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Review article

Potential uses of turmeric (*Curcuma longa*) products as alternative means of pest management in crop production

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Abstract

Curcuma longa (turmeric) is a small rhizomatous perennial herb of Zingiberaceae (Ginger family) originating from south eastern Asia, most probably from India. The plant produces fleshy rhizomes of bright yellow to orange color in its root system, which are the source of the commercially available spice turmeric. In the form of root powder, turmeric is used for its flavouring properties as a spice, food preservative, and food-colouring agent. Turmeric has a long history of therapeutic uses as it is credited with a variety of important beneficial properties such as its antioxidant, antibacterial, anti-inflammatory, analgesic, and digestive properties. Moreover, main constituents of the plant are under investigation for possible benefits in the treatment of cancer, Alzheimer's disease, liver disorders, and certain other diseases. However, except from its uses as a medicinal plant, the fresh juice, the aqueous extracts, and the essential oil of the plant are credited with interesting pesticidal properties against certain pests of agricultural importance as well as a noticeable repellent activity against noxious mosquito species. Research efforts so far and data from the international literature have shown a satisfactory potential of turmeric as a natural pesticide for possible use in crop protection and thus a highly promising future towards this direction, that is, the possibility of effective control of certain pests of agricultural importance with the use of turmeric products as a cheap and more environmentally friendly alternative to chemical pesticides already used for the same purpose.

Keywords: Essential oil, fungi, insects, pesticidal properties, plant extracts, rhizomes.

Introduction

Turmeric is one of most essential spices all over the world with a long and distinguished human use particularly in the Eastern civilization (Ravindran, 2007). It is a deep yellow-to-orange powder that comes from the underground stems of the tropical perennial herb *Curcuma longa* of the family Zingiberaceae. This spice with the subtle flavor is obtained from the dried and grounded rhizomes of the plant. The rhizomes are yellowish to orange tuberous juicy stems that are formed below the ground at the base of the plant consisting of the mother rhizomes with the primary, secondary, and even tertiary fingers. Apart from being a major ingredient in culinary, turmeric powder is used as food-colouring agent and also as natural dye (FAO, 1995). Just few drops of turmeric juice from the rhizomes can create permanent stain on clothes. The origin of the plant is not certain, but it is thought to be originated from south eastern Asia, most probably from India. The plant is cultivated in all parts of India (Kapoor, 2000). India produces most of the world supply (Leung and Foster, 1996), but turmeric is cultivated also in southern China, Taiwan, Japan, Burma, and Indonesia (Yen, 1992) as well as throughout the African continent (Iwu, 1993). The commercially available material (i.e. turmeric powder) in Europe is obtained mainly from India and somewhat from other south eastern Asian countries (Murugananthi et al., 2008). Turmeric powder has a peppery bitter flavor and a mild fragrance slightly reminiscent of orange and ginger. While turmeric powder is best known as one of the main ingredients used to make the curry spice, it also gives ballpark mustard its bright yellow color. Apart from its culinary uses, turmeric has been used widely in the traditional medicine in India, Pakistan, and Bangladesh because of its several beneficial properties (Chattopadhyay et al., 2004). For traditional Ayurvedics, turmeric plant was an excellent natural antiseptic, disinfectant, anti-inflammatory, and analgesic, while at the same time the plant has been often used to aid digestion, to improve intestinal flora, and to treat skin irritations. Also, in South Asia it has been used as a readily available antiseptic for cuts, burns, and bruises. However, several other beneficial properties are reported in folk medicine. Although there is plenty of information about the use of turmeric powder as a spice in culinary and apart from its multiple medicinal uses, the plant is credited with interesting pesticidal properties against insects and fungi of agricultural significance, including repellent properties against some noxious mosquito species. However, relatively less information is known regarding its potential use as a pest control agent in crop production. Thus, the aim of this paper was to provide a focus on the pesticidal properties of turmeric and its potential use in crop production as a pest control agent.

