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Original Research Article

Moroccans' Ethnobotanical Knowledge about Medicinal Tar

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ABSTRACT

Tar has been employed by humans since antiquity due to its importance and benefits. Up until now, it is still used in traditional medicine in different countries including Morocco. Using a quantitative research method, this study sheds light on the traditional properties and usage of tar from various social class perspectives in Morocco. To collect data about the general knowledge about tar, three groups of people were given an ethnobotanical questionnaire: general population, herbalists, and tar producers. An online survey was delivered to the general population, while a semi-structured questionnaire was employed to interview the other groups. The online participants were evenly split into two groups according to their gender. Also, there were twelve males for every one female for the herbalists, whereas the producers were entirely males. Tar usage was roughly the same across all three categories. Participants mentioned *Juniperus sp*., *Cedrus sp.*, and more, herbalists mentioned *Eucalyptus sp*., *Olea sp*., and the producers mentioned Yew. For tar production, the online participants and herbalists knew the procedure with a percentage of 21% and 40% respectively, followed by 100% for producers. In this study, producers have more information and understanding about tar production than herbalists, who have a better knowledge about tar usage. Furthermore, medicinal tar is an intriguing product that deserves to be respected.

Keywords: Ethnobotanical, Investigation, Morocco, Medicinal tar, Herbalists, Producers.

Introduction

Tar has been utilized by people from ancient times and has played an important role in the world. [1–3] Tar is defined as a dark or brown viscous liquid obtained by pyrolysis from organic matter.[4–8] It is known as pyroleum in pharmacopoeia.[6,9] Tar has evolved for the protection of waterproofing,[10] decorating, and object adherence.[11] It is also widely employed in both human and veterinary medicine for the treatment of skin illnesses.[12] In Morocco, tar use is still retained by all age groups and its uses differ from one individual to another. It's commonly utilized in traditional medicine in many regions in the country. The use of traditional medicine has grown in recent years. In fact, it is used by the vast majority of Africans.[13] This remarkable growth has piqued the interest of ethnobotanical specialists. Furthermore, the WHO has devised a strategy centered on spreading awareness of this field.[14,15] Ethnobotany is usually defined as the scientific study of humans' interactions with plants.[16] An ethnobotanical survey is a tool that allows us to interact with people to identify their knowledge about medicinal tar (Qtran in Arabic).

The present article, based on a study in Morocco, aims at giving an overview of the Moroccan population's knowledge of medicinal tar, which is obtained from different tree species. Using two different ethnobotanical questionnaires on the targeted category, innumerable uses of plant tar in several therapeutic areas are investigated. In addition, apart from identifying its many virtues, the additional objective of the investigation is to determine the possible toxicological risks associated with the use of tar. For this reason, our survey consists of three main parts: general information about tar's uses and risks, commercialization, and production. This ethnobotanical survey would make a decent resource for information about tar and raise awareness about the species used in its production, medically in particular.

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Materials and Methods

Study areas

Public

A web-based survey tool has been chosen to collect data about the perceptions of participants on the use of tar. The questionnaire was shared publicly on social media platforms (Facebook, LinkedIn...). This method has been applied to conduct research in many fields of study. [17,18]

Herbalists

A semi-structured questionnaire was used to collect data about herbalists' (usually referred to as *"Aachaba"* in Arabic) knowledge about medicinal tar. The participants work in the region of Rabat-Sale-Kenitra. (Figure 1)

Producers

The Forest Research Center of Rabat has coordinated two visits to the tar production's cooperatives located in Talgount and Itzer. The cooperative of Talgount is located in the region of Beni Mellal-Khenifra (31°40'32.7"N 7°15'58.7"W), with the visit scheduled on the 29th and 30th , March 2021; and Itzer is located in the region of Draa-Tafilalet (32°55'31.8"N 5°11'40.7"W) (Figure 2) .The visit took place on the 08th and 09th, June 2021. The interviews were conducted in the production sites using a semi-structured model of interview. In the report of the Agency of Economic and Social Development Promotion of the Northern Provinces conducted in 2012, only two cooperatives in Morocco were working in partnership with the High Commission for Water Forests and Combating Desertification to produce tar.[19]

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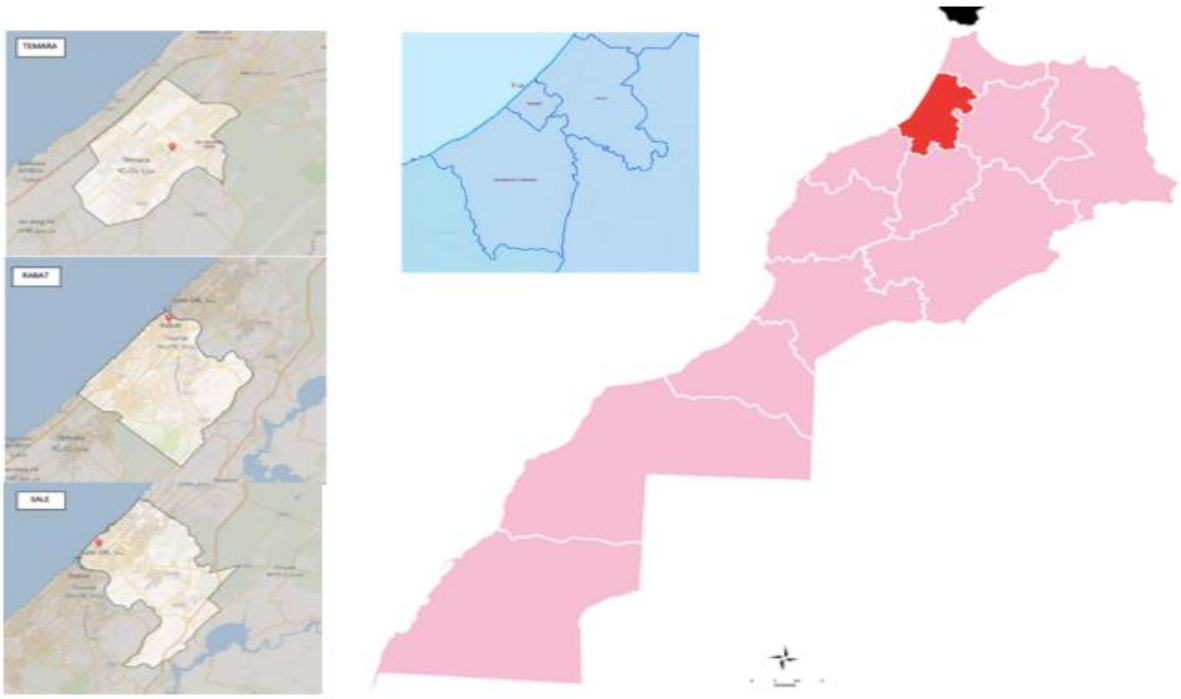

Figure 1: Location of Rabat-Sale-Kenitra region in Morocco (Source: commons.wikimedia.org; Google map)

Figure 2: Location of both Cooperatives (Talgount & Itzer) in Morocco (Source: Google Map)

Data collection

A survey was prepared in advance based on previous studies. In a survey, it is necessary to collect certain information such as general (location, date...), social (name, age, gender ....) and botanical (vernacular name of the plant, scientific name, parts used, medicinal use, mode of preparation and administration). [16,20]

All three categories of participants were informed about the purpose of the research. They responded voluntarily and anonymously to the

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ethnobotanical study.[21] The online ethnobotanical survey was anonymous with short and simple questions, focusing on choice questions created on *Google Forms*. The questionnaire was divided into four sections: personal information, general knowledge about tar, uses, and tar production.

