BIBLIOMETRIC REVIEW, PROXIMAL COMPOSITION, AND GASTRONOMIC PROPOSALS OF THE TASTY WEED *Portulaca oleracea* L., THE RICHEST PLANT IN OMEGA 3 FATTY ACID KNOWN AS PURSLANE OR VERDOLAGA

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SUMMARY

Purslane is called 'Verdolaga' in Venezuela and 'Beldroega' in Brazil. It is a frequent weed of the Portulacaceae family in backyards but not widely used as Mexican quelites are. We propose to integrate it in the Venezuelan scrambled eggs known as 'perico', arepa, lentils, pasta, pickles, rice, battered, salad, juice, fish, soup, and strawberries. The nutritional facts of P. oleracea plants from Merida were quantified in leafs, fruits, and stems (thin, medium, large), comparing their ash, moisture, protein, ether extract, and carbohydrate contents by proximate analysis. The Scopus database was used for the first bibliometric study on most productive countries, affiliations and authors in the last decade (2011-2021), where 1177 documents were retrieved from journals in English for portulaca oleracea OR purslane, 975 articles and 77 reviews. China, Iran, and India were the most productive countries with more than 100 documents each. The most prolific institutions, authors, and journals were tabulated for this weed of increasing scientific interest, easily available in the tropics, with potential health and social benefits. Bibliometrix was used to perform graphics on the most cited documents, trending topics of research, the multivariate analysis for the conceptual map, and the topic dendrogram which classified keywords in a weed control cluster plus three clusters on medicine, chemistry and bioactivity, and bioassays. A further gastronomic investigation was done with P. oleracea added fresh, dried or cooked, whole, leaves or stems in 12 Italo-Venezuelan recipes. Their acceptance was determined using a 7-point Likert scale with a panel of 24 assessors, with inclusions in ceviche and risotto rating the maximum acceptance of 7 mean liking score. This hybrid contribution on bibliometrics and food science is an evidence to advocate P. oleracea application in food science and technology by policy makers.

Introducción

he Global Naturalized Alien Flora (GloNAF) database shows that *Portulaca oleracea* is among the 10 most widely distributed species that cover about one third of the globe (Pyšek *et al.*, 2017). Common Purslane becomes quite permanently established where they are once introduced and will doubtless become weeds wherever they escape from cultivation —William Darlington (1859) — (Mitich, 1997. It is a seasonal plant in temperate countries, but permanent in the tropics. *Portulaca oleracea* is known as Verdolaga in Latinamerican countries, Beldroega in Brazil, and Purslane in English. The Latin name 'portulaca' derives from the terms 'portare' (to carry)

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and 'lac' (milk). In fact, the plant is used by nursing mothers to increase milk production, and also as medications on nipple pain and fissure (Niazi *et al*., 2021).

Purslane grows in many parts of the world, in a wide range of environments. It grows in every state of the United States, Mexico and south to Brazil. This herbaceous plant is appreciated in Asiatic, Latinamerican and Mediterranean diet as a source of bioactive polar lipids for human nutrition (Cannavacciuolo *et al*., 2022). It is a common herbal "quelite" kind of herbal leaves for Mexican food with more than 200 recipes online, used in similar ways of spinach. It has a slightly sour and salty taste, similar to spinach and watercress. Some varieties are more succulent than others, the stems of Venezuelan Purslane are fibrous. Obied *et al*. (2003) compared daily doses of *P. oleracea* meals of 5 g/kg body weight with *ad libitum* fed goats. Daily consumption was not recommended due to severe clinico-pathological effects. Purslane has been studied in enriched Korean Sulgidduk with best results for 3% addition in this rice cake (Jeon and Kim, 2016). In Brazil, it is neglected for human nutrition (De Souza *et al*., 2021), and in Venezuela it is used by farmers for animal nutrition of hens, pigs, and turtles (P. Vit, personal observations). Diet enriched with 8% Purslane meal were fed to laying hens in Indonesia, and the sensory quality of derived mayonnaise from egg yolks was rated well for the yellow color but were not significant for the emulsion stability, texture, homogeneity, aroma, taste, and flavor (Kartikasari *et al*., 2016). Nile Tilapia, *Oreochromis niloticus* from Egypt fed with 3% Purslane powder showed more than 80% survival against *Aeromonas hydrophila* infection, with significant increases in plasmatic superoxide dismutase, catalase, and glutathione peroxidase activities (Abdel-Razek *et al*., 2019). Leaf extracts of 1500 ppm Purslane had positive impact to enhance anti-oxidative properties of soybean oil during heating, similar to the control 100 ppm TBHQ (Shanker and Debnath, 2019).

In the food industry, floating trays used for clean, safe and high quality raw and minimal processing of fresh-cut vegetables industry were tested for two aeration flows of *P. oleracea*. The sensory and microbial quality determined 10 days of shelf life at 5°C, but 10-20% reduction of total and antioxidant capacity was observed (Rodríguez-Hidalgo *et al*., 2010). Anti-browning properties of Purslane aqueous extract rich in polyphenols and alkaloids were observed for fresh-cut potato (Liu *et al*., 2019). Spray-dried microcapsules of Purslane seed oil enhanced quality of mango juice (Abozed *et al*., 2021), and fortified yogurts was best with 2% Purslane extract (Salehi *et al*., 2021). Even in the fish industry, edible coating based on sturgeon gelatin and *P. oleracea* extract increased shelf life of fish sausages (Dehghan Tanha *et al*., 2021). Incorporation of Purslane powder in voluminous bread was possible and 10% was the optimum percentage for best acceptance (Delvarianzadeh *et al*., 2020). Similarly, 10% of Purslane leaf-powder in the bread was the best for sensory acceptance, water absorption, and specific volume, increasing moisture, dietary-fiber, protein, ash, and fat content in the toast bread (Sadeghzadeh Benam *et al*., 2022).

Investigation of lipophilic compounds from native species found that Purslane has the highest level of alpha-linolenic acid (ALA) compared to any leafy green vegetable. This omega 3 fatty acid is essential for human nutrition. A 100 g sample of Purslane contains 300-400mg ALA (3.2mg/g fresh leaves) five times higher than in spinach and lettuce. Good content of long-chain PUFAs, eicosapentaenoic acid (EPA) (20:5, ω-3) 0.01mg/g fresh leaves, and docosahexaenoic acid (DHA) (22:6, ω-3) 0.004mg/g fresh leaves (Uddin *et al*., 2014). The total carotenoid content was 281.3 - 361.9 g/100 g dry *P. oleracea*, and the most important volatile organic compounds by GC-MS were linalool (33.18%) and salicylaldehyde (21.23%), of therapeutic value for inflammations, diabetes and its complications (Anghel *et al*., 2019). *P. oleracea* oil anti-inflammatory pathway showed cell-mediated immune response via Th1 cytokines to treat atopic diseases and cancer (Arshad *et al*., 2018).

