Ethnopharmacological investigation and traditional cultural use of anticancer medicinal plants in Morocco's Casablanca-Settat region

Omaima Boudaia, Amal El Hamsas El Youbi, Zineb Sekkout, Souha Sahraoui, Chorouk Moustakbal, Nabil Ismaili, Najat El Amrani and Driss Radallah

Correspondence

Omaima Boudaia[1,*], Amal El Hamsas El Youbi[1], Zineb Sekkout[1], Souha Sahraoui[2], Chorouk Moustakbal[2], Nabil Ismaili[3], Najat El Amrani[1] and Driss Radallah[1]

[1]Laboratory of Biology and Health, Faculty of Sciences Ben M'Sik, University Hassan II, Casablanca, Morocco.
[2]Department of Radiotherapy, Hospital Center Ibn Rochd, Faculty of Medicine and Pharmacy, University Hassan II, Casablanca, Morocco.
[3]Department of Oncology, Faculty of Medicine, Mohammed VI University of Health Sciences/Cheikh Khalifa International University Hospital, Casablanca, Morocco.

*Corresponding Author: omaima.boudaia@gmail.com

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Research

Abstract

Background: This ethnopharmacological study investigated the usage of medicinal plants by the Moroccan population in the Casablanca-Settat region for combating different types of cancer, aiming to document the traditional knowledge of medicinal plant use passed down through generations, in the area, particularly in the context of cancer treatment.

Methods: Using a pre-established questionnaire, the study covered both urban and rural communities in the Casablanca-Settat region, involving 321 cancer patients and 33 herbalists and traditional practitioners over an 11-month period, from November 2021 to October. Data analyses employed ethnobotanical indices, including use value (UV), family use value (FUV), plant part value (PPV), factor informant consensus (FIC), and fidelity level (FL).

Results: The research revealed a diverse range of participants' age, with females comprising the predominant users of medicinal plants. The FIC method identified distinct patterns of medicinal plant usage for various cancers. Throughout the investigation, a total of 90 plant species were identified, of which four are endemic to Morocco, belonging to 54 families. Commonly utilized families included Pinaceae (FUV=0.150), Aristolochiaceae (FUV=0.119), Berberidaceae (FUV=0.102), and Lamiaceae (FUV=0.076). *Marrubium vulgare* (UV=0.534) was the most frequently mentioned species. The study highlighted that plant leaves were the most utilized parts, with decoction and oral route being the preferred methods of preparing and administering the herbal treatments, respectively. Moreover, toxic plants, notably *Aristolochia clematitis*, were also identified, posing risks like severe kidney damage.k

Conclusions: This research provides valuable insights into traditional medicinal practices in the region and their potential applications in cancer treatment.

Keywords: Casablanca-Settat region, Ethnopharmacology Investigation, Traditional Cultural Use, Medicinal Plants, Cancer disease

Background

Cancer represents a major public health problem that imposes a heavy economic, health, and social burden, and unfortunately, lacks a global solution, as highlighted in the United Nations High-Level Meeting on Non-Communicable Diseases (Obtel *et al.* 2015, Fitzmaurice *et al.* 2019). According to the World Health Organization (WHO), the prevalence of cancer worldwide is increasing at an alarming rate, with 19.3 million new cases reported in 2020 (Sung *et al.* 2021). Furthermore, the projected mortality rate for 2030 is expected to reach 23.6 million cases per year (Elidrissi Errahhali *et al.* 2016, Hamadeh *et al.* 2017). In Morocco, cancer tends to be the second leading cause of mortality after cardiovascular diseases, accounting for approximately 10.7 % of all deaths (Elidrissi Errahhali *et al.* 2016). The annual incidence of this disease is estimated at around 30,500 new cases per year nationwide, with 16,775 cases reported in females and 13,725 in males (Fouhi *et al.* 2020). Faced with this situation, the use of medicinal plants as natural remedies to treat various diseases, including cancer, has become a preferred and widely adopted practice in both developed and developing countries. This practice offers several advantages, such as lower treatment costs compared to conventional treatments and the potential curative effects attributed to the presence of bioactive molecules with promising pharmacological properties (Awan *et al.* 2011, Skalli & Jordan 2017, Tazi *et al.* 2013). Moreover, this therapeutic approach provides better accessibility and knowledge compared to conventional treatments (Tazi *et al.* 2013). In Morocco, the knowledge of using medicinal plants has deep roots in ancestral traditions (El Midaoui *et al.* 2011). The methods and techniques for preparing natural herbal remedies have been passed down from one generation to another, through either oral transmission or written documentation (El Hamsas El Youbi *et al.* 2016, Amrati *et al.* 2021). The country's ecological diversity and botanical richness have resulted in an impressive array of approximately 5,200 plant species and subspecies, of which around 600 are recognized for their medicinal and/or aromatic properties, offering potential treatment for various ailments, including cancer (El Hamsas El Youbi *et al.* 2016, Barkaoui *et al.* 2017). In this context, our study aimed to identify and compile a comprehensive inventory of the medicinal plants employed in cancer treatment by the population of the Casablanca-Settat region and to describe the cultural traditions associated with their use in this region.

Materials and Methods

Study area

The Casablanca-Settat region, situated in the west-central part of Morocco (Figure 1), encompasses an area of 19,448 square kilometers and is inhabited by a population of 6.862 million, resulting in a population density of 353 people per square kilometer. This region comprises 2.7% of the total national land area. Within the Casablanca-Settat region, there are seven provinces: Settat, Berrechid, Sidi Bennour, El Jadida, Mediouna, Nouaceur, and Benslimane, along with the prefectures of Casablanca, and Mohammedia (Figure 1). The region also consists of 153 municipalities, with 28 being urban and 127 rural, making up about 10% of all the municipalities in the entire country (Ministry of Equipment and Water 2014).

The Casablanca-Settat region experiences a Mediterranean climate characterized by cold and rainy winters as well as hot and humid summers. The annual rainfall rate varies between 220 and 760 mm, and the average temperature throughout the year is 22°C. The region usually experiences a UV index of five. Geographically, the area of Casablanca-Settat can be divided into to three distinct morphological units. The first unit comprises the coastline, stretching approximately 235 Km along the region's border. The second unit consists of plains and plateaus with scattered small hills, primarily located near the cities of Casablanca and El Jadida. Lastly, the Sahel region is part of the semi-arid domain, characterized by alternating depression and consolidated dunes. In addition to its diverse topography, the region of Casablanca-Settat boasts a rich variety of plant species and varieties, largely due to its extensive forest cover. Forests encompass nearly 114,107 hectares, representing approximately 6% of the total regional territory (Haut-Commissariat au Plan 2020). This abundance of natural vegetation contributes to the ecological richness and biodiversity of the region.

Study population

This survey was conducted in the Casablanca-Settat region of Morocco, encompassing diverse groups of participants, including herbalists, traditional healers, and individuals diagnosed with various types of cancer. The study involved cancer patients from two prominent healthcare facilities in Casablanca: the renewed Center of Cancer Treatment of Mohammed VI and the esteemed oncology department of Cheikh Khalifa International University Hospital.

Study period

This survey was conducted from November 28, 2021, to October 05, 2022, and it involved oral interviews conducted in Moroccan Arabic.

Study design and questionnaire conception

Participation in the survey was entirely voluntary, and no form of inducement or payment was provided to the participants. Each individual who expressed willingness to take part in the study was provided with detailed information about the research and its intended scientific publication. Subsequently, the interviewer recorded the participants' responses on the provided questionnaire sheets.

The questionnaire was structured in three parts. The first part aimed to gather socio-cultural and demographic information about the participants, including their name, gender, age, civil status, residency, level of education, and occupation. The second part focused on collecting data related to the specific cancer condition of the participants. This included details such as the type of cancer they were diagnosed with, the period and type of treatment they underwent, their satisfaction rate with the treatment, and any signs of improvement or cure they might have experienced. The third part of the questionnaire was dedicated to exploring the traditional knowledge of the respondents regarding medicinal plants used in the treatment of various types of cancer. This section inquired about the Arabic vernacular names of the plants, the scientific names of the species, and families to which they belong, the specific part of the plant used for treatment, the method of preparation, the route of administration, the recommended dosage, and the duration of treatment.

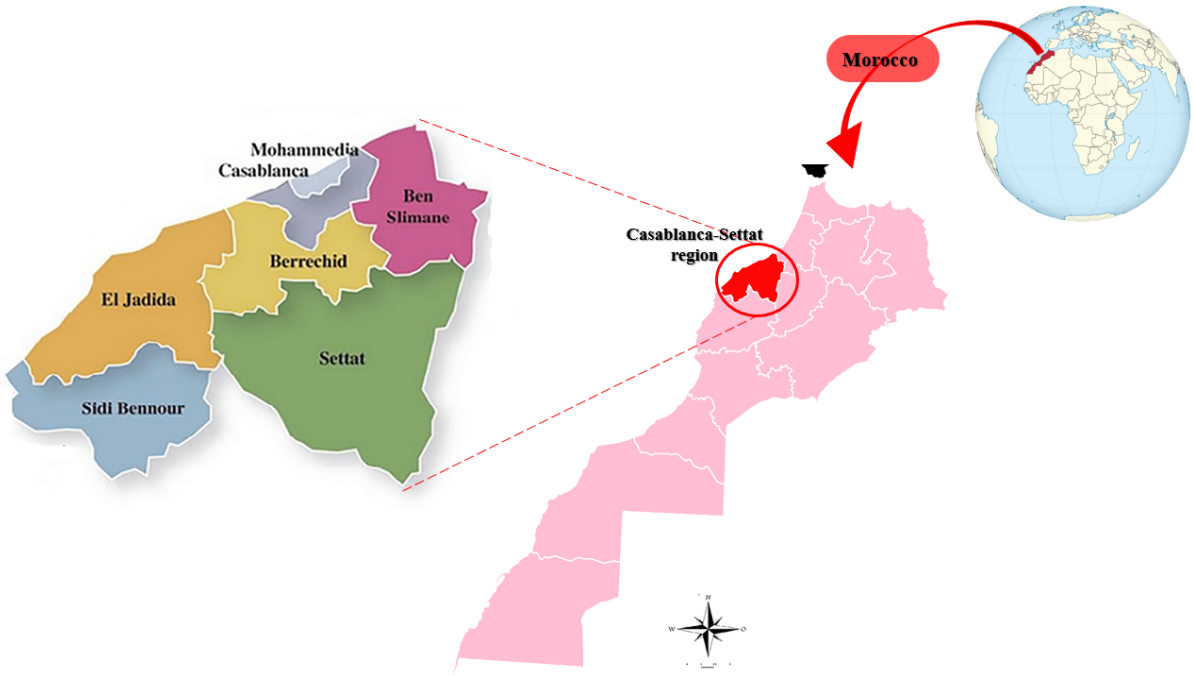

Figure 1. Map of the Casablanca-Settat region

Statistical analysis

The collected information was initially recorded on raw data sheets and subsequently entered into a database for statistical analysis using Microsoft Excel software, version 2016. The analysis encompassed both qualitative and quantitative variables. For the qualitative variables, the data were represented in tabular form, consisting of vernacular, scientific, and botanical names of all recorded plants, along with information regarding their traditional use such as used parts, methods of preparation, and administration routes.

Concerning the quantitative variables, a more detailed analysis was conducted, taking into consideration the following five factors:

Use Value (UV): This factor assisted in determining the local significance of each species recorded in the survey (Da Silva *et al.* 2014). It was calculated by considering the number of respondents mentioning a specific species relative (U_i) to the total number of informants (N).

$$UV = \Sigma U_i / N$$

Family Use Value (FUV): This index was employed in ethnobotanical studies to evaluate the cultural significance of a plant taxon and identify its importance within a specific family (Da Silva *et al.* 2014). It was calculated by considering the use value of each species in the family relative (UVs) to the total number of species within that family (Ns).

$$FUV = \Sigma UVs / Ns$$

Plant Part Value (PPV): This factor identified the specific plant part most frequently used by the respondents (Da Silva *et al.* 2014). It was calculated by considering the number of informants using a particular plant part relative (RUpp) to the total number of all parts recorded by participants (RU).

$$PPV = \Sigma RUpp / RU$$

Fidelity Level (FL): This percentage was used to assess the agreement among informants regarding the use of a plant species to treat a specific condition, in this case, a type of cancer. It was calculated by comparing the number of informants (I_p) citing the use of a species for the same major condition (type of cancer) relative to the total number of informants (I_n) who reported using the same plant to treat any type of cancer (Friedman *et al.* 1986).

$$FL = (I_p/I_n) \times 100$$

Factor Informant Consensus (FIC): This factor evaluated the diversity of plant consumption patterns concerning the different studied pathologies (Heinrich *et al.* 1998). It was calculated by considering the number of citations of medicinal plants for each category of studied pathology (N_{ur}) and comparing it with the number of plants used to treat the same category of pathology (N_t) (Rana *et al.* 2021).

$$FIC = (N_{ur} - N_t) / (N_{ur} - 1)$$

Results

Socio-demographic data

The demographic data parameters of the interviews are summarized in Table 1. Out of the 354 individuals who took part in the survey, the majority, 90.68% (321 participants), were cancer patients, while the remaining 9.32% (33 participants) were herbalists and traditional healers. Among the cancer patients, females constituted 87.23% (280 participants), whereas males accounted for only 12.77% (41 participants). The most prevalent marital status among the surveyed population was married, comprising 76.01% of the participants, followed by single individuals at 10.59%, divorced individuals at 5.61%, and widowed individuals at 7.79%. The age range of cancer patients varied from 1 year to 89 years, with an average age of 53 ± 13 years. Regarding educational background, 58.26% of the participants diagnosed with cancer were illiterate, 14.95% had completed primary education, 21.18% had completed secondary education, and 5.61% had attained a university education. Geographically, 87.23% of the cancer patients resided in urban areas, while the remaining 12.77% lived in rural areas (Table 1).

For herbalists and traditional healers, there were 28 men and five women, representing 84.85% and 15.15% of the group, respectively. The majority of herbalists were married (84.85%), followed by single individuals (12.12%), while divorced and widowed individuals accounted for 3.03% and 0%, respectively. The age range of the herbalists and traditional healers varied from 20 years to 99 years, with an average age of 47 ± 15 years. In terms of education, 54.55% of herbalists had a university education, 27.27% had completed secondary education, 3.03% had completed primary education, and 15.15% were illiterate. Geographically, 87.88% of herbalists and traditional healers resided in urban areas, with the remaining 12.12% living in rural areas (Table 1).

Table 1. Demographic description of the interviews

Variables		**Number of informants**		**Percentage (%)**	
		Patients	**Herbalists and traditional healers**	**Patients**	**Herbalists and traditional healers**
Gender	Women	280	5	87.23%	15.15%
	Men	41	28	12.77%	84.85%
Civil status	Single	34	4	10.59%	12.12%
	Married	244	28	76.01%	84.85%
	Divorce	18	0	5.61%	0.00%
	Widow	25	1	7.79%	3.03%
Age-group	[01-19]	1	0	0.31%	0.00%

	[20-29]	10	3	3.12%	9.09%
	[30-39]	31	10	9.66%	30.30%
	[40-49]	84	8	26.17%	24.24%
	[50-59]	95	5	29.60%	15.15%
	[60-69]	54	4	16.82%	12.12%
	[70-79]	40	2	12.46%	6.06%
	[80-89]	6	0	1.87%	0.00%
	[90-99]	0	1	0.00%	3.03%
Education level	Illiterate	187	5	58.26%	15.15%
	Primary	48	1	14.95%	3.03%
	Secondary	68	9	21.18%	27.27%
	University	18	18	5.61%	54.55%
Locality	City	280	29	87.23%	87.88%
	Village	41	4	12.77%	12.12%
Total		**321**	**33**	**90.68%**	**9.32%**

Geographic distribution of interviews

Figure 2 and Table 2 illustrate the geographical distribution of informants in the Casablanca-Settat region based on its provinces and prefectures.