The languages used are Arabic and French, and it was conducted from 30 June 2020 to 26 July 2020 (Figure 3).

The second group of interviewees consisted of 87 herbalists from Rabat-Sale-Kenitra region. The interviews took place in December, 2020 and varied between 15 to 35 minutes, depending on participants' knowledge about tar. ''*Darija'', the Moroccan dialect,* was used for the interviews. (Figure 4) The third group of interviewees included two people from two different tar producing cooperatives. The ethnobotanical information about tar was collected using two semi-structured interviews. The first one was conducted in a village called Talgount in the region of Beni Mellal-Khenifra in March 2021, while the second one took place in Draa-Tafilalet region in June 2021. (Figure 5)

Statistical Analysis

The data was collected, translated, and then categorized on a Microsoft office Excel sheet according to participants' age, gender, and education. The ethnobotanical survey results were analyzed using the Excel statistical package. The key indices evaluated included the sum of participants' number, the percentages of each category, and the frequencies of the species that were cited as shown later in the graphs.

Informant details				
Gender	❒ Male	❒ Female		
Age	❒ <20	❒]20-30]	❒]30-40]	
	❒]40-50]	❒]50-60]	❒ 60<	
Education Level	❒ Illiterate	❒ Elementary	❒ Secondary	❒ Post-secondary
Region	❒ Tanger-Tétouan-Al Hoceïma	❒ Rabat-Salé-Kénitra	❒ Marrakech-Safi	❒ Guelmim-Oued Noun
	❒ L'Oriental	❒ Béni Mellal-Khénifra	❒ Drâa-Tafilalet	❒ Laâyoune-Sakia El Hamra
	❒ Fès-Meknès	❒ Casablanca-Settat	❒ Souss-Massa	❒ Dakhla-Oued Ed-Dahab
General Questions				
Do you know tar	❒ Yes	❒ No		
How many types of tar do you know	❒ One type	❒ Two type	❒ I don't know	
Uses				
Do you use it	❒ Yes	❒ No		
What are the uses of it	❒ Cosmetic	❒ Therapeutic	❒ Decorative	❒ Other
How do you use it	❒ Intern use	❒ External use		
how frequently do you use it	❒ Always	❒ Sometimes	❒ Rarely	❒ Never
Do you use it	❒ Alone	❒ Mixed		
At which quantities do you use it	❒ 1 teaspoon	❒ 1 tablespoon	❒ 1 cup	❒ I don't use it
How are the results of the use	❒ Effective	❒ Improvement	❒ Ineffective	❒ I don't use it
Does the medicinal tar presented any danger or toxicity	❒ Yes	❒ No	❒ I don't know	
If yes what are the symptom	❒ vomit	❒ fever	❒ Other :	❒ I don't know
Production				
Do you know how tar is produced	❒ Yes	❒ No		
If yes which technique you know				
Do you know the species used to produce it	❒ Yes	❒ No		
	❒ Juniperus Sp	❒ Thuya	❒ Eucalyptus sp	
	❒ Olivier	❒ Pinus sp	❒ Other :	❒ I don't know
What part of the plant is used to produce it	❒ Leaves	❒ Flower	❒ Fruit	❒ Seeds
	❒ Branches	❒ Bark	❒ Other :	❒ I don't know
Are you Interested to know more informations about it	❒ Yes	❒ No		

Figure 3: Questionnaire for collecting information from public

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Informant details									
Gender	❒	Male	❒	Female					
Age	❒	<20	❒	]20-30]	❒	]30-40]			
	❒	]40-50]	❒	]50-60]	❒	60<			
Family situation	❒	Single	❒	Married	❒	Widowed	❒	Divorced	
Education level	❒	Illiterate	❒	Elementary	❒	Secondary	❒	Post-secondary	
City	❒	Rabat	❒	Salé	❒	Temara			
Commercialisation									
Do you sell medicinal tar	❒	Yes	❒	No					
Who buys it the most	❒	Male	❒	Female					
Which type of tar is highly demanded	❒	Liquid tar	❒	Thick tar					
How much does tar coast per litre	❒	>50dh	❒	]50-100dh]	❒	]100-500dh]	❒	1000dh<	
How much you sell per year	❒	<1l	❒	]1-10l]	❒	]10-100l]	❒	100l<	
How much you earn per month from selling it	❒	<50	❒	]50-100]	❒	]100-500]	❒	1000<	
Which season the tar is highly demanded	❒	Summer	❒	Autumn	❒	Winter	❒	Spring	❒ All seasons
How can you verify the quality of tar	❒	By colour	❒	By texture	❒	By smell			
Where do you storage it	❒	In plastic	❒	In glass					
From where do you buy it									
Uses									
Do you use it	❒	Yes	❒	No					
What are the uses of tar	❒	Cosmetic	❒	Therapeutic	❒	Decorative	❒	Other	
How do you use it	❒	Intern use	❒	External use					
Do you use it	❒	Alone	❒	Mixed	❒	I don't use it			
At which quantities do you use it	❒	1 teaspoon	❒	1 tablespoon	❒	1 cup	❒	I don't use it	
How are the results of the use	❒	Effective	❒	Improvement	❒	Ineffective			
Does the medicinal tar presente any danger or toxicity	❒	Yes	❒	No	❒	I don't know			
Production									
Do you know how tar is produced	❒	Yes	❒	No	If yes	By which technique			
Do you know the species used to produce it	❒	Yes	❒	No	If yes	Which species			
What part of the plant is used to produce it	❒	Leaves	❒	Flower	❒	Fruit	❒	Seeds	
	❒	Branches	❒	Bark	❒	Wood	❒	I don't know	

