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Assessing Important Components for the Utilization of *Ferula assa foetida* L Based on combination of Approach of Indigenous and Scientific Knowledge: A Case Study

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ABSTRACT

Aims Today, scholars and researchers, while collecting and applying traditional methods, are an attempt to consolidate the indigenous and scientific approaches into a superior body. This study was performed to apply a consolidated approach for the assessment of harvesting medicinal plant *Ferula assa-foetida* in Tangsorkh Rangelands, Boyer-Ahmad county, Iran.

Instruments & Methods In the descriptive study, a number of interviews were held with the local stakeholders along with a literature review to solicit information on the possible set of indicators determining different aspects of harvesting *F. assa-foetida.* The main method applied was the exploitation of indigenous knowledge based on a participatory-exploratory research method. For this purpose, the researcher traveled to the area during the harvesting season in the spring and summer 2015, to accompany the beneficiaries of *F. assa-foetida* in the Tangsorkh rangelands. During the interviews and direct observations, questions were asked to explore the factors affecting the utilization of *F. assa-foetida* and the results were qualitatively analyzed.

Findings Indigenous and scientific knowledge shared similarities in terms of cutting intervals, plant viability and cutting age, yet differing in cutting method and frequency. The consolidated approach of Indigenous and Scientific Knowledge suggested that conventional method, one and two-sided cuttings, four-day intervals, 20 cuttings per year and a plant age of 5-10 years as the suitable harvesting principles.

Conclusion There are evident differences between the indigenous and scientific knowledge of harvesting F. assa-foetida, with Dominated convergence. It appears that scientific knowledge has been considerably concerned with plant viability to achieve a sustainable level of production.

Keywords Boyerahmad County; Consolidated Approach; *Ferula assa-foetida*; Harvesting; Tangsorkh Rangelands

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Introduction

The initiation of development was concomitant with the modernization of lifestyles and the use of scientific knowledge and new technologies. Yet, in the onset of the Third Millennium, this approach proved futile. This stems from several factors such as the lack of respect for the locals and large-scale implementation of programs (in a national to international scale) without considering local variations and characteristics. Consequently, the emphasis has been put on the concepts such as participation, local activities and the utilization of indigenous knowledge [1]. The current era, otherwise known as the post-modern era, features the abundance of information, technologies and development at the same time with due attention to indigenous, and traditional knowledge [1]. Indigenous knowledge in Persian culture, means the collection of information and knowledge of the masses [2]. This knowledge accumulates gradually, yet the results have been frequently proved efficient. Such knowledge includes subtle and accurate observations about plants, animals, water, air, soil, pests and classification systems that fully comply with local circumstances [2].

Barani defines indigenous knowledge as knowledge of human groups, mainly oral and unwritten, associated with different backgrounds, life and livelihood in accordance with the social and natural environment, formed through trial, and error over time [3]. The majority of people by adapting to the environmental conditions have ascertained tolerable lifestyles. Therefore, this knowledge is the result of the accumulation of valuable experience of centuries, which could serve as a potential means of achieving sustainable development [4]. Indigenous knowledge has not been well documented and this runs the risk of extinction of so many local cultures [5-7].

Dependency and compatibility of indigenous knowledge refer to its geographical origin. To solve the problems of a country's development, exploration and scientific study of indigenous knowledge is required [8]. For many years, indigenous ecological knowledge has played a key role in the cultural and economic development of developing countries [9]. Indigenous knowledge shares various convergences and divergences with scientific knowledge. Obviously, this difference is not meant to make a contrast. On the contrary, the indigenous and scientific knowledge could be used to their own advantage. Chambers believes indigenous and scientific knowledge are complementary in terms of the strengths and weaknesses so that their combination can yield higher success rates that would not be achievable by applying them individually [10]. Nowadays, scholars and researchers, in addition to collecting and applying traditional methods, are consolidating the indigenous and scientific approaches into a superior knowledge [2].

