Ras El Hanout: Traditional blend of medicinal plants and spices - toxic compounds and poisoning risks

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Research

Abstract

Background: In Morocco, plants are not only used in isolation, but also in more complex preparations. These include the famous *Ras El Hanout* mixture, a traditional theriac used as a spice and for therapeutic purposes. The aim of this study is to identify the toxic plants making up this mixture and the extent of the risks involved in using them.

Methods: Using ethnobotanical investigations carried out among herbalists in the city of Meknes (Morocco) and by consulting various specialist journals and books, the aim is to determine which of the plants making up the *Ras El Hanout* mixture are toxic and to gather information on their toxicological profiles.

Results: As well as improving the taste and seasoning of dishes, the Ras El Hanout mixture is recommended for treating a number of health problems. However, research has revealed that 39 of the 60 plants making up the *Ras El Hanout* mixture are considered toxic or have side effects that affect all the body's physiological functions, particularly the gastrointestinal, hepatic and renal systems. Various toxic principles are incriminated, classified in several chemical groups dominated by phenolic compounds, terpenes and alkaloids.

Conclusions: Many of the plants in the Ras El Hanout blend are toxic. Despite their benefits, their toxicity calls for vigilance. This study therefore presents a database that could serve as an important source of information on the toxicity of medicinal plants used by herbalists.

Keywords: Ras El Hanout; Mixture; Spice; Medicinal plant; Toxicity; Traditional medicine.

Background

The use of medicinal plants has remained a fundamental pillar throughout the ages, despite significant advances in the pharmacological field, particularly in developing countries (Chaachouay *et al.* 2019, Dossou-Yovo *et al.* 2017, Najem *et al.* 2020b, Najem *et al.* 2021), especially in Africa where native plants are the main component of traditional medicinal recipes (Najem *et al.* 2020).

Morocco, with its 7,000 plant species, 4,500 of which are vascular, is a veritable phytogenetic reservoir (Fennane 2004). This wealth of species is distributed mainly in two major Mediterranean hotspots: the Middle and High Atlas mountains in the center of the country, and the Betic-Rifain complex which stretches from the north of Morocco to Andalusia and the Algerian Tell (Medail & Quézel 1997). This floristic heritage has enabled Morocco to occupy a privileged place among the countries of the Mediterranean rim which have a long tradition of plant-based medicinal products and ancestral know-how (Fennane 2004). In addition, knowledge of the medicinal properties of plants in Morocco has been enriched by the cultural mix of Amazigh, Jewish and Arab ethnic groups living in the country (El Rhaffari & Zaid 2002).

Throughout the world, several plant mixtures are used either in gastronomy to flavor dishes, as is the case with curry from the Indian subcontinent, the French bouquet garni or herbes de Provence, Mexican adobo, Chinese five spices and Georgian khmeli-suneli (Cahuzac-Picaud 2012); or in traditional therapy, such as Imbiza ephuzwato from southern Africa (Ndhlala *et al.* 2011). North Africa, and Morocco in particular, is known for its famous Ras El Hanout blend, which has two uses: culinary, to flavor traditional dishes, and therapeutic (Najem *et al.* 2024).

In fact, *Ras El Hanout* is a traditional theriac of warming products and spices. Given its composition, which contains a large number of spices and medicinal plants much in demand in Moroccan cooking and phytotherapy, the name *Ras El Hanout* means 'head of the grocery shop' in Moroccan dialect Arabic. Ras El Hanout can also be called *Msakhen*, which means 'warming'. For others, the name *Msakhen* is only used after the addition of other complementary ingredients (Bellakhder 1997, El Alami *et al.* 2019, Najem *et al.,* 2024).

Furthermore, plants are often wrongly perceived as harmless, and people use them in a variety of contexts, in the form of mixtures which they do not always know how to prepare and consume (Rhalem et al., 2010). In Morocco, as elsewhere, several of these plants used for culinary or therapeutic purposes are the cause of poisoning, usually accidental and sometimes deliberate, thus constituting a fairly serious public health problem (Chater 2016). Moreover, the cases of intoxication reported by the Moroccan Poison Control and Pharmacovigilance Centre (CAPM) show that the health problems caused by the uncontrolled use of plants are far from negligible (Rhalem *et al.* 2010).

More alarmingly, no clear distinction is made in the literature between medicinal plants and toxic plants, because most medicinal plants used as medication are in fact toxic in large doses. Indeed, the accumulation of certain active components in the human or animal body, even in minute quantities, can lead to numerous metabolic dysfunctions and cause various toxic symptoms (Al-Qura'n 2005).

Indeed, studies have reported the mutagenic activity of the mixture Imbiza ephuzwato characterizing southern Africa. Also, the Anti Poison and Pharmacovigilance Center of Morocco, during the period from 1990 to 2007, received six reports of cases of poisoning by *Ras el Hanout*, two of which presented a stage 1 coma (CAPM 2009)

Thus, this study aims to identify the toxic plants present in the *Ras El Hanout* mixture and to evaluate the risks of poisoning associated with its traditional use.

Materials and Methods

Presentation of the study area

The ethnobotanical investigations in this study were carried out in the city of Meknes, one of the 6 major cities in the Kingdom of Morocco. Due to its geographical position, the city represents a communication hub between the Atlantic plains, the pre-Rif hills, the Middle Atlas, and the high plateaus of the Oriental region. It is currently one of the two main urban centers in the Fez-Meknes region (H.C.P. 2014). The city is made up of the municipalities of Meknes, Toulal, Ouislane and El Mechouar Stinia, covering an area of 370 km^2, with a legal population of 632079 inhabitants in 2014 (HCP 2014). In 2013, the public hospital infrastructure in Meknes included 2 general hospitals, 2 specialized hospitals and 33 health centers (HCP 2013).

Meknes has a semi-continental Mediterranean climate, with cool, rainy winters and hot, dry summers. Influenced by its remoteness from the coast, Meknes' thermal regime varies considerably, with an average range of 30.7°C. The average maximum in the hottest month varies between 33° and 36°, while the average minimum in the coldest month varies between 3° and 7° (HCP 2017).

Target population

In order to obtain correct ethnobotanical information and original ideas about medicinal and aromatic plants, this study targeted herbalists from the study area who were reputed to be skilled and expert in the practice of phytotherapy or the trade in aromatic and medicinal plants. The target population was subdivided into strata each containing the same number of herbalists, resulting in a sample size of N=60 respondents. The strata were represented by the following urban districts: Old Medina, El Mechouar Stinia, Marjane, Zitoun, Toulat and Ouislane (Fig. 1).

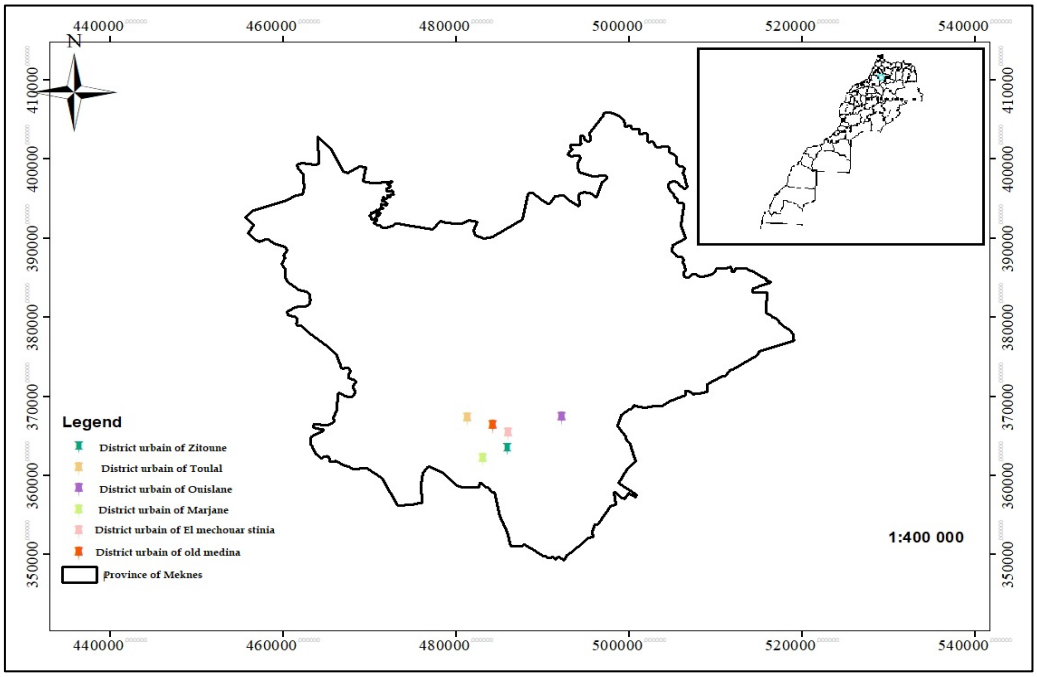

Figure 1. Study area

Research strategy

The research strategy adopted in this study is based on the following points:

1- The exploitation of data from ethnobotanical investigations carried out by our team among 60 herbalists in the town of Meknes (Morocco) on the *Ras El Hanout* mixture (Najem M. et al., 2024). These investigations enabled us to list the plants used in the formulation of this mixture. The ethnobotanical surveys were carried out in the local language (Moroccan dialect Arabic) and combined several techniques. These included the free listing technique, in which respondents were asked to list the plants and other various ingredients they use in preparing the *Ras El Hanout* mixture. The field diary technique, which consists of using audio recordings to gather information with the interviewee's permission. In addition, the traditional ethnobotanical knowledge of the herbalists surveyed about the *Ras El Hanout* mixture was documented using a semi-structured questionnaire, with respondents asked to answer closed and semi-closed questions. During each interview, informants were asked about the local name of each plant, the part or parts used, symptoms of intoxication and other information. The data collected was tabulated using spreadsheets (Excel) and analyzed statistically using SPSS Statistics 20 software.

2- The taxonomy of the plants was validated using the three volumes of the practical flora of Morocco (Fennane *et al.* 1999, Fennane *et al.* 2007, Fennane *et al*. 2014). In order to be consistent with the updated species nomenclature, in accordance with the APG III 'Angiosperm Phylogeny Group' classification, the 'WFO Plant List' database (https://wfoplantlist.org/) was consulted.

3- The in-depth study based on bibliographic research and analysis of scientific publications was carried out using relevant electronic resources, such as Embase, ScienceDirect, Medline PubMed, Google Scholar and Scopus. The first step was to

identify the toxic plants in the *Ras El Hanout* mixture, and then to compile as much information as possible about their toxicological profiles, in particular their toxic principles, undesirable effects and symptoms of intoxication.

Results and Discussion

Ras El Hanout is an emblematic theriac of Moroccan culture, occupying a central place in traditional culinary and medicinal practices. Ethnobotanical investigations carried out with herbalists in the city of Meknes revealed that there is no standard composition for Ras El Hanout and that the constituent plants of this mixture differ according to the herbalists and the intended use of the mixture and can go up to 60 species (Table 1).

Constituent plants of the *Ras El Hanout* mixture and their traditional uses

Traditionally, *Ras El Hanout* is used by Moroccans as much as any other spice blend to add subtle flavor and aroma to traditional Moroccan dishes such as Couscous, Mrouzia, Harira (traditional soup), Rfissa, Tride, Tambselt and Tajine.

In addition to its culinary uses, *Ras El Hanout* is reputed by Moroccans to be used as a theriac to treat various illnesses. In fact, ethnobotanical investigations carried out with herbalists in the city of Meknes have revealed that it is recommended for treating digestive, inflammatory, genital and cold-related illnesses, as well as being used as an aphrodisiac and tonic.

Table 1 lists the plants used to formulate the *Ras El Hanout* mixture, as well as the category or categories of use for each plant. The plants will be mixed according to their intended use, resulting in different mixtures, all called Ras El Hanout. Thanks to their accumulated experience and inherited traditional know-how, herbalists are able to make these mixtures according to the specific needs of their customers. The basic mixture can contain up to 45 species and is frequently used as a spice (Najem *et al.* 2024). The plants that enter into its composition are: *Aframomum melegueta* K. Schum, *Alpinia officinarum* Hance, *Ammodaucus leucotrichus* Coss. et Dur., *Anethum graveolens* L., *Brassica nigra* (L.) W.D. Koch., *Capparis spinosa* L., *Capsicum frutescens* L., *Carum carvi* L., *Ceratonia siliqua* L., *Cinnamomum cassia* (Nees & T. Nees) J. Presl., *Colchicum autumnale* L., *Coriandrum sativum* L., *Corrigiola telephiifolia* Pourr., *Crocus sativus* L., *Cuminum cyminum* L., *Curcuma xanthorrhiza* Roxb., *Elettaria cardamomum* (L.) Maton, *Eruca vesicaria* L., *Foeniculum vulgare* Mill., *Fraxinus excelsior* L., *Glycine max* (L.) Merr., *Illicium verum* Hook. F, *Laurus nobilis* L., *Lepidium sativum* L., *Linum usitatissimum* L., *Myristica fragrans* Houtt., *Nigella sativa* L., *Origanum compactum* Benth., *Pennisetum typhoides* (Burm.) Stapf et Hubb., *Pimenta officinalis* (L.) Merr., *Pimpinella anisum* L., *Piper cubeba* L.f., *Piper nigrum* L., *Piper retrofractum* Vahl., *Punica granatum* L., *Ranunculus bullatus* L., *Rosmarinus officinalis* L., *Rubia peregrina L.*, *Sesamum indicum* L., *Syzygium aromaticum* (L.) Merr. & L.M.Perry, *Thymus* sp., *Trigonella foenum-graecum* L., *Xylopia aethiopica* A. Rich., *Zingiber officinale* Rosc. and *Ziziphus lotus* L.

Other mixtures are prepared from the basic mixture, to which other plants are added depending on the intended purpose (Najem *et al.* 2024). The category of use of each plant is presented in Table 1. These mixtures are marketed in powder form.

Table 1. Constituent plants of *Ras El Hanout* and their uses

Family	Scientific name	Vernacular name	Specimen number	Use
Anacardiaceae	*Pistacia atlantica* Desf.	Lebtem	TRH01	Col
Annonaceae	*Xylopia aethiopica* A. Rich.	Bzar dakar	TRH08	Spi, Inf
Apiaceae	*Ammodaucus leucotrichus* Coss. and Dur.	Lkamoune Soufi	TRH45	Spi, Inf, Col
Apiaceae	*Anethum graveolens* L.	Chibt	TRH58	Spi, Dig, Inf
Apiaceae	*Carum carvi* L.	karwia	TRH44	Spi, Dig, Col
Apiaceae	*Coriandrum sativum* L.	kazbour	TRH36	Spi, Dig, Inf, Col, Gen
Apiaceae	*Cuminum cyminum* L.	Lkamoun	TRH25	Spi, Dig, Inf, Col
Apiaceae	*Ferula assa-foetida* L.	Hentit	TRH19	Col
Apiaceae	*Foeniculum vulgare* Mill.	Nafaâ	TRH02	Spi, Dig, Col, Gen
Apiaceae	*Pimpinella anisum* L.	Hbat Lhlawa	TRH24	Spi, Dig, Inf, Col
Apiaceae	*Smyrnium olusatrum* L.	Habbet gri	TRH59	Col
Asteraceae	*Centaurea pungens* Pomel	Neggir	TRH46	Col
Brassicaceae	*Brassica nigra* (L.) W.D. Koch.	Khardal aswad	TRH35	Spi, Col
Brassicaceae	*Eremophyton chevallieri* (baratte) Beg.	Galglan	TRH37	Col
Brassicaceae	*Eruca vesicaria* L.	Lharra	TRH03	Spi, Col