Among the 354 local informants interviewed, 69.77% of them (247 participants) belong to the prefecture of Casablanca, with 95.55% being cancer patients and 4.45% being herbalists. The province of Settat followed with 42 respondents (11.86%), comprising 80.95% cancer patients and 19.05% herbalists. The provinces of El Jadida and Berrechid accounted for 5.65% each (20 participants), with 95% of them being cancer patients and 5% being herbalists. Similarly, the province of Mediouna had a distribution rate of 2.54%, Sidi Bennour 1.98%, Benslimane 1.69%, and Nouaceur 1.41% (Table 2). In contrast, the prefecture of Mohammedia had only two herbalists participating, representing 0.56% of the total (Figure 2, Table 2).

The data presented in Figure 2 and Table 2 demonstrate that the prefecture of Casablanca had the highest number of informants (247), while the prefecture of Mohammedia (2) and the provinces of Settat, El Jadida, Berrechid, Mediouna, Sidi Bennour, Benslimane had relatively lower numbers of informants (Figure 2, Table 2).

Table 2. Distribution of informants by provinces and prefectures

Provinces and Prefectures	**Total**	**Percentage**	**Participants**	
			Patients with cancer	**Herbalists and Healers**
Casablanca	247	69.77%	236	11
			95.55%	4.45%
Settat	42	11.86%	34	8
			80.95%	19.05%
El Jadida	20	5.65%	19	1
			95.00%	5.00%
Berrechid	16	4.52%	13	3
			81.25%	18.75%
Mediouna	9	2.54%	4	5
			44.44%	55.56%
Sidi Bennour	7	1.98%	6	1
			85.71%	14.29%
Benslimane	6	1.69%	5	1
			83.33%	16.67%
Nouaceur	5	1.41%	4	1
			80.00%	20.00%
Mohammedia	2	0.56%	0	2
			0.00%	100.00%
Total	**354**	100%	321	33
			90.68%	9.32%

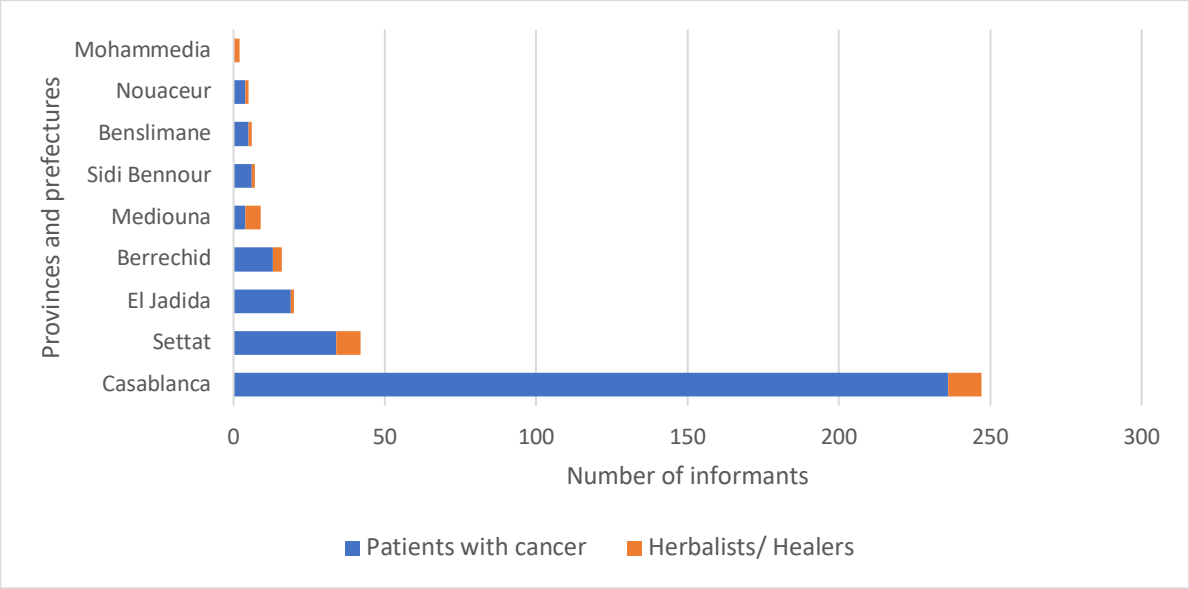

Figure 2. Number of informants by provinces and prefectures

Clinical data

As shown in Table 3, the survey included 321 cancer patients, and they were found to have 22 different types of cancer. The most prevalent type was breast cancer, accounting for 43.15% of the cases (233 patients), followed by uterine cancer at 20.56% (111 patients). Cancers related to the gastrointestinal tract, such as intestine and stomach cancers, comprised 8.33% and 4.26%, respectively (Table 3). Lung cancer and prostate cancer were observed in 22 and 15 patients, representing percentages of 4.26% and 4.07%, respectively. Brain and lower limb cancers had similar frequencies with a rate of 1.85% (10 patients), while skin, ovarian, blood, and bone cancers occurred in 1.67% of cases (9 patients). Bladder and esophagus cancers accounted for 1.48% and 1.30% of the cases, respectively (8 and 7 patients). The study population also included other types of cancer, such as jawbone, armpit, eye, mouth, tonsil, liver, arm, and bone marrow cancers, each with a frequency of less than 1% and a population of no more than four patients (Table 3).

Regarding the FIC value analysis of the surveyed data (Table 3), a high FIC value was observed in two types of cancer, affecting the feet and the eyes (FIC=1). Breast cancer had a FIC value of 0.83, while uterine, intestine, and brain cancers showed a FIC value of 0.79. Bone cancer presented a FIC value of 0.75, dermal and maxillary cancer scored 0.67, and prostate cancer had a FIC value of 0.65. The FIC value for ovarian cancer was 0.63, bladder cancer was 0.60, and both upper limb cancer and stomach cancer exhibited a FIC value of 0.50. Lung cancer had a FIC value of 0.36, underarm cancer was 0.25, and liver cancer had the lowest FIC value of 0.11. On the other hand, a FIC value of zero was reported for leukemia, mouth, tonsil, and bone marrow cancers (Table 3).

Table 3. Different cancer types cited and their FIC value

Type of cancer	Frequency	Percentage	FIC
Breast cancer	233	43.15%	0.83
Uterine cancer	111	20.56%	0.79
Intestine cancer	45	8.33%	0.79
Stomach cancer	23	4.26%	0.40
Lung cancer	22	4.07%	0.36
Prostate cancer	15	2.78%	0.65
Brain cancer	10	1.85%	0.79
Foot cancer	10	1.85%	1.00
Skin cancer	9	1.67%	0.67
Ovarian cancer	9	1.67%	0.63
Bones cancer	9	1.67%	0.75
Blood cancer	9	1.67%	0.00
Bladder cancer	8	1.48%	0.60
Esophagus cancer	7	1.30%	0.00

Jaw cancer	4	0.74%	0.67
Underarm cancer	3	0.56%	0.25
Eye cancer	3	0.56%	1.00
Oral cavity cancer	3	0.56%	0.00
Tonsil cancer	2	0.37%	0.00
Liver cancer	2	0.37%	0.11
Arm and hand cancer	2	0.37%	0.50
Bone marrow cancer	1	0.19%	0.00

Treatments used by cancer patients

The survey results revealed the presence of two categories of patients. The first category, which constituted 91.28% of the interviewed patients, relied on conventional treatments such as chemotherapy, surgery, and radiotherapy, along with the use of phytotherapy. On the other hand, the second category, representing 8.72% of the patients, exclusively relies on phytotherapy and traditional therapies for the treatment of various types of cancer.

Medicinal plants used for cancer treatment

Botanical families used to treat cancer and their family use value

Table 4 provides comprehensive ethnopharmacological information on the medicinal plants utilized for the treatment of cancer in the Casablanca-Settat region. It includes details such as the scientific name, botanical family, vernacular name, the specific plant part used, the method of preparation, the administered doses, and the duration of treatment. Additionally, the table presents data on the number of citations, Use Value (UV), and Family Use Value (FUV) for each plant species.

According to the results obtained, the survey identified a total of 90 plant species belonging to 54 families in the Casablanca-Settat region (Table 4). Among these families, the most frequently cited ones were Asteraceae with nine species, followed by Lamiaceae with eight species, and Apiaceae with seven species (Table 4). On the other hand, 44 families represented the least cited botanical families in the study area, such as Annonaceae, Apocynaceae, and Araliaceae (Table 4). Related to the FUV index, the family Pinaceae had the highest FUV value of 0.150, indicating its significant cultural importance in traditional cancer treatments. It was followed by Aristolochiaceae (FUV=0.119), Berberidaceae (FUV=0.102), and Lamiaceae (FUV=0.076) (Figure 3). Conversely, 40 families, including Alariaceae, Apocynaceae, and Bignoniaceae, displayed lower FUV values, all below 0.016 (Figure 3). These families were less frequently utilized in traditional cancer treatments in the region.

Table 4. Medicinal plants traditionally used to treat cancer by the population of the Casablanca-Settat region

Families	Species	Vernacular names in Arabic	Used parts	Methods of preparation	Doses administrated	Treatment periods	Number of citations	UV	FUV
Alariaceae	*Undaria pinnatifida* (Harvey) Suringar	Wakami	Leaves, Stems, roots	Raw, decoction	Not defined	Not defined	1	0.003	0.003
Amaryllidaceae	*Allium cepa* L.	Basla hamra	Bulbs	Juice	1 cup/day	7 months	14	0.040	0.040
	Allium sativum L.	Tûm	Bulbs	Infusion, decoction, poultice, hydrodistillation	2-3 spoons/day, 1-3 cups/days	3 months	14	0.040	
Annonaceae	*Annona muricata* L.	Graviola	Fruits, Leaves	Raw, capsules, powder	Not defined	Not defined	2	0.006	0.006
Apiaceae	*Ammodaucus leucotrichus* Coss.	Kammun es-sôfi	Leaves, Stems, roots	Decoction	1 cup/day	1 week	6	0.017	0.007
	Carum carvi L.	Karwiya	Leaves	Powder	1 spoon/day	Not defined	2	0.006	
	Coriandrum sativum L.	Qezbôr	Leaves	Juice	1 cup/day	Not defined	1	0.003	
	Foeniculum vulgare Mill.	Nafa'	Seeds	Powder, decoction	2 spoons/day, 1 cup/day	Not defined	4	0.011	
	Petroselinum crispum (Mill.) Fuss subsp. *crispum*	Ma'adnous	Seeds	Infusion	1-3 cups/day	1-2 weeks	1	0.003	
	Pimpinella anisum L.	Habbat hlâwa	Seeds	Infusion	1 cup /day	1 month	1	0.003	
Apocynaceae	*Nerium oleander* L.	Defla	Flowers	Decoction	1 time/ day	Not defined	1	0.003	0.003
Araliaceae	*Panax ginseng* C.A.Mey.	Jisink	Roots	Maceration	1 cup/day, 1 spoon/morning	3 months	2	0.006	0.006
Arecaceae	*Phoenix dactylifera* L.	Ttemra, tal3 nakhil	Fruits, pollen	Raw, capsules	3 date fruit/day	7-15 days	2	0.006	0.006
Aristolochiaceae	*Aristolochia clematitis* L.	Bereztom	Roots	Powder, decoction	1-2 cups/day, 2-3 granules/day	3 months, 1-2 weeks	42	0.119	0.119
Asphodelaceae	*Aloe vera* (L.) Burm.f.	Sibr	Leaves	Juice	1-3 cups/day	3 months	4	0.011	0.011
Asteraceae	*Artemisia herba-alba* Asso	Chîh	Roots	Powder	2 cups /day, 1 spoon/morning	3 months, 15 days	31	0.088	0.015

	Cynara cardunculus L.	Khorchef	Leaves, Stems, roots	Infusion	1 cup/day	3 months	3	0.008	
	Artemisia arborescens L.	Chiba	Leaves	Decoction	1 cup/day	40 days	1	0.003	
	Chamaemelum nobile (L.) All.	Bâbûnaj	Leaves, Stems, roots	Powder, decoction, infusion, fumigation	Not defined	Not defined	1	0.003	
	Echinops spinosissimus Turra	Taskra	Leaves	Maceration	1 cup/day	Not defined	2	0.006	
	Anacyclus pyrethrum (L.) Lag.	Taqendicht	Roots	Powder, decoction	1 granule/day	Not defined	2	0.006	
	Echinops spinosissimus subsp. *spinosissimus*	Chuk aj-jmâl	Roots	Infusion, decoction	1 granule/day	Not defined	1	0.003	
	Dolomiaea costus (Falc.) Kasana & A.K.Pandey	Qist al-hindi	Leaves, Stems	Decoction	2 cups/day	3 months	7	0.020	
	Cichorium intybus L.	Hindabâ	Roots	Powder	Not defined	Not defined	1	0.003	
Berberidaceae	*Berberis vulgaris* subsp. *australis* (Boiss.) Heywood.	Aghris, aghras	Barks, Leaves	Powder, decoction	1/2 spoon/day, 1 cup in 2 days, 1-3 granules/day	3 months	36	0.102	0.102
Bignoniaceae	*Handroanthus lapacho* (K.Schum.) S.O.Grose	Labatshu	Barks	Infusion	1 cup/day	Not defined	1	0.003	0.003
Brassicaceae	*Lepidium sativum* L.	Habb er-rchad	Seeds	Raw	7 seeds/ day	5 months	2	0.006	0.006
Cactaceae	*Selenicereus undatus* (Haw.) D.R.Hunt	Fakihat al-tinin	Fruit	Raw	1 fruit/day	Not defined	3	0.008	0.008
Camelliaceae	*Camellia sinensis* (L.) Kuntze	Atay	Leaves	Infusion	6 cups/day	Not defined	2	0.006	0.006
Capparidaceae	*Capparis spinosa* L.	Kabâr	Fruits	Decoction	1 cup/day	Not defined	2	0.006	0.006
Chenopodiaceae	*Beta vulgaris* L.	L-barba	Bulbs	Juice	1-3 cups/day	Not defined	2	0.006	0.006
Chlorellaceae	*Chlorella vulgaris* Beijerinck	Klorila	Leaves, Stems, roots	Powder	2-5g/day	Not defined	8	0.023	0.023
Ephedraceae	*Ephedra alata* Decne.	L-'a-lenda	Leaves	Decoction	2 cups/day	3 months	7	0.020	0.020