Genetic diversity of *Curcuma*

Curcuma is an economically important genus with many species, yet taxonomically rather difficult (Sasikumar, 2005). The genus shows high diversity in India and Thailand, with at least 40 species in each, followed by Burma, Bangladesh, Indonesia, and Vietnam. Little consensus exist upon the total number of species of the genus. Estimates vary from about 50 to 80 or even 100 species, while a detailed botanical exploration of India and southeast Asia may well bring their number to 120 (Sasikumar, 2005). *Curcuma* species exhibit inter- and intraspecific variation coupled with morphological variation with respect to the aboveground vegetative and floral characters as well as the belowground rhizome features. Thus, the overall appearance of many species is often similar as they only differ in small morphological details. *C. longa* (syn. *C. domestica*), the common turmeric, is the most known and economically valuable member of the genus. In addition to *C. longa*, other economically important species of the genus is *C. aromatica*, which is used in medicine and toiletry articles as well as several other species used in folk medicine of the southeast Asian nations, in culinary preparations, pickles, and salads or certain species with mainly floricultural importance (Sasikumar, 2005). Crop improvement work has been attempted mainly in *C. longa*. At present, there are several improved varieties of *C. longa* in India, mainly evolved through germplasm/clonal selection, mutation breeding as well as open-pollinated progeny selection. Conventional crop improvement methods are not suitable in turmeric because the plant is sterile and propagates exclusively by vegetative means (Nirmal Babu et al., 2007). Additionally, the rhizome yield is generally governed by polygenically controlled characters and thus direct selection for yield may not be a reliable approach because yield is highly influenced by environmental factors. Therefore, the development of reliable and reproducible molecular markers is essential to assess the genetic diversity for germplasm conservation and crop improvement in turmeric. During the last decades, the use of molecular markers has been increasing in plant biotechnology and the development of specific types of markers has raised their importance in understanding genomic variability and diversity between the same as well as different plants species (Kumar et al., 2009). Certain recent studies have described within and between-population diversity in *C. longa* using various molecular techniques (Siju et al., 2010; Jan et al., 2011; Sigrist et al., 2011; Záveská et al., 2011). Such novel techniques can be useful for the introduction of new genetic material required to develop more productive and better adapted cultivars with desirable quality characteristics.

Natural products as pesticides

With the growing demand for environmentally sound strategies in the control of pests, the development of alternative pesticides with minimal ecological hazards has now become an imperative need. This demand is also supported by the increasing concerns over the level of pesticide residues in food and over the level of resistance of pests to several pesticides, which both result from the overuse of chemical pesticides. Thus, increasing reports about the negative effects of synthetic pesticides often resulting from indiscriminate application have renewed the interest in natural pesticides as an ecochemical approach in pest control (Dubey et al., 2010). Natural pesticides are active substances derived from plants and are often used for pest management. Many plant extracts show a broad spectrum of activity against several pests and pose little threat to human health and the environment. Therefore, they have long been touted as attractive alternatives to synthetic pesticides for pest control. Moreover, plant essential oils or their constituents have a broad spectrum of activity against insect pests, plant pathogenic or other fungi, weeds, and nematodes (Dudai et al., 1999; Isman, 2000). Natural products showing activity against pests have been and are still being explored for possible production of commercially available natural products that can be effective on certain pests, selective in crops, non-toxic for the user, easily biodegradable, and that can be locally and easily produced, especially by farmers who usually cannot afford expensive synthetic pesticides. The available data suggest that several plant-based materials do affect some arthropod pests, vectors, and other pathogens, yet only a handful of botanicals are currently used for crop protection in the industrialized world and few prospects exist for commercial development of new botanical products. Plants may be an alternative to the currently used pesticides for the control of specific pests and plant diseases as they constitute a rich source of bioactive chemicals. The use of plant materials as traditional protectants of stored products is an old practice used all over the world (Tripathi and Dubey, 2004; Rajendran and Sriranjini, 2008). Peasant farmers from their experience frequently claim successful use of certain material of plant origin in pest control including spices and powders of plant parts. In fact, the management of pests in stored products using materials of natural origin has received much attention because of the little environmental hazards and the low mammalian toxicity of such natural materials. Previous research indicated that several plant products (powders, oils, and extracts) can strongly affect insects of stored grains showing high toxicity or inhibition of reproduction (Emeasor et al., 2005). Moreover, microbial antagonists have been reported to protect a variety of harvested perishable commodities from postharvest pathogens (Sharma et al., 2009). However, decreasing efficacy and lack of consistency when these methodologies are applied alone may restrict use under commercial conditions (Sharma et al., 2009). In any case, the possibility of replacing synthetic pesticides by natural products of plant origin, which are non-toxic and specific in their action, is gaining considerable attention. Natural products can be used not only directly for pest management, but they can serve as models for the development of new synthetic analogues with favorable biological and physicochemical properties. Since these products are often active on a limited number of target species, are biodegradable to non-toxic products, and are potentially suitable for use in integrated management programs, they could lead to the development of new classes of possibly safer pest control agents. Much research has been focused on plant products as a potential source of commercial pest control agents or as bioactive chemical compounds as a viable alternative to the synthetic pesticides (Wheeler, 2002). New improved methods and new instrumentation make this strategy faster and easier, but in the near future natural products will probably remain a relatively small part of most overall discovery processes. Future relative successes of the different discovery strategies will determine the long-term future of natural products in pesticide discovery. The development of botanical pesticides particularly from local plants can be considered as one of the steps towards sustainable agriculture. Since botanical pesticides originate from local natural resources which are biodegradable, the sustainability of pesticide production can be maintained and a healthy environment can be kept.

