-lipoxygenase activity. US Pat. Appl. Publ. US 2002, 86, 068, (Cl. 424-734: A61k35/78) 4 Jul. 2002, US Appl. 925, 415, 10 Aug 2001; 12 Pp Cont In Part of U.S. Ser. No 925, 415.
- Brindha R and Parvathy S. 2003. Ethnobotanical medicines of Anaimalai union pollachi taluk, Coimbatore district, Tamil Nadu. *Ancient Science of Life* **22**: 166–68.
- Brull S and Coote P. 1999. Preservative agents in foods: Mode of action and microbial resistance mechanisms. *International Journal of Food Microbiology* **50**: 1–17.
- Capasso R, Pinto L, Vuotto M L and Di Carlo G. 2000. Preventive effect of eugenol on PAF and ethanol-induced gastric mucosal damage. *Fitoterapia* **71**: 131–37.
- Das G K, Mehrotra S, Narayanan K, Kumawat B L, De U K and Khan T A. 2016. Estrus induction response and fertility performance in delayed pubertal heifers treated with *A. marmelos* and *M. koenigii*. *Journal of Animal Research* **6**: 921–26.
- Das P K. 2011. Ethnoveterinary practices for cattle diseases in Ganjam district of Orissa, India. *Life Science Leaflets* **18**: 700–06.
- Derar D R, Hasab-Enaby H S, Ali H H, Zain A and Shehata S H. 2011. Postpartum ovarian resumption in native dairy cows in upper Egypt and their relation to oxidant antioxidant status. *Endocrinology and Metabolic Syndrome* **S4**: 002.
- Dhankhar S, Ruhil S, Balhara M, Dhankhar S and Chhillar A K. 2011. *Aegle marmelos* (Linn.) Correa: A potential source of phytomedicine. *Journal of Medicinal Plants Research* **5**: 1497–1507.
- Dineshkumar B, Mitra A and Mahadevappa M. 2010. Antidiabetic and hypolipidemic effects of mahanimbine carbazole alkaloid from *Murrraya koenigii* Rutaceae leaves. *International Journal of Phytomedicines* **2**: 22–30.

- Duke J A. 1992. *Handbook of Biologically Active Phytochemicals and Their Activities*. CRC press, United States.
- Dutt R, Dalal J, Singh G, Gahalot S C and Chandolia R K. 2018. Medicinal uses of *Murraya koenigii* and *Aegle marmelos* for fertility augmentation in animals: A review. *International Journal of Current Microbiology and Applied Sciences* 7: 645–57.
- Dutt R, Mehrotra S, Hoque M, Shanker U, Singh G, Agarwal S K, Das G K and Singh S K. 2010. Effect of *M. koenigii* and *A. marmelos* combination on resumption of fertility in anestrus goats. *Journal of Applied Animal Research* 38: 275–78.
- Dutt R, Mehrotra S, Shanker U and Singh G. 2011. Effect of *M. koenigii* and *A. marmelos* feeding on anestrus buffaloes. *Indian Journal of Animal Reproduction* 32: 47–49.
- Eswaran S, Boomibalagan P and Rathinavel S. 2013. Ethnoveterinary medicinal practices of the villagers of Usilampatti Taluk of Madurai district, India. *International Journal of Botany* 9: 37–43.
- Gahlawat D K, Dheeraj K, Jakhar S and Dahiya P. 2014. *Murraya koenigii* (L.) Spreng: An ethnobotanical, phytochemical and pharmacological review. *Journal of Pharmacognosy and Phytochemistry* 3: 109–19.
- Geetha T and Varalakshmi P. 2001. Anti-inflammatory activity of lupeol and lupeol linoleate in rats. *Journal of Ethnopharmacology* 76: 77–80.
- Ghosh S and Playford R J. 2003. Bioactive natural compounds for the treatment of gastrointestinal disorders. *Clinical Science* 104: 547–56.
- Goel R K, Maiti R N, Manickam M and Ray A B. 1997. Antiulcer activity of naturally occurring pyrano-coumarin and isocoumarins and their effect on prostanoid synthesis using human colonic mucosa. *Indian Journal of Experimental Biology* 35: 1080–83.
- Gupta R S and Singh D. 2007. Protective nature of *Murraya Koenigii* leaves against hepato-suppression through antioxidant status in experimental rats. *Pharmacology Online* 1: 232–42.
- Gupta S, George M, Singhal M, Sharma G N and Garg V. 2010. Leaves extract of *Murraya koenigii* Linn for anti-inflammatory and analgesic activity in animal models. *Journal of Advanced Pharmaceutical Technology and Research* 1: 68–77.
- Hajra P K, Nair V J and Daniel P. 1997. *Flora of India*. Volume 4, Botanical Survey of India, Calcutta.
