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Tar production – traditional medicine and potential threat to biodiversity in the Marrakesh region

An ethnobotanical study

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Abstract

Cade oil is a tar made by destructive distillation of *Juniperus oxycedrus*. The use of Cade oil has a long tradition in European, North African and Mediterranean medicine. Medicinal tars, like Cade oil, in Morocco are made from different conifer species like *J. phoenicea, J. thurifera, Cedrus atlantica* and *Tetraclinis articulata.* The Moroccan name for tar is *Gatran* and it is sold in the markets of Marrakesh and surrounding villages. Plant resources in the forests of Morocco are used for many diverse things but overuse is a problem. The regression of the Moroccan forests has been estimated to 30 000 ha per year. The loss of forest is a threat to biodiversity as well as an enhanced risk for desertification. The Atlas Mountains are particularly vulnerable due to the steep slopes where fertile soil easily can be washed away during a rainfall. The loss of biodiversity does not only include the trees affected but also other flora and fauna depending on different forest habitats for their survival.

This study assessed whether production of medicinal tar constitutes a threat to biodiversity by looking at ways of production and which species, what part of the species and what amounts of wood are used in the production. An ethnobotanical aspect includes the use of medicinal tar among men and women. Semistructured interviews were conducted in the Marrakesh region with producers of medicinal tars, herbalists that sell the tar and traditional women healers who use it in their work. Samples of medicinal tars were bought from herbalists in different markets and also from producers and were analyzed using Gas Chromatography (GC).

The most frequent uses mentioned by herbalists and producers are against different hair and skin problems like dandruff, eczema, pruritis and skin infections. It is also used to decorate pottery and to give water a pleasant odour. In rural areas *Gatran* is sometimes added to drinking water as a disinfectant to improve the quality. Another important use is in veterinary medicine, as a treatment for intestinal parasites, and as an insect and snake repellent. *Ferraga*, traditional women healers, use *Gatran* when healing small babies.

Three different methods to produce *Gatran* were found in the Marrakesh region. All methods are based on the same principle of pyrolysis, an anaerobic combustion, of the woody parts of the trees. The differences were the amount of tar produced. Two methods produce tar on a small scale and generate 1-6 litres of crude tar using 10-40 kg of wood each round, while the other can generate about 30 litres in one round from 150-250 kg of wood. The producers use different parts of the trees but most frequently they use roots and trunks. Using GC to distinguish different species used in the production of specific tars is an interesting new method.

In areas with large tar production and the usage of tree roots the production is not sustainable. More sustainable ways of production, involving possibly cultivation, reforestation, and selective harvesting, need to be discussed with the people involved to be able to protect the forest and its resources for the future.

Keywords: Morocco, Ethnobotany, Juniperus, Cade oil, Medicinal tar, Endemism, Biodiversity, Marrakesh, Atlas mountains, Desertification.

Introduction

Cade oil and other medicinal tars

Cade oil is a tar made by destructive distillation of *Juniperus oxycedrus*. It is a red-brownish to dark-brownish clear or turbid thick liquid with a smoky smell. The use of Cade oil has a long tradition in European, North African (Koller 2003) and Mediterranean medicine, and was first mentioned by the Greek Theophrastus in the 3rd century B.C. In more modern times it has been incorporated in many western pharmacopoeias and the US dispensatory (Oleum Cadinum. U. S., Br. Oil of Cade Oil. Oil of Juniper Tar, Oleum Juniperi Empyreumaticum). It is used in medicine as an analgesic, disinfectant and towards different skin diseases like psoriasis and dandruff (Anon 2001). It is also used in cosmetics like soaps and shampoo, both for its disinfectant properties and as a perfume (FAO 1998).

Literature sources (Bellakhdar 1998) indicate that medicinal tars, like Cade oil, in Morocco are made from different conifer species like *J. phoenicea, J. thurifera, Cedrus atlantica* or *Tetraclinis articulata.*

The field study

The field study was conducted from October 11th until December 20th, 2006, in and around the city of Marrakesh in Morocco. The aim of the study was to contact producers, sellers and users of a medicinal tar product to find out more about the production and use of this product and to assess if the scale of use constitutes a threat to biodiversity. Studies on toxicity and chemical composition were made to see if the use of medicinal tars constitutes a threat to human health. The research was conducted in collaboration with my fellow student and colleague Marcus Lindborg. The data was then divided between us. This report deals with the ethnobotanical and biodiversity aspect of the project. For information on toxicity and human health I refer to my colleague (Lindborg 2008).

Background

Morocco

Morocco is situated in the North-west of Africa and borders to the Mediterranean Sea in the north and to the Atlantic Ocean in the west. It is the only country in Africa that has direct access to both these waters, and this is likely to have contributed to its long history of trade. The large amount of arable land and the Mediterranean climate are beneficial for agriculture, and Morocco produces different food crops for both its people and for export to Europe. Tourism has increased since 1980 and is now the most significant source of foreign currency to Moroccan economy (CIA 2007).

Morocco has a population of 33.2 million (estimated in July 2006) and the largest ethnic groups are the Arabs and the Imazigen (also referred to as Berbers), which together

constitute 99.1 %. The majority of the population is Muslim and the official language is Arabic, but different dialects of Berber are also spoken. French is often used in business, government and diplomacy and dates back to French colonial rule in 1912 to 1956 (CIA 2007). According to OECD (2001) Morocco is classified as a developing country with 19% of the population living below the poverty line (CIA 2007).

Marrakesh

The city of Marrakesh (Fig. 1) is situated in the middle of Morocco near the High Atlas Mountains. It was founded in 1070-1072 (UNESCO 2007) by a confederation of Saharan Amazigh tribes called the Almoravids (Encyklopædia Britannica Online 2007). The *medina* of Marrakesh was added to the list of World Heritage Sites in 1985 because of its monuments and cultural values as well as the activities on square Djemma el Fna as a cultural sight (UNESCO 2007). Marrakesh has a large traditional market (Fig. 2), which is a centre for herbal trade in southern Morocco. This is the place where many herbalists work and sell different products for various uses. You can find everything from single herbs to blends with many different species. Also different minerals, liquids and animal skins are sold in the stands. Most of the herbalists in Marrakesh are men, and traditional women healers (*Ferraga*) buy their raw materials from them and combine and alter these for their specific purposes.

Fig. 1. The big square "Djemma el Fna" near the famous mosque "Kotoubia" in the center of Marrakesh.

Fig. 2. Herbalists selling their products in a market in Marrakesh.

The Imazigen

The Imazigen (sing. Amazigh), often called Berbers, are the indigenous people of north Africa and live in Morocco, Algeria, Tunisia, Libya, Egypt and the northern parts of Mauritania, Mali, and Niger (Encyklopædia Britannica Online 2007). They speak different dialects of the Berber language of which three are spoken in Morocco. The Tachelhit dialect is spoken in the south west of Morocco from the High Atlas Mountains to the southern parts of the Anti Atlas mountain chain. This includes the region of Marrakesh city. The Tamazight and Rif dialects are spoken in the central and northern parts respectively (Mountassir 2004). Most of the Imazighen are farmers while some move with their livestock to mountain pastures during summer or live nomadic lives all

year round. Since the Arab invasion in the 7th century the Imazigen have been influenced by the Arabic culture and religion, but still some Imazigh traditions and religious practices have been preserved (Encyklopædia Britannica Online 2007). Many of the Imazighen live in the mountains of Morocco but it is not uncommon that family members migrate to cities to seek employment.

Moroccan flora

Because of its special climate, influenced by the Atlantic Ocean in the West, the Mediterranean in the North and the desert in the South, the diversity of the Moroccan flora is high. The heterogeneous ecological conditions has led to the development of around 4200 species from 940 genera and 150 families of which over 600 are endemic to the country (Hmamouchi 1999). Plant resources in the forests of Morocco are used for many diverse things. People harvest herbs, trees and shrubs for herbal medicines, food, fuel wood, and construction wood for houses, and products like furniture and handicrafts. Their livestock graze the landscape and agricultural land is expanding (Gaddes 1999). Overuse is a problem and constitutes a threat to biodiversity as well as an enhanced risk for desertification. Both these factors constitute a threat to people depending on natural resources in their surroundings for their livelihood. The regression of the Moroccan forests has been estimated to 30 000 ha per year (Hmamouchi 1999). Places that were once rich in trees and shrubs are now bare ground (Fig. 3a and b). But the government has started to take notice of the problems and its causes and several national and natural parks have been established (Hmamouchi 1999). It has also banned cutting of wild forest trees and anyone who gets caught in such an action can face prosecution leading to fines and/or imprisonment.

Fig. 3a and b. A region near Marrakesh where trees and shrubs once covered the slopes and mountains.

The Atlas Mountains

The extensive use of plant resources in the Atlas mountain chains has led to a decrease of vegetation. Trees are important to protect the soil from rainfall erosion with their canopy and root system, but due to livestock activities and uprooting and cutting of trees for fuel wood and charcoal production more and more trees disappear, which leaves the soil

exposed to degradation. Mountain areas are extra vulnerable due to the steep slopes where fertile soil easily can be washed away during a rainfall. The loss of biodiversity does not only include the trees affected but also other flora and fauna depending on different forest habitats for their survival. Reforestation in mountainous areas is highly recommended as well as other measures to stop the negative development towards decertification and loss of biodiversity in the Atlas Mountains, but reintroduction of vegetation can be difficult in areas with extensive soil loss (Klik et al 2002; Gauquelin 1999).

Cupressaceae

Juniper species

The *Juniperus* genus belongs to the family Cupressaceae. This family is characterized by evergreen trees and shrubs with scale-like or sharp-pointed leaves (Polunin & Huxley 1972). All Juniper species are slow growing and aromatic with berry-like fruits that ripen the second year. In the Atlas Mountains of Morocco several *Juniperus* species form parts of the important forests that protect the mountain slopes from soil erosion.

Juniperus oxycedrus

Juniperus oxycedrus (Fig. 4a and b) is a dioecious shrub or tree of up to 15 m (Tutin 1993). The leaves are up to 2 cm, greyish and sharp-pointed. The fruits are shiny and dark red to purple when ripe (Blamey & Grey-Wilson 1993). It grows in the Mediterranean region and it has several subspecies with different morphology and habitats (Tutin 1993). The Moroccan name in the Marrakesh region is *Tîqqi*. No differentiations seem to be made by the Imazigen between the different subspecies. It is an important forest tree in the Atlas Mountains of Morocco and it is used to produce the medicinal tar Cade oil. The wood is durable and is used for carvings and furniture as well as for charcoal production (Blamey & Grey-Wilson 1993).

Fig. 4a. A lonely *Juniperus oxycedrus* tree growing in a region near Marrakesh.

Fig. 4b. Leaves and fruits of *Juniperus oxycedrus*.

Juniperus thurifera

Juniperus thurifera (Fig. 5) is a dioecious shrub or tree that can reach up to 20 m. (Tutin 1993). It is pyramid shaped with bluish-green scale-like leaves of 1.5 to 2 mm (Polunin 1969). The fruits have 2-4 seeds and show a dark purple colour when ripe (Tutin 1993). It is endemic to the western Mediterranean and can be found in Algeria, Morocco, Spain, the Alps and Pyrenees of France and the highlands of Corsica (Gauquelin et al 1999).

Fig. 5. Branches and fruits of *Juniperus thurifera*.

The Moroccan name for *J. thurifera* is *Adruman.* Some Moroccans also call it *Ar'ar* due to its similarity to *J. phoenicea* (Bellakhdar 1998). In Morocco it grows in the open woodlands of the Atlas Mountains from 1700 up to 3000 m elevation. It can survive hot and dry summers as well as cold winters. It is an important forest tree but *J. thurifera* stands are today heavily degraded due to human and livestock activity. The wood is used for construction, tar production, and as fuel wood for cooking and heating. The leaves are used as food for sheep and goats (Gauquelin et al 1999).

Juniperus phoenicea

Juniperus phoenicea is a dark green dense shrub or small tree of up to 8 m. It has oval, scale-like leaves of 1 mm. The fruits are round, dark red and contain 3-9 seeds (Polunin 1969). *J. phoenicea* grows around the Mediterranean and is an important forest tree in Morocco due to its tolerance to drought (Blamey & Grey-Wilson 1993).