Nutridense products were prepared with fresh and dried Purslane in ten traditional recipes from India, and spinach was used as a control (Tarkergari *et al*., 20 13). These authors used a 5-point hedonic scale, and 20 sensory panelists, and found that 5% addition was rated higher than 10% Purslane addition, in color, juiciness, tenderness and flavor of redgram, paneer curry, uthappan, and pulihora. Mérida learned that *P. oleracea* was edible and good addition in vegetarian dishes from the Indian ethno-botanist Dr. Keshava Bhat, professor at Universidad de Oriente in Cumaná, who was also a naturalist teaching Ayurvedic medicine in Venezuela. In his book this weed was used as tea for the dry skin, and to brush the teeth with the stems to fortify gums (Bhat, 1985). He knew the benefits on keeping healthy arteries, preventing strokes, and heart disease. In recent studies from Brazil, bioactive capacities, as scavenging capacity against HOCl, H_2O_2 and ROO• induced oxidation. *P. oleracea* was the highest cytostatic effect against ovarian and kidney tumor cells (De Souza *et al*., 2021).

P. oleracea is an underutilized plant of interest for the UN–SDGs (United Nations – Sustainable Development Goals), integrating indigenous knowledge with technological developments. It's remarkable nutritional, medicinal, pharmacological, and phytoremediation properties were reviewed (Srivastava *et al*., 2021). It has essential minerals (potassium, magnesium, calcium, phosphorus, iron) and four types of omega-3 fatty acids.

A bibliometric study was conducted on the last decade of research (2011-2021) on *Portulaca oleracea* or its ethnic name in English Purslane, which etymology is from the Old French porcelain, having those tiny, shiny and succulent leaves. The proximal composition was evaluated in fruits, leaves and stems (thin, medium, large), comparing their ash, moisture, protein, ether extract, and carbohydrate contents. Gastronomic preparations with Purslane were proposed and tested for acceptance.

Materials and Methods

Bibliometric study

Scopus database

The bibliometric search was carried out in the Scopus database (2011-2021), in the "TITLE-ABS-KEY" field, the 27th May, 2022. The operator AND was used for portulaca AND oleracea, with the operator OR for purslane of all documents, and for the last ten years using the following query string:

TITLE-ABS-KEY (portulaca AND oleracea OR purslane) AND PUBYEAR > 2010 AND PUBYEAR < 2022 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j"))

These results were filtered using the inclusion and exclusion criteria selected in Table I, for articles and reviews published in English.

Bibliometrix statistical analysis and visualization

Statistical techniques and visualizations were performed using Bibliometrix R package (Aria and Cuccurullo, 2017) in R Version 4.2.1 and the Biblioshiny App. They were applied to frequency graphics of the ten most cited

Inclusion	Exclusion
Documents with search words in the title, abstract, or keywords	Without exclusion
Articles and reviews	Other types of documents
Source type journals	Other sources.
Documents written in English	Documents written in other languages different to English

documents worldwide, and evolution of trending topics. Multivariate factorial analysis were done to investigate correlations and classifications of authors' keywords with multivariate graphical tools for conceptual structure mapping by Multiple Correspondence Analysis (MCA), and topical dendrograms by Hierarchical Cluster Analysis (HCA).

Plant sample

Aerial parts of Purslane were randomly and carefully collected, approximately 2 kg, in May 2022 from a natural wild population in a backyard (Merida, Venezuela; GPS coordinates N 08° 33.245', W 071° 12.629', 1,233 m.a.s.l.). A Voucher No. 056269 of the plant was deposited at the MER Herbarium, Faculty of Forestry and Environmental Sciences, Universidad de Los Andes, Merida, Venezuela. The plant specimen was identified as *Portulaca oleracea* L. by the botanist Dr. José Guevara.

Five plant fractions were separated manually from 100 g of Purslane, and the yield of each fraction was quantified: 1. Leaves (30%), 2. Fruits (18%), 3. Thin stems (10%), 4. Medium stems (12%), and 5. Large stems (20%). These fractions were illustrated in Figure 1.

Proximate composition of fruits, leaves and stems

The harvested *P. oleracea* were subdivided into five fractions. Proximal analysis were done in the fresh material in duplicates, following the AOAC methods (2012). The proximate composition consisted on determinations of: 1. Ash by using a muffle furnace according to the AOAC 923.03 method, 2. Moisture by using a stove AOAC 984.25 method, 3. Fat content was determined after Soxhlet extraction according to AOAC 983.23 method, 4. Protein content by the microKjeldahl nitrogen method (N × 6.25) according to the AOAC 984.13 method,

and 5. Total carbohydrates were calculated by the difference of ash, fat, moisture, and protein. The results were expressed in g/100g Purslane fraction.

Gastronomic inclusion of Purslane in Italo-Venezuelan recipes

Twelve recipes of traditional Venezuelan (juice, perico, arepa, beef shank, ceviche, and sweet potato salad) and Italian (lentils, risotto, rotolo, pastella, giardiniera, and strawberry gelatin) preparations were experimentally tested with the inclusion of diverse forms of Purslane raw, cooked, dried, whole, leaves, or stems.

Sensory evaluation. Acceptance by a panel of 24 assessors

Before the tasting session, the assessors were introduced to the *P. oleracea* plant in the garden, the fractions analyzed in this study, and the dried powder used for one preparation. Servings were fluent during one hour tasting, and water at room temperature was available to rinse the mouth and clean the palate between the 12-courses.

A 7-point Likert scale was considered to be the most accurate among all, easier to use, and better for true evaluation of assessors. Therefore a 1-7 liking sensory questionnaire was selected for the acceptance test. The 12 Italo-Venezuelan food recipes prepared with inclusion of Purslane were tasted by a panel of 24 assessors for the sensory acceptance, 15 female and 9 male, 38 to 90 years old. Their professions varied from accountant, biologist, chemist, dentist, driver, economist, educator, food technologist, housewife, and pharmacist. A mean liking score was evaluated (Gutiérrez Salomón *et al.*, 2014) for each dish with Purslane inclusion.

Results

Four sections of results were presented for this research: 1. Bibliometric analysis, 2. Proximate composition, 3. Gastronomic inclusion of Purslane, and 4. Acceptance test.

Bibliometric analysis

The Scopus database provided the sources of published research ranked for countries, affiliations, authors, sources, and subject areas. The absolute number of documents was exported in CSV Excel datasets for the Bibliometrix statistical analysis and visualization.

Scopus database

The bibliometric descriptors of *Portulaca oleracea* or Purslane research in the last decade, using inclusion-exclusion criteria and the query string informed in the methods section, were presented in Table II.
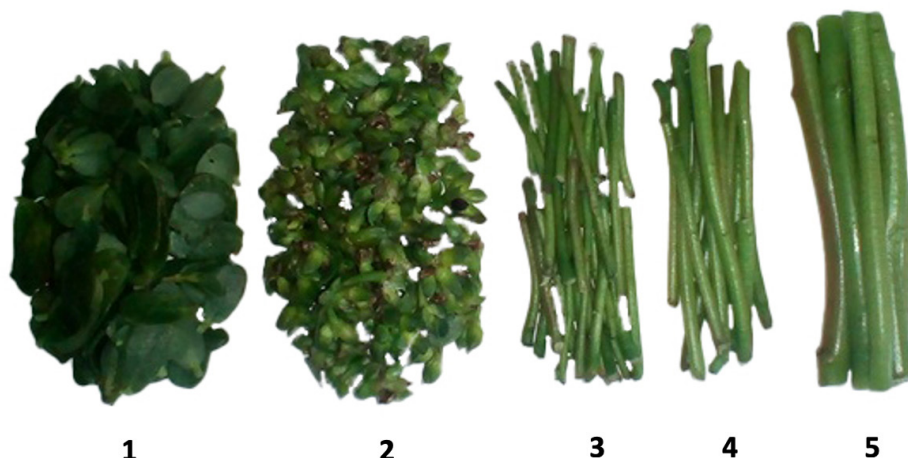

Figure 1. Fractions of *Portulaca oleracea* known as Purslane and Verdolaga. From left to right: 1. Leaves, 2. Fruits, 3. Thin stems, 4. Medium stems, and 5. Large stems.