Figure 4: Questionnaire for collecting information from herbalists

Informant details						
Gender	❒ Male	❒ Female				
Age	❒ <20	❒]20-30]	❒]30-40]			
	❒]40-50]	❒]50-60]	❒ 60<			
Family situation	❒ Single	❒ Married	❒ Widowed	❒ Divorced		
Education level	❒ Illiterate	❒ Elementary	❒ Secondary	❒ Post-secondary		
City						
Production						
Do you produce tar	❒ Yes	❒ No				
How did you learn tar production	❒ My ancestors	❒ Hobby	❒ Curiosity			
How long have you been producing tar	❒ <10year	❒ 10<year				
What are the methods that you are using	❒ Per descensum distillation	❒ Per ascensum distillation	❒ Oven distillation			
Are there different methods to produce tar	❒ Yes	❒ No	❒ If yes what are they			
What are the species used to produce tar	❒ Juniperus sp	❒ Thuya	❒ Eucalyptus sp	❒ Olivier	❒ Pinus sp	
What part of the plant do you use to produce it	❒ Leaves	❒ Flower	❒ Fruit	❒ Seeds	❒ Root	
	❒ Branches	❒ Bark	❒ Wood	❒ Other:		
From where do you get the wood	❒ Forest	❒ Other				
Are the same species used in the past as today	❒ Yes	❒ No				
How many times do you produce it in a year	❒ Once	Twice	More			
When is it the period of production	❒ Summer	❒ Autumn	❒ Winter	❒ Spring		
How can you verify the quality of it	❒ By colour	❒ By texture	❒ By smell			
Are you facing any difficulties or obstacles with the production	❒ Yes	❒ No	❒ If yes, what are they			
Is there any regularization	❒ Yes	❒ No				
Commercialisation						
Where do you sell it						
Who buys it						
Which season the tar is highly demanded	❒ Summer	❒ Autumn	❒ Winter	❒ Spring	❒ All seasons	
How much does it coast per litre (dh)	❒ <50dh	❒]50-100dh]	❒]100-500dh]	❒ 1000dh<		
Has the price changed with time	❒ Yes	❒ No				
Is tar production your main source of income	❒ Yes	❒ No				
How much you earn per month from selling it (dh)	❒ <50dh	❒]50-100dh]	❒]100-500dh]	❒ 1000dh<		
Where do you storage it	❒ In plastic	❒ In glass	❒ Other:			
Uses						
Do you use it	❒ Yes	❒ No				
What are the uses of it	❒ Cosmetic	❒ Therapeutic	❒ Decorative	❒ Other:	❒ I don't use it	
At which quantities do you use it	❒ 1 teaspoon	❒ 1 tablespoon	❒ 1 cup	❒ Other:	❒ I don't use it	
How do you use it	❒ Intern use	❒ External use			❒ I don't use it	
How are the results of its use	❒ Effective	❒ Improvement	❒ Ineffective		❒ I don't use it	
Does the medicinal tar presente any danger or toxicity	❒ Yes	❒ No	❒ I don't know			

Figure 5: Questionnaire for collecting information from producers

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Results and Discussion

Public

Sociodemographic status

Table 1 and Figure 6 illustrate the online results for the public, with 136 responses collected. In terms of gender distribution, we have a rate of 49% (n=67) for men and 51% (n=69) for women. Our results are slightly in line with Statista (Global business data) where they found that in the USA, 77% of women and 61% of men use Facebook platforms.[22] The highest age percentage was 64% (n=87), followed by 19% (n=26) ranging from]20-30] to]30-40] respectively. Then, a rate of 10% was collected for the under-20 age group, and 3% (n=4) and 4% (n=6) for the]40-50] and]50-60] age groups respectively. Our results regarding the age of online participants are fully consistent with Joseph Johnson's 2019 result where he found that one third of online users worldwide were aged 25-34 followed by the age group]18-24].[23] In terms of educational attainment, the highest percentage is 80% (n=109) representing those with post-secondary education. This is followed by 18% (n=24) who have secondary education and only 2% (n=3) who have elementary education. These statistics are consistent with those of Joseph Johnson in 2021, which showed that 98% of university graduates were Internet users. Figure 6 below shows the distribution of participants according to their region of residence. The region of Rabat-Sale-Kenitra has the highest percentage with 69% (n=94), followed by the regions of Fes-Meknes and Marrakech-Safi with 9% (n=12) and the region of Casablanca-Settat with 7% (n=9). This could be explained by the algorithm used by Social Media, which is based on recurrence, popularity, type of content and relationships.

Table 1: Online survey results of socio-demographics respondents

Characteristics		
Informant details	N = 136	
Gender		
Male	67	49%
Female	69	51%
Age		
<20	13	10%
]20-30]	87	64%
]30-40]	26	19%
]40-50]	4	3%
]50-60]	6	4%
60<	0	0%
Education Level		
Illiterate	0	0%
Elementary	3	2%
Secondary	24	18%
Post-secondary	109	80%

Uses

This part of the survey contains several questions about tar, starting with basic questions on knowledge about it (Figure 7(a)). The results showed that 91% (n=124) know what tar is, while 9% (n=12) never heard of this plant product. The graph in Figure 7 (b), demonstrates the types of tar, with almost half of the questionnaire participants 46% (n=63) aware of the existence of two types of tar (liquid and thick), while 29% (n=39) are only aware of one type of tar and 25% (n=34) responded with "I don't know" as their answer. Figure. 7 (c) shows that 44% (n = 60) of participants use tar, whereas 56% (n = 76) do not use it. Furthermore, concerning the types of tar use in Figure. 7 (d), the highest percentage is for the response of "other uses" with a percentage of 46% (n = 99), followed by therapeutic uses with 30% (n = 66) and cosmetic uses with 21% (n = 45). The Histogram in Figure 7 (e) represents the other uses of tar cited by the participants, with 48% (n = 66) as "Insect repellent", 19% (n = 26) for decorative uses (decorating the clay cup for cooling effects), 8% (n = 11) for hair care (usually combined with other oils, which is an excellent remedy for hair loss). The remaining proportion is divided between perfumery, antiseptic, alopecia and witchcraft, adhesive, anti-parasitic and animal repellent with varying percentages.

The findings of this survey are consistent with previous studies, although there are a few differences. In a study conducted by archaeological researchers, tar was found to be the oldest artificial adhesive. [24,25] However, over time, archaeological uses were replaced by therapeutic ones, namely curing skin diseases.[2] Moreover, other research has shown the use of tar in witchcraft. [6,26]

Figure 8 shows how the participants of the survey administer tar. We have grouped the responses based on a variety of factors; including the type of use (i.e. internal and external), the frequency of use, whether it is mixed with substances or not, and finally, the quantities administered**.** In the first pie chart, 49% (n = 66) represent external use, while 37% (n = 51) are for internal use. These results are in line with a study conducted in Beni-Mellal shows that people use both internal and external plant extracts. [27] In the second graph, the response "rarely used" obtained the highest percentage with 41% (n = 56), followed by 34% (n = 47) for "sometimes", 22% (n = 28) for "never" and only 4% (n=5) for "constant use". In the third chart, 67% (n = 91) of the responses correspond to the use of pure tar, while 19% (n=26) correspond to its combination with other ingredients. The fourth graph shows that 65% (n = 89) of people did not know the exact quantities to use, while 27% (n = 37) and 7% (n = 9) recognised the use of a teaspoon and a tablespoon respectively.

In the fifth graph Figure. 8 (e), 47% (n = 64) of the participants reported improvement after the use of tar, and 29% (n = 33) testified to its effectiveness, while none of the participants mentioned its ineffectiveness. These results are in line with those of Dulla and Jahan, where they claimed that 42 different diseases were cured by the plants. [28] Also, the ethnobotanical study done on Tetraclinis articulata shows that more than 90% of the participants were satisfied with the healing results.[27]

In regards to toxicity (Figure 8f), about half of the participants with a percentage of 45% (n=61) were unaware of the toxic properties of the tar, while an approximately equal percentage is shared between those who recognised the toxicity of tar 28% (n=38) and those who recognised the opposite 27% (n = 37). These results are quite different from the ethnobotanical study, which showed that 87% say the absence of toxicity of Thuja,[27] a species used in tar production. Another study indicated that herbal medicines are supposed to be less toxic than pharmaceutical drugs.[29] In the context of our study, the majority of the participants have university degrees with a percentage of 80%. Therefore, we can conclude that the use of this tradition is not determined by an individual's level of education or lack thereof.

