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Biological activity of Lemongrass *(Cymbopogon citratus)* and its applications in industry

Actividad biológica de la Hierba Luisa *(Cymbopogon citratus)* y sus aplicaciones en la industria

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Abstract

In the investigation, an analysis was carried out on the importance of the biological activity of Lemongrass (Cymbopogon citratus), its benefits and application in the food and non-food industry. The objective was to identify, analyze, organize and compare the information on the bioactive components of the plant species in the industry. The method used is exploratory with a documentary approach of secondary order, since a detailed search of bibliographic information of documents obtained in scientific bases that support the work was carried out. 8 bioactive components and 11 constituents of essential oils were determined, in relation to their use in industry, 2 applications were determined: in food used in beverages (energizing, moisturizing, functional) and as a food additive (antioxidants, preservatives and flavorings) and in the non-food area in the agricultural area (insecticide, fungicides and herbicide), in the cosmetics area (perfume, deodorants and shampoos) and in the pharmacological area (antibacterial and antifungal). The Cympogon citratus for its biological components has been used in the industry during the last years, in the non-food field. Myrcene, citronella, citronellol and geraniol are the components that are most used in the non-food area and citral is the bioactive that is used in the food part.

Keywords: Chemical composition, Agricultural, Cosmetics, Pharmaceutical, Food additive.

Resumen

En la investigación se realizó un análisis sobre la importancia de la actividad biológica de la Hierba Luisa (Cymbopogon citratus), sus beneficios y aplicación en la industria alimentaria y no alimentaria. El objetivo fue identificar, analizar, organizar y comparar la información sobre los componentes bioactivos de la especie vegetal en la industria. El método empleado es exploratorio con enfoque documental de orden secundario, ya que se realizó una búsqueda minuciosa de información bibliográfica de documentos obtenidos en bases científicas que sustentan el trabajo. Se determinó 8 componentes bioactivos y 11 constituyentes de los aceites esenciales, en relación a la utilización en la industria se determinaron 2 aplicaciones: en lo alimentario utilizado en bebidas (energizantes, hidratantes, funcionales) y como aditivo alimentario (antioxidantes, conservantes y aromatizantes) y en lo no alimentario en el área agrícola (insecticida, fungicidas y herbicida), en el área de cosméticos (perfumería, desodorantes y shampoos) y en el área farmacológica (antibacteriales y antifungicas). El Cympogon citratus por sus componentes biológicos ha sido aprovechado en la industria durante los últimos años, en el campo no alimentario. El mirceno, citronela, citronelol y geraniol son los componentes que más se aprovechan en el área no alimentaria y el citral es el bioactivo que se aprovecha en la parte alimentaria.

Palabras claves: Composición química, Agrícola, Cosméticos, Farmacéutica, Aditivo alimentario.

Introduction

The Food and Agriculture Organization of the United Nations (FAO), the Pan American Health Organization (PAHO) and the World Health Organization (WHO), as international agencies, mention the importance of functional foods (Intriago, 2019) because they contain nutritional characteristics, which help reduce the risk of the presence of diseases; therefore, they possess physiologically active components of plant origin that have pharmacological, therapeutic, antibacterial effects that promote health, physical capacity and mental state of the person (Asgary *et al.*, 2018).

We are currently experiencing profound political and social changes related to clear modifications in people's conduct and behaviour. We are even changing our eating habits, leaving aside the traditional diet, rich in cereals and legumes, to adopt a new culture such as fast food, with high energy value, but deficient in some essential nutrients (Ramírez *et al.*, 2003). For this reason, society is looking for a healthy diet, so science is developing products fortified with a component or bioactive ingredient that provides properties to the body (Britez & Romero, 2019).

In addition, a common product differs from a functional food by having a contaminant-free protein source (Di Cerbo *et al.*, 2017). There are also factors that contribute to food choices, such as familiarity, tastes, convenience, price, knowledge of the food and consumption trends (Britez & Romero, 2019). For this reason, marketing is growing and becoming more varied (Salama & Bustos, 2018).

