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Spirulina in Tunisia: an ethno-pharmacological survey on consumption, traditional applications, and health benefits

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ABSTRACT

Ethnopharmacology, is a field where human and nature intersect. It's the study of how people utilize nature to develop sustainable ways of treating diseases with the use of natural products. We have studied the ethnicity, culture, and belief systems associated with spirulina, which is a blue-green algae that many people regard as healthy food. The purpose of our research and the results of our investigation are to determine how people understand, perceive, and utilize in the future the use of spirulina. In our investigation we recorded the demographic characteristics of the participants; then determined how frequently they consumed spirulina and how they understood the health benefits of spirulina, by collecting responses to a questionnaire regarding the health benefits of spirulina, how they would prepare or take spirulina, and how they would take or administer it orally. In our investigation, we found that there is a consensus in Tunisia that spirulina has a health benefit due to its nutritional and biological properties. However, because people do not consistently utilize spirulina, the amount of knowledge regarding spirulina is limited. The majority of spirulina users incorporated spirulina with various foods such as beverages, culinary dishes, and capsules/flaks; oral administration was the method of administration of spirulina. Those individuals who consumed spirulina understood it to have potential therapeutic uses to assist those with both obesity and metabolic disorders, including cholesterol and diabetes. Therefore, our research has provided insight into the therapeutic uses of spirulina and will provide future opportunities for pharmacological, phytochemical, and experimental studies to develop interventions based on the use of spirulina.

KEY WORDS

Spirulina;
Ethnopharmacology;
Therapeutic effect;
Survey; Tunisia

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Introduction

Spirulina (SP) has been extensively in alternative medicine for a long time; even ancient cultures already acknowledged this blue-green microalga's health advantages [1]. Today, the medical world is turning to natural remedies and complementary therapies again, although the progress of medical science is very fast. Spirulina, a superfood of freshwater and alkaline lake origin, carved a niche for itself among the medical and nutritional applications due to its assortment of health-promoting properties [2].

Arthrospira platensis, more commonly known as spirulina, is a filamentous cyanobacterium that constitutes one of the microscopic members to the Oscillatoriaceae family [3]. Because of its wide composition, the product has long been accepted in the food and dietary supplement categories. This composition includes vitamins, essential and non-essential amino acids, minerals, fatty acids, β-carotene, phycocyanin, and dietary fiber [4,5]. Spirulina supplement has been advised as an adjuvant therapy for the treatment of many health issues in the past due to its various biologicals activities, such as antioxidant, anti-inflammatory, antitumor, antiviral, antibacterial, and immunomodulatory activities [6,7].The studies done in various parts of the world have already brought forth the idea of utilizing spirulina as a remedy for obesity along with its dosage to be adjusted for individual patients based on the factors such as absorption of nutrients, gut microbiota, and oxidative stress [8]. Besides that, spirulina has been used like therapeutic remedies for neurodegenerative diseases [9]. Moreover, several research indicates that it can protect against inflammatory reponse on hippocampal cells and improved systemic inflammation provoked by lipopolysaccharides (LPS) [10].

The globale production of spirulina has increased remarkably in the last few years, reflecting expanding consumer interest in nutraceuticals and traditional therapies. Market watchers forecast that the growth will continue to be stimulated by the public's increasing awareness of the health benefits linked to diets and the demand for sustainable bioactive sources. Despite this, information on spirulina utilization, awareness, and traditional methods in North Africa, and specifically in Tunisia, remain limited. Tunisia possesses suitable climatic and ecological environments for spirulina production, yet knowledge about its dietary practices, local application, and ethnopharmacological importance is mostly anecdotal and undocumented.

Ethnopharmacology, at the junction of human and natural therapies , presents a background for understanding how

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local populations understand and use natural products for disease management and health promotion. Conducting ethnopharmacological surveys enables the systematic collection of information on consumption patterns, traditional uses, formulation, and supposed health benefits, suggesting critical insights for pharmacological exploration and potential therapeutic innovation.

In this context, the aim of this study is evaluating the knowledge, traditional uses, and consumption behaviours, of SP in Tunisia. We are documenting these practices with the intention of laying down a base for future studies in the fields of pharmacology, phytochemistry, and clinical studies besides the fact that, spirulina's potential as a culturally accepted functional food and natural therapeutic agent in the Tunisian is also emphasized.