Brassicaceae	*Lepidium sativum* L.	Hab rchat	TRH18	Spi, Inf, Col, Gen
Capparaceae	*Capparis spinosa* L.	Kebbar	TRH57	Spi, Inf, Col
Caryophyllaceae	*Corrigiola telephiifolia* Pourr.	Tasrghinte	TRH43	Spi, Col
Colchicaceae	*Androcymbium gramineum* (Cav.) J.C.Manning & Vinn.	Sgeat lerneb	TRH34	Col
Colchicaceae	*Colchicum autumnale* L.	Bakbouka	TRH47	Spi, Inf, Col, Aph and Ton
Cyperaceae	*Cyperus esculentus* L.	Habb ezzalam	TRH04	Dig, Aph and Ton
Euphorbiaceae	*Euphorbia calyptrata* Coss. & Kralik	Rremada	TRH17	Inf, Col
Fabaceae	*Acacia raddiana* Savi	Talh	TRH56	Dig, Inf, Col
Fabaceae	*Ceratonia siliqua* L.	Kharroub	TRH23	Spi, Dig, Inf
Fabaceae	*Glycine max* (L.) Merr.	Souja	TRH38	Spi, Gen
Fabaceae	*Trigonella foenum-graecum* L.	Lhalba	TRH05	Spi, Dig, Inf, Col, Gen
Iridaceae	*Crocus sativus* L.	Zaafran	TRH16	Spi, Dig, Inf
Lamiaceae	*Marrubium desertii* DeNoe	Ja'da	TRH33	Dig, Inf, Col, Gen
Lamiaceae	*Origanum compactum* Benth.	Zaatar	TRH09	Spi, Dig, Inf, Col
Lamiaceae	*Rosmarinus officinalis* L.	Azir	TRH26	Spi, Dig, Inf, Col
Lamiaceae	*Thymus* sp.	Ziitra	TRH15	Spi, Dig, Inf, Col
Lauraceae	*Cinnamomum cassia* (Nees & T. Nees) J. Presl.	Lkarfa	TRH22	Spi, Dig, Inf, Col, Gen, Aph and Ton
Lauraceae	*Laurus nobilis* L.	Asayt Sidna Moussa	TRH32	Spi, Dig
Linaceae	*Linum usitatissimum* L.	Zriât alkattane	TRH06	Spi, Col
Lythraceae	*Punica granatum* L.	Rman	TRH48	Spi, Dig, Inf, Col, Aph and Ton
Myristicaceae	*Myristica fragrans* Houtt.	Lgouza	TRH39	Spi, Inf, Col
Myrtaceae	*Pimenta officinalis* (L.) Merr.	Nwiwira	TRH55	Spi, Col, Aph and Ton
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Lqronfil	TRH07	Spi, Inf, Col, Gen
Oleaceae	*Fraxinus angustifolia* Vahl.	Taslent	TRH20	Col, Aph and Ton
Oleaceae	*Fraxinus excelsior* L.	Lsan Attir	TRH31	Spi, Inf, Col
Pedaliaceae	*Sesamum indicum* L.	Zenjlane	TRH14	Spi, Inf
Piperaceae	*Piper cubeba* L.f.	Lkbbaba	TRH10	Spi, Inf, Col, Gen, Aph and Ton
Piperaceae	*Piper nigrum* L.	Lbzar	TRH40	Spi, Inf, Col
Piperaceae	*Piper retrofractum* Vahl.	Melwi f ksatou	TRH49	Spi, Col, Aph and Ton
Plumbaginaceae	*Limoniastrum guyonianum* C. & D.	Zeyyat	TRH30	Col
Poaceae	*Pennisetum typhoides* (Burm.) Stapf & Hubb.	Illane	TRH50	Spi, Col
Ranunculaceae	*Nigella sativa* L.	Sanouge	TRH11	Spi, Inf, Col, Gen
Ranunculaceae	*Ranunculus bullatus* L.	Wdan Alhalouf	TRH21	Spi, Col
Resedaceae	*Reseda villosa* Coss.	Sbib lakhruf	TRH27	Aph and Ton
Rhamnaceae	*Ziziphus lotus* L.	Nbag	TRH41	Spi, Dig
Rubiaceae	*Gaillonia reboudiana* Coss. & Dur	Fessyet echikh	TRH52	Col
Rubiaceae	*Rubia peregrina L.*	Lfoua	TRH54	Spi, Dig, Col
Schisandraceae	*Illicium verum* Hook. F	Badyana	TRH12	Spi, Dig, Inf, Gen
Solanaceae	*Capsicum frutescens* L.	Sudaniya	TRH28	Spi, Inf
Urticaceae	*Urtica pilulifera* L.	Hurriga mziraa	TRH51	Inf, Aph and Ton
Zingiberaceae	*Alpinia officinarum* Hance	Khoudnjal	TRH60	Spi, Inf, Col, Gen, Aph and Ton

Zingiberaceae	*Aframomum melegueta* K. Schum.	Lgouza Sahraouia	TRH53	Spi, Dig, Inf, Col
Zingiberaceae	*Curcuma xanthorrhiza* Roxb.	Kharkoum	TRH42	Spi, Inf, Col, Aph and Ton
Zingiberaceae	*Elettaria cardamomum* (L.) Maton	kaâkala	TRH29	Spi, Dig, Inf, Gen, Aph and Ton
Zingiberaceae	*Zingiber officinale* Rosc.	Skinjbir	TRH13	Spi, Dig, Inf, Col, Aph and Ton
Spi: Spices, **Dig:** digestive, **Inf:** inflammatory, **Col:** genital and cold-related illnesses, **Aph and Ton:** aphrodisiac and tonic				

In addition to improving flavor and seasoning dishes, spices can be considered as sources of useful substances for human health (Seladji *et al.* 2021). Consumption of spices can provide a broader spectrum of physiological protection against oxidation, bacterial infections, inflammation, cancer, hyperglycemia, hypercholesterolemia, etc. (Iserin 2001). These virtues are due to their richness in secondary metabolites known as active principles, which act directly on the body (Al-Gabbiesh *et al.* 2015).

The plants that make up the *Ras El Hanout* blend contain a large number of active ingredients such as flavonoids, terpenes, saponins, tannins, coumarins, alkaloids, quinones, lipids, glycosides, steroids, essential oils and many other active ingredients involved in a variety of biological, pharmacological and even toxicological activities (El Alami *et al.* 2019, Kumar 2021, Kumar *et al.* 2021, Kumar Gupta & Sharma 2014, Seladji *et al.* 2021).

Toxicity of plants constituting the *Ras El Hanout* mixture

Several active ingredients in the plants making up the Ras El Hanout blend have been shown to have pharmacological and medicinal properties. However, some of them may be capable of causing various disorders and intoxications (El Alami *et al.* 2019). In fact, plants themselves constitute a complex system of substances, some of which are beneficial and others potentially harmful (Najem *et al.* 2020a). Moreover, it is difficult to identify poisonous plants, as they do not look very different from their non-toxic relatives (Sharawy & Alshammari 2009). Worse still, an excellent medicinal plant can become a toxic plant if it is misused (Najem *et al.* 2018).

Similarly, in China, many intoxications have occurred during the preparation of traditional remedies, and their seriousness is accentuated by the fact that the remedies used are multi-component (Efferth & Kaina 2011). Indeed, the *Ras El Hanout* mixture traditionally formulated by herbalists includes up to 60 plants. However, most research into the toxicology or efficacy of plants has focused on isolated plants or isolated principles, which does not reflect the reality of their use in practice (Wang *et al.* 2009).

Analysis of a number of articles relating to laboratory research and the results of observations and clinical tests carried out, as well as consultation of a number of reviews, confirmed the toxicity of 39 of the 60 plants involved in the formulation of *Ras El Hanout*, i.e. 65%. The impact of these plants on the body and the severity of intoxication varies, as do the toxic principles. Table 2 lists the plants with a toxic effect, the toxic principles and the symptoms of intoxication.