Following (Totosaus, 2011), foods are evaluated according to three functions: their nutritional value, i.e. their role in providing standard nutritional components; two, based on their sensory properties and a third function is the role of food components in preventing diseases by modulating the physiological system. At the same time (Heredia, 2016), deduces that the functions and health objectives that have been targeted by research in the area of functional foods are: growth and development, metabolism or nutrient utilisation. (Aguilera *et al.*, 2008) considers that some foods can play a beneficial role in addition to their own as suppliers of energy and nutrients.

The International Lile Science lnstitute (ILSI) certifies that a food is functional if it can be successfully demonstrated to have a beneficial effect on one or more specific functions. For this reason, the idea was developed in Japan during the 1980s as a necessity to reduce the high cost of health insurance (Chasquibol *et al.*, 2003). (Hurtado & Zamora, 2015) argue that functional foods are intended to strengthen, improve and stabilise metabolic activity.

Phytochemical properties of functional foods of plant origin

Polyphenols

They originate mainly from plants, which synthesise them in large quantities, and are a product of secondary metabolism. Some are indispensable for plant physiological functions (Pregowska *et al.*, 2012). It is a heterogeneous set of molecules with antioxidant activity that includes acid phenols and flavonoids, characterised by having an aromatic ring (Drago *et al.*, 2006). (Pregowska *et al.*, 2012) mentions that phenolic compounds are a large group of non-energetic substances that are present in plant foods. For this reason, a diet rich in polyphenols helps to stabilise health and reduce the incidence of diseases.

Phytoestrogens

They are a group of non-steroidal compounds that are made up of isoflavones, coumestanes, lignans and flavonoids, and are abundant in legumes, fruits, herbs, grasses and legumes (Cortés-Sánchez *et al.*, 2016). They are of great importance because they have a high biological activity due to their properties of modulating different valuable cellular processes such as cell cycle and cell death (Torres *et al.*, 2017). Furthermore, the effect of phytoestrogens depends exclusively on the type and quantity present in the plant species consumed (R. S. Márquez, 2012).

Vegetable lipids

Vegetable lipids are the oils that we consume in our diet, they are in liquid form, standing out for their chemical structure as monounsaturated and polyunsaturated acids (L. García, 2009). For this reason, they play an essential role in nutrition, because they are an important source of non-protein energy and fat-soluble vitamins, thus generating a saving of food proteins (García *et al.*, 2010).

Would the use of bioactive elements from lemongrasss (*Cymbopogon citratus*) bring benefits to the industry?

Plants produce a wide variety of secondary metabolites or phytochemicals, many of which have protective functions (Bermúdez-Vásquez *et al.*, 2019b). Besides (Oliveira & Santos, 2021), state that *C. citratus* is widely used in industry for the properties it provides. This article aims to identify the biological compounds of lemongrass and their application in the food and non-food industry.

Methodology

Location

The research was carried out at the Amazon State University, located in the city of Puyo, Pastaza province; Km. 2½, on the road from Puyo to Tena (Paso Lateral).

Method

The method used is exploratory of secondary order, since a thorough search of bibliographic information of documents obtained in scientific databases such as Scopus, Springer, Scielo, Google Scholar, Researchgate, undergraduate, master's and doctoral theses was carried out. In order to meet the research objectives, a critical reading of the main selected bibliographic documents was carried out, which were subsequently classified and separated according to the information supporting the work.

Type of research

Table 1: Type of research.

Descriptive	Documentary
According to (Guevara et al., 2020) it aims to describe some fundamental characteristics of homogeneous sets of phenomena, it uses systematic criteria that allow to establish the structure or behaviour of the phenomena under study, providing systematic and comparable information. The data collection methods used are observation, survey and case study.	(Falcón. & Serpa, 2021) argue that it is a set of operations aimed at representing a document and its content in a form different from its original form, in order to enable its subsequent retrieval and identification, and whose purpose lies in the transformation of the original documents into secondary ones to enable both their retrieval and their dissemination, including both a physical description of the document and an analysis of its content.