Materials and Methods

Study design

This study carried out as a cross-sectional survey to assess the level of knowledge, attitudes, and consumption behaviours of the Tunisian population towards SP. Their research methodology was based on classic survey methods often used in studies of dietary and functional food [11]. Data were gathered during a three-month period i.e. June to September 2025, which enabled the researchers to collect responses continuously and thus have a broad picture of the consumption and perception patterns over time. Studies with cross-sectional designs like this one have frequently been applied to study the consumer behaviour towards nutraceuticals and functional foods [12].

Study population

The research population consisted of two hundred seventy-nine (279) adult individuals (aged 20 years or older) who were living in different areas of Tunisia. A convenience survey was utilised to capture individuals of all ages, sexes, educational levels, and places of residence. According to the literature, 'convenience surveys' are commonly used in dietary behaviour research to obtain an 'inclusion' of individuals with varying and diverse demographic profiles [13]. To achieve this project's recruitment goals, 2 major ways were chosen to get participant information: 1) distribution of information via the internet and the use of the following internet resources: Google Forms, Facebook and WhatsApp; 2) in-person interviews conducted in public locations such as markets, cafes and community centres. Combining both online and in-person approaches was used to increase geographical and sample diversity [14].

Data collection

A structured questionnaire was employed to collect information in both Arabic as well as French language. The questionnaire presents three main sections:

1. Demographic Information (section A - including age, sex, nationality, residency, education, marital status, and employment). This section was designed to obtain demographic information on the study participants, consistent with other demographic assessments completed in consumer health studies, such as [15].
2. Health & Medical Data (section B - all participants provided height, weight, chronic health problems, adherence to selected dietary practices). This section is similar to other studies investigating the influence of functional food consumption on health [15].
3. Knowledge, Attitudes, and Consumption Patterns of Spirulina (section C). This section included questions assessing the participants' awareness of spirulina, perceived health benefits associated with consumption of spirulina, and pattern of consumption of spirulina as reported by the participants.

The questionnaire has been administered both online as well as via in person methods. For online response, links to the questionnaire were shared through various social media and message applications to obtain responses from as large a group of people as possible. The in-person respondents completed the questionnaire by utilizing either a tablet or mobile device, allowing for immediate entry of data into the database and the ability to include individuals who are not typically engaged in the use of digital platforms. Thus, using both online and in-person methods provides a greater representation of the sample population and allows for a broader range of people to be included [16].

Data analysis

To analyse the data collected using BIOSTAT software, we used descriptive statistics to summarise the demographic characteristics of each group and the results of the survey by calculating the proportions, averages and standard deviations. The investigation of group differences used the Kruskal-Walli's test and set statistical significance at $p < 0.05$.

Results

The ethnopharmacological survey performed in Tunisia revealed in-depth knowledge of how spirulina was perceived and the various ways in which it is consumed. The information was gathered through online surveys and interviews with experts to ensure that, as much as possible, the demographic and geographical representation within the sample demographic and the various sample regions were representative of the populations of Tunisia. The results demonstrate the many different tastes, motivations for use, and the potential for health-related uses of spirulina.

Demographic characteristics of participants

The distribution of participants was even throughout the Tunisian geographic area (17%) as seen in figure 1. There was an even distribution of male and female participants (47% male and 53% female) as can be observed in figure 2A. As for age, the majority of respondents fell within the range of 20 years to 29 years (44.2%) or within the range of 30 years to 49 years (47.7%), while only (9%) were aged 50 years and older (as illustrated in figure 2B). When looking at education and occupation profiles, the majority of the respondents held a university degree (84%) as seen in figure C, followed by those who were employed (44%) and those who were self-employed (26%) (as shown in figure 2D).

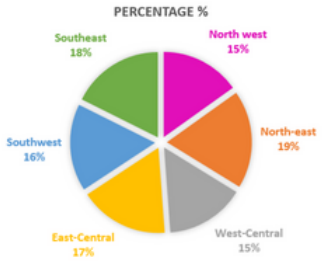

Figure 1. The participants have been distributed throughout the regions of Tunisia.

