|  |  |
| --- | --- |
| cetlogo ***CHEMICAL ENGINEERING TRANSACTIONS*** ***VOL. 96, 2022*** | A publication ofaidiclogo_grande |
| The Italian Associationof Chemical EngineeringOnline at www.cetjournal.it |
| Guest Editors: David Bogle, Flavio Manenti, Piero SalatinoCopyright © 2022, AIDIC Servizi S.r.l.**ISBN** 978-88-95608-95-2; **ISSN** 2283-9216 |

Lethality of hydroalcoholic extracts from fruit plant leaves in the Peruvian jungle.

Ana N. Sandoval\*a, Karla L. Mendozaa, Herry Llocllaa, Ludwig N. Villanuevaa, Jose C. Rojasb

aUniversidad César Vallejo

bUniversidad Nacional de San Martín

\*asandoval@ucv.edu.pe

Lethality of hydroalcoholic extract from fruit plant leaves in the Peruvian jungle in *Artemia salina* was evaluated. The type of study was experimental with a control group (K2Cr2O7). The biological material was fruit leaves (*Cocos nucifera*, *Mauritia flexuosa*, *Theobroma cacao L*, *Coffea sp*, and *Musa sp*) collected in San Martín Region; Likewise, the phytochemical march to the leaves was carried out to identify their active principles. The *Artemia salina* eggs were provided by the department of animal physiology of the National University of Trujillo, they were kept under specific conditions such as artificial light, a temperature of 25 ° C and a time of 24 hours, allowing them to mature up to 48 hours. For the preparation of the hydroalcoholic extract it was by the maceration method using 500g of leaves and 500mL of 70° alcohol; for 15 days under stirring, the solution was taken to a vertical rotary evaporator to obtain a dry extract preparing concentrations of 10, 100, 250, 500 and 1000 μg/mL. The sample consisted of 10 larvae for each plant species and concentration, performing the test in triplicate. The LC50 lethality of *Artemia salina* in the samples was classified as: ˃1000 μg/mL. (Non- lethality), 500 ˂ LC50 ≤ 1000 (Low toxicity), 100 ˂ LC50 ≤ 500 (Moderate lethality), LC50 ˂ 100 (High lethality). It was obtained as a result that *Mauritia flexuosa* and *Theobroma cacao L.* in concentrations 10, 100 μg/mL present high and moderate lethality.

1. **Introduction**

Medicinal plants have been used since ancient times as a curative means, receiving interest for their healing potential due to their active components (Afsar et al., 2015). Nowadays, the consumption of medicines has raised their costs which has generated limited access for the population, opting for the use of medicinal plants for the treatment of diseases as part of primary health care (WHO, 2015; Teles and Costa, 2014). The use of botanical and plant-derived medicines was valued at $23.2 and $24.4 million between 2013 and 2014 and is expected to reach $25.6 million in 2015 and $35.4 billion in 2020 (BCC, 2017). The ethnobotanical use of plants is important because it allows research and through it the discovery of new therapeutic alternatives. Studies have shown that plant parts such as seeds, fruits, leaves and roots have been used for disease control (Moraia et al., 2019). However, a phytochemical analysis must be performed to identify the bioactivity possessed by each active compound to avoid side effects (Ullah et al., 2014).

