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Biocidal Activity of *Azadirachta indica* and *Ocimum basilicum* against Three Strains of Adult *Aedes aegypti* in Perú

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ABSTRACT This work aimed to evaluate the biocidal activity of extracts and oils from *Azadirachta indica* and *Ocimum basilicum* grown in Peru against three strains of adult *Aedes aegypti*. The chemical profile of these plant species was also determined using liquid chromatography/mass spectrometry. The aqueous, ethanolic, and hexane extracts from both species were toxic to the adults of *A. aegypti*, and concentration-dependent 100% mortality was achieved within 15–105 min. Moreover, the ethyl acetate extract of *A. indica* acted specifically on the strain Sullana (100% mortality in 40 min). In comparison, the essential oil from *O. basilicum* was toxic to all the strains (100% mortality in 15–30 min). In the chemical analysis, 32 compounds were identified in the *O. basillicum*, while 14 were described for *A. indica*. In conclusion, the biocidal potential of both plants grown in Peru against local *A. aegypti* adult strains was significant in terms of the eco-friendly advantages of botanical products.

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INTRODUCTION

In the entomological fauna of the world, mosquitoes constitute one of the most critical groups in public health, in which diseases transmitted by mosquitoes (vectors) have high morbidity and mortality rates. According to the WHO, they incur 17% of all infectious diseases in the world, with 1000 million cases and 1 million deaths annually (WHO, 2017). These constitute

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In the chemical identification by UHPLC-MS/MS, 14 substances were identified from *A. indica*, whereas 32 compounds were determined for *O. basilicum*. The major limonoids, represented by 7-desfuran-17-(21-hydroxy-20(22)-ene-21,23-γ-lactone)nimbandiol, 24,25,26,27-tetranor-apotirucall-6α,22-dihydroxy-7α-acetoxy1,14,20(21)-trien-3-one-21,23-olide and salannic acid, in addition to quinic acid are characteristic for *A. indica*, besides quercetin and kaempferol conjugates (Forim *et al*., 2010; Prakash *et al*., 2018). In the *O. basilicum* analysis, sagerinic acid, carnosol, carnosic acid, and other caffeic acid family molecules as rosmarinic acid conjugates are common in this species, besides organic acids, and flavonoids (Pandev and Kumar, 2016).

Limonoids block the synthesis and release of molting hormones, leading to sterility in adult females and incomplete ecdysis in immature insects (Isman, 2006). The effects of *A. indica* are also probably related to the presence of the three major limonoids, including sallanic acid, since they are among the five main substances of the extract and have already presented proposed or confirmed mechanisms for insecticidal activity. However, other compounds like quercetin can contribute with possible synergic action. Furthermore, salannic acid and quercetin induce feeding deterrence in *A. aegypti*. It was suggested that quercetin oxidation by larvae generates reactive oxygen species that can degrade the nutritional quality of food present in the gut lumen of the insects. Quercetin also affects transhydrogenase activity, negatively impacting their growth, and leading them to death (Pessoa *et al*., 2018). In turn, salannic acid shows a relationship between sensory input and feeding inhibition, supporting the hypothesis that the medial deterrent cell's response directly causes feeding inhibition (Koul, 2008).

In the case of *O. basilicum*, the antifeedant effect has already been observed in extracts rich in rosmarinic acid, carnosol, and carnosic acid (Santana-Méridas *et al*., 2014), which would add to the similar effect of quercetin (Pessoa *et al*., 2018). Therefore, the main contributions to the insecticidal activity of the extract are probably related to the presence of carnosol and carnosic acid since these is among the four major substances. In addition, kaempferol causes the inhibition of the ecdysone 20-monooxygenase enzyme in females, which can suppress their oviposition (Mitchell *et al*., 1993). Furthermore, the caffeic acid family compounds, such as rosmarinic acid conjugates and sagerinic acid, reduce insect herbivory in several ways, such as discouraging feeding and oviposition, declining fertility, and shortening the insect life span (Isman, 2006; Dawkar *et al*. 2013). Moreover, some authors suggest that the neurotoxic effect of essential oils and their constituents is produced by modulating the biological activity of their molecular targets, which include some ion channels (Leyva *et al*., 2015) and receptors tyramine, octopamine, GABAa, and acetylcholine (Rattan, 2010). Other researchers suggest that compounds such as thymol, Pulegone, and carvacrol are positive allosteric modulators of GABA receptors in insects (Tong and Coats, 2010). The presence of mutations in the target sites of insecticide action is a mechanism that mediates resistance to various compounds in different arthropod species (Leyva *et al*., 2015), which in turn can contribute to the insecticidal effect of both plants on *A. aegypti*.

It can be concluded that both plant species studied were biocidal to mosquitoes from Rio Seco (Trujillo), Ferreñafe (Chiclayo) and Sullana (Piura). The study also determined the chemical profile of the ethanolic extracts from both species, which included 14 substances for *A. indica*, with limonoids predominance, and 32 substances for *O. basilicum*, which included molecules from caffeic acid, besides carnosol, and carnosoic acid as main compounds. These substances have been recognized as insecticidal and are probably responsible for the action against Peruvian varieties of *A. indica* and *O. basilicum*. However, the efficacy of individual compounds remains to be evaluated in the continued research going on in our lab. Moreover, the quality study of the extracts and oils indicated that they comply with recommended standards of quality, which can be seen as safety alternatives to synthetic insecticides.

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