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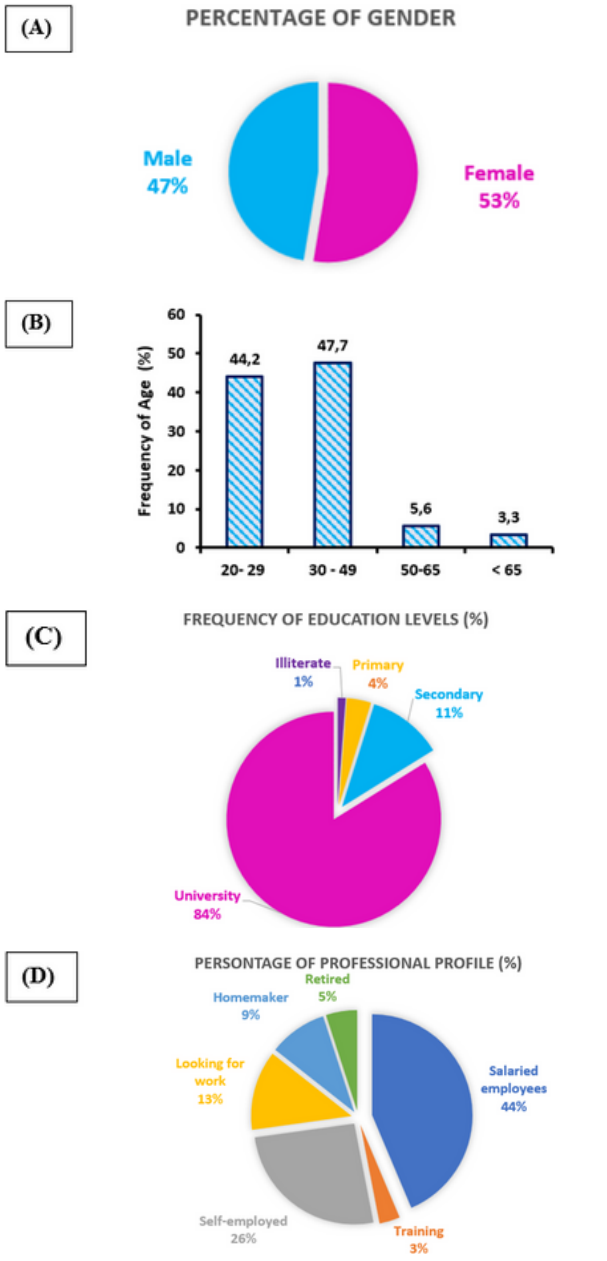

Figure 2. Demographic profile of respondents based on the age group (A), Distribution of respondents based on the gender in Tunisia (B), Education stat(C) and Inventories Professional profile (D).

Application and use of spirulina

Consumption frequency

The majority of respondents indicated that they regularly ate spirulina: 65 percent of said they did it regularly as a natural supplement to offset the adverse effects of prescription medications, 30 percent were irregular, and 5 percent never did (Figure 3A).

Daily spirulina consumption

The figure illustrates how spirulina was consumed per day by the participants. Most (65%) of them said that they consumed 1-3 g per day which is an amount of nutritional supplement that is well advised. The lesser percentage (21) fed on 4-7 g/day, which is within the range that can be applied to particular therapeutic or physiological effects. Only 9 percent of respondents indicated an increased consumption of 810g per day which is normally consumed in experimental or clinical studies. Lastly, 5 percent said that they never took spirulina (0 g) (Figure 3B).

Purchasing sources

The findings show that the modern channels of distribution are predominantly used to buy Spirulina. The most frequent source (42.2%), which is the internet ordering, indicates the comfort and availability of online sources (Figure 3C). Producers sell directly, covering 27.8 per cent, indicating that locality or artisanship products are the most preferred. Pharmacies constitute 22.2 percent of purchases, probably because of image of quality and safety, and traditional local stores are hardly ever utilized (3.4), perhaps due to a lack of availability or awareness. On the whole, these results outline the increased use of online and direct sources of acquiring spirulina.