Prepared by Alvarado & Poveda (2022).

This literature review has a non-experimental documentary approach, adapting to a collection of information through an analytical reading of documents and bibliographic materials related to the biological activity of lemongrass (*Cymbopogon citratus*) in industry, with the aim of obtaining background information on studies conducted in order to deepen and investigate the problem.

The study is qualitative with a descriptive scope, because its purpose is to explain the function of lemongrass and its contributions to the industry.

Results and Discussion

Origin and distribution of Cymbopogon citratus

This species originated in Southeast Asia and, like the rest of the species of the genus *Cymbopogon*, is distributed in tropical and subtropical regions of the world (Álvarez & Yepes, 2014). Known by the common names 'lemongrass', 'caña santa', 'lemongrass', 'lemon tea', 'citronella' and others (Rojas *et al.*, 2012). It grows up to 2 metres tall, with aromatic leaves between 30 and 100 centimetres, widely distributed and used around the world as a decoction and infusion (Wannissorn *et al.*, 2005).

Chemical composition

The volatile fraction is a prominent characteristic of lemongrass (Bandoni, 2003). Its essential oil yield fluctuates between 0.2 and 1.0 % depending on several factors such as the plant species, its origin, geobotanical conditions and cultivation, as well as extraction methods, duration and temperature (Jaramillo *et al.*, 2017). The main and most abundant biologically active component is citral, a mixture of two monoterpene, stereoisomeric aldehydes from geranial and neral (Lopez, 2022). The bioactive components of lemongrass are listed in table 2.

Table 2: Bioactive components of lemongrass.

Phytonutrients	Mineral content	Vitamins
Flavonoids	Sodium	Vitamin A
Alkaloids	Potassium	Vitamin C
Vitamins	Calcium	Vitamin E
Tannins	Iron	Folate
Phenols	Phosphorus	Thiamine
Saponins	Selenium	Niacin
Essential Oils	Zinc	Pyrodixin
Steroids	Magnesium	Rivoflabin
Constituents of essential oils		
Citral	α-Terpineol	β-Mircene
Burneol	β-O-Cimene	Allo-o-cimene
α-Pinene oxide	Myrcenol	t-Muurolol
Linalool	1-Octin-3-ol	trans- chrysanthemum
Citronellal	Neral	3-Undencyne
Nerol	trans-(–)-Carveol	Geraniol
Geranial	Nerol	Citronellol
Methyl-n-nonylketone	Dextro-carvonene	Geranic acid
α-Bergamotene	Isolongifolene	Muurolene
α-Farnesene	α-Elemol	α-Gurjunene
Viridiflorol	Humulene	α-Selinene

Prepared by: Enriquez et al., (2023).
Source: (Ekpenyong et al., 2014) & (Ayay & Infante, 2018)

Applications in industry

According to (Aćimović *et al.*, 2020) *C. citratus* is considered to be of great interest in the industry because it has a rich source of bioactive compounds with a wide range of applications such as food and non-food as detailed in table 3.

Table 3: Applications in industry.

Areas	Application
Food	Beverages, Food additives
Non-food	Agricultural, cosmetics, pharmaceutical.

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Food industry

C. citratus industrially, (Table 4) serves as an additive, flavouring, preservative in beverages and food (Oladeji *et al.*, 2019).

Table 4: Applications of lemongrass extract in the food industry.