Table 2. Summary table of plants constituting *Ras El Hanout* with toxic effects, their toxic principles, and symptoms of poisoning

Family	Scientific name	Vernacular name	Traditional use	Toxic principles	Symptoms of intoxication
Anacardiaceae	*Pistacia atlantica* Desf.	Lebtem	Col	Not identified	Hepatotoxicity and nephrotoxicity (Dyary *et al.* 2017)
Annonaceae	*Xylopia aethiopica* A. Rich.	Bzar dakar	Spi, Inf	Xylopic acid and its derivative, deacetyl xylopic acid (Fetse *et al.* 2016)	Spermatotoxic effects *et al.* 2016)
Apiaceae	*Anethum graveolens* L.	Chibt	Spi, Dig, Inf	Carvone, limonene and furanocoumarins (Filliat 2012)	Allergic reactions, oral pruritus, tongue and throat swelling, urticaria, vomiting and diarrhea (Al-Snafi 2014)
Apiaceae	*Carum carvi* L.	karwia	Spi, Dig, Col	Carvone (Bensalek 2018)	Dizziness, lightheadedness as well liver and kidney damage (Hmammouchi 1999)
Apiaceae	*Coriandrum sativum* L.	kazbour	Spi, Dig, Inf, Col, Gen	Camphor and linalool (Duman *et al.* 2010)	Coriander seed essential oil exhibits underlying oxidative tissue damage due to the biological transformation of its dominant component, linalool (Wei *et al.* 2019)
Apiaceae	*Cuminum cyminum* L.	Lkamoun	Spi, Dig, Inf, Col	Not identified	Growth impairment and enterohepatonephropathy in rats (Al-Snafi 2016)
Apiaceae	*Ferula assa-foetida* L.	Hentit	Col	Ferulic acid, sesquiterpenic and coumarinic derivatives (Hammiche *et al.* 2013)	It causes liver disorders with persistent elevation of transaminase levels. In very young children, it causes methemoglobinemia (Hammiche *et al.* 2013)
Apiaceae	*Foeniculum vulgare* Mill.	Nafaa	Spi, Dig, Col, Gen	Estragole or methyl chavicol (Levorato *et al.* 2018) anethole or trans-anethole (Lamarti *et al.* 1993)	- Neurological disorders: daze, hallucinations and convulsions (Bellakhdar 1997) ; -Hepatotoxicity and nephrotoxicity (Al-Hizab *et al.* 2018) ; - Respiratory distress, movement disorder and unresponsiveness to external stimulation (Ostad *et al.* 2001).
Apiaceae	*Pimpinella anisum* L.	Hbat Lhlawa	Spi, Dig, Inf, Col	Anethol (Bellakhdar 1997)	Neurological disorders: general excitement, hallucinations and epileptiform seizures (Bellakhdar 1997)
Brassicaceae	*Brassica nigra* (L.) W.D. Koch.	Khardal aswad	Spi, Col	Thiocynnates released by thioglucosides under the action of myrosinase (Benkhnigue *et al.* 2011)	* Hyperthyroidism with goiter, gastrointestinal disorders (and rarely kidney irritation) may occur following internal administration. * Inhalation of allylisothiocyanate produced during preparation and application of mustard

					slurries may cause sneezing, coughing and asthma attacks. * External application causes lesions such as blistering, suppurating ulceration and necrosis (Esmail Al-Snafi 2015).
Brassicaceae	*Lepidium sativum* L.	Habrchat	Spi, Inf, Col, Gen	Not identified	- Enterohepato-nephrotoxicity; - Organ damage with anemia and leukopenia correlated with alterations in serum AST, ALT, total protein, cholesterol, urea, and other serum constituents (Adam 1999).
Capparaceae	*Capparis spinosa* L.	Kebbar	Spi, Inf, Col	Not identified	Abdominal pain, salivation, and diarrhea (Sharawy & Alshammari 2009)
Caryophyllaceae	*Corrigiola telephiifolia* Pourr.	Tasrghinte	Spi, Col	Saponins (Lakmichi *et al.* 2011)	Abdominal contractions, inactivity, prostration, intense diarrhea, and anorexia, respiratory complication (Lakmichi *et al.* 2011)
Colchicaceae	*Androcymbium gramineum* (Cav.) J.C.Manning & Vinn.	Sgeat lerneb	Col	Colchicine and demecolcine (Moussaid *et al.* 2012)	Hematuria, spleen congestion and lung problems (Moussaid *et al.* 2012)
Colchicaceae	*Colchicum autumnale* L.	Bakbouka	Spi, Inf, Col, Aph and Ton	Colchicine and tropolonic alkaloid (Hammiche *et al.* 2013)	Vomiting, diarrhea, quick pulse; gastrointestinal irritation, with burning sensation and kidney and respiratory failure (San Andrés Larrea *et al.* 2014)
Euphorbiaceae	*Euphorbia calyptrata* Coss. & Kralik	Rremada	Inf, Col	Helioscopinolide C, D, E, F and I (Wu *et al.* 2009)	Intense inflammation of the eyes, nose, mouth and skin (Wu *et al.* 2009)
Fabaceae	*Glycine max* (L.) Merr.	Souja	Spi, Gen	phytoestrogens such as soy isoflavones (Ogarah *et al.* 2017)	Reduce spermatogenic activities and sperm quality, reproductive dysfunctions and infertility (Ogarah *et al.* 2017)
Fabaceae	*Trigonella foenum-graecum* L.	Lhalba	Spi, Dig, Inf, Col, Gen	Trigonelline (Kharchoufa *et al.* 2018)	In teratogenic dosages can decrease the severity of bone marrow cell proliferation and increase fetal mortality rate (Mozaffari *et al.* 2010)
Iridaceae	*Crocus sativus* L.	Zaafran	Spi, Dig, Inf	Safranal and glucoside (El Alami *et al.* 2019)	Pathological changes were seen in the kidney and lung, increased platelet count, ataxia, lethargy, hypothermia (El Alami *et al.* 2019)
Lamiaceae	*Marrubium desertii* DeNoe	Ja'da	Dig, Inf, Col, Gen	Not identified	Nausea, vomiting and diarrhea (Saad *et al.* 2021)
Lamiaceae	*Rosmarinus officinalis* L.	Azir	Spi, Dig, Inf, Col	Verbenone and camphor (Hedayat *et al.* 2020)	- Epileptiform convulsion (Brneuton 1996) ; -Hepatotoxicity (Lima *et al.* 2003)
Lamiaceae	*Thymus* sp.	Ziitra	Spi, Dig, Inf, Col	Thymol (Li *et al.* 2019)	Impairment of hepatic and renal bioenergetic homeostasis, DNA damage in human lymphocytes, and the onset of memory

					disorders and blood-brain barrier rupture (Li *et al.* 2019)
Lauraceae	*Cinnamomum cassia* (Nees & T. Nees) J. Presl.	Lkarfa	Spi, Dig, Inf, Col, Gen, Aph and Ton	Cinnamic acid, coumarin compound (Singh *et al.* 2021)	* Stomach and intestinal disorders, vomiting and allergic reactions. * Throat irritation, breathing difficulties and risk of pneumonia or lung collapse. * Oral lesions in the form of erythematous patches with varying degrees of keratosis or superimposed ulceration (Kowalska *et al.* 2021)
Lauraceae	*Laurus nobilis* L.	Asayt Sidna Moussa	Spi, Dig	Sesquiterpene lactones (Cheminat *et al.* 1984)	Allergic contact dermatitis (Cheminat *et al.* 1984).
Linaceae	*Linum usitatissimum* L.	Zriat alkattane	Spi, Col	Linamarin, linustatin and neolinustatin (Shim *et al.* 2014)	Gastroenteritis (Al-Qura'n 2005)
Myristicaceae	*Myristica fragrans* Houtt.	Lgouza	Spi, Inf, Col	Myristicin and elemicin (Ha *et al.* 2020)	Drowsiness, paresthesia, delirium, numbness, reality detachment, vomiting, ileus, hypotension and tachycardia (Ha *et al.* 2020)
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Lqronfil	Spi, Inf, Col, Gen	Eugenol (Mohammadi Nejad 2017)	- Significant decrease in sperm count, motility and testosterone (Dehghani et al., 2012) ; -Hepatotoxic effects, acute respiratory distress with hemorrhagic pulmonary edema, toxic effects on mitochondrial function, damage in kidney and some morphological alteration and cell apoptosis in renal cells and changes in blood chemistry (Mohammadi Nejad 2017).
Piperaceae	*Piper nigrum* L.	Lbzar	Spi, Inf, Col	Piperine (Bellakhdar 1997)	Edema of the mucous membranes of the lungs, larynx and pharynx (Bellakhdar 1997)
Plumbaginaceae	*Limoniastrum guyonianum* C. & D.	Zeyyat	Col	Not identified	Alterations in kidney and liver tissue (Benkhaled *et al.* 2020)
Ranunculaceae	*Nigella sativa* L.	Sanouge	Spi, Inf, Col, Gen	Thymoquinone (Anlar & Bacanli 2020)	-Toxic effects on the histological structure of the kidney, hepatic toxicity (Zaghlol *et al.* 2012); -Changes in hemoglobin metabolism and the fall in leukocyte and platelet (Zaoui *et al.* 2002).
Ranunculaceae	*Ranunculus bullatus* L.	Wdan Alhalouf	Spi, Col	Not identified	The plant is irritating to the skin and mucous membranes. Ingested, it can cause stomatitis, burns and ulcerations (Lahsissene *et al.* 2009).
Rubiaceae	*Rubia peregrina L.*	Lfoua	Spi, Dig, Col	Alizarin and rubiadin (Inoue *et al.* 2009)	Carcinogenicity in the kidney and liver, microvesicular vacuolar, degeneration in the