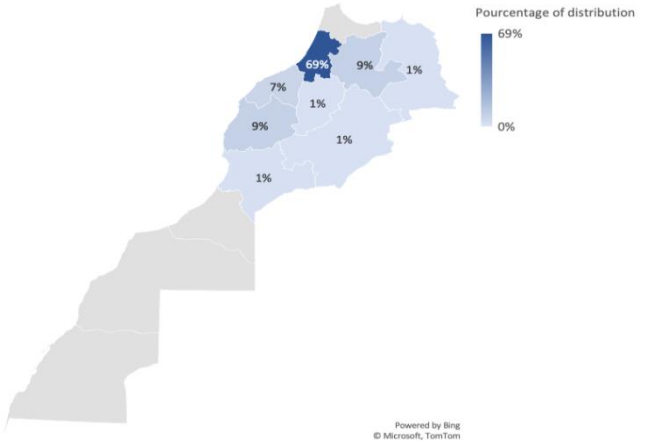

Figure 6: The distribution of respondents in accordance to their Residence

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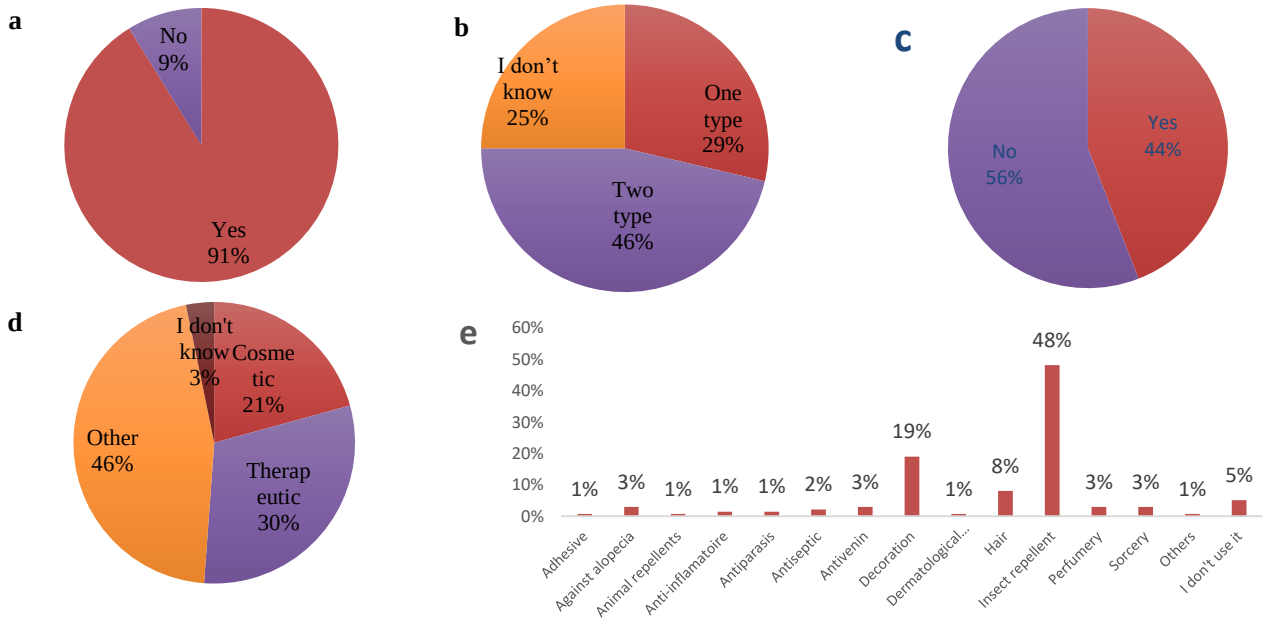

Figure 7: (a) Percentage of tar consciousness;(b) representation of tar type percentage of use;(c) the use of it;(d) tar uses fields; (e) Tar uses

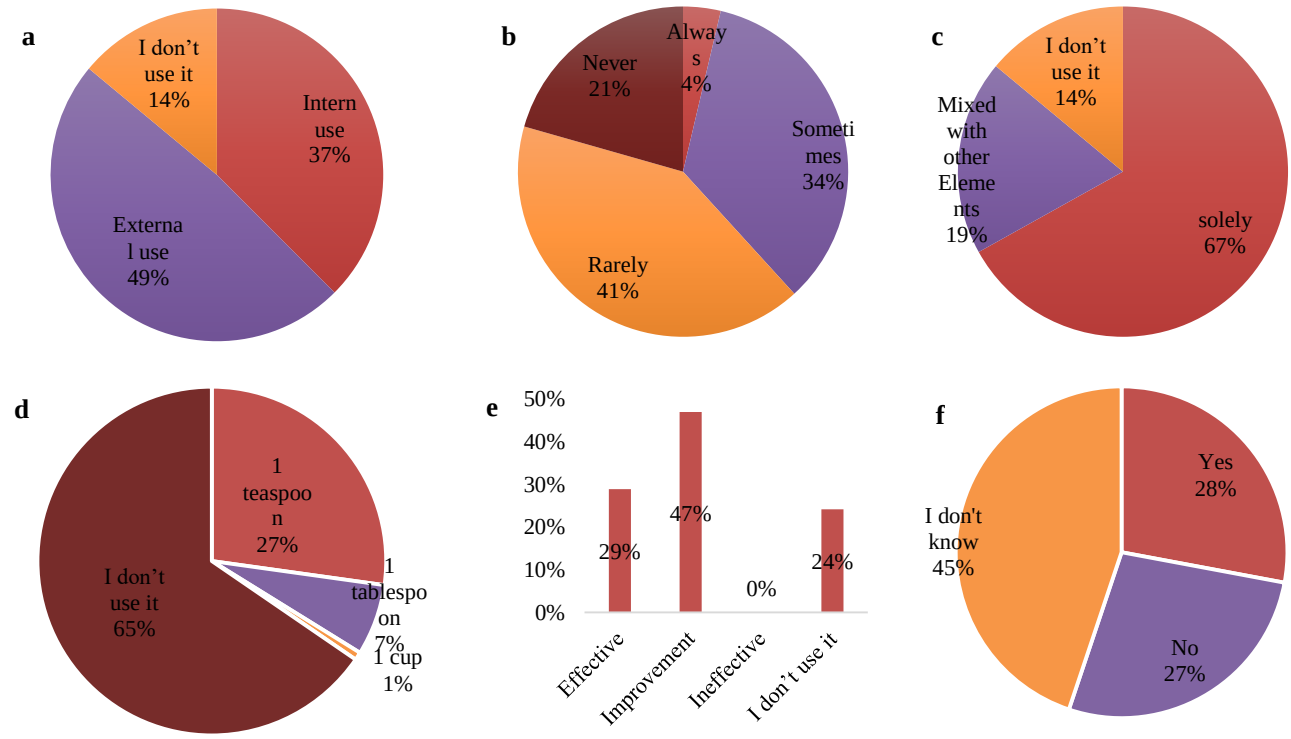

Figure 8: (a) Percentage of use-type; (b) the percentage of use-frequencies; (c) the mixed method-use ; (d) the percentage of the required quantities ; (e) Use-result ; (6) Percentage of Toxicity

