11 Natural Biological Products from Plants as Rodenticides

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Abstract

Infestation by rodent is considered as one of the main pest problems since it not only affects health but also causes serious damages to agricultural fields and households including transportation business. Numerous methods and approaches to control rodent infestation are being tried, such as environmental, cultural, mechanical, and chemical methods including their combination. It is also possible that in biological control methods the use of reproduction inhibitors or rodent predators or diseases may ultimately be developed for rodent control purposes. Moreover, different kinds of chemicals that are used to control rodents are harmful to mammals particularly human beings. Such control also adds cost to the approach. Due to probable toxicity of the chemical compound, various alternatives like natural extracts should be considered. Hence, the use of plant natural extracts as a rat repellent practice may be an improved alternative approach. Various natural extracts are experimented on different rat species in a behavioral mode of study. These kinds of natural products are easily available in present society and have no adverse effect on environment and mammals. The rodenticidal effects of many plant extracts solved by various chemical substances could be deliberated upon under various conditions, and that has given very satisfactorily outcome. It is very possible to implement these results in problematic areas. We can, therefore, accomplish that such natural extracts can deter the rodents. Still, some more studies need to be carried out to see whether these extracts are of practical use.

Keywords

Rodents · Rodenticides · Biological products · Pesticides · Plant extracts

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J. Singh, A. N. Yadav (eds.), *Natural Bioactive Products in Sustainable Agriculture*, https://doi.org/10.1007/978-981-15-3024-1_11

11.1 Introduction

Rodents were killed by rodenticides which are considered as pesticides. Rodents are not rats and mice but also include squirrels, woodchucks, chipmunks, porcupines, nutria, and beavers. Rodents are found in nature and play a very important role and may require control. They can damage crops, violate housing codes, transmit disease, and also cause ecological damage. Using rodenticides for controlling rodents is a communal approach; however, most of rodenticides are toxic to human being. For example, on a ship, these rodents (rats) can cause much damage to food and cargo. Moreover, droppings of these rodents contain microorganism that causes various diseases (WHO 1988). It is estimated that the total cost of devastation by rats in the United States may be as high as $19 billion per annum (Pimentel et al. 2005), while in India, information accessible on economic losses including the damage due to rodents in various crop sectors, forestry and horticulture, poultry farms, and urban and rural residences and storage services exhibited that enduring damage ranging from 2% to 15% continued throughout the country, and sometimes up to 100% loss of the field crop was also observed in severe damage (Parshad 1999). Many approaches are practiced to control this infestation such as biological, mechanical, environmental, cultural, and various chemical methods. Various techniques are beneficial under different situations; like in a ship, mechanical method (trapping) is a decent method to keep down the rat number and is more effective and practical than other techniques (WHO 1988), whereas the use of chemicals to check rodent's population is the better methodology in South Asia country (Parshad 1999). Various rodenticides can be categorized into fast-acting and slow-acting rodenticides (WHO 1988). Anticoagulants type of rodenticides like diphenadione and warfarin must be swallowed for several succeeding days before they act effectively. At the same time, bromethalin and zinc phosphide are also acknowledged as acute rodenticide types and often destroy particular rodents with a single dose. Nevertheless, most rodenticides are noxious to human beings and their effectiveness depends upon the assortment of a suitable compound as bait. Moreover, the method adopted and application time are very important and need to be considered before application. One major problem of using bait is that if the rats have taken preliminary nonfatal dose, it can depress the rats from taking further bait known as bait shyness. Chemicals used are not only restricted to rodenticides, but some are repellents like thiram, copper oxychloride, cycloheximide, tributyltin, and beta-nitrostyrene that had been effectively established under laboratory conditions (Tigner 1966; Parshad 1999). Foremost factors that restrict the use of chemical repellent substances may possibly be being hazardous in management and causing food contamination, when applied on packing or individual boxes containing food items for humans (Tigner 1966). Because of possible toxicity, various alternatives like natural extracts should be deliberated. Consequently, using natural plant extracts as a rat repellent substance may be a better substitute. Numerous plant extracts can be investigated whether they could prevent a rat infestation when testing in the behavioral model. Observed substances were peppermint oil, bergamot oil, geranium oil, and wintergreen oil. They were applied either as single material or in combination with each other. The rats exhibited the maximum activity during the commencement of the night time test. It may therefore be concluded that these natural plant extracts can deter the rats as decided by rat's actions under circular open field conditions. Still, more investigations are required to evaluate whether these natural extracts are practical in actual environment. In order to assess the effectiveness of rat repellents, there are a number of laboratory assessment methods like food acceptance experiment, graded strip test, and barrier test (Weeks 1959). In food recognition test, the repellent substance is mixed with food to be provided, and the efficiency is based on the quantity of food eaten by a rat in observed period of time. Unfortunately, in this investigation, some chemical substances were able to make the food not acceptable but were unsuccessful to deter the rats. During barrier test, hungry rodents must be trained to pass through repellent-coated paper obstruction, and time required to cross the paper may be recorded. In graded strip evaluation, a rat has to pass through the paper (ribbon-like strip) coated with diverse concentration of repellent chemicals to get to food which is placed under each paper piece, and then the repellent action is considered based on numbers of obtained food items such as peanuts. For the other two tests, the rats must be trained and hungry; furthermore, the instruments must be specifically made and evaluated with carefulness. The open field condition is a behavioral model generally used for study of anxiety or locomotor activity. During this experiment, the rats are permitted to travel freely in the apparatus for a period of time, and then time spent in each segment of the machine or the number of lines crossed by rodents is evaluated according to test type. Circular open field situation is also considered for measurement of locomotor action of rats. During this study, the circular open field situation was adapted in order to perceive 24-h action of the rats exposed to different repellents. The aim of this study was, therefore, to perceive the natural performance of rats in the circular-type open field when exposed to different natural repellents or if these repellents were as effective as assessed in species of rodents.