The Moroccan name for *J. phoenicea* is *Ar'ar*. In the Marrakesh region it is also called *Âyfs* (Bellakhdar 1998). Its uses are similar to *J. turifera*. The appealing odor and durable wood also makes it suitable for furniture production (Polunin 1969).

Tetraclinis articulata

Also belonging to the Cupressaceae family is *Tetraclinis articulata*. It is a drought resistant tree with small scale-like leaves and woody cones with four scales. It grows in Morocco, Algeria, Tunisia, southern Spain and on Malta (Polunin 1976). The Moroccan name is *Ar'ar*, the same as for *J. phoenicea*, which can be confusing. The Imazigen call it *Âzuka*. The wood is desired to make wood carvings, furniture and souvenirs, especially the roots with its red-brown colour and patterns of darker and lighter areas. It has been classified as near to threatened in the IUCN redlist of threatened species (2007). It is a risk that the increasing tourism in Morocco can lead to an increased demand for souvenirs made from *Tetraclinis articulata* roots.

Cedrus atlantica

Cedrus atlantica, also called the Atlas cedar, belongs to the family *Pinaceae*. It is native to the Atlas Mountains of Morocco and Algeria (Terrab et al. 2006). It is a large evergreen tree that can reach 40 m. The leaves are needle-like, 1-3 cm long, and have a blue-green colour. They grow in clusters on the side shoots of the tree. Female cones are erect, 5-6 cm long, and have numerous scales which shatter when ripe to spread the winged seeds. Male cones are slightly smaller reaching 3-5 cm. (Blamey & Grey-Wilson 1993; Polunin 1976)

In Morocco *C. atlantica* grows in the Rif Mountains and the High and Middle Atlas mountains at elevations from 1000 to 2500 m. It is used for a variety of things such as furniture, construction material, tar production and production of essential oils for the perfume industry (Terrab et al. 2006). 12 % of the coniferous wood consumed per year in Morocco is *C. atlantica*. It is an important source of income for rural families and generates jobs for a large number of people. The Cedar forests today represents 2,3 % of the total Moroccan forest (Renau-Morata 2005). From 1940 to 1982 Morocco lost 75 % of its original Cedar forests (Terrab et al. 2006). The large density of the rural population and grazing animals may still have a large impact and all uses must therefore be limited to a minimum (Ajbilou et al. 2006).

Objectives

The main objectives of this study are to assess the following:

- *What are the main uses of medicinal tars in the Marrakesh region and do they differ between men and women?*
- *How extensive is the use of medicinal tars in the Marrakesh region?*
- *What methods of production are there and what species are used?*
- *How big volumes are produced and how much wood is used in the process?*
- *Is the production of medicinal tars sustainable from a biodiversity perspective, and thus also for the people depending on it?*

The different uses and possible gender specific differences are important issues in order to understand the importance of medicinal tars in the society. The extent of the use, volumes produced, what species that are used and how much wood the process is in need of are important questions when investigating the sustainability of the production and discover possible risks for loss of biodiversity and means of self maintenance. The production technique is interesting from an ethnobotanical point of view but also for future projects in terms of for example its efficiency or effect on chemical composition.

Methods

Interviews

Semistructured interviews (Martin 2004) were conducted with producers of medicinal tars, herbalists and traditional women healers (*Ferraga*). A set of questions for each had been prepared (Appendix 1) as a base for the interview, but depending on the situation questions could be excluded, altered or added during the interview.

A male interpreter originating from Marrakesh with good knowledge of Moroccan Arabic, Tachelhit Berber, French and English helped us to carry out interviews with herbalists and producers, which all were men. A female interpreter originating from a small village in the region of Marrakesh, also she with good knowledge in Moroccan Arabic, Tachelhit Berber, French and English helped to interview *Ferraga*. One *Ferraga* was interviewed with the help of a female Moroccan friend that had good knowledge in French and Moroccan Arabic.

Because of the culture and religion (Islam) in Morocco it is in many cases necessary to work with a colleague of the opposite sex to be able to complement each other in different parts of the study. In this study it would have been very difficult for a man to interview *Ferraga*, even though he had a female interpreter. Within their culture it is not considered appropriate to let a man from outside the family in to their home. It might also be that the information you get could be affected because of your sex. Women might feel embarrassed to talk about women's diseases and problems in the presence of a man. In the same way it might be easier for a man to get information on tasks that are traditionally carried out by men (Martin 2004, Pfeiffer & Butz 2005).

According to CODEX (2007) no names of the informants or detailed descriptions of places are mentioned in this report. This is to protect the integrity of the people being interviewed.

Producers

My male colleague, Marcus Lindborg, and I were both present during interviews with producers. Through contacts our interpreter helped us to get in touch with six different producers. Since the action of cutting down trees used in the production is strictly prohibited it would have been hard to find producers willing to give information on the matter in any other way. The producers were all interviewed in or near their home village.

Herbalists

Interviews with six herbalists were made by Marcus Lindborg. These were added to information from earlier interviews we made with 11 herbalists in the Marrakesh medina, in May and June 2006, during a course in Ethnobotany (Uppsala University). In total 17 herbalists were interviewed in the markets of Marrakesh and surrounding villages. The herbalists were randomly picked while walking around the medina or in village markets.

Ferraga

Using a female interpreter I was able to meet 16 *Ferraga* and allowed to interview 15 of them. Thirteen of the *Ferraga* lived in Marrakesh while the other two lived in villages outside the city. We went from door to door in the medina of Marrakesh to ask for the addresses for different *Ferraga* and the interviews were conducted in their homes. It was a time consuming work. Many times we were told by relatives in their home that the *Ferraga* was traveling or had run for an errand. When we returned one or a few days later to look for them again some of them would let us in, and some of them told us that they had been afraid during our first visit, in case we were from the government. After hearing rumors about us being students they felt safe to let us in the second or third time we arrived. They told us that the government does not approve with the old traditional healing methods used by the *Ferraga*.

Gas Chromatography for species identification in tar samples

Samples of medicinal tars were bought from herbalists in different markets and also from producers. They were diluted with dichloromethane and analyzed using Gas Chromatography (GC). The GC was performed using an AgilentTechnologies 6890N with 30m HP-5, 0.32 mm id and 0.25 µm solid thickness column. Carrier gas was (He) 1ml/min and the injector temperature 275 °C with split 1/200. Temperature program was 60 °C for 2 min, +4 °C/min to 280 °C and 280 °C for 10 min. The chromatograms can enable identification of species used in unidentified samples with the help of references made from each species. Unfortunately we were not able to make this kind of references during this study.

Results

Fig. 6. Bottles of tar in a market place in the Marrakesh region.

Medicinal tars in the Marrakesh region

The Moroccan name for tar is *Gatran* and it is sold in the markets of Marrakesh and surrounding villages. You can find both different commercial extracts in the form of oil and shampoo as well as tar in big plastic bottles, originally used for cooking oil, that are poured in smaller containers when sold (Fig. 6). The consistency varies from water like to very thick and viscous. The thinner one is called *Gatran Rkik* while the thicker one is called *Gatran Ghlid* in Moroccan Arabic. It seems arbitrary at what viscosity the tar goes from being *Rkik* to being *Ghlid* and vice versa. It is manufactured all over the country but especially in regions where the raw material is more abundant as for example in the High Atlas Mountains near Marrakesh. The manufacturers are mainly Amazight.

Uses of medicinal tars

The most frequent uses mentioned by herbalists and producers (Tab. 1) were against different hair and skin problems like dandruff, eczema, itchiness and skin infections. It is also used to decorate pottery and to give water a pleasant odor. In rural areas *Gatran* is sometimes added to drinking water as a disinfectant to improve the quality. Other important uses is for animals as a treatment against intestinal parasites and as a repellent towards snakes and scorpions.

Table 1. The most frequent uses of medicinal tars in the Marrakesh region. In total 17 herbalists and six tar producers in and around Marrakesh were asked about the uses of medicinal tars.

Uses	Frequency	Respondent %
Hair	14	70
Skin	11	55
Pottery	9	45
Fumigation	9	45
Ferraga	8	40
Snake repellent	7	35
Black magic	6	30
Animals	6	30
Insect repellent	4	20
Water	4	20
White magic	2	10
Cold	2	10
Hepatitis in cows	2	10

Ferraga

Ferraga are traditional women healers who receive patients in their homes, mostly women and children. They use different herbs and herb mixes of which the knowledge has been past on for generations in their family. All the *Ferraga* knew about *Gatran* and all except one used it for healing. Only two *Ferraga* knew that *Gatran* was made out of *Ar'ar*. *Gatran* was mainly used for small babies. They believed that if the baby felt what they called "bad smells" from talismans, which are protective amulets carried by some people, or if they had been influenced by bad spirits it made them ill. This illness could be cured with *Gatran*. The *Gatran* is used in different ways (Tab. 2) but the most frequent is to apply it on or under the nose, around the wrists, on the hands, temples and head of the baby.

Table 2. The most frequent places where *Ferraga* apply medicinal tars on babies to cure them from different diseases. The respondents are 15 Ferraga in and around Marrakesh.

Uses for babies	Frequency	Respondent %
Nose	11	69
Wrists	10	63
Hands	8	50
Temples	8	50
Head	7	44
Ankles	5	31
Fontanels	3	19
Feet	2	13
Tonsils	2	13
Ears	2	13
Knees	1	6
Gum	1	6
Throat	1	6
Palate	1	6
Navel	1	6
Ingested with herbs	1	6
Armpit	1	6
Body	1	6
Chest	1	6

Producers

Three different methods to produce *Gatran* were found in the Marrakesh region. They all work around the same principle which is a pyrolysis, an anaerobic combustion, of the woody parts of the trees. The differences were the amount of tar produced. Two methods produce tar on a small scale and generate 1-6 liters of crude tar using 10-40 kg of wood each round, while the other can generate about 30 liters in one round from 150-250 kg of wood. Among the six producers interviewed four were using the small-scale method while two worked with the large-scale method.

The small scale producers made tar only for their own uses and sometimes also for the village. From time to time one producer sold it to a man that would sell it further in a

market. They produced tar during a limited time of the year in the spring or summer months (April-August). This is the time when people take their animals to graze in other areas. The *Gatran* is fed to the animals to treat them against intestinal parasites. During this time the tar making process is run many times and generates several liters of tar, depending on the demand. Apart from tar production small scale producers also worked with agriculture.

Fig 7. Several entities for large scale production of tar.

One village was found where large scale production of *Gatran* was conducted. Around 10 production sights (Fig. 7) existed in this place with about two to five running every day. Trunks and branches were used as fuel wood for the process, and only roots were used for tar production. About 150-250 kg of roots (Fig. 8) was used in one load for the process. One man was the business man of this "factory". Producers in the village sold their tar to him. The leftovers were sold as charcoal. One of these villagers was interviewed and stated that he was totally dependent on the tar production for his income. The "business man" sold the tar further in different markets. Large amounts were also sold to a man from Spain, a man from Casablanca and a man from the northern part of Morocco. They all came to the village to make business with this producer. The Spanish man came 6-7 times per year and bought 2000 liters every time. The man from Casablanca came 5-6 times per year to buy 1000 liters each time and the other Moroccan bought 2000 liters 10-16 times per year.

Fig. 8. Roots of *Juniperus* sp. about to be used in large scale tar production.

When asking about the difficulties of tar production they all stated that the biggest problem with the production was the forest guards. They guard the forests from illegal cutting of trees. If you get caught you have to pay a fine. In the village with continuous large scale production an amount of 300 dirham per month were paid as a bribe to be able to get the trees necessary for the production. Sometimes forest guards came to the village to see that they did not take too much. One man also mentioned the problem that *J. oxycedrus* does not resprout after you have cut it.

Species used

The informants mentioned the use of *J. oxycedrus, J. thurifera, J. phoenicea, T. articulata* and *C. atlantica*, with *J. phoenicea* and *J. oxycedrus* being the most frequent

(Tab. 3). *Neriun oleander*, *Eucalyptus* and *Olea* were only used as substitutes for *Ar'ar* when this could not be found. *Pistacia* sp. was only used in small amounts. Some producers used a mix of species for their tar production. They all stated that wood with a good tar producing capacity had "a good smell". Some also mentioned that it should have a reddish colour to be of good quality.

Table 3. The most frequent species used by six producers in the Marrakesh region to make medicinal tar.

