



(RESEARCH ARTICLE)



## Overview of artisanal production and consumption of spirulina in southern Algeria: example of Tamanrasset

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### Abstract

Spirulina or *Arthrospira platensis* is a filamentous cyanobacterium known for its nutritional properties. The aim of this work is to provide an overview of the consumption and artisanal production of this microalgae in Tamanrasset in southern Algeria. The study demonstrates that there are three determining factors: temperature, light, and pH of the environment. The field survey provided information on the profile of consumers, mode, reason, and frequency of use. It also allowed for the identification of a profile of consumers who believe in the therapeutic virtues of spirulina, although it is only a dietary supplement, making chemical and pharmacological screening more than essential.

**Keywords:** Spirulina; Tamanrasset; Algeria; Artisanal production; Consumption

### 1. Introduction

Spirulina or *Arthrospira platensis* is a filamentous cyanobacterium known primarily for its nutritional properties but also for its therapeutic virtues. It naturally grows in alkaline waters of certain lakes in hot zones (1). The first artisanal culture of Spirulina sensu stricto was probably initiated by Fox Ripley, who was the first to launch this activity in India in 1973, in collaboration with Navsāri Agricultural College. Since then, many advances have been made to improve its exploitation on a small scale in all regions of the world (2).

In Algeria, more precisely in the province of Tamanrasset (Adrienne, 22° 47' 6" N 5° 31' 22.001" E), farms comprising of basins have been installed for the cultivation of Spirulina, and small production units have been set up in different regions: Ouargla (31° 56' 60" N 5° 19' 0.001" E) and Oran (35° 41' 51.555" N 0° 38' 1.455" W) (3).

### 2. Material and methods

#### 2.1. Artisanal production of Spirulina

We traveled to Tamanrasset for a short stay to explore the artisanal culture of Spirulina and its different stages at Mr. HIRI's production station.

##### 2.1.1. Study location

Tamanrasset is a vast arid land located in the middle of the Algerian Sahara, it is the capital of Hoggar. Its surface area is 619,360 km<sup>2</sup> and an altitude of 1400m, and is located 1500 km from the sea. The city of Tamanrasset is an essential axis for nomads and Tuaregs, who roam the dunes, regs of the Sahara, from Mali to Niger, passing through Chad and Libya (3).

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### 2.1.2. Weather conditions

The climate in Tamanrasset is said to be desert. According to the Köppen-Geiger classification, the climate is of the BWh type (4).

### 2.1.3. Temperature

according to the National Office of Meteorology in Tamanrasset, the Tamanrasset region has a mild winter and a hot summer; summer temperatures are high, with an average of 30°C, with a maximum in June. For winter temperature, it varies between 15 and 17°C (2007-2016) (5,6).

### 2.1.4. Precipitation

it is very low, almost nil (0 mm) in winter and very high in summer, with a maximum of 47.2 mm recorded in July 2016 (3).

### 2.1.5. Relative humidity

Humidity is high in August and December, with a maximum value of 33% in August (5,6).

## 2.2. Survey on Spirulina consumption in the Tamanrasset region

### 2.2.1. Objectives of the survey

The aim is to study the profiles of consumers (socio-demographic and professional); evaluate their knowledge (method of use, benefits, and risks); and identify cases of a direct link between consumption and a favorable evolution of the consumer's health or, on the contrary, cases of complications related to Spirulina consumption.

### 2.2.2. Study methodology (7,8,9,10,11,12,13,14 &15) :

Study location

Wilaya of Tamanrasset and its surroundings (South of Algeria).

Type of study

Prevalence study, descriptive, observational, declarative through a questionnaire.

Target population

Spirulina consumers.

Inclusion criteria

Spirulina consumers.

Exclusion criteria

Non-consumers of Spirulina and non-respondents to most questions.

### 2.2.3. The questionnaire

It includes (24) questions divided into (04) main axes

Sociodemographic data

Aim to study the profile of consumers to determine any subgroups during the analysis of the results. It contains (07) questions to know : the age and sex of consumers; the level of education and professions of consumers; the consumer's support by social security and the reason why they consume Spirulina (1,3,5,7).

Medical data

includes (07) questions ; in case the consumer uses Spirulina for treatment; it allows us to know: the treated pathology (8,9,10).