Among the studies concerning indigenous and scientific knowledge, one could point out to the indigenous and scientific knowledge of the vine farmers in Kohgiluyeh and Boyer-Ahmad province [11], indigenous knowledge on issues related to irrigation among the saffron farmers in South Khorasan [12], combined ethnobotanical with geographic information systems [13], combining indigenous and scientific knowledge for natural disaster risk reduction and climate change [14], the consolidation of indigenous ecological knowledge and management practices in the Papyrus swamp in a semi-arid region [15], incorporating indigenous ecological knowledge in coastal restoration a city in a mountainous region of southwestern China [16] and other studies. Indigenous knowledge is largely mixed with the beliefs and religion of the local population. Customs, traditions and land use practices play an important role in the sustainable management of natural resources and livelihoods [17]. Ethnobotany is part of the indigenous knowledge of plants used by people for generations. This knowledge has long been defined as part of traditional knowledge that seeks to understand how plants are used as food, shelter, medicine, clothing, hunting, etc. [18].

Iran is a country with different climate conditions and in result rich plant flora [19]. Iran is home to as many plants as 8000 species and 1810 of them are autochthonous (endemic), on the other hand, more than 2300 of them are used as sources of industrial chemicals, pharmaceuticals, etc. [20].

In recent years, the application of medicinal plants in order to cure and prevent diseases has dramatically increased worldwide, especially in Iran [21]. Studies show that nearly 80 percent of people in developed countries depend on traditional medicines [22].

Ferula assa-foetida is known as one of the medicinal species of Iran's rangelands that has been used by the local people since ancient times. *Ferula assa-foetida* L. belonging to Apiaceae family. The plant gum is used as medicine and spice in some countries [23-25].

The importance and exploitation of *F. assa-foetida* are due to the oleo-gum-resin stored in the root. Harvesters use special methods to extract, collect and store the oleo-gum-resin. Oleo-gum-resin marketing is an important economic activity in the area. The important issues in harvesting *F. assa-foetida* are the conditions and stages under which the utilization is carried out. Several studies have been conducted by several researchers, but the evidence seems to be inconclusive [26-28]. The lack of incorporating the indigenous knowledge is one of the main similarities between these studies. There are beneficiaries with a rich knowledge in harvesting *F. assa-foetida* in the area whose knowledge needs to be documented and then consolidated with the scientific knowledge to achieve the goals of sustainable development.
The aim of this study was to identify the factors affecting the exploitation of F. *assa-foetida* by applying a consolidated approach in the Tangsorkh rangeland, Kohgiluyeh, and Boyer-Ahmad province.

Materials and Methods

The present study is descriptive.
The study area: Tangsorkh Rangeland is located 50km away from Yasouj, in the southeastern part of the Kohgiluyeh and Boyer-Ahmad province. The area is located at 51° 49' 42" E and 30° 28' 04" N, with an average elevation of 2301m (Figure 1).
Tangsorkh rangeland receives an annual precipitation of 832mm and its average annual temperature approximate 15.4°C. Being a summer grazing rangeland, the study area is utilized for more than 120 days for grazing purposes [29]. Tangsorkh is one of the main habitats of *F. assa-foetida*, being traditionally used by the locals. Given the reduction of *F. assa-foetida* in the region and with the support from the Provincial Directorate of Natural Resources and Watershed management, the harvesters have initiated different activities to restore and grow *F. assa-foetida* stands in the rangelands. There are numerous harvesters in the area due to the profitable market for the *F. assa-foetida*. With proper management and sustainable utilization, it is expected to achieve economic growth, improve the livelihoods, and finally provide protection for the remaining *F. assa-foetida* plants in the area.