Insecticidal and repellent activity of turmeric

Turmeric has been found effective in controlling certain agricultural and animal pests due to the presence of a variety of bioactive constituents that interfere with insect behavior and growth. Its products have been found active as insect repellents and insecticidal agents. The international literature reports on insect control properties of turmeric pertaining to the powder, the plant extracts, the essential oil, and certain bioactive constituents of the plant.

Rhizome powder

Rhizomes of *C. longa* were evaluated for their repellency against adults of three insects of stored products, *Tribolium castaneum*, *Sitophilus granarius*, and *Rhyzopertha dominica* and the powder was found effective against *S. granarius* and *R. dominica* (Jilani and Su, 1983). Moreover, turmeric powder in combinations with mustard oil has been reported to protect milled rice against *Sitophilus oryzae* (Chander et al., 1991). A combination of 4 ml/kg of mustard oil and turmeric powder at 20 g/kg provided the best protection of milled rice by completely suppressing progeny emergence of *S. oryzae*. Fly ash (fine particles of ash produced during combustion) plus turmeric dust 10% indicated promising activity against some pests of rice (*Cnaphalocrosis medinalis*, *Oxya nitidula*), some pests of eggplant (namely *Epilachna vigintioctopunctata*, *Aphis gossypii*, *Urentius hystricellus*, *Coccidohystrix insolitus*), and against several pests of okra (namely *Amrasca devastans*, *Tetranychus neocaledonicus*, *Dysdercus cingulatus*, *Oxycarenus hyalinipennis*, *Anomis flava*, *Spodoptera litura*, and *Earias vittella*) inflicting up to 80% mortality depending on species (Sankari and Narayanasamy, 2007). Likewise, dust from rhizomes was shown to be effective against store-grain pests such as lesser grain borer (*Rhyzopertha dominica*) (Chander et al., 2003). In particular, turmeric powder (or grit) provided 63.2% suppression of progeny of the test insect at 0.5% level (Chander et al., 2003). Also, there was complete mortality of adult insects on milled rice treated with 6 ml oil plus 1-4 g of turmeric powder (Chander et al., 2003), whereas mustard oil in various combinations with turmeric powder suppressed the progeny by more than 92%.

Plant extracts

Solvent extracts from rhizomes were effective against *T. castaneum* (Jilani and Su, 1983). Also, the petroleum ether extracts from rhizomes were more effective than the acetone and ethanol extracts (Jilani and Su, 1983). Chander et al. (1992) evaluated the acetone extracts of turmeric, in the laboratory, as repellents on the jute fabric against *Tribolium castaneum*. Rhizome extracts were highly effective even at the lowest concentrations of 2.5 and 3.12 mg/cm² of jute fabric. The concentrations exhibited repellency even after three months of their ageing at room temperature. Acetone extract of turmeric rhizomes acted as repellent against *T. castaneum* (Chander et al., 1994). Chander et al. (2000) observed that turmeric extracts showed some repellency on *Tribolium castaneum*, *Oryzaephilus surinamensis*, *Cryptolestes ferrugineus*, *Sitophilus oryzae*, and *Corcyra cephalonica* even after three months of ageing under laboratory conditions, thereby substantiating the results obtained under warehouse conditions. Lower insect counts in most of the effective treatments were probably due to their repellent action. Matter et al. (2008) observed that surface treatment of wheat seeds with turmeric extracts were not effective in causing mortalities among adults of *Sitophilus oryzae*, except from petroleum ether extract which gave low mortality percentage (20.4%) at 4.0% concentration. The same concentration of extracts gave the highest effect (90.8%) against the adults of *Rhyzopertha dominica*. Petroleum ether and diethyl ether extracts of turmeric showed noticeable reduction (36.0 and 33.6 %, respectively) in F_1 progeny of *S. oryzae* especially at the high concentration level (4.0%), while all extracts of turmeric except diethyl ether extract showed obvious reductions in F_1 progeny of *R. dominica*. Petroleum ether extract provided complete protection, whereas acetone extract gave 85% reduction in F_1 progeny. Petroleum ether extract at 4% concentration scored the best repellent activity causing 98.3 and 73.3 % repellency, respectively, on the second day after the treatment of adults of *R. dominica*. The rhizome and aerial part extract offered dose mortality action against *T. castaneum* adults which was found promising (Abida et al., 2010). The LD_{50} values for rhizome extract were 0.337 and 0.201 mg cm^{-2} for 24 and 48 h of exposure respectively while aerial part extract were 0.695 and 0.639 mg cm^{-2}. Chloroform extracts of rhizomes and the aerial part of the plant showed strong repellent activity against *T. castaneum* adults. However, the extracts of the aerial part was found weaker compared with the rhizome extract.