					cortex and karyomegaly in the outer medulla, hepatotoxicity (Inoue *et al.* 2009)
Schisandraceae	*Illicium verum* Hook. F	badyana	Spi, Dig, Inf, Gen	Sesquiterpene lactones (veranisatins, anisatin, neoanisatin, pseudoanisatin...) (Paris 2007)	Convulsions and lethal toxicity (Wang *et al.* 2011)
Solanaceae	*Capsicum frutescens* L.	Sudaniya	Spi, Inf	Capsaicin (Batiha *et al.* 2020)	Hemorrhage of the gastric fundus, myocardial infarction and tenacious dermatitis (Batiha *et al.* 2020)
Spi: Spices; **Dig:** Digestive diseases; **Inf:** Inflammatory diseases; **Col:** Cold-related diseases**; Gen:** Genital diseases, **Aph and Ton:** Aphrodisiac and tonic					
Urticaceae	*Urtica pilulifera* L.	Hurriga mziraa	Inf, Aph and Ton	5-Hydroxytryptamine, acetylcholine and histamine (Aouadhi 2010)	Irritation to the skin (AlShuwayeb & Al-Khatib, 2013)
Zingiberaceae	*Aframomum melegueta* K. Schum.	Lgouza Sahraouia	Spi, Dig, Inf, Col	6-gingerol, 6-shogaol and 6-paradol (Ilic *et al.* 2010)	Liver toxicity (Ilic *et al.* 2010)
Zingiberaceae	*Alpinia officinarum* Hance	Khoudnjal	Spi, Inf, Col, Gen, Aph and Ton	Diarylheptanoïdes (Abubakar *et al.* 2018)	Asthenia, piloerection, anorexia, urination, diarrhea (Al-Adhroey *et al.* 2010)
Zingiberaceae	*Elettaria cardamomum* (L.) Maton	kaakala	Spi, Dig, Inf, Gen, Aph and Ton	Not identified	In Swiss albino mice: a significant increase in creatine phosphokinase levels, morphological disturbances in the heart, an inhibitory effect on glyceraldehyde 3-phosphate dehydrogenase and a significant increase in thiobarbituric acid reactive substances, succinate dehydrogenase and catalase activity (El Malti *et al.* 2007)
Zingiberaceae	*Zingiber officinale* Rosc.	Skinjbir	Spi, Dig, Inf, Col, Aph and Ton	(6)-Gingerol and (6)-shogaol (Awwad & Elkhishin 2009)	Hypotensive and bradycardic effects (Awwad and Elkhishin 2009) ; Nephrotoxicity (Gabardi *et al.* 2007)

Biodiversity of toxic plants used in the preparation of Ras El Hanout

The toxic plants used in the preparation of Ras El Hanout are divided into 23 families, of which the most represented are the Apiaceae (7 plants), the Zingiberaceae (4 species) and the Lamiaceae (3 species). The remaining 20 families are each represented by two or a single plant (Fig. 2 and Table 2).

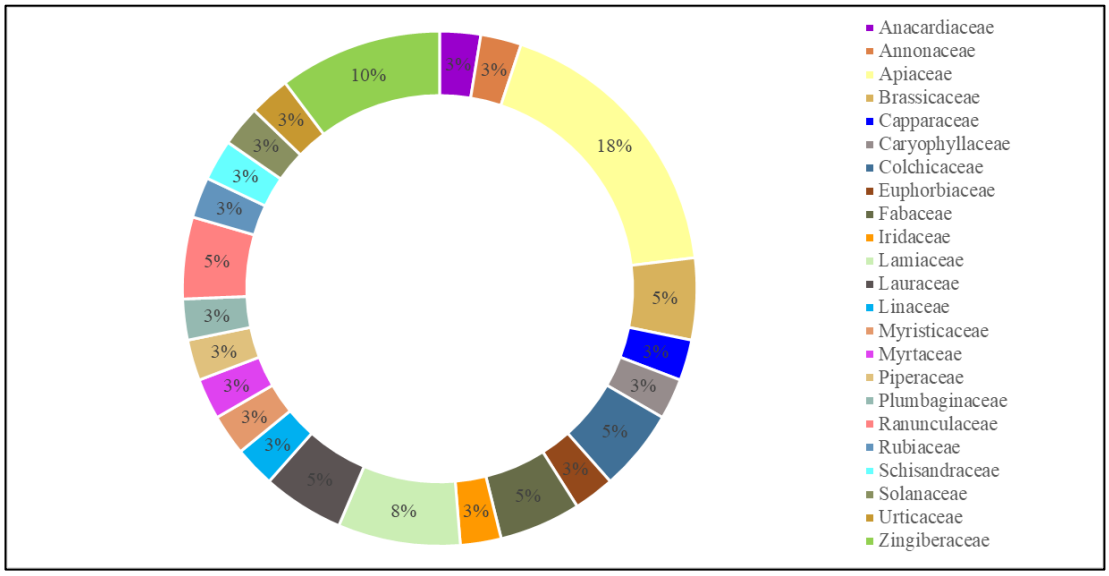

Figure 2. Specific richness of botanical families of poisonous plants found in *Ras El Hanout*

Diversity of toxic principles contained in the plants used to make *Ras El Hanout*

One of the major characteristics of plants is their ability to produce bioactive substances known as secondary metabolites in addition to their primary metabolites. These secondary metabolites are produced by plants to combat predators and pathogens, but they also constitute an immense reservoir of chemically diverse compounds with a wide range of biological activities and toxic effects (Kar 2003).

Of the plants with a toxic effect used in the preparation of the *Ras El Hanout* mixture, 31 species have had toxic principles identified (Table 2). These toxic compounds are divided into several chemical groups based on their structural and chemical properties, including phenolic compounds (34%), terpenes (26%), alkaloids (11%), glycosides (11%) and many others (Fig. 3).