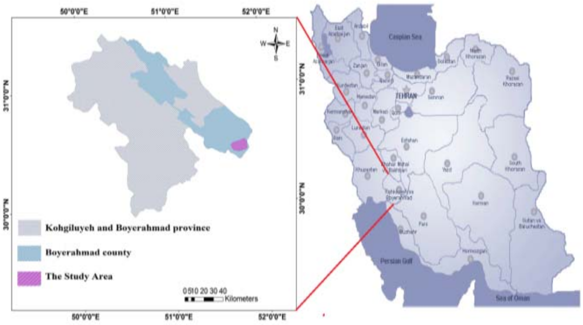

Figure 1) Location of the study area in Boyer-Ahmad County, Kohgiluyeh and Boyer-Ahmad province in Iran

To investigate the practicality of the factors and to verify the consolidated approach, several field visits were organized.
The applied methodology in this study could be organized into two general classes:
Literature review on the exploitation of *F. assa-foetida*: This section started by a thorough desk study to interpret and categorize the current state of knowledge on different aspects of *F. assa-foetida* oleo-gum-resin collection.
Evaluation of harvesters' indigenous knowledge: Data was collected using structured interviews, direct observations, and regularly attending oleo-gum-resin collection activities, in the form of an exploratory-participatory research method. For this purpose, in the spring and summer 2015, after identifying local harvesters, those with a long history in this activity were requested to give permission to participate in the oleo-gum-resin collection activities. In the present study, the knowledge was extracted through the presence of people and participate in their activities. The total beneficiaries were in the field about 35 people among which 10 people, were involved in the research. The questions stages, cutting age, number of cutting and cutting methods on the amount of sap and plant survival, and the questioning with the users continued until the continuation of the dialogues, a new point to the findings Previous were not added. Further visits provided information about the plant selection criteria, twisting and laying the plant

canopy cover (Figure 2A), excavating a hole around the plant (Figure 2B), cutting (Figure 2C), and oleo-gum-resin collection (Figure 2D).

Figure 2) A: Twisting and laying the plant's canopy cover, B: Hollow out a hole around the plant, C: Conventional cutting method, D: Oleo-gum-resin collection, E: One sided cutting method, F: Two sided cutting method

During the direct interviews, harvesters were inquired about the factors affecting oleo-gum-resin collection plant age, cutting frequency, cutting method and plant viability). This was reiterated until no extra information was gained. One of the primary conditions for data collection and organization is to put emphasis on the local spoken language and accent. Sometimes, misinterpretation of questions would result in collecting biased information. Given that the researcher was already a local resident, there was no extra concern accordingly. Subsequent to the data collection phase, data were extracted and qualitatively interpreted [3].

Findings

Since 1996, five studies have been conducted on harvesting *F. assa-foetida*. Despite the existence of numerous studies, only those in the scope of this paper were considered (Table 1).

There were three studies on the different cutting methods and frequencies for *F. assa-foetida* oleo-gum-resin collection. As for the effects of cutting on the plant regrowth, four studies were found (Table 1).

The majority of studies have considered a four-day interval between cutting sessions. All studies of equal age older than 5 years have been considered suitable (Table 2). A number of similarities and differences existed between the conducted studies. Differences also existed in the amount of oleo-gum-resin and plant viability following each cutting method and frequency (Table 2). The outcome of the 6-month inquiries conducted by the researcher regarding the local indigenous knowledge was shown Oleo-gum-resin collection was performed mainly via cutting (Table 3). In total, a number of 6 key findings were solicited from the data.

As for the different cutting methods, the locals solely rely on the conventional cutting mode (Table 4).

The scientific knowledge suggested that the diagonal, concave, one-sided and two-sided techniques are the superior cutting methods (Table 5).

Table 1) Studies conducted on the effects of different factor on the plant oleo-gum-resin and viability

Author (s)	Cutting Method	Annual Cutting Frequency	Cutting Intervals	Plant Age	Plant Viability
Shad [31]	✓	✓	✓	-	✓
Omidbeigi *et al.* [27]	✓	-	-	-	✓
Omidbeigi and Pirmoradi [28]	-	✓	-	-	-
Gholami and Faravani [26]	✓	✓	-	-	✓
Eskandari Damane and Sharafatmandrad [20]	-	-	-	-	✓

Table 2) Summary of findings in relation to the factors affecting oleo-gum-resin production and plant viability