Euphorbiaceae	*Euphorbia officinarum* subsp. *echinus* (Hook.f. & Coss.) Vindt	Ddaghmûs	Leaves, latex	Powder, decoction	1 spoon/day, 1-3 cups/ day	40 days	15	0.042	0.027
	Euphorbia resinifera O.Berg	Zaqqûm	Leaves	Infusion	3 granules, 1 cup/morning	Not defined	4	0.011	
Fabaceae	*Ceratonia siliqua* L.	L-kherrôb	Fruits	Maceration	1 cup/day	Not defined	1	0.003	0.021
	Cicer arietinum L.	Hamos	Seeds	Cooked	1 time/day	1 month	1	0.102	
	Retama sphaerocarpa L.	Rrtem	Leaves	Decoction	1 cup/day	2 months	1	0.003	
	Senna alexandrina Mill.	Sannâ mekkâ	Flowers	Decoction	1 cup/day	Not defined	1	0.003	
	Trigonella foenum-graecum L.	L-helba	Seeds	Infusion, germination	1 cup/morning	Not defined	8	0.006	
	Vachellia seyal (Delile) P.J.H.Hurter	L-'alk	Latex	Decoction	1 cup /day	Not defined	4	0.011	
Gentianaceae	*Schenkia spicata* (L.) G.Mans.	Gosset l-hayya	Leaves, Stems	Decoction	1 cup/day	1 month	3	0.008	0.008
Ginkgoaceae	*Ginkgo biloba* L.	Jinko do chiqayn	Leaves	Decoction	1 cup/day	3 months	3	0.006	0.008
Hericiaceae	*Hericium erinaceus* (Bull.) Pers	Orf al-âsad	Fruit	Powder, capsules	1g/day	28 days	2	0.006	0.006
Hypercaceae	*Hypericum perforatum* L.	Hirfariqoun	Leaves	Infusion	3 cups/day	3 months	1	0.003	0.003
Iridaceae	*Crocus sativus* L.	Za'fran	Flowers	Powder	2 spoons/day	90 days	2	0.006	0.006
Lamiaceae	*Ajuga iva* (L.) Schcreb.	Chendgoura	Leaves	Infusion	1 cup/day	Not defined	1	0.003	0.076
	Lavandula angustifolia subsp. *angustifolia*	Khzama	Leaves, flowers	Decoction	1-4 times/day	Not defined	1	0.003	
	Origanum compactum Benth.	Za'tar	Leaves	Cooked, decoction, poultice	1-2 cups/day	3 months	10	0.028	
	Salvia rosmarinus Spenn.	Azir	Leaves	Infusion	1-2 cups/day	3 months, 10 months	10	0.028	
	Thymus saturejoides Coss.	Z'itra	Leaves, Stems, roots	Infusion	Not defined	Not defined	1	0.003	
	Origanum majorana L.	Merdedûch	Leaves	Infusion, decoction, hydrodistillation	Not defined	Not defined	1	0.003	

	Marrubium vulgare L.	Merriwut	Leaves, Stems, roots	Infusion	1 cup/morning	15-21 days, 1 week per month	189	0.534	
	Salvia officinalis L.	Sâlmiya	Leaves, Stems, roots	Infusion	Not defined	Not defined	1	0.003	
Laminariaceae	*Saccharina japonica* (Aresch.) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	Kombo	Leaves, Stems, roots	Raw, decoction	Not defined	Not defined	1	0.003	0.003
Lauraceae	*Camphora officinarum* Nees	Kâfûr	Barks	Maceration	1 cup/day	Not defined	1	0.003	0.003
Linaceae	*Linum usitatissimum* L.	Zerri'at l-kettân	Seeds	Powder, raw	25g, 7 seeds/day	3-5 months	4	0.011	0.011
Loganiaceae	*Strychnos nux-vomica* L.	Ech el-ghorâb	Seeds	Decoction	2 g/day	3 months	1	0.003	0.003
Lythraceae	*Punica granatum* L.	Roman	Fruits	Juice	1/4L/day	Not defined	1	0.003	0.003
Malvaceae	*Adansonia digitata* L.	Bawbab, tabeldi	Fruits	Powder	2 spoons/day	Not defined	1	0.003	0.003
Microcoleaceae	*Arthrospira platensis* Gomont	Spirulina	Leaves, Stems, roots	Powder, capsules	2g/day	Not defined	21	0.059	0.059
Moraceae	*Ficus carica* L.	Chriha	Fruit	Raw	7 fruits/day	Not defined	1	0.003	0.003
Moringaceae	*Moringa oleifera Lam.*	Moringa	Leaves, roots	Infusion	1 cup/day	4 months	7	0.020	0.020
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Qoronfel	Flowers	Infusion, decoction, ethanolic extraction	3 cups/day, massage every day	Not defined	6	0.017	0.008
	Eucalyptus camaldulensis Dehnh.	Kalibtûs	Leaves	Infusion, fumigation	2 times/day	Not defined	2	0.006	
	Myrtus communis L.	Rïhân	Leaves	Infusion	Not defined	Not defined	1	0.003	
Nitrariaceae	*Peganum harmala* L.	Harmel	Seeds	Powder	1 spoon/day	Not defined	5	0.014	0.014
Oleaceae	*Olea europaea* L.	Zaytûn	Leaves, fruits	Decoction	2 cups/day	3 months	3	0.008	0.008

Ophiocordycipitaceae	*Ophiocordyceps sinensis (*Berk.) Sung, Sung, Hywel-Jones and Spatafora	Cordiceps	Fruits	Capsules	1-2 capsules/day	Not defined	1	0.003	0.003
Pinaceae	*Cedrus atlantica* (Endl.) Manetti ex Carrière	Qitrân er-raqîq	Barks	Decoction	1 cup/day	Not defined	53	0.150	0.150
Poaceae	*Hordeum vulgare* L.	Ech'ir	Seeds	Cooked	1 bowl/day	Not defined	1	0.003	0.003
Polyporaceae	*Ganoderma lucidum* (Curtis) P.Karst.	Fiter al-richi	Fruits	Powder, capsules	1-3g/day	28 days	12	0.034	0.034
Ranunculaceae	*Nigella sativa* L.	Sanûj, haba sawdaa	Seeds	Decoction, infusion, powder	9 g/day, 4 spoon/day	3 months	7	0.020	0.020
Rhamnaceae	*Ziziphus lotus* (L.) Lam.	Sedra	Leaves	Infusion	1 cup/day	1 month	1	0.003	0.003
Rosaceae	*Prunus amygdalus* Batsch	Lûz hârr	Seeds	Raw	1 date/day	Not defined	1	0.003	0.003
	Prunus armeniaca L.	Mechmach	Seeds	Powder	9,6,3 spoons/day	3 days	1	0.003	
	Prunus avium L.	Habb el-mlûk	Barks	Powder	1 spoon/day	Not defined	1	0.003	
	Rosa × *damascena* Herrm.	Werd	Flowers	Infusion	Not defined	Not defined	1	0.003	
Rubiaceae	*Morinda citrifolia* L.	Morinizi	Fruits	Juice	3 cups/day	28 days	8	0.023	0.023
Rutaceae	*Citrus* x *limon* (L.) Osbeck	Hâmmed	Fruits	Decoction	1 cup/day, 2 cups/day	3 months	1	0.003	0.003
Salvadoraceae	*Salvadora persica* L.	Arâk	Barks	Decoction	3 cups/day	Not defined	4	0.011	0.011
Simaroubaceae	*Eurycoma longifolia* Jack	Esa 'li	Roots	Powder	1 spoon/day	Not defined	1	0.003	0.003
Smilacaceae	*Smilax aspera* L.	Ullîq	Roots	Decoction	3 cups/day	3 months	1	0.003	0.003
Solanaceae	*Hyoscyamus albus* L.	Sikran	Leaves	Powder	1/2 spoon/day	Not defined	1	0.003	0.006
	Solanum linnaeanum Hepper & P.-M.L.Jaeger	Hedja	Fruits	Decoction	1 cup, 2 times/week	Not defined	3	0.008	
Urticaceae	*Urtica urens* L.	L-hurrîga	Leaves	Infusion	3 cups/day	Not defined	2	0.006	0.006

Zingiberaceae	*Curcuma longa* L.	Kharqum	Roots	Decoction, maceration	1 cup/morning	21 days	19	0.054	0.016
	Zingiber officinale Roscoe	Skenjbîr	Roots	Decoction	2 cups/day	3 months	2	0.006	
	Alpinia officinarum Hance	Khodenjal	Stems	Decoction, raw	3 cups/day	1 month	1	0.003	
	Elettaria cardamomum (L.) Maton	Qa'qolla	Seeds	Decoction	Not defined	Not defined	1	0.003	

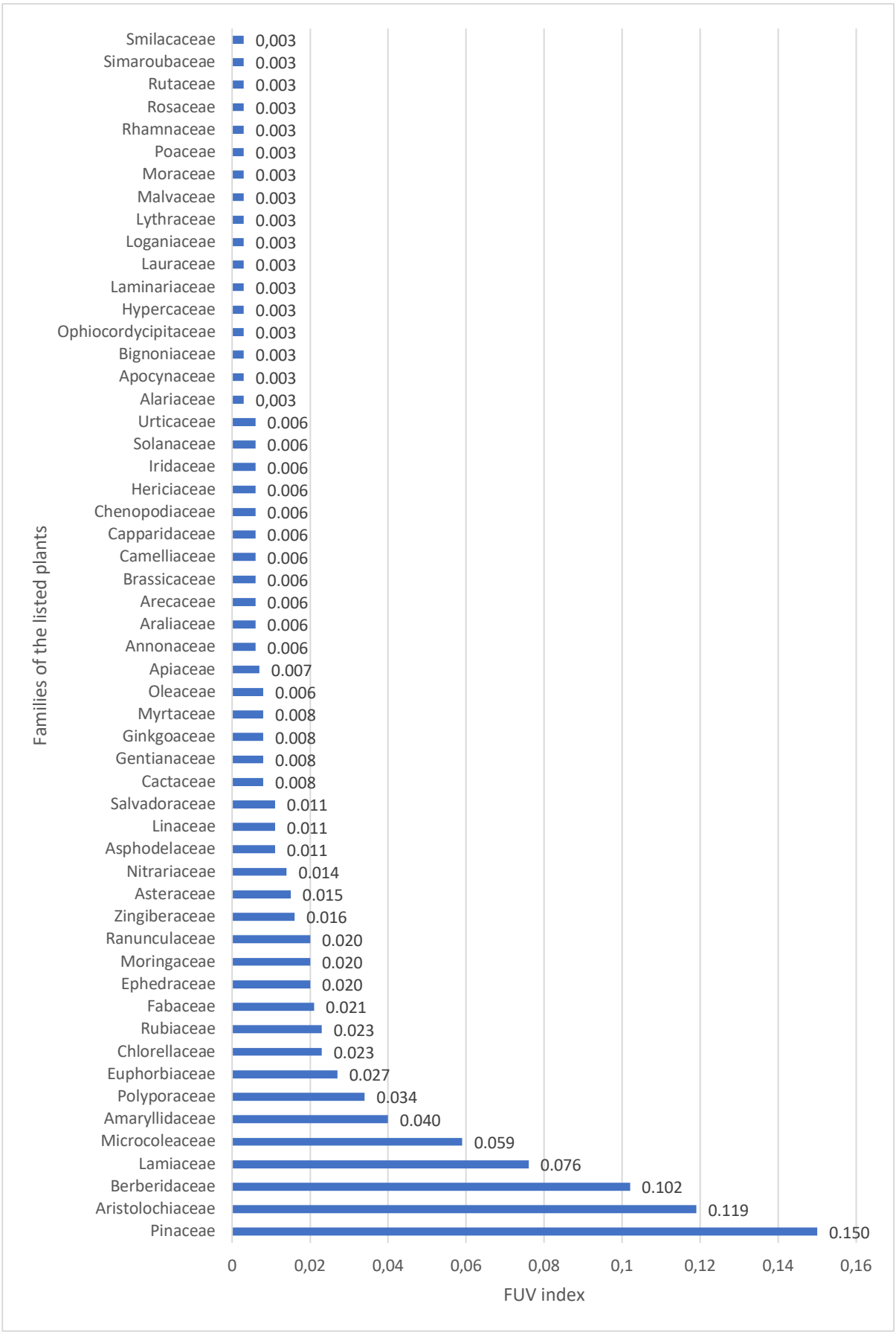

Figure 3. Families of species used in cancer treatment

Plant species used to treat cancer and their fidelity level index

The analysis of the 90 identified plant species involved ranking them based on the number of citations and the Fidelity Level index (FL) (Tables 4 and 5). In terms of the citation number, *Marrubium vulgare* emerged as the most frequently cited species with 190 citations, followed by *Aristolochia clematitis* with 42 citations, and *Berberis vulgaris subsp. australis* with 35 citations (Table 4). However, 30 plant species were the least cited, with only 1 citation each, including *Artemisia arborescens, Pimpinella anisum*, and *Nerium oleander* (Table 4). In terms of the Fidelity Level index (FL), its value ranges from 0% to 100%. An FL of 100% indicates a strong preference for the use of a particular plant species in the treatment of a specific type of cancer by the population in the study area (Table 5). For instance, 30 species, such as *Lepidium sativum* for uterine cancer, *Capparis spinosa* for breast cancer, and *Schenkia spicata* for gastrointestinal cancers, had an FL of 100%. This means that these species were specifically favored and frequently used for treating those particular types of cancer. Conversely, an FL of 0% indicates a general use of the species for treating all types of cancer. In this context, 20 plant species were found to have an FL of 0%, including *Annona muricata*, *Petroselinum crispum* subsp*. crispum*, and *Pimpinella anisum* (Table 5). These species were commonly utilized in the treatment of various types of cancer, showcasing their broad applications in traditional medicine for cancer treatment in the Casablanca-Settat region.