Species (Moroccan name)	Species (Latin name)	Frequency	Respondent %
Ar'ar	*Juniperus phoenicea*	4	67
Tîqqi	*Juniperus oxycedrus*	4	67
Azuka	*Tetraclinis articulata*	2	33
Taddût	*Acacia gummifera*	2	33
Adruman	*Juniperus thurifera*	2	33
?	*Pistacia*	1	17
Lers	*Cedrus atlantica*	1	17
Zitun	*Olea*	1	17
?	*Nerium oleander*	1	17
?	*Eucalyptus*	1	17

The producers used different parts of the trees but most frequently they used the roots and the trunk (Table 4). When only the roots were used for tar extraction the trunk and the branches were often used as fuel wood for the process.

Table 4. Parts of the tree that are used for tar extraction. The respondents were six tar producers in the Marrakesh region.

Part of tree	Frequency	Respondent %
Roots	4	67
Trunk	4	67
Branches	3	50

Small scale production

In the most common small scale production method among the producers interviewed different clay pots are used to build up a construction of two compartments (fig. 9, 10 a and b). Three of the producers interviewed used this method for their tar production.
A round clay pot called *tikint* is filled with wood and turned up-side-down. It is placed on a *takssrit*, a traditional clay plate. A hole has been made in the middle of the *takssrit* so that vapour from the combustion can be led down to a container, in this case a clay jar called *takonbit*, that is buried in the ground. The narrow opening between the *tikint* and the *takssrit* is sealed with damp clay not to get oxygen into the system. This sealing is called *talaght*. Fuel in the form of wood, straw or dry manure is placed around the *tikint*. A wall called *sour*, made of stones and clay, is built around the fuel with a hole on top to provide the fire with oxygen. When the fire has started vapour from the anaerobic combustion is led through the hole in the *takssrit* to the *takonbit* where it cools down and condenses to tar.

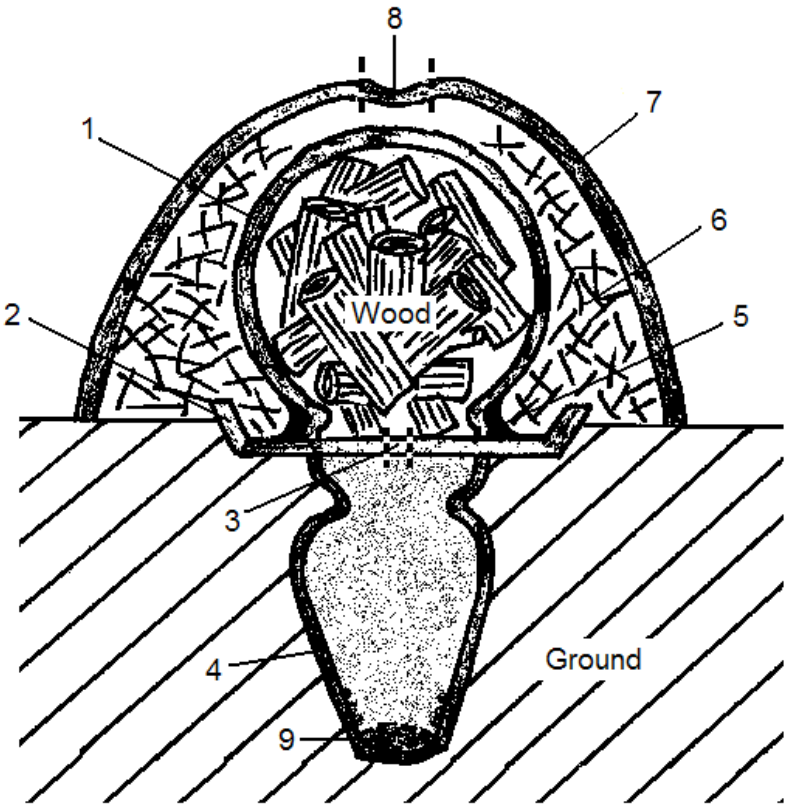

Fig. 9. A method for small scale tar production. A round clay pot called *tikint* (1) is filled with wood and turned up-side-down. It is placed on a *takssrit* (2), a traditional clay plate. A hole (3) has been made in the middle of the *takssrit* so that vapour from the combustion can be led down to a container, in this case a clay jar called *takonbit* (4), that is buried in the ground. The narrow opening between the *tikint* and the *takssrit* is sealed with damp clay not to get oxygen into the system. This sealing is called *talaght* (5). Fuel in the form of wood, straw or dry manure (6) is placed around the *tikint*. A wall called *sour* (7), made of stones and clay, is built around the fuel with a hole (8) on top to provide the fire with oxygen. When the fire has started vapour from the anaerobic combustion is led through the hole in the *takssrit* to the *takonbit* where it cools down and condenses to tar (9).

Fig. 10 a and b. The principle of small scale tar production. A round claypot called *tikint* is filled with wood and then placed on a clay plate, *takssrit* (left). The green leaves symbolises the fire used to heat the wood inside the *tikint* (right). The clay formation in the bottom represents the ground where the tar is gathered in a container.

Fig. 11. Metal barrel used for small scale tar production.

One producer used a slightly different method for small scale production. The upper compartment containing the wood (for tar extraction) was a metal barrel with a hole in the bottom running through the ground and out in a hole under the construction (Fig. 11). The same principle with fire around the container and vapour condensing to tar in the cooler cavity under the barrel was used.

Large scale production

In the large scale production (Fig. 13) the two compartments for the process constitute two holes dug in the ground. One hole is filled with wood for tar extraction and around this hole is a half circle shaped tunnel with a "chimney" in each end. This is the compartment for the fire. The wood compartment is covered with a mix of clay, soil and water not to get oxygen into the system. The vapour is then led through a long hole to the second compartment where it cools and condenses to tar. Some water has been added in the bottom of the second compartment to cool the tar and to generate vapour that rises and passes through leafy tree branches of *Juniperus* spp. that is put on top of the compartment. When the branches start to get black in colour (Fig. 12) it indicates that the process is finished. The tar is then transferred into plastic containers for cooking oil and big oil barrels.

Fig. 12. Branches of *Juniperus* sp. turning black of the tar smoke indicating that the tar production is finished.

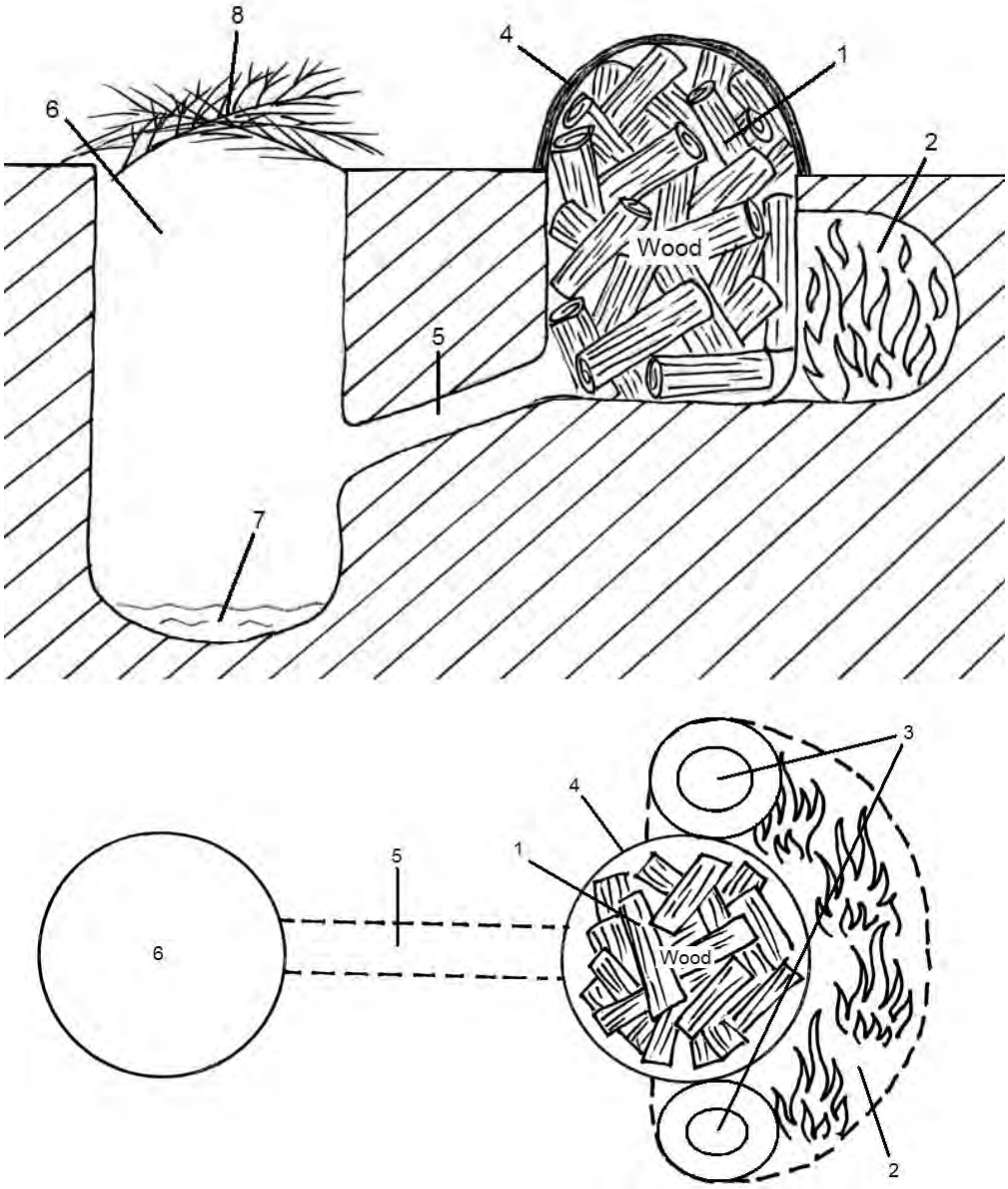

Fig 13. A method for large scale tar production. A hole in the ground is filled with wood for tar extraction (1) and around this hole is a half circle shaped tunnel (2) with two "chimneys" (3) in each end. This is the compartment for the fire. The wood compartment is covered with a mix of clay, soil and water (4) not to get oxygen into the system. The vapour is then led through a long hole (5) to the second compartment (6) where it cools and condenses to tar. Some water has been added in the bottom of the second compartment (7) to cool the tar and to generate vapour that rises and passes through leafy tree branches of *Juniperus* spp. (8) that is put on top of the compartment.

Gas Chromatography

Similarities and differences can be found among the different gas chromatograms shown in Appendix 2. This indicates that gas chromatography can be used to identify what

species that have been used to make a specific tar. Chromatogram 1 is from *Tîqqi* (*J. oxycedrus*) and is very similar to chromatogram 2-5, which indicates that these originate from the same species. Chromatogram 6 comes from *Ar'ar*, in this case most probably *T. articulata*. Chromatogram 6 shows many similarities with chromatogram 7-12 which indicates that these also originate from *T. articulata*. Chromatogram 13 is from a commercial extract with an oily consistence but similarities with chromatogram 6 can be found. The oil might cause the differences that can be seen. According to the informants the tar in chromatogram 14 is from *Lers* (*C. atlantica*).

Discussion

Biodiversity

Several sources indicate the threat to and decrease of Moroccan forests (Ajbilou et al. 2006; Renau-Morata 2005; Terrab et al. 2006; Gauquelin et al. 1999; Klik et al. 2002; Hmamouchi 1999) which play an important role for both people and species dependent on them (Renau-Morata 2005; Terrab et al. 2006). When large parts of forest disappear biodiversity is lost as well as means for self maintenance for rural people. The species used in tar production constitute an important part of Moroccan forests in the Atlas Mountains. When these are cut down or being uprooted the fertile soil layer loses its protection against soil erosion. Revegetation is then difficult to accomplish in mountain areas when the soil layer has been washed away by rain leaving only bare rock. Slow growing species like *Juniperus* have difficulties to keep up the production with the consumption of trees. There are many different threats to the Atlas forests, like cutting of trees for fire wood, construction material and clearing land for agriculture. Tar production is one that is especially destructive in areas with large tar production and where the use of tree roots is extensive. Uprooting leaves no chance for the tree to continue living and reproduce itself and if the production continues at this rate and these volumes the tree resources for the production will be lost and people will lose their source of income. Also people that are not directly dependent on *Gatran* for their income will be affected, since it is an important medicine for their livestock, and the livestock are in turn important to them. In areas with small scale production using only branches and trunks the threat is not as acute as in areas with large scale production, but together with other uses of the trees it can play an important role.