### Method of Spirulina use

In this part, (06) questions allow us to collect information: means to obtain Spirulina ; the frequency of consumption (11,12,13).

### Risks associated with Spirulina use

This part contains (04) questions aimed mainly at detecting side effects associated with Spirulina consumption (14,15).

#### 2.2.4. Investigation process

Prior to its distribution, the questionnaire was developed and validated following a thorough literature analysis and based on other similar studies. The data is processed on Microsoft Excel (2019).

## 3. Results

### 3.1. Artisanal production of spirulina in Tamanrasset

#### 3.1.1. Essential elements for the cultivation of spirulina

##### Culture medium

it must provide all of the following elements (see Table 1) :

**Table 1** Composition of Spirulina culture medium (2,6)

For (01) liter of water	
Composant	Quantity (g/l)
Natron	1.6
Sodium chloride	1
Ammonium phosphate	0.1
Sulfate de potassium	0.5
Magnesium sulphate	0.1
Iron	0.01
Urea (nitrogen)	0.1
Calcium chloride	0.1

##### Water quality

Spirulina grows in water that is both salty and alkaline. The water used for the culture medium should preferably be potable (but not strongly smelling of chlorine).

##### Ponds

(04) ponds of (02) m<sup>2</sup> and (03) ponds of (01) m<sup>2</sup> in length and width that comply with J.P. JOURDON's standards (5) (should not have sharp angles, but rather rounded shapes at least at the ends in the case of rectangular ponds. The bottom should be as flat as possible, with a slight slope towards a deeper place that is easily accessible to facilitate drainage. The edges of the pond should be above ground level, to reduce the entry of dust and animals, and at least 20 to 40 cm above the bottom, they are covered by plastic that has a dual role: protecting against excess rain, sun, or cold, and against falling leaves, thus keeping the temperature at 25C°.

### 3.1.2. Starting a culture

#### Preparation of the culture medium

We prepared a 100 L culture medium under agitation until a homogeneous solution was obtained, which would then be used as the culture medium. Natron plays a fundamental role in maintaining high levels of carbon nutrients and alkalinity in the medium.

#### Inoculation of the strain into the culture medium

The strain should be inoculated into a culture medium [(01) volume of strain for (05) volumes of culture medium] and an algebraic volume progression should be performed: 500 ml of concentrated strain are inoculated into 2.5 L of culture medium, then into 12.5 L of culture medium, and so on until a sufficient quantity is obtained to fill a 1000 L pond.

#### Agitation

The culture is subjected to continuous agitation by a pump to ensure good distribution of light among all spirulina and to promote the elimination of oxygen

#### Filtration or Harvesting

The harvested spirulina must be concentrated before being filtered and washed. Harvesting is done in a way to maintain the concentration of spirulina in the basin at a concentration level between 0.3 and 0.7 g/L. The harvest involves filtering a part of the culture on a fine mesh (25 to 60  $\mu$ ). The filtration duration must be sufficient to obtain a sufficient quantity and a wet mass (cheese) that adheres to the filter wall.

#### Declogging

After filtration, the mesh is unclogged using spatulas and the biomass is collected in a container. The biomass is a little liquid, and at this stage, spirulina can be consumed fresh. It does not have a particular taste, but on toast with goat cheese, for example, it is delicious.

#### Drying

The biomass is then transformed into long spaghetti-like filaments using an extruder. These filaments are deposited on trays and dried at low temperature (less than 45°C) and away from light. This drying technique allows spirulina to retain all of its nutritional properties.

#### Packaging

For commercialization, spirulina is finally packaged in well-labeled bags with no additives or preservatives (100% spirulina).

#### Quality Control

To ensure safe and good-quality spirulina, measures and analyses are carried out throughout the culture.

### 3.1.3. During production

#### Temperature

is one of the fundamental parameters that directly influence the growth rate of spirulina. Using a digital thermometer, we measure the temperature which was between 25 and 27°C (winter), hence the role of the plastic cover to keep it practically constant.

#### Ph

The very high alkalinity of the culture medium (pH 8.5 to 11.0) constitutes an excellent barrier against most contaminations, both bacteria and yeasts, fungi, or algae. Moreover, it seems that certain substances secreted or contained in spirulina have an interesting bactericidal or at least bacteriostatic activity. Using pH paper, we have controlled the pH of the culture medium before and after inoculation and ensured that it was between 10 and 11

## Microscopic examination

During the cultivation period, microscopic observation is carried out to monitor the morphology and multiplication of Spirulina.