TABLE II
BIBLIOMETRIC DESCRIPTORS OF PUBLISHED *P. oleracea* OR PURSLANE
RESEARCH IN ENGLISH (2011-2021)

Bibliometric descriptor	Counts of *Portulaca oleracea* or Purslane documents	
	All documents	Documents (2011-2021)
Number of documents	1,787	1,177
Number of articles	1,609	975
Number of reviews	92	77
Documents in English	1,701	1,052

The evolution trend on publications of *P. oleracea* or Purslane research showed growing interest because the number of publications was increasing at a steady rate until 2021, as observed in Figure 2.

Half of the documents on *Portulaca oleracea* or Purslane have been published by the three top-countries China, Iran and India in the last ten years (Table III). The United States, Egypt, Italy, and South Korea follow with a third of those documents. Spain and Nigeria produced more than 30 documents each.

In Table IV, the most productive affiliations have three Chinese, two Nigerian and two Iranian top-ten, being these countries the top-three institutions represented by three universities.

Half of the top-ten scientists researching on *P. oleracea* were from China, including the two most productive authors (Table V). Two authors from Malaysia, two from Nigeria, and one from Iran revealed the geographic distribution of nine universities and one clinic investigating the chemical composition and biomedical applications of Purslane in modern life.

The most relevant sources hosting *P. oleracea* or Purslane research from 2011 to 2021 were the top-ten journals ranked by their number of publications in Table VI. Additionally, the h-index, quartile and impact scores of these journals were retrieved online.

Agricultural and Biological Sciences was the most frequent Scopus subject area of *P. oleracea* or Purslane published research in the period 2011 to 2021, with 29.6% of the documents. The following subject areas of interest were Pharmacology, Toxicology and Pharmaceutics (16.3%), Biochemistry, Genetics and Molecular Biology (14.9%), Medicine (10.8%), Environmental Science (6.8%), Chemistry (6.7%), Immunology and Microbiology (2.2%), Chemical Engineering (1.9%), Nursing (1.4%), and Engineering (1.2%).

Bibliometrix statistical analysis and visualization

Bibliometric analyses were supported by Bibliometrix, which is programmed in R, and constantly upgraded, and integrated with other statistical R-packages (Aria and Cuccurullo, 2017). After data collection from the Scopus database, statistical computing analysis and graphics were performed using the Biblioshiny interface. Two graphics on frequencies were prepared to feature most cited documents and trends on topical evolution. Two graphics on multivariate analysis were to investigate correlations and classifications of authors' keywords with multivariate graphical tools for conceptual structure mapping by Multiple Correspondence Analysis (MCA), and topical dendrograms by Hierarchical Cluster Analysis (HCA).

The ten most cited documents were retrieved with Bibliometrix and visualized in a graphic with their global citations, surname of first author,
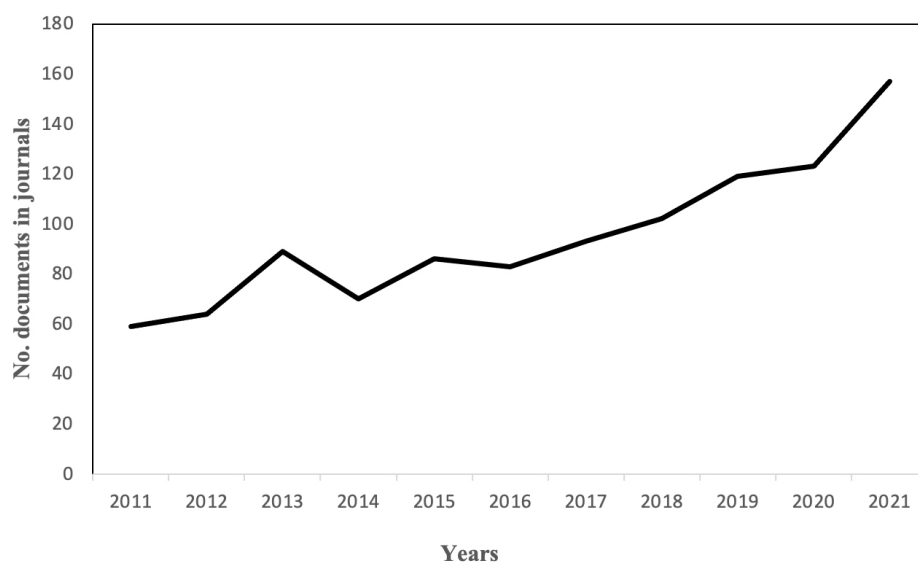

Figure 2. Increasing trend of scientific publications on *P. oleracea* or Purslane research in the period from 2011 to 2021.

TABLE III
NUMBER OF DOCUMENTS IN THE 20 COUNTRIES MOST PRODUCTIVE ON
P. oleracea OR PURSLANE RESEARCH (2011-2021)

Ranking	Country	No. Documents	Ranking	Country	No. Documents
1	China	196	11	Nigeria	36
2	Iran	159	12	Germany	10
3	India	101	13	Bulgaria	9
4	United States	76	14	Irak	9
5	Egypt	67	15	Israel	8
6	Italy	60	16	Czech Republic	7
7	South Korea	54	17	Tunisia	7
8	Spain	38	18	Argentina	5
9	Brazil	37	19	Morocco	5
10	Turkey	37	20	Russian Federation	5

TABLE IV
NUMBER OF DOCUMENTS ON *P. oleracea* OR PURSLANE RESEARCH (2011-2021) RANKING TOP TEN MOST PRODUCTIVE AFFILIATIONS WORLDWIDE

Ranking	No. Documents	Affiliation	Country
1	42	Liaoning University of Traditional Chinese Medicine	China
2	31	University of Ibadan	Nigeria
3	27	Mashhad University of Medical Sciences	Iran
4	22	Afe Babalola University	Nigeria
5	21	Ministry of Education China	China
6	19	Chinese Academy of Sciences	China
7	19	Universiti Putra Malaysia	Malaysia
8	18	National Research Centre	Egypt
9	14	King Saud University	Saudi Arabia
10	13	Tehran University of Medical Sciences	Iran

TABLE V
TOP-TEN MOST PRODUCTIVE RESEARCHERS IN *Portulaca oleracea* OR PURSLANE (2011-2021) WITH THEIR AFFILIATIONS AND COUNTRIES

Ranking	No. Documents	*Portulaca oleracea* or Purslane		
		Author	Affiliation	Country
1	39	Ying, Xixiang	Liaoning University of Traditional Chinese Medicine, Shenyang	China
2	22	Zhang, Wenjie	Liaoning University of Traditional Chinese Medicine, Shenyang	China
3	19	Oyedeji, KO	Afe Babalola University, Ado Ekiti,	Nigeria
4	15	Juraimi, Abdul Shukor Bin	Universiti Putra Malaysia, Serdang	Malaysia
5	15	Ying, Zheming	School of The First Clinic, Shenyang	China
6	12	Bolarinwa, Adeyombo Folashade	University of Ibadan, Ibadan	Nigeria
7	12	Yang, Guanlin	Liaoning University of Traditional Chinese Medicine, Shenyang	China
8	11	Xiang, Lan	Shandong University, Jinan	China
9	10	Alam, Md. Amirul	Universiti Malaysia Sabah, Kota Kinabalu	Malaysia
10	10	Askari, Vahid Reza	Iran Mashhad University of Medical Sciences	Iran

Trending topics of research in *P. oleracea* were visualized in triplet themes per year in Figure 4 to follow their evolution. The current interest was on obesity, chlorophyll a, and intestine flora; preceded the previous year by phytochemicals, interleukin 1 beta, and anti-inflammatory agents.