- Jagadeeswary V, Reddy M S and Satyanarayan K. 2014. Ethno-veterinary practices used by tribals of Chittoor district, Andhra Pradesh, India. *Indian Journal of Animal Research* 48: 251–57.
- Jagetia G C, Venkatesh P and Baliga M S. 2004. Fruit extract of *Aegle marmelos* protects mice against radiation-induced lethality. *Integrative Cancer Therapies* 3: 323–32.
- Jondhale N S, Mehrotra S, Agarwal S K, Singh S K, Das G K and Deori S. 2009. Effect of *A. marmelos* and *Ficus religiosa* leaves extracts on the ovarian function in rats. *Indian Veterinary Journal* 86: 353–55.
- Kok S Y Y, Mooi S Y, Ahmad K and Sukari M A. 2012. Antitumour promoting activity and antioxidant properties of girinimbine isolated from the stem bark of *Murraya koenigii*. *Molecules* 17: 4651–60.
- Krishnan B B, Kumar H, Mehrotra S, Singh S K, Goswami T K and Narayanan K. 2014. Subclinical endometritis increases oxidative stress and modulates polymorphonuclear leukocyte functions in crossbred cows. *Indian Journal of Animal Reproduction* 84: 1192–95.
- Kumar B, Das G K, Mehrotra S, Chaudhary J K, Singh V, Mishra S K and Saxena A. 2012. Estrus induction response and pregnancy rate in delayed pubertal heifers treated with herbal plants. *Proceeding of the National symposium of XXVIII Annual Convention of the Indian Society for Study of Animal Reproduction*. Khanapara, Guwahati, India, pp 43.
- Kumar B, Sachan V, Kumar A, Singh V, Das G K and Saxena A. 2016. Effect of supplementation of *A. marmelos* and *M. koenigii* on the follicular development in delayed pubertal Sahiwal heifers. *Journal of Animal Research* 6: 1047–52.
- Kumar N S, Mukharjee P K, Bhadra S, Saha B P and Pal B C. 2010. Acetylcholinesterase inhibitory potential of a carbazole alkaloid, mahanimbine from *Murraya koenigii*. *Phytotherapy Research* 24: 629–31.
- Kumar R and Bharti A V. 2013. Folk veterinary medicines in the Bareilly district of Uttar Pradesh, India. *Indian Journal of Traditional Knowledge* 12: 40–46.
- Kumar R, Singh R and Rajkumar. 2007. Control of anestrus in buffaloes through locally available resources. *Italian Journal of Animal Science* 6: 659–62.
- Kumawat B L, Das G K, Narayanan K, Mehrotra S, Prasad J K, Ghosh S K and Kumar H. 2016. Effect of *A. marmelos* and *M. koenigii* on estrus induction, conception and calving rate in delayed pubertal heifers under field condition. *Indian Journal of Animal Reproduction* 37: 17–19.
- Lachure P S. 2012. Exploration of some Medicinal Plants used by tribals from Digra region of District - Yavatmal, Maharashtra, India. *International Journal of Scientific Research* 2: 1–4.
- Leblanc S J. 2008. Postpartum uterine disease and dairy herd performance. *Veterinary Journal* 176: 102–14.
- Maity P, Hansda D, Bandyopadhyay U and Mishra D K. 2009. Biological activities of crude extracts and chemical constituents of Bael, *Aegle marmelos* (L.) Corr. *Indian Journal of Experimental Biology* 47: 849–61.
- Mandal N A, Kar M, Banerjee S K, Das A, Upadhyay S N, Singh R K, Banerji A and Banerji J. 2010. Antidiarrhoeal activity of carbazole alkaloids from *Murraya koenigii* Spreng Rutaceae seeds. *Fitoterapia* 81: 72–74.
- Mehrotra S, Singh S K, Shanker U and Agarwal S K. 2005. Effect of certain indigenous medicinal plants on ovarian hormone profile and reproductive performance in anoestrus cattle. *Indian Journal of Animal Reproduction* 26: 20–23.
- Mehrotra S, Shanker U, Jawaharlal, Majumdar A C and Agarwal S K. 2003. Effect of indigenous medicinal plantson onset of puberty in immature female rats. *Indian Journal of Animal Reproduction* 24: 131–33.
- Misra P, Pal N L, Guru P Y, Katiyar J C and Tandon J S. 1991. Antimalarial activity of traditional plants against erythrocytic stages of *Plasmodium berghei*. *International Journal of Pharmacognosy* 29: 19–23.
- Nandini M S, Veena T and Swamy M S. 2010. Effect of extracts of *M. koenigii* Spreng. and *Morus albalinn* on the age of attainment of puberty and ovarian folliculogenesis in rats. *Journal of Basic and Clinical Pharmacy* 1: 203–07.
- Nigam V and Nambiar V S. 2015. Therapeutic potential of *Aegle marmelos* (L.) correa leaves as an antioxidant and antidiabetic agent: A review. *International Journal of Pharmaceutical Sciences and Research* 6: 611–21.