Is a sustainable tar production possible?

It is difficult to see how this large scale production can be turned into a sustainable process. The use of tar has a long tradition in Morocco and the use is wide spread. An attempt to implement the use of substitutes will be difficult. The Moroccan government is aware of the problem of tree cutting but their means to deal with it fails due to ineffective forest guards. On the other hand people need to sustain themselves. It is important to find a compromise that satisfies both the people and the conservation of forests. The big question is if this is possible and if so how is it going to be made? It is important to engage the people involved in the tar production and together with them discuss the

importance of a sustainable production. Cooperation in the different areas with production might be a possible solution. This form of involvement has been a success when it comes to *Argania spinosa*, a tree used for oil production that is endemic to Morocco (Lybbert 2002, 2007). Even though the different Juniper species, *Tetraclinis articulata* and *Cedrus atlantica* are not endemic to Morocco they are still important and valuable to protect. They are a resource for the people and a protection against the spreading erosion and desertification. Replanting of trees, development of the tar production process to make it more efficient and the use of other parts than roots for the extraction might be steps on the way. Also an important step could be to revalue the tar. Today it is very cheap and if it is correct that foreigners are interested in buying large volumes the prices could be raised and production decreased. Alternatively production could be raised, especially if the production method is developed to be more efficient, and money gained from selling the tar could be used to replant trees. Investigations on whether replanting is successful for the species used must be done. Alternative uses where leaves and fruits are used should also be discussed. What are the demands for essential oils on the market? Can these bring an income and can these also be used in daily life instead of tar?

Further studies need to be made to find producers in other areas of Morocco to investigate if large scale production occurs in these places and how extensive it is. Studies concerning the people's view on forest sustainability and attitudes towards alternative production of for example essential oils could also be made, as well as on the possible use of these oils.

Safety

Medicinal tar is used both internally and externally for several health problems. It is known that tar has negative effects on health (Shoket 1990). The extensive use among the *Ferraga* for curing babies is thus very concerning (Lindborg, 2008). Studies about the safety of using different medicinal tars needs to be made.

Gas Chromatography

This study indicates that gas chromatography can be used to identify what species that have been used to make a specific tar, but no conclusions can be made from these chromatograms since there are uncertainties concerning the distinction of species in our samples. The only information is that of the informants producing the tar. Preferably the study should be made with full control of the whole process to be sure what species have actually been used and to get proper references for the GC analysis. If this method is successful tars sold on the market can be analyzed with GC to find out what species that have been used in the production.

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Questions for Producers:

Name: Nr:

Age: Date:

Sex: Place:

Home village:

Married: yes no

No. of children:

For how long have you been making Cade oil?

Who tought you how to produce Cade oil? When and where did you learn this?

Are there different methods for producing Cade oil? If so, what methods?

Which method do you use?

Are there different kinds of Cade oil? If so, how many and what are the differences?

What species are used to make Cade oil?

IF DIFFERENT: Which species are the best and why?

IF ONE OR A FEW: If you don't get enough wood of this species, is there other wood you can use?

What parts of the plants are used to make cade oil?

Where and how do you get the plants?

How much material do you use every time?

How much Cade oil do you get?

Are there variations in quality of Cade oil? If so, how do you tell a good quality from a bad quality?

How often do you produce Cade oil? (How many times per year)

Are there any difficulties with the production of Cade oil? If so, what are the difficulties?

Where do you sell your Cade oil?

Who buys it? (men/women, young/old, tourists/Moroccans)

How much do you sell? (ex. per week)

Does the demand vary over the year? (with the seasons)

How was the demand for it in the past and has it changed untill today?

Did they use different species in the past than you do today?

What is the price of Cade oil today and how was it in the past?

Do the price vary with the seasons?

How much do you earn per month from selling Cade oil?

What do you do other than producing and selling Cade oil for income?

What is your whole income per month, including all different work you do?

Is Cade oil production your major source of income?

Are you dependent on Cade oil production to support your family?

How do you store your Cade oil?

What is Cade oil used for?

Do you use Cade oil?

Do you know any stories from the past about Cade oil?

In what quantities are you supposed to use Cade oil?

Is it dangerous to use too much? If so, how much?

What are the symptomes of intoxication? (for both oral administration and skin)

Questions for Herbalists:

Name: Nr:

Age: Date:

Sex: Place:

Married: yes no

Nr. of children:

Education:

For how long have you been working as a harbalist?

Who tought you how to be a herbalist?

When did you learn to be a herbalist?

Where did you learn the work of a herbalist?

Do you sell products in other markets? If so, where?

Do you know what Cade oil is?

Do you sell Cade oil?

Are there different kinds of Cade oil? If so, how many and what are the differences?

Which kind do you sell the most?

What is Cade oil used for?

Is it used alone or is it mixed with other products?

Do you use cade oil? If so, for what?

Who buys it? (men/women, young/old, turists/Moroccans)

How much Cade oil do you sell in one week?

Does the demand vary over the year?

How was the demand for it in the past and has it changed untill today?

What is the price today and how was it in the past?

Do the price vary with the seasons?

Where do you buy the Cade oil?

Do you know how to make Cade oil? (species used etc.)

Are there variations in quality of cade oil? If so, how do you tell a good quality from a bad quality?

How do you store your Cade oil?

Do you know any stories from the past about Cade oil?

In what quantities are you supposed to use Cade oil?

Can it be dangerous if you use too much? If so, how much?

What are the symptomes of intoxication? (for both oral administration and skin)

Questions for *Ferraga*:

Name: Nr:

Age: Date:

Education: Place:

Married: yes no

No. of children:

How long have you been working as a midwife?

How did you learn your profession?

Who tought you?

Where did you learn your profession?

Do people come to you for help or do you visit them?

Do you know the Cade oil?

Do you use it in your work?

Are there different kinds of Cade oil? If so, how many and what are the differences?

If different kinds, which one do you use the most?

How do you use it? (all kinds)

How often do you use it? How many patients per day or week are recommended to use Cade oil in any way?

Is it used alone or mixed with other products?

Where do you buy it?

Do the price vary with the seasons?

Was there a different price in the past?

Is there any other product that can be used instead of Cade oil with the same effect?

Are there times when Cade oil should NOT be used?

Do you know how Cade oil is produced?

What species are used?

Are there variations in quality of cade oil? If so, how do you tell a good quality from a bad quality?

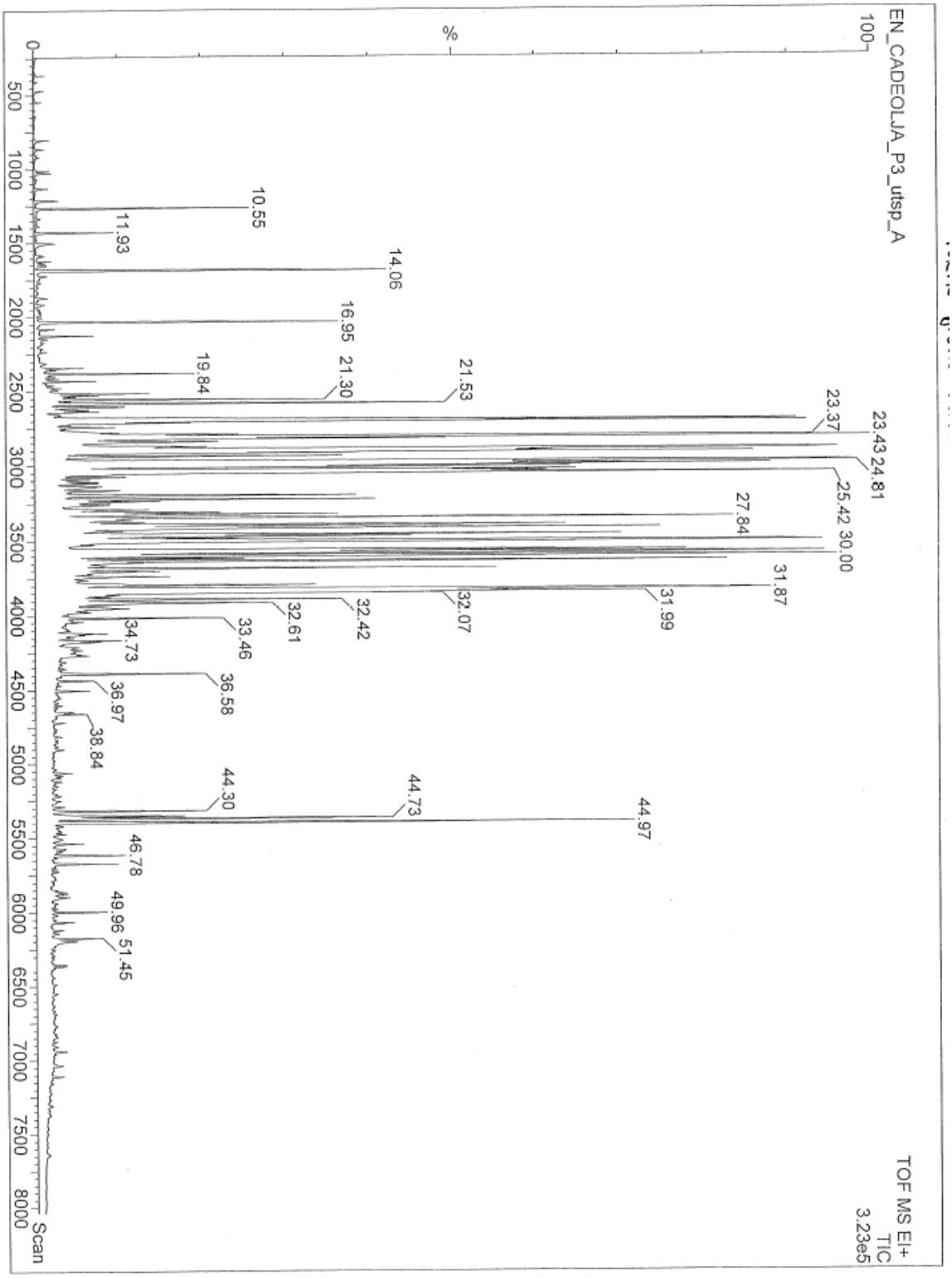
How do you store your Cade oil?

Do you know any stories from the past about Cade oil?

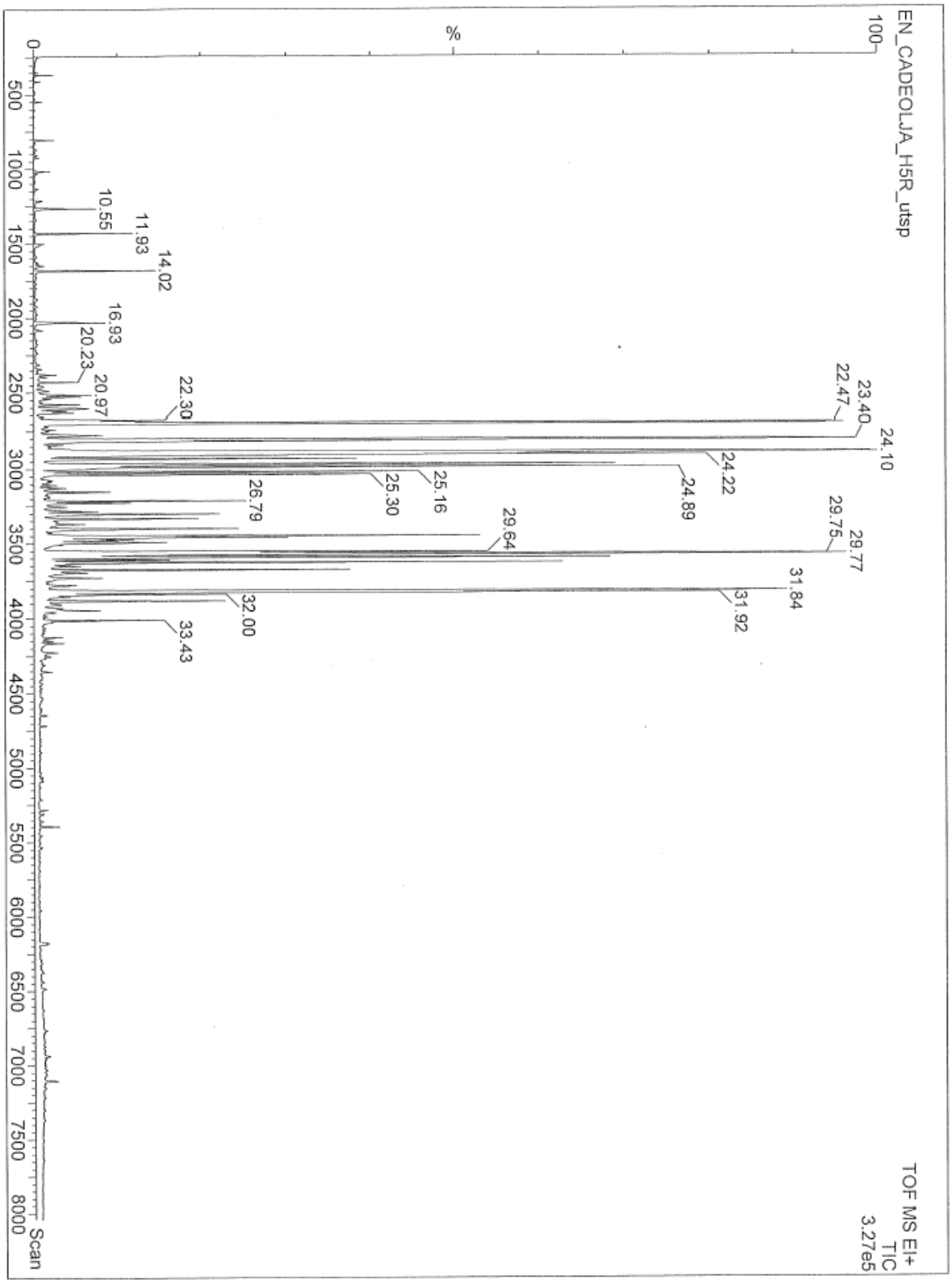
In what quantities are you supposed to use Cade oil?