Application	Type	Benefit	Reference
Beverages	Energising	[1]Because of its citral content, it provides nutritional values and has the capacity to [2]contain antioxidant agents, which represent health benefits.	[1](G. M. Silva, 2016) [2](Castro, et al., 2020)
	Hydrating	Consumed as beverages with a pleasant aroma and taste because it contributes to the good functioning of the organism.	(Campo & Cunalata, 2020)
	Functional	Improves the availability of nutrients due to its phenolic content.	(Ramos, 2016)
Food additives	Antioxidant	[1] Due to its high content of phenolic compounds with high reducing power [2]when applied in food it is considered safe and natural.	[1](Castillo et al., 2018) [2](Majewska et al., 2019)
	Preservative	Lemongrass extract is an oily, volatile liquid with citral as its main constituent, which is responsible for antioxidant and fungitoxic activity.	(Silva et al., 2019)
	Flavourings	For the flavouring of oils, dressings and vinegars; likewise in confectionery it is used to give better flavour and aromas to cakes, creams, among others due to the presence of citral.	(Criollo, 2019)

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According to Silva (2016), energy drinks contain citral to provide health benefits, and Ramirez *et al.* (2021) states that they are non-alcoholic because they are composed of plant extracts that include vitamins, minerals, etc. (Salazar, 2006). While Perez (2015) mentions that hydrating drinks have natural flavouring in order to replenish the energy and electrolytes lost by the human body during physical activity, (Salazar, 2006) argues that consumption is due to its pleasant taste ensuring proper hydration. Cucaita (2017), adds that *Cymbopogon citratus* functional beverages have bioactive components that reduce the risk of disease and Yilmaz *et al.* (2019), states that it contributes to nutritional well-being due to its high consumption rate. And when making beverages, it becomes important for its functional properties that benefit human mental or bodily health (Enriquez *et al.*, 2023).

Non-food industry

Society has implemented the functionality of biologically active compounds that have applications in agricultural and cosmetic areas (Table 5) (Gamero *et al.*, 2021).

Table 5: Applications in the non-food industry.

Application	Type	Benefit	Reference
Agricultural	Insecticide	Lemongrass extract repels insects like mosquitoes, aphids, so it contains citral and also myrcene, citronella, citronellol and geraniol.	(Kaur, 2021)
		It kills insects and also keeps them away.	(Narayan & Maheshwari, 2017)
	Fungicide	The high fungicidal power is due to the citral component, which inhibits the germination and mycelial development of the fungus.	(Rodríguez et al., 2018)
	Herbicide	Marketed as an organic herbicide, but its potential use for weed control is due to its main compound citral.	(García, 2013)
Cosmetics	Cosmetics	Perfumery Citral is mainly used in perfumery.	(Duran et al., 2021)
		It contains less myrcene and therefore has a longer shelf life.	(Narayan & Maheshwari, 2017)
	Deodorant	Due to its antibacterial and cleansing properties that help fight unpleasant body odour and prevent fungal and bacterial infections.	(Narayan & Maheshwari, 2017)
		Rich in antioxidant compounds, for skin care.	(Kim et al., 2022)
	Shampoo	Due to its repellent effects on lice.	(Narayan & Maheshwari, 2017)
		It is also used to reduce dandruff through its antimicrobial and anti-inflammatory properties.	(Tabassum, 2020)

Elaborated by: Enriquez *et al.*, (2023).

Kaur, (2021) indicates that lemongrass oil has the ability to repel insects that are present in the environment. On the other hand, Tacoaman, (2018) suggests that being a natural producto, it helps to stimulate the metabolic processes of crops to strengthen them and protect them from microorganisms. Also, Rodriguez et al (2018) argues that in their study on the antifungal activit.y of *C. citratus* the main component is (citral), which has the characteristic of inhibiting the growth of moulds and fungi. In addition, Vargas, (2013) considers that being an organic input, it contributes to the defence functions of plants, influencing as a tonic to counteract adverse conditions. Montero *et al.*, (2017) underlines that herbicides provide weed control in the field because they destroy the cell membrane and cause the desiccation of invasive plants.

Duran *et al.*, (2021) emphasise that in the production of perfumes, the active ingredients enhance their aroma. Kim

et al. (2022) also states that deodorants contain antioxidants that eliminate body odour and have a protective capacity on the skin. Similarly, Tabassum, (2020) defines in his study on lemongrass shampoo that it has effects on the presence of dandruff on the scalp. The use of *C. citratus* in the non-food area has non-toxic effects due to its natural active ingredients and has a friendly impact on the environment.