Rodenticides are pesticides that may damage all kinds of rodents. These are formulated as baits with some attractive ingredients like peanut butter, molasses, etc. These types of baits may provide short-time control of rodent. Human beings, their pets, and wildlife are analogous to rodents, so they may also be harmed by such rodenticides. Although rodents play vital roles in nature, they may require some kind of regulation. Rodents especially rats and mice can harm the crops, spread various diseases, and also cause ecological damage.

Rodents are also mammals like human beings, dogs, and cats. Rodenticides have the similar kind of effect when eaten by any mammal. Their effect on birds is very important and significant. Usually various rodenticides are formulated as poisonous baits, which are deliberated to attract animals. Additives may include peanut butter, molasses, or fish oil. Especially baits that are used in agriculture or natural areas may contain vegetables, grains, fruits, or ground meat. Being flavored, they may be attractive to children and pets, so keep them out of their reach, or use them in area which is difficult to approach. So keeping the above in view, focus has definitely shifted from the prevailing use of one chemical to new concept called integrated pest management (IPM). In other words, we can say that the focus is on biological control, and other natural resources have increased with reduced dependency on chemicals (Schmutterer 1981). Since the ancient times, different plant extracts, having pesticidal characteristics, have been used by humans that continues to the modern time (Fellows 1979). Use of such pesticides is more common in developing countries, where plants are grown frequently and are cheaper than the man-made chemical pesticides (El-Gengaihi et al. 1997). Various plants have been studied and evaluated for pesticidal properties, and many of them have been reported to be active. These plants were phytochemically examined to decide their chemical compositions. The cardenolides, steroidal glycosides, etc. are deliberated as the most important of all the naturally happening products. During ancient times, extract from these plants was used for arrow poisoning or as drugs (Hussein 1991).

11.2 Damage

It is reported by Nowak (1999) that rodents is composed of 1400 species and it is the major and largest group in taxonomic study containing creatures. Their territories are common but of different types. Some rodent kinds are adaptable and comparatively small but a prolific, mysterious one. They have constantly increasing incisors which require constant corroding by nibbling activity. It is supposed that they have productive potential, though there is substantial inconsistency between different species regarding the age during first reproduction phase, the number of litters per year, and size of litters. Various rodent species have economic, social, ecological, and scientific uses. They reutilize various minerals and nutrients, distribute crop especially grain seeds and also spores, aerate fields, and influence plant activities. Rodents provide meat and fur-like items. Some rodent kinds are used in medical science for experiment purpose. Furthermore, they are used as prey base for many predatory species. Worldwide, less than 5% rodent species are considered as serious pests. Prakash (1988) and Witmer and Singleton (2012) published a list of their genera and species. Many health and economic complications can result from interaction of rodent and human beings. It has been reported by Marsh (1988) and Witmer and Singleton (2012) that rodents can damage standing agricultural crops and stored grains, orchards and forests, property (structures, cables), rangelands, and natural flora and faunal. It was assessed that in Asia alone, the extent of grains damaged by rodents can provide necessary nourishment to 200 million individuals for 365 days (Singleton et al. 2003). Singleton et al. (1999) and Witmer and Singleton (2012) described that to control rodent species which causes the damage, various managing strategies are employed with different aspects of biotic–abiotic–-cultural with level of the damage and involved rodent population. Such kind of impairment activities can be insane when the population of rodents occur thoroughly (Singleton et al. 2010). Generally, the commensal rodent species include Norway rat (*R. norvegicus*), black rat, Polynesian rat (*Rattus exulan*s), and house mouse. Rodents live in adjacent vicinity to human beings and are influenced by the favorable conditions. Rodents (rats) have widely spread throughout different areas in the world and lead to lot of damage to warehoused foods, etc. Furthermore, Angel et al. (2009) and Witmer and Pitt (2012) described that they have also been particularly harmful to limited ecologies when introduced, mostly accidently to dissimilar islands. Rodenticides have been completely depended upon time factor, regardless of the several methods accessible to reduce rodent population or damage caused by them (Witmer and Eisemann 2007; Witmer et al. 2007). Nevertheless, there has been emerging concern about the weaknesses posed by most of rodenticides, particularly about the toxicity and perseverance in tissues in case of anticoagulant type of rodenticides (Pelz 2007; Eisemann et al. 2010; Rattner et al. 2012, 2014a, 2014b; Proulx 2014; Nogeire et al. 2015; Pitt et al. 2015). The purpose of this chapter is to detail various alternative techniques to anticoagulant rodenticides for the monitoring of rodents' populations and damage caused due to their activities. Both toxic and nontoxic methods are documented, and the value of an integrated pest management (IPM) technique or rodent management approach based on ecological system is also deliberated. There are small numbers of rodent species which are creating problems, and they require some kind of particular management. According to Singleton et al. (2007), only 4–5% of rodent types pose a noteworthy risk to humans' globally. Different species may be included in commensal rodents, such as rice field rats, black rats, Norway rats, and house mice (*Mus musculus*), as well as field rodents including the lesser bandicoot rat (*Bandicota bengalensis*) that can cause much damage and multimammate mice (*Mastomys* spp.) (Buckle and Smith 2015). Under some situations, reasonable damage only occurs when enormously overplentiful populations build up during population occurrences (Delattre et al. 1992; Singleton et al. 2007) and in the tropics (Doungboupha et al. 2003; Leirs et al. 1997). Adversative effects of rodents are many and include impairment of preharvest crop and postharvest damage to stored grains including infrastructure. Singleton et al. (1999) described that preharvest rodent damage is predominantly common in Africa and Asia. Such kind of preharvest losses in Asia led to reduction in yield of 5–20% in rice crop (Singleton et al. 2003). It is equivalent to an annual loss of 77 million tons of food or so (John 2014), and above all, this is sufficient food to feed 200 million people for duration of a year (Singleton et al. 2003). Epidemic of bamboo rats in Asian continent has more dramatic influences as competition for food between rodents and people and livestock may lead to widespread famine (Singleton et al. 2010). When stored products are destroyed or contaminated by commensal rodents, postharvest kind of losses occur. Furthermore, these rodents contribute to health complications for human beings and diseases to livestock including companion animals like zoonotic diseases. They have various kinds of pathogens which include viruses like hepatitis E virus, hantavirus, and tick-borne encephalitis virus; bacteria (e.g., Borrelia, Rickettsia, and Leptospira); and parasites like toxoplasmosis and various infections like echinococcus infection and giardia infection (Meerburg et al. 2009). The cost accompanying the spread of various rodent-borne diseases is supposed to be analogous to the losses due to rodents in crop production (Bordes et al. 2015). Annual cost of preharvest and postharvest rodent damage, losses of stored goods, and expenditure for disease inhibition and management is likely to surpass US$23 billion (Jacob and Buckle 2018).