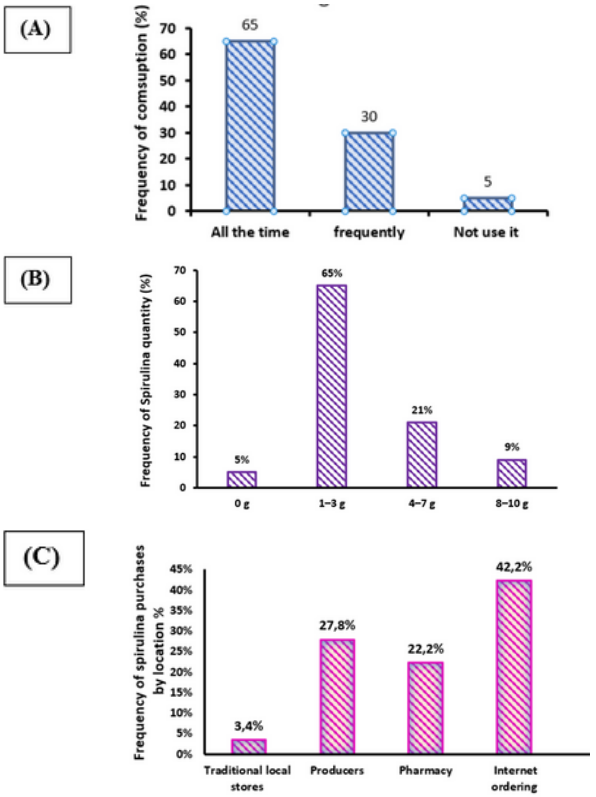

Figure 3. The frequency of Spirulina Consumption (A) and Daily Spirulina Consumption (g/day) (B) by Purchasing Sources (C).

Knowledge levels

The level of awareness of the respondents as far as spirulina is concerned was quite high. Over fifty-four percent (54) stated that they had a very good level of knowledge (level 5), and 22 and 17 percent stated that they had moderate level of knowledge (levels 4 and 3, respectively). There was a very low percentage (3) who answered none whatsoever. These findings indicate that the Spirulina is well-known among the population, and most people have a high level of familiarity with its attributes and applications (Figure 4A).

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Discovery sources

Figure 4B shows the initial awareness of the participants of spirulina. The most popular source was experience of other people (36.7%), which means that the word-of-mouth is highly important to cause the awareness of spruulina. The social media (23.3%) also has a substantial amount of information, as there is an increase in the impact of online health and wellness content. Nutritionists and doctors (21.1%) made significant input to the knowledge of the population, which highlights the significance of professional recommendations. In contrast, through this survey, 16% of respondents said they had known of Spirulina from a smaller group of people, only 4 1/2 % from Scientific Research or less than 1 3/4 % from reading materials. This means that direct education and scientific research have a much lower impact on the spread of Spirulina compared to other sources.

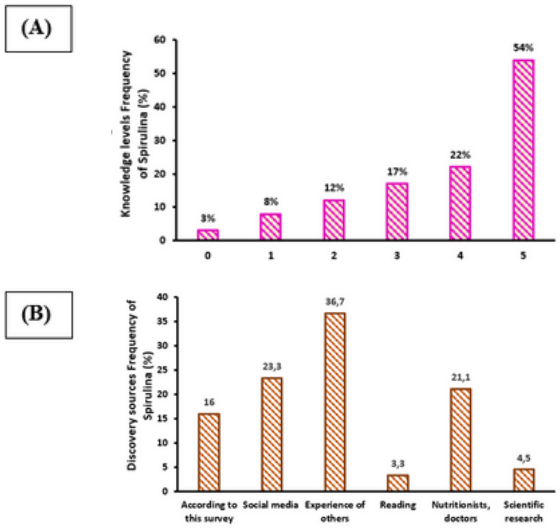


Figure 4. Knowledge levels (A) and levels of information (B) regarding the discovery of Spirulina.

Selection criteria

Figure 5 (A) provides the frequency of the criteria that affect whether the consumers choose spirulina or not. Most of them (72%) indicated that they needed Spirulina mostly because of its health properties, by noting that it is a functional and therapeutic supplement. A lower percentage (26) stated that they made the decision because of medical advice, which is an increased medical support or recommendation in its use. Pleasant taste was mentioned as a determining factor by only 2% and indicates that sensory properties are insignificant in contrast to perceived health benefits.

Reported health benefits

The applications of spirulina for therapeutic purposes are presented in Figure 5 (B), with the most common of all applications being Antiobesity at 32.7%, followed by Anti-inflammatory 25.3% and Antidiabetic 20%. The application of spirulina against neurodegenerative diseases has contributed 6.7% to this survey, whereas it has answered for 13.2% of applications to Nutritional Deficiencies / Anemia and 13.3% to Digestive Disorders. My hormonal balance 6.7% for healthcare and assistive skin/hair; assistance of biological immunity 9.2%. All these findings indicate the many different theories of therapeutic use for SP.