Factor studied	Shad [31]	Omidbeigi *et al.* [27]	Omidbeigi and Pirmoradi [28]	Gholami and Faravani [26]	Eskandari Damane and Sharafatmandrad [20]
Cutting Methods	Oleo-gum-resin production in the diagonal cutting method (innovative method) was higher than the conventional method.	There were no significant differences between the two-sided and lateral cutting methods.	-	Highest oleo-gum-resin production was achieved via concave cutting	-
Annual Cutting Frequency	Highest production was achieved for 4 Cutting per year.	-	An increasing trend to the ninth cutting and a decreasing trend afterwards.	A number of 10 cuttings have been perceived suitable.	-
Cutting Intervals	No evident differences between cutting intervals.	A four-day cutting interval has been considered.	A four-day cutting interval has been considered.	A five-day cutting interval has been considered.	-
Plant Age	-	-	-	-	-
Plant Viability	Highest plant regrowth (by 60%) under the diagonal cutting.	Highest viability under the one- and two-sided cuttings.	-	Highest viability rate under the concave cutting and 10 cuttings frequency.	45 degree cutting with the plant density of 50 x 70.

Table 3) The overall indigenous knowledge regarding the effects of different factors on harvesting *F. assa-foetida*

Influential factors	Indigenous knowledge
Cutting methods	Commonly used method
Annual cutting frequency	17-20 cuttings
Cutting intervals	4 days
Plant age	Higher ages are more apt to produce greater amounts of oleo-gum-resin. Plants younger than 5 years do not have the necessary conditions for harvesting.
Plant viability	The majority of the harvesters agreed that plant cutting inhibit the subsequent plant regrowth, yet the contrary was reported by a minority of harvesters.

Table 4) Convergences and divergences of indigenous and scientific knowledge with regard to the factors critical to harvesting *F. assa-foetida*

Influential factors	convergence	divergence	Description
Cutting methods		✓	On the contrary to the scientific knowledge, harvesters believe no other method is as efficient as the conventional method in producing oleo-gum-resin.
Annual cutting frequency		✓	The indigenous and scientific knowledge does not agree on the number of cuttings.
Cutting intervals	✓		The indigenous and scientific knowledge are consistent in terms of cutting intervals.
Plant age	✓		No hard evidence found concerning the suitable harvesting age. Yet, ages higher than 5 years are considered adequate.
Plant viability	✓		Studies suggest no further plant regrowth subsequent to the conventional cutting method, which agrees to the indigenous knowledge.

Table 5) Consolidation of indigenous and scientific knowledge with regard to harvesting *F. assa-foetida*

Influential factors	Consolidation
Cutting Methods	conventional, one and two-sided cutting
Annual Cutting Frequency	4-20
Cutting Intervals	Four days (Both knowledge are converging and affirmative)
Plant Age	5-10 (Both knowledge are converging and affirmative)
Plant Viability	The results of both knowledge suggest the lack of viability or low viabilities viability in conventional cutting methods

From the perspective of the harvesters, the diagonal method may result in plant destruction while the concave method was not applicable due to frequent cutting episodes per year, exceeding 20 cuttings. Generally, both indigenous and scientific knowledge agreed on four-day cutting intervals.

The minimum cutting age was determined 5 years, according to the indigenous and scientific knowledge, with the indigenous knowledge suggesting the plants of at least 7 years of age or older for efficient oleo-gum-resin production.

Discussion

This study was performed to apply a consolidated approach for the assessment of harvesting medicinal plant *F. assa-foetida* in Tangsorkh Rangelands, Boyer-Ahmad county, Iran.

Experience shows that not only indigenous knowledge does not contradict with scientific knowledge, but its different characteristics have made it a good complement to the scientific knowledge [30]. When used jointly, they offer results that are not achievable by applying them individually. The main objective of this study has been the consolidation of the indigenous and scientific knowledge in harvesting *F. assa-foetida*. The scientific knowledge in this paper has been formed by compiling the findings of different studies, while the indigenous knowledge has been the outcome of the participatory activities in the field. Results of the present study suggested that cutting age, method, frequency, intervals and plant viability have to be considered when initiating *F. assa-foetida* oleo-gum-resin collection endeavors.