Due to the ill effects of rodents on crop production and human health, rodent control is serious in some cropping systems and under urban conditions (Buckle and Smith 2015). Though large-scale strategies of rodent controlling in an agricultural environment include practices that reduce habitat temporally or are unsuitable for rodents (e.g., plowing) and adaptation of biocontrol (e.g., promoting predation), they rely largely on the application of rodenticides to decrease damage to crops. For the controlling of commensal rodents in rural and urban areas, anticoagulant rodenticides often are the weapon mostly used, though the increased resistant populations pose a massive challenge to future approaches. Main difficulty in using poison such as rodenticide is the danger to nontarget species. It can be either by direct consumption of such poisonous bait or indirectly via the ingestion of poisoned prey or meat. This kind of report regarding secondary poisoning which is posed by anticoagulants is frequent worldwide (Eason et al. 2002; Geduhn et al. 2015) that is very important from conservation and biodiversity point of view. The problems related with the use of such poison to manage rodent populations and efforts to increase effectiveness of rodent control have concluded in a call for ecologically based rodent management (Singleton et al. 1999) that involves the use of a toolbox of control methods that are socially, economically, and ecologically suitable.

11.3 Aspects for Development of Natural Pesticides

11.3.1 Novelty

In current years, the prominence on plant protection has shifted from the prevailing chemical pesticides to the integrated pest management; the emphasis is on biological control techniques and other natural kind of resources with reduced dependence on chemical pesticides (Schmutterer 1981). Many research workers recommended that the elementary research must be focused toward the discovery of safe types of pest control approach in order to guarantee high production and conservation of various agriculture products (Schmutterer 1981; Saleh et al. 1986; Qureshi et al. 1991; Afifi et al. 1992; Oji et al. 1994). Different plant extracts have been used as natural pesticides by human beings since before the time of the prehistoric Romans, and this practice continues to the present with several plant species with pesticidal properties (Fellows 1979). Using toxic plants in this context is especially predominant in the developing countries, where plants are grown locally and are cheaper than synthetic pesticides of chemical nature (El-Gengaihi et al. 1997; Gabr et al. 2004). Rodent pests are governed by chemical compounds that cause threats to the health and pollution of the environment and ultimately led to the toxic effect to nontarget species. These kinds of problems provided a motivation to get natural poisonous materials that could be used against rodenticides. Some plant materials like extract of oshar leaves and abamectin (Vertimic biocide) exhibited to be promising in rodent control (Gabr et al. 2004). The secondary metabolites of some plants are good basis for compounds which have wide range of biological events/actions. This kind of variety is largely the outcome of coevolution of plant species with altogether including numerous types of microorganisms and animals. Therefore, secondary compounds from several plants are assumed to have guarantee along with biological activity in plant protection against particular competitor or herbivore pathogen. In this phase, information regarding species, habit, nature, etc. of the harmful pest may provide valuable recommendations in forecasting that what can help to regulate these pests. Such kind of approach has resulted in the innovation of numerous marketable pyrethroid, natural pesticides, etc. Assortment of such compounds and chemical details of plant extracts having vigorous biological actions can be a primary step to compare or synthesize a new artificial compound. Nevertheless, the affirmation of biological action and more development in procedures of contamination removal including structural documentation are ever-changing the odds in courtesy of normal materials.

Bearing this in mind, the possibility of secondary natural plant products is being used in plant–pest relations; during interaction of plant–pest, the possibility of plant secondary metabolite is of main and primary significance; the technique of casually isolating, classifying, and bioassaying these constituents may also be an imperative technique of pesticide discovery. These extractions from the specific plants will show activity against attacking pathogen and help the plant to govern adverse effects due to pest which is responsible for the attack. In spite of these numerous plant secondary metabolites present in natural materials, screening is done properly for such pesticidal activity.

The discovery procedure for these kinds of natural pesticides is more complex than for synthetic one. Conservatively, new chemical has been developed (pesticides/insecticides) by synthesis method, bioassay, and assessment. If the end product is suitably encouraging one, assessable structure–action–relationship-based synthesis of equivalents is used to advance necessary pesticidal characters. The finding of such expected products is intricate in nature due to many issues.

First of all, the decontamination method is performed. It is supposed to be variable for most of the plants, as there is no hard and fast rule for such plants. Moreover, from secondary metabolites, different compounds are assessed in comparatively smaller volumes compared to the quantities of synthesized substances for broadcast pesticide activity. Consequently, bioassays necessitating very less quantities of material will be beneficial in screening of the natural compounds. In the allelochemical field, various methods are available for assaying less quantities of compounds for biological and pesticidal activities that are accessible. In discovery method, structural identification is a foremost and prime requirement, while in certain cases, it is a very problematic process. Ultimately, synthesis along with equivalents must be reflected which is somewhat more complicated. Irrespective of such difficulties, recent contributory analysis and upgraded approaches are lessening the price, levels of complicity, and requisite time in such approaches.