### 3.1.4. After harvesting

Apparent and organoleptic qualities: Fresh Spirulina paste should be very dark green, practically odorless and tasteless. A blue-reddish tint indicates too violent pressing or exceeded storage time (in the latter case, a smell of rotten eggs). Good quality dried Spirulina should be very dark green, with a characteristic (algae/mushroom) odor that is not pronounced and a weak taste. A turquoise blue color indicates strong exposure to light (not dangerous, but greatly reduced nutritional quality).



**Figure 1** The various stages involved in the artisanal production of spirulina in Tamanrasset, which include : (1) geographical location, (2,3) culture basins, (4) use of natron, (5) filtration, (6) drying, (7) microscopic appearance, and (8) final product

## 3.2. Survey Results: We received 45 responses

### 3.2.1. Questions (1,2,3)

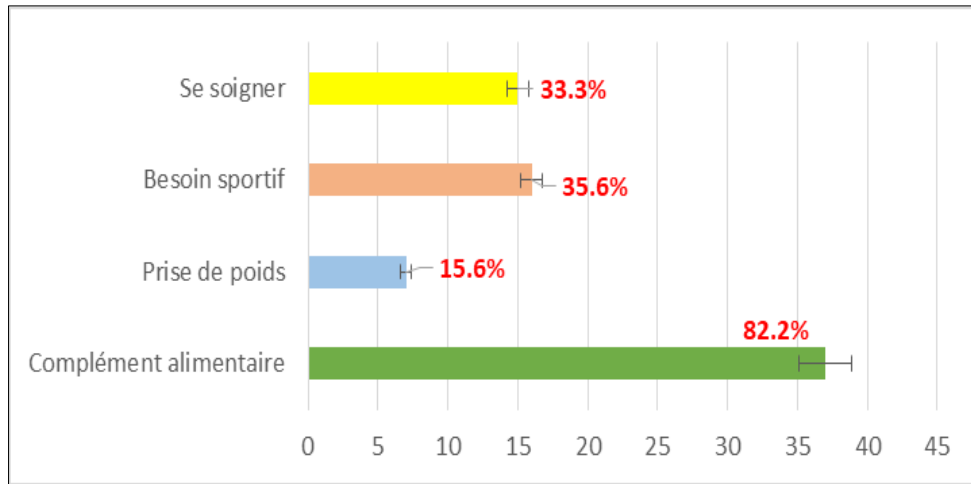
Age, gender and education level ? According to these results: (71%) of our study population are between 20 and 60 years old, of which 60% of consumers are between 20 and 30 years old. The male/female ratio is  $(58/42) = 1.38$ . We found that over 60% have a university education level and 20% are high school students, as

### 3.2.2. Question (4)

Socio-occupational category? The results show that 20% of our study population are students, 15.6% are self-employed, 15.6% are employees, and the same percentage of 15.6% are inactive.

### 3.2.3. Question (7)

Why do you consume Spirulina ? According to these results, 82% consume Spirulina as a dietary supplement, 33.3% for health reasons, and 15.6% for weight gain.