Essential oil

In a food preference chamber, fewer adults of red flour beetle (*Tribolium castaneum*) settled in rice grain when treated with 100, 500, or 1,000 ppm of turmeric oil (Jilani et al., 1988). Repellency increased with increasing concentrations of the oil. In a second choice test, filter paper strips that were treated with turmeric oil at 200, 400, or 800 µg/cm^2 repelled insects during the first 2 weeks, whereas repellency decreased rapidly thereafter. Red flour beetle adults fed on wheat flour, which had been treated with turmeric oil at 200 ppm produced fewer and underweight larvae, pupae, and adults compared with those fed on untreated flour (Jilani et al., 1988). In another study, repellency of turmeric oils was monitored against the lesser grain borer (*Rhyzopertha dominica*) for 8 weeks (Jilani and Saxena, 1990). It was found that filter paper strips treated with the test materials at 200, 400, or 800 µg/cm^2 repelled the insect. Turmeric oil was significantly more repellent during the first 2 weeks, but thereafter, the repellency decreased rapidly. *R. dominica* adults made significantly fewer and smaller feeding punctures in filter paper disks treated with the test materials at 100, 500, or 1,000 µg/cm^2 than in control disks (Jilani and Saxena, 1990). Saju et al. (1998) observed a significantly higher number of apterous adults of cardamom aphid (*Pentalonia nigronervosa*) on the control shoots than the shoots treated with 0.5 and 1% concentration of turmeric oil. Aphids contacted the treated shoots with lower frequency than the untreated leaves, whereas the highest mortality (10.8%) was observed with 1% concentration. Tripathi et al. (2002) investigated the essential oil extracted from the leaves of turmeric for contact and fumigant toxicity and its effect on progeny production in three stored-product beetles, namely *Rhyzopertha dominica*, *Sitophilus oryzae*, and *Tribolium castaneum*. Oviposition-deterrent and ovicidal actions of the leaf oil were also evaluated against *T. castaneum*. The oil was found insecticidal in both contact and fumigant toxicity assays. The adults of *R. dominica* were highly susceptible to contact action of leaf oil with LD_{50} value of 36.71 µg/mg weight of insect, whereas in the fumigant assay, the adults of *S. oryzae* were highly susceptible with LC_{50} value of 11.36 mg/L air. Furthermore, in *T. castaneum*, the oil reduced oviposition and egg hatching by 72 and 80%, respectively at the concentration of 5.2 mg/cm^2. At the concentration of 40.5 mg/g food, the oil totally suppressed progeny production of all the three insects. Nutritional indices indicated >81% antifeedant action of the oil against *R. dominica*, *S. oryzae* and *T. castaneum* at the highest concentration tested. Three experimental plant-based essential oil formulations provided complete protection from mosquito landing and biting for up to 9 h (duration of the experiment) (Tawatsin et al., 2006). Similar results were obtained against black flies, i.e. protection 100% for 9 h and protection 96-82% after 10 and 11 h after treatment. Also, the products provided 100% protection against land leeches for at least 8 h. Turmeric oil was evaluated for possible larvicidal activity in the laboratory against 4th instars of *Aedes albopictus*, *A. aegypti*, and *Culex pipiens* (Zhu et al., 2008). LT_{50} values for turmeric oil at the dosage 0.2 mg/ml were 6.32 h for *A. aegypti*, 9.28 h for *A. albopictus*, and 0.90 h for *C. pipiens*, respectively.