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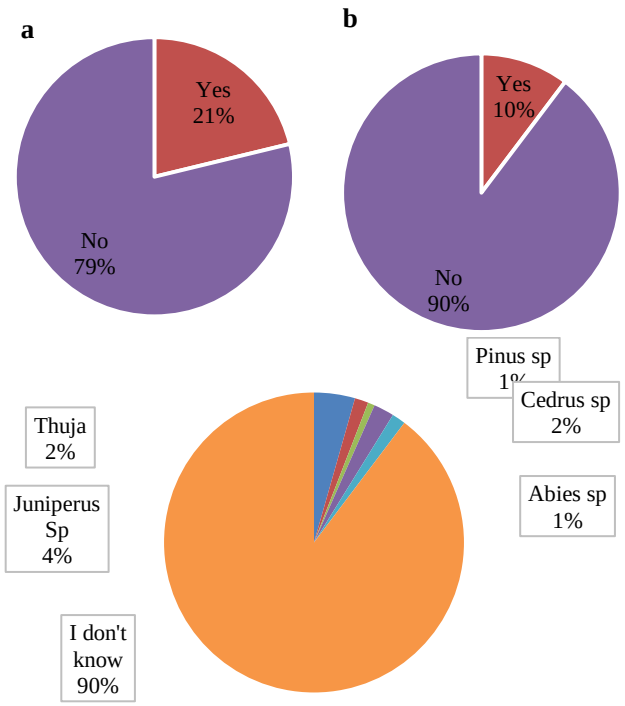

Figure 9: knowledge about tar production. (a) Technique of production; (b) Species used in tar production ;(c) Species used in production.

Production

In this part of the online survey, we asked four questions, from which the first three are presented in Figure 9. The first pie chart Figure. 9 (a) represents the participants' answers on their knowledge of tar production techniques.

Figure 10: Photo of herbalists (Taken by Ninich Oumaima)

Only 21% (n=28) responded with a positive answer. In the second graph, 10% (n=14) of the participants know the exact species used to produce tar. In the third graph Figure. 9 (b), only 10% (n=14) revealed the use of five species, namely: 4% (n=6) for Juniper (*Juniperus sp*), 1% (n=2) for Thuja (*Tetraclinis articulata*), 1% (n=1) for Pinus sp, 2% (n=3) for *Cedrus sp*, and 1% (n=2) for *Abies sp*. In fact, 90% (n=122) of the participants do not know the species used in tar production. Regarding the fourth question on the parts of the species used, only 15% (n=20) reported the use of wood while the rest reported ignorance of the subject (Figure 9c).

These results are in line with the literature. Moreover, they are consistent with those of a survey on the use of herbal medicine in the Casablanca region, which shows that knowledge of traditional herbal practices is generally transmitted from one generation to the next. [30] The findings of this study are almost the same as those of others, who claim that knowledge and skills have been safeguarded over time by passing them from one generation to another.[31,32] Similarly, the findings of another study in Turkey are consistent with the abovementioned ones.[33]

Herbalists

Through ethnobotanical surveys of herbalists (Figure.10) carried out in December 2020, data was collected, based on a semi-structured questionnaire. Only 67 of the 86 herbalists interviewed agreed to provide information. The herbalists were selected randomly.

Sociodemographic status

Descriptive statistics using frequencies and percentages were used to analyse the socio-demographic data of the herbalists, and the results are presented in Table 2. The distribution of traditional herbalists by gender showed that 93% (n=62) are male, and only 7% (n=5) are female. The ratio of males to females was 12 to one, and in favour of the male gender. The results are in agreement with those of Labiad *et al*.[34] The distribution of traditional herbalists by age showed that the highest age group is 50-60 years with a rate of 34% (n=23), followed by 40-50 years with 28% (n=19), then 30-40 years with 21% (n=14). Only 15% (n=10) are 20-30 years old and 1% (n=1) are over 60. These results are in line with those of Labiad *et al*,. [34] with the 30-50 age group having the highest rate. Based on the results mentioned in the table, we found that married herbalists represent a percentage of 85% (n=57) compared to 10% (n=7) for single herbalists. Concerning the marital status of the herbalists in the Intissar study, 49% were married, 29% were single, 14.5% were widowed and 7.2% were divorced.[35]

In terms of academic level, illiterate and elementary level are almost equally represented at 34% (n=23) and 36% (n=24) respectively. This is followed by a rate of 22% (n=15) for secondary education, and only 7% (n=5) for post-secondary education.

Table 2: Socio-demographics of the herbalists responds

Characteristics	N=67	
Informant details	n	%
Gender		
Male	62	93%
Female	5	7%
Age		
<20	0	0%
]20-30]	10	15%
]30-40]	14	21%
]40-50]	19	28%
]50-60]	23	34%
60<	1	1%
Marital status		
Single	7	10%
Married	57	85%
Widowed	3	4%
Divorced	0	0%
Education level		
Illiterate	23	34%
Elementary	24	36%
Secondary	15	22%
Post-secondary	5	7%
City	N=86	
Rabat	28	33%
Salé	39	45%
Temara	19	22%

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These results are consistent with those of a study conducted in Marrakech on the use of medicinal plants, where 53% of the participants were illiterate, 47% distributed between primary and secondary education and only 9% attended higher education level.
Most traditional knowledge of medicine acquired by ancestors is empirical. [35] Few herbalists reported acquiring knowledge by reading books, while another group reported that they only practice tar marketing.
The interviewed herbalists were distributed over three cities in the Rabat-Sale-Kénitra region, as shown in the table. Many districts were investigated in different cities with different economic statuses. In Rabat, we visited the districts of Ocean, Akaari, Agdal, Hay Riad, Souissi, Manal, Yaakoub El Mansour, Irfaan and Medine. In Sale, we visited Qaria and the Old Medina. In Temara, we went to the Souk Sebt, Massira and Milano districts. We did not find any herbalists in the richest districts of Rabat (Agdal, Hay Riad, Souissi), which shows that the wealthy class in these areas has no interest in herbal products. Supporting this claim, Rasu's study shows that economic status has an influence on the choice of the type of health care.[36]