Cutting age: Most studies conducted suggest harvesting the plants of equal age older than 5 years [20, 31, 32]. During the interviews, the harvesters indicated that older plants will produce higher amounts of oleo-gum-resin. Harvester believes that plants of older ages thicker roots, which enable them storing greater amounts of oleo-gum-resin in the underground tissues, which is in conformity with the findings of [33]. Likewise, one study by Omidbeigi and Pirmoradi [28] suggested higher oleo-gum-resin production of thicker roots of this plant. Higher oleo-gum-resin production in older plants is attributable to plant's wide canopy and thicker roots. The amount of oleo-gum-resin stored is a function of the plant's canopy [32]. Harvesters also reported lower growth rate during the first two years, when the plant emerges in the form of a narrow strip on the ground. By the passing of time, the plants develop wide canopies and thick bases. *F. assa-foetida* does not produce significant amounts of oleo-gum-resin in the first five years of its life. Oleo-gum-resin production increases constantly, with a major increase after the seventh year, until the plant starts to develop the flower bearing stems; an especial stage, believed by the local harvesters, in which plant turns into a male state.

Cutting method and plant viability: The cutting method being applied in the region has been a conventional method that has been passed on through generations. In this method, the upper root area (apex) was cut open in a circular form via a special device. Each plant is normally subject to a frequency of 17-20 cuttings per year, depending largely on plant vigor (thick and healthy roots). A four-day cutting interval has been traditionally established via trails and errors, each cutting being preceded by oleo-gum-resin collection cutting renewal. With regard to the plant's age, stakeholders believe older plants are apt to produce more oleo-gum-resin. Plants younger than 5 years are not considered for harvesting due to the inherent plant weaknesses and infeasible oleo-gum-resin production, suggesting an age of higher than 7 years would be most practical. There was no consensus on plant regrowth in the subsequent year to harvesting or harvest. This might be explained by the certain fear among the harvesters from the fact that the Provincial Directorate of Natural Resources and Watershed management would prohibit any further activities due to the destructive impacts of currently used harvesting method. The majority of the harvesters agreed that plant cutting inhibits the subsequent plant regrowth, yet the contrary was reported by a minority of harvesters.

There is some evidence concerning the low efficiency of this cutting method in oleo-gum-resin production [26, 31]. However, some studies found no evident deviation from the two-sided cutting technique. The indigenous knowledge suggests that higher cutting frequencies will result in a greater amount of oleo-gum-resin production, and this assumption is followed until there is no extra gain in oleo-gum-resin excretion. On the contrary, the scientific knowledge stipulates that the number of cuttings should be no more than 10 times a year, or the plants may fail to regrowth. Both indigenous and scientific knowledge, comply with that the four-day interval is the best cutting frequency. Despite the lack of hard evidence regarding the suitable plant age of oleo-gum resin collection, yet most studies [20, 31, 32] have considered the age of 5 years or older, which is consistent with that of the indigenous knowledge. This convergence also exists regarding the effects of the conventional cutting method on plant viability.

Various cutting methods have been applied with different outcomes. A diagonal cutting was suggested by Shad [31], a two-sided cutting by Omidbeigi *et al*. [27], a concave method by Gholami and Faravani [26], and a cutting at 45 degree angle by Eskandari Damaneh and Sharafatmandrad [20]. The most frequently cited cutting method in this study was the conventional cutting method. It is believed that this technique provides comparatively the maximum amount of oleo-gum resin yet with fatal consequence. For the sake of plant viability, one to two plants are remained intact among every five plant bases. Moreover, harvesters also attempt to cultivate new plants in autumn in order to compensate for the lost plants. The important role of Indigenous ecological knowledge in the field of sustainable use of natural has been frequently reported [34-36]. During the interviews, new alternative cutting methods were suggested to the harvesters (based on the scientific knowledge). Positive signs of acceptance were observed among the harvesters, provided that the proposed method might be able to produce higher amounts of oleo-gum-resin and guarantee plant viability.