Can it be dangerous to use too much? If so, how much?

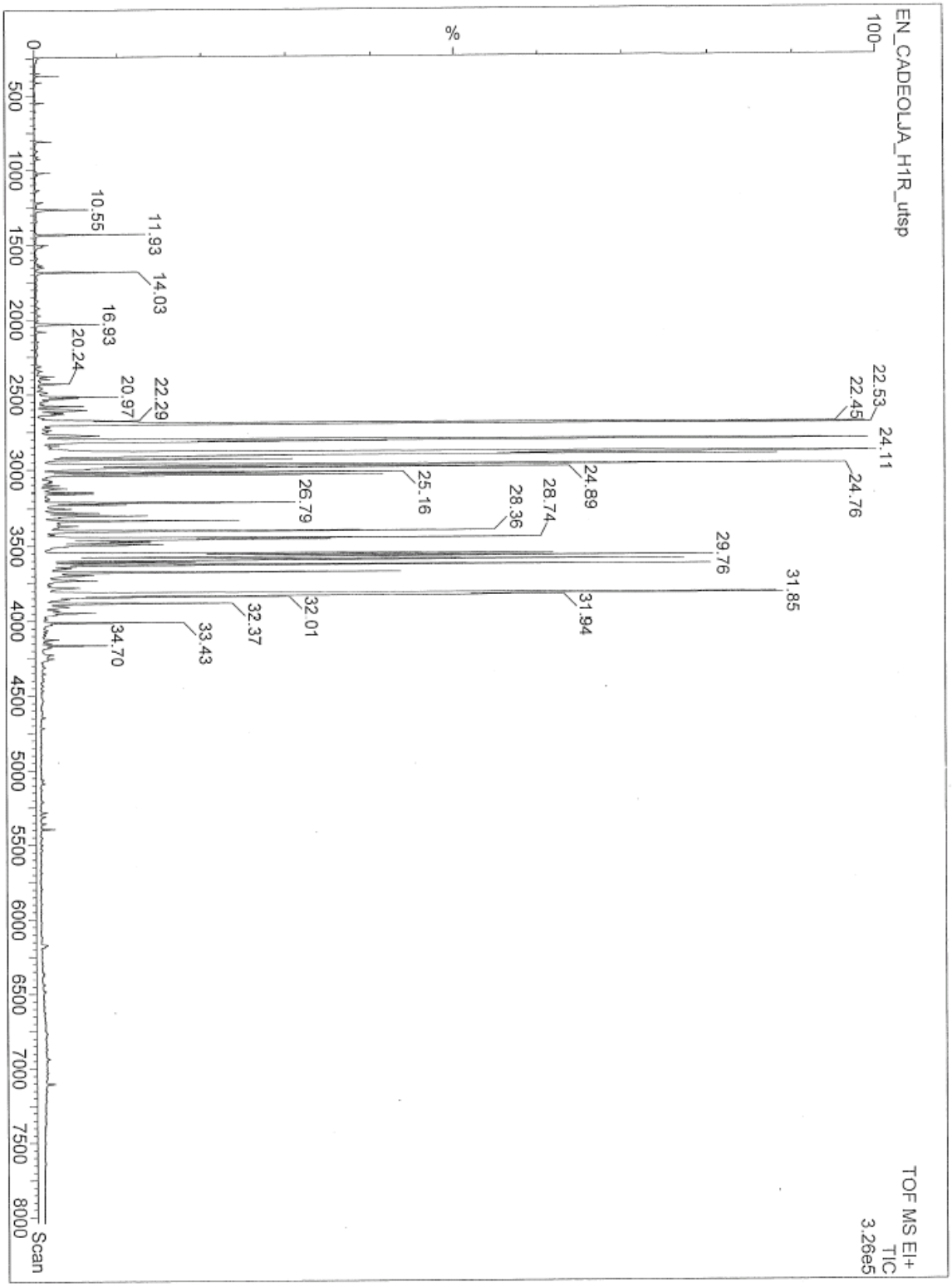
What are the symptomes of intoxication? (for both oral administration and skin)



Chromathogram 1: *Gatran Rkik* from *Tîqqi* (*Juniperus oxycedrus*).



Chromathogram 2: *Gatran Rkik*, probably from *Tîqqi* (*Juniperus oxycedrus*).



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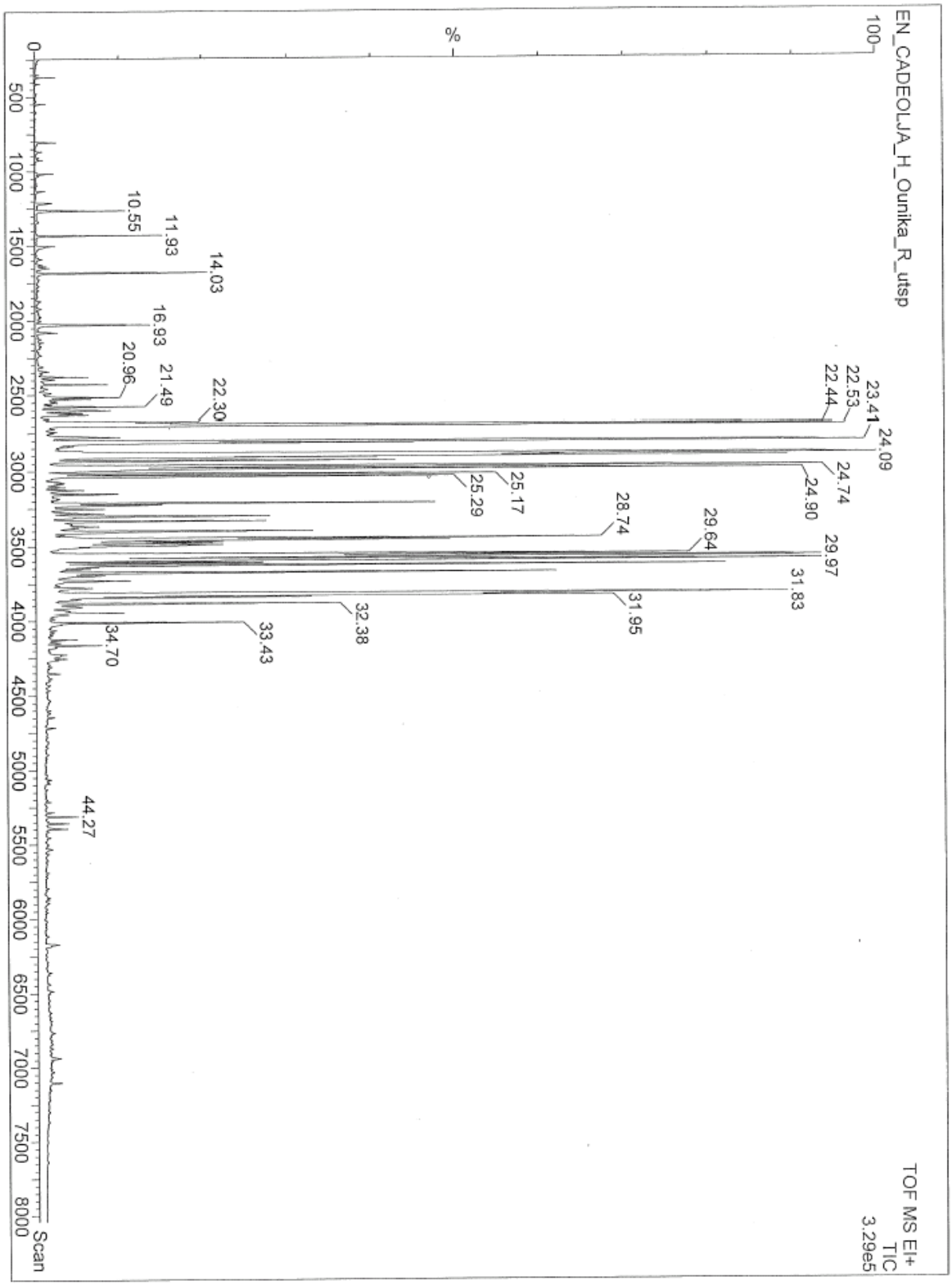
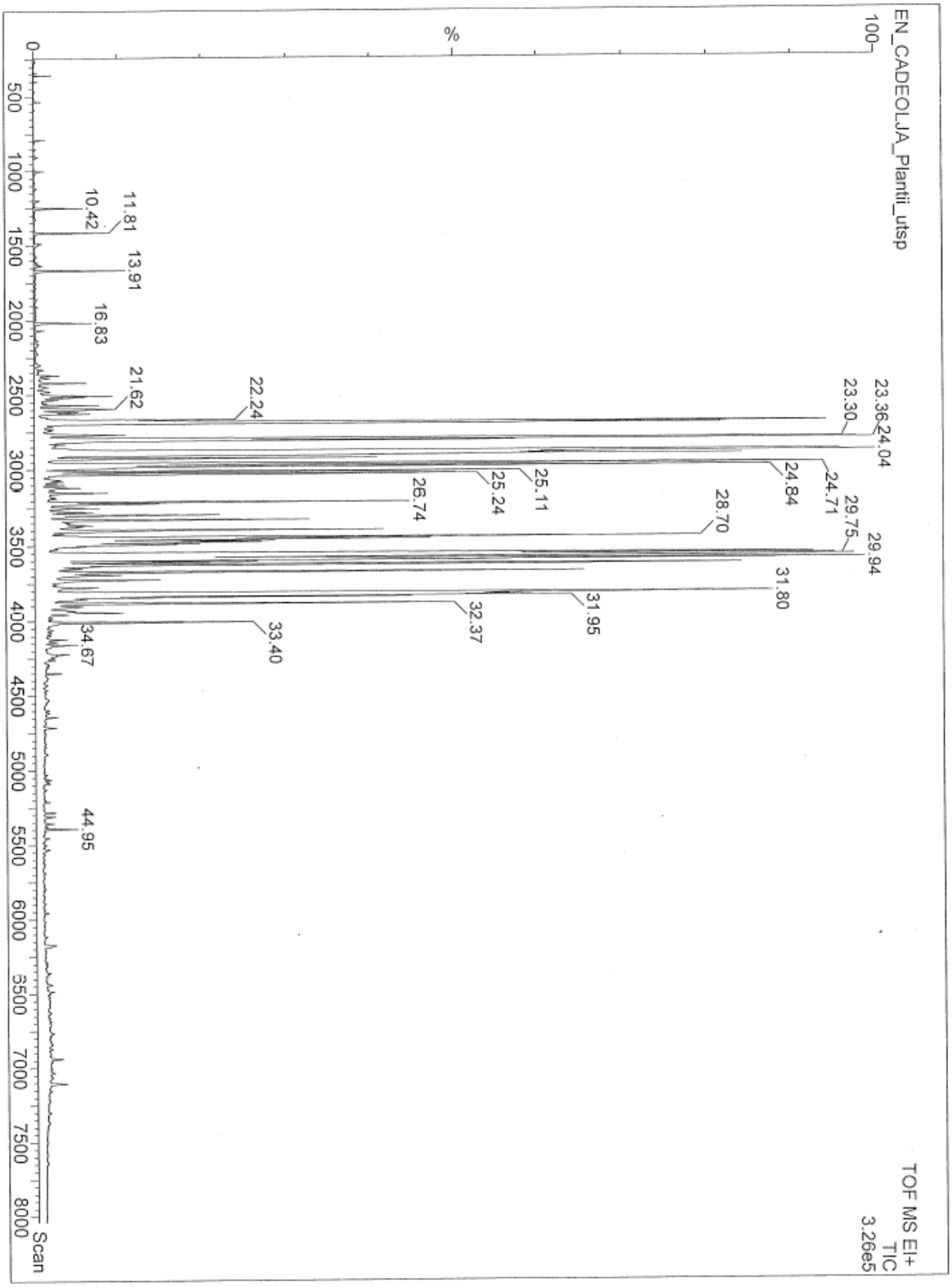
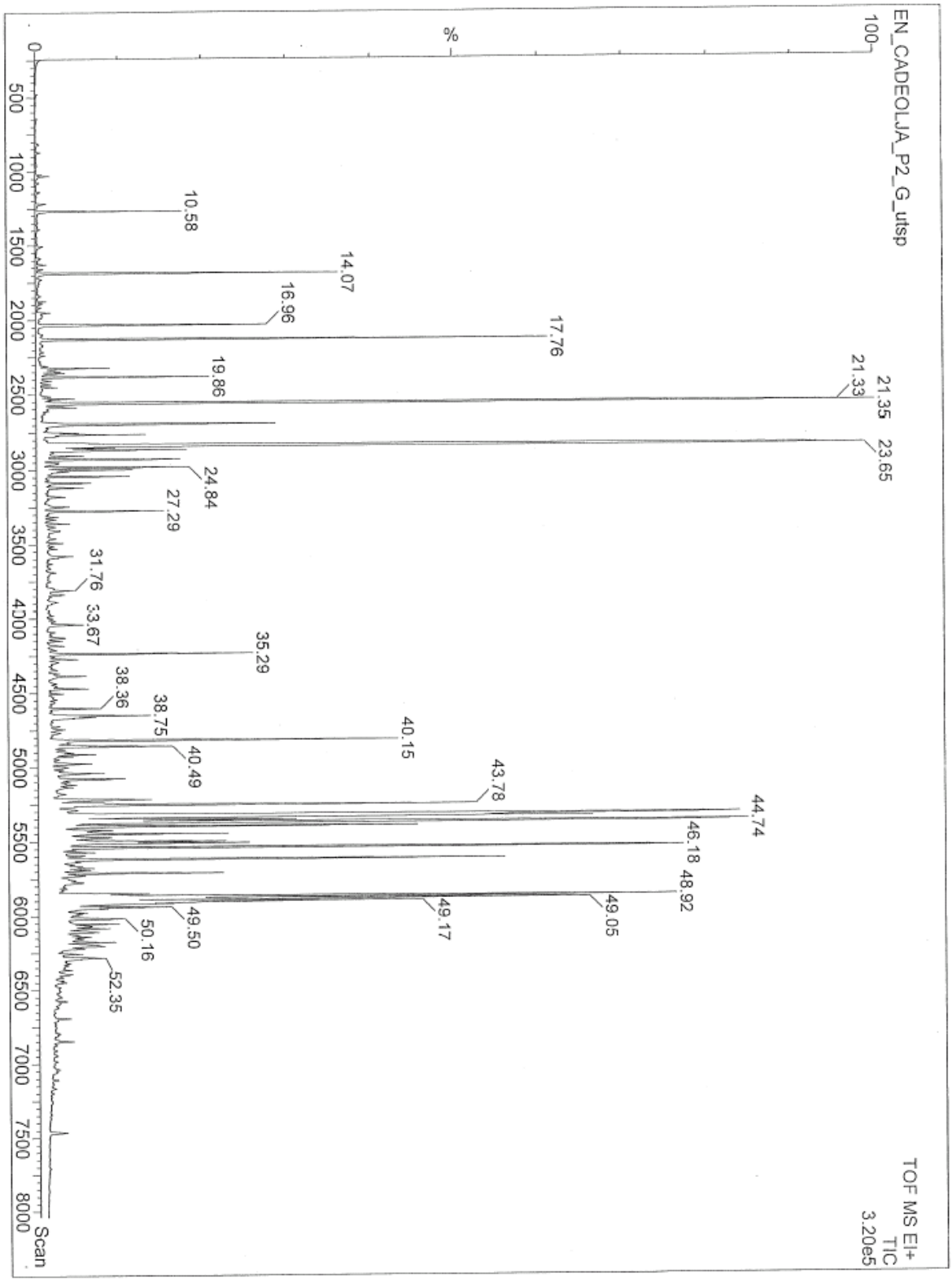