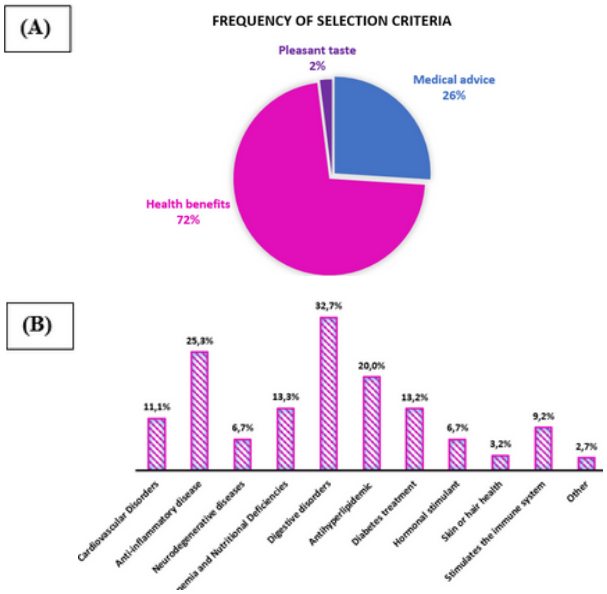


Figure 5. Reasons why it was chosen (A) and the therapeutic applications of Spirulina (B).

Modes of administration

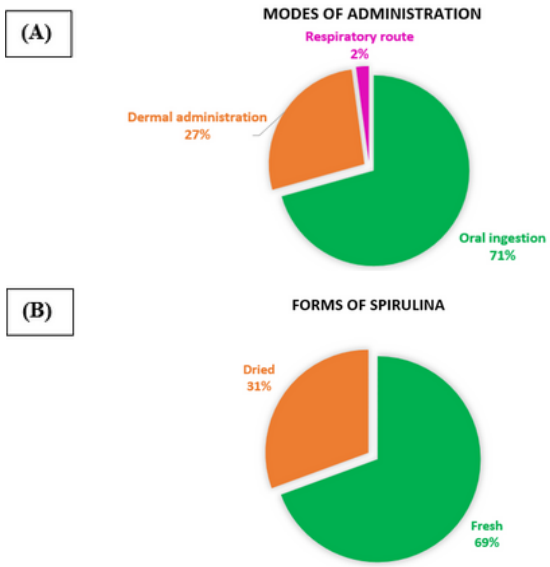
Methods used to administer SP, as well as the nutritional benefits associated with using SP are provided in Figure 6A. Most users (71%) take SP orally; however, less than 25% of consumers use SP by either topical or inhalation means.

Utilization patterns

Consumption of Spirulina is shown in Figure 6B. Even with nearly 70% of respondents reporting they purchase SP as a fresh product, there remains a large volume of SP powder available for sale (31%).

Nutritional uses

Figure 6C indicated that capsules and/or tablets of SP are the preferred choice of people, followed by SP-enhanced foods (24%), dried powder (15%), and liquid extracts/suspensions (12%).



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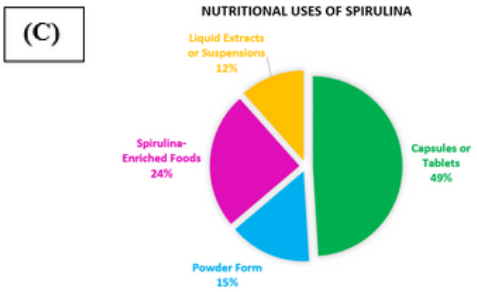

Figure 6. Ethnopharmacological survey of Spirulina administration (A), status of usage (B), and preparation (C).

Satisfaction levels and interest in further information about spirulina

As shown in Panel (A) of Figure 7, the majority of participants (73%) reported they were extremely satisfied with SP, while 27% indicated they were satisfied. This indicates that the vast majority of consumers have enjoyed their experience with SP. Panel (B) shows that 77% of respondents demonstrate an interest in obtaining additional information regarding SP use, while only 23% were uninterested. This suggests that there is a substantial elevation in the public's desire to learn more about the nutritional and therapeutic effects of SP.