The Peruvian rainforest has a great diversity of flora including fruit plants of species Cocos *nucifera, Mauritia* *flexuosa, Theobroma cacao L., Coffea sp and Musa sp* (MINAM, 2019); species that are used as an alternative for traditional medicine due to their active principles, such as steroids, phenolic compounds, flavonoids, terpenes, reducing sugars, lactones, among others (Pereira et al., 2016; Sandoval et al., 2020). Some research has shown that hydroalcoholic extracts of leaves of some species are toxic for human consumption due to the combination of their active compounds (Leite et al, 2015; Paredes et al., 2018; Sandoval et al., 2020). *Artemia salina* is a light brown shrimp of the Crustaceae family, with a size of 1 to 7 mm. It is cosmopolitan, lives in salt water at a temperature of 6ºC to 35ºC, and feeds on algae and bacteria. The study of its physiology concludes in performing preliminary tests because they are low cost, easy to handle and present minimum requirements for laboratory manipulation. Toxicology studies indicate the presence of sensitivity to certain toxic agents and therefore provide reliable results. As this is a practical, sustainable and sustainable method, it is used to evaluate the pharmacological potential of synthetic and natural compounds measured through their lethality in plants, which implies only life or death (Avalos et al., 2014; Silva et al., 2015). Therefore, the objective of the study was to evaluate the lethality of hydroalcoholic extracts of Peruvian rainforest fruit leaves on *Artemia salina.*

1. **Method**

**2.1. Vegetal material**

500 grams of leaves of the species *Cocos* *nucifera, Mauritia flexuosa, Theobroma cacao L., Coffea sp and Musa sp*, were collected in the district of Cacatachi, San Martín, at 295 m. above sea level and 12 km north of Tarapoto (6°29'40" south latitude and 76°27'57" west longitude). The samples were placed in vacuum bags and labeled with their name at a temperature of 37 °C. Afterwards, they were taken to the Truxillense Herbarium of the Universidad Nacional de Trujillo (National University of Trujillo) for identification and deposit with a registration code for each species: *Cocos nucifera* (COD. 59603), *Mauritia flexuosa* (COD.59597), *Theobroma cacao L.* (COD. 59599), *Coffea sp* (COD. 59609) and *Musa sp* (59608).

**2.2 Preparation of hydroalcoholic extract**

The leaves were washed with distilled water and disinfected with 70° ethanol. They were fractioned to an approximate size of 4 mm. For the extraction of the hydroalcoholic extract, the maceration method was used: 350 g of leaves and 500 mL with 70° ethanol for 15 days under agitation with a vertical rotary evaporator (Scilogex RE-100) at 75 revolutions per minute to obtain dry extracts. Dilutions at concentrations of 10, 100, 250, 500 and 1000 μg/mL were prepared with the sample obtained.

* 1. **Phytochemical analysis**

The hydroalcoholic extract of fruit leaves was evaluated in order to identify its active principles. Each sample was subjected to solvents of increasing polarity to obtain secondary metabolites according to their solubility using reagents and dyes to determine the presence or absence of active components such as: steroids, triterpenes, quinones, phenolic compounds, flavonoids, lactones, alkaloids, reducing sugars, tannins and saponins, by using the protocol described by Lock (2016). 3 mL of pure extract was added to 10 test tubes to identify secondary metabolites through color change, classified as light, moderate or strong. The tests used to determine the presence of each type of secondary metabolite are listed in Table 1.

*Table1*. Phytochemical analysis of the hydroalcoholic extract of the leaves of medicinal plants from the Peruvian Jungle.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Assay** | **Secondary metabolites** | ***Cocos nucífera*** | ***Coffea sp*** | ***Theobroma cacao L*** | ***Musa sp*** | ***Mauritia flexuosa*** |
| Lieberman-Bouchard | Steroids and triterpenes | (++) | (+) | (++) | (++) | (++) |
| Borntrager | Quinones | (-) | (-) | (-) | (-) | (-) |
| Ferric chloride | Phenolic compounds | (+) | (+) | (+) | (++) | (+++) |
| Shinoda | Flavonoids | (+) | (+) | (-) | (+++) | (+++) |
| Baljet | Lactones | (+) | (-) | (-) | (++) | (+) |
| Dragendorff | Alkaloids | (-) | (+) | (-) | (-) | (-) |
| Mayer | Alkaloids | (-) | (+) | (-) | (-) | (-) |
| Fehling | Sugar reducers | (++) | (+) | (++) | (++) | (++) |
| Gelatin | Tannins | (++) | (+) | (-) | (-) | (++) |
| Foam | Saponins | (-) | (-) | (-) | (-) | (-) |

Note: Color changes of secondary metabolites in (+) = slight, (++) = moderate and (+++) = strong.