Factorial analysis of conceptual structured map was performed by Multiple Correspondence Analysis (MCA) of authors' high-frequency keywords used in publications of *P. oleracea* or Purslane research (2011-2021). The conceptual structure was visualized in a small blue cluster on weed control, and a large red cluster on medicine, chemistry, bioactivity, and bioassays (Figure 5).

A topic dendrogram by Hierarchical Cluster Analysis (HCA) using Euclidean distance and Ward method was done for author's keywords used in *P. oleracea* or Purslane research (2011-2021) in Figure 6. Keywords were classified in a small red cluster for weed control, Portulacaceae, and weed; segmented from the blue cluster with three branches covering three topics on medicine, chemistry and bioactivity, and bioassays.

Proximate composition of Portulaca oleraceae leaves, fruits, and stems

The proximate composition (ash, fat, moisture, protein, and carbohydrates) of the leaves, fruits and stems of *P. oleracea* was presented in Table VII.

Gastronomic inclusion of Purslane in Italo-Venezuelan food recipes

One of the most enticing ethnic preparations of Purslane online

year of publication, and journal identifiers in Figure 3. DNA barcoding use to detect contamination and substitutions in North American herbal products (Newmasters *et al.*, 2013) has received 376 citations and became the most cited document, investigating product integrity and authenticity for consumers' protection. The top second with 323 citations was on flavonoids, phenolics and antioxidant potential screening of nine wild plants from Nepal (Aryal *et al.*, 2019). Understanding and management of plant invasions worldwide from Pyšek *et al.* (2017) with 41 co-authors received 237 citations, as the third most cited article. Uddin *et al.* (2014) research on Purslane as a source of omega-3 fatty acids and antioxidants was cited 155 times.
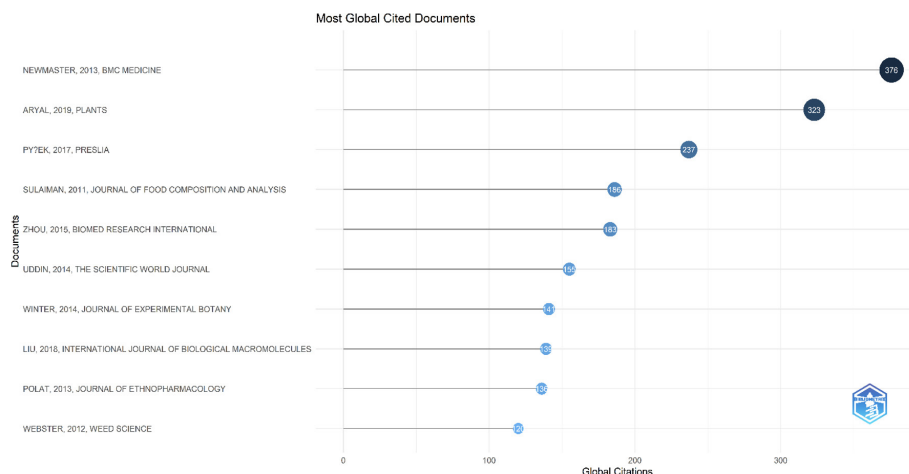

Figure 3. Ten most cited documents in *Portulaca oleracea* or Purslane research (2011-2021).

were the Turkish strained yogurt with garlic 'Yoğurtlu Semizotu' and the Greek 'Andrákla' often fried with tomatoes, feta cheese, and olive oil. For this research, experimental gastronomy was assayed including Purslane in 12 traditional dishes and gourmet Italo-Venezuelan cuisine described below. For cooking purposes, there was no need to separate the leaves from stems and fruits, which are called here Purslane greens.

Juice of liquidized stems. Chop the large stems in the liquidizer, add filtered water, liquidize and remove fibers with a sieve. The juice has a nice foam. Variations adding fruit pieces or fresh juices are good, such as squeezing half orange into a glass of liquidized Purslane.

Perico with Purslane. This is a Venezuelan breakfast. Chop a small tomato, a small onion, a clove of garlic and stir fry gently in a spoon of oil. When tenderized add two spoons of Purslane greens, salt, black pepper to taste, and two scrambled eggs. Cook to your preference. Serve with a toast, cassava bread or arepa.

Purslane dark arepa. Arepa is considered a staple food in Venezuela. It is based on corn meal made of precooked maize flour, mixed with water, kneaded, shaped like a disk, and cooked in diverse ways such as baked, fried or grilled. For a variation, dehydrated or stir fried greens of Purslane were added to the dough. The fried arepa has a central hole and the natural dehydration produced dark leaves and plenty black seeds that were ground into a coarse powder.

Lentils with Purslane. Soak 200 g lentils in water for 2 h, chop a small carrot, a celery stem, a small onion, a clove of garlic, salt and black pepper, stir fry and add the lentils until they are done. Sprinkle with 50 g of Purslane baby greens and two spoons of tomato puree. Serve with Greek yogurt.

Purslane risotto in zucchini rings. Liquidize a branch of Purslane with 2 cups of water, sieve the liquid and the jelly, stir fry thick slices of zucchini, empty the center and chop it, stir fry with chopped spring onions, red pepper and garlic, add a cup of rice, salt and pepper, the two cups of Purslane juice, cook for 20 min, add a spoon of butter, fill the zucchini rings with the rice, sprinkle chopped Purslane on top and decorate with tiny leaves.

Beef shank soup and Purslane. Beef shank is called Lagarto in Venezuela, and is the ultimate soup for children and elderly, considered of high nutritional quality. The accompanying vegetables vary from high to moderately farinaceous. Stir

TABLE VI
MOST PRODUCTIVE JOURNALS HOSTING RESEARCH OF *Portulaca oleracea* OR PURSLANE (2011-2021)

Ranking	*Portulaca oleracea* or Purslane Source (h index, Quartile, impact score)[1]	NP[2]
1	*Journal of Ethnopharmacology* (h 205, Q1, 5.09)	33
2	*Weed Technology* (h 70, Q2, 1.81)	18
3	*Natural Product Research* (h 58, Q1, 2.46)	17
4	*Food Chemistry* (h 281, Q1, 8.69)	15
5	*International Journal of Pharmacy and Pharmaceutical Sciences* (h 81, Q1, 3.24)	15
6	*International Journal of Pharmaceutical Sciences Review and Research* (h33, Q, 0)	13
7	*Plants* (h 47, Q1, 4.67)	13
8	*Molecules* (h 171, Q1, 4.67)	11
9	*Planta Daninha* (h 32, Q1, 0.90)	10
10	*Phytotherapy Research* (h 140, Q1, 7.07)	9