11.3.2 Development

There are limited pesticide compounds that are established as decidedly effective in assessment and are constantly brought to bazaar. Several issues must be deliberated in the pronouncement to improve and market such pesticide. A primary deliberation is the patentability of such compounds. A patent exploration must be done for all these natural compounds as with any synthetic one. Earlier publication of a compound with pesticidal properties could pose patent problems. Paralleled to synthetic materials, there is a lot of available knowledge on the biological activity of these natural products. Due to this purpose, patenting synthetic equivalents without reference of the natural source might be harmless than patenting the natural produce under some circumstances. Toxicological and environmental traits of all compounds must be deliberated. Simply because of this reason that a compound is a natural product and does not confirm that it is harmless. The utmost toxic mammalian poisons are also known as natural materials, and most of these are produced by plants. Introduction of different intensities of toxic natural substances into the environment that would never be established in nature could cause adversative influences. But there is solid evidence that natural products generally have a petite half-life in the environment in comparison to synthetic ones. Actually, the comparatively brief environmental perseverance of such natural compounds can be a problem, because many chemicals must have some kind of lasting activity in order to show some effectiveness. As with pyrethroid compounds, chemical alteration can increase persistence process. After favorable biological action is discovered, extraction of more amounts of the compound for further wide-ranging bioassays can be deliberated. Likewise, equivalents of such compound should be synthesized by modification of the same. Structural management of such compound could result in development of useful action, transformed environmental influences, toxicological properties, or finding such products that can be frugally produced. This may be the case with various natural-occurring compounds that have been used as a source for many commercial compounds, that is, for pesticides (e.g., pyrethroids). Before a conclusion is drawn to synthesize a natural pesticide compound for commercial application, profitable resources including means of manufacture must be assessed. Though this is a decisive question in deliberation of the advancement of any pesticide, it may be much complicated and thought of in case of natural products. Factually, preparations of simple natural product combinations have been used as pesticide chemicals. However, the possible complications in clearing a complicated combination of several biologically active compounds for use may be restrictive in today's governing environment. Therefore, the query that will possibly be deliberated is whether a pure compound will be formed by purification, biosynthesis process, etc., or by traditional chemical method. Beforehand, bearing in mind any other matters, there are two major benefits to the pesticide business from synthesis of such compounds. One of them is heavy investment in personnel and facilities for this kind of methodology. Shifting this tactic may be problematic for employees proficient in disciplines geared to use it. Secondly, copyrights for chemical synthesis often guard the investment that particular company makes in advancement of a synthetic pesticide.

Natural compounds are very much complicated that their synthesis would be excessive, even so, much economically synthesized equivalents with acceptable or better biological action may tip the steadiness toward industrial synthesis. If not, biosynthesis must be considered. There are increasing number of biosynthetic choices.

The easiest technique is to prepare the extract of the compound from field-grown common plants. To advance production, the variety of that particular type that produces the highest amount of that compound must be identified and cultivated under such conditions that will improve their biosynthetic potential. Hereditarily manipulation of the producing plants by classical or biotechnological approaches could also enhance the production of some secondary plant products. For example, low concentrations of ether herbicides, namely diphenyl, can cause enormous upsurges in phytoalexins in a crop variety. Another substitute technique is to culture the compound in cell or tissue culture process. Cell lines that yield higher levels of the required compounds can be quickly chosen. Still, genetic constancy of these characters has been a hurdle in cell or tissue culture for the creation of secondary plant products. Cells that yield and collect huge quantities of probably autotoxic plant secondary metabolites are apparently at metabolic hindrance and are thus designated contrary to under several cell or tissue culture situations. An approach, such as restrained cell column that constantly eradicates such secondary plant products, can increase production by decreasing feedback inhibition of synthesis, possibly increasing generic stability and reducing autotoxicity. Further culture procedures that improve production can also be applied. For example, providing economical synthesized metabolic predecessors can significantly increase biosynthesis of several secondary products. Similarly, various PGR, metabolic blockers, and elicitors can be used to improve the production rate. Genetic engineering and biotechnology may permit for the production of secondary plant products by gene transfer technique to various microorganisms and production by fermentation-like process. This approach is striking because of the prevailing fermentation know-how for production of such plant secondary products. Still, this may be too problematic for complicated secondary nature of products in which many genes govern the alteration of some complex intermediates to the anticipated produce. Under some circumstances, genetic engineering process might also be used to supplement the genetic material for production of plant-based pesticides from one particular plant species to another species to safeguard it from pests. Still, such transgenic management of the complicated metabolism of a higher plant might be enormously problematic. Another simple substitute might be contaminated plant-colonizing microorganisms with the anticipated genetic machinery to yield the natural pesticide.

11.3.3 Plant Extracts

Presently, research has concentrated on how to choose ecological-responsive sterilants but without effecting effluence level and to comprehend control of pest rodents. Tran and Hinds (2012) shortened 13 plant species with antifertility properties on female rodents from plants along with planned application routes and recognized many plant extracts with good probable response. In China, various sterilants based on plant sources that have been tried on rodents include gossypol, *Tripterygium wilfordii*, *Camellia oleifera*, *Ruta graveolens*, colchicine, semen ricini (*Ricinus communis*), radix trichosanthis (*Trichosanthes kirilowii*), neem (*Melia azedarach*) and acrogenous turmeric rhizome (*Curcuma aeruginosa*). Still, all of these compounds had been used as baits for animal experimentation under lab conditions or sprayed for animal scavenging, which had a positive effect; the practical applications have been acceptable (Croxatto 2000). And that the researches on various aspects like pathology, physiology, contraceptive, and pharmacology influences of the shikonin are not adequate (Zhang et al. 2004; Coulson et al. 2008; Conn and Crowley 1991). Shikonin is an extract of *Arnebia euchroma* plant of family Boraginaceae and is commonly dispersed in Xinjiang, Inner Mongolia, and Gansu provinces (Herbert et al. 2006). It has been seen in "Shennong's Herbal" that radices lithospermi has antipyretic, anti-inflammatory, and antifertility influences. Earlier study has focused on anti-HIV, antitumor, and anti-inflammatory influences (Miller et al. 1998; Zhang et al. 2004), while there is occasional, tentative indication of its antifertility properties and the procedure through which this consequence happens. During this experiment, three dissimilar doses of shikonin were used for fertility control in rats (mice), and its probable mechanism of action was considered. It is expected that plant-source-based sterilant, which are environment friendly and without pollution, can be used for sustainable regulation of rodents.