**2.4 Obtaining and breeding Artemia salina**

The 20-day-old *Artemia salina* eggs were provided by the Department of Animal Physiology, Universidad Nacional de Trujillo, and were washed with filtered seawater to remove impurities. An incubation chamber with abundant oxygenation was used, adding to this container one gram of eggs (equivalent to 700-800 eggs), allowing incubation in 5 liters of filtered seawater under artificial fluorescent light at 110 Watts, temperature of 25 °C and adjusted to a pH of 7-8 for 24 h.The *Artemia salina* eggs were fed with commercial yeast extract to hatch and continue their biological cycle for approximately seven days. Then, 10 7-day-old larvae per each concentration (10, 100, 250, 500 and 1000 μg/mL) at stage III were used as a toxicity marker due to its high sensitivity (Silva et al., 2015; Jaramillo et al., 2016).

**2.5 Lethality testing**

Concentrations of 10, 100, 250, 500 and 1000 µg/mL of filtered seawater were prepared according to the protocol described by Seremet et al (2018). Then 5 µg of extract was diluted in 5 mL of filtered seawater, equivalent to 10 μg/mL, 50 μg of extract in 5 mL of filtered seawater, equivalent to 100 μg/mL, 125 μg of extract in 5 mL of filtered seawater, equivalent to 250 μg/mL, 250 μg of extract in 5 mL of filtered seawater, equivalent to 500 μg/mL and 500 μg of extract in 5 mL of filtered seawater, equivalent to 1000 µg/mL.Ten larvae were placed in a test tube containing 10 mL of filtered seawater and 0.5 mL of the hydroalcoholic extract; this was for each plant species and concentration. Each assay was performed in triplicate and a K2Cr2O7 control group of 250 μg/mL was used for comparison (Goncalves et al., 2019; Simoes and Almeida, 2015). The larvae were exposed to the treatments for 24 hours; after this time the number of dead larvae was counted only if there was no movement of their appendages for 10 seconds (Socea et al., 2015); for this purpose, a stereoscope (Eurolab NSD-405) was used.

The toxicity criteria for *Artemia salina* samples were classified as follows: ˃ 1000 µg/mL (non-toxic), 500 LD 50 ≤1000 (low toxicity), 100 ˂ LD 50 ≤ 500 (moderate toxicity), LD 50 ˂ 100 (high toxicity) (Alonso et al., 2017 and Monteiro et al., 2018). The toxicity percentage of the organisms exposed to the effect of the extract was estimated as follows:

Toxicity (percentage) = (TNA - NAA) / TNA\*100 (1)

Where: TNA = Total number of *Artemia salina*.

 NAA = Number of live *Artemia salina* (Jan and Khan, 2016).

**2.6 Ethical Statement**

*Artemia salina* does not represent a danger to the environment. It is not an endangered species, as it does not appear on the red list of the International Union for Conservation of Nature (IUCN), the species is used for scientific purposes (IUCN, 2019).

1. **Results**

*Figure 1. Concentration of 10μg/mL of hydroalcoholic extract vs. positive control group (K2Cr2O7).*

It is observed that the 5 plant species have high lethality compared to the positive control group, with *Mauritia flexuosa* having the highest percentage of lethality.

*Figure 2. Concentration of 100μg/mL of hydroalcoholic extract vs. positive control group (K2Cr2O7).*

It is evident that the 4 plant species have high lethality compared to the positive control group, with *Mauritia flexuosa* having the highest percentage of lethality.

*Figure 3. Concentration of 250μg/mL of hydroalcoholic extract vs. positive control group (K2Cr2O7).*

It is observed that the 4 plant species have moderate lethality (*Coffea sp, Cocos nucífera, Musa sp and Mauritia flexuosa*) compared to the positive control group, with *Mauritia flexuosa* having the highest percentage of lethality.