Uses
We assessed the knowledge of tar use among herbalists. Figure 11 shows the responses' distribution on the use of tar, the area and modes of use, the administration modes and results, and finally toxicity.
With respect to the field of use (Figure 11a), 23% (n=25) of the participants say that they use it for therapy, some herbalists claimed that they can cure cancer with liquid tar. Others use tar to cure skin diseases such as eczema and certain animal diseases. 18% (n=19) of herbalists reported that tar is used by pottery makers ("*fakhara*" in Moroccan dialect) to decorate clay cups and 8% (n=8) are using it as an animal repellent. Only one herbalist reported its use in witchcraft and another reported its use in making explosives. Herbalists claimed that women bought liquid tar for hair care in the belief that it would make hair grow faster. In Casablanca, a study showed that 85% of the population uses traditional medicine as a remedy for diseases.[30] It is worth mentioning that Ethnobotanical uses depend on the plant species, the knowledge of the civilisation and the prevailing diseases in a given time and place.[37]
In terms of the way of use (Figure 11b), 53% (n=30) of the participants claim that they use tar only, whereas the remaining 47% (n = 27) report the use of tar mixed with other essential oils of medicinal plants before application, in particular for hair care, arguing that this mode of use contributes to pure tar's dilution and its effectiveness.
In the mode of administration (Figure 11c), 81% (n=46) of the participants stated that tar has an external use while 19% (n=11) spoke about its internal use. Oral administration was the most used method with 94% in the study conducted by Dibong *et al*.[29]
The result of use as shown in Figure. 11d are similar to those of the public (paragraph Public-use). Up to 16% (n=9) reported the effectiveness of tar after use, while 21% (n=12) reported improvement following tar treatment. None of the herbalists interviewed spoke of its ineffectiveness, while the majority, specifically 63% (n=36) acknowledged their ignorance regarding the effectiveness of tar, saying that they never asked their clients whether the tar worked or not. According to Dibong *et al*,[29] the ability to treat diseases varied from place to another.

The toxicity
The result for the toxicity of medicinal tar is shown in Figure 11e. For the herbalists, since tar is a natural product that comes from nature and from the tree, it does not present any danger or toxicity, which gave us a percentage of 60% (n=34). While 33% (n=19) of the herbalists stated that they did not know if tar had a toxic effect, and 7% (n=4) stated that tar is toxic. The study conducted by Zahir *et al*, [27] concluded that Thuja is not toxic with a percentage of 87%. The study conducted by el jemli *et al*,[38] concluded, consecutively, that oral administration of *T. articulata* essential oil for 15 days had no effect on the growth functions of animals at a concentration of (2 and 5 g/kg) and caused no mortality. In another toxicity study, Thuja oil from the Tafoughalt forest in Morocco was inhaled at doses of 1% and 3% to rats. After 24 hours, no toxicity and no deaths were recorded.[39]
With very little published information on the safety of cade oil (tar), only a few studies have been reported on cade oil poisoning. Differently, tar is promoted as a cosmetic and health product in Morocco.[40]

Commercialization
Seller (Figure 12a): For those who sold tar, 74% (n=42) said that they did not sell more than one litre, and the demand for tar is stable in all seasons, while 26% (n=15) of the herbalists said that sales increase in summer.

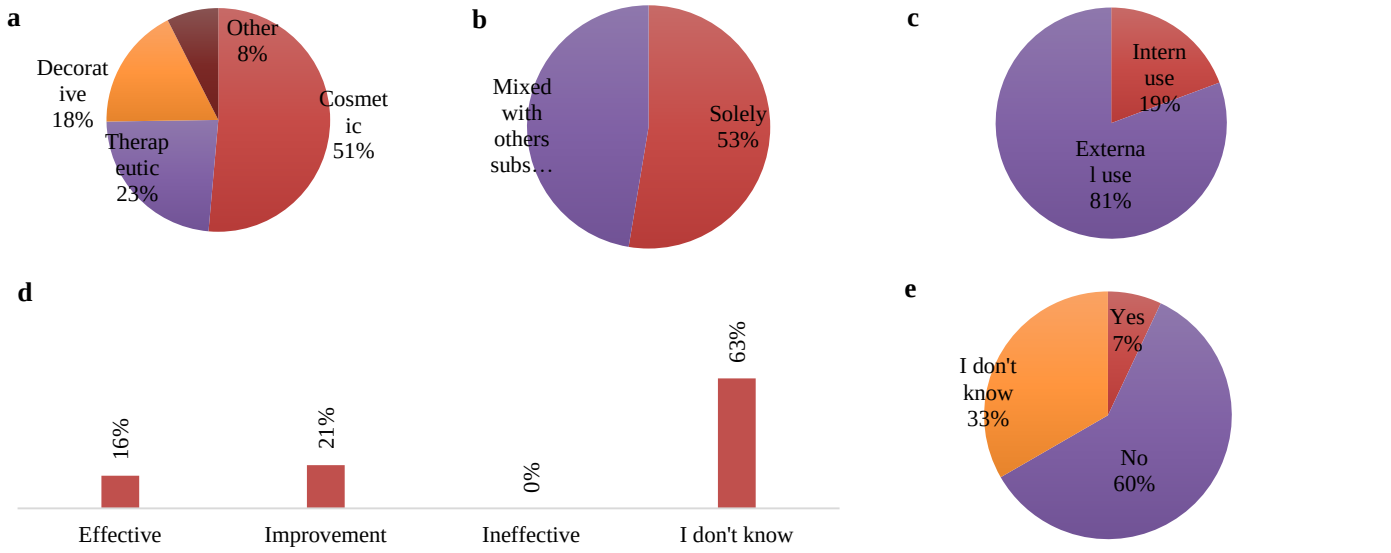

Figure 11: Graphics representation of the percentages; (a) Field of use; (b) the mixture; (c) mode of administration, (d) the results; (e) Toxicity

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Table 3: Species used in tar production mentioned by herbalists

Plant Family	**Species**	**Species (Moroccan name)**	**Frequency**	**%**
Cupressaceae	*Juniperus sp*	Araar, Tîqqi	23	38%
	Tetraclinis articulata (Vahl) Mast	Thuja,Ar'ar	3	5%
Myrtaceae	*Eucalyptus sp*	Eucalyptus	1	2%
Oleaceae	*Olea sp*	Zitun	1	2%
Salicaceae	*Salix sp*	sefsaf	1	2%
Apocynaceae	*Nerium oleander L.*	Defla, Diflâ	1	2%
Pinaceae	*Cedrus sp*	Arz, larz	2	3%
Apiaceae	*Ferula communis L*	L-klekh , Alk kelakh	5	8%
I don't know	-	-	24	39%

Consumers (Figure 12b): The results showed that the majority of tar users are women, which is in accordance with the study of Khadija *et al*. where female gender were shown to predominates (64.21%), against 35.78% of men.[41] Another study on the use of Thuja showed that 57% of tar users are women, while the remaining are men. Women also have more traditional knowledge than men.[27] In another study, 73% of women were reported as users of herbal extracts internationally, with many studies also showing similar results in France and Mali.[30] These results are consistent with several previous studies showing that women are the most common group of consumers of medicinal plants.

Quality (Figure 12d): For tar's quality, 42% (n=24) of herbalists stated that they could not differentiate between its different qualities, while 58% claimed that there is unsullied tar and tar are mixed with other substances such as black engine oil to obtain a higher quantity, and since tar has a strong smell, it is almost impossible to detect it. Up to 35% (n=20) stated that good tar is known by its smell, whereas 14% (n=8) recognize the quality of tar by its colour and 9% (n=5) by its texture.