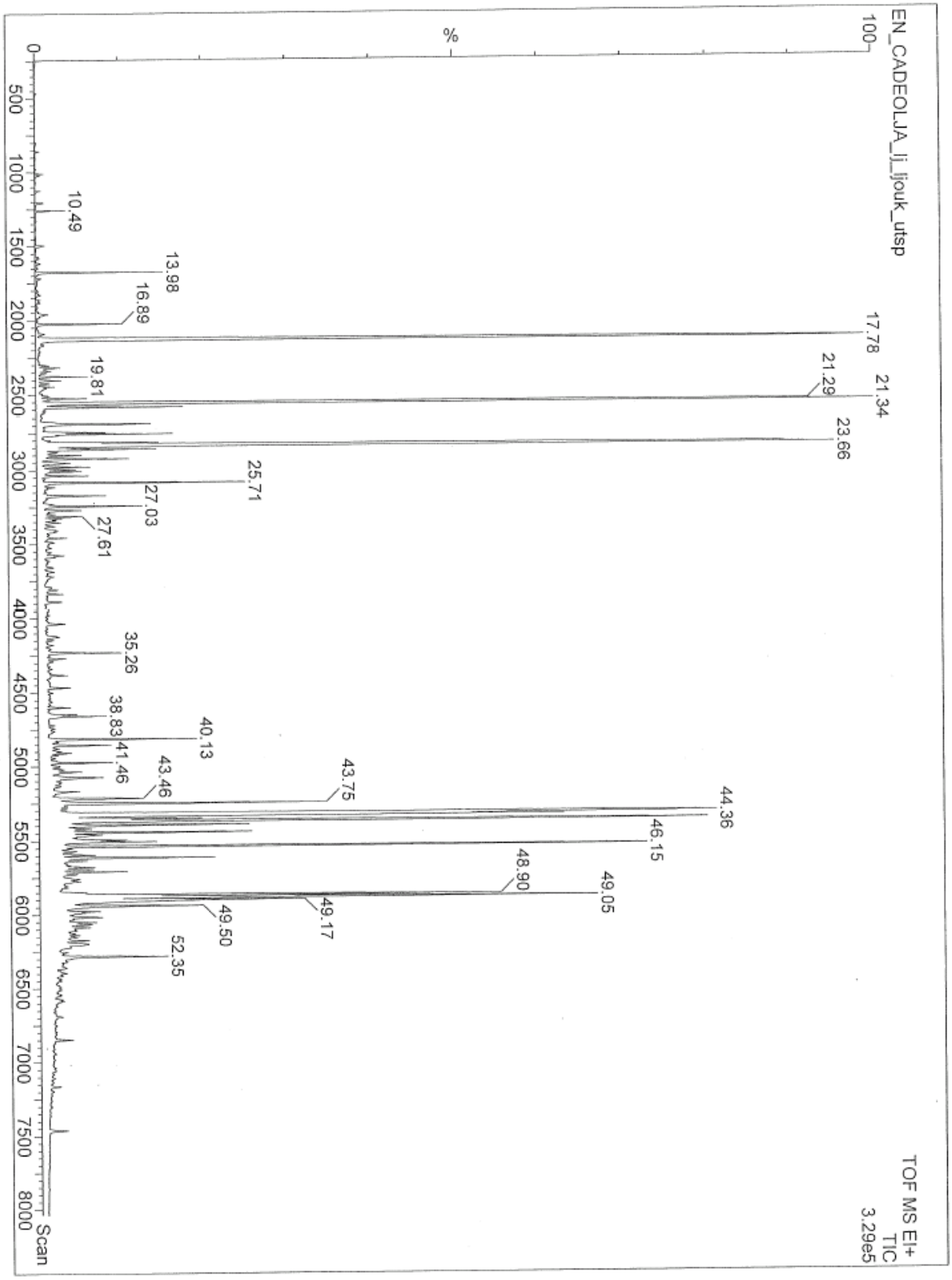
Chromathogram 4: *Gatran Rkik*, probably from *Tîqqi* (*Juniperus oxycedrus*).



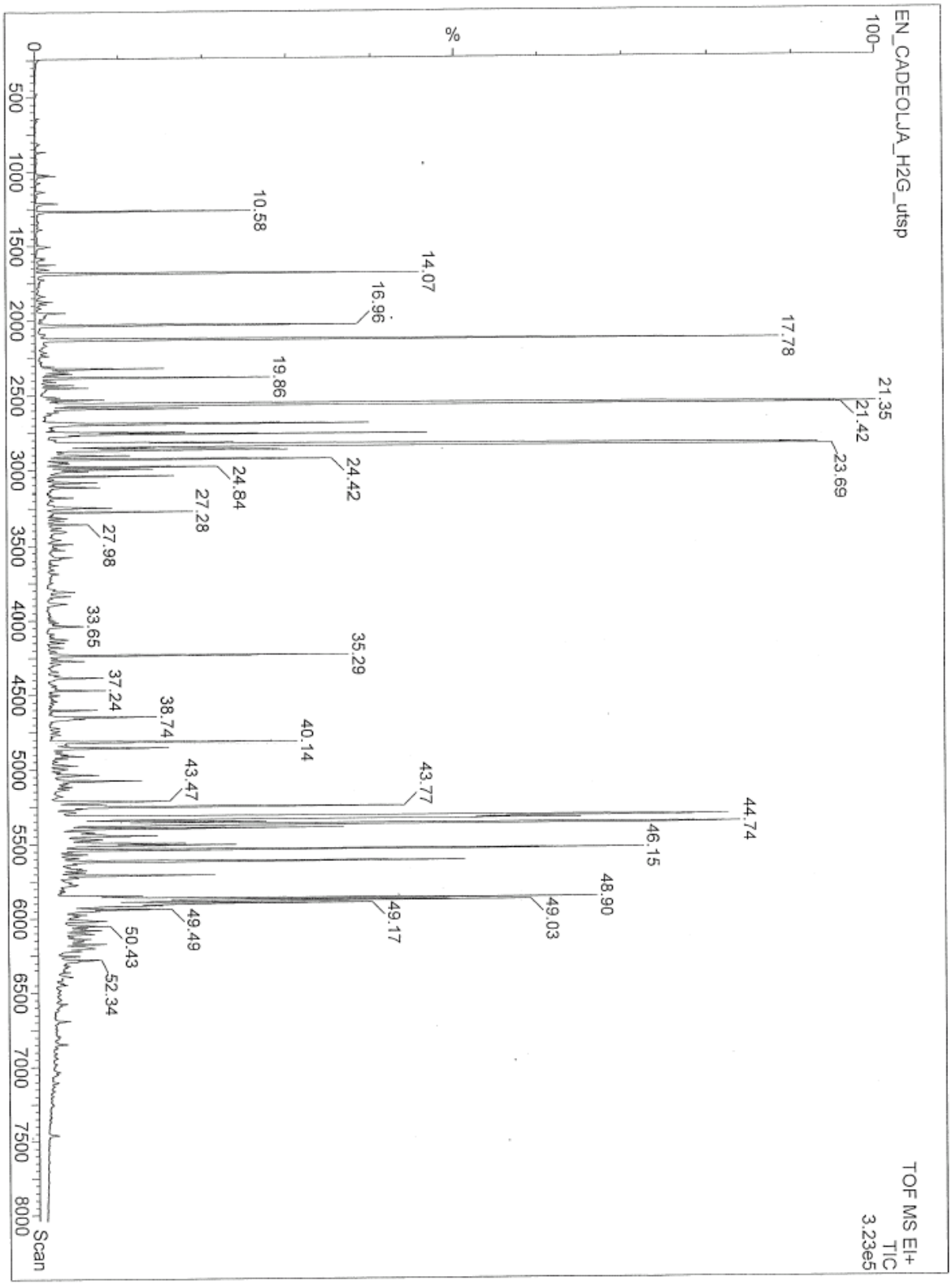
Chromathogram 5: Comersial extract, probably from *Tîqqi* (*Juniperus oxycedrus*).