Fuente: [1]https://www.resurchify.com. [2]NP number of publications.
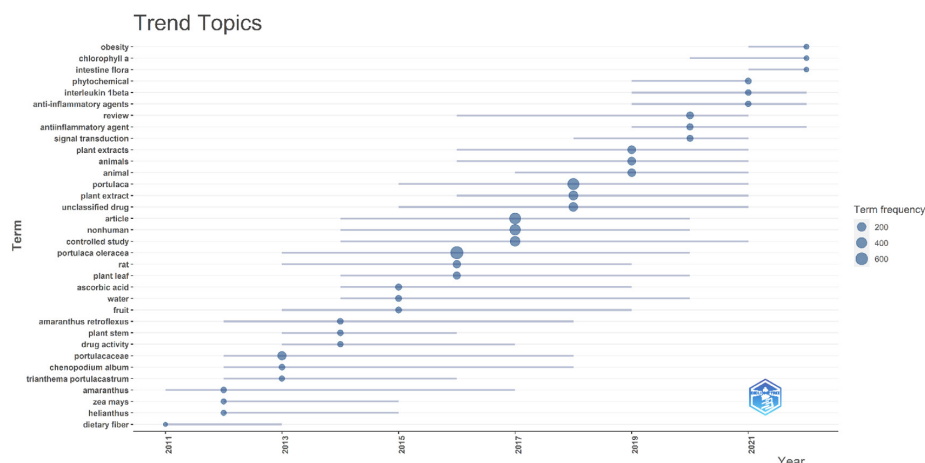

Figure 4. Trending topics of *P. oleracea* or Purslane research (2011-2021) recently focused on obesity, chlorophyll a, and intestine flora.

fry half kilogram of shank nicely cut in the pressure cooker, with chopped garlic, sliced leeks, bay leaf, salt and pepper. Deglaze with half glass of white wine. Add water, half kilogram of celery, celery root, onion, pumpkin, carrots and corn cob. Close the pressure cooker and moderate the flame for 30 minutes after the whistle. Sprinkle fresh Purslane in each serving, to keep their shiny green color and flavor.

Purslane Rotolo. This is an Italian entrée or primo piatto. Chop a small onion, a bacon slice, and a clove of garlic, stir fry,

ass salt, black pepper, a teaspoon of butter, and 100 g of Purslane greens. Reserve. Prepare the dough with flour and water or buy it ready. Get a half cm thick pasta in a rectangle shape to be spread with the pre-cooked Purslane, leave 2 cm free at one end, sprinkle with grated cheese of your preference, add a line of red peppers in the rolling end. Start rolling, stick the free end with water and envelop waterproof with aluminum foil, boil for 30 min. Let it cool and peel off the foil. Cut slices of rotolo and serve with your favorite sauce. Melted
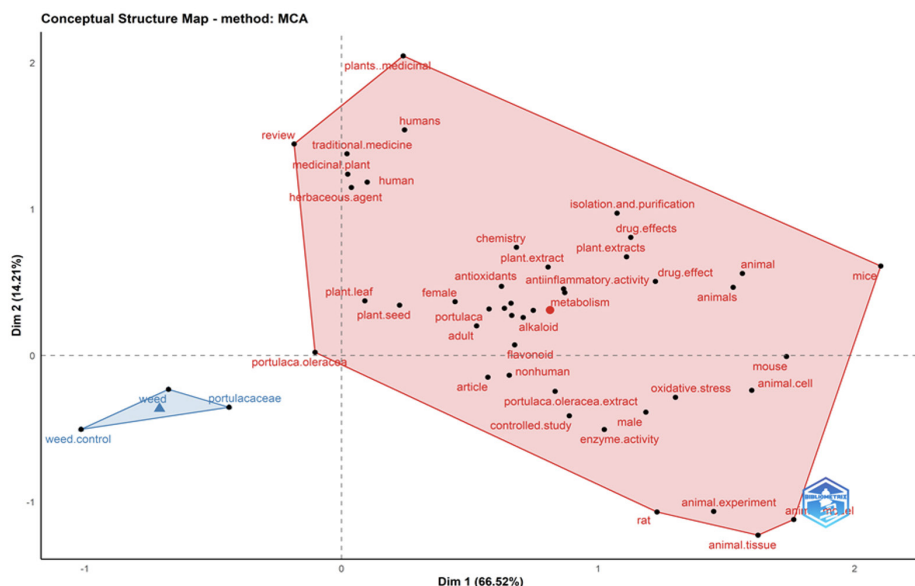
Figure 5. Conceptual structure map by Multiple Correspondence Analysis (MCA) of author´s keywords used in *P. oleracea* or Purslane research (2011-2021). The conceptual structure was visualized in a blue cluster on weed control, and a pink cluster on medicine, chemistry, bioactivity, and bioassays.
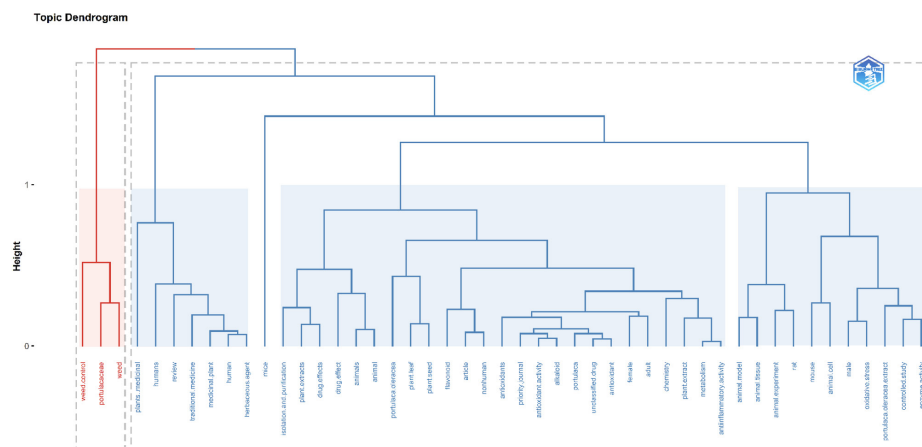

Figure 6. Topic dendrogram by Hierarchical Cluster Analysis (HCA) of author's keywords used in *P. oleracea* or Purslane research (2011-2021). The weed control topic to the left (red) was segmented from the large blue cluster to the right, further divided into three topics on medicine, chemistry and bioactivity, and bioassays.

butter with Purslane leaves was the option used here.

Ceviche. Chop half purple onion into a bowl with two spoons of white vinegar and half teaspoon of salt, add one chopped chili, one tomato and 100 g of a fish filet chopped nicely, dice a slice of avocado, 50 g of Purslane leaves, squeeze the juice of two lemons, mix and keep refrigerated before serving.

Purslane in pastella. This is an Italian dish made with all types of vegetables as a snack or one bit hors d'oeuvres. Pastella is a thick slurry used for deep fry. Mix 100 g of wheat flour with 100 mL of beer, make it savory at your preference with salt, white pepper, hot paprika, any seeds. Soak little bunches of Purslane into the pastella and deep fry into hot oil until blond, dry with absorbent paper, and serve this crispy delicacy hot.