Table 5. Number of citations and fidelity level index of medicinal plants used to treat cancer in the Casablanca-Settat region

Species	**Treated Cancer**	**FL**
Undaria pinnatifida (Harvey) Suringar	Stomach	100.00%
Annona muricata L.	All cancer types	0.00%
Ammodaucus leucotrichus Coss.	Stomach	50.00%
	Intestine	50.00%
Petroselinum crispum (Mill.) Fuss subsp*. crispum*	All cancer types	0.00%
Carum carvi L.	Uterine	100.00%
Coriandrum sativum L.	Breast	100.00%
Foeniculum vulgare Mill.	Breast	66.67%
	Ovarian	33.33%
Pimpinella anisum L.	All cancer types	0.00%
Nerium oleander L.	Skin	100.00%
Artemisia arborescens L.	Brain	100.00%
Panax ginseng C.A.Mey.	Breast	66.67%
	Lungs	33.33%
Aristolochia clematitis L.	Stomach	14.29%
	Ovarian	3.57%
	Intestine	3.57%
	Breast	35.71%
	Uterine	21.43%
	Prostate	7.14%
	All cancer types	14.29%
Artemisia herba-alba Asso	Intestine	12.50%
	Uterine	25.00%
	Breast	37.50%
	Esophagus	6.25%
	Bladder	12.50%
	Tonsils	6.25%
Cynara cardunculus L.	Breast	12.50%
	Intestine	12.50%
	Uterine	12.50%
	Liver	25.00%
	Stomach	12.50%
	All cancer types	25.00%
Chamaemelum nobile (L.) All.	All cancer types	0.00%
Echinops spinosissimus Turra	Breast	66.67%
	Intestine	33.33%

Anacyclus pyrethrum (L.) Lag.	Breast	100.00%
Echinops spinosissimus subsp. *spinosissimus*	Liver	100.00%
Dolomiaea costus (Falc.) Kasana & A.K.Pandey	Breast	75.00%
	All cancer types	25.00%
Cichorium intybus L.	Liver	100.00%
Berberis vulgaris subsp. *australis* (Boiss.) Heywood	Intestine	8.33%
	Stomach	5.56%
	Bladder	2.78%
	Brain	2.78%
	Breast	41.67%
	Prostate	11.11%
	Uterine	8.33%
	Lungs	8.33%
	All cancer types	11.11%
Handroanthus lapacho (K.Schum.) S.O.Grose	Liver	100.00%
Lepidium sativum L.	Uterine	100.00%
Selenicereus undatus (Haw.) D.R.Hunt	Breast	66.67%
	Ovarian	33.33%
Camellia sinensis (L.) Kuntze	All cancer types	0.00%
Capparis spinosa L.	Breast	100.00%
Senna alexandrina Mill.	Blood	100.00%
Ceratonia siliqua L.	Prostate	100.00%
Beta vulgaris L.	Breast	100.00%
Chlorella vulgaris Beijerinck	All cancer types	0.00%
*Ophiocordyceps sinensis (*Berk.) Sung, Sung, Hywel-Jones and Spatafora	All cancer types	0.00%
Ephedra alata Decne.	Breast	60.00%
	Prostate	40.00%
Euphorbia officinarum subsp. *echinus* (Hook.f. & Coss.) Vindt	Breast	40.00%
	Uterine	50.00%
	Ovarian	10.00%
Euphorbia resinifera O.Berg	Breast	33.33%
	Uterine	33.33%
	All cancer types	33.33%
Cicer arietinum L.	Intestine	100.00%
Retama sphaerocarpa L.	Uterine	50.00%
	Ovarian	50.00%
Trigonella foenum-graecum L.	Liver	16.67%
	Intestine	16.67%
	Breast	16.67%
	Stomach	16.67%
	Colon	16.67%
	All cancer types	16.67%
Schenkia spicata (L.) G.Mans.	Intestine	100.00%
Ginkgo biloba L.	Stomach	33.33%
	Intestine	33.33%
	Bones	33.33%
Hericium erinaceus (Bull.) Pers	Stomach	100.00%
Hypericum perforatum L.	Colon	25.00%
	Uterine	25.00%
	Liver	25.00%
	Stomach	25.00%
Crocus sativus L.	Uterine	100.00%
Ajuga iva (L.) Schreb.	Breast	100.00%

Lavandula angustifolia subsp. *angustifolia*	Bladder	100.00%
Origanum compactum Benth.	Stomach	60.00%
	Blood	20.00%
	All cancer types	20.00%
Salvia rosmarinus Spenn.	Stomach	44.44%
	Skin	22.22%
	Breast	33.33%
Thymus saturejoides Coss.	Blood	100.00%
Origanum majorana L.	All cancer types	0.00%
Marrubium vulgare L.	Lungs	1.89%
	Uterine	29.25%
	Breast	41.51%
	Ovarian	1.89%
	Prostate	3.77%
	Foot	1.89%
	Intestine	9.43%
	Bladder	1.89%
	Tonsils	0.94%
	Eye	1.89%
	Brain	0.94%
	Skin	0.94%
	Jaw	0.94%
	Esophagus	1.89%
	Mouth	0.94%
Salvia officinalis L.	All cancer types	0.00%
Saccharina japonica (Aresch.) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	Stomach	100.00%
Camphora officinarum Nees	All cancer types	0.00%
Allium cepa L.	Uterine	37.50%
	Ovarian	12.50%
	Breast	37.50%
	Lungs	12.50%
Allium sativum L.	Skin	5.56%
	Colon	11.11%
	Breast	16.67%
	Uterine	22.22%
	Liver	5.56%
	Stomach	22.22%
	Lungs	5.56%
	All cancer types	11.11%
Aloe vera (L.) Burm.f.	All cancer types	0.00%
Smilax aspera L.	Ovarian	100.00%
Linum usitatissimum L.	Breast	66.67%
	Uterine	33.33%
Strychnos nux-vomica L.	All cancer types	0.00%
Adansonia digitata L.	All cancer types	0.00%
Vachellia seyal (Delile) P.J.H.Hurter	Breast	50.00%
	Brain	50.00%
Ficus carica L.	Stomach	100.00%
Moringa oleifera Lam.	All cancer types	0.00%
Syzygium aromaticum (L.) Merr. & L.M.Perry	Colon	16.67%
	Stomach	16.67%
	Uterine	16.67%
	Liver	16.67%

	Foot	8.33%
	Breast	8.33%
	Intestine	8.33%
	All cancer types	8.33%
Eucalyptus camaldulensis Dehnh.	Stomach	50.00%
	Lungs	50.00%
Myrtus communis L.	All cancer types	0.00%
Olea europaea L.	Breast	33.33%
	Uterine	33.33%
	All cancer types	33.33%
Arthrospira platensis Gomont	All cancer types	0.00%
Phoenix dactylifera L.	Breast	100.00%
Cedrus atlantica (Endl.) Manetti ex Carrière	Breast	48.78%
	Lungs	4.88%
	Stomach	2.44%
	Foot	2.44%
	Uterine	26.83%
	Intestine	14.63%
Hordeum vulgare L.	Breast	100.00%
Ganoderma lucidum (Curtis) P.Karst.	All cancer types	0.00%
Punica granatum L.	Breast	50.00%
	Prostate	50.00%
Nigella sativa L.	Jaw	40.00%
	Uterine	20.00%
	All cancer types	40.00%
Prunus amygdalus	Breast	100.00%
Prunus armeniaca L.	Intestine	100.00%
Prunus avium L.	Prostate	100.00%
Rosa × *damascena* Herrm.	Stomach	100.00%
Morinda citrifolia L.	All cancer types	0.00%
Citrus × *limon* (L.) Osbeck	Stomach	100.00%
Salvadora persica L.	Stomach	75.00%
	Lungs	25.00%
Eurycoma longifolia Jack	All cancer types	0.00%
Hyoscyamus albus L.	Uterine	50.00%
	Intestine	50.00%
Solanum linnaeanum Hepper & P.-M.L.Jaeger	Breast	100.00%
Urtica urens L.	Stomach	100.00%
Curcuma longa L.	Breast	25.00%
	Uterine	12.50%
	Ovarian	12.50%
	Stomach	12.50%
	Prostate	12.50%
	Mouth	12.50%
	All cancer types	12.50%
Zingiber officinale Roscoe	Prostate	66.67%
	All cancer types	33.33%
Alpinia officinarum Hance	All cancer types	0.00%
Elettaria cardamomum (L.) Maton	All cancer types	0.00%
Peganum harmala L.	Breast	50.00%
	Ovarian	25.00%
	Jaw	25.00%

Plant species used to treat cancer and their UV index

The UV index was determined to assess the local importance of reported plant species used to treat cancer (Table 4). The results revealed that *Marrubium vulgare* had the highest UV (0.534), indicating its significant local importance in cancer treatment. This was followed by *Cedrus atlantica* (UV=0.150), *Aristolochia clematitis* (UV=0.119), *Berberis vulgaris* subsp. *australis*, and *Cicer arietinum* (UV=0.102), which also showed considerable importance in traditional medicinal practices for cancer. While, the lowest UV values recorded for *Coriandrum sativum, Petroselinum crispum* subsp. *crispum, and Pimpinella anisum* (UV=0.003), as well as *Annona muricata, Carum carvi, and Panax ginseng* (UV=0.006), indicating that these species were relatively less utilized for cancer treatment in the region (Table 4).

Plant parts used and their PPV index

The collected data showed that cancer remedies were prepared using nine different plant parts, namely leaves, roots, stems, latex, seeds, fruits, bark, and bulbs (Figure 4). Among these plant parts, leaves were the most commonly utilized, with a PPV index of 0.411, indicating their predominant role in traditional cancer treatments. Following leaves, roots were also frequently employed (PPV=0.175), followed by stems (PPV=0.090), latex (PPV=0.072), seeds (PPV=0.060), fruits (PPV=0.050), bark (PPV=0.047), and finally bulbs (PPV=0.042) (Figure 4).

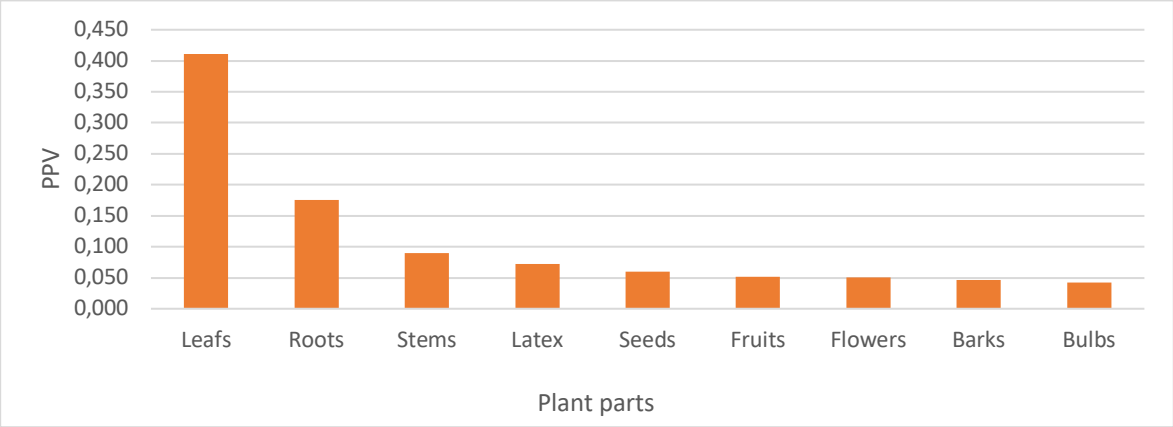

Figure 4. Plant Parts used to treat cancer by the population of the Casablanca-Settat region

Preparation methods used

Our survey identified 12 preparation methods of medicinal plants inventoried in the study area (Figure 5). Indeed, the decoction was the most used method with a rate of 51%, followed by the powder form with a frequency of 14%, the infusion (8%), the encapsulation to form capsules or suppositories (7.5%), the hydrodistillation (6.42%) and the juicing (5.2%). However, the least used methods were maceration (2.29%), poultice (0.31%), and cigarette (0.31%) (Figure 5).

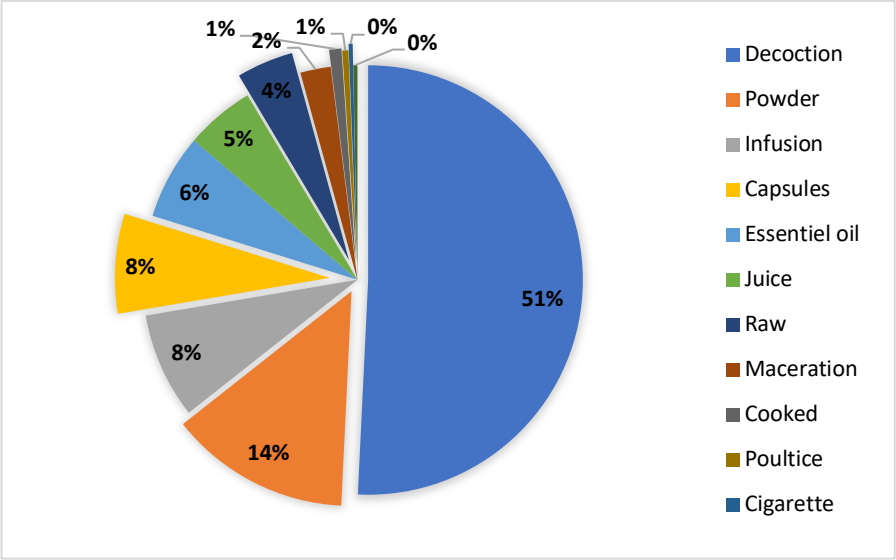

Figure 5. Preparation methods used by the population in the study area

Modes of administration used

Five methods of drug administration were identified in this study (Figure 6). Among these preparations, the oral route exhibited the highest percentage 89.74%, indicating its widespread usage. On the other hand, the remaining modes of administration, namely vaginal, cutaneous, nasal, and ocular routes, accounted for 6.84%, 2.74%, 0.34%, and 0.34%, respectively (Figure 6).

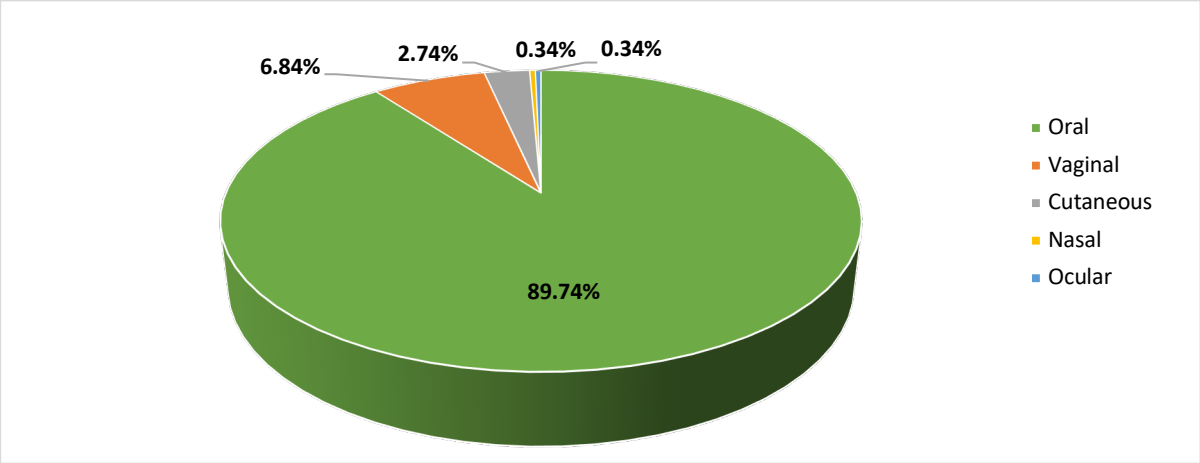

Figure 6. Administration routes reported by the surveyed population.

Improvement state

Following the utilization of medicinal plants, approximately three-quarters of the participants in the study (75.99%) reported experiencing improvements in their conditions, such as pain relief, restored energy, and a reduction in tumor volume (Figure 7). However, among the respondents who suffered from cancer, 18.36% did not observe any discernible effects after using medicinal plants. Additionally, 5.65% of the participants reported an aggravation of their pathological situation, which included the development of metastases and various hepatic and renal issues, and, in the worst cases, even death (Figure 7).

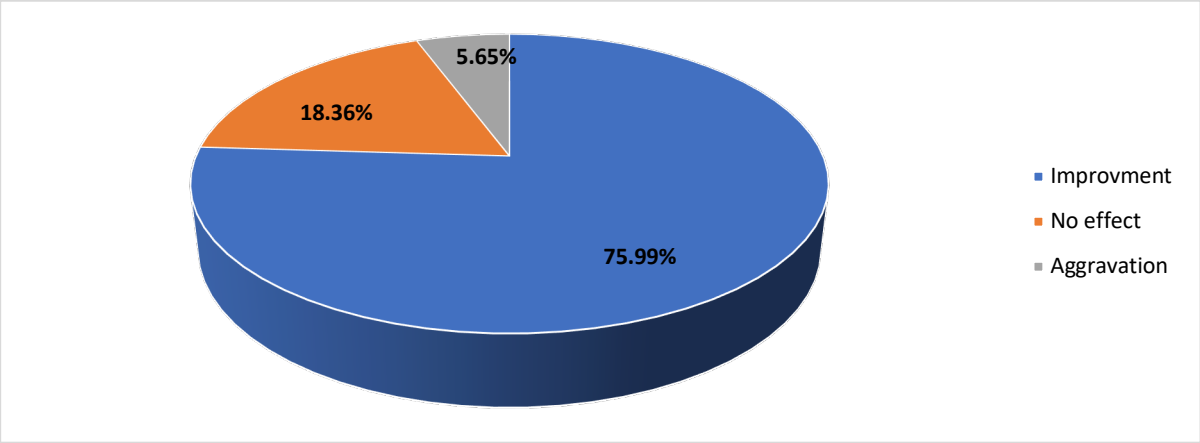

Figure 7. Improvement status observed after administering the mentioned medicinal plants.