11.3.3.1 *Thevetia peruviana*

An albino strain of non-fasted Norway rats *was* treated with *Thevetia peruviana*, by being fed a bait containing ground grains from the plant or managed aqueous extracts of the kernels by intubation. No abnormal behavioral or mortality or physiological variations were recorded for control group or those applied with crude aqueous extract. Rodents treated with bait comprising fatal doses of ***Thevetia peruviana*** demonstrated signs of poison within 1 h and died after treatment. Poisoning signs involved tail erection and pilomotor, diarrhea, ataxia, paroxysmal tachycardia, and diuresis limb paralysis. Poisoned rats were easily terrified, became aggressive by touching, and showed coprophagic tendencies.

11.3.3.2 Argel

Leaves of argel were dried and grounded to a fine powder. Extraction was done according to the Freedman et al. (1979) method. Leaf powder was saturated in solvent (ethanol 95% or water) for a period of 3 days in brown-painted bottles. These bottles were shaken. Extract was then filtered over anhydrous Na_2So_4 and evaporated till waterlessness under reduced pressure conditions. The extracts were then balanced and kept in cold conditions till use. Then argel powder was mixed carefully with crushed maize grains. The recorded results exhibited that baits of argel (ethanol extract) at various levels were very effective against *R. norvegicus* and result in killing. Attained results also showed that the palatability of male rats was 35.9%, 32.1%, and 33.8%. Temporarily, the palatability and death percentages for female rats for the former's concentrations were 38.7%, 34.9%, and 38.4% and

25%, 25% and 75%, correspondingly. On the other hand, various tried concentrations of argel aquatic extract had diverse effects on rat mortality. The average time mandatory for death was 18.0, 14.5, and 16.5 days for females and 16.0, 12.7, and 8.25 days for males, correspondingly, trailed by argel powder leaves which were 16.0, 15.0, and 12.7 days for females and 14.5, 12.5, and 8.0 days for males, separately, while the mean time required for death in case of aquatic argel extract for the same doses were 13.0, 19.7, and 9.7 days for males and 16.0, 21.0, and 18.0 days for females, correspondingly.

11.3.3.3 Neem Tree (*Azadirachta indica* L.)

Extracts of many plant parts (leaves and bark) have been linked with productiveness, mainly in Indian culture. The plants like neem have many effects in human avoiding troublesome implantation, spermatogenesis, and abortion. In rats, oral application of neem oil (seed) for 18 days disturbed the estrous rotation and encouraged significant alteration in uterine system and results in 70–100% (almost) in rat infertility (females) that soon mated after ending of application (Dhaliwal et al. 1998). These experiments also meaningfully decreased numbers of follicle in all steps of advancement (Dhaliwal et al. 1999). Irregularity in estrous cycles, with extended diestrous stages, was also recorded in female rats when ethanol extracts of the neem plant (flowers) were given orally for a period of 3 weeks (Gbotolorun et al. 2008). Hexane and methanol extracts of neem seeds, after oral application to female rats for a period of 18 days, meaningfully lessened the follicle number at different steps of follicular growth (Roop et al. 2005), and higher doses led to delay in creation of first litters by 52–67 days, correspondingly (Morovati et al. 2008). In in vitro investigation, neem leaf extract led to apoptosis in oocytes of rat (Shail et al. 2006). These investigations specify that neem extracts influence the reproductive system by governing HPG hormones that control development of follicle of the ovary. Still, these extracts are very lethal at higher quantities.

11.3.3.4 Papaya (*Carica papaya* L.)

Papaya plants were grown in large scale in subtropical and tropical regions found in regions both subtropical and tropical. Extracts from various parts have been used as antioxidants, antibiotics, and contraceptives for both sexes. Seed extracts have harmful influences toward the reproduction system of females, inducing irregularity in estrous cycles, disturbing ovulation, and preventing implantation (Raji et al. 2005; Joshi and Chinoy 1996; Chinoy et al. 1997, 1995; Dosumu et al. 2008). Oral application of chloroform extract of papaya seeds, for a period of 14 days, led to noteworthy decrease in weight of the ovary, extended diestrous stage, and noticeable increase in atretic follicles number along with decrease in pregnancies (60%) number. Oral application of a benzene extract of plant seeds, in rats (female), for certain period led to irregularity of estrous cycles; important contrary variations in the uterus through changes in enzyme, glycogen, and protein levels; and 100% sterility subsequent one breeding valuation (Joshi and Chinoy 1996). Likewise, seed (an ethanol extract) when applied orally for a specific period led to anomalies in the estrous sequence and substantially decreases fertility rates (Chinoy et al. 1997), but papaya seed extracts have reversible effects after 30 days of treatment withdrawal (Joshi and Chinoy 1996).

11.3.3.5 *Melia azedarach* (Dharek)

It is concluded that the pulmonary fibrosis and NPF of *M. azedarach* and *A. indica* seed extracts meaningfully lessened normal follicles number in rats, with the maximum reduction occurring in *Azadirachta* extract. This is constant with its use in traditional medicine as an anti-conceptional mediator (Roop et al. 2005).

11.3.3.6 Peppermint Oil

Peppermint oil is supposed to prevent rats from entering treated zones. At high concentrations, oil of peppermint may exhibit some repellency properties. The major constraint in its application is the requirement that it should be applied at concentration that is unfriendly for the owner regarding smell. Once the aroma becomes tolerable to the individual, it is no longer exhibiting repellent characters.