Biological constituents

Two compounds (ar-turmerone and turmerone) that were isolated from turmeric powder showed strong repellency against *Tribolium castaneum* (Su et al., 1982). Ar-turmerone gave an average repellency 62.9% and 43.1%, respectively, against *Tribolium castaneum* after 8 weeks of study. Turmerone was unstable thermally and also at ambient temperature in the presence of air, yielding its dimer or the more stable ar-turmerone (Su et al., 1982). Fractionation of the volatile oil from turmeric rhizomes also afforded ar-turmerone, which displayed insecticidal activity against mosquitoes with an LD_{100} of 50 µg mL^{-1} on *Aedes aegyptii* larvae (Roth et al., 1998). Bioassay-directed fractionation of hexane extract from the turmeric leaves yielded lambda-8(17),12-diene-15,16 dial, which displayed insecticidal activity 100% against mosquitoes on *A. aegyptii* larvae at 10 µg mL^{-1} (Roth et al., 1998). Curcuminoids, which comprise three closely related curcumins (I, II, and III) of turmeric rhizome powder, were tested for their inhibitory activity on insect growth (Chowdhury et al., 2000). Curcumin-I, which was the major constituent, was converted to five alkyl ether derivatives, which were tested along with the parent compounds and other extractives for inhibitory activity on insect growth against desert locust (*Schistocerca gregaria*) and red cotton bug (*Dysdercus koenigii*) nymphs. At dosage of 20 µg per nymph, benzene extract and dibutyl curcumin-I were the most active (60% inhibition) against *S. gregaria*, whereas at 50 µg these substances exhibited moderate inhibitory activity (45%) against *D. koenigii* nymphs. At these concentrations, turmeric oil caused 50–60% nymphal mortality in both test insects. The insect control activity of most turmeric products was comparable to or better than that of a commercial neem formulation. In a test with female adults of brown planthopper (*Nilaparvata lugens*), ar-turmerone caused 100 and 64% mortality at 1,000 and 500 ppm, respectively (Lee et al., 2001). Against the larvae of *Plutella xylostella*, the compound provided 100 and 82% mortality at 1,000 and 500 ppm, respectively. Against *Myzus persicae* female adults and *Spodoptera litura* larvae, ar-turmerone at 2,000 ppm was effective but weak insecticidal activity was observed at 1,000 ppm. At a dose of 2.1 mg/cm^2, ar-turmerone was almost ineffective (<10% mortality) against adults of *Sitophilus oryzae*, *Callosobruchus chinensis* and *Lasioderma serricorne* as well as larvae of *Plodia interpunctella* (Lee et al., 2001).

Fungicidal activity of turmeric

Turmeric has been found effective in controlling certain agricultural and animal pests due to the presence of a variety of bioactive constituents that interfere with fungi behavior and growth. Products of the plant are also active as fungicidal agents. The international literature reports on fungi control properties of turmeric pertaining to the plant extracts, the essential oil, and certain bioactive constituents of the plant.

Plant extracts

Bioassay-directed fractionation of hexane extract from turmeric leaves yielded lambda - 8 (17) , 12- diene - 15, 16 dial with antifungal activity against *Candida albicans* at 1 µg/ mL and inhibited the growth of *Candida kruseii* and *Candida parapsilosis* at 25 µg/ mL (Roth et al., 1998). Fungicidal activity of turmeric rhizome-derived materials was tested using a whole plant method *in vivo* against *Botrytis cinerea*, *Erysiphe graminis*, *Phytophthora infestans*, *Puccinia recondita*, *Pyricularia oryzae*, and *Rhizoctonia solani* (Kim et al., 2003). At 1000 mg/L, the hexane extract showed fungicidal activity against *E. graminis*, *P. infestans*, and *R. solani*, and the ethyl acetate extract showed fungicidal activity against *B. cinerea*, *P. infestans*, *P. recondita*, and *R. solani*. Curcumin that was isolated from the ethyl acetate fraction using chromatographic techniques had fungicidal activity against *P. infestans*, *P. recondita*, and *R. solani* with 100, 100, and 63% control values at 500 mg/L and 85, 76, and 45% control values at 250 mg/L, respectively. In the test with components derived from turmeric, turmerone exhibited weak activity against *E. graminis*, but no activity was observed from treatments with borneol, 1,8-cineole, sabinene, and turmerone. In comparison, potent activity with chlorothalonil against *P. infestans* at 50 mg/L and dichlofluanid against *B. cinerea* at 50 mg/L was exhibited (Kim et al., 2003). Methanol extract of turmeric rhizomes effectively controlled development of anthracnose of red pepper caused by *Colletotrichum coccodes* (Cho et al., 2006). In addition, three antifungal substances (curcumin, demethoxy-curcumin, and bisdemethoxy-curcumin) were identified from the methanol extract of the rhizomes. The curcuminoids in a range 0.4-100 ug/ml (µg/ml) effectively inhibited the mycelial growth of three red pepper anthracnose pathogens *C. coccodes*, *C. gloeosporioides*, and *C. acutatum*. The three curcuminoids inhibited mycelial growth of *C. coccodes* and *C. gloeosporioides* to an extent similar to the fungicide dithianon, but the synthetic agent was a little more effective against *C. acutatum*. Curcuminoids effectively inhibited germination of spores of *C. coccodes* with bisdemethoxy-curcumin being the most active, whereas among the three curcuminoids, only demethoxy-curcumin was effective in suppressing anthracnose of red pepper caused by *C. coccodes* in a greenhouse test (Cho et al., 2006).