- Pande M S, Gupta S P B N and Pathak A. 2009. Hepatoprotective activity of *Murraya koenigii* Linn bark. *Journal of Herbal Medicine and Toxicology* 3: 69–71.
- Pande M, Das G K, Khan F A, Sarkar M, Pathak M C, Prasad J K and Kumar H. 2013. Endometritis impairs luteal development, function, and nitric oxide and ascorbic acid concentrations

- in buffalo (*Bubalus bubalis*). *Tropical Animal Health and Production* **45**: 805–10.
- Patel P K, Sahu J, Sahu L, Prajapati N K and Dubey B K. 2012. *Aegle marmelos*: A review on its medicinal properties. *International Journal of Pharmaceutical and Phytopharmacological Research* **1**: 332–41.
- Ramsewak R S, Nair M G, Strasburg G M, Dewitt D L and Nitiss J L. 1999. Biologically active carbazole alkaloids from *Murraya koenigii*. *Journal of Agricultural and Food Chemistry* **47**: 444–47.
- Rastogi R P and Mehrotra B N. 1998. *Compendium of Indian medicinal plants*. CDRI, Lucknow and Publications and Information Directorate, New Delhi, India.
- Rautela R, Das G K, Khan F A, Prasad S, Kumar A, Prasad J K, Ghosh S K, Dhanze H, Katiyar R and Srivastava S K. 2018. Antibacterial, anti-inflammatory and antioxidant effects of *Aegle marmelos* and *Murraya koenigii* in dairy cows with endometritis. *Livestock Science* **214**: 142–48.
- Rautela R, Das G K, Prasad S, Kumar A, Prasad J K, Ghosh S K and Kumar N. 2017. *In vitro* antibacterial potential of aqueous and ethanolic extract of *Aegle marmelos* and *Murraya koenigii* leaf on the bacterial strains isolated from endometritic cows. *Indian Journal of Animal Science* **7**: 844–45.
- Reisch J, Adebazo A C, Kumar V and Aladesanmi A J. 1994. Two carbazole alkaloids from *Murraya koenigii*. *Phytochemistry* **36**: 1073–76.
- Santos F A and Rao V S. 2001. 1,8-cineol, a food flavoring agent, prevents ethanol-induced gastric injury in rats. *Digestive Diseases and Sciences* **46**: 331–37.
- Savitha G and Balamurugan S. 2014. Pharmacognostical and antibacterial evaluation of *Murraya koenigii* (L) spreng. *International Letters of Natural Sciences* **22**: 44–50.
- Sekar D K, Kumar G L, Karthik L and Rao K V B. 2011. A review on pharmacological and phytochemical properties of *Aegle marmelos* (L.) Corr. Serr. (Rutaceae). *Asian Journal of Plant Sciences* **1**: 8–17.
- Sheldon I M, Price S B, Cronin J, Gilbert R O and Gadsby J E. 2009. Mechanism of infertility associated with clinical and sub-clinical endometritis in high producing dairy cattle. *Reproduction in Domestic Animal* **44**: 1–9.
- Sherwood E R and Toliver-Kinsky T. 2004. Mechanisms of the inflammatory response. *Best Practice and Research: Clinical Anaesthesiology* **18**: 385–405.
- Song T E and Chin L L. 1991. Carotenoid composition and content of Malaysian vegetables and fruits by the AOAC and HPLC methods. *Food Chemistry* **41**: 309–39.
- Tachibana Y, Kikuzaki H, Lajis N H and Nakatani N. 2001. Antioxidative activity of carbazoles from *Murraya koenigii* leaves. *Journal of Agricultural and Food Chemistry* **49**: 5589–94.
- Tachibana Y, Kikuzaki H, Lajis N H and Nakatani N. 2003. Comparison of antioxidative properties of carbazole alkaloids from *Murraya koenigii* leaves. *Journal of Agricultural and Food Chemistry* **51**: 6461–67.
- Takase H, Yamamoto K, Hirano H, Saito Y and Yamashita A. 1994. Pharmacological profile of gastric mucosal protection by marmin and nobiletin from a traditional herbal medicine, *Aurantii fructus immaturus*. *Japanese Journal of Pharmacology* **66**: 139–47.
- Verma S and Singh S P. 2011. Current and future status of herbal medicine. *Veterinary World* **1**: 347–50.
- WHO. 2003. Traditional medicine. A report by Secretariat. Available online at: https://apps.who.int/gb/archive/pdf_files/WHA56/ea5618.pdf
- Yesaswini K V S R R, Sneha R, Sudharshan J and Sheik A. 2014. Evaluation of the antibacterial activity of *Aegle marmelos* at different concentrations and temperatures. *Helix* **5**: 594–99.