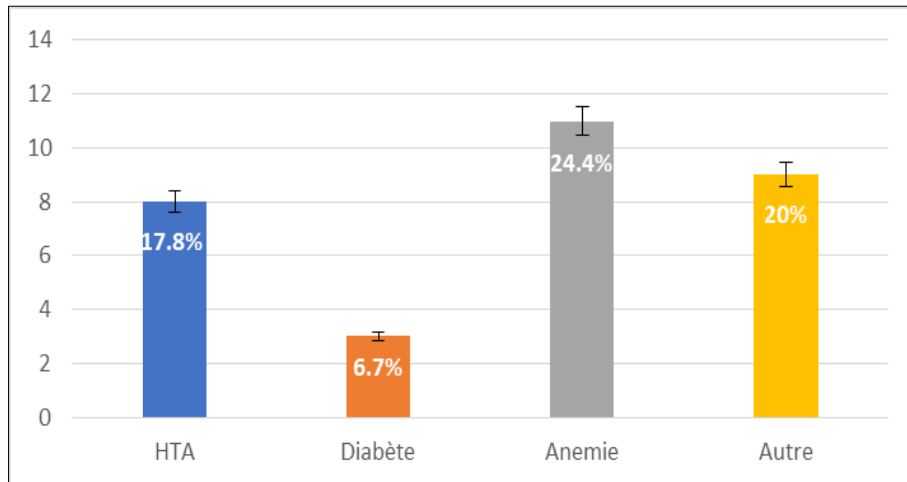


**Figure 2** Distribution of reasons for consuming spirulina

**3.3. The next four questions (9-12) pertain to individuals who consume spirulina for medicinal purposes:**

**Question (9)**

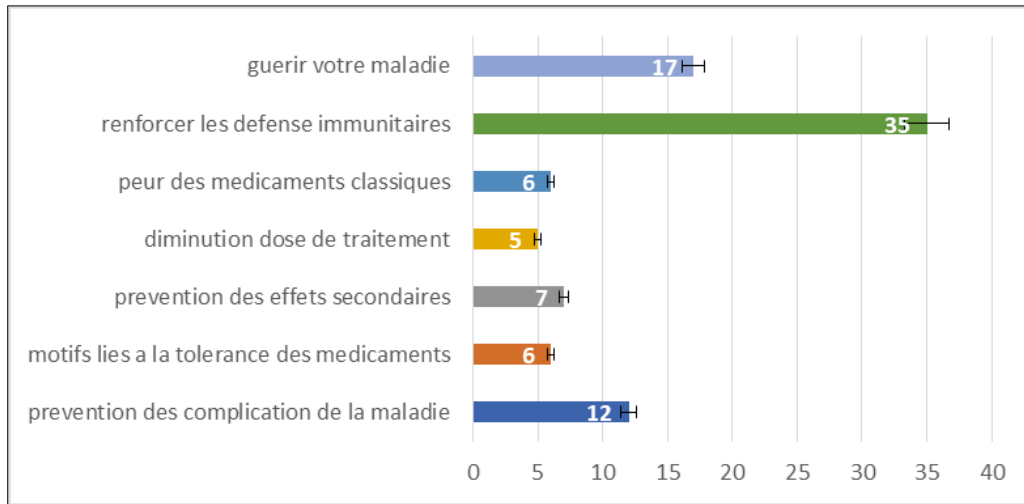
Which reason? We found that 24.4% of consumers use spirulina to treat anemia and 17.8% to treat high blood pressure (HTA).



**Figure 3** Distribution of consumers according to their chronic diseases

**3.3.1. Question 10**

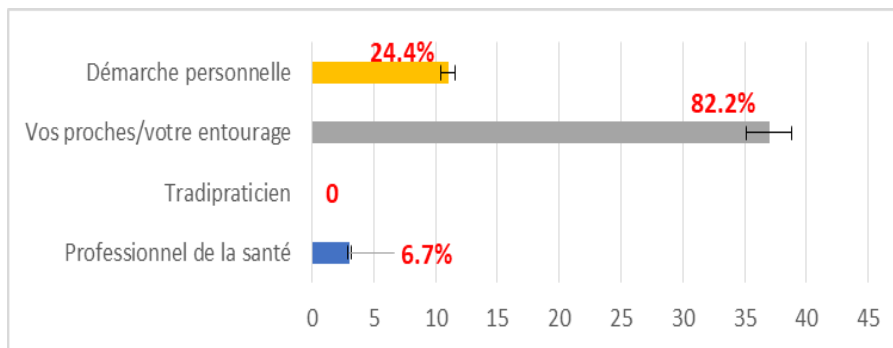
The exact reasons for consuming spirulina? These results show that (35%) of consumers take spirulina to strengthen their immune system; (17%) to cure their respective diseases and (12%) to prevent their complications.