Harvesters also indicated that the diagonal cutting method has fatal consequences after 3-4 cuttings. This method is reportedly suitable for ferula plants (locally known as Beriz Bookhash) while destructive for *F. assa-foetida*. Another study [26] has found positive influences for the concave cutting method which is in contradiction to the perspectives of the harvesters, already finding it inefficient for higher than 20 annual cuttings [29]. Moreover, concave cutting needs a special cutter out of the maneuver range of currently used tools. In addition to the acceptable oleo-gum resin production, cuttings are expected to be quick and simple. With regard to the one and two-sided cutting methods, harvesters reported their acceptance as long as suitable oleo-gum-resin production and plant viability are guaranteed. Given the opinion of the harvesters and frequently cited application of the two-sided and one-sided Cuttings (Figure 2E, 2F), this technique is seemingly more practical. The conventional cutting method has proved fatal by so many studies [20, 28, 31]. This is, to a large extent, due to a lack of plant regrowth subsequent to the cutting, in which the bulk of the root tissue is removed at each cutting stage [27].

Cutting frequency: Scientific knowledge suggests at least 4 [31], to maximally 10 cuttings [28] are suitable for harvesting *F. assa-foetida*, beginning in mid-July and ending in early October. Indigenous knowledge suggests that there is an increasing trend in oleo-gum-resin production from the beginning towards the middle of harvesting period. Oleo-gum-resin production increases from 7-8 to 12-13 cuttings, and then decreases. According to the local harvesters, this might be due to the concurrency with the hotter days of the year and rush of smoother oleo-gum-resin onto the root surface. Oleo-gum-resin production decreases remarkably towards October, mainly as a result of less oleo-gum-resin production and lower temperature, which inhibit the secretion of oleo-gum-resin from the root surface. Towards the late harvesting season, oleo-gum-resin production has another reduction, which is associated with less water availability [32]. The ten episodes of Cutting, suggested by the scientific knowledge, was reported inefficient by the harvesters, as it does not cover the full range of oleo-gum-resin production period in plants.

Cutting intervals: Both indigenous and scientific knowledge are compatible in terms of suitable cutting intervals (four-day intervals). At each cutting, oleo-gum-resin is totally extracted from the upper root section, and the cutting has to be continued afterward. The excreted oleo-gum-resin dries at longer intervals and gradually degrades plant roots by clogging root stomata and oxidation permanently its peripheral tissues. Shorter periods would also result in less oleo-gum-resin production (inhibits complete oleo-gum-resin excretion) and loss of plant vigor and viability. Plant roots are not tolerant to higher cutting frequencies. This is an important inference from the results of this study, as four-day intervals are most suitable to maintain plant vigor and to completely extract the oleo-gum-resin stored in root tissues.

Yet, further studies, which take this factor into account, will need to be undertaken. Given the current convergence in terms of cutting methods, further studies need to concomitantly consider the methods accepted by both indigenous and scientific knowledge. In future studies, it might be possible to conduct research by applying the principles of the consolidated approach with regard to the factors affecting oleo-gum-resin production from *F. assa-foetida* (cutting age, frequency and method) in a systematic framework.

The implications of this approach for harvesting *F.assa-foetida* has to be field tested in order to maximize the product and plant viability in rangelands.

The limitation of this research included not using field test at the final result of the combination approach for utilization *F. assa- foetida*.

It is suggested that the results of this research be tested in rangelands.

Conclusion

There are evident differences between the indigenous and scientific knowledge of harvesting *F. assa-foetida*, with Dominated convergence. However, the contradictions of the indigenous and scientific knowledge do not necessarily mean the denial of one for the other. It appears that scientific knowledge has been considerably concerned with plant viability to achieve a sustainable level of production. Both of them are affirmative and obvious in terms of the four-day cutting intervals. Greater convergence of the two sources of knowledge occurs for cutting age, which is most efficiently performed in plants at five years age or older.

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