*Figure 4. Concentration of 500μg/mL of hydroalcoholic extract vs. positive control group (K2Cr2O7).*

It is evident that the 5 plant species have low lethality compared to the positive control group, which has the highest percentage of lethality.

*Figure 5. Concentration of 1000μg/mL of hydroalcoholic extract vs. positive control group (K2Cr2O7).*

It is observed that the 5 plant species do not present lethality compared to the positive control group, which presents the highest percentage of lethality.

**4. Conclusions**

The active compounds of the hydroalcoholic extracts of fruit leaves from the Peruvian rainforest were analyzed, finding steroids, triterpenes, phenolic compounds, flavoniods and tannins. *Artemia salina* was used as an indicator to measure lethality. The results indicated that concentrations less than or equal to 100 μg/mL have high lethality, concentrations of 250 μg/mL moderate lethality, concentrations of 500 μg/mL low lethality and concentrations equal to or greater than 1000 μg/mL are not lethal. The hydroalcoholic extracts with the highest lethality concentration were *Mauritia flexuosa* and *Theobroma* *cacao L.* The consumption of medicinal plants has been increasing due to their probable effectiveness. However, indiscriminate use is a latent risk due to the toxicity of some compounds within the plant that can cause collateral damage. For this reason, it may be useful to study medicinal plant extracts to show therapeutic or toxic activity of their active compounds. Other studies indicate that if a sample is not lethal to *Artemia salina*, its effects will also be similar for humans.

**References**

Afsar T., Khan M., Razak S., Ullah S., Mirza B., 2015, Antipyretic, anti-inflammatory and analgesic activity
of Acacia hydaspica R. Parker and its phytochemical analysis, [BMC Complementary and Alternative Medicine](https://bmccomplementmedtherapies.biomedcentral.com/), 15, 136.

Alonso A., Domínguez F., Ruíz A., Campos N., Zapata J., Carranza C., Maldonado J., 2017, Medicinal
Plants from North and Central America and the Caribbean Considered Toxic for Humans: The Other Side
of the Coin, [BMC Complementary and Alternative Medicine](https://bmccomplementmedtherapies.biomedcentral.com/), 9439868.

Ávalos J., Treviño J., Verde M., Rivas C., Oranday A., Moran J., Serrano L., Morales M., 2014, Cytotoxic evaluation of *Azadirachta indica* (A. Juss) ethanolic extracts against differents cells lines. Magazine Mexican Pharmaceutical Sciences, 45(3), 39–44.

BCC., 2017, Botanical and Plant-Derived Drugs: Global Markets. BCC BIO022G.

Goncalves A., Vasconcelos M., De Carvalho M., Takahashi J., Ferraz V., Chagas E., Chagas P., De Melo A., 2019, Phytochemical Trial and Bioactivity of the Essential Oil from *Coriandrum Sativum* on Pathogenic Microorganisms, Chemical Engineering Transactions, 75, 403-408

IUCN, (International Union for Conservation of Nature’s Red List), 2019, [www.iucnredlist.org/](http://www.iucnredlist.org/)

Jan S., Khan., M., 2016, Protective effects of *Monotheca buxifolia* fruit on renal toxicity induced by CCl4 in
rats, [BMC Complementary and Alternative Medicine](https://bmccomplementmedtherapies.biomedcentral.com/), 17, 16, 1, 289.

Jaramillo C., Jaramillo A., D’Armas H., Troccoli L., Rojas L., 2016, Concentrations of alkaloids, cyanogenic
glycosides, polyphenols and saponins in selected medicinal plants from Ecuador and their relationship with
acute toxicity against *Artemia salina*, Journal of Tropical Biology, 64,3, 1171-1184.

Leite S., Dantas A., Oliveira G., Gomes A., De Lima S., Citó A., De Freitas M., Melo-Cavalcante
A., Dantas J., 2015, Evaluation of toxic, cytotoxic, mutagenic, and antimutagenic activities of natural
and technical cashew nut shell liquids using the Allium cepa and *Artemia salina* bioassays, Biomed Res
Int, 626835.