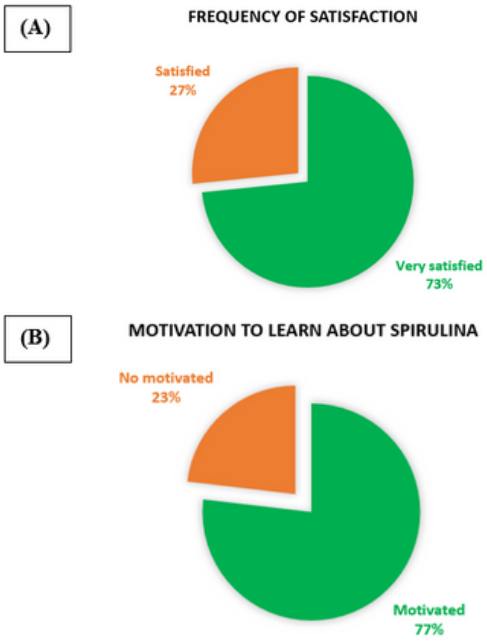

Figure 7. Level of satisfaction (A) and desire to learn more about Spirulina (B) frequency.

Discussion

In the ethnopharmacological survey of the Tunisian population, information was collected about participants' knowledge of SP and how they employ it in food and various traditional applications. It has led to new insights on how SP could be better incorporated into the population's diet and used for health and wellness.

The highest percentage of respondents were female, indicating that women are more likely to know about and have access to SP, probably because they often play a central role in the health and nutrition of the family. Most participants mentioned using SP in their nutrition regularly, typically adding SP flakes or powder to beverages like yogurt and salads. There is a strong correlation between the ways people use SP globally and the increasing popularity of using SP in smoothies, fortified foods, and dietary supplements for protecting health and therapeutic treatment. Interviewees ranged from 20 years old to 70 years old, with the majority being age 30-49 and often described as the most health-conscious group. Most respondents had a high education level, suggesting that educated consumers are aware of SP and choose to consume natural products. This pattern is also seen in other countries in the region, where individuals with a higher level of education exhibit a greater willingness to try new nutraceuticals. Ethnopharmacological investigations indicate that the primary use of spirulina is as an obesity and metabolic disorder treatment.

The data in Figure 5 demonstrate that consumers are choosing spirulina for health reasons (72%), and 26% choose spirulina for medical recommendations, while only 2% choose it for its taste. This reflects the consumer's strong opinion of spirulina as having many health-related benefits and containing numerous bioactive compounds that give spirulina its therapeutic properties. Consistent findings have also been documented by Arrari et al. and Belay, where consumers link spirulina to better vitality, enhanced immune function, and chronic disease prevention [17,18]. The reasons why consumers chose spirulina at a high rate for perceived health benefits could be explained by the fact that more people are becoming aware of natural products as safer alternatives to synthetic supplements and pharmaceuticals.

Regarding therapeutic uses, respondents reported that the most common uses for spirulina were for antihyperlipidemia (32.7%), anti-inflammatory purposes (25.3%), and antidiabetic purposes (20%). These results are supported by many preclinical and clinical studies indicating the ability of spirulina to impact lipid metabolism, decrease oxidative stress, and give better control of glycemic levels. For example, Dubey et al. found the supplementation of spirulina in hyperlipidemic patients to significantly decrease their triglycerides and low-density lipoprotein (LDL) cholesterol levels [19,20].

The current study suggests that SP is primarily used as a preventative and therapeutic agent rather than just as a vitamin supplement. In addition, many of the motivations related to health demonstrate a high degree of confidence in the bioactive properties of SP and that a number of therapeutic uses exist for SP. This suggests that there is potential to use SP to treat a variety of metabolic, inflammatory, and nutrition-based disorders. Furthermore, another common use of SP has been during the flu and/or for enhancing overall immune function. The high levels of bioactive minerals in spirulina (including iron, zinc, and vitamins A, B, C, and E) combined with its immunomodulatory properties, such as enhancing cytokines and stimulating the production of natural killer cells, are likely the reasons for this common observation [8].

Additionally, many studies have documented spirulina's antioxidant effects [21]. The ethnopharmacological data in Figure 6 indicates that the majority (71%) of the ethnic groups have used SP in a food or drink form, with the next highest (27%) usage being in topical applications, and very little (2%) of the total uses are via inhalation. The predominance of food and drink forms is consistent with the findings of Hoseini and Belay, who found that the palatability of SP, along with its ease of use and rapid absorption, are the major reasons why SP has become the most common form of consumption in the category of dietary supplements [18,22].