11.3.3.7 Asafetida (*Ferula jaeschkeana* Vatke)

The extracts of parts (aerial) of asafetida including roots of the plant encouraged integration of ovarian system, variations in the reproductive system, and an anti-implantation impact in mice and feminine rats (Prakash and Jonathan 1996; Homady et al. 2002). Oral application of extract (hexane) of the plant parts to juvenile feminine rats for particular period led to noteworthy lessening in the number of emerging and maturating follicles (Prakash and Pathak 1994; Prakash and Sharma 1997). Likewise, female rats, when orally applied with the extract of hexane for some days, exhibited substantial variations in the uterine structure by increasing the luminal epithelium tissue height and gland number of uterine system and an absenteeism of follicles particularly the mature ones (Prakash and Jonathan 1996). However, a different species named *F. hormonis* seems to constrain the reproductive system in female mice. It is observed that when oral application of root extract of the plant *F. hormonis* (an ethanol) for a period of 42 days was induced, ovarian degeneration with reversion of corpora lutea is noted. Such treatment led to decreasing the quantity of pregnant creatures and female productiveness (Homady et al. 2002).

11.3.3.8 *Urginea maritima* (*Drimia maritima* Red Squill)

Urginea maritime is a species of flowering plant of family Asparagaceae. It has been used as a poison and also a medicinal remedy. It led to a digitalis-like activity and results in paralysis of the heart. This glucoside (present in plant) was first isolated from a marine plant called *Urginea maritima*. It was first industrialized and used in Switzerland but was later registered in many other countries like the United States. Nowadays this kind of product is not accessible as its use has stopped significantly in preference to the second-generation anticoagulant compounds. This product contains 0.05% active ingredient (Timm 1994; Buckle and Eason 2015).

11.3.3.9 Sodium Fluoroacetate (1080) Compound

Also identified as composite compound 1080, it was first isolated from an African plant named *Dichapetalum toxicarium* in Europe. It was reported that sodium fluoroacetate might be beneficial as a vertebrate poison. This chemical is quickly absorbed in the gastrointestinal system and blocks the tricarboxylic acid sequence which led to togetherness of citric acid and impediment of glucose metabolism process, which ultimately results in spasms and further more respiratory or circulatory system failure. It has toxic influence in most of vertebrates and in various nations, especially New Zealand and Australia. Presently, it is used at very limited scale in the United States as collars in livestock protection only. Such items usually contain 0.08% or 0.5% a.i. (Buckle and Eason 2015; Timm 1994).

11.3.3.10 *Strychnos* Spp.

Strychnine was firstly isolated from seeds of *Strychnos* spp., a tree. Being an alkaloid-natured antagonizing glycine compound and acetylcholine receptors, this led to muscle restlessness and twitching, trailed by sudden appropriations and fierce contractions and lastly death. Firstly, it was established as a rodenticide in Europe. It is used at large scale when it was produced commercially relatively than extraction from seeds of the plant. As it is highly toxic to many animal species, hence, its use is restricted in several nations. In the United States, it is only allowed as rodenticide in burrows and, in particular, in pocket gopher holes, not above the ground. Its use in Europe is banned. But its use is still prevalent in Australia for governing house mouse irruptions (“plagues”). Pelleted baits usually contain 2% a.i. but to coat grains, fruits, and vegetables at 0.5% active ingredient.

11.3.3.11 China Rose (*Hibiscus rosa-sinensis* L.)

This plant is indigenous to China and extensively grown and cultivated as a decorative plant throughout the subtropics and tropics. Extracts of various plant parts (China rose) adversely influence ovulation process and avoid process of implantation. In females, oral treatment of the extract (benzene) of *China rose* flowers for a specific period increased the quantity of atretic follicles and lessened uteri and the ovaries weights. Within application for 21 days, all females were in extended diestrous position; still, the influences were adjustable in a limit of 30 days of removal of application (Kholkute et al. 1976). In female mice, oral application of flower extract (benzene) creates unbalance diestrous cycles with extended metestrus and estrus and a considerable increased quantity of atretic follicles. These consequences proposed an antiovulatory influence of the flower extract (Murthy et al. 1997), but these influences were changeable after the termination of application.

11.3.3.12 White Cedar (*Melia azedarach* L.)

It is indigenous to Asia (Southeast), Australia, and Indochina. *Melia azedarach* has important antioxidant influences and protects from many skin diseases (Saleem et al. 2008; Samudram et al. 2009). Root extracts and seed of white cedar cause decreases in ovarian follicle and avoid gestation by disturbing implantation process (Keshri et al. 2003, 2004; Mandal and Dhaliwal 2007). Oral application of methanol and hexane fractions of white cedar seed extracts for a period of 18 days lessened the follicle number at different phases of advancement in ovaries of treated ones. An important decrease in quantity of follicle may have been due to disturbing of follicle enrollment owed to atresia (Roop et al. 2005). Moreover, extract mixture of chloroform + methanol (by volume, 9 + 1) of white cedar seeds when given orally to rats for a period of 18 days prohibited pregnancy in 50 and 100% of animals correspondingly. Consistent variations in metabolism of uterine led to reduction in the stature of the luminal epithelium system and a diminished uterine gland number (Mandal and Dhaliwal 2007).

11.3.3.13 Sensitive Plant (*Mimosa pudica* L.)

Mimosa pudica is native to South America and Central America. Root extracts affect the reproduction system of females both in rats and mice. These extracts alter and extend estrous cycles, increase degeneration of follicles, and lessened litter size in females (Valsala and Karpagaganapathy 2002; Ganguly et al. 2007). Root powder of the plant, when applied orally, extended the diestrous phase of estrous cycle. This application also resulted in a substantial lessening of ova number and increased the number of ova degeneration in the treated ones (Valsala and Karpagaganapathy 2002). Various outcomes submitted for Swiss albino mice (female) when oral treatment was given, that is, root extract for a period of 21 consecutive days (Ganguly et al. 2007), with lessening in litter number produced by treated rats, though the productiveness was reestablished 2–3 weeks after removal of application (Valsala and Karpagaganapathy 2002).