Lock O., 2016, Phytochemical Research: Methods in the study of natural products. 3rd Edition, Editorial of the Department of Sciences, Pontifical Catholic University of Peru, 6-8.

MINAM (environment ministry), 2019, Sixth National Report on Biological Diversity: Biodiversity in figures. Lima - Perú.

Monteiro J., Ferreira J., Oliveira R., Batista F., Pinto C., Silva A., Morais S., Silva M., 2018,
Bioactivity and Toxicity of *Senna cana* and *Senna pendula* Extracts. Biochem Res Int, 8074306.

Moraia K., Morais B., Oliveira C., Vilarinho L., Chagas P., Goncalves A., Takahashi J., De Melo A., 2019, Bioactive Extracts of *Capsicum Chinense* in the Northern Amazon, Chemical Engineering. Transactions, 75, 433-438

Paredes B., Zegarra J., Zanabria J., Cuadros F., Chavez J., Huanca P., 2018, plant consumption medicinal products of habitual use and possible adverse effect on the health of the population, as a result of the plant contamination, Arequipa, Peru. Advances in Science and Engineering Magazine, 9(3), 13-22.

Pereira J., Barros K., Lima L., Martins M., Araujo C., DA Silva G., De Souza J.,
Ferreira P., 2016, Phytochemistry Profile, Nutritional Properties and Pharmacological Activities of
*Mauritia flexuosa*, J Food Sci 81, (11): R2611 – R2622.

Sandoval A., Valverde Flores J., Calla K., Alba R., Lloclla H., Sotero S., Ismino A., Salazar M., 2020, Toxicity in Artemia Salina by Hydroalcoholic Extracts of Monocotyledonous and Dicotyledonous Varieties of Medicinal Plants from the Peruvian Amazon, Chemical Engineering Transactions, 79, 367-372

Sandoval A., Valverde Flores J., Calla K., Alba R., Lloclla H., Sotero S., Ismino A., Salazar M., 2020, Hydroalcoholic Extracts of Fruit Leaves from the Peruvian Amazon as Antibacterial Potential of Gram-negative and Gram-positive Bacteria, Chemical Engineering Transactions, 79, 319-324

Seremet O., Olaru O., Gutu M., Nitulescu M., Ilie M., Negres S., Zbarcea E., Purdel C., Spandidos
D., Tsatsakis A., Coleman M., Margina D., 2018, Toxicity of plant extracts containing pyrrolizidine
alkaloids using alternative invertebrate models, Mol Med Rep, 17, 6, 7757–7763.

Silva E., De Castro R., Barreto F., De Morales M., Souza A., Feitosa A., Cerqueira M., 2015, Estudo in
vitro do potencial citotóxico da *Annona muricata* L, Journal of Applied Basic Pharmaceutical
Sciences, 36 (2), 277-283.

Simoes R., Almeida S., 2015, Phytochemical study *Bauhinia forficata* (Fabaceae), Amazon biota, 5, 1, 27-31. p27-31.

Socea L., Socea B., Saramet G., Barbuceanu, S., Draghici C., Constantin D., Tudorel O., 2015,
Synthesis and cytotoxicity evaluation of new 5h-dibenzo<7>annulen-5-yl acetylhydrazones, Rev Chim, 66,
1122–1127.

## Teles D., Costa M., 2014, Study of the joint antimicrobial action of aqueous extracts of broadleaf plantain *Plantago major* L, *Plantaginaceae* and *Punica granatum* L., *Punicaceae* and their interference in the in vitro activity of amoxicillin, Revista Brasileira de Plantas Medicinais, 16 (2), 323–328.

Ullah S., Khan M., Shah N., Shah S., Majid M., Farooq M., 2014, Ethnomedicinal plant use value in the
Lakki Marwat District of Pakistan, J Ethnopharmacol, 158, 412–22.

WHO, 2015, Traditional Medicine Strategy 2014-2023, Geneva, Switzerland.