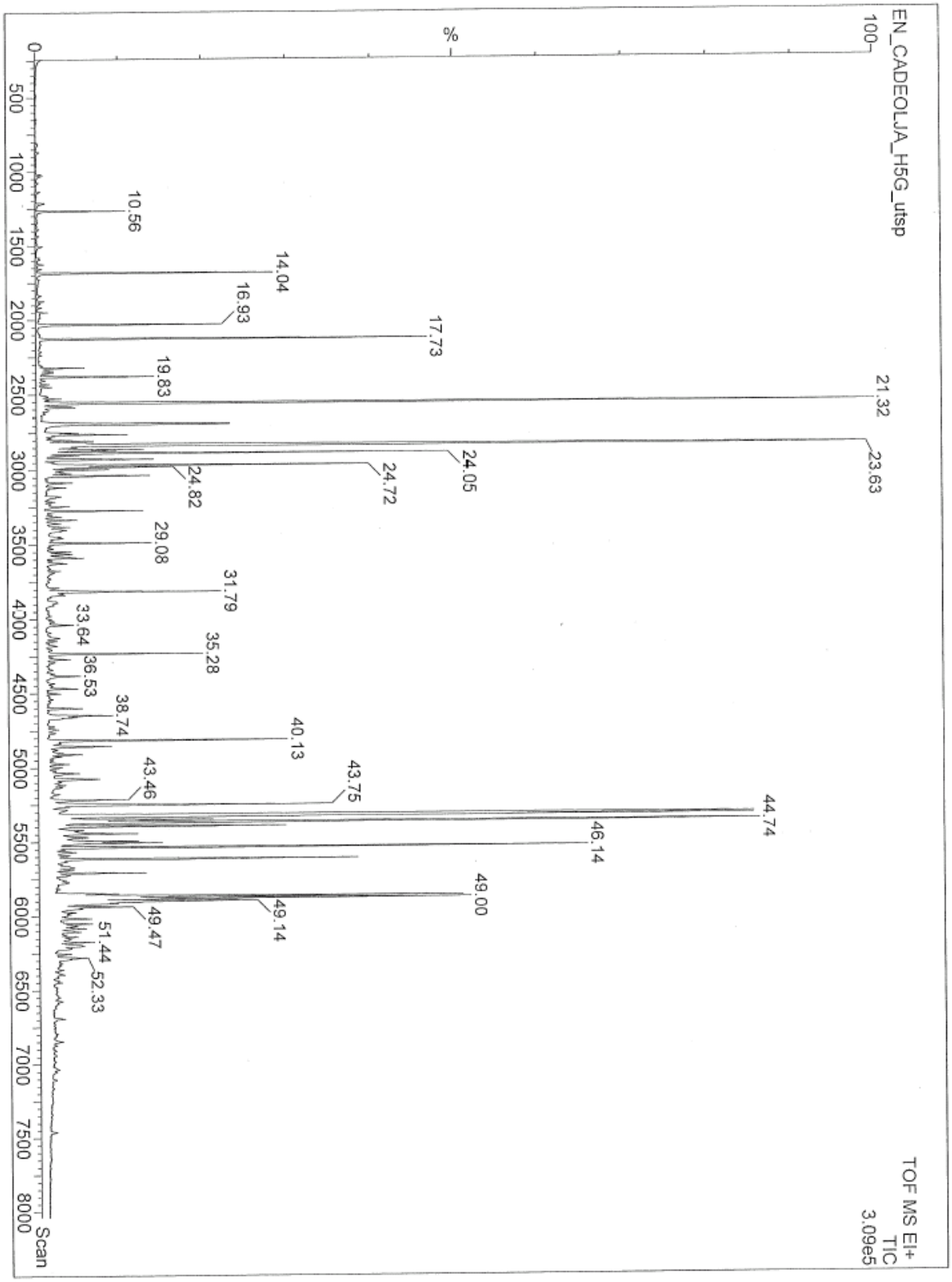
Chromathogram 6: *Gatran Ghlid* from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



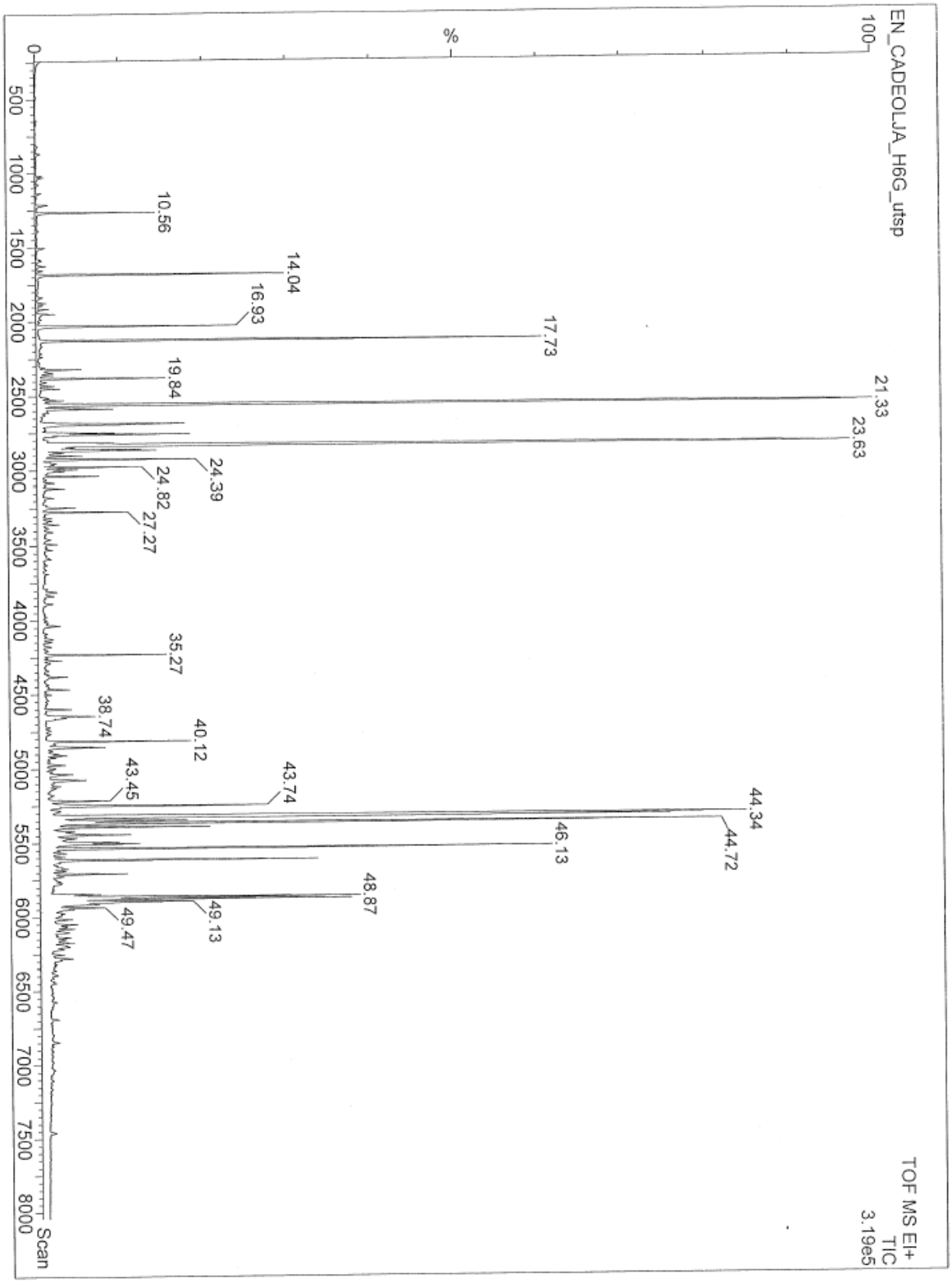
Chromathogram 7: *Gatran Ghlid*, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



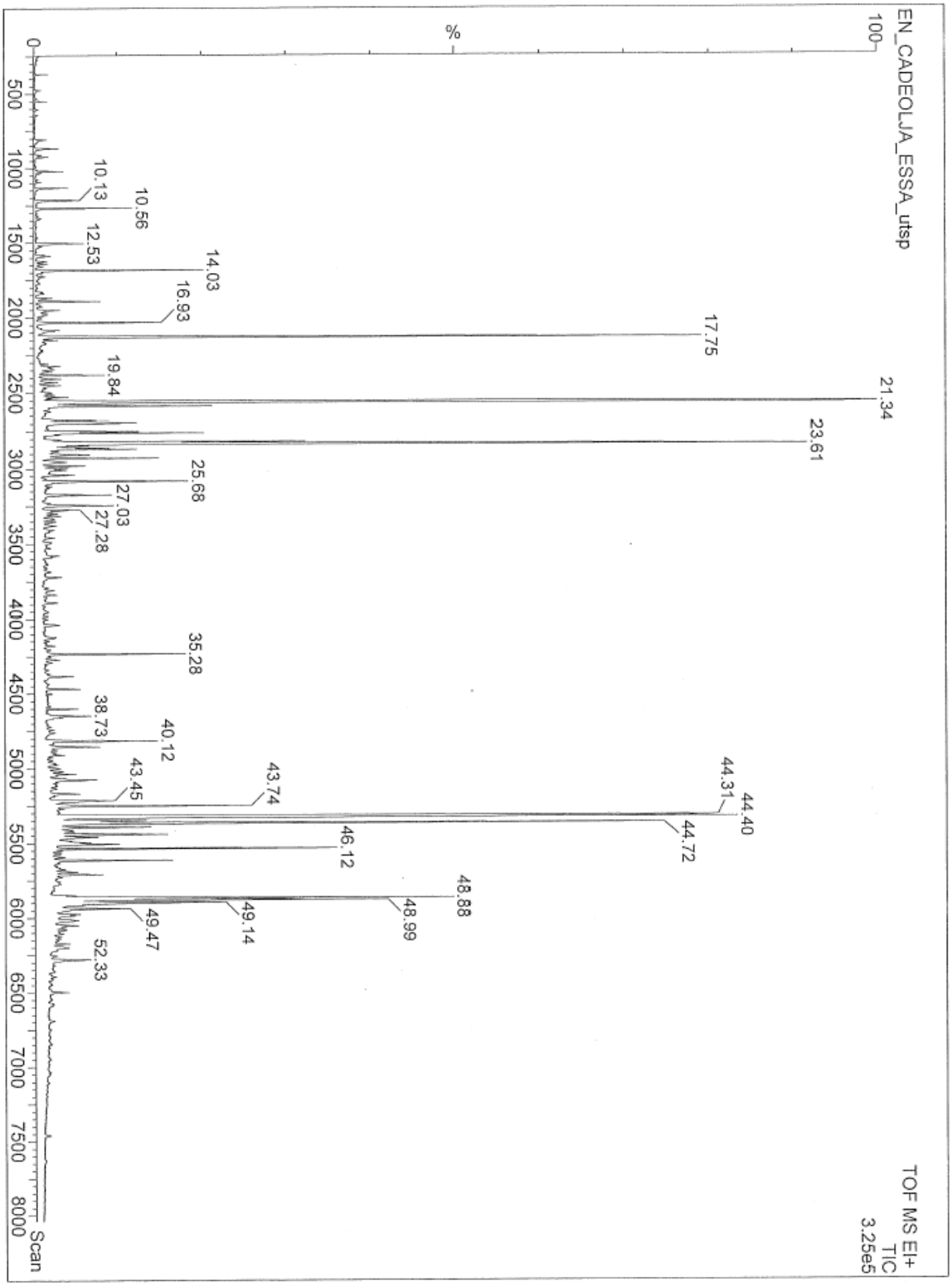
Chromathogram 8: *Gatran Ghlid*, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