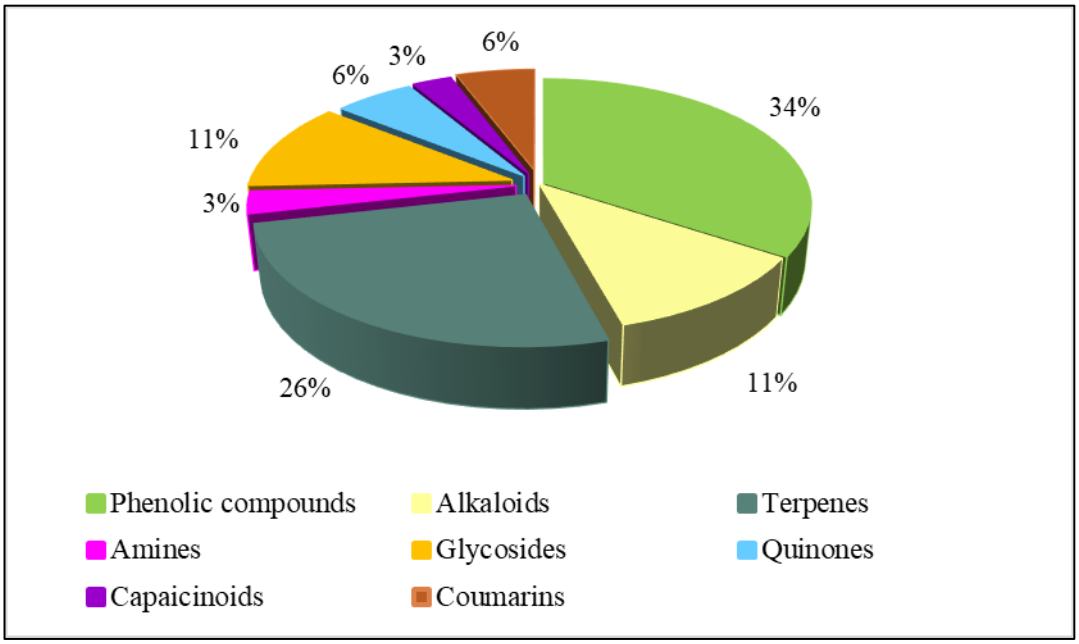

Figure 3. Distribution of toxic compounds by classes of chemical compounds

Alkaloids are one of the largest groups of secondary metabolites, being extremely diverse in terms of structure and biosynthetic pathways, comprising more than 20,000 different molecules distributed in around 20% of known vascular plants (Matsuura & Fett-Neto 2015), their toxicity largely depending on the nature, the quantity of alkaloid ingested and the sensitivity of the consumer (Lee *et al.* 2014). Some alkaloids can be extremely harmful, as in the case of the steroidal alkaloid cyclopamine, which is responsible for teratogenic effects leading to craniofacial malformations at birth (Lee *et al*. 2014). Tropane alkaloids have anticholinergic and hallucinogenic effects, causing constipation, photophobia, pupil dilation, blurred vision and drying of the mucous membranes of the upper digestive and respiratory tracts (Koleva *et al.* 2012). Highly toxic carcinogenic and genotoxic effects are the main mechanism of action of pyrrolizidine alkaloids (Shimshoni *et al.* 2015). The acute and chronic liver toxicity of these pyrrolizidine alkaloids in humans and other animals is well known, as are certain symptoms of acute intoxication such as abdominal pain, nausea, vomiting, diarrhea and oedema (Koleva *et al.* 2012). It should be noted that the dose is a key factor in determining the toxicity of alkaloids; for example, low-dose colchicine (1mg/day to 3mg/day) has a positive impact in the treatment of inflammation, but high doses cause gastrointestinal irritation and digestive disturbances that can be fatal (Lioté 2011). The same is true of the myristicin contained in nutmeg (*Myristica fragrans* Houtt.), which is renowned for its gastronomic and therapeutic properties (Najem *et al.* 2024). These recreational properties (Table 2) appear after ingestion of 5 to 30 g, but the first toxic effects appear after ingestion of 10 g (Gavroy 2022).

Phenolic compounds derived from natural sources have been associated with potential beneficial activities. However, they can also be a source of intoxication. This dual function of phenolic compounds also becomes evident when their carcinogenic or cytotoxic or even genotoxic potential are examined (Bhuyan & Basu 2017). In fact, the genotoxic activity of phenolic compounds is revealed by DNA double strand breaks and oxidative damage to DNA, especially in the presence of transition metal ions, as in the case of tea catechins (Furukawa *et al*. 2003). Some flavanones have negative cytotoxic activity, acting as inhibitors of a number of protein kinases and potentially modulating intracellular signaling cascades vital for cell function (Williams *et al.* 2004). Although flavonoids are often considered harmless because they are of plant origin, they should be consumed with caution, as some of them are thought to have carcinogenic properties. This carcinogenic activity results from direct interaction with DNA, modification of carcinogenic activation and pro-oxidant mutagenic effects (Hodek *et al.* 2006).

Coumarins are also known to be hepatotoxic, and studies on rats have shown that administration of coumarins increases the incidence of cholangiocarcinoma and parenchymal liver cell tumours (Born *et al.* 2000).

Certain terpenoids are known to induce toxic effects in humans and animals. They have negative effects on cellular respiration, local irritant effects and can cause gastrointestinal disorders (Mbaveng *et al.* 2014). Manifestations in the central nervous system range from altered mental status to epileptic seizures and coma (Mbaveng *et al*. 2014).

Relationship between the toxic principles of *Ras El Hanout*'s constituent plants and the diversity of botanical families

In terms of the relationship between the chemical composition of the toxic medicinal plants used in the preparation of the *Ras El Hanout* mixture and the diversity of botanical families, the Apiaceae family was found to hold the highest percentage of toxic compounds (26%), followed by the Zingiberaceae (9%), the Colchicaceae, Lauraceae, Iridaceae, Fabaceae and Lamiaceae (6% each), while the remaining families were represented by 3% each (Fig. 4).

Target systems and symptoms of Ras El Hanout intoxication

Manifestations of intoxication declared by herbalists surveyed

During the ethnobotanical investigations carried out, the herbalists interviewed confirmed the toxicity of the mixture studied, by declaring certain symptoms of intoxication which can be produced following its consumption and which are grouped together in Table 3. According to these respondents, intoxication by this preparation can affect various vital biological systems to varying degrees of severity. The system most affected is the digestive system, with different types of symptoms such as nausea, vomiting and diarrhea. The nervous system is affected by a variety of symptoms, including convulsions, hallucinations and, in the worst cases, coma. The respiratory and cardiovascular systems are the third most affected, with 12 cases each. The symptoms observed are respiratory distress, heart rhythm disorders and hypertension (Table 3).

Systems targeted by the toxic plants in the Ras El Hanout mixture

Documentation on the plants making up *Ras El Hanout* has revealed that the toxic medicinal plants in this mixture are responsible for a wide range of intoxications (Fig. 5). The top five systems affected are the gastrointestinal system, with 14 plants implicated, followed by the hepatic system, with 13 plants implicated, and the cardiovascular system, with 12 plants implicated. The respiratory and renal systems come fourth, with 11 plants implicated in each. However, the nervous system

was implicated with 9 plants (Table 2 and Fig. 5). The declarations of the herbalists questioned, and the bibliographical research are correlated, since the systems most affected are the same.

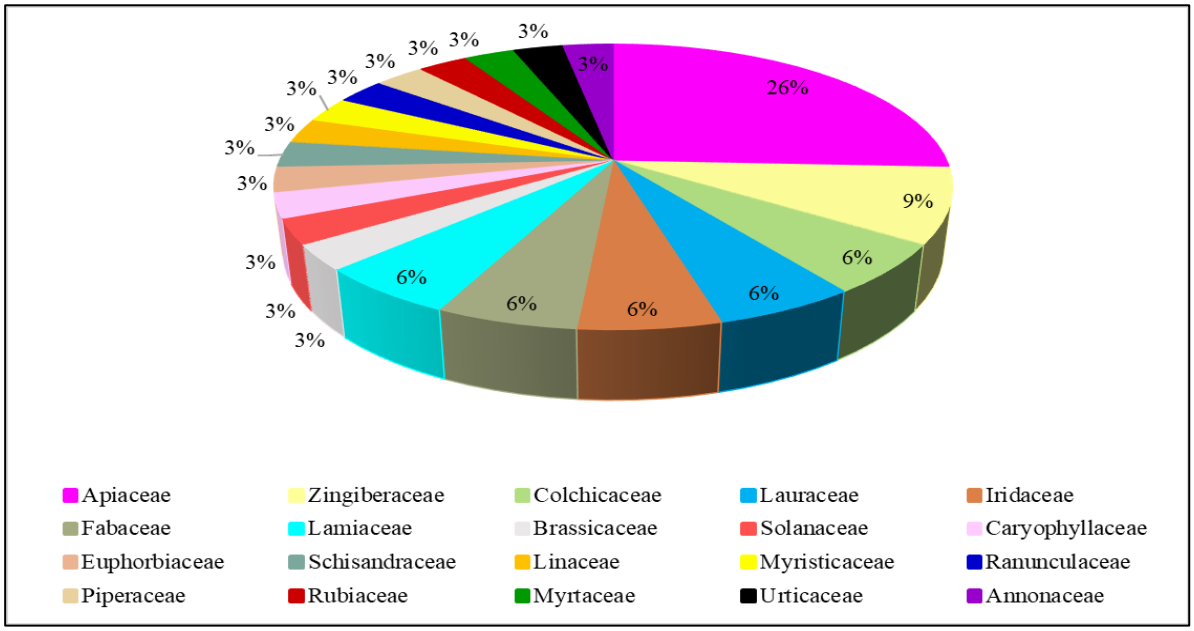

Figure 4.Distribution of toxic compounds by plant family

Table 3. Symptoms of *Ras El Hanout* poisoning reported by herbalists surveyed

Categories according to the system affected	Frequency of citation	Symptoms
Digestive Signs	45	Constipation, hematemesis, jaundice, mouth lesions, diarrhea, abdominal and digestive pain, nausea, vomiting
Neurological Signs	20	Consciousness disorders, neurological disorders, seizures, dizziness, hallucinations, stupor, agitation, coma
Respiratory Signs	12	Respiratory distress
Cardiovascular Signs	12	Arrhythmias, hypertension
General Signs	10	Asthenia, fever, hyperthermia, localized pain
Genitourinary Signs	9	Urinary retention, anal irritation, hematuria, metrorrhagia, renal failure, nephropathy
Cutaneous-Mucosal Signs	5	Local edema, allergy
Neuropsychic Signs	4	Insomnia, behavioral disorders
Sensory Signs	2	Lethargy