Pharmaceutical industry

It plays a major role in healthcare systems worldwide (Márquez, 2019). The practice of herbal medicine is based on the therapeutic use (Table 6) of plants as a medicinal supplement. It uses their extracts in different formulations (Gallegos, 2016).

Table 6: Pharmacological activities.

Pharmacological activity	Bioactive Component	Reference
Antibacterial activity	These effects are attributed to neral (ÿ-citral), cineol, ÿ-pinene, geraniol p-cymene, (ÿ-citral) ÿ-and terpineol, camphene and limonene help kill bacteria.	(Ekpenyong et al., 2015)
	They are attributed to three specific compounds: α-citral, myrcene and α-citral which individually act on gram-negative and gram-positive bacteria.	(Bermúdez et al., 2019)
	This activity is due to geranial and neral.	(Giler, 2018)
	Volatile components, terpenes such as geraniol and citronellol, are attributed to the antibacterial effect.	(Morillo & Ibarra, 2018)
	Ethanolic extracts of lemongrass leaves, especially flavonoids and tannins found in the extract, are responsible for the activity.	(López, 2022)
Antifungal activity	Main constituent is citral because it causes the death of the fungus.	(Coello, 2022)
	They can be attributed to the presence of several constituents, including citral, ÿ-myrcene, linalool and geraniol possessing inhibitory effects.	(Ekpenyong et al., 2015)
	Two main constituents: geranial (42.2%) and neral (31.5%).	(Boukhatem et al., 2014)
	Series of constituents, including Citral, α-myrcene, linalool and geraniol, have been proven to have antifungal effects.	(López, 2022)
Antioxidant activity	Among which are isoorientin 2-V-rhamnoside, isoorientia and swertiajaponin prevent cell damage.	(Alvis et al., 2012)
	Reported methanol, aqueous ethanol, flavonoids are free radical scavengers.	(Julieth & Cetina, 2018)
	Lemongrass contains flavonoids that have antioxidant properties.	(Giler, 2018)
	Main compounds are citral, β-myrcene and geranium.	(Duran et all, 2021)
	The role of phenolic acid and flavonoids present in lemongrass are responsible for the antioxidant activity.	(López, 2022)

Elaborated by: Enriquez et al, (2023).

Also, Ekpenyong *et al.* (2015) evaluated the antifungal activity resulting in the destruction of phytopathogens present in the environment. In addition, Giler, (2018) describes that flavonoids contain antioxidant properties that contribute to the reduction of cardiovascular diseases. *Cymbopogon citratus* is used in the pharmaceutical industry to produce medicines and cleaning products, and research has shown its effectiveness against diseases, fungi and bacteria. According to (Chambal, 2015), lemongrass essential oil has an inhibitory capacity against Candida albicans strains, suggesting the potential value of this element for this skin treatment.

Furthermore, Kishore *et al.* (1993) carried out studies on ointments and creams containing this element and found it to be effective in its use, taking into account the susceptibility of Candida spp. to antifungals. According to (Enriquez *et al.*, 2018), in his study on Guaviduca indicates that the antioxidant activity of a plant species is the expression of the different phenolic elements that are being used to neutralise reactive oxygen species.

Conclusion

Forty-six scientific articles were analysed, of which 60% indicate the biological power and use of lemongrass extract in the food and non-food industry. After the literature review, the antibacterial and significant antifungal effect on Gram (+) and Gram (-) strains was identified, and as it is a promising source of antimicrobial chemical compounds, it was used in the food and non-food line. In the non-food field, myrcene, citronella, citronellal, citronellol and geraniol are the components that are most used, and in the food industry, the bioactive citral is used to give functionality to products, lower costs and avoid toxicity. The use of lemongrass extract plays an important role in the local and global industry due to its biological components that substitute, preserve and improve the final products offered in the food and non-food market.

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