Knowledge sources

In the conducted survey, the information provided by the respondents was mainly derived from their personal experiences with the disease and its treatment (32%) (Figure 8). Additionally, 30% of the participants reported using medicinal plants based on recommendations from their relatives, friends, and neighbors. Some respondents, about 14%, relied on their professional knowledge and training, while 7% sought guidance from herbalists when using medicinal plants (Figure 8). Moreover, 12% followed cultural traditions when utilizing these remedies. However, a smaller proportion of informants (5%) opted for herbal medicines to treat cancer based on online research (Figure 8).

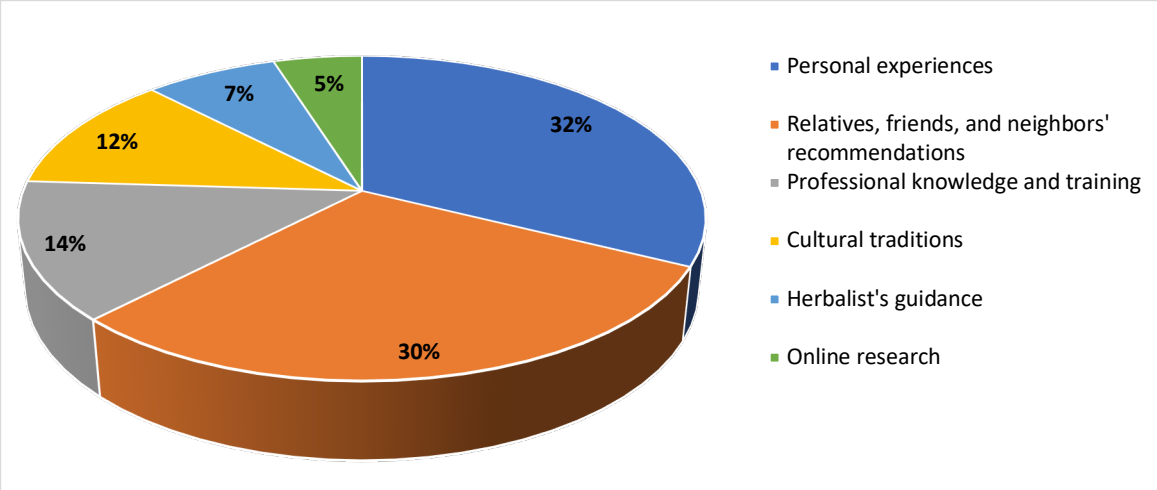

Figure 8. Sources of knowledge for the respondents

Toxicity effect of anticancer plants used

Apart from the beneficial medicinal effects of the plants mentioned, it is essential to acknowledge that some of them possess toxic effects, especially when used in certain quantities. This could lead to various physiological imbalances at different levels. Among the plants cited by our study population as anti-cancer, 21 species are considered toxic and have been reported to cause various biological disorders, as documented in Table 6.

Table 6. The toxicity effects of anticancer plants as reported by the interviewed participants in the study area

Species	Toxicity effects	References
Aloe vera (L.) Burm.f.	Intense congestion of organs, abortive, and eczematous dermatitis or erythema	(Bellakhdar 2020, Guo & Mei 2016)
Absinthe arborescente	Seizures, jaw constriction, and lip foam	(Bellakhdar 2020)
Anacyclus pyrethrum (L.) Lag.	Severe inflammation of the digestive, respiratory and skin mucosa, headache, ringing of the ear, pallor, epigastric pain, nausea, and loss of consciousness	(Bellakhdar 2020)
Annona muricata L.	Neurological disorders, kidney disease, hypoglycemia, and hyperlipidemia	(Abdul Wahab *et al.* 2018, Mohanty *et al.* 2008)
Aristolochia clematitis L.	Irreversible renal lesions, haematuria, and limb paralysis	(Amrati *et al.* 2021, El Hamsas el Youbi & Bousta 2020, El Omari *et al.* 2020)
Artemisia herba-alba Asso	Infant and pregnant intoxication, dizziness and seizures	(Boukhennoufa *et al.* 2021)
Camellia sinensis (L.) Kuntze	Theism: insomnia, anorexia, weight loss, constipation, and nervous disorders	(Bellakhdar 2020)
Ephedra alata Decne.	Psychotic disorder	(Munafò *et al.* 2021)
Euphorbia officinarum subsp. *echinus* (Hook.f. & Coss.) Vindt *Euphorbia resinifera* O.Berg	Severe inflammation of the digestive mucosa with gastroenteritis, gastrointestinal ulcers, arrhythmia, convulsions, haematuria, death by asphyxia, photophobia, conjunctivitis, keratitis, pruritus, phlycten, rhinitis, coryza, laryngitis, bronchial hemorrhage, tingling throat, vomiting, intestinal hemorrhage, and abortifacient.	(Bellakhdar 2020)
Ginkgo biloba L.	Hemorrhage if consumed with warfarin	(Heck *et al.* 2000, Stoddard *et al.* 2015)
Hyoscyamus albus L.	Dry mouth and throat with burning sensation, mydriasis, dizziness, hallucinations, erotic vision, deep sleep, drunkenness, restlessness, polyuria, profuse sweating, rash, nervous disorder, coma, death, peptic, and duodenum pains	(Al-Qura'n 2005, Bellakhdar 2020)

Lepidium sativum L.	Mucosal irritation, skin inflammation, infant intoxication	(Morton 1990)
Nerium oleander L.	Weakness, vomiting, syncope, aphonia, convulsions, diarrhea, mydriasis, weak and intermittent pulse, mental confusion, bradycardia, sometimes deep sleep, chills, hyperthermia, and death from heart failure	(Al-Qura'n 2005, Kharchoufa *et al.* 2021)
Nigella sativa L.	Dry mouth, oral-pharyngeal irritation, inflammation of the tongue, palate, tonsils and rhinopharynx, aphonia, ulcer of this mucosa, dyspnea, oliguria, choking, and chest pain	(El Yahyaoui El Drissi *et al.* 2017)
Peganum harmala L.	Vomiting, dizziness, stimulation, tremors, tingling extremities, intense heat sensation, paresthesia, visual and auditory hallucinations, anger attacks, severe headaches, deep sleep, heart problems, paralysis, nephrotoxicity, and death	(El Yahyaoui El Drissi *et al.* 2017)
Pimpinella anisum L.	Neurological disorders, general arousal, stupefaction, hallucination, and epileptic seizures	(Bellakhdar 2020)
Prunus armeniaca L.	Apricot kernel poisoning of children: headache, confusion, tachycardia, respiratory disorders, vomiting, muscle stiffness, convulsive coma, dilated pupils, acidosis, and hypotension	(Chaouali *et al.* 2013, Bellakhdar 2020)
Retama sphaerocarpa L.	Abortive and death	(Bellakhdar 2020)
Solanum linnaeanum Hepper & P.-M.L.Jaeger	More or less serious poisoning if unsafe consumption of berries	(Bellakhdar 2020, Kharchoufa *et al.* 2021)
Strychnos nux-vomica L.	General CNS excitement, with muscle tone, sensory stimulation and increased sensitivity to light and noise, anxiety, vomiting, abundant salivation, tetanus seizures, asphyxiation, and death	(Bellakhdar 2020, Guo *et al.* 2018)

Endemic and cultivated anticancer species used in the study region

Out of the total 90 recorded plant species, four (4.44%), namely *Euphorbia resinifera*, *Olea europaea* subsp. maroccana, *Echinops spinosissimus* Turra and *Thymus saturejoides*, were found to be endemic to Morocco, meaning they naturally grow in various regions across the country. On the other hand, 86 medicinal plants (95.56%) used by the survey participants were cultivated and imported from other countries, including China (*Alpinia officinarum*, *Camellia sinensis*, and *Ginkgo biloba*), India (*Moringa oleifera*, *Citrus* x *limon*, *Elettaria cardamomum*, and *Curcuma longa*), Mediterranean Europe (*Lavandula angustifolia* subsp*. angustifolia*), and Australia (*Eucalyptus camaldulensis*) (Table 7).

Table 7. Endemic and cultivated anticancer plants identified in the study area

Species	Endemic	Cultivated	References
Vachellia seyal (Delile) P.J.H.Hurter		X	(Hall & McAllan 1993)
Adansonia digitata L.		X	(Hassler 2023)
Ajuga iva (L.) Schreb.		X	(Bouyahya *et al.* 2020)
Allium cepa L.		X	(Hassler 2023)
Allium sativum L.		X	(Maaß & Klaas 1995)
Aloe vera (L.) Burm.f.		X	(Hassler 2023)
Alpinia officinarum Hance		X	(Khairullah *et al.* 2020)
Ammodaucus leucotrichus Coss.		X	(Hassler 2023, Mohammedi *et al.* 2018)
Anacyclus pyrethrum (L.) Lag.		X	(Hassler 2023)
Annona muricata L.		X	(Ravaomanarivo *et al.* 2014)
Chamaemelum nobile (L.) All.		X	(Hassler 2023)
Aristolochia clematitis L.		X	(Hassler 2023, Nath *et al.* 2022)
Artemisia arborescens L.		X	(Garcia *et al.* 2006)
Artemisia herba-alba Asso		X	(Mohamed *et al.* 2010)

Berberis vulgaris subsp. *australis* (Boiss.) Heywood		X	(Hassler 2023)
Beta vulgaris L.		X	(Dale *et al.* 1985)
Camellia sinensis (L.) Kuntze		X	(Vijayan *et al.* 2009)
Capparis spinosa L.		X	(Hassler 2023)
Carum carvi L.		X	(András *et al.* 2015, Hammami *et al.* 2018)
Cedrus atlantica (Endl.) Manetti ex Carrière		X	(Peltier 2022)
Schenkia spicata (L.) G.Mans.		X	(Hassler 2023)
Chlorella vulgaris Beijerinck		X	(Hassler 2023)
Cicer arietinum L.		X	(Hassler 2023)
Cichorium intybus L.		X	(Bais & Ravishankar 2001)
Camphora officinarum Nees		X	(Hassler 2023)
Citrus × *limon* (L.) Osbeck		X	(Hassler 2023)
*Ophiocordyceps sinensis (*Berk.) Sung, Sung, Hywel-Jones and Spatafora		X	(Hassler 2023)
Coriandrum sativum L.		X	(Diederichsen 1996, Diederichsen & Hammer 2003)
Crocus sativus L.		X	(Hassler 2023)
Curcuma longa L.		X	(Hassler 2023)
Cynara cardunculus L.		X	(Hassler 2023)
Echinops spinosissimus Turra	X		(El Hachlafi *et al.* 2021, Hassler 2023)
Echinops spinosissimus subsp. *spinosissimus*		X	(Hassler 2023)
Elettaria cardamomum (L.) Maton		X	(Hassler 2023)
Ephedra alata Decne.		X	(Hassler 2023)
Eucalyptus camaldulensis Dehnh.		X	(Butcher *et al.* 2009, Hassler 2023)
Euphorbia officinarum subsp. *echinus* (Hook.f. & Coss.) Vindt		X	(Hassler 2023, Peltier 2022)
Euphorbia resinifera O.Berg	X		(Hassler 2023, Peltier 2022)
Eurycoma longifolia Jack		X	(Hassler 2023)
Ficus carica L.		X	(Badgujar *et al.* 2014)
Foeniculum vulgare Mill.		X	(Hassler 2023)
Ganoderma lucidum (Curtis) P.Karst.		X	(Hapuarachchi *et al.* 2015)
Ginkgo biloba L.		X	(Lin *et al.* 2022)
Handroanthus lapacho (K.Schum.) S.O.Grose		X	(Espeche *et al.* 2014)
Hericium erinaceus (Bull.) Pers		X	(Hassler 2023)
Hordeum vulgare L.		X	(Hassler 2023)
Hyoscyamus albus L.		X	(Hassler 2023)
Hypericum perforatum L.		X	(Hassler 2023)
Lavandula angustifolia subsp. *angustifolia*		X	(Diass *et al.* 2021, Hassler 2023)
Lepidium sativum L.		X	(Wadhwa *et al.* 2012, Hassler 2023)
Linum usitatissimum L.		X	(Ataii *et al.* 2021, Hassler 2023)
Marrubium vulgare L.		X	(Hassler 2023)
Morinda citrifolia L.		X	(Brown 2012, Hassler 2023)
Moringa oleifera Lam.		X	(Hassler 2023)
Myrtus communis L.		X	(Hassler 2023)
Nerium oleander L.		X	(Hassler 2023)
Nigella sativa L.		X	(El Yahyaoui El Drissi *et al.* 2017, Hassler 2023)
Olea europaea L.	X		(Breton *et al.* 2005, Hassler 2023, Peltier 2022)
Origanum compactum Benth.		X	(Aboukhalid *et al.* 2017)
Origanum majorana L.		X	(Hassler 2023, Lombrea *et al.* 2020)
Panax ginseng C.A.Mey.		X	(Hassler 2023)

Peganum harmala L.		X	(Hassler 2023)
Petroselinum crispum (Mill.) Fuss subsp. *crispum*		X	(Peltier 2022)
Phoenix dactylifera L.		X	(Hassler 2023, Spennemann 2018)
Pimpinella anisum L.		X	(Shojaii & Abdollahi Fard 2012)
Prunus amygdalus		X	(Hassler 2023)
Prunus armeniaca L.		X	(Bourguiba *et al.* 2020)
Prunus avium L.		X	(Hassler 2023)
Punica granatum L.		X	(Hassler 2023)
Retama sphaerocarpa L.		X	(Hassler 2023)
Rosa × *damascena* Herrm.		X	(Ersan & Başayiğit 2022, Hassler 2023)
Salvia rosmarinus Spenn.		X	(Diass *et al.* 2021, Hassler 2023)
Saccharina japonica (Aresch.) C.E.Lane, C.Mayes, Druehl & G.W.Saunders		X	(Zhang *et al.* 2015)
Salvadora persica L.		X	(Hassler 2023)
Salvia officinalis L.		X	(Rešetnik *et al.* 2016)
Dolomiaea costus (Falc.) Kasana & A.K.Pandey		X	(Amara *et al.* 2017, Hassler 2023, Rathore *et al.* 2021)
Smilax aspera L.		X	(Hassler 2023)
Solanum linnaeanum Hepper & P.-M.L.Jaeger		X	(Hassler 2023)
Arthrospira platensis Gomont		X	(Vardaka *et al.* 2016)
Strychnos nux-vomica L.		X	(Hassler 2023)
Syzygium aromaticum (L.) Merr. & L.M.Perry		X	(Hassler 2023)
Thymus saturejoides Coss.	X		(El Hachlafi *et al.* 2021, Hassler 2023)
Trigonella foenum-graecum L.		X	(Basu *et al.* 2019, Hassler 2023)
Undaria pinnatifida (Harvey) Suringar		X	(Báez *et al.* 2010, Hassler 2023)
Urtica urens L.		X	(Hassler 2023)
Zingiber officinale Roscoe		X	(Yu *et al.* 2022)
Ziziphus lotus (L.) Lam.		X	(Hassler 2023, Zerrouk *et al.* 2018)

Plants and provinces

Table 8 presents the prevalence of citation and utilization of identified anticancer plants across the provinces in the Casablanca-Settat study region. The percentage of citation and use for the same species varied significantly from province to province. For example, *Marrubium vulgare* had a prevalence of 22.64% in Casablanca, 2.83% in Settat, 1.26% in Berrechid, 1.10% in El Jadida, 0.63% in Nouaceur and Benslimane, 0.47% in Sidi Bennour, and 0.31% in Mediouna. Conversely, there were a total of 54 plants (60.67%) that were exclusively recommended by the population in a single area within the Casablanca-Settat region. For instance, plants like *Carum carvi*, *Artemisia arborescens*, *Cichorium intybus*, *Handroanthus lapacho*, *Lepidium sativum*, *Selenicereus undatus*, *Camellia sinensis*, and *Ficus carica* were specifically cited in Casablanca. *Undaria pinnatifida and Petroselinum crispum* (Mill.) Fuss subsp. *crispum* were uniquely recommended in El Jadida, while *Chamaemelum nobile* and *Elettaria cardamomum* were exclusive to Benslimane. Similarly, *Alpinia officinarum* and *Hypericum perforatum* were only found in Settat, and *Ajuga iva* was solely mentioned in Berrechid. However, it is worth noting that a significant proportion (39.32%) of the recommended anticancer plants was shared by the population in different provinces within Casablanca-Settat. These shared plants include *Ammodaucus leucotrichus*, *Aristolochia clematitis*, *Artemisia herba-alba*, *Cynara cardunculus*, *Dolomiaea costus*, *Berberis vulgaris* subsp. *australis*, *Ephedra alata*, *Marrubium vulgare*, and *Aloe vera* (Table 8). Consequently, the Casablanca region stood out among all provinces, exhibiting the highest prevalence of citation and utilization of medicinal plants for the treatment of various types of cancer (Table 8).