11.3.3.14 Bitter Gourd (*Momordica charantia* L.)

It is widely grown in Asia, Africa, and Caribbean as its fruit is edible and extensively cultivated in subtropical and tropical areas. It has been used as traditional remedy for controlling diabetes disorder and many other diseases, burns, birth control, and skin problems (Beloin et al. 2005; Sridhar et al. 2008). Seed extracts of bitter gourd lessen ovarian follicles number, modify normal estrous sequences, and prevent pregnancy (Sharanabasappa et al. 2002; Chan et al. 1984, 1986; Ng et al. 1988). Application of chloroform, benzene, and petroleum ether including ethanol seeds extract of bitter gourd orally for 30 days induced unbalance diestrous cycles, which led to substantial decrease in ovarian weight and in emerging follicles, Graafian follicles, and corpora lutea (Sharanabasappa et al. 2002).

11.3.3.15 Betel Vine

This plant is native to Southeast Asia. Leaves of this plant have been used as traditional remedies to cure various ailments like relieve toothache, headaches, and indigestion problem. Betel extracts show adverse effect against reproduction in rats (Adhikary et al. 1989; Choudhuri et al. 1991; Sharma et al. 2007; Pin et al. 2010; Al-Adhroey et al. 2011). Hypodermal application of ethanol extracts of the plant (stalk) for a period of 21 days increased the number of follicular atresia. The treated ones exhibited substantial reductions in weights of the ovaries and uterine systems and enlarged levels of cholesterol in the ovaries of treated ones. Treatment with the extract results estrous cycles but after application and repressed conception in treated rats (Adhikary et al. 1989). An ethanol extract of the leaves of vine brought analogous variations: oral application in rats for specified period extended estrous cycles and increased decreases in uterine weights. Conception rate was repressed in treated rats, and substantial reductions in litter size were also noted (Sharma et al. 2007).

11.3.3.16 Kudzu (*Pueraria tuberosa* DC.)

Kudzu is a woody tuberculated stem with climbing nature. Tubers of the plant are used as traditional drug to cure different ailments like malaria fever, cough sand rheumatism. Kudzu encourages antioxidant and antifertility actions in both rat sexes. Tubers extract lessened ovarian follicles number, increased the numbers of atretic follicles and evade implantation in females. Oral application of a butanol extract including tubers of kudzu in rats induced degeneration of the oocyte in follicles afterward for a period of 12 days (approximately) of the application. Subsequently in 18 and 24 days of application, a noteworthy increase in atretic number of follicles was noted. In addition these extracts led to a noteworthy increase in level of glycogen, protein absorption, and weight of the ovary of treated ones. *Pueraria tuberosa* plant extract seems to be inducing disturbance of hypothalamic–pituitary–gonadal axis responses rather than a straight influence at the follicular level.

11.3.3.17 Midnapore Creeper (*Rivea hypocrateriformis* Desr.)

Midnapore creeper is a climbing-type woody shrub commonly available in subtropical region. Plant extracts, from diverse parts, have good influence in the reproduction system of females by disturbing implantation and ovulation process. In female rats (albino type), oral application of an ethanol extract for 15 repeated days distressed estrous cycle, by decreasing the duration of estrous and metestrous stages and extension of the proestrous phase. Treated female rats had fewer Graafian follicles and expressively more atretic follicles than in control ones.

11.3.3.18 Soap Nuts (*Sapindus trifoliatus* L.)

Soap nuts are indigenous to warm tropical areas and cure asthma-like problem and also antifertility properties. Oral application of an acetone fraction of soap nuts extract for a period of 21 days disturbed cycle of estrous by encompassing the diestrous stage. This extract results in disintegration of emerging follicles and lesser pregnancy and rate of implantation. The treated rats exhibited decreased levels of luteinizing and follicle-stimulating hormone. Therefore, the extract led to reduction in gonadotrophin secretion and ultimately disturbance of follicular growth and the estrous cycle. These influences are reportedly rescindable once application is stopped.

11.3.3.19 Snake Gourd (*Trichosanthes cucumerina* L.)

Snake gourd is a subtropical as well as tropical vine. Various plant parts are used in traditional remedies like curing of inflammatory conditions, gastrointestinal problems, and liver disorders. The plant also disturbed ovulation process in rats. When oral treatment of an ethanol extract was applied for a period of 30 days, disturbed estrous process resulted in substantial increase in the metestrous and estrous stages. There was a noteworthy lessening of weight of the ovary, and the same was imitated in meaningfully fewer well follicles and an improved follicle number undergoing regression including atresia.

11.3.3.20 Thunder God Vine (*Tripterygium wilfordii* H.)

It is also known as an old Chinese drug, and its extracts have antitumor, immune suppressive, and anti-inflammatory effects. Thunder god vine has antifertility effects in females and males (Lue et al. 1998; Huynh et al. 2000). Oral application of triptolide (main ingredients of thunder god vine) to female rats for certain period results in a considerable increase in apoptotic secondary follicle number and led to continuation of the estrous cycle. In another experiment, oral higher doses of triptolide were given, for a period of 3 months (approximately); decreased serum levels of P and E2; and increased the levels of other hormones like FSH and LH. These applications resulted in a noteworthy decrease in the ovaries weights and uteri and ultimately decreased the number of emerging follicles, and atretic follicle number is increased. The results of this study suggested that triptolide (source: thunder god vine) had a straight influence especially on the advancement of ovarian follicles (secondary and tertiary).

11.3.3.21 Quickstick (*Gliricidia sepium*)

Commonly known as quick stick, it belongs to the family Fabaceae. It is a very important, multipurpose legume tree. It is very common in tropical and subtropical nations and used for various purposes such as fodder, live fencing, shade, coffee (Zhang et al. 2004) green manure, firewood, and rat poison. Live fences can be grown from *Gliricidia sepium* in just a month. It can be intercropped with maize crop.