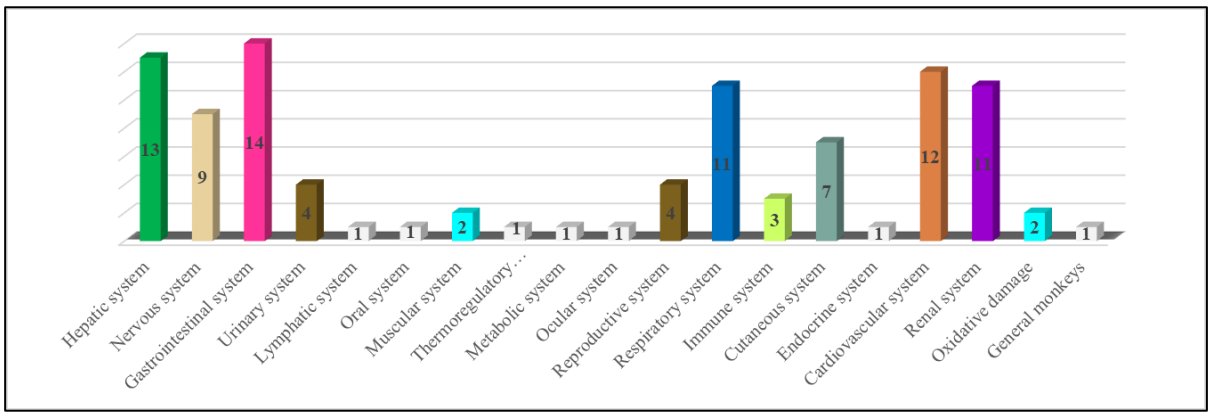

Figure 5. Distribution of the various ailments caused by the toxic plants making up the *Ras El Hanout* mixture

- ***Gastrointestinal system***

Practically all plants can cause digestive problems, and depending on the quantity ingested, these problems are often the first sign of intoxication. Depending on the plant, certain symptoms may predominate, such as mouth and throat irritation, vomiting and diarrhea (Flesch 2005).

Plants with toxic potential can act on the digestive system by causing direct damage to the membranes of the epithelial cells of the esophagus and stomach, as well as acting directly on the mucous membranes (Gelberg 2018). Or even by acting indirectly on the function of certain enzymes and the absorption mechanism of other compounds (Navarro del Hierro *et al.* 2018).

The gastrointestinal system is one of the targets of saponins, which are glycosides of steroids, steroidal alkaloids or triterpenes present in plants. Depending on the dose used, their effects can be both beneficial and toxic (Shen *et al.* 2008). Saponins are responsible for severe distension of the gastrointestinal tract and submucosal changes in the small intestine (Shen *et al.* 2008), as well as inhibition of certain digestive enzymes (Navarro del Hierro *et al.* 2018). The events that occur during digestion are closely related to their bioactivity, as saponins are poorly absorbed and have a long residence time in the intestinal tract (Navarro del Hierro *et al.* 2018). Furthermore, lectins, which are plant glycoproteins, interact specifically with certain carbohydrates on cell membranes, including intestinal epithelial cells (Gelberg 2018). In addition, capsaicin, produces striking pharmacological effects on sensory neurons in the gastrointestinal tract and other parts of the body (Gelberg 2018).

Among the plants that make up the *Ras El Hanout* mixture, fourteen species can cause gastrointestinal poisoning. These include *Alpinia officinarum* Hance, *Brassica nigra* (L.) W.D. Koch., *Capsicum frutescens* L. and *Colchicum autumnale* L.

- ***Hepatic system***

Many toxic plants damage the liver, since it is the first organ exposed to intestinal portal blood and possesses numerous mixed-function oxidases capable of bioactivating xenotoxins (Clayton *et al*. 2020). Toxins are bioactivated by hepatocytes and damage different sections of the liver lobule Some plant toxins are rapidly bioactivated and become powerful alkylating agents that denature hepatic proteins and nucleic acids in the first hepatocytes they encounter. This leads to periportal hepatocellular degeneration and necrosis (Clayton *et al.* 2020). Other toxins require more specific bioactivation, lower oxygen tension or oxidative protections such as those present in centrilobular hepatocytes. Damage caused by these toxins results in centrilobular swelling and necrosis (Clayton *et al*. 2020).

Alkaloids and terpenoids are the two main groups of hepatotoxins. Pyrrolizidine alkaloids, characterized by the presence of a pyrrolizidine nucleus, are the most toxic, capable of causing hepatocellular necrosis (Quan *et al*. 2020). In addition to these two groups, certain volatile compounds, proteins, glycosides, saponins, glycoside-saponin compounds, terpenoid lactones, anthraquinones and even several phenolic compounds also have hepatotoxic potential (Quan *et al.* 2020).

Among the plants in the *Ras El Hanout* mixture implicated in liver poisoning we mention *Ferula assa-foetida* L., *Syzygium aromaticum* (L.) Merr. & L. M. Perry and *Thymus* sp.

- ***Cardiovascular system***

The toxicity of plants can derive from their chemical composition. Alkaloids, proteins and amino acids (enzymes, glycoproteins), glycosides, oxalates, resins, tannins and phenolic compounds are phytotoxins. Of these toxins, alkaloids and glycosides are the groups that most affect the heart (Baskin *et al.* 2007).

Indeed, toxic alkaloid compounds derived from plants are generally made up of heterocyclic rings and generally affect the passage of ions across membranes, leading to various disturbances in cardiac arrhythmia (Baskin *et al.* 2007). In addition, cardiac glycosides from various plants produce positive ionotropy and cardiac arrhythmias through inhibition of cardiac Na^+/K^+-ATPase (Baskin *et al*. 2007). Other compounds, such as capsaicin in high doses, can cause constriction of coronary arterioles and even myocardial infarction (Hiett *et al*. 2014).

As shown in Table 2, some medicinal plants such as *Capsicum frutescens* L., *Colchicum autumnale* L., *Elettaria cardamomum* (L.) Maton and *Myristica fragrans* Houtt., used in the formulation of *Ras El Hanout*, have been reported to produce cardiovascular conditions.

- ***Renal system***

The kidney plays a vital role in the metabolism and excretion of xenobiotics. As a result, it is constantly exposed to large quantities of toxic substances, predisposing it to nephrotoxicity causing acute or chronic kidney damage (Touiti *et al.* 2019). Indeed, in developing countries, particularly in Africa and Asia, traditional plant-based remedies have been associated with 35% of cases of renal failure, with mortality rates ranging from 24% to 75% (Jha 2010). Other studies have shown that tubulointerstitial nephritis is the most common side effect related to the use of plants among patients at the National Institute of Oncology (INO) in Rabat, Morocco, with an incidence rate of 15.7% (Chebat *et al.* 2014). In addition, in patients suffering from kidney disease, the use of medicinal plants seems to involve more risks than in the general population (Zyoud *et al.* 2016).

In terms of renal pathology associated with plant use, the most common diseases included acute kidney injury, acute tubular necrosis, cortical necrosis and acute interstitial nephritis (Touiti *et al.* 2019). Several plants may be implicated, some of which act as irritants for the tubular cell, while others may alter serum electrolytes (Singh & Prakash 2011). *Zingiber officinale* Rosc. is potentially nephrotoxic due to its mechanism of inhibition of cyclooxygenase, thus altering renal haemodynamics (Gabardi *et al.* 2007). *Foeniculum vulgare* Mill. has been shown to have a diuretic effect and should be used with caution by healthy individuals and patients suffering from renal failure (Touiti *et al.* 2019).

Several plants can cause kidney poisoning, including *Colchicum autumnale* L., *Foeniculum vulgare* Mill., *Limoniastrum guyonianum* C. & D., *Nigella sativa* L. and *Rubia peregrina* L.