Price (Figure 12e): In Sale, the price of tar varies according to the quantities requested. While in general the basic price is between 5 and 10 dh for a small 10 mL bottle, the price per litre was estimated at less than 50 dh according to 51% (n=34) of the survey responses. Many vendors stated that tar prices vary between 30 and 35 dh. Up to 25% (n=17) of the herbalists questioned on the subject stated that a litre of tar can be sold at a price between 50 and 60 dh and about 6% (n=4) stated that pure tar contains phyto-therapeutic substances "that can cure cancer" can cost between 800 and 1000 dh per litre. Only 3% (n=2) of herbalists reported that pure tar could be sold between 350 and 400 dh per litre. The WHO mentioned that 80% of the population in developing countries relies on traditional uses of medicinal plants for health, thus ensuring the survival of this social class as in Cameroon. [29]

Storage: All herbalists interviewed informed us that the storage of any type of tar is always in a plastic bottle. Some of them said that it should be stored in darkness, while others did not insist on packaging.

Cities (Figure 12f): The sixth graph represents the percentage of different cities of origin of tar sold in herbalist shops; the answer "I don't know" with 34% (n=25) was the most recurrent, followed by 12% (n=9) for Casablanca and the Middle Atlas as places of origin, 8% (n=8) for Rabat and 7% for Marrakech and Boujaad. Other cities names mentioned with a percentage of less than 4% (< 3) include Zaaer, Mountainous regions, Khenifra, Essaouira Beni-Mellal, South of Morocco, Ouad Zem and Khouribga.

Producers

Sociodemographic status

The Talgount cooperative has ninety people in charge of tar production. All the producers were male; their age varies with almost the same percentage. We found that the highest percentage of the age range was]40-50], and we can see that 21% (n=4) for three age groups]20-30],]30-40] and [50-60]. Finally, 11% (n=2) for those over sixty, with all producers married.

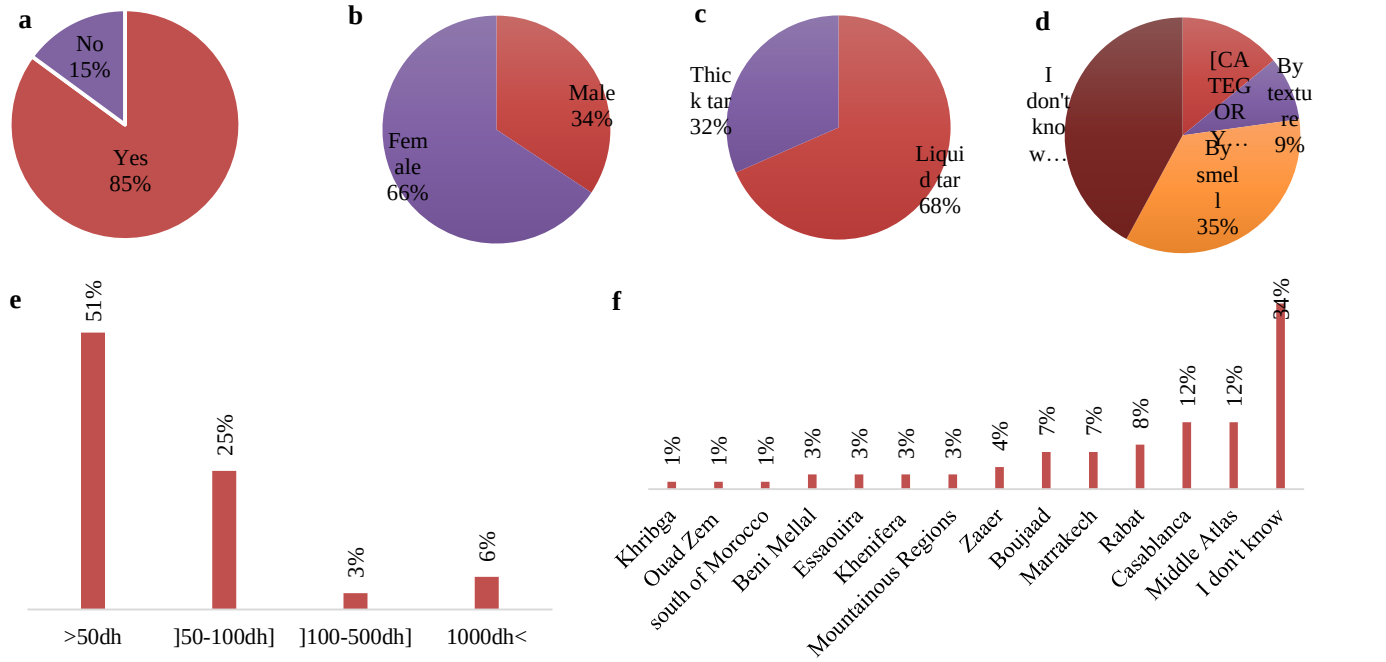

Figure 12: Graphical representation of percentage; (a) sell; (b) consumers ; (c) demand; (d) price ; (e) quality ;(f) origin

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Moreover, for their education level, it varies between all levels with different percentages: 37% (n=7) are illiterate, 32% (n=6) have secondary level, 26% (n=5) with elementary level and 5% (n=1) for post-secondary level. Mr. Said, the representative of the Talgount cooperative, provided all the information (Table 4).
The Itzer cooperative in the Drâa-Tafilalet region has six (male) members, aged between 40 and 60, married and uneducated.

Uses
Tar is mainly used in the veterinary field, especially for sheep and cows, with internal and external administration. The use of a teaspoon of liquid tar with lemon and olive oil is an excellent antiseptic and antimicrobial agent for sheep, as well as wound healing in animals. In Turkey, according to the work of Süleyman *et al*.[33] the use of tar in animal husbandry to cure animal diseases is recognised. The second recipe is to use a few drops of the tar in the soup for children in order to eliminate intestinal parasites, according to the head of the Itzer cooperative. Similarly, the healing of an individual who suffered from skin cancer has proved the anti-cancer effect of tar. Furthermore, the tar used to cure cancer is not from Juniper or Cedar, but is a tar obtained from *Taxus baccata L*. 'Yew' called 'Tagga' by the Talgount cooperative and 'Igni' by the Itzer cooperative, and is said to be difficult to find. On the contrary, the authors state that the use of tar presents health risks as it is toxic by mouth and contains carcinogenic substances.[43] Tar is also used with asthma patients for prevention and to cure eczema, dandruff and ulcers in humans. It is also said to be an antiseptic for wounds and scratches. However, It is considered as a cure for intestinal parasites in animals worldwide,[11,12,31,33] and as an insect and animal repellent.[44] The healing and therapeutic power of tar were influenced by factors such as the tree's age. In addition, uses differ according to the knowledge of the civilisation.[37,42] In an ethnopharmacological study in Iran, the use of patterns for animal husbandry may vary according to environmental conditions.[45] In Bangladesh, distance may play a role in the choice of traditional medicine.[28]

Commercialization
Tar is sold at seven dirhams per litre and rarely at ten dirhams by Talgount cooperative. This low price is one of the main reasons for cooperative creation, hence the need to valorise tar as cosmetic and therapeutic products. The Itzer cooperative sells huge quantities of tar to wholesalers, with a cost of 100 dirhams per cup of Yew specie's tar. As far as sales outlets are concerned, both cooperatives sell their products in all regions of Morocco, and their clients are herbalists, travellers, camp organisers, and breeders for the veterinary quality of the tar in curing animal diseases. The manager of the Talgount cooperative said that he has an American customer who buys tar to use as an animal repellent since he lives in the countryside. Itzer cooperative's manager added that tar is exported to Spanish companies of tobacco and shampoo.