Table 8. Citation and utilization's prevalence of identified anticancer plants within the provinces of the Casablanca-Settat study region

Species	Provinces	Prevalence of citation and utilization (%)
Undaria pinnatifida (Harvey) Suringar	El Jadida	0.16
Annona muricata L.	Mohammedia	0.16
	Settat	0.16
Ammodaucus leucotrichus Coss.	Casablanca	0.47
	Berrechid	0.16
	Settat	0.31
Carum carvi L.	Casablanca	0.31
Coriandrum sativum L.	Casablanca	0.16
Foeniculum vulgare Mill.	Casablanca	0.63
Petroselinum crispum (Mill.) Fuss subsp. *crispum*	El Jadida	0.16
Pimpinella anisum L.	Berrechid	0.16
Nerium oleander L.	Berrechid	0.16
Panax ginseng C.A.Mey.	Settat	0.16
	Casablanca	0.16
Aristolochia clematitis L.	Berrechid	0.31
	Casablanca	4.25
	El Jadida	0.47
	Médiouna	0.16
	Nouaceur	0.31
	Settat	0.94
	Sidi Bennour	0.16
Anacyclus pyrethrum (L.) Lag.	Casablanca	0.16
	Settat	0.16
Chamaemelum nobile (L.) All.	Ben Slimane	0.16
Artemisia arborescens L.	Casablanca	1.89
Artemisia herba-alba Asso	Berrechid	0.47
	Casablanca	2.04
	El Jadida	0.31
	Médiouna	0.16
	Settat	0.16
Cichorium intybus L.	Casablanca	0.16
Cynara cardunculus L.	Berrechid	0.16
	Casablanca	0.16
	Settat	0.16
Dolomiaea costus (Falc.) Kasana & A.K.Pandey	Casablanca	0.16
	Berrechid	0.31
	Settat	0.31
	El Jadida	0.31
Echinops spinosissimus Turra	Casablanca	0.31
Echinops spinosissimus subsp. *spinosissimus*	Casablanca	0.16
Berberis vulgaris subsp. *australis* (Boiss.) Heywood	Berrechid	0.16
	Casablanca	3.30
	El Jadida	0.31
	Nouaceur	0.16
	Settat	1.57
Handroanthus lapacho (K.Schum.) S.O.Grose	Casablanca	0.16
Lepidium sativum L.	Casablanca	0.31
Selenicereus undatus (Haw.) D.R.Hunt	Casablanca	0.47
Camellia sinensis (L.) Kuntze	Casablanca	0.31

Capparis spinosa L.	Berrechid	0.16
	Nouaceur	0.16
Senna alexandrina Mill.	Casablanca	0.16
Ceratonia siliqua L.	Casablanca	0.16
Beta vulgaris L.	Casablanca	0.31
Chlorella vulgaris Beijerinck	Casablanca	1.10
	El Jadida	0.16
*Ophiocordyceps sinensis (*Berk.) Sung, Sung, Hywel-Jones and Spatafora	Casablanca	0.16
Ephedra alata Decne.	Berrechid	0.16
	Casablanca	0.31
	Médiouna	0.31
	Settat	0.31
Euphorbia officinarum subsp. *echinus* (Hook.f. & Coss.) Vindt	Ben Slimane	0.31
	Casablanca	1.57
	Settat	0.47
Euphorbia resinifera O.Berg	Casablanca	0.63
Cicer arietinum L.	Casablanca	0.16
Retama sphaerocarpa L.	Casablanca	0.16
Trigonella foenum-graecum L.	Casablanca	0.47
	El Jadida	0.16
	Médiouna	0.16
	Settat	0.47
Schenkia spicata (L.) G.Mans.	Casablanca	0.47
Ginkgo biloba L.	Casablanca	0.31
	El Jadida	0.16
Hericium erinaceus (Bull.) Pers	Casablanca	0.16
	Médiouna	0.16
Hypericum perforatum L.	Settat	0.16
Crocus sativus L.	Berrechid	0.31
Ajuga iva (L.) Schreb.	Berrechid	0.16
Lavandula angustifolia subsp. *angustifolia*	Casablanca	0.16
Marrubium vulgare L.	Ben Slimane	0.63
	Berrechid	1.26
	Casablanca	22.64
	El Jadida	1.10
	Médiouna	0.31
	Nouaceur	0.63
	Settat	2.83
	Sidi Bennour	0.47
Origanum compactum Benth.	Berrechid	0.16
	Casablanca	0.94
	El Jadida	0.16
	Settat	0.31
Origanum majorana L.	Ben Slimane	0.16
Salvia rosmarinus Spenn.	Casablanca	0.79
	El Jadida	0.16
	Médiouna	0.16
	Settat	0.47
Salvia officinalis L.	Ben Slimane	0.16
Thymus saturejoides Coss.	Casablanca	0.16
Saccharina japonica (Aresch.) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	El Jadida	0.16

Camphora officinarum Nees	Casablanca	0.16
Allium cepa L.	Ben Slimane	0.16
	Casablanca	1.73
	Settat	0.31
Allium sativum L.	Ben Slimane	0.16
	Casablanca	1.10
	El Jadida	0.31
	Settat	0.63
Aloe vera (L.) Burm.f.	Berrechid	0.16
	Casablanca	0.16
	El Jadida	0.16
	Settat	0.16
Smilax aspera L.	Settat	0.16
Linum usitatissimum L.	Settat	0.16
	Casablanca	0.47
Strychnos nux-vomica L.	Settat	0.16
Adansonia digitata L.	Casablanca	0.16
Vachellia seyal (Delile) P.J.H.Hurter	Ben Slimane	0.16
	Casablanca	0.16
	El Jadida	0.31
Ficus carica L.	Casablanca	0.16
Moringa oleifera Lam.	Berrechid	0.31
	Casablanca	0.31
	Mohammedia	0.16
	Settat	0.31
Syzygium aromaticum (L.) Merr. & L.M.Perry	Ben Slimane	0.16
	Casablanca	0.47
	El Jadida	0.16
	Settat	0.16
Eucalyptus camaldulensis Dehnh.	Casablanca	0.31
Myrtus communis L.	Ben Slimane	0.16
Olea europaea L.	Casablanca	0.47
Arthrospira platensis Gomont	Casablanca	0.94
	El Jadida	0.31
	Médiouna	0.16
	Mohammedia	0.16
Phoenix dactylifera L.	Casablanca	0.16
	El Jadida	0.16
Cedrus atlantica (Endl.) Manetti ex Carrière	Ben Slimane	0.31
	Berrechid	0.47
	Casablanca	6.13
	El Jadida	0.47
	Nouaceur	0.31
	Settat	0.63
Hordeum vulgare L.	Casablanca	0.16
Ganoderma lucidum (Curtis) P.Karst.	Casablanca	1.10
	El Jadida	0.47
	Médiouna	0.16
	Settat	0.16
Punica granatum L.	Casablanca	0.16
Nigella sativa L.	Casablanca	0.63
	Settat	0.31
	Sidi Bennour	0.16

Ziziphus lotus (L.) Lam.	Médiouna	0.16
Prunus amygdalus Batsch	Sidi Bennour	0.16
Prunus armeniaca L.	Casablanca	0.16
Prunus avium L.	Casablanca	0.16
Rosa × *damascena* Herrm.	Ben Slimane	0.16
Morinda citrifolia L.	Casablanca	0.79
	El Jadida	0.31
	Settat	0.16
Citrus × *limon* (L.) Osbeck	El Jadida	0.16
Salvadora persica L.	Berrechid	0.31
	Casablanca	0.31
Eurycoma longifolia Jack	Casablanca	0.16
Hyoscyamus albus L.	Casablanca	0.16
Solanum linnaeanum Hepper & P.-M.L.Jaeger	Casablanca	0.47
Urtica urens L.	Casablanca	0.16
	El Jadida	0.16
Curcuma longa L.	Casablanca	2.04
	El Jadida	0.31
	Settat	0.47
	Sidi Bennour	0.16
Zingiber officinale Roscoe	Ben Slimane	0.16
	Médiouna	0.16
Alpinia officinarum Hance	Settat	0.16
Elettaria cardamomum (L.) Maton	Ben Slimane	0.16
Peganum harmala L.	Casablanca	0.79

Anticancer recipes used

As shown in Table 9, during this survey, we identified 29 recipes used in cancer treatment. All these recipes were prepared using a combination of several plants, at least two, with or without honey and its derivatives, or milk. Additionally, we observed the use of animals such as scorpions in some of these recipes. According to certain respondents, the therapeutic effects of these recipes are primarily attributed to the synergistic effects of the medicinal plants used in their preparation. The treatment duration is usually long, varying from one week to five months or even longer until the patient's condition improves.

Many patients have confirmed the effectiveness of these recipes in treating several categories of cancers. However, some patients did not report any changes in their health status, while others experienced adverse effects during the treatment of vaginal cancer, such as irritation, pruritus, and tumor spreading to the uterus.

Other anticancer natural substances used

In this current study, 11 other natural products of animal and plant origin have been identified for the treatment of cancer (Table 10). Among them, camel urine was the most frequently recommended product, followed by royal jelly, propolis, amber, Shilajit, honey, pollen, Omega 3, camel milk, scorpions, and snail broth. While snail broth, scorpions, and camel milk are specifically prescribed for breast, skin, and liver cancers, respectively, it is noteworthy that most of these products are suggested for the treatment of various types of cancer (Table 10).

Comparative analysis

Out of the 90 medicinal plants identified in this survey, the anticancer activity of the extracts from 84 of these species has already been confirmed by the literature through *in vitro* and *in vivo* pharmacological studies, and clinical trials (Table 11). However, the remaining six plants, namely *Ajuga iva*, *Camellia sinensis*, *Senna alexandrina*, *Schenkia spicata*, *Euphorbia officinarum* subsp. *echinus*, and *Handroanthus lapacho*, have not yet been studied for their anticancer activity (Table 11).

Table 9. Recipes used for cancer treatment in the Casablanca-Settat study region

Recipes	Modes of preparation	Administration routes	Doses	Treatment periods	Cancers treated	Remediation signs
Phoenix dactylifera + *Nigella sativa* + honey	Powder	Oral	1 spoon/morning	TIS	Breast	Amelioration
Hordeum vulgare + honey + scorpions	Powder	Local	1 spoon/day	7-14 days	Skin	Amelioration
Olea europaea + salt	Powder	Local	1 spoon/day	TIS	Foot	Amelioration
Salvia rosmarinus + *Eucalyptus camaldulensis* + *Nigella sativa* + *Thymus saturejoides* + *Syzygium aromaticum*	Decoction	Oral	1 cup/day	TIS	ACT	Amelioration
			1/2 L three times/day	28 days	Breast	Amelioration
Salvia verbenaca + *Camellia sinensis*	Decoction	Oral	1 cup/day	TIS	Breast	Amelioration
Salvia rosmarinus + snail + spices	Decoction	Oral	1 cup/jour	1 month	Intestine	No effect
Citrus x *limon* + *Olea europaea*	Digestion	Oral	2 cups/jour	3 months	Leukemia	Amelioration
Phoenix dactylifera + *Marrubium vulgare* + *Allium sativum*	Evaporation	Oral	1 date fruit/morning	TIS	Uterine	Amelioration
Solanum linnaeanum + *Hordeum vulgare* + milk	Evaporation	Oral	1 cup/week	5 months	liver	Amelioration
Fermented butter + *Camphora officinarum*	Suppository	Rectal	1 suppository/day	TIS	Intestine	Amelioration
Fermented butter + *Teucrium polium*	Suppository	Rectal	1 suppository/day	TIS	Intestine	Amelioration
Salvadora persic + *Nigella sativa* + *Pistacia lentiscus* + *Citrus* x *limon* + milk	Infusion	Oral	1 cup/day	TIS	Bladder	Amelioration
Propolis + *Euphorbia* + royal jelly + *Crocus sativus* + honey of *Euphorbia officinarum* subsp. *echinus*	Powder	Oral	2 spoons/day	3 months	Uterine	Amelioration
					Liver	
					Colon	
Propolis + royal jelly + honey of *Euphorbia officinarum* subsp. *echinus*	Powder	Oral	3 spoons/ day	3 months	ACT	Amelioration
Linum usitatissimum + *Peganum harmala* + *Trigonella foenum-graecum* + honey	Powder	Oral	1 spoons/morning	TIS	Uterine	Amelioration
Lavandula angustifolia subsp. *angustifolia* + *Origanum compactum* + *Citrus* x *limon* + *Eucalyptus camaldulensis*	Decoction	Nasal	Vapor aspiration one time per night	15 days	Lung	No effect
Berberis vulgaris subsp. *australis* + *Aristolochia clematitis* + *Panax ginseng* + propolis + royal jelly + honey of *Euphorbia officinarum* subsp. *echinus*	Powder	Oral	1 spoon/morning	3 months	ACT	Amelioration
Artemisia herba-alba + *Cicer arietinum* + *Vicia faba* + *Aristolochia clematitis* + *Marrubium vulgare* + honey of *Euphorbia officinarum* subsp. *echinus*	Powder	Oral	1 spoon/morning	TIS	Lung	Amelioration
Propolis + pollen + royal jelly + honey of *Euphorbia officinarum* subsp. *echinus or Origanum compactum*	Powder	Oral	1-3 spoons/day	3 months	ACT	Amelioration