**Figure 4** Distribution of consumers according to the exact reason for taking spirulina

3.3.2. Question 11

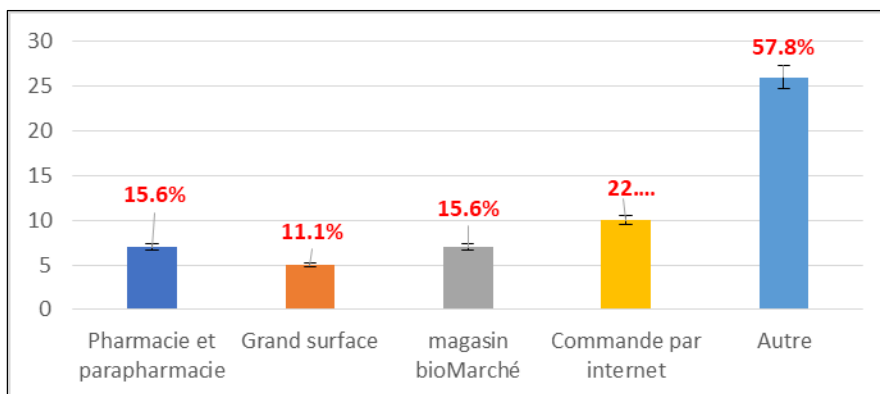
Who recommended spirulina to you? The results show that 82.2% of the studied population used spirulina under the influence of their friends and acquaintances.



**Figure 5** Distribution of consumers according to the means of obtaining spirulina

3.3.3. Question 13

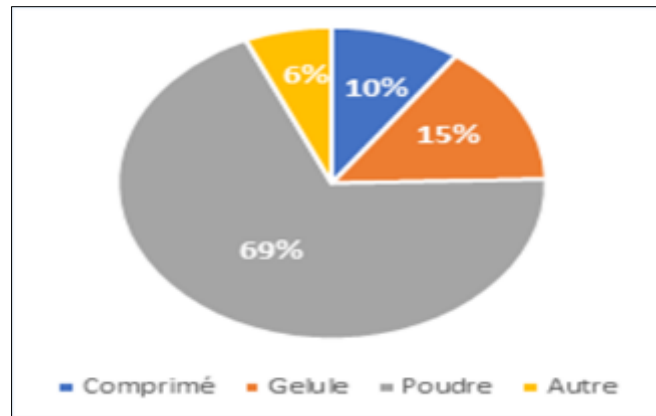
How do you obtain spirulina ? These results show that 57.8% of consumers obtain spirulina locally from artisanal producers in Tamanrasset. Interestingly, 22% of respondents reported using the internet (online purchasing) to obtain spirulina.



**Figure 6** Different forms of spirulina consumption

3.3.4. Question 14

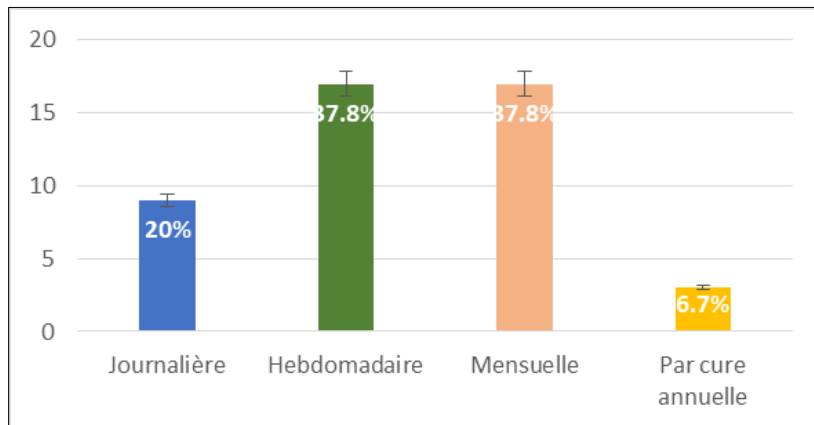
In what forms do you use spirulina ? According to the results obtained, we observe that more than half of the studied population consumes spirulina in the form of powder, given its almost exclusive availability in the Algerian market



**Figure 7** Various forms of using Spirulina

3.3.5. Question 16

Frequency of spirulina consumption



**Figure 8** Frequency of Spirulina consumption

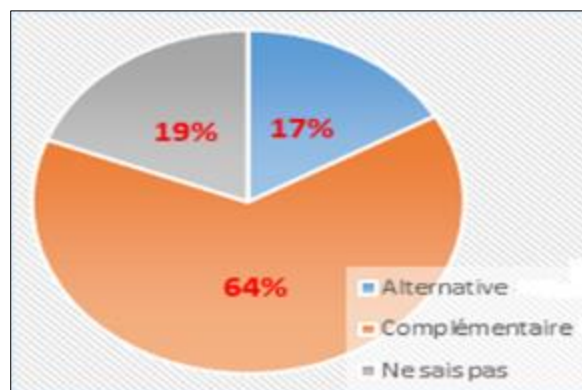
3.3.6. Question (17, 18, 19)

Are you satisfied with the help provided by Spirulina for your health problem? The results show that (60%) of consumers are very satisfied with the effect of Spirulina and (35%) are moderately satisfied, of which (40%) attribute their satisfaction to the attenuation and disappearance of symptoms and weight gain.