Giardiniera with Purslane. Italian pickles are giardiniera because they resemble a colorful garden. Nicely chop one cauliflower, three carrots, two celery stems, two purple onions, and thin stems of Purslane. For the boiling juice mix 200 mL water, 200 mL vinegar, 200 mL wine of your choice, add two bay leaves, 10 kernels of black pepper, one star anise, half tea spoon of mustard, one spoon of salt, one spoon of brown sugar, and hot paprika to taste. Bring to boil and simmer 7-10 min each vegetable until desired texture. Mix all the vegetables in a bowl, pour over the pickling juice, cover with a lid, and keep refrigerated until use.

Purslane sweet potato salad. Cut 200 g of cooled boiled sweet potatoes in dices. Season with a vinaigrette of 50 g Purslane greens, one grated turmeric root, 1-2 cloves of garlic, one spoon of red wine vinegar, two spoons of olive oil, and a teaspoon of mustard sauce. Mix sweet potatoes and the green vinaigrette.

Purslane and strawberries light gelatin. No sugar was added here for the plain gelatin, just the natural organic acids and

TABLE VII
PROXIMATE COMPOSITION OF *P. oleracea* FRACTIONS (G/100 G FRESH WEIGHT)

Chemical Parameters	*P. oleracea* fractions				
	Leaves	Fruits	Thin stem	Medium stem	Large stem
Ash	1.10 ± 0.05ab	1.05 ± 0.14a	1.76 ± 0.30c	1.53 ± 0.03bc	1.46 ± 0.01abc
Fat	0.14 ± 0.02a	0.13 ± 0.02a	0.14 ± 0.02a	0.40 ± 0.00b	0.46 ± 0.00c
Moisture	92.63 ± 0.66bc	87.97 ± 0.39a	92.56 ± 0.13b	93.81 ± 0.55cd	94.52 ± 0.15d
Protein	2.26 ± 0.12b	3.44 ± 0.28c	1.59 ± 0.48ab	1.67 ± 0.00ab	1.05 ± 0.10a
Carbohydrates	3.87 ± 0.57a	7.40 ± 0.76b	3.95 ± 0.27a	2.58 ± 0.57a	2.51 ± 0.18a

Values are averages ± SD. Different superscripts in the same row show significant difference between *P. oleracea* fractions with ANOVA one-way post-hoc Tukey test ($P<0.05$) using SPSS (IBM, 2019).

TABLE VIII
ACCEPTANCE OF PURSLANE INCLUSION IN ITALO-VENEZUELAN DISHES

Purslane preparations	1 ☹☹☹ dislike it a lot	2 ☹☹ dislike it	3 ☹ moderate dislike it	4 ☺ neither like nor dislike it	5 ☺ moderate like it	6 ☺☺ like it	7 ☺☺☺ like it a lot	Mean liking score (total)
Liquidized juice	-	-	-	-	4	13	7	**6.1** (147)
Perico	-	-	-	-	-	2	22	**6.9** (166)
Dark arepa	-	-	-	1	2	14	7	**6.1** (147)
Lentils	-	-	-	-	-	2	22	**6.9** (166)
Risotto	-	-	-	-	-	-	24	**7.0** (168)
Beef shank soup	-	-	-	-	1	-	23	**6.9** (166)
Rotolo	-	-	-	-	-	12	12	**6.5** (156)
Ceviche	-	-	-	-	-	-	24	**7.0** (168)
Pastella	-	-	-	-	1	4	19	**6.8** (162)
Pickled giardiniera	-	-	-	-	-	7	17	**6.7** (161)
Sweet potato salad	-	-	-	-	1	5	18	**6.7** (161)
Strawberry gel	-	-	-	-	2	5	17	**6.6** (159)

sweetness of the chopped strawberries, and the Purslane little branches, prepared in a bowl or in goblets. Pour the melted gelatin diluted with cold water on the chopped fruit and Purslane, refrigerate until it sets. Customize as needed or enjoy cubes of this neutral balance with a vanilla ice-cream.

Images of the Purslane inclusion in each of the 12 Italo-Venezuelan food recipes described above, were presented in Figure 7: Juice of liquidized stems, perico, dark arepa, lentils, risotto in zucchini rings, beef shank soup, rotolo, ceviche, pastella, pickled giardiniera, sweet potato salad, and strawberries light gelatin.

Sensory evaluation

The acceptance results of the 24 assessors were presented in Table VIII. All the acceptances were positioned in the like section of the 7-point Likert scale, from 4 to 7. Mean liking scores (MLS) were estimated for each food recipe. Purslane is not very tasty after cooking because it loses the distinctive sour taste, ant its emerald green color fades and turns pale (P. Vit, personal observation).

The sensory mean liking score varied from 6.1 for the liquidized Purslane large stems and the dark arepa with dried Purslane, to 7.0 for the ceviche and risotto in zucchini rings, both served with fresh Purslane branches.

Some acceptances were valued more related to sensory

Figure 7. Purslane inclusion in Italo-Venezuelan food recipes.

background of the assessors than to the current Purslane inclusion in a traditional or gourmet dish. Memory from childhood was elicited from two assessors. Expressions like too hot or lack of sugar were frequent. Choosing a light dessert would not be recommended in future options because the sweet taste was expected, and the healthy 'light' was not valued.

Discussion

Raw Purslane contains about 93% of water, 3% of carbohydrates, and 2% of protein, and may preserve agro-biodiversity for sustainable development (Srivastava *et al.*, 2021). This hybrid paper on bibliometric review, and food science on proximate analysis and sensory analysis of gastronomic proposals including *Portulaca oleracea* was discussed in the following sections.

Bibliometric review

A steady growth of the number of publications has been observed since 2011, with 123 documents in 2020 up to 157 in 2021 (Figure 2). In the last decade of *P. oleracea* or Purslane research, China, Iran, and India were ranked as the three top-countries (Table III), and the most productive affiliations were from China, Nigeria, and Iran, with Nigeria having affiliations overcoming India as a country (Table IV). The top-five scientists researching on this succulent weed were from China, Malaysia, and Nigeria (Table V). China seemed to have supremacy in this research, with five of the top ten authors from universities, one University of Traditional Chinese Medicine, and one from clinics (Table IV). This fact shows interest in applications of *P. oleracea* as a medicinal food. The top journals hosted 33 to 9 documents, and the highest ranks were for the Journal of Ethnopharmacology (33), Weed Technology (18), and Natural Product Research (17) (Table VI). This confirms the interest on bioactive components and medicinal application of this succulent tasty green, with a biological nature that also attracts scientist of weed technology.

The subject areas were prioritized for the frequent and fundamental interest on agronomical approaches. Combined major topics of research represented over 70% of the publications on Agricultural and Biological Sciences, Pharmacology, Toxicology and Pharmaceutics, Genetics and Molecular Biology, and Medicine. These areas were also reflected in the ten most cited documents in Figure 3, and the following top-five journals with number of citations in

parenthesis: 2013 BMC Medicine (376), 2019 Plants (323), 2017 Preslia (237), 2011 Journal of Food Composition and Analysis (186), and 2015 Biomed Research International (183).