Production
The leaders of both cooperatives learned about tar production from their parents. The knowledge was passed on from one generation to the next. This is the same system that has been used in Turkey for the transmission of tar production methods to the next generations.[27,28,33,37]
In Talgount, tar is extracted through a traditional technique, the pyrolysis method with the excavated indirect combustion kiln, in a sealed state with the absence of oxygen and the presence of semi-circular fire (Figure 14a). The wood is converted into liquid gas and charcoal is produced. [44] While the method of tar production at the Itzer cooperative is different. Two traditional methods have been used for small quantities, the inverted pot with fluid channel in the case of yew, and for cedar, they use a charcoal kiln linked directly to the fire (Figure 14b). In a study by burri *et al* [26] in Morocco, these techniques were cited, while in an earlier work,[46] they had stated that the literature was not rich in information on tar production methods. In regards to the species and parts used, the Talgount cooperative uses Juniper wood, while the Itzer cooperative utilizes the roots of *Cedrus atlantica* and *Taxus baccata*. Therefore, the wood and roots are chosen according to certain special criteria including the colour, which must be yellow, indicating the resin contained within.
The sensory pathways detect other requirement criteria. The use of the senses has proven to be an important tool in the selection of raw materials.[46] The Talgount Cooperative has stated that only dead Juniper wood that has certain criteria is used; therefore, using undead wood will only yield water that is of no value. The use of old and dead wood has also been cited by Ari *et al*, and Teixidor-Toneu *et al*.[12,31] In addition to these physical criteria, the phytosanitary aspect is also checked. The wood that meets the selection criteria is put into an excavated indirect combustion kiln and the fire is kept burning for twenty-four hours at Talgount.

Table 4: Socio-demographics of Talgount Cooperative

Informant details		
Gender		%
Male	19	100%
Female	0	0%
Age		
<20	0	0%
]20-30]	4	21%
]30-40]	4	21%
]40-50]	5	26%
]50-60]	4	21%
60<	2	11%
Marital status		
Single	0	0%
Married	19	100%
Widowed	0	0%
Divorced	0	0%
Education level		
Illiterate	7	37%
Elementary	5	26%
Secondary	6	32%
Post-secondary	1	5%

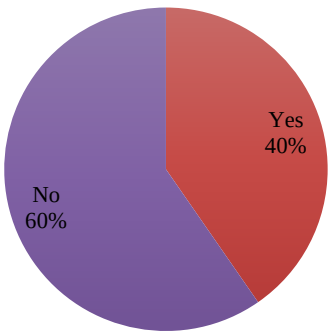

Figure 13: tar production knowledge

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Figure 14: Photo of site of tar production (a) in Talgount (Excavated indirect-fired); (b) In Itzer (Charcoal kiln Direct fired) (Taken by Ninich Oumaima)

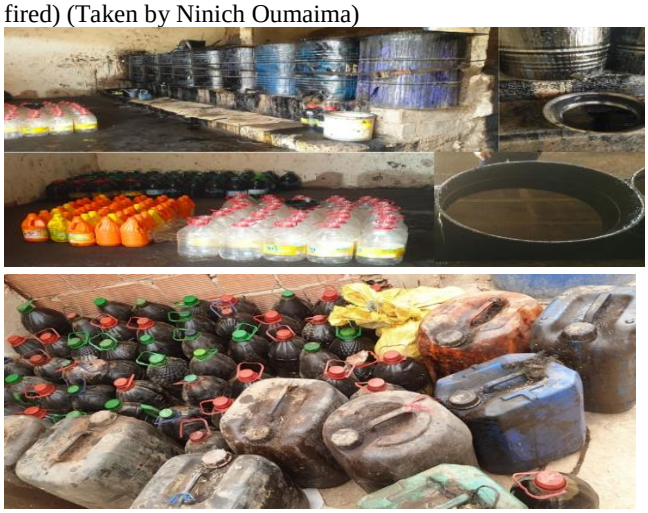

Figure 15*:* Photo of tar decantation and conservation (Taken by Ninich Oumaima)

For the Itzer cooperative, the sensory criteria of the roots are checked on site and the extraction is done using a charcoal kiln for direct firing, with the fire remaining lit for seven days. In a comparative study between traditional and laboratory tar production, traditional tar production can last between 2-15 days, while the laboratory method lasts only a few hours. [37] Afterwards, the tar is decanted into barrels where the separation of tar and water takes place, the latter has been removed at all times and the tar is stored in five litre plastic bottles (Figure. 15). During this time, the quality of the tar can be guaranteed by its viscosity and smell. Regarding the quantities, the Talgount cooperative stated that to produce one litre of tar, 45 kg of dead wood would be needed. In the case of the Itzer cooperative, 40 kg of roots are needed to produce one litre. In the literature, the quantities of tar produced now are slightly lower than the ones which were generated before World War I which was about 283 tons, and 25 tons in 1939, according to a study.[47] The decline was manifested by the unavailability of plant raw materials, falling demand and replacement by synthetic chemicals. Tar production is done twice a year; during the summer for the Talgount cooperative, while for the Itzer cooperative, production starts from November and ends in May, which corresponds to the winter.

Regarding the obstacles that the two cooperatives face, both of them have mentioned that authorization is the biggest problem they confront. To exploit forest resources, the cooperatives need to obtain an authorization, which is renewed every month, from the High Commission for Water, Forests, and Fight against Desertification. Moreover, Tar production has been restricted in the Eastern Mediterranean region by law since the second half of the 20th century.[47]

Another study[26] shows that there are two practices, a legal practice where dead wood of cedar and thuja is used and an illegal production wherein protected species (juniper, yew) are cut down. The cooperatives devoted sites in the forest to the production of tar. This allowed them to join efforts in protecting the forest from illegal practices that might endanger its species.[46] The second obstacle for the Talgount cooperative was the transport of dead wood from the forest to the tar production site. This is not the case for the Itzer cooperative where cedar tar is produced at the site where they collect tree roots. The third obstacle that the Itzer cooperative faced was the taxing administrative procedure for the legal creation of a cooperative; the person in charge has expressed his intention to give up his tar production activity.

Conclusion

The ethnobotanical survey was neither representative nor sufficient to detail all the information on tar's plants, its production methods and uses in all regions of Morocco. The online survey targeted only internet users causing marginalisation of people who do not use it. For herbalists, there was absence of registers containing their addresses and contacts in the country which is a major limitation. Considerable data could have been collected from producers in other regions; however, they were in illegal status. Morocco has a rich cultural heritage of tar knowledge that needs to be preserved, transformed, proven, and turned into scientific knowledge. Therefore, governmental actions need to be taken in this context for more comprehensive research in the future.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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