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The oral intake of spirulina is remembered in its native form with its thermo-labile (heat-sensitive) substances (e.g., Phycocyanin and γ-Linolenic Acid), which augment antioxidants and anti-inflammatories [23]. Most participants in the survey have indicated that fresh spirulina (69%), rather than dried spirulina (31%), was preferred by a majority of the respondents, which could be explained by the fact that most of the participants saw fresh spirulina, being more nutritious and hence having a better bioavailability than dried ones. Oliveira et al. showed that it is possible to test such degradation through the process of dehydration and/or drying at higher temperatures and thus affecting important pigment/enzyme activity [24].

The increasing availability of dried/encapsulated spirulina on the other hand makes it convenient and shelf-stable therefore providing more accessibility and convenience to consumers. Figure 6C showed that (49) percent of respondents gave capsules or tablets as the preferred form of spirulina to be taken as nutraceutical, (24) percent gave fortified foods, (15) percent gave powdered forms, and (12) percent gave liquid extracts.

The existing use of such different types of spirulina is in line with the preference of consumers who were analyzed using global surveys by Vakarelova et al. in which spirulina encapsulated was the popular choice among the nutraceutical segment, partly because of the convenience and regular doses [25]. Moreover, spirulina is becoming a popular functional food additive in tandem with the trends noted on the growing preference of using spirulina in food products (e.g., pasta, beverages, and/or baked goods) due to its potential as a sustainable and rich protein additive [26].Data in Figure 7 shows very high-levels of consumer satisfaction as 73 percent of the participants expressed that they were very satisfied and 27 percent were satisfied with the use of spirulina. This positive image can be explained by the significant changes in the level of energy, the state of the skin, and health, which were appreciated by Ragusa et al. in clinical trials that evaluated spirulina supplementation [27].

The increasing trust in the safety and the lack of adverse effects of spirulina is also related to high levels of satisfaction, increasing the compliance and continuous use [28]. Moreover, the survey indicates that the majority of the respondents (77 percent) are highly motivated to learn more about spirulina to stimulate the idea that people are very interested in deepening their understanding of the nutritional and therapeutic properties of this product. This result is reflected in that of Annunziata and Pascale, (2009), who highlighted that functional foods consumers are characterized by curiosity and active interests in health information [29].

This fact of high satisfaction and desire to learn is an indication that users of spirulina believe they have real gains and they are interested in knowing how it works, whether it is safe and the way it can be used. Such a favorable standing of the consumer makes a possibility to disseminate the scientifically tested facts via the health-related programs, education campaigns, and guidance of the healthcare professionals so that the interest could be converted into the consumption based on the evidence-grounded practice and not on the anecdotal assertions. In general, the results indicate the increasing acceptance of spirulina as a functional food and a therapeutic supplement, and users' express satisfaction and rather a desire to learn more. The relationship between educational degree , health status, and sources of information and their effect on consumption patterns and their motivation to learn should be studied in the future to utilize more effectively the nutritional and health potential of spirulina by engaging more people.

Conclusion

As a result of the ethnopharmacological survey, there is evidence that SP is growing the number of its users as food supplements and as a natural form of treatment. The majority of respondents reported that they have used SP for health-related reasons; the two most frequently reported uses were for the purposes of lowering lipid levels and inflammation, as well as for the regulation of blood sugar levels, which are all rigorously supported through numerous peer-reviewed research papers. The majority of SP users also felt it was beneficial to take spirulina in capsule and tablet form, as well as to get the added nutritional benefits of the raw product. Users of SP appeared to be satisfied and interested in obtaining additional information about SP, which seems to demonstrate a substantial interest within the general public to learn about SP and build trust in it. This apparent increase in interest in SP provides an excellent opportunity for researchers and health care professionals to provide clear, research-supported recommendations to ensure the safe and effective use of spirulina by consumers. Overall, spirulina has significant potential as a viable long-term sustainable alternative for the health and nutrition of the general public.

Author Contributions

F.A. and M.-A.J. performed the experiments; F.A. and M.-A.J. analyzed the data and wrote the article; I.H. helped with this data analysis of the study; M.M assisted in reviewing, and editing, and H.S. provided reagents and materials and participated in data processing and the design of experiments and resources. All authors have reviewed and approved the final version of the manuscript for publication.

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Research Ethics Committee Approval

The research paper was permitted to be published in any open access journal.

Conflicts of Interest

The authors of the paper have no conflict of interest.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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