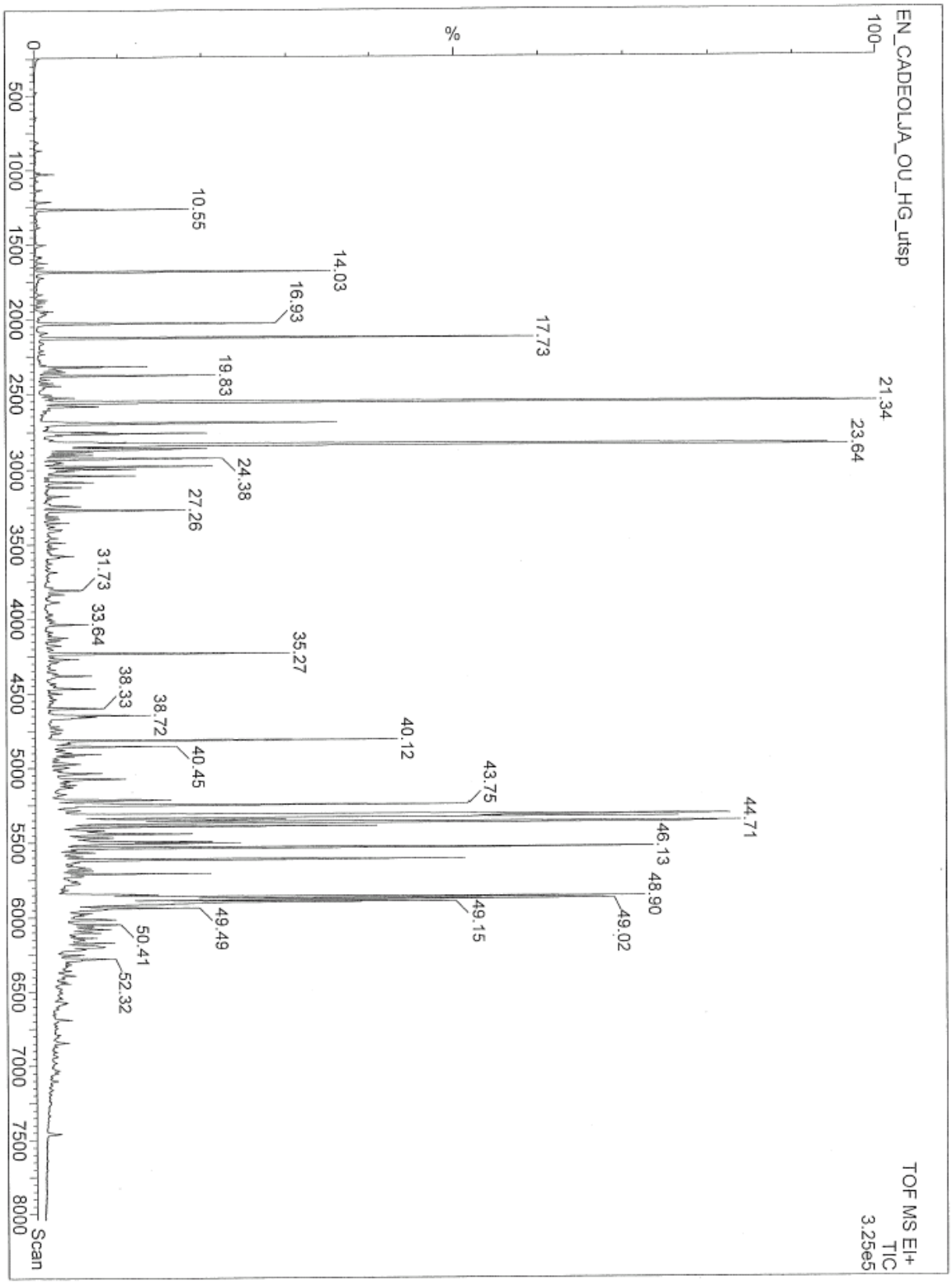
Chromathogram 9: *Gatran Ghlid*, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



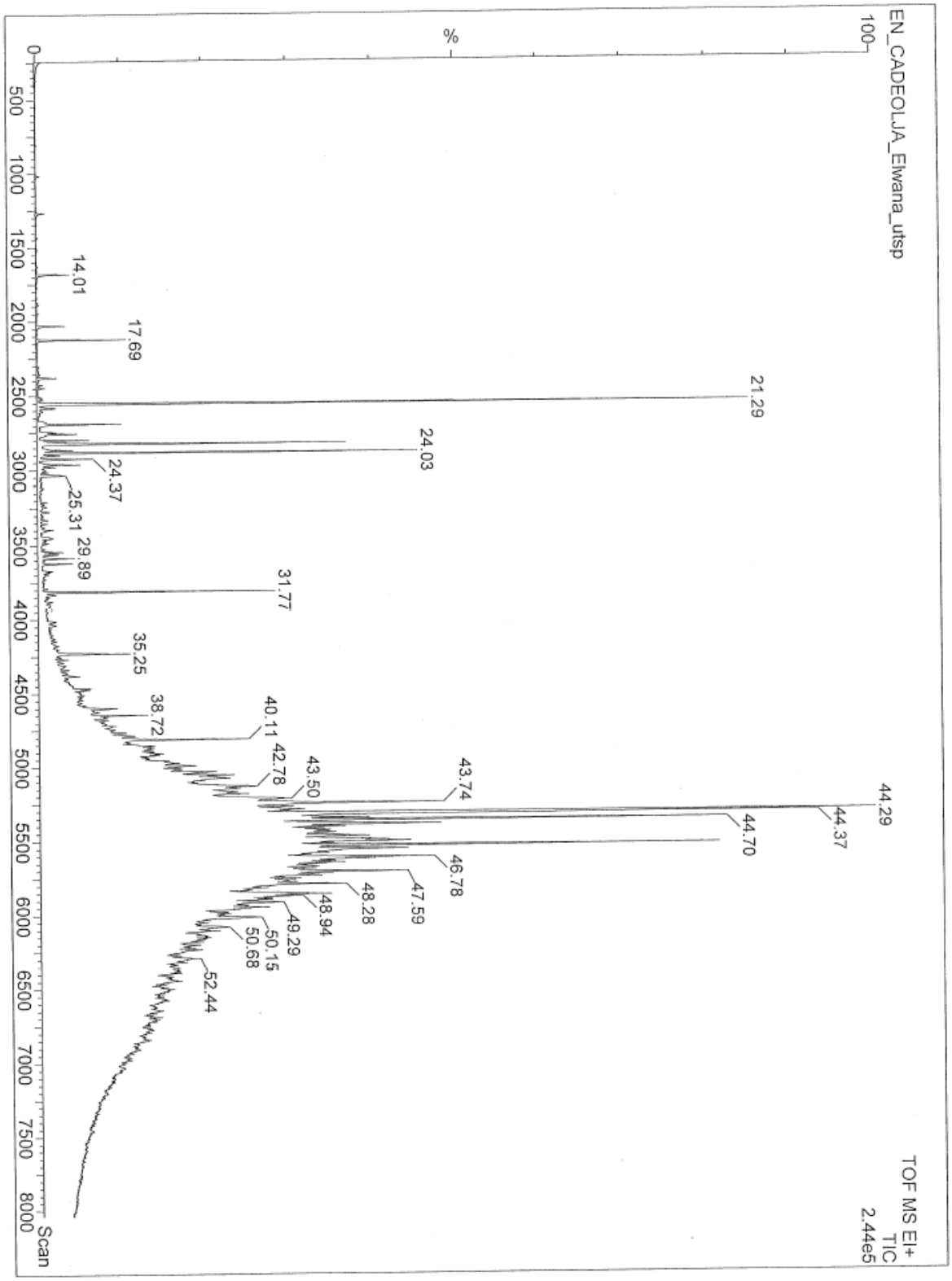
Chromathogram 10: *Gatran Ghlid*, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



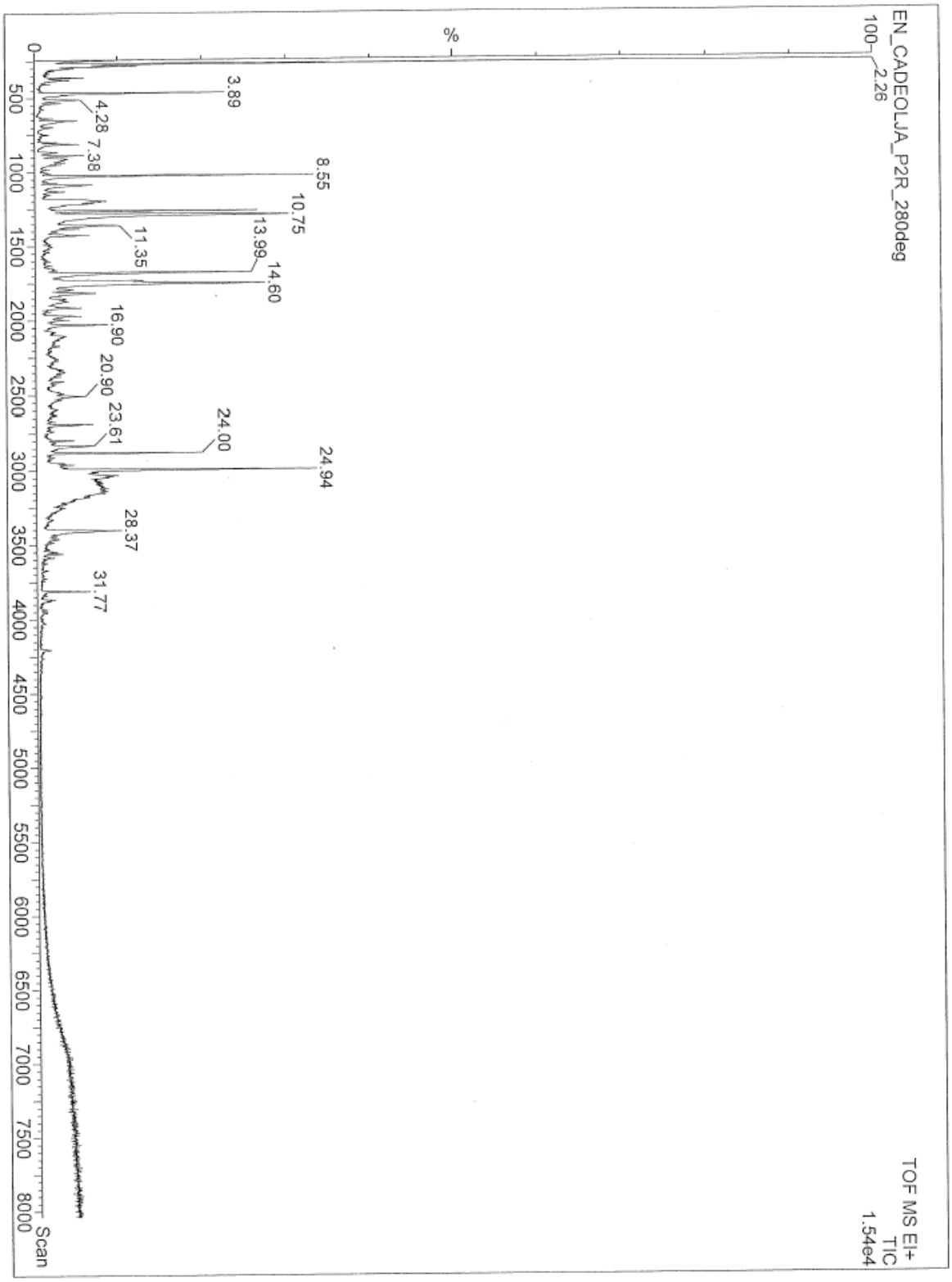
Chromathogram 11: Comersial extract, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



Chromathogram 12: *Gatran Ghlid*, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



Chromathogram 13: Comersial extract in oil, probably from *Arar* (*Juniperus phoenicea and/or Tetraklinis artikulata*).



Chromathogram 14: *Gatran Rkik* from *Lers* (*Cedrus atlantica*).