Proximate analysis of Portulaca oleracea fractions

A comprehensive nutritional profile of Purslane parts was obtained after the proximate analysis in Table VII. Proteins (3.44%) and carbohydrates (7.40%) were most concentrated in the fruits, ash (1.76%) in the thin stem, fat in medium (0.40%) and large (0.46%) stems, and moisture in the fibrous large stems. Moisture varied from 87.97% in fruits to 94.52% in large stems. Average moisture for the leaves was between 83.12% and 88.39% (Fukalova Fukalova *et al.*, 2022), similar to fruit values here. No previous studies were found in the literature for the *P. oleracea* fractions studied here, except a recent research on leaves and thin stems from the Valencian coast in Spain (Fukalova Fukalova *et al.*, 2022). These authors compared the composition of wild and cultivated *P. oleracea*, the ash content was lower in the wild (2.62%) than the cultivated (3.39%). Foliar crude protein in Spain was similar in both systems, wild 1.56% and cultivated 1.49%, included in the range from 1.05% in large stems and 3.44% in the fruits of Venezuelan Purslane (Table VII). The *P. oleracea* fat content of cultivated Spanish plants was 0.99%, three-fold higher than wild plants 0.32%. The Venezuelan Purslane ranged from 0.13% fat in fruits to 0.46 in large stems (Table VII). Similarly, the carbohydrate content was 8.41% in cultivated Purslane, and about half of that, 4.72% for the wild plants. In Table VII, carbohydrates were most concentrated in fruits (7.40%), and less in thin stem (2.51%) fractions of Purslane, with intermediate values of 2.58 to 3.95 for the other three fractions.

From this study, the proximate composition of *P. oleracea* varied according to the analyzed fractions of the plant. In Table VII, significant statistical differences were contrasted between the lowest ash content in fruits and highest in thin stems, indicating more minerals in the growing branches. Fat content of leaves, fruit and thin stem were lower than medium and large stem having more fat reserve. Fruits containing the seeds were the driest fraction with 87.97 % moisture, with other moister fractions varying from 92.56 to 94.52% for the highest water content, possibly related with the fibrous texture of the large stem, where 1.05 % of protein content was the

lowest, and varied between 1.59 to 3.44% in the fruits, leaves, thin and medium stems. Finally, carbohydrates were the energetic reserve in the fruits in contrast to fat in the large stem. Indeed, fruit carbohydrate content (7.40%) was about double than carbs in leaves and stems (2.51% to 3.95%). The percentage of each fraction in the plant varied between 10% for thin stems to 30% leaves. Considering that little branches of Purslane were frequently used in the recipes, possibly leaves and thin stems, representing 40% of the plant, could be a fraction to be analyzed in further studies for gastronomic applications.

Sensory analysis of Portulaca oleracea in Italo-Venezuelan preparations

The acceptance observed for inclusion of *P. oleracea* in the Italo-Venezuelan recipes elicited mostly positive reactions, valued with mean liking score from 6.1 to 7.0 in Table VIII. Some forms of the weed (e.g. fresh) were more accepted than others (e.g. dried). The large stems were very fibrous, and therefore non eatable unless mashed or squeezed to extract their juices. The thin stems were included in the softer baby branches, there was no need to have leaves only for the preparations. They were also defoliated for the giardiniera pickle preparation for a distinctive contrast in color, shape, and texture, but loss of taste that merged in the vinegar-based recipe.

This study with Venezuelan Purslane inclusion was a descriptive comparison between 12 recipes to explore their acceptability. Further controlled studies for selected ideas could be developed for commercial proposals. For example, the liquidized juice was not the best rated, but is a potential matrix for the nutritional properties of fresh Purslane, and deserve further studies to improve sensory properties by admixtures with other juices. A 78 years old female assessor kin on healthy food rated it 7, and her comment was "I would drink a gallon of it". Taste of Purslane addition to ten traditional Indian recipes from India was rated higher than spinach in four of them (Tarkergari *et al.*, 2913). Purslane seemed decorative in ceviche, and the visual green contrast was well rated in descriptive appreciations. One assessor felt transported to Peru after closing her eyes while tasting ceviche. Both ceviche and the beef shank soup were offered with optional servings to assessors who could add more Purslane before tasting the fish and the soup. During the tasting, Purslane was associated to broccoli, spinach, clover, and other childhood greens.

The sensory descriptions and perceptions annotated along the rankings were processed and contributed to value this edible weed. Positive comments of the 24 assessors retrieved during the tasting session were: interesting alternative with citrusy taste, fruity, refreshing, different and original fusion with familiar dishes, Purslane was a good match with lentils, amalgamated well with the garlic vinaigrette and sweet potatos, crispy cake, enticing combination of colors, taste and texture, visually and gustatively pleasant, attractive organoleptic matrix, tasty, fresh Purslane intensifies lentils taste, amusing blend, non-invasive, the onions of perico and Purslane add crispy texture, the minute seeds of dried Purslane were perceived in the arepa, delightful mixture integrating Purslane with other vegetables, Purslane boosted the soup flavor, fragrant in the rotolo with distinctive sour taste and harmonizing flavours, Purslane complemented the characteristic flavor of ceviche, and apparently absorbed the juice known as 'leche de tigre'—tigers' milk used to name the citrus-based marinade that cures the seafood— attractive marriage with traditional food, appetizing curiosity, the Japanese tempura was also elicited after tasting a deep-fried Purslane, the contrasting texture enhanced the dessert, happy appearance, special like a Sunday lunch, temptress Purslane vinaigrette, striking combination, a mingling culinary green, red strawberry and green Purslane enhanced their shiny colors in the gelatin. Some of the comments were precise for sensory science, while others reached the emotions, and were valid too for the overall perception and rating. Having small servings for a 12-course-menu was also appreciated as food beautifully set for dolls 'muñecas' in Spanish. This type of expressions is from the inner world of the assessor, for others it was a routine, asking for next. Before informing the negative perceptions, also descriptive neutral words were used by the assessors, such as normal, eatable or edible, visually simple.

The negative comments were related to the loss of Purslane taste and flavor in some preparations, compared to the raw green. Despite the highly rated successful crispy delicacy of Purslane in pastella, the branches were visually present but taste and retronasal aroma were lost after deep-fry. Geometrically showy in the rotolo, but the Purslane taste was lost. The juice was cloudy, the arepa was small, lentils were bitter, non-perceptible. The green became pale in the pickles. Rotolo was the paradox, not for the two adjacent values in the Likert scale, 50% each, but for the comments: Fragrant, sour taste, attractive color, harmonious flavors and spices. Or analogy with a breaded jelly roll "brazo gitano", a traditional Spanish dessert. Purslane is present, and other flavors too. Soft texture. Conventional.

For a Spanish proposal to follow the Fukalova Fukalova *et al.* (2022) study, Purslane inclusions would be recommended on any iconic traditional Spanish foodie or gastronomic dish such as paella, 'gazpacho' cold silky tomato soup, 'tortilla española' Spanish potato omelette, cured ham, 'croquetas' fried bechamel croquettes, milanesa steak, 'albóndigas' meat balls, 'fideuá' vermicelli, 'patatas bravas' brave potatoes, 'fabada' broad bean-based pot, 'escalivada' roasted vegetables, Murcian salad, 'migas' fried breadcrumbs, any stew, 'arroz con leche' rice pudding, 'leche frita' fried milk pudding, 'churros' fried dough pastry, and fish choice, perhaps 'chipirones rellenos' stuffed baby squids, 'gambas al ajillo' garlic prawns, 'bacalao' salted cod, or 'marmitako' tuna soup. An idea for the unique tapas crawl, may become a popular Purslane promotion for family and friends in communal atmosphere. From the 12 Italo-Venezuelan specialties assessed here, the Purslane in pastella would be a good candidate for tapas.