11.4 Discussion

For governing fertility in rodents, targets comprise anticipation of the advancement and ovarian follicles development, hindering the pathway of ova process in oviduct, stoppage and fertilization of oocytes, prevention of implantation process, and intrusion with pregnancy process. Various studies regarding the effects of plant extracts on productiveness have revealed that these extracts may influence the reproductive system of females in both rats and mice. As a consequence, an applied extract may prevent fruitfulness by various mechanisms, such as follicle diminution, disturbance process of ovulation, fertilization, gestation or implantation, and abortion. Several plant extracts were evaluated following post-coitum application at various stages of pregnancy to estimate abortifacient/anti-implantation actions. Though for fertility control, plants encouraging inhibitory influences at the ovarian level should be theoretically better contenders since they may offer permanent and long-term influence on the reproductive system of the target. Indirect influences occur at the hypophysial or hypothalamic level, and they cause suppression of normal gonadotrophin secretion. These changes lead to prevention of consistent ovarian steroidogenesis (estrogen/progesterone), and thus, estrous cycles are disturbed, just like ovulation process. Otherwise, the influence may be straight and shortest if the extract of the plant constrains the regular advancement of the different phases of ovarian follicles. As females have limited number of primordial follicles since birth, the reproductive potential may be lessened if they are treated with various substances that may cause reduction or weakening of the primordial follicle system. But the effects are reversible when applications stopped, and influenced follicles will be substituted by other follicles. The initial follicular phases are targeted and washed out by another approach, the influences on productiveness will be overdue until the modest further (secondary and others) follicles are engaged and exhausted – prominently such result will be everlasting and cause sterility. Several experiments have described the effects on productiveness of female rodents by treatment with different plant extracts. Some of these plants are commonly available like *Azadirachta indica, Melia azedarach*, *Hibiscus rosa-sinensis, Trichosanthes cucumerina, Tripterygium wilfordii*, *and Momordica charantia.* Extracts of these plants demonstrate variable potential. The extracts of these plants at verified doses require constant and long periods of oral application to attain anticipated effects, but such influences are inverted soon after cessation of the application. While such plants are well intentioned for future search, inappropriately no one directly influences the non-regenerating primeval follicle numbers. A number of extracts, their duration and types, have been tested, and the result specifies that responses depend on the applied dose, but up to now, structured-dose-based experiments have not recognized the optimum doses obligatory. Overall, advanced doses will be required for testing purposes, but with this approach, palatability may be affected. Thus, recognition of the active component in such plant extract might be indispensable. This, though, would decrease the capability of farmers to formulate such extracts on his field. In spite of so much research related to such plant extracts, the precise active ingredient of compounds accountable for multiplicative influences has not been acknowledged, and synthesis of such chemicals is also posing a problem. While working, scholars should be conscious that the levels of such active compounds accessible in various plant materials may differ according to places, soil, and growth conditions. Further, extracts from the similar plant, but using dissimilar solvents for extraction of active compounds, may lead to dissimilar reactions. It is therefore recommended that further researches should lay emphasis on the recognition of contributing active ingredients in plant extracts and suitable solvents. Principally it is problematic to regulate distinct and effective responses; there is lack of consistency in terms of difficult valuation of various kinds of extracts and then in the range of practices used to evaluate generative influences. Research investigations have observed the influence on different stages of the estrous cycle, while others observed histological modifications in the uterus and ovary. The length of the treatment and course of treatment, as well as doses excerpts, are also contradictorily pragmatic. Consequently, recently a typical protocol is proposed for trying various extracts, which should be recognized to permit direct assessments. The protocol for female rats would include evaluating a range of verbal doses over applied periods of application/treatment along with assessment of different reproductive constraints. Finally, more comprehensive characterization of extracts, such as GLC or HPLC and mass spectrometry, should be accessible to permit other scholars for recurrence of published experiments/studies. Therefore, for practical application in productiveness control of such rodents, the anticipated testing procedure would commence to address the serious necessity for oral transfer of an agent that quickly and permanently diminishes productiveness. This would then result in the development of target-specific, edible, and persistent produce for use. In spite of recorded restrictions arising beforehand accessible to related research experiment, the use of plant extracts in productiveness could still deliver a number of benefits, and these substances are not penetrated in the subsequent trophic level. Furthermore, many plant species are commonly available and may be economical, particularly when such plant extracts are readied by local farmers. Still, there are some contests/challenges; for example, plant extracts need to be consumed on daily basis by the target species for achieving good results. Also, high concentrations of these extracts are mandatory to obtain their desired influences; this may influence their tastiness and decrease bait acceptance frequency. Lastly, a future prospect could present itself if a plant range of different ingredients are recognized and used in combination with various chemosterilants. These combinations may provide complementary influences and lead to quicker and everlasting alterations in ovarian system. Overall, these mediators may deliver an effective supplementary means for use in integrated administration of pest populaces.

11.5 Conclusion and Future Prospects

Some plants contain an effectively unexploited reservoir of chemicals with natural pesticidal properties that can be used straightly as prototypes for synthetic pesticides. Several factors have increased the interest of the pesticide business in such source of natural produce. These include lessening returns with traditional pesticide detection approaches, increased toxicological and environmental anxieties with synthetic insecticides, and increased level of dependence of modern agriculture on the pesticides. Despite the moderately small amount of earlier effort in advancement of plant-derived compounds as pesticides, they have made a huge influence in the related area. Immaterial rate of successes may be found in rodenticides, herbicides, and fungicides. Number of possibilities must be taken into account in advancement. Moreover, the molecular complexity, inadequate environmental loyalties, and low activity of several biocides from the plants, in comparison to synthetic pesticides, are depressing. Still, advances in biotechnology and chemicals are increasing the ease and speed with which mankind can formulate and advance secondary compounds of the plants as pesticides.

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