Essential oil and biological constituents

Apisariyakul et al. (1995) studied turmeric oil and curcumin isolated from *C. longa* against four isolates of pathogenic molds. The four isolates of pathogenic fungi were inhibited by turmeric oil at dilutions of 1:40-1:80, but none of them were inhibited by curcumin. From this study, it was found that curcumin has no antifungal activity. Turmeric oil was subjected to fractional distillation under vacuum to get two fractions which were tested for antifungal activity against *Aspergillus flavus*, *A. parasiticus*, *Fusarium moniliforme*, and *Penicillium digitatum* by the spore germination method (Jayaprakasha et al., 2001). Fraction II was found to be more active. Determination and identification of chemical constituents of turmeric oil, fraction I, and fraction II indicated that aromatic turmerone, turmerone, and curlone were the major compounds in the fraction II along with other oxygenated compounds. In antifungal assays of leaf essential oils against the fungal pathogens *Fusarium oxysporum* f. sp. *dianthi* and *Alternaria dianthi* infecting carnations, and *F. oxysporum* f. sp. *gladioli* and *Curvularia trifolii* f. sp. *gladioli* infecting gladiolus, the residual oil showed better antifungal activity over other oil samples tested (Babu et al., 2007). The high content of sesquiterpenoids or the combined effect of the composition and ratio of the mono- and sesquiterpenoids might have enhanced the antifungal activities. The three curcuminoids were effective in suppressing blast on rice and Phytophthora late blight on tomato plants among the 6 plant diseases tested. Out of the three curcuminoids, demethoxy-curcumin showed the highest *in vivo* antifungal activity, followed in order by curcumin and bisdemethoxy-curcumin. This study revealed that curcumin had antifungal activity only on rice blast among the three plant diseases. The essential oil of turmeric rhizomes showed toxicity to 7 fungi that were involved in the deterioration of stored agricultural commodities (Dhingra et al., 2007). Depending upon the fungus tested, the *in vitro* growth inhibition varied from 36%-77% at 0.1%. *Aspergillus flaws*, *Fusarium semitectum*, *Colletotrichum gloeosporioides*, and *C. musae* were the most sensitive with growth inhibition over 70%. Ar-turmerone constituted 87% of the fungitoxic component of the oil. The purified ar-turmerone showed antifungal activity similar to the crude oil (Dhingra et al., 2007).

Conclusions

Experimental data from the international literature, as reviewed herein, indicated a highly promising potential of turmeric products as natural pesticides. Although there is plenty of information about the use of turmeric as a spice and apart from its multiple medicinal uses, turmeric is credited with interesting pesticidal properties against certain agricultural pests and with promising repellent properties against noxious mosquito species. Rhizomes of turmeric have been used widely particularly in Asia, not only as a spice, but also as a common household medicine without showing toxicity to humans. Prospective pesticides based on turmeric products could find commercial application not only in the protection of stored commodities, but also in protected crops (e.g. greenhouse crops), high-value row crops, and within organic food production systems, where only few alternative pesticides are available. Such natural pesticides would be a practical alternative for effective and sustainable crop protection that could substantially minimize potential for environmental contamination and human health risks. Whether new products based on turmeric plant will be eventually developed in the future for pest control remains to be proved in practice.

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