- ***Respiratory system***

Many of the plants in the *Ras El Hanout* mixture affect the respiratory system. These include *Androcymbium gramineum* (Cav.) J.C.Manning & Vinn., *Brassica nigra* (L.) W.D. Koch., *Cinnamomum cassia* (Nees & T. Nees) J. Presl. and *Colchicum autumnale* L.

The clinical manifestations due to this type of intoxication are highly polymorphous, ranging from simple benign symptoms to serious illness requiring hospitalisation and intensive care (Essafi *et al.* 2021). Symptoms include intense inflammation of the respiratory tract, oedema of the mucous membranes of the lungs, acute respiratory distress, asthma attacks, respiratory failure, risk of pneumonia or pulmonary collapse and toxic effects on mitochondrial function. Cellular respiration, which takes place in the mitochondria and generates ATP, is another vulnerable target. Substances contained in certain plants are inhibitors of the Krebs cycle and mitochondrial oxidative phosphorylation, so they block cellular respiration and the synthesis of ATP from ADP (Essafi *et al.* 2021).

Distribution of the toxic effects of the Ras El Hanout plant families on body systems

Analysis of the heatmap of toxic effects by plant family and body system reveals (Fig. 6) a number of interesting trends. There are families with high multisystemic effects, such as the Lamiaceae and Apiaceae, which stand out for their diverse effects on several systems, including the hepatic, neurological, gastrointestinal and renal systems. The results also show that certain systems are particularly vulnerable, such as the hepatic and renal systems, which are the most affected by a large number of plant families. This is due to the pharmacology of plant compounds, which are metabolised in the liver and eliminated in the kidneys (Najem *et al,* 2020a). The nervous system is also affected due to the neurotoxins contained in certain Ras El hanout plants. In addition, certain families have specific effects, such as the Solanaceae, which show impacts on the cardiovascular system, which is in line with their historical toxicological profile given their bioactive alkaloid content (Kimpouni *et al.* 2012). These results illustrate the importance of careful and informed use of medicinal plants, particularly those from families known for their potential toxic effects.

Conclusion

Ras El hanout is not just a mixture of spices with subtle flavors and great diversity, but a socio-cultural heritage that reflects a rich culture, a blend of several civilizations, ancestral know-how and traditional local organoleptic and phytotherapeutic practices. However, this Moroccan culinary and medicinal heritage calls for some reflection. Some of the plants that make up this mixture may present a risk of toxicity if used without care.

This study shows that 39 species out of the 60 plants making up the Ras El Hanout therapeutic theriac and spices have side effects and present a major risk of intoxication due to the chemical diversity of their toxic bioactive compounds. However, little is known about the toxicokinetics and toxicodynamics of the active ingredients present in certain plants.

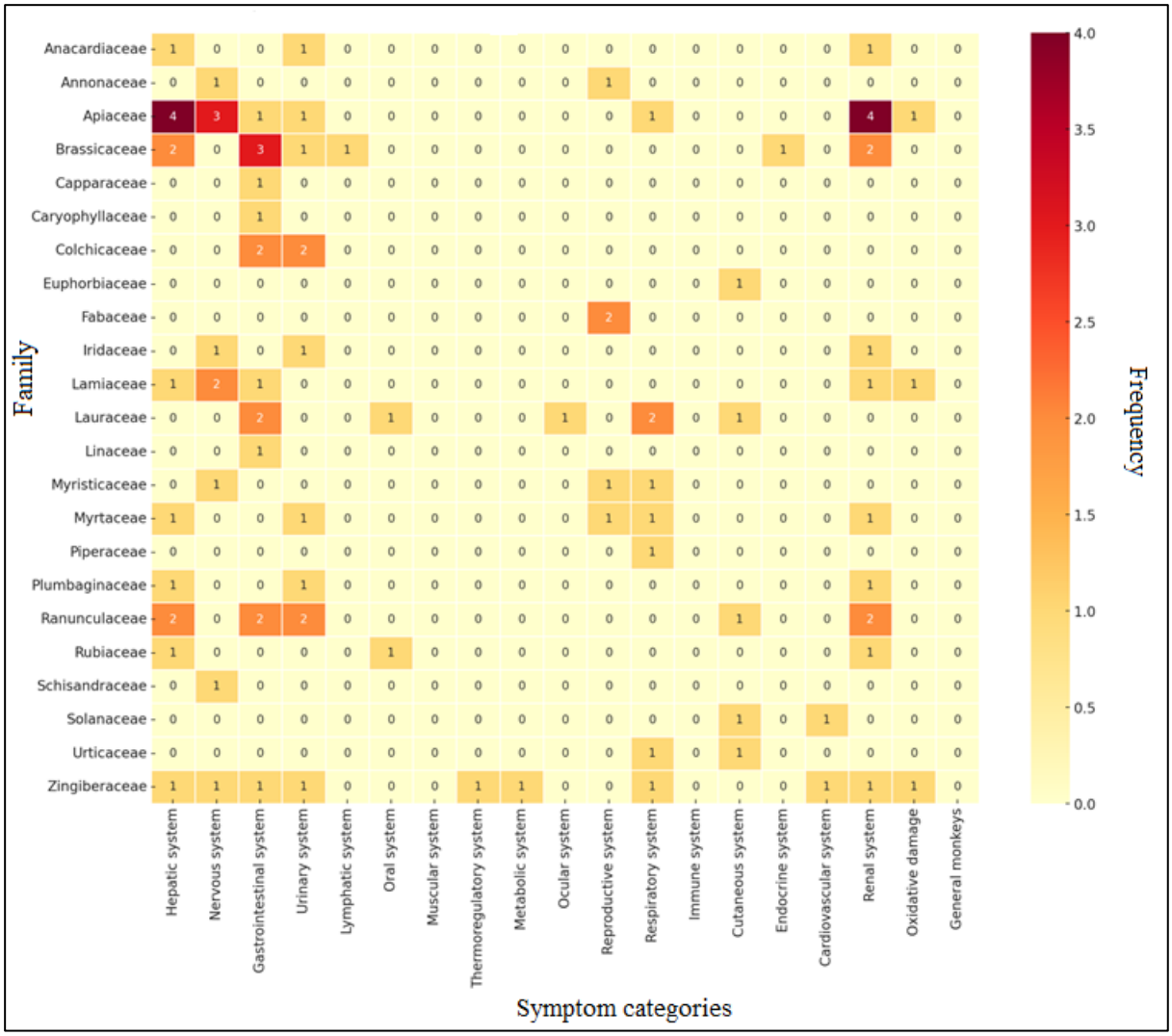

Figure 6. Heatmap of toxic effects frequency by plant family and Symptom category

The fact that herbalists are aware of the risk of poisoning inherent in the consumption of *Ras El Hanout* is already a positive point; what remains is to investigate ways of circumventing the risks of poisoning by providing ongoing training for herbalists, raising consumer awareness and documenting local recipes to maintain a collective memory.

In addition, the safe use of Ras El Hanout requires specific, targeted scientific research. Biochemical, pharmacological and toxicological studies need to be carried out on species that have never been assessed. This will make it possible to identify the plants at risk and determine their toxicity thresholds, as well as the cumulative effect of their active ingredients. Another area of research that cannot be overlooked is the study of the interactions between plants and their effects on the body when consumed as a mixture, especially as blending is a traditional practice much appreciated by the Moroccan population. Clinical tests are also an approach that will enable us to test formulations and propose standardized formulas adapted to therapeutic needs, while preserving the cultural authenticity of the Ras El Hanout blend.

Moreover, it is impossible to prohibit the use of plants with toxic effects, which is why it is essential to regulate the aromatic and medicinal plant sector by bringing together the efforts of several partners: health authorities, traditional medicine practitioners, scientists and political decision-makers.

The aim of this work is twofold: to promote Morocco's traditional culinary and therapeutic heritage and to protect users and consumers from the inherent risks of intoxication.

Declarations

List of abbreviations: Not applicable.
Ethics approval and consent to participate: All participants gave their prior consent knowing the reason for the study.
Consent for publication: Oral permission was taken from all participants.
Availability of data and materials: The data was not deposited in public repositories.
Competing interests: The authors do not have any competing interests.
Funding: This research did not receive funding.
Author contributions: Mariame Najem: Conceptualization, Investigation, Analysis, Writing original draft; Youssef Ouadjane: Analysis, Revision; Jamal Ibijbijen: Analysis, English language revision; Laila Nassiri: Supervision, Analysis, Revision.

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