A typical five-course meal consists of hors d'oeuvres, a plated appetizer, a palate-cleansing salad, the main entrée, and dessert. A soup between the appetizer and salad courses is an option if you omit the hors d'oeuvres. A 17 course French classical menu based on Purslane could be the scope of a future project after these results encouraged to revalue Purslane, and increasing research with 1,177 documents in the last decade.

Both the traditional, gourmet and innovative expectations, beside the social applications or veterinary uses, are possibilities of valid exploration and implementation. The undervalued Purslane nutritional qualities are available for all needs with no discrimination.

Conclusions

This bibliometric review identified the Asian interest on *P. oleracea* research, with Chinese leadership in productivity of countries, affiliations, and authors. Journals, and subject areas were ranked. Bibliometrix was useful to visualize top articles, topic trends, and clustering high frequency author's keywords using MCA and HCA factorial analysis. Purslane has medicinal and food uses as a vegetable, herb, and in technological preparations. Diverse applications of Purslane were reviewed on research to enrich hen meals, antioxidant role in heated oils, inclusions in Indian and Korean traditional food, yogurt fortified with extracts, bread enriched with leaf powder, quality of baby leaves in floating tray systems, enriched dough and breads, and advanced food technological approaches such as spray-dried microcapsules of Purslane in mango juice.

Nutritional parameters of five *P. oleracea* fractions were quantified with proximal analysis of ash, carbohydrates, fat, moisture, and protein contents. The inclusion of Purslane in familiar Italo-Venezuelan recipes was well accepted, and would be suitable for further sensory approaches. Mean liking score was higher in recipes with addition of fresh branches such as ceviche and risotto, than use of dried powders proposed for the preparation of dark arepa. A recent study optimized concentrations of *P. oleracea* leaf powder on dough and toast bread in Brazil for sensory best acceptance at 10% dosage causing an increase of ash, dietary-fiber, fat, moisture, and protein contents in the enhanced toast-bread (Sadeghzadeh *et al*., 2022). This impact of Purslane on bread enriched with its dried powders justify further research with the Venezuelan bread 'arepa'. The proposal of this underutilized weed with positive nutritional and sensory qualities is aligned to engage with a healthy planet of healthy people. Scholars benefit from science mapping giving intellectual structure to their disciplines and to policy-makers (Aria and Cuccurullo, 2017). This hybrid contribution is an evidence to advocate *P. oleracea* application in food science and technology.

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REVISIÓN BIBLIOMÉTRICA, COMPOSICIÓN PROXIMAL Y PROPUESTAS GASTRONÓMICAS DE LA SABROSA YERBA *Portulaca oleracea* L., LA PLANTA MÁS RICA EN ÁCIDOS GRASOS OMEGA 3 CONOCIDA COMO PURSLANE O VERDOLAGA

Patricia Vit, Bertha Santiago, Javier Ruiz, Rosa Alba Vielma, José Guevara y Zhengwei Wang

RESUMEN

La Verdolaga llamada 'Purslane' en inglés y 'Beldroega' en Brasil. Es una maleza frecuente de la familia Portulacaceae en los patios traseros pero poco utilizada como lo son los quelites mexicanos. Proponemos integrarlo en los huevos revueltos venezolanos conocidos como 'perico', arepa, lentejas, pasta, encurtidos, arroz, rebozados, ensalada, jugo, pescado, sopa y fresas. Se cuantificó el valor nutricional de plantas de P. oleracea de Mérida en hojas, frutos y tallos (delgados, medianos, grandes), comparando su contenido de cenizas, humedad, proteína, extracto etéreo y carbohidratos por análisis proximal. Se utilizó la base de datos Scopus para el primer estudio bibliométrico sobre los países más productivos, afiliaciones y autores en la última década (2011-2021), donde se recuperaron 1177 documentos de revistas en inglés para portulaca oleracea OR verdolaga, 975 artículos y 77 revisiones. China, Irán e India fueron los países más productivos con más de 100 documentos cada uno. Se tabularon las instituciones, autores y revistas más prolíficos para esta maleza de creciente interés científico, fácilmente disponible en los trópicos, con beneficios potenciales para la salud y la sociedad. Se utilizó Bibliometrix para generar gráficos sobre los documentos más citados a nivel global, tendencias en temas de investigación, análisis multivariados para un mapa de estructura conceptual y el dendrograma de temas que clasificó las palabras clave en un grupo de control de malezas más tres grupos de medicina, química y bioactividad, y bioensayos. Se realizó una investigación gastronómica adicional con P. oleracea añadida fresca, seca o cocida, entera, en hojas o tallos en 12 recetas Italo-Venezolanas, y se determinó su aceptación mediante una escala Likert de 7 puntos con un panel de 24 evaluadores, donde la inclusión en recetas de ceviche y risotto obtuvieron la puntuación máxima de 7. Esta contribución híbrida sobre bibliometría y ciencia de los alimentos es una evidencia para justificar la aplicación de P. oleracea en la ciencia y tecnología de los alimentos por parte de los formuladores de políticas.

REVISÃO BIBLIOGRÁFICA, COMPOSIÇÃO PROXIMAL E PROPOSTAS GASTRONÔMICAS DA SABOROSA ERVA DANINHA *Portulaca oleracea* L., A PLANTA MAIS RICA EM ÁCIDO GRAXO ÔMEGA 3 CONHECIDA COMO PURSLANE OU BELDROEGA

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RESUMO

Beldroega é chamado de 'Verdolaga' na Venezuela e 'Purslane' em inglês. É uma erva daninha frequente da família Portulacaceae em quintais mas pouco utilizada como as quelites mexicanas. Propomos integrá-lo nos ovos mexidos venezuelanos conhecidos como 'perico', arepa, lentilhas, massas, picles, arroz, empanados, salada, sumo, peixe, sopa e morangos. Os dados nutricionais de plantas de P. oleracea de Mérida foram quantificados em folhas, frutas e caules (finos, médios, grandes), comparando seus teores de cinzas, umidade, proteína, extrato etéreo e carboidratos por amálise centesimal. A base de dados Scopus foi utilizada para o primeiro estudo bibliométrico sobre os países, afiliações e autores mais produtivos na última década (2011-2021), onde foram recuperados 1177 documentos de periódicos em inglês para portulaca oleracea OR purslane, 975 artigos e 77 revisões. China, Irã e Índia foram os países mais produtivos com mais de 100 documentos cada. As instituições, autores e revistas mais prolíficos foram tabulados para esta erva de crescente interesse científico, facilmente disponível nos trópicos, com potenciais benefícios sociais e de saúde. O Bibliometrix foi utilizado para executar gráficos em os documentos mais citados globalmente, trending topics de pesquisa, a análise multivariada para o mapa conceitual e o dendrograma de tópicos que classificou as palavras-chave em um cluster de controle de plantas daninhas mais três clusters sobre medicina, química e bioatividade e bioensaios. Uma nova investigação gastronômica foi feita com a inclusão de P. oleracea fresca, seca ou cozida, inteira, folhas ou caules em 12 receitas Italo-Venezuelanas, e sua aceitação foi determinada usando uma escala Likert de 7 pontos com um painel de 24 avaliadores, onde a inclusão nas receitas de ceviche e risoto obteve a aceitação máxima de 7. Esta contribuição híbrida em bibliometria e ciência de alimentos é uma evidência para defender a aplicação de P. oleracea em ciência e tecnologia de alimentos por formuladores de políticas.