Allium cepa + *Origanum compactum* + Apple cider + salt	Decoction	Local	1 cup/day	1 month	Vaginal	Aggravation
Euphorbia officinarum subsp*. echinus* + *Citrus* x *limon*	Powder	Oral	1 cup/day	TIS	Breast	Amelioration
Hordeum vulgare + *Trigonella foenum-graecum* + *Lens culinaris* + *Sesamum indicum* + *Glycine max*	Powder	Oral	1 cup/day	TIS	Breast	Amelioration
Euphorbia officinarum subsp*. echinus* + *Hordeum vulgare*	Cooked (bread)	Oral	1 piece/day	TIS	Uterine	Amelioration
Solanum linnaeanum + traditional yeast + sulfur + mercury + fermented butter	Cataplasm	Local	One cutaneous application per day	TIS	Skin	Amelioration
Phoenix dactylifera + *Prunus amygdalus*	Raw	Oral	1 date fruit/day	TIS	Breast	Amelioration
Phoenix dactylifera + *Marrubium vulgare* + *Peganum harmala*	Evaporation	Oral	1 date fruit/day	1 month	Breast	Amelioration
Allium cepa + *Allium sativum* + *Olea europaea* + *Hordeum vulgare*	Cooked (soup)	Oral	1 bowl/day	TIS	Breast	Amelioration
Marrubium vulgare + *Berberis vulgaris* subsp*. australis* + *Aristolochia clematitis* + honey	Powder	Oral	1 granule/day	TIS	Breast	Amelioration
Phoenix dactylifera + *Marrubium vulgare*	Raw	Oral	1 date fruit/day	TIS	Breast	Amelioration
					Brain	
			3 date fruit/day	15 days	Breast	No effect
			1 date fruit/day	2 months	Uterine	Amelioration
					Ovarian	
			3 date fruit/day	TIS	Lung	Amelioration

TIS: Till improvement of status

ACT: All cancer type

Table 10. Other natural products identified for the treatment of cancer in the study area

Vernaculars names		Number of citations	Administration routes	Modes of preparation	Doses	Periods	Cancer treated
In English	In Arabic						
Yellow amber	Lubân	2	Oral	Decoction	1 cup/day	TIS	ACT
Snail	Bebouch	1	Oral	Decoction	1 cup/ day	TIS	Breast
Royal jelly	Ghidaa lmalikat	3	Oral	Capsules	1 capsule/day	TIS	ACT
Camel milk	Hlib jmel	1	Oral	Raw	1 cup/day	5 months	Liver
Pure honey	L'sel hor	12	Oral	Decoction	1 cup/day	TIS	ACT
Shilajit	Chilajit	1	Oral	Decoction	1 cup/day	TIS	ACT
Omega 3	Omega 3	1	Oral	Capsules	3 capsules/day	3 months	ACT
Pollen	Hoboub liqah	1	Oral	Decoction	1 cup/day	TIS	ACT
Propolis	‘agbar	3	Oral	Powder	1 spoon/day	TIS	ACT
Scorpions	‘agreb	1	Cutaneous	Powder	1 cutaneous application/day	3 days	Skin
Camel urine	Boul dyal jmel	10	Oral	Cru	1 cup/day	TIS	ACT

TIS: Till amelioration of the status

ACT: All cancer types

Table 11. Anticancer plant species identified and comparison with existing literature

Species	Confirmation of the anticancer activity		Reference
	Treated cancer	Used part of the plant	
Vachellia seyal (Delile) P.J.H.Hurter	Liver and breast cancer	Lectin from leaves	(Patel *et al.* 2014)
Adansonia digitata L.	Breast cancer	Methanolic extract of branks	(Odunola 2021)
Ajuga iva (L.) Schreb.	-	-	-
Allium cepa L.	Breast, prostate, ovaries, lungs, and colon cancer	Alcoholic extract of bulbs	(Fadholly et al. 2019, Wang et al. 2012)
Allium sativum L.	Lungs and kidneys cancer	Aqueous extract of bulbs	(Özkan *et al.* 2021)
Aloe vera (L.) Burm.f.	Breast and uterus cancer	Aqueous extract of leaves	(Hussain *et al.* 2015, Majumder *et al.* 2020)
Alpinia officinarum Hance	Breast cancer	Methanolic extract of rhizomes	(Ghil 2013)
Ammodaucus leucotrichus Coss.	Breast, colon, liver, uterus, and lungs cancer	Essential oil	(Naima *et al.* 2019, Ziani *et al.* 2019)
Anacyclus pyrethrum (L.) Lag.	Colorectal cancer	Ethanolic extract	(Mohammadi *et al.* 2017)
Annona muricata L.	Breast, colon, liver, and lungs cancer	Aqueous extract of leaves and fruits	(Abdul Wahab *et al.* 2018)
Chamaemelum nobile (L.) All.	Skin cancer	Bioactive molecules	(Gardiner 1999)
Aristolochia clematitis L.	Burkitt lymphoma	Aqueous extract of roots	(Benarba et al. 2014)
Artemisia arborescens L.	Skin cancer	Essential oil	(Bordoni *et al.* 2021, Russo *et al.* 2020)
Artemisia herba-alba Asso	Bladder and larynx cancer, leukemia	Methanolic extract of seeds	(Khlifi *et al.* 2013)
Berberis vulgaris subsp. *australis* (Boiss.) Heywood	Epidermoid laryngeal carcinoma	Alcoholic extract of roots	(Boudjlida *et al.* 2019)
Beta vulgaris L.	Cervical and colorectal cancer	Aqueous extract of leaves and roots	(Gennari *et al.* 2011, Romero *et al.* 2021)

		Alcoholic extract of seeds	
Camellia sinensis (L.) Kuntze	-	-	-
Capparis spinosa L.	Breast, uterus, and bone cancer	Essential oil	(Moghadamnia *et al.* 2019)
Carum carvi L.	Leukemia and colon cancer	Methanolic extract of fruits and essential oil	(Bogucka-Kocka *et al.* 2008, Khatamian *et al.* 2019)
Senna alexandrina Mill.	-	-	-
Cedrus atlantica (Endl.) Manetti ex Carrière	Liver and colon cancer	Aqueous extract of stems	(Huang *et al.* 2022, X. F. Huang *et al.* 2020)
Schenkia spicata (L.) G.Mans.	-	-	-
Ceratonia siliqua L.	Breast cancer	Phenolic extract of pods	(Gregoriou *et al.* 2021)
Chlorella vulgaris Beijerinck	Liver and colon cancer	Ethanolic and aqueous extract	(Cha *et al.* 2008, Md *et al.* 2006)
Cicer arietinum L.	Breast, prostate, ovaries, liver, and colon cancer	Protein extract of seeds	(Gupta & Bhagyawant 2021, Magee *et al.* 2012)
Cichorium intybus L.	Skin, blood, liver, breast, lungs and colon cancer	Aqueous and alcoholic extracts of leaves	(Choudhary *et al.* 2021, Imam *et al.* 2019)
Camphora officinarum Nees	Colorectal cancer	Methanolic extract of leaves	(Bandopadhyaya *et al.* 2015)
Citrus × *limon* (L.) Osbeck	Leukemia	Extract of fruits	(Raimondo *et al.* 2015)
*Ophiocordyceps sinensis (*Berk.) Sung, Sung, Hywel-Jones and Spatafora	Breast, prostate, colon, bladder, and lung cancer	Extract of fruits	(Xu *et al.* 2022)
Coriandrum sativum L.	Colon, breast, and liver cancer	Ethyl acetate extract of roots	(Chithra & Leelamma 2000, H. Huang *et al.* 2020, Tang *et al.* 2013)
Crocus sativus L.	Breast, skin, uterus, bladder, lung, colorectal, blood, and pancreas cancer	Extract of stigmata	(Aung *et al.* 2007, Escribano *et al.* 1996, Samarghandian *et al.* 2010, Samarghandian & Borj 2014)
Curcuma longa L.	Breast, colon, lungs, ovaries, skin, stomach, pancreas, and prostate cancer	Extract of rhizomes	(Sultana *et al.* 2021)
Cynara cardunculus L.	Breast and colorectal cancer	Alcoholic extract of leaves	(Simsek & Uysal 2013, Velez *et al.* 2012)
Echinops spinosissimus Turra	Breast and bladder cancer	Methanolic extract	(Mothana *et al.* 2011)
Echinops spinosissimus subsp. *spinosissimus*	Liver cancer	Methanolic extract	(Samir *et al.* 2018)
Elettaria cardamomum (L.) Maton	Colon and spleen cancer	Aqueous extract of seeds	(Majdalawieh & Carr 2010)
Ephedra alata Decne.	Breast and liver cancer	Alcoholic extract of aerial part	(Bourgou *et al.* 2020)
Eucalyptus camaldulensis Dehnh.	Breast and colorectal cancer	Methanolic extract of leaves and essential oil	(Hrubik *et al.* 2012, Taheri *et al.* 2020)
Euphorbia officinarum subsp. *Echinus* (Hook.f. & Coss.) Vindt	-	-	-
Euphorbia resinifera O.Berg	Kidney cancer	Alcoholic extract of aerial part	(Mbayo *et al.* 2016)
Eurycoma longifolia Jack	Liver, ovaries, blood, breast, uterus, colon, and lungs cancer	Alcoholic extract of roots	(Thu *et al.* 2017)

Ficus carica L.	Breast, colon, and stomach cancer	Alcoholic extract of leaves	(Hashemi *et al.* 2011, Soltana *et al.* 2019, Zhang *et al.* 2018)
Foeniculum vulgare Mill.	Breast cancer	Essential oil	
Ganoderma lucidum (Curtis) P.Karst.	Liver, prostate, blood, and stomach cancer	Alcoholic extract	(Cheng & Sliva 2015, Jin *et al.* 2016)
Ginkgo biloba L.	Breast, prostate, lungs, ovaries, and stomach cancer	Alcoholic extract	(Zhang *et al.* 2008)
Handroanthus lapacho (K.Schum.) S.O.Grose	-	-	-
Hericium erinaceus (Bull.) Pers	Cervical, colorectal, mammary, hepatic, and gastro-intestinal cancer	Alcoholic extract of fruits	(AM 2017, Li *et al.* 2014)
Hordeum vulgare L.	Cervical, colorectal, mammary, pulmonary cancer	Aqueous extract	(Czerwonka *et al.* 2017)
Selenicereus undatus (Haw.) D.R.Hunt	Breast, colon, and lungs cancer	Fruit, pulp and bark extract	(Salam *et al.* 2022)
Hyoscyamus albus L.	Prostate cancer, glioma	Methanolic extract of the aerial part	(Yahia *et al.* 2018)
Hypericum perforatum L.	Breast and bladder cancer	Methanolic extract	(Mirmalek *et al.* 2015, Stavropoulos *et al.* 2006)
Lavandula angustifolia subsp. *angustifolia*	Breast, colon, liver and lungs cancer	Essential oil	(Fahmy *et al.* 2022)
Lepidium sativum L.	Breast, prostate and brain cancer	Aqueous extract of seeds	(Mahassni & Al-Reemi 2013)
Linum usitatissimum L.	Breast, prostate and ovaries cancer	Alcoholic extract of seeds	(Farshori *et al.* 2013)
Marrubium vulgare L.	Cervical cancer, glioma	Ethanolic extract of leaves and essential oil	(Kozyra *et al.* 2019, Paunovic *et al.* 2016, Zarai *et al.* 2011)
Morinda citrifolia L.	Colorectal cancer	Extract of fruits	(Brown 2012)
Moringa oleifera Lam.	Breast and colon cancer	Alcoholic extract of leaves, stems and seeds	(Al-Asmari *et al.* 2015)
Myrtus communis L.	Breast cancer	Aqueous and alcoholic extract	(Hrubik *et al.* 2012)
Nerium oleander L.	Breast, lungs, brain and skin cancer	Alcoholic extract of leaves	(Calderón-Montaño *et al.* 2013, Siddiqui *et al.* 2012)
Nigella sativa L.	Breast, liver and skin cancer	Aqueous extract of seeds	(Majdalawieh & Fayyad 2016)
Olea europaea L.	Blood and pancreas cancer	Aqueous extract of leaves	(Antoniou & Hull 2021, Goldsmith *et al.* 2015)
Origanum compactum Benth.	Breast, liver and lungs cancer	Alcoholic extract of the aerial part	(Chaouki *et al.* 2010, Chaouki *et al.* 2015)
Origanum majorana L.	Breast and colon cancer	Essential oil	(Athamneh *et al.* 2020, Dhaheri *et al.* 2013)
Panax ginseng C.A.Mey.	Prostate and liver cancer	Methanolic extract of roots	(Hawthorne *et al.* 2022, Hou *et al.* 2022)
Peganum harmala L.	Bladder, larynx and blood cancer	Methanolic extract of seeds	(Khlifi *et al.* 2013)
Petroselinum crispum (Mill.) Fuss subsp. *crispum*	Breast cancer	Alcoholic extract of seeds	(Farshori *et al.* 2013)

Phoenix dactylifera L.	Liver cancer	Fruits extract	(Ishurd & Kennedy 2005, Khan et al. 2017)
Pimpinella anisum L.	Prostate and stomach cancer	Methanolic extract of seeds Essential oil	(Kadan *et al.* 2013, Rahamoz-Haghighi & Asadi 2016)
Prunus amygdalus Batsch	Colorectal cancer	Plant extract	(Park *et al.* 2005)
Prunus armeniaca L.	Breast, liver and colon cancer	Fruits extract	(Gomaa 2013)
Prunus avium L.	Liver, stomach, ovaries and bladder cancer	Prunetin extract from fruits	(Patel & Patel 2022)
Punica granatum L.	Breast, bladder colon, blood, lungs, liver, prostate and skin cancer	Plant extract	(Dıkmen *et al.* 2011, Khwairakpam *et al.* 2018)
Retama sphaerocarpa L.	Cervical cancer	Alcoholic extract	(Benbacer *et al.* 2012)
Rosa × *damascene* Herrm.	Colorectal, cervical, and gastric cancer	Essential oil	(Khatib *et al.* 2013, Rezaie-Tavirani *et al.* 2013, Zamiri-Akhlaghi *et al.* 2011)
Salvia rosmarinus Spenn.	Breast and bladder cancer	Methanolic extract	(Mothana *et al.* 2011)
Saccharina japonica (Aresch.) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	Prostate and liver cancer	Ethanolic extract of algae	(Jo *et al.* 2012, Jung *et al.* 2014)
Salvadora persica L.	Mouth and breast cancer	Methanolic extract of roots	(Hammad *et al.* 2019, Hamza *et al.* 2022)
Salvia officinalis L.	Lungs, colon, kidneys, ovaries, prostate, breast, blood, skin, and brain cancer	Plant extract	(Kadioglu & Efferth 2015)
Dolomiaea costus (Falc.) Kasana & A.K.Pandey	Breast, colon, and liver cancer	Ethanolic extract of leaves	(Shati *et al.* 2020)
Smilax aspera L.	Breast, ovaries, and lungs cancer	Roots extract	(Dalkılıç *et al.* 2022)
Solanum linnaeanum Hepper & P.-M.L.Jaeger	Skin cancer	Glyco-alkaloïdes extract	(Cham & Meares 1987)
Arthrospira platensis Gomont	Pancreas and colon cancer	Aqueous extract	(Konícková *et al.* 2014)
Strychnos nux-vomica L.	Liver and blood cancer	Roots and seeds extract	(Vyas 2016)
Syzygium aromaticum (L.) Merr. & L.M.Perry	Mammary and cervical cancer	Aqueous extract of floral button	(Kumar *et al.* 2014)
Thymus saturejoides Coss.	Skin cancer	Plant extract	(El Hachlafi *et al.* 2021)
Trigonella foenum-graecum L.	Breast, colon, and skin cancer	Essential oil	(Al-Oqail *et al.* 2013)
Undaria pinnatifida (Harvey) Suringar	Digestive, mammary, and pancreatic cancer	Ethanolic extract of algae	(Nishibori *et al.* 2012, Wang *et al.* 2014)
Urtica urens L.	Lungs, breast, skin and colon cancer	Aqueous extract of leaves	(Al Doghaither *et al.* 2016)
Zingiber officinale Roscoe	Lungs, breast, colon, kidneys, ovaries, and skin cancer	Gingerol extract from roots	(De Lima *et al.* 2018)
Ziziphus lotus (L.) Lam.	Breast cancer	Ethanolic extract of leaves	(Souid *et al.* 2018)

Discussion

The present ethnopharmacological investigation aimed primarily to document the medicinal plants used by the Moroccan population in the Casablanca-Settat region for the treatment of various types of cancer. This ambitious survey also seeks to assess the traditional culture of medicinal plant use, passed down through generations within this region. In this regard, it aims to gather valuable knowledge about natural herbal remedies specifically used to combat cancer. The findings of this research could not only enrich our understanding of local medical practices but also contribute to the valorization of ancestral medicinal heritage and potentially open new promising avenues in cancer research. By shedding light on this traditional knowledge, this investigation aspires to facilitate collaboration between conventional medicine and ancestral wisdom, with the ultimate goal of improving treatment options and care for cancer patients in both this region and beyond. To carry out this investigation, a comprehensive coverage was conducted, encompassing a wide range of urban and rural communities in the Casablanca-Settat region. The participants in this study come from two distinct groups. The first group consists of herbalists and traditional practitioners who possess ancestral knowledge that has been passed down through generations. The second group comprises cancer patients who bring their personal experiences related to the use of medicinal plants in combating the disease.