3.3.7. Question 20

Do you consider your consumption of Spirulina as an alternative or a complement to medications? According to these results, 64% of consumers believe that they use Spirulina as a supplement to medications; this is consistent with the previous results





**Figure 9** Distribution according to the purpose of spirulina consumption

### 3.3.8. Question 21

These results show that 95% of consumers did not experience any adverse effects related to their use of spirulina.

### 3.3.9. Question 22 and 23

Side effects? According to these results, more than half of consumers (57%) believe that there are no risks associated with the use of spirulina, however, 39% have no knowledge in this regard. The adverse effects reported are mainly digestive and represent only (05) % of cases.

### 3.3.10. Question 24

Do you think that spirulina can interact or modify the effect of drugs ? The results show that more than half of consumers (56%) do not know if spirulina can interact with other drugs or not, while 36% claim that there is no interaction with allopathic drugs.

## 4. Discussion

- Our participation in the culture and artisanal production of spirulina in Tamanrasset allowed us to observe that there are three determining factors : temperature, light, and pH of the medium. However, there are also other less important factors to consider, such as the agitation of the medium. Microscopic examination of the finished product allows us to observe and confirm the species ; this microalgae is presented in the form of "slightly wavy" filaments similar to those described by Ripley Fox (spirulina needs less defense against photolysis than in a natural pond, so one could possibly find straight filaments in commercial spirulina farms).
- In parallel with the production of spirulina, the field survey on its consumption (the first of its kind in the region) allowed us to make the following observations : Regarding socio-demographic and professional data, the male/female ratio of participants is 1.4, of which 71% are aged between 20 and 60 years; among them, 60% have a university education and 86% are insured. These subjects consume spirulina as a dietary supplement in 82% of cases, but what caught our attention is the 33.3% who use it for medicinal purposes (contrary to the definition of a dietary supplement). For this category, the pathologies concerned are hypertension (18%), diabetes (71%), and anemia (24%).
- Analyzing the medical data : 35% of consumers believe that spirulina strengthens the immune system ; 17% are convinced that it has healing power ; 5% to reduce the dosage of medications; 7% to prevent their side effects; and 6% to completely substitute for medications. We also found that one out of two doctors is aware of this supplementation. In terms of supply, 58% of subjects consume local artisanal products, 16% from parapharmacies, and 22% by ordering online (a new trend that is gaining momentum in Algerian society). The most commonly used forms are in decreasing order: powder (69%), capsules (15%), tablets (10%).
- We also highlight the 'constant' nature regarding the frequency of spirulina consumption, where (76%) of the population are weekly and monthly consumers. It is worth noting that (91%) of the subjects convinced of the 'benefits' of spirulina are satisfied, of whom (40%) think that it is the cause of attenuation and disappearance of symptoms to a point where (64%) suggest the association of the product with medications, and in (17%) of cases, as an alternative (natural remedy).
- Regarding the adverse effects associated with this consumption, only (05%) reported digestive manifestations and think that it can interact with allopathic medications by modifying their effects on the body. Finally, we

cannot extrapolate these results to the entire population, but we have gathered a lot of information, particularly the "therapeutic" nature of spirulina in the minds of the studied population.

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## 5. Conclusion

Spirulina grows in a particular microclimate, in addition to its relatively low production cost, giving the Tamanrasset region additional economic potential given its geographical proximity to sub-Saharan African countries, whose populations generally live below the poverty line. This study calls for further pharmacological screening by studying the hematopoietic, anti-inflammatory, hypoglycemic, and cytotoxic properties; more in-depth chemical research to isolate bioactive compounds; and in vivo and in vitro toxicity studies.

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## Compliance with ethical standards

### *Acknowledgments*

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### *Disclosure of conflict of interest*

The authors and all co-authors declare that they have no conflicts of interest in connection with this document, and the material described is not in the process of being published nor is it intended for publication elsewhere.

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