According to the results obtained, our study sample includes individuals of all ages, ranging from the age of one to 98 years, with an average age of 52 years and a standard deviation of 14 years. The most represented age group is the 40 to 59 age range, accounting for 54.24% of the participants. In addition, the female gender is the most represented in this study. These women are also the most frequent users of medicinal plants, in line with similar research conducted by Tahraoui *et al.* (2007) and Taïbi *et al.* (2020). This predominance of women in the use of medicinal plants can be explained by the nature of their daily responsibilities, such as taking care of their children and maintaining their health in an effective and economical manner. Thus, their in-depth knowledge of medicinal plants is a direct consequence of their central role in preserving family health and well-being (Pépy 2018). Furthermore, we observed a prevailing trend indicating a higher frequency of cancer among women compared to men. Our research involved 321 surveyed patients, through which we identified 22 types of cancer. Of these, breast cancer emerged as the most prevalent within our study population, accounting 43.15% of all reported cancer cases. These results are consistent with other ethnopharmacological investigations conducted in various regions of the Kingdom of Morocco, as demonstrated by the studies of Kabbaj *et al.* (2012) and Samouh *et al.* (2019). The elevated occurrence of breast cancer among Moroccan women appears to be a significant contributing factor to the increased prevalence of cancer observed among women in our study, a trend similarly noted by Kabbaj *et al.* (2012). The FIC analysis revealed three distinct patterns of medicinal plant usage for treating these cancers. In the first case, characterized by high FIC values, specific agreement and homogeneity were observed in the use of certain medicinal plants for treating breast, uterus, intestine, brain, bone, skin, jaw, prostate, ovary, and bladder cancers. The second case, with FIC=1, indicated that only a few medicinal plants were reported and commonly used by most informants to treat foot and eye cancers. The third case, with FIC values lower than 0.5, a random selection of plant species was cited and used to treat cancer such as, stomach, lung, armpit, liver, mouth, tonsil, leukemia, and bone marrow. These findings highlight the diverse patterns of medicinal plant used to treat different types of cancer in the studied population, ranging from specific agreements for certain cancers to more varied and random practices for others.

In the context of ethnopharmacology, our study has identified a total of 90 plant species, with 4 of them being exclusive to Morocco. These species belong to 54 diverse families, highlighting the extensive array of medicinal plants employed in cancer treatment. This underscores the importance of traditional medicine for the population of the Casablanca-Settat region, encompassing cancer patients, herbalists, and traditional healers. Among these plant families, our analysis reveals that Pinaceae were the most commonly employed in cancer treatment, followed by Aristolochiaceae, Berberidaceae, and finally Lamiaceae. These findings accentuate the prevalence of specific plant families in traditional medicinal practices for combating cancer. Additionally, it is noteworthy that our study aligns with certain plant families from another ethnobotanical study conducted in the province of Casablanca, namely Aristolochiaceae, Lamiaceae, Euphorbiaceae, and Ephedraceae (Bourhia *et al.* 2019). Importantly, the use of these identified plant families for cancer treatment extends beyond the Casablanca-Settat region, being widespread in other North African countries, with a predominance of Lamiaceae, as noted in the study by Alves-Silva *et al.* (2017). Thus, these medicinal plant families have a significant and widespread presence in Moroccan and African traditional medicine. These findings underscore the significance of preserving and promoting traditional knowledge of herbal medicine in the Casablanca-Settat region and North Africa. Indeed, a deeper understanding of these age-old medical practices can be valuable in identifying new research avenues in oncology and developing complementary and integrative therapies in the battle against cancer. The prominent mention of these plant families in our survey indicates their genuine and steadfast use in Moroccan traditional medicine, particularly in the Casablanca-Settat region, for cancer treatment. These long-held practices and knowledge have been transmitted across generations, underscoring the confidence in the medicinal properties of these botanical families for addressing this condition.

Additionally, it is noteworthy that a majority of the plant families identified in our study exhibit significant pharmacological effects against cancer, as documented in the research by Amjad *et al.* (2020). This scientific validation further reinforces the credibility of Moroccan traditional medicinal practices and underscores the therapeutic potential of species from these families in the fight against cancer.

In our investigation, *Marrubium vulgare* emerged as the most frequently mentioned species by the informants, with a UV=0.534. It was closely followed by *Cedrus atlantica*, *Aristolochia clematitis*, and *Berberis vulgaris* subsp. *australis*. These findings corroborate with previous ethnobotanical studies conducted by Kabbaj *et al.* (2012), Chebat *et al.* (2014), and Bourhia *et al.* (2019), which also identified *Marrubium vulgare* as one of the most commonly used medicinal plants for cancer treatment. The widespread use of *Marrubium vulgare* can be attributed to its proven effectiveness in treating various types of cancer, including breast cancer and uterine cancer (El Hachlafi *et al.* 2022). Multiple researchers have confirmed its anticancer properties, further validating its traditional application for these ailments (Zarai *et al.* 2011, Paunovic *et al.* 2016, Kozyra *et al.* 2019). The acknowledgment of *Marrubium vulgare* and other medicinal plants by local communities for cancer treatment emphasizes the importance of preserving and valuing ancestral knowledge in herbal medicine. These plants have the potential to serve as a valuable source of bioactive compounds and novel anticancer molecules, warranting further exploration and research.

Our study has yielded valuable insights into the use of plant parts and preparation methods commonly employed in cancer treatment by the surveyed population. Notably, plant leaves emerged as the most frequently utilized part, corroborating findings from studies conducted by Bhat *et al.* (2013), Bourhia *et al.* (2019), El Hamsas El Youbi *et al.* (2016), El Youbi *et al.* (2016), Taïbi *et al.* (2020), and Rana *et al.* (2021). These consistent research outcomes underscore the significant role of plant leaves in traditional medicine for addressing various health conditions, including cancer. The popularity of leaves in cancer treatment within traditional medicine may be attributed to their year-round availability and the ease of harvesting and preparation. Moreover, we observed that the predominant mode of preparation was the decoction method. This observation aligns with the conclusions of studies conducted by Samouh *et al.* (2019) and Taïbi *et al.* (2020). However, it is noteworthy that Amrati *et al.* (2021) reported the powdered form as the most common preparation method in their study. These variations in preparation methods might reflect regional practices and the diverse cultural traditions inherited across different areas of Morocco.

In terms of administration, our study's findings confirmed that the oral route was the preferred method for the majority of participants, with a high rate of 89.74%. This preference is in line with findings from other ethnobotanical surveys conducted in Morocco as reported by Amrati *et al.* (2021) and El Hamsas El Youbi *et al.* (2016). Several factors contribute to the popularity of the oral route in traditional cancer treatment. Firstly, oral administration is considered easy and convenient, involving the simple ingestion of herbal preparations through the mouth. It does not require special techniques and is accessible to most individuals. Additionally, oral administration is perceived as less risky compared to other methods like injection or topical application, which may be more invasive or cause undesirable reactions. Its generally well-tolerated nature renders it an appealing option for numerous patients. Moreover, the ease of preparing and consuming herbal medicines orally allows for seamless integration into people's daily routines, enhancing treatment adherence and following the recommendations of traditional medicine practitioners. The preference for the oral route in administering herbal treatments also underscores the significance of transmitting traditional knowledge and practices from one generation to another in the Casablanca-Settat region. In cultures where traditional medicine plays a crucial role, the oral route becomes a favored means to perpetuate medicinal traditions.

In terms of dosage, our study revealed a notable difference between the doses prescribed by the informants and the doses actually used by the patients. These dosage variations were expressed in diverse measures, such as teaspoons, tablespoons, cups, or bowls. This indicates that standardized dosages have not yet been well-established in Moroccan traditional medicine, including the treatment of conditions like cancer. These findings are consistent with Taïbi *et al.*'s (2020) observations, where discrepancies in reported dosages by traditional medicine practitioners were also noted. Several factors could contribute to these variations. One significant factor is the level of education among informants, which significantly influences the transmission of traditional knowledge. In certain regions, many traditional medicine practitioners may have limited education, which can influence how they communicate treatment dosages. The use of familiar measures like teaspoons or tablespoons might be more common for them than standardized dosage units. Additionally, a lack of awareness regarding the potential toxicity of certain medicinal plants when consumed in excessive amounts might contribute to contradictory prescribed dosages. Insufficient pharmacological knowledge and scientific research could lead to a lack of understanding of safe and effective dosages. Besides, traditional medicine often relies on knowledge passed down from

generation to generation, leading to variations in practices and interpretations across regions and families. This oral transmission of knowledge can result in differences in prescribed dosages.

Our study's data analysis also unveiled that among the plants mentioned by the participants, 21 of them were identified as toxic and capable of causing various physiological disruptions. These toxic effects were primarily associated with disturbances in neurological, hepatic, renal, and digestive functions (Bellakhdar 2020). Among the plants reported as toxic, *Aristolochia clematitis* was the most frequently cited by the participants. This particular plant is well-known for its harmful pathological effects, mainly attributed to the presence of aristolochic acid in its roots (Amrati *et al.* 2021, El Hamsas el Youbi & Bousta 2020, El Omari *et al.* 2020). Previous scientific studies have indeed demonstrated that the consumption of *Aristolochia clematitis* can lead to irreversible kidney tissue damage. Aristolochic acid is a toxic chemical compound that can cause severe kidney injuries when ingested by humans. These kidney lesions can result in serious health complications and, in severe cases, may even be fatal (Han *et al.* 2019, Vervaet *et al.* 2017).

Apart from monotherapy, herbalists and traditional practitioners in the Casablanca-Settat region have also suggested plant-based mixtures and preparations for cancer treatment. The efficacy of these mixtures was evaluated, and except for three recipes that showed no effectiveness, the other 29 mixtures demonstrated significant efficacy in treating various types of cancer among the users. This effectiveness is largely attributed to the synergistic effect of the bioactive molecules found in the diverse ingredients used for each preparation. Certain medicinal plants contain an array of bioactive compounds such as polyphenols, flavonoids, alkaloids, terpenes, and other health-beneficial substances (Riaz *et al.* 2023, Sun & Shahrajabian 2023). When combined in specific mixtures, these bioactive molecules interact synergistically, augmenting their effectiveness in treating cancer. This practice of blending medicinal plants in therapeutic mixtures is a common approach in traditional medicine, rooted in the belief that certain plants can work synergistically to enhance healing properties and mitigate undesirable effects.

In addition to herbal medicines, the population of the Casablanca-Settat region also employed various natural products for treating cancer. These products were derived from diverse sources, including plants like amber and Shilajit, as well as animals such as honey, royal jelly, pollen, camel urine and milk, scorpions, and snails. The use of these natural products in cancer treatment might stem from the belief in their beneficial health properties, particularly their potential to demonstrate anticancer effects. Several studies have indeed indicated that certain natural products extracted from animals or plants possess anticancer properties by influencing various physiological and molecular pathways involved in tumor growth (Taïbi *et al.* 2020). Nevertheless, it is essential to acknowledge that the use of these natural products can spark controversy. Some studies have established a link between the use of these remedies and patients' limited access to standard anticancer therapies or even their ineffectiveness in certain cases (Ahmad *et al.* 2017).

Conclusion

In conclusion, this ethnopharmacological investigation has successfully documented the diverse array of medicinal plants used by the Moroccan population in the Casablanca-Settat region for the treatment of various types of cancer. The study has not only provided valuable insights into the traditional medicinal practices of the region but has also contributed to the preservation and appreciation of ancestral medicinal heritage. Furthermore, the findings from this research have the potential to open new and promising avenues for cancer research and treatment. By bridging the gap between traditional and modern medicine, this investigation aims to foster collaboration and integration, ultimately leading to improve treatment and care prospects for cancer patients. The comprehensive coverage of urban and rural communities in the region and the inclusion of both herbalists and traditional practitioners, as well as cancer patients, have provided a holistic insight on the use of medicinal plants for cancer treatment. The study sheds light on the prevalence of cancer among women, particularly breast cancer, and highlights the significant role of *Marrubium vulgare* in traditional cancer treatment. The emphasis on plant leaves and the decoction method for preparation is consistent with regional practices, highlighting the importance of preserving and promoting traditional knowledge. The identification of 90 plant species, with 4 considered endemic in Morocco, and the prevalence of specific plant families, such as Pinaceae, Aristolochiaceae, Berberidaceae, and Lamiaceae, in cancer treatment showcases the richness and potential of Moroccan traditional medicine. The scientific validation of the pharmacological effects of these plant families further enhances their credibility in cancer treatment. However, it is crucial to address the discrepancies in dosages and the toxicity associated with certain medicinal plants, like *Aristolochia clematitis*. Awareness and caution should be spread regarding the use of plants without scientific validation to ensure patient safety and efficacy in cancer treatment. The incorporation of plant-based mixtures and preparations into cancer therapy, which have demonstrated significant effectiveness, underscores the potential benefits of combining

traditional knowledge with modern medical practices. Overall, this comprehensive study provides valuable insights into traditional medicinal practices, offering a platform for further research and the preservation of ancestral knowledge in herbal medicine. Integrating this knowledge into modern oncology research can foster the development of innovative therapeutic approaches to cancer treatment, preserving cultural heritage while advancing medical science.

Declarations

List of abbreviations: ACT - All Cancer Type; FIC - Factor Informant Consensus; FL - Fidelity Level; FUV - Family Use Value; PPV - Plant Part Value; TIS - Till Improvement of Status; UV - Use Value; WHO - World Health Organization

Ethics approval and consent to participate: The authors affirm that they acquired verbal consent was obtained from each participant before interviews, and they ensured the protection of the subjects' privacy rights. This study does not contain any experiment(s) on humans and animals. During the ethnopharmacological data collection from informants a prior oral consent and written permission from local authorities has been taken.

Consent for publication: Not applicable - this manuscript has no personal data from the authors.

Availability of data and materials: The original data is presented in the article. There is no supplementary data. The raw data without the names of informants can be provided by authors.

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